A PRACTICAL GUIDE TO MANGROVE REHABILITATION HANDBOOK

A Guide to Community-Based Ecological Mangrove Restoration

MANGROVE ACTION PROJECT

ACTED

dwb ecology

Wetlands INTERNATIONAL

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INTRODUCTION AND BACKGROUND

This Practical Guide to Mangrove Rehabilitation Handbook provides a clear, concise and proven methodology for carrying out Community based Ecological Mangrove Rehabilitation (CBEMR). The handbook is available in English and Kiswahili.

The main intended users of this handbook are the people directly involved in rehabilitating mangroves at the community level.

Mangrove restoration is an inherently complex task that is prone to failure when the necessary conditions are not met. Traditional mangrove rehabilitation follows the same principles as the restoration of terrestrial forest. This involves collecting seeds, planting them in a prepared nursery and transplanting the seedlings to the desired location. However, these efforts can have limited results.

In addition to this handbook, in this series there are three Policy Briefs as follows:

1. Mangroves for the Future of Rakhine State
2. Why is Land Tenure Important for the Future of Mangroves?
3. What is Community Based Ecological Mangrove Rehabilitation?

The Mangrove Action Project (MAP) has developed and promoted the CBEMR methodology given in this handbook and much of the information given is adapted from a previous publication by the Global Nature Foundation (GNF), which MAP has contributed.

CBEMR is a holistic approach to mangrove restoration that views the plant and animal communities as part of a larger ecosystem, connected with other ecological communities and their functions.

WHAT IS COMMUNITY-BASED ECOLOGICAL MANGROVE RESTORATION

The basis of the CBEMR concept is the fact that mangrove forests can self-repair, or successfully undergo secondary succession, by first meeting some preconditions. CBEMR thus focuses on re-establishing the hydrology that will facilitate this natural regeneration process. One of the advantages is the restoration of a more biodiverse, natural species composition, as compared to the rather "artificial" composition achieved through single species, hand planting.

The technique also explicitly engages local communities in the restoration process, empowering them to be stewards of their environment, and enabling them to regain the livelihoods lost when whichever reasons caused the loss of the mangroves. Three to eight-day intensive workshops can train local people on the basic principles and applications of CBEMR, follow-up processes, long-term community management as well as monitoring plans to ensure project sustainability.

Where mangroves are not growing where they should or could be growing, ask why... take action to assist natural regeneration and then ask why again... and again.

Photo: JKivata/Wetlands International

Participatory Action Research

The success of the CBEMR approach is due to excellent planning and preparation. CBEMR uses the principles of Participatory Action Research (PAR) in a repeated cycle of group observation, reflection (in this case research), planning and then acting, before repeating the cycle again.

The meaning of Participatory Action Research is in its name, as follows:

P - Participation is a key to success. If the local community are not fully involved in the process, they are unlikely to contribute to its success

A - Action is an important part of any project. As the saying goes, "actions speak louder than words".

R – Research is a focus of the PAR approach, not only in the formal research in an academic way but also in terms of using good communication, common sense and learning from experience. Experience shows that most often problems with mangrove regeneration are not technical but are in fact social.

Very often with development projects, there is a natural enthusiasm to take action and gain visible results immediately. This has happened many times with traditional mangrove projects in the past. The main emphasis is on raising seedlings and then planting as many as possible, as quickly as possible. However, the results of mangrove planting projects have often been very disappointing with few seedlings surviving beyond one or two years and very little to show after three to five years.

With a CBEMR approach the question which is asked is not "how many seedlings can we plant and where?" but "What do mangroves need to regenerate naturally?" and "Where did mangroves grow in the past and why are they not growing there anymore?" In this way, CBEMR tries to get to the root of the problem and takes a long-term approach.

For this reason, as well as taking action, this handbook focuses on observation, collecting data and information before taking action and monitoring.

CBEMR is a holistic approach and over the years, MAP has been able to use it very effectively to restore both the biodiversity and functionality of mangrove ecosystems. It aims to restore certain ecosystem traits and replicate natural funtions. Scientific evidence shows that mangrove forests worldwide can successfully undergo secondary succession over periods of 15 to 30 years if:

- Conditions ensure a normal tidal hydrology.
- The availability of waterborne seeds or seedlings (propagules) of mangroves from adjacent stands is ensured and not disrupted or blocked.

Because mangrove forests may recover without active restoration efforts, the CBEMR approach recommends that restoration planning should first look at the potential existence of stresses such as blocked tidal inundation that might prevent natural secondary succession from occurring, and removing those stressors before attempting reforestation. If stressors are responsible for the lack of regeneration, these should be determined by observing the site for six months to a year after stress removal. There should be evidence of volunteer seedlings appearing on site within 12 months after the hydrological adjustments. If this is not the case, a reassessment of the hydrology and identification of other potential problems should be undertaken. If seed limitation is a factor, then the rehabilitation team can broadcast buckets of collected seeds from a nearby source on an incoming spring tide.

Only if natural recovery is not occurring after these activities, the team may consider the third step of assisting natural recovery, through hand planting of nursery-raised seedlings or propagules collected in the correct zonation.

Unfortunately, many mangrove restoration projects move immediately into planting of mangroves without determining why natural recovery has not occurred. There may have even been large capital investments in growing mangrove seedlings in a nursery before assessing the stress factors; this often results in major failures of planting efforts.

Mangrove: a tropical tree or shrub that grows in swampy areas and has tangled roots located above ground, or a tidal swamp with a number of these types of trees and shrubs.
(http://www.yourdictionary.com/mangrove

ADVANTAGES OF CBEMR OVER OTHER CURRENT METHODS

CBEMR involves a methodological ecosystem approach as opposed to the usual monoculture restoration efforts, incorporating natural mangrove dispersal and ecological recovery. The key is in the re-establishment of the hydrology of the area considered for restoration, and then working with nature itself to help facilitate regeneration of the area's naturally occurring mangrove species.

The designer of CBEMR based the approach on a set of basic ecological principles capable of producing a much more naturally functional and biodiverse mangrove ecosystem than other more capital and labour-intensive methods such as hand planting. Principles of community engagement and empowerment form the basis of CBEMR, recognising that sustainable restoration requires the active participation of the affected local communities. To ensure success, CBEMR projects have built-in long-term monitoring and evaluation into the restoration framework to assess progress and take corrective action, if required. Since short-term progress may be less visible at CBEMR sites than after classical reforestation, monitoring should involve a sufficient time span (at least three to five years) to understand the nuances that determine success or failure at each unique restoration site.

Mangrove area at low tide

Photo: Dominic Wodehouse

WHEN TO USE PLANTING AND CBEMR

If the site meets certain preconditions such as an intact hydrology, most often, planting is not required. However, the project does need to ensure proper protection from people and grazing livestock during the time of natural succession. With patience, if allowed to restore naturally, a higher species biodiversity and mangrove restoration closer to the original species composition will be the result.

Most often, if allowed to restore naturally, the result is a higher species biodiversity and mangrove restoration closer to the original species composition.

If planting is desirable, the team should still closely follow all the principles of CBEMR, which includes full involvement of communities from the earliest planning stages to monitoring. Before planting, one must ensure that any stress factors that may have caused prior mangrove loss and destruction are resolved, as for example a changed hydrology or contaminated soils. During planting, it is critical to mimic nature by using as many species as were naturally occurring on site, by emulating natural growth patterns, and by planting each species in its correct zonation.

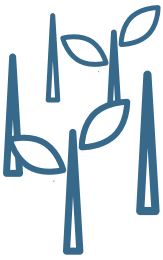
Monitoring is an important final step in order to assess success rates, being able to implement corrective measures if needed, and to develop a set of lessons learned in order to improve the quality of future restoration activities.

The following list of pros and cons of CBEMR and traditional reforestation might help in decision-making and to determine what is best suited for a specific site.

TRADITIONAL REFORESTATION

A typical example of planted mangroves. One species of the same age mostly planted in rows.

PROS	CONS
Planting speeds up recovery.	Planting may be a waste of time and resources if an area can regenerate naturally.
Can be a way to demonstrate claim to an area if there is danger of encroachment.	Reforestation often involves the wrong species in the wrong zones, for example on tidal mudflats or eroding high energy zones, and possibly the wrong time, which results in a high failure rate.
If planted in the correct tidal zone, economically desirable plants, for example Nypa Palm, can be promoted.	Dense plantations are less biologically diverse than natural mangrove stands. Also relatively few mangrove species tend to be grown in nurseries.
Planting can create employment, as the maintenance of nurseries requires a fair amount of labour at least over the project period.	Monocultures are more vulnerable to diseases and insect infestation.
Nurseries can be used for environmental education and raising awareness, especially if signposted with educational information and labelled species.	Nurseries may be affected by insects, drought, floods or poor maintenance.
Involving local communities in controlled and informed planting is important for developing awareness and ownership of a project.	Often mangrove planting occurs without assessing and eliminating disturbances, which is a guarantee for failure.

CBEMR	
	
PROS	**CONS**
Success rates are generally higher.	Recovery is generally slower initially as it depends on natural seeding and production cycles so projects require a longer timeframe.
Community is involved from planning to implementation to monitoring, which ensures success.	If little or no mangrove seed is available nearby the restoration site, lack of propagules entering the site will pose a problem.
CBEMR works with nature and natural cycles so mangroves grow in the correct zone, which ensures good growth rates.	Donors prefer projects with high visibility, that provides good photo opportunities like planting. Naturally regenerating sites may not be as visually attractive as planted sites.
Naturally regenerated mangroves are closer to the original forest and have higher biodiversity.	CBEMR creates less employment.
Restoring large areas can be less expensive using CBEMR.	Nurseries may be affected by insects, drought, floods or poor maintenance.
To promote stewardship and project ownership, projects can utilise small-scale planting of desired species in the correct zone. 	Often mangrove planting occurs without assessing and eliminating disturbances, which is a guarantee for failure.

GUIDANCE TO SUCCESSFUL MANGROVE RESTORATION ACCORDING TO THE FOUR STEPS OF PARTICIPATORY ACTION RESEARCH

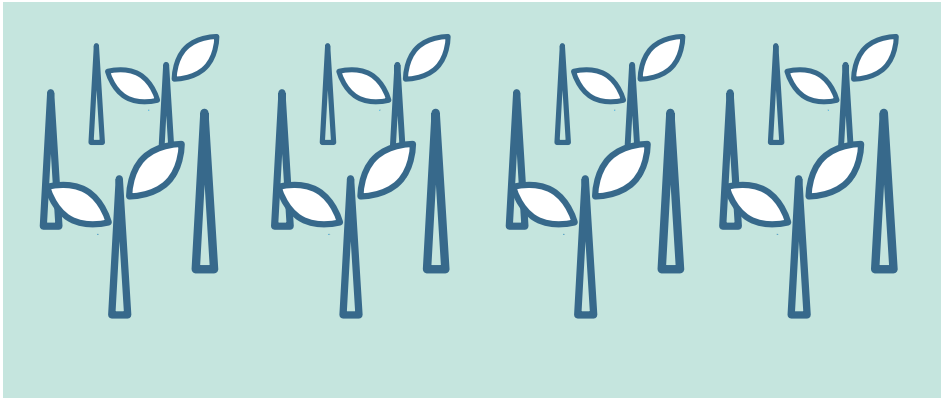
The following summary gives a brief guide to four steps of Participatory Action Research (PAR) as applied to CBEMR. To complete each step, the team will need to answer between one and three questions to ensure successful mangrove restoration. As each restoration site is unique, this system, however, can only serve as a basic set of good practices, which the project will need to translate into tailor-made work plans for the respective region.

It is important to remember that only when combined with the protection of remaining mangrove ecosystems, along with close cooperation and involvement of local communities, can restoration activities be sustainable and have a long-term success.

Table 1: Steps in the CBEMR Process

Steps in PAR	Question	Description
	1. How do the mangroves grow?	**Species ecology** In a participatory way, work out which individual species grow best where and what are the best conditions for communities of species to grow together and thrive. If possible, have a close look at how naturally regenerating mangroves grow in the area. In some cases that may be quite far away.
	2. What is stopping mangrove seeds from spreading?	**Movement of water** Mangroves spread and reproduce themselves by using water. For this reason, try to understand how the water in the area would naturally flow if there was nothing to stop it.
	3. Why are mangroves not growing here now?	**Disturbance** Investigate what has changed in the area to explain why mangroves have been degraded and are not growing back by themselves. This may include finding out who owns the land or who is responsible for the protecting the mangroves.

Steps in PAR	Question	Description
 Plan	4. What is the best way to bring the mangroves back?	**Plan** Keeping in mind the information that you found out from steps 1 – 3, and considering the resources that you have both money and people, choose the sites that you will restore and work out the best ways so that the mangrove can naturally regenerate in the long term.
 Act	5.What is the best way to do the work needed?	**Action** Carry out the plans made in step 4. Depending on how things go, the project team may need to adjust the plans as they progress.
	6. Does the site need extra seeds or seedlings?	**Seeds** If some types of mangroves species are no longer in the area or that some parts of the site may not receive enough seeds simply by water flow, consider scattering or planting extra seeds or seedlings in those places which may need it.
 Observe	7. Did it work?	**Follow up** Make sure to go back to the site regularly and check to see how the mangrove rehabilitation is going. If need be, take action to fix any problems that may come up. Note how the process could be more effective next time.



BEFORE YOU START: BE PREPARED TO SELECT AN APPROPRIATE SITE!

Before you start a mangrove restoration project it is always useful to check whether there were any similar programmes in that area. If so, it is helpful to gather information regarding their success and/or failure, and to learn from former consolidated findings.

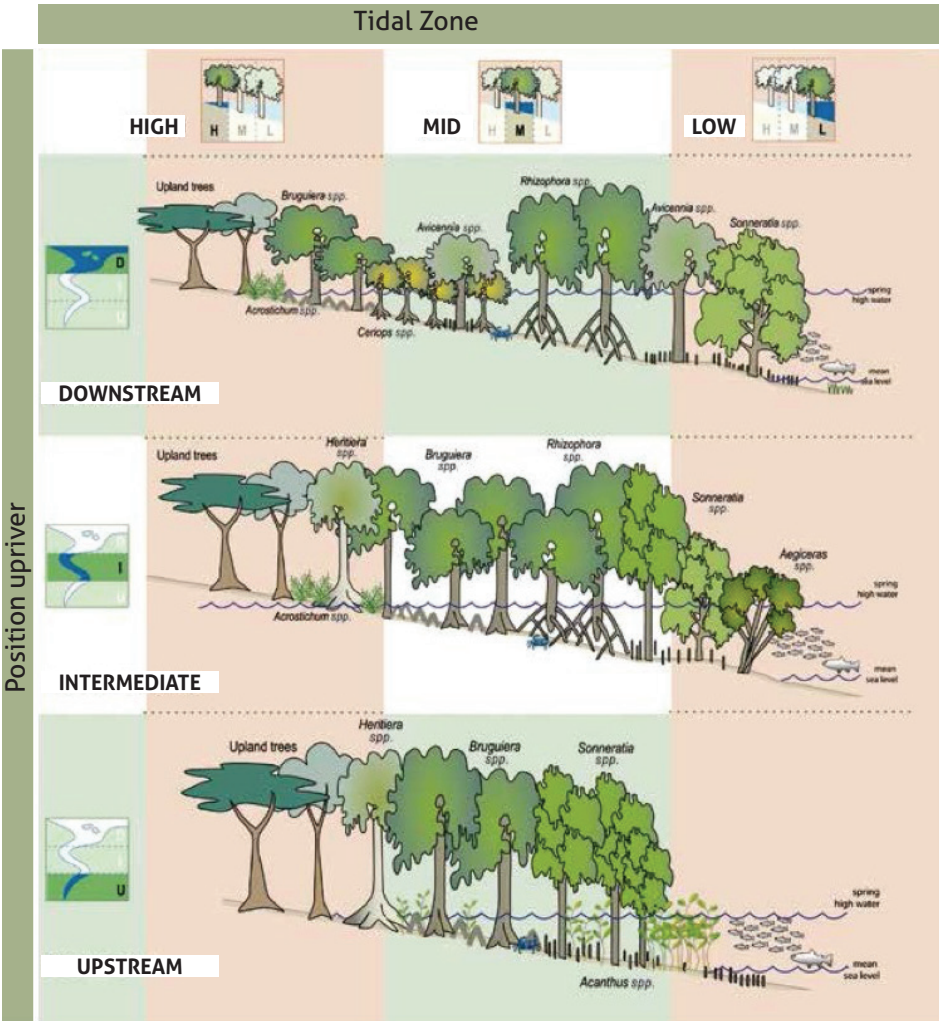
Equally important is the selection of an appropriate restoration area that has a good chance for rehabilitation and that the project can successfully work on given the available funds, time and human resources. It may also involve resolving land ownership and land-use issues necessary to ensure long-term access to and conservation of the site and its associated wildlife.

Try to gather as much information as possible about your site (historical photographs, literature, tidal conditions, etc.). Understanding your site and the normal hydrologic patterns is one of the most important attributes of targeted planning. A reference mangrove site for examining normal hydrology in the particular area might be useful.

THINGS YOU MAY NEED BEFORE STARTING MANGROVE RESTORATION ACTIVITIES

- ✓ Information on biophysical features of the location (i.e. area topographic maps, land-use plans, historical air photos, if available, and remote sensing images like Google Earth).
- ✓ Major climate parameters (i.e. rainfall, temperature etc.) and information on the tidal and hydrological system (tide tables) as well as earth movements (e.g. land subsidence).
- ✓ Dominant soil type.
- ✓ Water chemistry (salinity, pH, temperature).
- ✓ Type of forest (primary, secondary, degraded). A forestry management map may be available.
- ✓ Species inventories (flora and fauna).
- ✓ Local knowledge/traditional uses and land tenure.
- ✓ Ecosystem products, functions and attributes.
- ✓ Pressures and threats to the area.
- ✓ Potential areas available for rehabilitation/restoration.
- ✓ Survey equipment (camera, compass, rope, stakes, notebook, measuring tape, GPS unit, auto-level).

Table 2: Tidal and Estuarine Effects – Local Distribution



Natural mangrove distribution depends on the preferences of a particular species for various conditions, such as tidal zone and estuarine position (according to Duke, 2006).

GET STARTED!

Research

1. How do the mangroves grow?

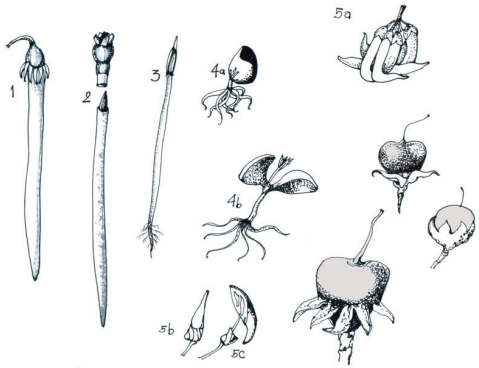
Species ecology

In a participatory way, work out which individual species grow best where and what are the best conditions for communities of species to grow together and thrive. If possible, have a close look at how naturally regenerating mangroves grow in the area. In some cases that may be quite far away.

In order to understand the patterns of reproduction, propagule distribution and successful seedling establishment, it is necessary to have a look at the individual species ecology of the mangroves – technically known as their autecology.

Because of their various shapes and sizes, propagules can float differently. Furthermore, it is important to consider the different plant zonation which is characterised by different conditions, depending on the tidal zone and the position of the restoration site upriver, such as how far the tide comes inland, salinity and the amount of fresh water available (Table 2).

Different mangrove species prefer different conditions and for that reason grow in in different zones. Take into account which species is appropriate for which zone.



A propagule is a plant part that detaches to grow into a new plant. In mangroves, these tend to float well and are often woody or contain air.

2. What is stopping mangrove seeds from spreading?

Movement of water

Mangroves spread and reproduce themselves by using water. For this reason, try to understand how the water in the area would naturally flow if there was nothing to stop it.

Each mangrove species thrives at a different level above the sea, which in some part dictates the amount of exposure the mangrove will have to tidal waters. Understanding the normal hydrologic patterns that influence the distribution and growth of existing natural mangrove plant communities in the restoration area is thus essential. Therefore, a sufficient understanding of the determining factors such as depth, duration and frequency of tidal inundation or flooding is vital. There are various tide classifications to work out, like those mangroves that all high tides cover, those by all medium-high tides, or those by normal tides. In addition, there are those floods that only happen during spring tides or equinoctial tides.

Be sure to evaluate the three import ant points concerning the tides as follows:

- Height and depth of the tides.
- Duration of the tidal inundation.
- Frequency of the tides.

If a nearby healthy mangrove forest exists, it is helpful to copy the slope and topography of the different surfaces.

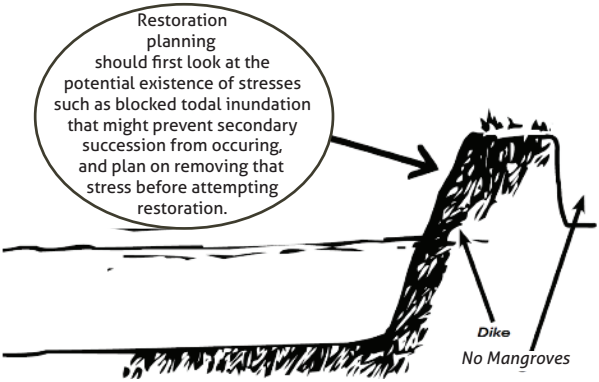
Intertidal zone: *A coastal area between the high-tide and low-tide zones which is alternately covered with water and exposed to the air.*

3. Why are mangroves not growing here now?

Disturbance
Investigate what has changed in the area to explain why mangroves have been degraded and are not growing back by themselves. This may include finding out who owns the land or who is responsible for the protecting the mangroves.

The team must work out whether the target area for an intended restoration was a mangrove area in the past. If so, it is important to understand why the original mangrove cover vanished, if external stressors or disturbances have been responsible for the loss, and if they currently prevent the natural return of mangrove forest.

To make sure that new mangrove saplings can survive, the team will need to investigate potential stresses on the location and remove or at least reduce them to a level that makes long-term survival possible.



If you cannot correct these, you should consider picking a new site. It is also crucial to involve the local communities in this process.

Some potential stressors could be:

- Disturbing human activities (shrimp ponds, dykes, tree felling, agricultural encroachment or run off, road construction, etc.).
- Hypersaline or acid sulphate soils (usually after intensive shrimp farming)
- Overgrazing by animals.
- Blocked tidal inundation.
- Lack of groundwater or freshwater runoff.
- Shoreline abrasion and lowered substrate level caused by high wave energy.

Plan

4. What is the best way to bring the mangroves back?	**Plan** Keeping in mind the information that you found out from steps 1 – 3, and considering the resources that you have both money and people, choose the sites that you will restore and work out the best ways so that the mangrove can naturally regenerate in the long term.

The basic theory behind restoring natural waterways is the recreation of the original slope and height above sea level, which will support normal tidal flow, and the natural re-establishment and growth of mangrove seedlings.

Another important factor is to ensure free flow of tidal streams through the entire restoration area. This can happen by either unblocking restricted canals or water flows or by creating new streams, for example by digging canals. The natural exchange and flow of water – through the whole mangrove area from the edge of the land to the sea – is essential, as the streams create the site, including its zone-specific mix of fresh water and salinity in the area. Ground water, springs, runoff and streams from upland areas, feed mangroves downstream and connect this fresh water inflow with the salt water of the seaside, making tidal flooding of the mangrove area possible. When these tidal streams are disturbed, a mangrove may dry out and die over time.

In case you want to restore abandoned shrimp ponds or areas close to such ponds blocking the hydrology of your site, the best option is to level their dyke walls. If you cannot level the walls entirely, making strategic gaps in the right places – usually the mouths of historic tidal creeks – may be enough to support the exchange of tidal waters and should lead to further degradation and removal of the walls over time. For excavated areas, by backfilling or refilling an excavated area, the site supports the recreation of the natural slope. The definition and use of a benchmark reference site further helps to rebuild the exact tidal elevations relative to this reference site, thus ensuring that the hydrology is correct.

Always keep in mind: Even if mangroves survive for several years in the rehabilitation area, they may remain stunted or even die out unless the regular flow of water is truly supportive of mangrove growth.

Backfilling: *to refill (an excavated hole) with the material dug out of it.*

For a successful restoration, imitate nature and ensure that hydrological conditions are truly supportive of mangrove growth.

Act

5. What is the best way to do the work needed?

Action
Carry out the plans made in step 4. Depending on how things go, the team may need to adjust the plans as they progress.

Carry out the restoration plan by using the natural nearby mangroves as an example and for reference. Be aware of the soil surface level in reference to mean sea level or a datum marker and imitate natural tidal waterways so that the frequency, depth and duration of tidal inundation are also similar.

Tidal creeks should be snake-like in shape, and wider at the mouth and narrowing as they move up-slope. A good tidal channel will be self-flushing, preventing siltation. It is important not to pile the dugout soil and mud on the channel banks as this will block tidal flushing and the movement of water will wash it back into the waterway. Move the soil into islands as far away from the edge as reasonably possible.

Use local human labour for excavation and adjusting water ways where possible, as it provides local wages, builds a sense of ownership for the restoration site, and has proven to be an excellent tool for teaching the principles of CBEMR by doing and observing. These skills will be very useful for needed future adjustments or restoration work.

Photo: JKivata/Wetlands International

6. Does the site need extra seeds or seedlings?

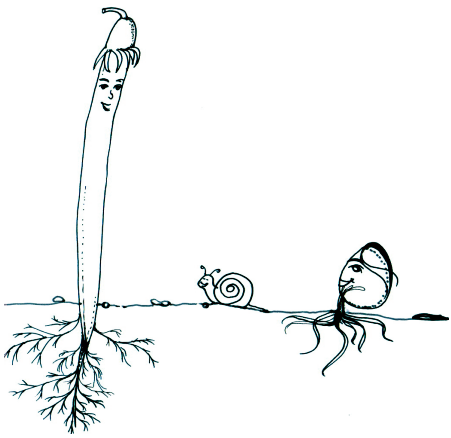
Seeds
If some types of mangroves species are no longer in the area or that some parts of the site may not receive enough seeds simply by water flow, consider scattering or planting extra seeds or seedlings in those places which may need it.

If seedlings have established in the rehabilitation area but at lower densities than hoped for, you may consider further supporting the site by direct hand planting. It is important to plant mangrove species that previously occurred naturally on the site and in the correct zone.

The team needs to choose the area for a mangrove nursery carefully. Preferably, the nursery should be located in the inter-tidal zone so that hand watering is not required. Building the nursery close to households will make it easy to access and allow for regular maintenance.

If there have been mangroves in the area before, ask yourself why they have vanished and eliminate possible stressors before you start growing seedlings (see Disturbance above). Then, you need to ensure that sufficient person power and knowledge on growing the seedlings is available. Additionally, it is recommended to clearly define and record criteria such as species, type of seed, months of seed collection, indicators of maturity, seed selection, seed storage, sowing, shading, watering and pest control.

When planting, it is always best to follow nature, for example in the species composition of a site, growth patterns and distribution of species in their correct zonation. Enough space between the seedlings allows natural volunteers to grow, ensuring species diversity. It is best to plant seedlings or propagules at the beginning of the rainy season, which is the ideal growing season with plenty of moisture and lower saline conditions.



Dissemination of Seedlings

The project can apply different strategies for reforestation through planting, they are:

- Raising seedlings in a nursery from local seed sources.
- Planting propagules (seeds) directly.
- Relocating natural seedlings from unsuitable areas or very dense sites into the restoration area.
- Broadcasting propagules by throwing them on the water surface during incoming tides. This enables seeds to find their own suitable location for rooting and thus supports natural distribution and growth patterns. Experts recommend doing this on a series of different tides during the month of maximum availability of the seeds.and thus supports natural distribution and growth patterns. Experts recommend doing this on a series of different tides during the month of maximum availability of the seeds.

No matter which strategy you decide on, you should always make sure to use local sources for seeds and seedlings, as they are well adapted to the local environment and ensure natural (site-specific) species composition.

Propagules and seeds suitable for collection are commonly found along high-tide lines. If an area lacks natural seed sources, seeds may be collected from a similar area that has a lot of seeds, transported to the restoration site, and distributed by one of the strategies above.

7. Monitoring

Monitoring is the final step most often overlooked or carried out only once shortly after restoration, while many potential problems that might impact the project's success could yet occur over the next few years. Monitoring has several critical functions including informing if the restoration is meeting the goal for recovery, helping to recognise problems and make early corrections, and is an important tool for learning and improving future restoration projects. Monitoring can be simple time-lapse photos, or more scientific, using fixed or random quadrats or transects. The method or combination of methods selected should suit the skills, time and budget available over a period of three to five years. Regular monitoring allows tracking changes over time, and seeing if the modifications are working. According to international experts, monitoring is recommended to be scheduled at the following monthly intervals: Time Zero (TO), + 3, 6, 9, 12, 18, 24, 36, 48 and 60 months (where "Time Zero" is the completion of physical restoration work). Four monitoring sessions occur in the first year, to find any problems early and correct them.

The main goal of CBEMR monitoring is to measure the density of natural seedling recruitment over time. Besides observing volunteer seedlings on site, there should be an evaluation of the site hydrology to see if tidal flooding is occurring in a similar way to the natural mangrove reference forest. Observation should include other flora and fauna occurring on-site which can also be a good indicator of problems or rehabilitation success.

***Monitoring** – looking at where you want to be compared to where you are, to see if you are getting closer or not and the reasons for that.*

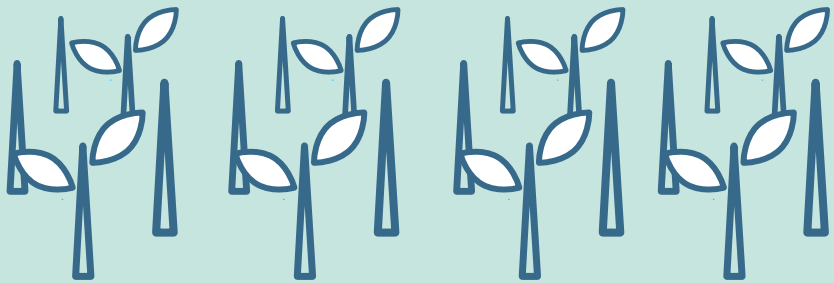


Photo: Dominic Wodehouse

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