Mangrove Restoration: It's More Than Just Planting

Dominic Wodehouse PhD, Executive Director
Jim Enright, CBEMR Trainer
Laura Michie PhD, Program Manager

Introduction – The Importance of Conservation Before Restoration

This article summarizes Mangrove Action Project's (MAP) 'Community-Based Ecological Mangrove Restoration' (CBEMR) technique, which focuses on facilitating the natural regeneration of mangroves. It's intended for groups interested in understanding or undertaking CBEMR. **MAP emphasizes the importance of conserving existing mangroves before restoring degraded ones**, as mature mangroves provide full ecosystem benefits and are likely to be more biodiverse than planted mangroves. Planting is risky and has a high failure rate. Disturbing mature mangrove soils, especially for aquaculture, can release stored carbon and degrade soil quality. Live mangrove roots improve soil quality by leaking oxygen and carbohydrates and and breaking up the soil structure. Thus, conserving existing mangroves with proper hydrology and minimal disturbance is recommended over restoration.

Every site is unique, so there is no universal restoration solution, but some general principles apply globally. Unlike dry-land forestry, mangrove restoration must consider salt and low-oxygen soils. Elevation relative to sea level is critical in determining species distribution. Extensive research and MAP's practical experience help avoid past project mistakes.

Figure 1: Where mangrove forests meet mudflats. Mangroves should not be planted in the mudflat zone (left side), below the mangrove fringe, which is around mean sea level. Nature shows where mangroves can thrive, as indicated by the absence of natural regeneration on the mudflats (left).

1. Getting Started - Community Collaboration & Background Research

To start the restoration process, thoroughly understand the site and its context. This involves more than a brief visit with GPS and camera. Discuss with local people to determine ownership and future plans for the site, ensuring clarity to avoid future conflicts. Understand the community's needs from the mangroves, considering different perspectives from men, women, fishers, farmers, and business people. Gather local knowledge and advice, and assess current site uses, such as mooring boats or grazing animals. Evaluate if there is over-harvesting of mangrove wood and what materials and fuels local communities use. Consider introducing 'Improved Cooked Stoves' or alternative fuels and building materials to reduce resource consumption.

Figure 2: Collaboration with the local community is crucial for project success. Begin working with the community early on in your project, conducting informal interviews to understand site specifics and identify local expertise.

Do not assume the community lacks understanding of their mangrove forests; they have observed many changes, including seasonal ones. Their local knowledge of the site, its history, and its use is crucial. Conversely, don't assume all community members are aware of all mangrove benefits, know how to restore them, or are willing to manage them sustainably. Engage with as many community members as possible, both men and women, especially fishers whose livelihoods depend on the mangroves.

Conducting multiple community consultation meetings is crucial (Fig. 2), ensuring careful management of expectations as reaching a consensus can be challenging. Additionally, conduct a stakeholder analysis for your site to identify interested groups and their influence, including local and national government units, NGOs, ministries, military, coast guard, local businesses, etc.

From a **technical and biophysical standpoint**, it is crucial to engage local residents in understanding why there are currently no mangroves or why the mangrove areas on the site are degraded. This process demands a careful and honest review. Consider whether there are identifiable stressors, such as diverted freshwater, infrastructure like roads disrupting tidal connections, or aquaculture pond structures isolating areas, that have contributed to the degradation or demise of the mangroves. Evaluating the feasibility of removing or mitigating these stressors is essential. Walk the site to understand how often it is inundated and for how long, as the soil around mangrove roots needs to be drained and oxygenated more than 60% of the time. If it's a former aquaculture pond, inadequate flushing or waterlogged soils from poor drainage might be an issue. Restoration efforts often involve re-establishing proper hydrology and topography to enhance tidal flushing and facilitate natural regeneration. Observing water flow dynamics, drainage patterns, freshwater input, tidal fluctuations, and inundation frequency through on-site inspections, particularly during different tidal and lunar cycles, is essential. Understanding seasonal variations in freshwater input, wave energy, and average temperature is crucial. This comprehensive approach ensures a nuanced understanding of the site's ecological dynamics and informs effective restoration strategies.

Next, assess if there is any natural regeneration on the site and identify which species are present. This is a crucial indicator for assessing the suitability of the site for restoration. For instance, planting mangroves on mudflats is often unsuccessful due to unsuitable conditions, as depicted on the left side of Fig. 1 and Fig. 4. It's advisable to avoid utilizing such areas (along with coral flats, seagrass beds, or salt pans) as observed by MAP staff, who have witnessed numerous failed planting attempts on mudflats. Unless there is rapid soil accretion resulting in firm soil that can support mangroves, it's best to avoid these areas.

Figure 3: (left) Researchers assess tide points at a restoration site. Understanding the site's elevation relative to sea level is crucial, as mangroves only thrive in the top half or top third of the intertidal zone (coastal area between high and low tide).

Figure 4: (right) A mudflat indicating an unsuitable planting area. Working below mean sea level may lead to poor results or project failure

Figure 5: Mangrove area suffering from soil erosion with roots exposed

Also, assess soil pH, type (sand/silt/clay), pore water salinity (the water the mangrove roots are in contact with), erosive forces (refer to Fig. 5), and levels of wave/wind energy, especially during the monsoon season. Identify which species are likely to thrive. Involve local residents in this research to learn from their knowledge, foster participation and enhance their skills.

For afforestation efforts (**new mangroves**; planting mangroves where they didn't previously exist), understand why the area isn't naturally colonized by pioneer species like *Sonneratia alba*, *S. apetala*, *Avicennia marina*, and *A. alba*. If these species aren't present, your planting endeavor may not succeed.

2. Many Answers are at a Natural Mangrove Reference Site

Collaborate with local residents to visit a nearby reference mangrove site. Identify a natural or healthy mangrove with similar inundation conditions as your restoration site. A healthy mangrove will have a closed canopy overhead, with trees having lush foliage and unimpeded water flow. Observe which species are thriving, their positioning relative to mean sea level, floating seeds and propagules during seeding season, water and soil salinity, soil conditions, and drainage duration before tidal inundation. Mangroves typically inhabit the upper half to top third of the intertidal range, so areas with consistently saturated soil or standing water at low tide may not support mangrove growth as roots require oxygen.

In many countries, large areas of mangrove forests have been cleared for charcoal production and later replanted. However, these replanted mangroves often lack the biodiversity and natural structure of original old-growth forests. They usually consist of a few species planted in rows, similar to terrestrial plantation forestry. Back zone (landward) mangrove species may be sparse or absent, and the trees are generally of uniform age. As a result, there is limited species zonation and little variation within stands. While these reforested areas can serve as reference sites, it's essential to interpret their characteristics cautiously.

3. Detailed Knowledge of the Expected Species

Understand the anticipated species for the restoration site based on their habitat preferences and ecological zones. Local community preferences may not always align with these species. Some species thrive only in the upper tidal zone, preferring free-draining sandy soils and occasional inundation, while others tolerate daily flooding with roots in muddy clay soil. Pioneer species typically colonize lower mangrove zones, while higher elevations may see plants like *Acrostichum* sp. fern or *Acanthus* sp. arriving first. Some species thrive in almost fresh water. Local mangrove guidebooks or online resources (see end of article) can provide species preferences.

Fortunately, facilitating natural regeneration (recommended) allows nature to distribute each species appropriately without planting. Many restoration projects fail by planting *Rhizophora* sp. too low in saturated mudflat or indiscriminately. This often results in stunted growth due to poor soil conditions and lack of oxygen. It's also important not to assume that government mangrove agencies possess specialized knowledge, as they may also misjudge species preferences.

4. Sharing your Research, Discuss and Agree Objectives, Plan Activities

Now that the complexity of mangroves and the surrounding social situation is understood, we suggest **discussing and planning activities** with local communities and other key stakeholders. Carefully discuss and **agree on project objectives**, considering what is possible on the restoration site. Remember that stakeholders may have different and evolving objectives. These objectives will influence implementation and monitoring, so take the time to debate and agree on them. Also, decide beforehand who will benefit from the restored mangrove, whether sustainable use is permitted, or if the mangroves will be left untouched.

Create a map of the site to show all local stakeholders and communities what will happen. This is especially important if literacy, internet access, electricity, or mobile phone signal is limited. Use community map drawing, Google Earth images (see Fig. 6) with boundaries, drone imagery, or local authority maps. Ensure local stakeholders take ownership for the project and encourage them to lead the project, with outside groups providing technical and facilitation support. Encourage local people lead the mangrove project, with outside groups providing technical and facilitation support. Provide training for the community team and other stakeholders, such as local government, mangrove agency staff, local businesses, fishers, and forestry officials. Allocate time and budget for this training in the plan. Mangrove restoration should improve ecosystems, build capacities, and empower local stakeholders, rather than serve as a short-term photo opportunity.

Figure 6: A high-resolution Google Earth screenshot, printed on vinyl, helps communities understand and discuss restoration and conservation efforts. These affordable maps, costing only a few dollars, are very useful to the community.

5. Implementation

Maintain a holistic view of the community and its needs. Solutions may be predominantly social rather than biophysical. For example, degradation might stem from a lack of income opportunities. **Prioritize conserving existing mangroves**, as mature mangroves provide the full range of ecosystem goods and services when well connected to daily tidal inundation.

Based on the plan and project objectives, your activity list might include the following:

- Build awareness about mangrove benefits, ecology, and biology, as well as climate change adaptation, restoration work, and the importance of hydrology, topography, and biodiversity. Arrange for older community members to share traditional mangrove knowledge with students at local schools. Promote environmental education, mangrove study visits, and small-scale test planting or field maintenance by youth to ensure long-term community support. Explain the consequences of losing mangroves to reduce or manage over-harvesting.

Figure 7: Community members regraded shrimp pond embankments to expand mangrove growth area. Previously, the pond had steep walls and a poorly drained bottom. This work increased suitable elevation for mangrove growth and enhanced pond drainage.

- Cooperate with local people to make sure natural regeneration can thrive. For example, a government project in Myanmar failed because planting was conducted where community members landed their boats, resulting in no surviving mangrove seedlings.
- Initiate wider community meetings to explain the project, emphasizing it is not solely about building a nursery and planting in straight rows. Explain what is feasible on the restoration site, considering social and technical factors.
- If research reveals insufficient hydrological connectivity or poor drainage, adjust the topography and hydrology accordingly (see Fig. 7). This may require a period of observation to assess the effectiveness of community efforts and whether natural mangrove regeneration occurs. In El Salvador, a project revitalized mangroves by improving almost 10km of channels without the need for planting. Restoring a former aquaculture pond poses technical challenges, and contacting MAP for specific assistance is recommended.
- Collect and recycle or dispose of plastic **debris** properly: clear all debris which is likely to float over the site and damage young plants. Make sure young plants are not broken by entanglement with seaweed or smothered by mangrove vines and creepers like *Finlaysonia* sp. or *Derris* sp. **Weeding** of natural regeneration might be all that is needed.
- If the community members are expecting to show people around the site, you might want to **'interpret' the site**, by installing signs, producing leaflets, using time lapse photos to show progress, roping off test monitoring plots, training community guides and so on, so visitors will be able to understand what has been done.
- Other possible activities include establishing a community forest management and/or waste management group, removing mangroves from channels, providing alternative livelihoods, adjusting species for high salinity, introducing fuel-efficient cook stoves, creating terrestrial woodlots, offering alternative cooking fuels, managing *Acrostichum* sp. growth, addressing timber poaching, advocating for a ban on mangrove wood sales, and supplementing natural regeneration with additional seeds and propagules. This list is not exhaustive.
- Promote the growth of locally occurring species to enhance biodiversity, improving mangrove resilience to changes such as sea-level rise and climate change.

6. Monitoring

Ensure thorough baseline data collection before beginning the project.

- Project objectives should guide extended monitoring beyond initial mangrove stressor mitigation. Continue site monitoring, patrolling, and protection for 3-5 years, with local community training and support to ensure long-term commitment.
- Key elements to monitor include hydrological functionality, soil drainage, natural regeneration, and resolution of issues like salinity levels and social agreements. Avoid standardized hydrological solutions like the 'fishbone' excavation design, as it requires continuous maintenance.
- If natural regeneration is inadequate, determine the causes, such as limited local seed sources or degradation caused by grazing animals. If necessary, install fencing or enhance regeneration by collecting seeds and propagules from nearby areas and broadcasting them on incoming tides, neap tides are best. Evaluate soil quality and potential issues like pollution or invasive species.

7. Planting only if Long-Term Monitoring Shows it is Necessary

If natural regeneration is still insufficient but hydrology is effective, consider planting. However, planting should follow completion of all the preceding stages. Prioritize test planting to assess suitability before larger-scale implementation. Remember, planting the right species in the correct zone cannot replace effective hydrology and drainage. Various planting methods exist, with advice widely available online. It's crucial to consider the specific mangrove zone and duration of inundation for effective planting. Avoid assuming that *Rhizophora* sp. is universally suitable for all zones. Methods include direct seeding, growing nursery stock in polybags, and transplanting wildlings, each with its own advantages and disadvantages.

For plants in polybags, do not let them grow through the bag and root into the soil. Extracting from the nursery will severely damage the roots and degrade their ability to establish. If *Avicennia* sp is being grown, this species will need protection from crabs and herbivores. Ensure prompt planting of collected propagules and wildlings to prevent root damage and loss of viability. Proper seed/propagule storage is essential if immediate planting is not possible. Select firm and ripe propagules, discarding any with signs of insect damage. Test direct planting before large-scale implementation and prioritize planting multiple species with zonation in mind. **Avoid planting in channels** and seek guidance from experienced community members on seed collection.

In Myanmar, the Mangrove Service Network (MSN) collaborated with a village conservation group to establish a greenbelt near Sittwe to combat coastal erosion. Following MAP's CBEMR process, they selected a site just above mean sea level, suitable for low mangrove zone pioneer species. MSN grew seedlings in polybags for a year before community planting, using various pioneer species for this zone. They fenced the area to exclude grazing animals and monitored and maintained the mangroves during early stages, resulting in a healthy greenbelt and significantly reduced erosion.

Figure 8: An example of what not to do: planting in straight lines and in the water channel contradicts nature's processes, and will block tidal inundation, if they survive at all.

DO NOT PLANT IN STRAIGHT LINES OR CHANNELS. Fig. 8 illustrates what not to do. Just because the government or plantations use rows does not justify such planting, unless for production forestry. Planting in lines can overlook changes in micro-topography and fill channels with mangroves. If mangroves grow in channels, consider removing them because as the roots develop they will reduce tidal flushing.

Mangroves differ from dryland forests and forestry, often with non-flat sites. We recommend planting in clumps or clusters, with propagules spaced about 5-10cm apart on elevated areas. Natural thinning occurs over time. Clumped planting offers benefits such as physical protection, soil improvement through root oxygenation, reduced acidity, a build-up of organic material and promotion of beneficial bacteria. This mimics natural patterns where seeds and propagules cluster under the canopy of mother trees. Hydrology is crucial for both natural regeneration and planting, whether on an aquaculture pond (Fig. 9) or an open site. Natural river-delta mangroves feature wide, meandering channels that are narrower upstream and wider at the river mouth, allowing for unimpeded water flow.

When excavating new channels, they should replicate these natural dimensions and in addition, have sides that gradually slope, with excavated material placed in mounds not in berms, set well back from the channel's edge. Well-drained soil is healthier than constantly saturated soil. Effective hydrology facilitates natural regeneration by bringing in seeds and propagules, introduces necessary bacteria and nutrients, reduces soil salinity build-up, removes toxins and acidic buildup, and exports leaf and plant litter essential for the local food web. This organic matter supports algae, fungi, and bacteria, which in turn sustain fish, crabs, shrimp, and other animals, providing food and livelihoods for local communities.

Figure 9: Hydrology is critical for successful restoration. Ensure the drainage rate matches that of natural mangroves outside the pond. If there's a bottleneck, widen the channel by digging, as demonstrated here beside a former sluice gate, until drain rates equalize.

What should a Natural Mangrove look like?

Figure 10: This section of back mangrove in Pangani, Tanzania, illustrates a varied mangrove floor with undulations and a well-defined channel for unimpeded water flow. Higher ground shows no standing water, with trees of different heights, densities, and species creating diverse light intensities. The channel curves naturally, with no vegetation growing within it. Limited natural regeneration is evident, as mangroves tend to be shade intolerant with minimal understory once the canopy has closed.

Next Steps- Resources and Readings

Thank you again for your interest in mangrove forests. We hope that you found this information sheet helpful and informative. Please remember that this is an introduction into the complexities of mangrove restoration, and not an exhaustive guide. Before getting started on your project we suggest becoming more familiar with the CBEMR methodology by utilizing the following resources:

There are many other resources to download on MAP's site.

Join MAP's Groups.IO e-group of over 500 mangrove practitioners!

Stay informed by reading our blog for updates on MAP's activities.

If you still have specific questions about a particular site, we encourage you to reach out to MAP, as we would love to try and help! See below for further readings and resource recommendations.

Please consider inviting MAP to run a training course on CBEMR.
Contact: dominic@mangroveactionproject.org for more information.

Further Readings:

- Mangrove Restoration: To plant or not to plant (available in 9 languages)
- Mass mangrove restoration: Driven by good intentions but offering limited results
- Global Nature Fund. 2015. Mangrove restoration guide: Best Practices and lessons learned. GNF. Germany
- Lewis & Brown. 2014. Ecological mangrove restoration- a field manual for practitioners. Version 3. 275 p.
- Lewis. 2005. Ecological engineering for successful management and restoration of mangrove forests. Ecol. Eng. 24: 403-418.
- FAO: Mangrove trees and shrubs
- Zoological Society of London: Manual: Community-based Mangrove Rehabilitation
- WIOMSA: The Guidelines on Mangrove Ecosystem Restoration for the Western Indian Ocean Region
- The Global Mangrove Alliance has posted many resources on their site.
- Watch our latest film, created in partnership with the Indonesia chapter of the Global Mangrove Alliance

Explore MAP's award-winning CBEMR films on our YouTube