the BLUE CARBON initiative

GLOBAL MANGROVE ALLIANCE

Best practice guidelines for mangrove restoration

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Appendix B: Summary of methodologies and publications relevant to mangrove restoration

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Cover image

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Community groups constructing permeable structures to trap sediment in Demak, Indonesia, © Nanang Sujana

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Glossary

Adaptive management – A process of experimentation, learning, and continuous improvement informed by successes and mistakes.

Allometric equations – Allometric equations establish quantitative relationships between key characteristics that are easy to measure (i.e., stem height/diameter) and other properties that are often more difficult to assess (i.e., biomass).

Anoxic conditions – Environments found in seawater, freshwater, or groundwater in which dissolved oxygen is absent.

Arheic – An area lacking surface runoff or drainage, such as deserts, in which surficial drainage is almost completely lacking, or where rainfall is so infrequent that all water sinks into the ground or evaporates.

Baseline – Land use prior to a restoration project where carbon stocks and emissions are assumed to be in a 'business as usual' trajectory (BAU) that would occur in the absence of the project.

Biomass – The total amount of matter comprising living organisms. For trees this is leaves, roots and wood.

Brackish – Water that is saltier than freshwater, but less salty than seawater. Freshwater has salinity of 0 parts per thousand (often expressed as ppt) while seawater has salinity of approximately 35 ppt.

Bulk density – The ratio of the weight of dry soil (mass) and its volume that includes the volume of particles and the pores between particles. Also called dry bulk density.

Bathymetry – The topographic survey of subaquatic depth of land covered by water bodies, such as the sea bottom, waterways, lakes, rivers, reservoirs, etc.

Blue carbon – The carbon stored in mangroves, tidal saltmarshes, seagrass meadows, macroalgal beds, intertidal mudflats, saltpans (salt flats), and supratidal forests. Carbon is stored within sediments, the living biomass above ground (leaves, branches, stems), the living biomass below ground (roots), and the non-living biomass (litter and dead wood).

Capital costs – Fixed, on-time expenses, incurred during a project.

Carbon abatement – The sum of carbon gains (removed) and losses (emitted) to the atmosphere / ocean as a result of management activities. Total project abatement is calculated from the changes in carbon pools and greenhouse gas fluxes during a restoration project and is reported as an equivalent amount of tonnes of carbon dioxide (CO_2e).

Carbon credits (or carbon credit units) – Mechanisms created as a national and international effort to reduce the concentration increase of greenhouse gasses (GHG). One carbon credit is equal to one tonne CO_2 equivalent.

Carbon pool – Carbon pools refer to systems – such as soil, vegetation, water, and the atmosphere – that have the capacity to accumulate, store, and release carbon. Together carbon pools make up a carbon stock.

Carbon stock – The total amount of organic carbon stored in a blue carbon ecosystem of a known size. A carbon stock is the sum of one or more carbon pools.

Climate change – The modification of the earth's climate that has occurred when compared to its history. It is directly or indirectly attributed to human activity.

Digital Elevation Model (DEM) - A representation of the ground's surface topography.

Ecosystem – A system with interactions between living organisms and their physical environment.

Ecosystem function – The capacity of natural processes and components of an ecosystem to provide goods and services that satisfy human needs, either directly or indirectly.

Ecosystem processes – The transfer of matter and energy through interactions between biotic (living) and abiotic (not living) components of an ecosystem. Examples include nutrient cycling and carbon cycling.

Ecosystem services – The benefits people obtain from ecosystems such as flood control, and resources including food, water, and timber.

Emission factors – A term used to describe changes in the carbon content of a predefined area due to change in land use (e.g., conversion from mangroves to shrimp ponds) or changes within a land use type (e.g., nutrient enrichment of seagrass).

Global warming potential (GWP) – A measure of how much energy the emissions of 1 metric tonne of a gas will absorb over a given period of time, relative to the emissions of 1 metric tonne of carbon dioxide (CO_2). The larger the GWP, the more that a given gas warms the Earth compared to CO_2 over that time period. GWPs provide a common unit of measure, which allows analysts to add up emissions estimates of different gasses (e.g., to compile a national GHG inventory), and allows policymakers to compare emissions reduction opportunities across sectors and gasses.

Greenhouse gasses (GHG) – Refers to the gasses emitted naturally and anthropogenically (from human activity) that accumulate in the atmosphere of Earth and absorb the sun's infrared energy. This creates the known greenhouse effect, which contributes to the global warming of the planet.

Hydroperiod – The pattern of inundation by water that is described by flooding level, frequency, and duration in a specific area i.e., how long an area is regularly under water.

Indexed-based insurance - A non-traditional insurance product that offers pre-specified payouts based upon a trigger event. Also called parametric insurance.

IPCC tiers – The Intergovernmental Panel on Climate Change (IPCC) has identified three tiers of detail in carbon inventories that reflect the degrees of certainty or accuracy of a carbon stock change inventory (assessment).

Tier 1 – Tier 1 assessments have the least accuracy and certainty and are based on simplified assumptions and published IPCC default values for certain activities and emissions factors. Tier 1 assessments may have a large error range (e.g., +/- 50% for aboveground pools and +/- 90% for soil carbon pools).

Tier 2 – Tier 2 assessments include country-specific or site-specific data and hence have increased accuracy and resolution. For example, a country may know the mean carbon stock for different ecosystem types within the country.

Tier 3 – Tier 3 assessments are based on high quality data of the carbon stocks in each component ecosystem or land use area, and repeated measurements of key carbon stocks through time to provide estimates of change or flux of carbon into or out of the ecosystem or land use area. Estimates of carbon flux can be provided through direct field measurements or by modeling.

Mangrove – A tree, shrub, palm, or ground fern, that grows in tropical, subtropical, and warm temperate latitudes, normally at or above mean sea level in the intertidal zone of marine coastal environments, including bays, estuaries, lagoons, and backwaters. A mangrove is also a term used to describe the intertidal habitat or ecosystem comprising such trees and shrubs.

Mean Sea Level (MSL) – The level of the sea halfway between the mean high tide and the mean low tide.

Mitigation – An abatement or reduction action of the negative environmental impact caused by different activities in order to lower the impact to tolerable amounts or to a level within the limits of current standards.

Nature-based Solutions (NbS) – Actions that use ecosystems and the services they provide to address diverse societal challenges, such as climate change, biodiversity loss, food security, or disaster risk reduction, benefitting people and nature.

Natural capital – Includes all natural assets which provide natural resource inputs and environmental services for economic production.

Natural regeneration – A process where propagules or seeds of mangroves (or other ecosystem components) are naturally recruited. This may occur in both degraded and non-degraded areas.

Opportunity cost – The loss of potential gain from other alternatives when one alternative is chosen.

Organic matter – Is composed of organic compounds that come from the remains of organisms that once were alive, such as plants, animals, and their waste products in the natural environment.

Parametric insurance - A non-traditional insurance product that offers pre-specified payouts based upon a trigger event. Also called index-based insurance.

Propagule – The reproductive unit of many mangrove species (e.g., those in the generas Rhizophora, Ceriops, Bruguiera and Avicennia). Propagules are not seeds but rather germinated seedlings. Some mangroves have true seeds (e.g., Sonneratia). In some mangrove literature propagules are also referred to as "seeds".

Reference site – A system of plants and other organisms able to act as a model or benchmark for restoration.

Rehabilitation – The act of partially or fully recovering structural or functional characteristics of an ecosystem.

Remote sensing – A remote-sensing system, such as aerial photography, satellite images and radar, that can be used to observe and map vegetation such as mangroves or other features of interest. Restoration – The act of bringing an ecosystem back, as near as possible, to its original condition.

Restoration – The act of bringing an ecosystem back, as near as possible, to its original condition.

Saltmarsh – Also called salt marsh and tidal marsh, is a coastal ecosystem in the upper intertidal zone that is flooded by the tides. It is dominated by salt tolerant plants such as herbs, grasses, and/or low shrubs.

Seagrass meadows – Seagrasses are flowering plants belonging to four plant families in the order Alismatales, which grow to form meadows in marine and brackish environments. They can be intertidal and subtidal.

Sediment – A deposit or accumulation of particles (sand, gravel, silt, organic matter, or mud) that can be transported by air or water to the soil of wetlands.

Seedling – An early developmental stage of plants that starts when a seed breaks its dormancy and germinates. Seedling stages are often small (e.g., less than 50 cm in height).

Sequestration – The process of atmospheric carbon, usually in the form of carbon dioxide, being captured from the atmosphere and transferred to a biological or geological carbon store.

Soil organic carbon (SOC) – The carbon component of the soil organic matter. The amount of soil organic carbon depends on soil texture, climate, vegetation, and historical and current land use/management.

Stratification – A technique used to divide large heterogeneous areas of sites (which require many samples to account for variation) into smaller more homogeneous areas (where fewer samples are needed to characterize them). Stratifying sites can be a useful strategy to increase efficiency for field sampling and other logistics with resource limitations.

Subsidence – The gradual caving in or sinking of land.

Tidal inundation – The process in which seawater is driven into an area that is otherwise dry. In the case of mangroves this may happen twice a day with each tide cycle or more rarely as part of events like king tides.

Tidal range – The difference in height between high tide and low tide.

- Microtidal areas have a range of less than 2 meters
- Mesotidal areas have a range between 2 and 4 meters
- Macrotidal areas have a range greater than 4 meters.

Zonation – Unique sections within a mangrove forest being dominated by a similar type of vegetation and/or under similar conditions (inundation time, soil type, etc.).

Acronyms

AFOLU: Agriculture, Forestry, and Other Land Uses

BACI: Before-after control-impact (assessment)

DBH: Diameter at breast height

ERR: Emissions Reductions and Removals

FPIC: Free, Prior, and Informed Consent

FREL: Forest Reference Emissions Level

GHG: Greenhouse Gas(es)

KPI: Key Performance Indicator

LULUCF: Land Use and Land Use Change and Forestry

NbS: Nature-based Solutions

NDC: Nationally Determined Contribution

NGHGI: National Greenhouse Gas Inventory

REDD+: Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries

UNFCCC: United Nations Framework Convention on Climate Change

VCM: Voluntary Carbon Market

Published by: Global Mangrove Alliance.

Mangroves and needlefish off Mansuar Island © Conservation International

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1 Introduction

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1.1 The opportunity

Healthy mangroves support people, biodiversity, and our climate.

Mangroves support the livelihoods and well-being of hundreds of millions of coastal inhabitants around the world, provide food security, sequester and store large quantities of carbon, regulate water quality, and protect the coast.[1]

Some regions still see failure rates of up to 80%.

However, during the last five decades, 20-35% of our mangroves have disappeared. In many parts of the world, mangroves have been converted into fishponds and agricultural areas[2] or have been removed to make way for urban sprawl and coastal development. Remaining mangroves are under threat of degradation from unsustainable exploitation for timber and fuelwood or from infrastructure developments that alter the nutrient, sediment, and water supplies that mangroves depend upon.

In some cases, ground water extraction has caused entire coastal areas to sink, resulting in mangrove loss and coastal erosion. Mangrove degradation and loss has altered the structure and function of valuable coastlines, weakening the ecosystem services mangroves provide and releasing carbon back to the atmosphere in the process.


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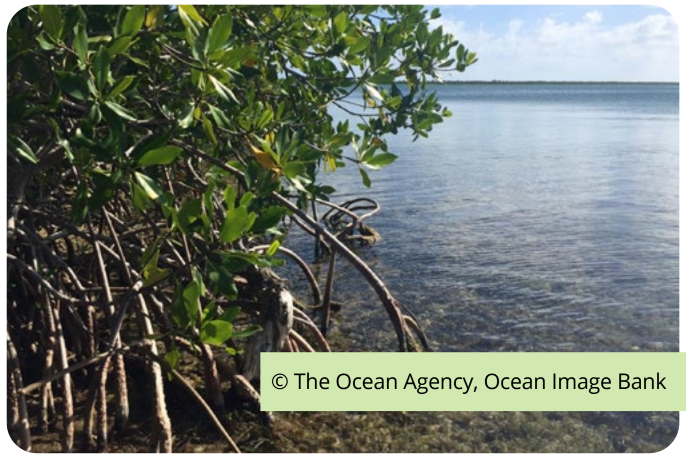
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The most successful way to restore mangroves is to create the right biophysical and socioeconomic conditions.

As nations, institutions, and communities start to feel the impact of losing their mangroves, a major desire and opportunity for restoration is emerging.[3] Of the 1,100,000 hectares (ha) of mangroves that have been lost since 1996, around 818,300 ha of mangroves are considered "restorable" while other areas are considered irretrievably lost to urbanization, erosion, or other causes. While there have been many successful mangrove restoration efforts, some regions still see failure rates of up to 80% due to science-based methods not being followed – most notably poor project planning and lack of local engagement, reliance on planting in unsuitable areas, or planting without also addressing hydrology, nutrient, and sedimentation requirements.[4,5]

The position of mangroves in the landscape, at the margin of land and sea, also adds complexity as environmental conditions for mangrove establishment can vary on small spatial scales, and land ownership and management of the area may be unclear. Sometimes restoration may even cause environmental damage when other valuable habitats such as mudflats and seagrass beds are planted over with mangrove saplings.

The good news is, in recent years, many innovative and successful restoration guidance documents and tools have emerged that advocate for more effective approaches to restoration. Specifically, the most successful way to restore mangroves is to create the right biophysical conditions for mangroves to grow back naturally and the right socioeconomic conditions to incentivize their long-term protection.


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Mangrove restoration efforts that are thoughtfully planned out, based on proven methods, and stimulate a feeling of stewardship over the area are more likely to result in a sizable, diverse, functional, and self-sustaining mangrove that offers the desired benefits for nature and people.

The growing success of restoration efforts and the urgency to protect our coastlines has stimulated an increase in public and private finance, and inclusion of mangrove restoration in global policy frameworks including the Paris Agreement, Kunming - Montreal Global Biodiversity Framework, the Ocean Science for Sustainable Development and the UN Decade on Ecosystem Restoration. Several countries, including the United Arab Emirates, Indonesia, India, and China have pledged to safeguard and restore mangroves. Multinational companies that have committed to achieving carbon neutrality are investing in the carbon mitigation value of mangrove restoration, known as blue carbon (Module 1), informed by the High-Quality Blue Carbon Principles and Guidance.

The excitement and potential for mangrove restoration has never been higher and it is imperative that we get this right. With this idea in mind, the Global Mangrove Alliance (GMA) and the Blue Carbon Initiative (BCI), are initiating and hosting these Global Mangrove Restoration Guidelines, and are bringing together NGOs, governments, scientists, industry, local communities, and funders towards a common goal of conserving and restoring mangrove ecosystems in a science-based, fair, and equitable manner. This is a living document and will be updated regularly as new information, new technologies, and new opportunities are presented.

Mangroves are treasure troves that store huge amounts of carbon, protect us against the sea, provide us with food and materials, and host incredible biodiversity.

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1.2 Audience

Helping you achieve mangrove restoration success

The audience for the guidelines is primarily restoration project managers and those interested in mangrove restoration best practices more broadly. As such, this document is meant to get into the details and allow the reader to come away with a comprehensive strategy for restoration that has a high likelihood of success. To achieve this goal, the document tries to balance high-level key messages and concepts with more in-depth discussion of critical components. To strengthen ownership, credibility, and reach of our guidelines we mobilized a team of dozens of leading mangrove scientists, members of the Global Mangrove Alliance and the scientific working group of the Blue Carbon Initiative to develop the scientific basis. We then involved user groups – including Aquaculture Stewardship Council (ASC), World Bank, blue carbon investors, coastal engineers, Boskalis and those implementing mangrove restoration on the ground all over the world to help structure the guidelines to address multiple needs (Box 1).

Box 1: What do these guidelines offer to you?

For public and private practitioners and coastal zone managers, these guidelines offer a practical stepwise approach throughout the project cycle, from feasibility through to implementation and long-term maintenance. They also help ensure that you are aware of and adopt best practice approaches and continue to improve and adapt in response to dynamic developments as needed.

For (inter)national policy makers and private sector branch organisations, these guidelines offer inspiration and evidence to help drive integration of mangroves in sustainable development, climate and biodiversity policies and sectoral strategies.

The six principles for successful restoration help set the quality benchmark, while purposeful target setting, along with associated key performance indicators, help monitor and deliver tangible impacts.

For investors and development banks, these guidelines support selection of high-quality propositions, they can help to de-risk investments by reducing failure risks and ensuring compliance with international criteria for environmental and social sustainability and enhance cost efficiency. It also provides monitoring and evaluation criteria for determining the impact of their investments.

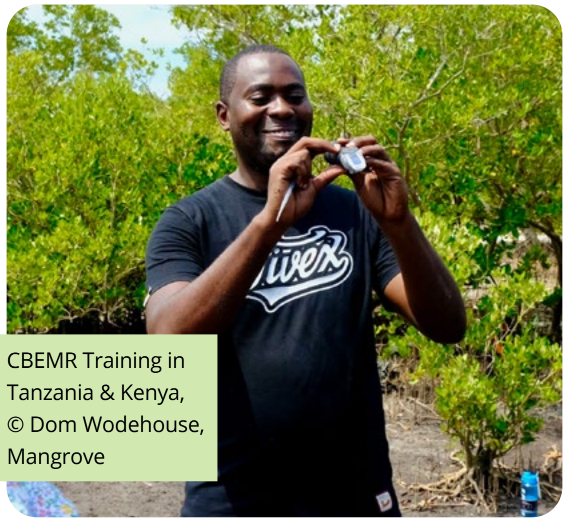
1.3
How to use the guidelines

Using the project cycle as a foundation

These best practice guidelines for mangrove restoration go beyond physical restoration activities. Drawing on a wealth of experience, they include the additional factors that can make or break a restoration project.

- Developing specific and achievable goals and objectives
- Assessing site feasibility
- Project design
- Stakeholder engagement
- Implementation planning
- Monitoring and adaptive management

The role of these guidelines is not to replicate the excellent existing guidance for restoration activities (presented in Appendix B). Instead, our intention is to complement existing information, and to provide pathways to decide which existing guidance is appropriate for a specific restoration context and specific restoration goals and objectives.


CBEMR Training in Tanzania & Kenya, © Dom Wodehouse, Mangrove


Monitoring seagrass, © Gabriel Akoko

For easy uptake, these guidelines are organized according to the project cycle, with sections on facilitating goal setting, site suitability and feasibility analysis, project design, planning, stakeholder engagement, implementation, monitoring, and adaptive management (Figure 1). For each step in the project cycle, we describe the basic ideas that you may want to consider and link those ideas to key messages and principles for successful mangrove restoration. Key messages and frequently asked questions can be found at the beginning of each chapter and in Appendix A.

Figure 1

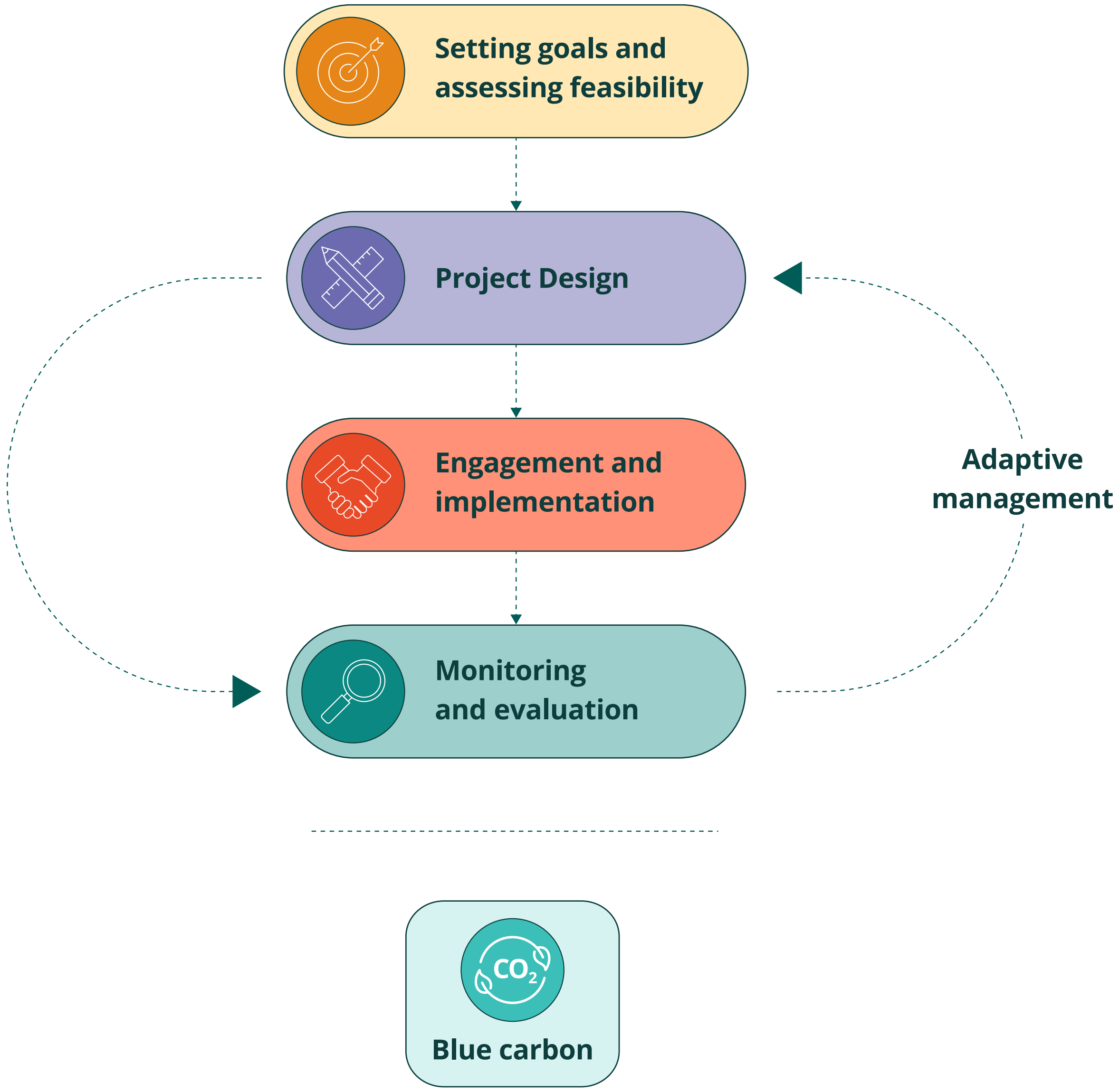


Figure 1. *Project stages for mangrove restoration. Stages are pictured linearly but at many points multiple processes may be happening at the same time. Monitoring and evaluation of progress towards project objectives informs adaptive management and revision / improvement of project design and implementation.*

CBEMR Training in Tanzania & Kenya,
© Dom Wodehouse, Mangrove Action Project

Perhaps most unique to these guidelines is the modular structure. In addition to general information, the guidelines aim to identify and highlight issues related to specific goals. Goals related to restoration for climate mitigation benefits, fisheries improvement, and coastal protection are presented as modules that focus on the unique requirements for achieving those goals.

- Module 1: Blue carbon (completed) – focuses on restoration for climate mitigation and includes guidance on accounting for the carbon benefits related to mangrove restoration within the context of national commitments, greenhouse gas accounting, and carbon finance
- Additional modular extensions are in preparation, covering mangrove restoration in different contexts or for other specific outcomes such as food security and coastal protection. Readers of the guidelines are encouraged to contact the authors with ideas for additional modules.

These guidelines are part of a broader set of tools that are being developed by the global mangrove community (Box 2) and efforts have been made to align tool development to critical components outlined here such that, when used together, they provide a holistic approach to mangrove restoration.

Box 2: Related Tools

Global Mangrove Watch

Global Mangrove Watch (GMW) is an online platform that provides the remote sensing data and tools for monitoring mangroves. It gives universal access to near real-time information on where and what changes there are to mangroves across the world and highlights why they are valuable. With hi-res information on topography, soil conditions, and hydrology, Global Mangrove Watch provides coastal resource managers, policymakers, and practitioners with the evidence needed to respond to changes in mangrove extent, pinpoint the causes of local mangrove loss, and track restoration progress.

Mangrove Restoration Tracker Tool

The Mangrove Restoration Tracker Tool (MRTT) will aid the mangrove conservation community in quantifying how specific conservation actions lead to outcomes for biodiversity, mangrove resilience, management effectiveness, communities, and governance. In turn, this will help improve mangrove conservation implementation and build a community to support more effective mangrove restoration projects. The MRTT has three overarching sections to record information through the lifetime of a mangrove restoration project: (i) site background and pre-restoration baseline, (ii) the restoration interventions and project costs, and (iii) post-restoration monitoring that incorporates both socio-economic and ecological factors.

Mangrove Knowledge Hub

Managed by the Global Mangrove Alliance, the Mangrove Knowledge Hub is a global clearing house for better understanding of mangrove ecosystems. Knowledge is generated by Alliance members. The hub is where anyone can find the most up to date news related to mangroves, links to tools and resources, and reports such as the "State of the Worlds Mangroves Report."

Mudskipper, © Yus Rusila Noor, Wetlands International

1.4

Guiding principles for successful mangrove restoration

Outlining our six core principles

This guidance aims to connect practical implementation of mangrove restoration to six principles. These principles are woven throughout the document and can be applied in every phase of the project cycle.

1. Safeguard nature and maximize biodiversity

At the bare minimum, negative impacts to nature need to be understood and avoided: no planting in valuable mudflats or seagrass beds or on top of naturally regenerating saplings. Purposefully striving for positive biodiversity impacts will in many cases be beneficial. Instead of planting monocultures, aim for restoring a mangrove with multiple species and natural zonation. A biodiverse mangrove has greater variety in root types, tree sizes, foliage, and fruits, and can therefore fulfill different functions and attract diverse fauna. This results in the provisioning of multiple goods (timber, fodder, honey, fruits, and fish) and services (enhanced coastal protection, carbon storage, water purification, fisheries enhancement). Such mangroves are also likely to be more resilient to climate change. A sizable area is required for a mangrove system to be self-sustaining and adaptive, so operating at land and seascape scale is key.

2. Employ the best information and practices

Make use of the best available science, including lab and field-based measurements as well as traditional and local knowledge and experiences that has often been developed and refined over centuries. Convene a multi-disciplinary and multi-sectoral team to help integrate biophysical as well as socioeconomic aspects and to ensure different stakeholder perspectives are represented and addressed. System understanding at all these levels is needed to get to the root causes of mangrove loss and degradation, so that solutions can be developed that tackle these. Given that mangroves depend on water and sediment coming from the land as well as the sea, such connections need to be understood and accommodated at the land and seascape scale for mangroves to thrive. These dynamic environments often require a “learning by doing” attitude along with adaptive management to be successful.

3. Empower people and address their needs

Local actors – and their representative institutions – need to have the capacity to meaningfully engage in project design and implementation and advocate for their needs in policy dialogues. For example, through training (e.g., coastal field schools) combined with tailored finance to enhance community capacity to contribute leadership, knowledge, experiences, and ideas. The project governance structure needs to facilitate participation and decision-making as well as fair and equitable benefit sharing. Mangroves can offer many tangible benefits to local communities, some of which can be monetized e.g., ecotourism, wild capture fisheries, provision of food and fodder. Some projects may also be able to monetize non-tangible mangrove services such as carbon sequestration. Restoration could aim to create a mangrove-based economy that optimizes such benefits while avoiding over-exploitation and introducing sustainable wood harvesting and alternative livelihoods that do not degrade mangroves. The safety of all people, but especially vulnerable and marginalized populations such as indigenous people or women and children, should be prioritized in all aspects.

4. Align to the broader context - operate locally and contextually

Given the position of mangroves between land and sea, there are typically several government agencies involved from the local to the national level, each with different mandates and targets. Again, taking a land and seascape approach is key. This involves integrating projects within coastal zone management policies as well as into other relevant policies and plans. One government agency may strive to protect the mangrove for carbon storage and coastal protection, another may advance aquaculture for food security, and yet another may seek to develop a national highway or waterfront city along the coast. These perspectives can be aligned in a shared vision and plan that supports mangrove conservation and restoration. Further, formal and informal land ownership and use rights are often complex, uncertain, and conflicts may need to be resolved.

Multi-stakeholder collaboration in Demak Central Java, © Yus Rusila Noor, Wetlands International

5. Design for sustainability

All projects have risks to sustainability that may occur beyond the project lifetime. Besides generic project risks (i.e., political change, long-term financing), mangrove projects also face marine-specific risks, including sea level rise and land subsidence, extreme storms, changes in ocean temperatures, and other climate change scenarios which play out over a range of timescales (interannual to decadal). Risks need to be carefully mapped and understood, so that risk mitigation measures can be put in place. Mitigation measures include creating policies sensitive to the broader context (principle 4), designing solutions that address biophysical and socioeconomic root causes of loss and degradation (principle 1 and 2) and ensuring local ownership (principle 3). Again, taking a landscape, seascape, or "ridge-to-reef" approach can mitigate risks. For example, a healthy coral reef can protect a seagrass bed or mangrove forest. Likewise, a healthy upland forest and watershed can enhance the resilience of a mangrove forest downstream. Further, projects should aim to adopt time frames of at least 20 years to ensure sustainability.

6. Mobilize high-integrity capital

Reverting the trends of loss and degradation requires transformational societal changes as well as large-scale restoration for those mangroves that are not irretrievably lost. The 2021 UNEP State of Finance for Nature report estimated funding needs at USD 15 billion for historic mangrove restoration overall until 2050, of which USD 450 million is needed to restore just half of the recent losses (since 1996) by 2030. Governments and public financing alone cannot foot the bill with the urgency needed. Private sector funding must be mobilized at scale and at speed alongside government funding. Over the last decade, the world has begun to recognize the importance of mangroves. Conservation and restoration of mangroves is starting to drive large-scale finance aimed at supporting local to national-scale actions. However, mobilization of capital needs to avoid false benefits (greenwashing) and ensure equitable access to funds. Specifically, the private sector needs to commit to reducing negative impacts within their own supply chain (GHG, biodiversity loss, etc.) in addition to financing conservation and restoration activities. Also, contracts with local communities should be fair and transparent.

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2

Setting goals and assessing feasibility

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Mangrove restoration projects are planned, designed, implemented, and managed by people with diverse backgrounds and different scientific and sociopolitical agendas. As such, these projects are responsive to multiple stakeholders and agents who hold different values. Many mangrove restoration projects have failed because of a lack of community involvement, inappropriate governance structures, and a failure to align objectives and goals of external agents with those of local stakeholders. Chapter 2 guides the reader through the importance of setting realistic, clear, and agreed upon goals and objectives as a critical first step in any restoration project, followed by basic first stage site feasibility assessment.

Key messages

- Establishing clear goals and measurable objectives helps to communicate and set expectations with stakeholders and provides an early opportunity to integrate shared goals into project design
- Restoration is a social enterprise and local leadership is key. Projects often fail without sufficient community and political support to sustain management in the long-term
- Building trust, engagement, skills, empowerment, and ownership are essential for launching and maintaining mangrove restoration projects, and this takes time and commitment
- Mangrove restoration typically fails in sites with prolonged inundation (e.g., in seagrass beds or mudflats that are low in the intertidal zone) or otherwise unsuitable conditions where mangrove seedlings cannot survive for long.

FAQs

How do I set measurable ecological and social goals and objectives for mangrove restoration?
Section 2.1.1

What is land tenure, and how does it affect my mangrove restoration project?
Section 2.2.1

Who do I need to consider when defining project goals and objectives?
Section 2.2.2

What is Community Based Ecological Mangrove Restoration?
Section 2.2.2

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Reading list

International principles and standards for the practice of ecological restoration (second edition) https://onlinelibrary.wiley.com/doi/10.1111/rec.13035	Guidelines for ecological restoration, including socioeconomic components, establishing goals in the planning phases. Describes the “recovery wheel” to project evaluation.
Land tenure considerations are key to successful mangrove restoration https://doi.org/10.1038/s41559-019-0942-y	On the need to think about ecological criteria and social criteria when making restoration decisions, particularly highlighting land tenure.
An introduction to decision science for conservation https://doi.org/10.1111/cobi.13868	A guide to making mangrove restoration decisions systematically and collaboratively.
Mangrove restoration under shifted baselines and future uncertainty https://doi.org/10.3389/fmars.2021.799543	On the changed environmental conditions between mangrove degradation and restoration, on functionality and on local priorities.
Getting it right, a guide to improve inclusion in multi-stakeholder forums https://www.cifor.org/knowledge/publication/7973/	This guide explains how to operationalize the inclusion of women, indigenous peoples and other under-represented groups in multi-stakeholder forums.
IUCN Legal Frameworks for Mangrove Governance https://portals.iucn.org/library/node/48361	A 2018 review of literature and legal information on international and national law and policy for mangrove ecosystems.
USAID LandLinks Tools and Guides repository https://www.land-links.org/tools-and-mission-resources/tools-and-guides/	A suite of tools to guide restoration and development practitioners in addressing land tenure issues.
Mangrove restoration: To plant or not to plant https://www.wetlands.org/publications/mangrove-restoration-to-plant-or-not-to-plant/	This publication aims to contribute to best practice by exploring the question that everyone involved in mangrove restoration should ask: ‘To plant or not to plant?’

2.1

What are you trying to accomplish?

Getting clear on your goals and objectives

Efforts to restore mangrove ecosystems around the world are increasing. This is largely because of the increasing recognition of the valuable ecosystem services they provide, including carbon sequestration, coastal protection, biodiversity, and fisheries values. However, mangrove restoration comprises a series of complex processes that go well beyond a narrow focus on biophysical conditions (e.g., tidal inundation and mangrove zonation) to include a wider range of socioeconomic factors (e.g., land tenure, community needs, and government engagement and consultation). The reasons that different stakeholders have for restoring mangroves will be motivated by different pressures, and different stakeholders may hope for different outcomes. You need to be aware of all the various mutual or conflicting needs and wants of relevant groups and be able to work to align as many goals as possible while setting realistic expectations and guardrails.

2.1.1 Setting goals and objectives

How do I set measurable ecological and social goals and objectives for mangrove restoration?

Restoration projects start with the general understanding that there is an area where mangroves have been lost or degraded and everyone involved wants to repair the area to regain a healthy mangrove ecosystem. However, this shared desire is not enough, and specific objectives required to meet those goals must be defined, agreed upon, and interpreted in the same way by those involved[23]. Goals set during this early stage can be quite simple or high level as they are expected to evolve or be revised during an iterative project design phase, for example to be inclusive of stakeholder- or community-defined objectives.

- **Goals** can be short, medium, or long-term. They are statements which outline the desired outcome(s) resulting from ecosystem recovery. For example, a goal may be to "increase mangrove area by 20% by 2030 within my project site."
- **Objectives** are shorter-term statements that act as interim guides towards meeting goals. Objectives are often prefaced with 'to...' as this provides a targeted directive. For example, an object may be "to develop a restoration strategy and budget within the first 6 months of implementation." The objective directly relates to the goal.

To ensure the best chance of restoration success, goals and objectives should be relevant to the target mangrove ecosystem, measurable via indicators, be specific, and time-bound.[6] In addition, restoration goals and objectives should be set for both ecological and social outcomes.[6,7]

Each project goal will have interim objectives linked to specific and measurable indicators to assess the project prior to and after restoration, ideally compared to a reference site. To evaluate progress, each restoration objective should clearly articulate:

- Desired outcomes
- The indicators to be measured
- The desired magnitude of effect (compared to no restoration actions scenario)
- The time frame for achievement.

Figure 2

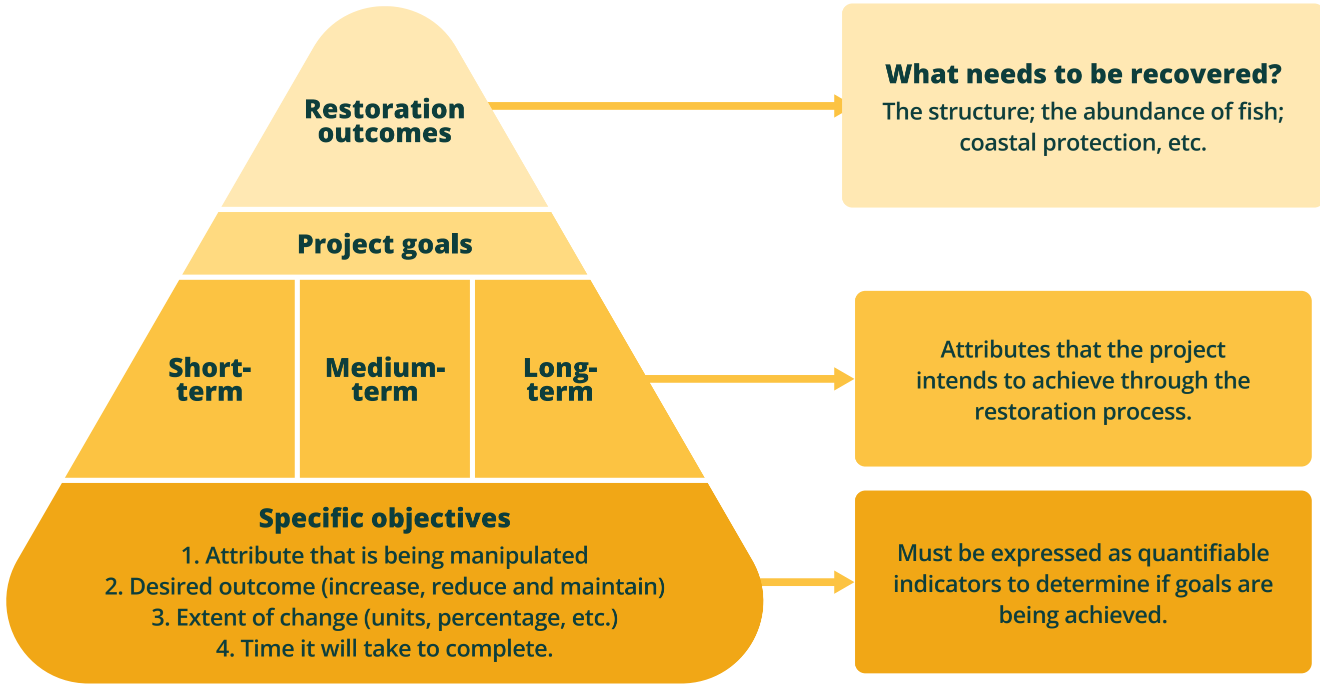
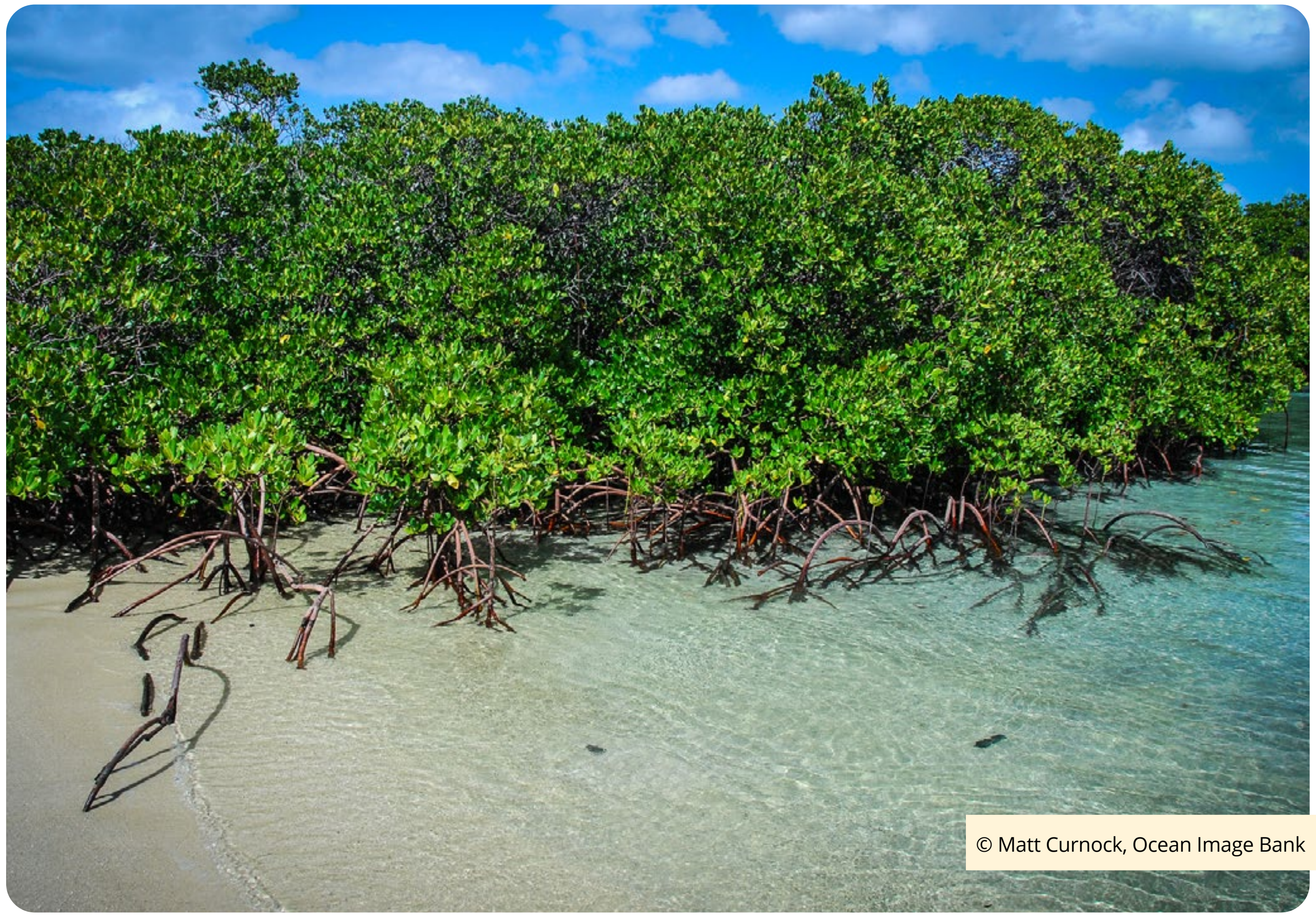


Figure 2. *summarizes the characteristics of goals and objectives while Appendix D shows a framework and guidance for establishing clear ecological and social goals, objectives, and indicators for a mangrove restoration project (adapted from Teutli-Hernandez et al., 2021[16]).*

Once you have agreed upon goals and objectives, the next step is to understand how to meet those goals. Who will help you? Where are the conditions favorable and likely to succeed? How might issues in the broader landscape impact success? How might future conditions impact the project?

In addition to identifying the goals of yourrestoration project, constraints should be considered to give the best possible opportunity to plan and implement restoration projects successfully. Many of these constraints are common to all project types and include the levels of available funding, costs of implementation, social and policy constraints (and enablers), and biophysical constraints.

In addition to identifying the goals of your restoration project, constraints should be considered to **give the best possible opportunity** to plan and implement restoration projects successfully.



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2.2

Is it feasible?

How to assess what's possible

There are four initial factors to consider when assessing the feasibility of mangrove restoration projects:

- **Land tenure** and securing permission or rights to restore/manage mangroves
- **Communities and other stakeholders** – who they are, and how to integrate their needs
- **Current land use** and the drivers of mangrove loss/degradation
- **Site suitability** and the basic conditions mangroves need to thrive.

Understanding the starting position of the area to be restored across these four factors is the first step towards deciding whether to move forwards into more fine-scale data collection and project design.

2.2.1 What legal permissions are required?

What is land tenure, and how does it affect my mangrove restoration project?

Land tenure, or the ability to claim legally recognised management or ownership rights, is a complex and persistent challenge for mangrove restoration projects.

Depending on location, you may need to secure legal permission, or pay fees, to the entity owning or managing the mangrove area before:

- Implementing any activities which modify a mangrove site (i.e., any restoration activity)
- Carrying out data collection activities, especially when removing samples from the site
- Accessing the mangrove site, by water or on foot, for any reason
- Flying drones over the mangrove site or surrounding areas.

For example, when carrying out data collection for a proposed restoration site in a national park or marine protected area, it is common to need to apply for a research permit.

Where there is no entity claiming ownership, usage rights or legally recognised governance of the restoration site, you may need to secure ownership or management rights on behalf of the project or community partners.

Challenges arise in locations where there are several layers of overlapping governance, or where there is no clear indication who the entity responsible for mangrove governance might be, or who the mangroves may belong to[9]:

- Most commonly, mangroves are considered state land. However, not all nations have clear procedures to clarify land tenure, and contacting local, regional, and national governing bodies may be required to obtain clear permission to carry out any restoration activity, or to secure site management rights
- Mangroves may also be subject to de facto ownership or management by local communities under traditional land use practices. In some – but not all – countries, traditional or community ownership or management rights are legally recognized
- Where traditional or community rights to own or manage mangroves are informally recognized or lacking in clear supporting legislation, registering a legally recognized community organization (e.g., forestry associations or fishery management groups) for the declared purpose of managing a mangrove site has been shown to be one method of securing legal recognition of community rights to manage mangroves[10]
- Some nations permit private ownership, concessions, or long-term lease of mangrove areas, with records and transfers of ownership most likely managed at regional or local levels
- National laws regarding conversion of mangroves to aquaculture or production forestry concessions may provide a framework for achieving the legal right to manage a mangrove area. However, they may be specific only to those uses and require clarification that concessions may be repurposed for restoration or conservation use
- In a few locations mangroves may be subject to overlapping classifications and not under the jurisdiction of any one governing entity. For example, the lower intertidal may be described as seabed, while the upper intertidal is described as land.

When assessing land tenure, it will be more feasible in some settings to establish restoration projects in areas which have a level of formal legal protection rather than unprotected land with no clear ownership, management body, or enforceable protections.[11]

Where there is legislation governing mangrove ownership and use at a national level, regional or local interpretations may vary. Restrictions on mangrove development or damage, where applicable, will also vary in how strongly they are enforced. In some regions where mangroves are converted for aquaculture and subsequently abandoned after ponds become unproductive or unviable to maintain, mangrove restoration managers need to be wary that residual claims to old ponds may still apply, and the owners may be difficult to trace.

The "On the land and in the sea" report explores mangrove land tenure in greater detail, while further online resources are available from USAID.

2.2.2 Who needs to be onboard?

Who do I need to consider when defining project goals and objectives?

Mangroves are multiple-use systems providing multiple resources to multiple users. This can lead to a range of conflicts[12] which warrant stakeholder identification, consultation, and engagement to ensure that the interests of each group are collaboratively and consensually taken into consideration.

Bringing everyone together is difficult but vital to success.

Community-level stakeholder participation and co-management is a process that can come with challenges, such as the potential for conflicting priorities related to short-term or individual benefits versus long-term communal and environmental solutions. Other challenges can include mismatched expectations, reduced coordination, risk of conflicts within or between neighboring communities, and slow progress.[13] The benefits of community leadership and involvement far outweigh the challenges. Practical guidance for stakeholder engagement is provided in Chapters 3 and 4, while further stakeholder analysis resources are provided in Appendix C.


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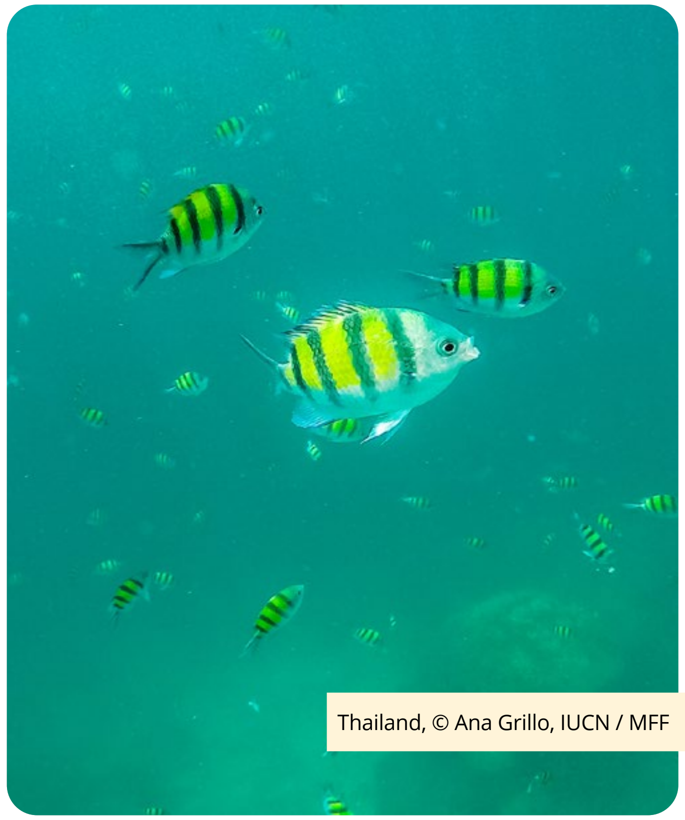

Thailand, © Ana Grillo, IUCN / MFF

Stakeholders include direct and indirect beneficiaries of the restoration and those benefiting from the loss/extraction of mangroves (note that these may or may not be the same people), economic contributors, and local authorities. The participation and representation of all sectors involved throughout the restoration process may include, but is not limited to, the following[14]:

- **Local communities** including landholders and customary landholders
- **Civil society organizations** including local cooperatives, small-scale fisher's associations, women's groups, or community-based organizations
- **Scientists/technical experts** including academia, consultants, and NGOs. Practical implementation of the restoration may involve different professionals from a variety of disciplines such as policy makers, biologists, ecologists, economists, and engineers
- **Economic players** including the business community that benefits from the provision of goods and ecosystem services, funding agencies, and a carbon buyer if a project is meant to generate carbon credits
- **Resource managers** including local management associations, community leaders, and local authorities
- **Regulatory institutions** including international, national, and subnational government.

CBEMR Training in the Rufiji Delta, Tanzania,
© Dom Wodehouse, Mangrove Action Project

Step 1 - Define the stakeholder groups and specific stakeholders within each group through a process of stakeholder identification and analysis. Even a simple level of identification and analysis enables the inclusion of stakeholders who may not have been thought of previously but who may offer significant contributions, in positive or negative ways. Examples of simple stakeholder analysis include the WWF Stakeholder Analysis guide. Ultimately, a good stakeholder analysis process will help to avoid impediments later and enable appropriate planning and resourcing.[15] Developing a list of potential individuals, groups, or organizations that may be engaged as part of the project requires a systematic and reflective approach that moves beyond the obvious or usual groups. One way of approaching this process is to think through different categories of stakeholders and rationales for engaging, including but not limited to the following:

- **Sector** – public, private, voluntary, or civil society
- **Function** – user, service provider, regulator, landowner, or decision-maker
- **Geography** – living within a specific postal district or flood risk area
- **Socioeconomic** – income, gender, age, disability, race and ethnicity, religion or belief, or length of time living in area
- **Impact** – directly affected, indirectly affected, or able to influence the project (livelihood dependency, income)
- **Understanding and experience of restoration** – none, low, medium, or high (can be linked to education)
- **Known or likely position on the restoration project** – for or against the project or issue.

Step 2 - Understanding the level of influence, specialties, and impact for each stakeholder group will help to determine the intensity of engagement required. Similarly, the nature of specific decisions may also impact the overall intensity of engagement required. Knowing where and how to involve stakeholders in the process is an essential part of an engagement plan for restoration. A range of approaches can be used, but most involve a two-scale matrix based on the following:

- Likely **influence** they have over the decisions to be made
- Likely **impact** on the implementation.

It is not always possible to have participation of all stakeholders from the beginning of a project. However, participation can be encouraged throughout the restoration process through workshops, training, and adequate communication, highlighting the benefits for each sector involved.[16]

What is Community Based Ecological Mangrove Restoration?

The Community-Based Ecological Mangrove Restoration (CBEMR) method has seen worldwide success and demonstrates an effective and sustainable approach to mangrove restoration. Unlike many planting projects, CBEMR works with nature to restore degraded mangroves by mimicking natural processes.

The CBEMR method is derived from the Ecological Mangrove Restoration approach developed by Robin Lewis III. This approach steered mangrove restoration away from the conventional wisdom of 'gardening' – building a nursery, growing seedlings, and planting mangroves – towards the restoration of fundamental ecological processes, such as hydrology, that once enabled healthy mangroves to thrive.

CBEMR works to build capacity and empower local stakeholders and communities by teaching them how to restore mangrove forests. Working with local communities is integral to the success of projects, ensuring that those living within the area will be involved in the restoration efforts. Involvement of the community, as well as local NGOs and government staff, begins at the planning stage, and includes implementation right the way through to monitoring and management. This way, local coastal communities are empowered to become stewards of the mangrove, taking ownership of the restoration project and maintaining the long-term benefits of the ecosystem.


A giant mudskipper gaurding it's pool, © IUCN / MFF


© Dom Wodehouse


Oyster farming in the mangroves, © Joeri Borst, Wetlands International

The CBEMR approach starts with a detailed investigation of the proposed restoration site to understand the reasons for previous mangrove loss and why mangroves are not naturally regenerating. Every site is different and there is no one-size-fits-all solution to mangrove restoration, so it is vital to understand the biophysical parameters of the site.

Hydrology and elevation relative to sea level are extremely important and are normally the key factors controlling species distribution. There also needs to be an investigation of the social factors that might inhibit mangrove regeneration, including land tenure, site usage, site history, what restoration attempts have been tried already, and other relevant factors such as livelihoods that impact on mangroves. This research, combined with a study of a nearby natural healthy mangrove reference site, will reveal what has changed on the site and what needs to be done to restore normal mangrove conditions.

The next step is to discuss and agree with all local stakeholders project objectives and what restoration activities need to take place to restore the mangroves.

Implementation can take many forms, from digging to improve site hydrology, to diverting fresh water to a site, or implementing community mangrove management rules about harvesting of mangroves.

The restoration work and social agreements need to be monitored to ensure interventions work and social agreements are being adhered to. If interventions fail to work, monitoring will help with adaptive management to ensure successful outcomes. The process will also hopefully demonstrate that local communities, and all local stakeholders, must preserve and protect the mangroves they have, and manage them sustainably in order to secure a sustainable future for themselves.

Training in CBEMR techniques is available from Mangrove Action Project and Blue Forests - Yayasan Hutan Biru.

2.2.3 What is the current land use?

In addition to identifying stakeholders, it is important to understand how these different stakeholder groups interact with the potential restoration site and the surrounding landscape.

Mapping current land use of the project site and adjacent area can provide insights into:

- **Potential land tenure issues** for example, the presence of old aquaculture ponds or other constructions which may be privately owned or managed
- **Causes of mangrove loss driven by human activities** for example, tree cutting, building roads that disrupt site hydrology, or grazing animals straying into mangroves
- **Other potential stakeholders** for example, if there is a tourist development further along the coast, they may be supportive of restoration for recreational use.

Mangroves are productive and resource-rich ecosystems which tend to be subject to human use. How they are used will vary depending on location and the needs of nearby settlements, from high-tech cities which may threaten mangroves with a need for waterfront property development or aquaculture production, to small low-tech villages where populations utilize mangrove resources for subsistence needs or to generate income, for example through charcoal or salt production.

Online remote assessment tools are available which enable remote mapping of current land use and visualization of historic patterns of gain or loss of mangrove area over time, both on the project site and surrounding areas. These include:

- Google Earth
- Global Mangrove Watch
- Mapping Ocean Wealth
- Planet.

What should I be looking for when carrying out a remote assessment?

When undertaking a remote land use assessment, particular attention should be paid to:

- **Current land uses which impact water supply to the project site**, such as ponds or dikes, and also modification of watercourses to supply or drain settlements or aquaculture, or to irrigate crops. Changes in freshwater supply may affect site hydrology and salinity, and therefore the potential for successful restoration
- **Indicators of active cutting or deforestation**, such as cleared areas and access tracks adjacent to areas where mangroves are being lost over time
- **The presence of buildings or other infrastructure**, such as roads, moorings for boats, sheds or cabins, and ponds or dikes. All indicate previous or current human use of the site, and continued access for owners or users may be required
- **Past events which coincide with changes in mangrove extent**, such as infrastructure construction, land use change, or changes in coastal morphology. These may indicate a driver of mangrove loss.

Any remote assessment should be combined with stakeholder and community knowledge of the past and current use of mangroves and adjacent land, especially to identify current uses which are essential for livelihoods, material resources or food provision, and which will need to be considered when deciding if the proposed restoration site is feasible.

If large areas of the proposed restoration site are currently in active use, project goals may need to be adjusted to accommodate continued use, enable transition to sustainable alternative uses based on stakeholder consensus, or a different restoration site may need to be considered.

Thailand, © Ana Grillo, IUCN / MFF

The Mangrove Restoration Potential Map

A global map of the biophysical potential for mangrove restoration is available on the Global Mangrove Watch portal to help project managers understand where opportunities for restoration are greatest and identify the potential benefits from restoration.

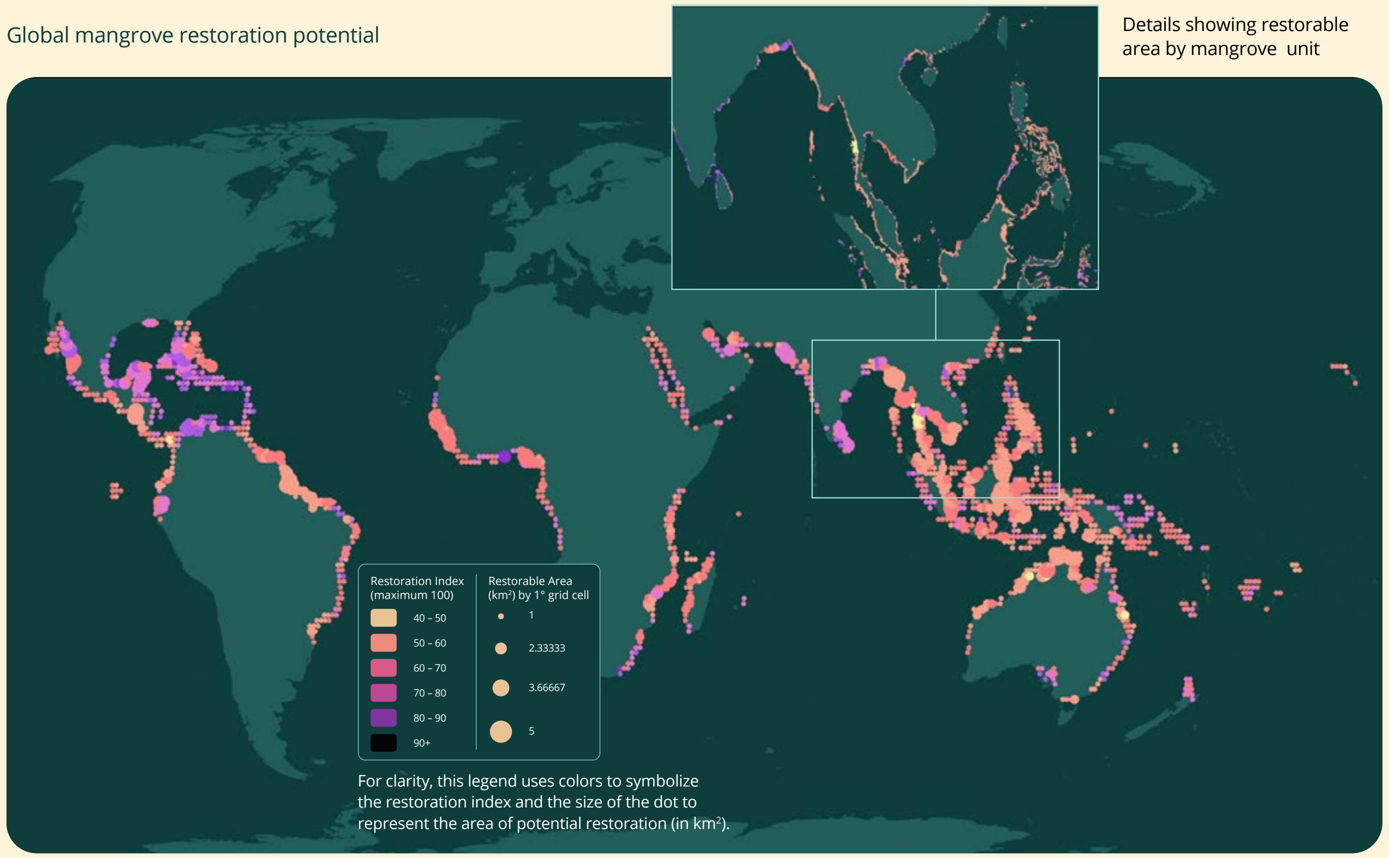
The map uses the Global Mangrove Watch dataset to identify areas of mangrove loss between 1996 and 2020, defining the temporal and spatial footprint within which restoration can be considered. Within these areas of loss, those that had been converted to land uses that were deemed too costly or too challenging to restore were removed. The analyses identified potential restoration opportunities in 110 countries and territories, covering 8,183 km^2.

These are mangrove areas cleared to bare land or for commodities, or those impacted by extreme weather events. At the national level, Indonesia had the largest biophysically suitable area (over 2,000 km^2) with large extents also identified in Mexico, Australia, and Myanmar.

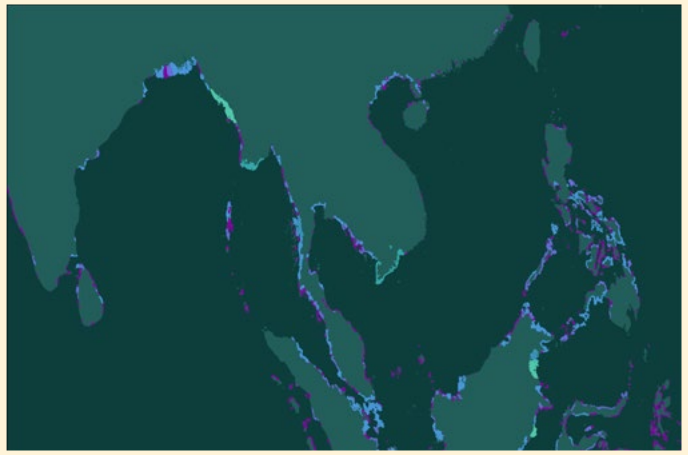
The analysis is based on a relative index of the restoration potential of mangrove patches, which was created using an expert derived model that weights the importance of different geospatial data layers including: drivers of land use change, environmental settings (tidal range, future sea level rise risk and hydrological disturbance) and mangrove loss dynamics (loss patch size and number, connectivity and the timing of the mangrove loss).

Global mangrove restoration potential

Details showing restorable area by mangrove unit

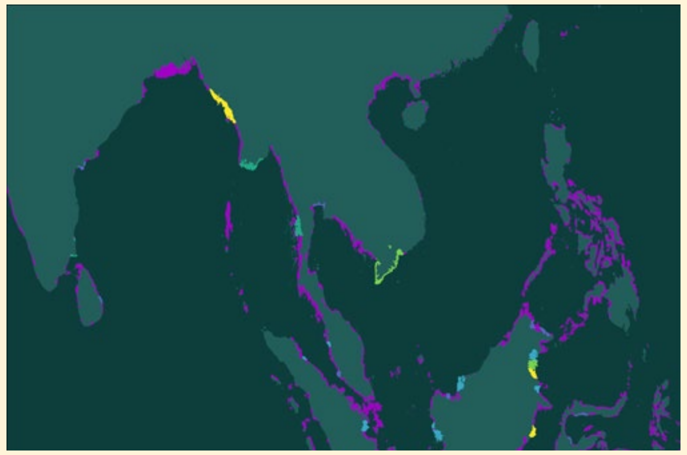


Global carbon restoration potential



Total Carbon (Mg)
- 0 – 20,000
- 20,000 – 60,000
- 60,000 – 600,000
- 600,000 – 1,600,000
- 1,600,000 –3,500,000
- >3,500,000

Global fish restoration potential



# of Individuals
- 0 – 60,000,000
- 60,000,000 –200,000,000
- 200,000,000 – 600,000,000
- 600,000,000 – 1,000,000,000
- 1,000,000,000 – 2,000,000,000
- >2,000,000,000

The model predicts that mangrove restoration potential is particularly high across the coasts of Southeast Asia, with high index values also concentrated on the north coast of South America and northern Australia. Certain countries combine both extensive biophysically suitable restorable areas and high restoration index values. For example, it is estimated that there are over 600 km^2 of restorable mangroves within Myanmar. This is equivalent to over 10% of its current mangrove extent, with the majority scoring very highly on the restoration index.

To provide an estimate of the potential outcomes from restoration, the map of restorable areas has been linked with models of ecosystem service values to identify hotspots of restoration opportunity with large potential benefits. Currently available are models of aboveground and soil carbon storage, and enhancement of commercial marine fisheries. High restoration potential resulting in large amounts of additional carbon and fishery impacts was centered on Southeast Asia. Models of other services, such as coastal protection, will add further information to support restoration as these become available.

The global map provides a broad-scale overview of which areas offer the greatest potential for restoration and the possible benefits in terms of carbon and commercial fisheries.

Practical application of the tool to fully benefit from restoration actions requires more detailed, local understanding of the underlying social-ecological conditions behind restoration success.

2.2.4 Can my site be restored?

What is the most important question to ask to understand if a site is suitable for restoration?

The most important question to ask when assessing the suitability of a restoration site is: Have mangroves naturally grown here before? Follow up questions should also be asked: What happened to the mangroves that were here? Why have they not recovered naturally? And how can that be fixed? Addressing these questions is the foundation to planning successful mangrove restoration.

Mangrove distribution can potentially extend from mean sea level up to the level of the highest astronomical tide (Figure 3, top panel), and therefore attempts to grow mangroves at sites that have always been below mean sea level, or above the high tide limit, fall outside the natural mangrove habitat envelope and have little chance of success[17,18] (Figure 3, bottom panel).

Sites that had mangroves in the past but where mangroves have been lost must be investigated to understand why mangroves no longer establish or grow under the present conditions (Section 3.3). This knowledge can then be used to design restoration interventions that promote suitable conditions for successful mangrove establishment – known as ecological mangrove restoration (Section 3.4). In some cases, the ecological conditions of a site may have changed so much that restoration interventions may be highly challenging or not be possible, leaving mangroves unable to grow in areas where they once existed.[19]

The different geomorphic settings in which mangroves exist (e.g., deltaic, estuarine, open coast, lagoonal, and carbonate mangroves) can also influence feasibility. For example, mangroves occupying estuarine environments are possibly more feasible than those located in open coastal settings that have comparatively higher exposure to wind and wave damage.

A crab-eating macaque (Macaca fascicularis), © IUCN / MFF

Figure 3

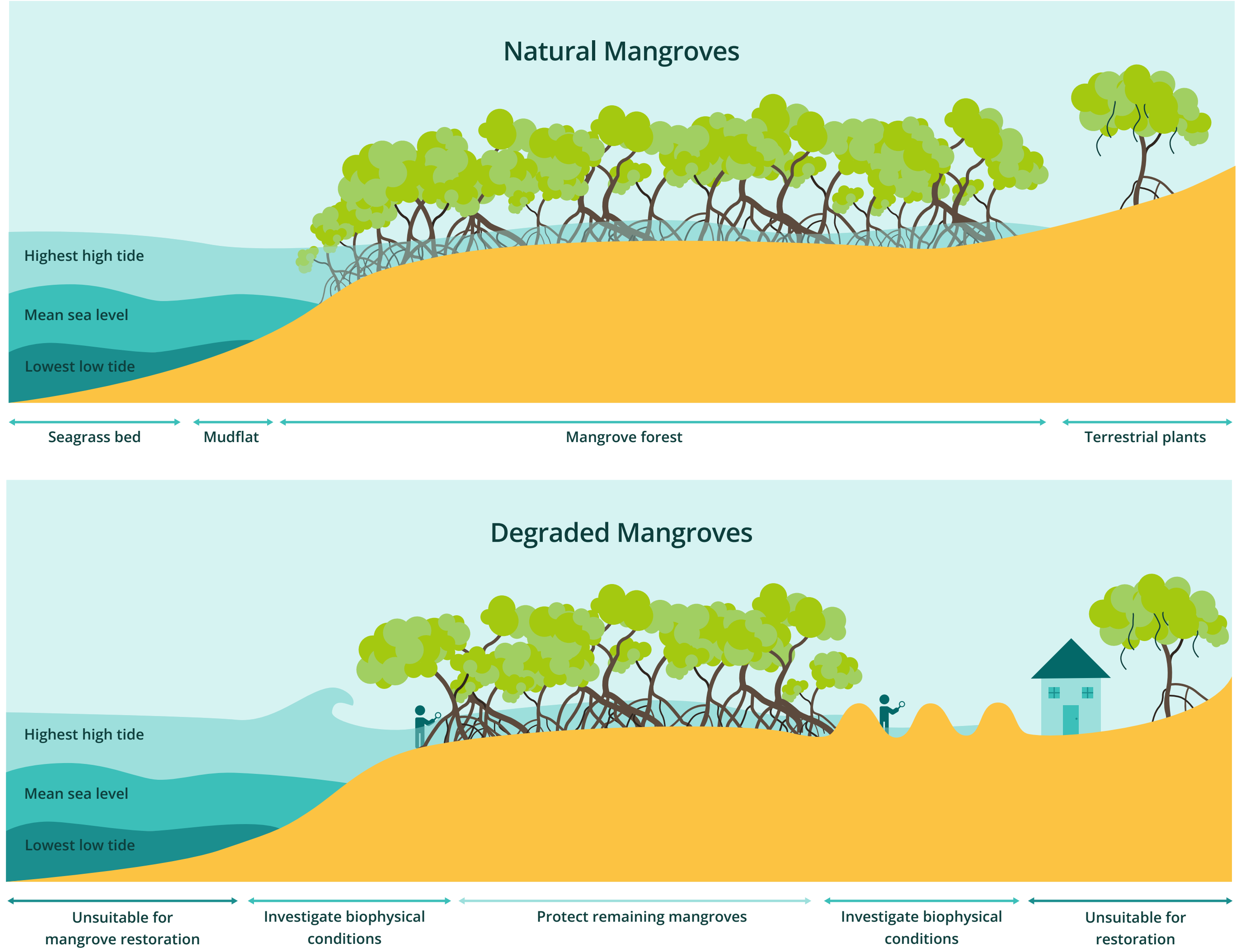


Figure 3 Top panel: *A commonly found natural mangrove zonation pattern across the intertidal zone and the elevation of the mangroves compared to tidal planes.* **Bottom panel:** *suitability of sites for mangrove restoration based on site history. Landward areas that are unsuitable for restoration may become suitable with sea level rise. The tidal datums are indicative and may vary across sites. Adapted from Primavera (2012).[20]*

To establish the extent of recovery needed, restored ecosystems are compared with natural ecosystems of the same type.[8] Comparison between the site to be restored and a nearby site in good condition – ideally pristine – allows you to understand how degraded your restoration site is (Section 3.3.1). Knowing which areas of your project site are intact and which are degraded helps establish the level of active intervention required to achieve restoration (Figure 4). Intervention techniques are generally described in three ways:

- **Natural regeneration** – Where damage is low, natural regeneration (i.e., without human intervention) may be possible after reducing or stopping the underlying causes of degradation. For example, reducing the harvest of mangroves for fuel or timber could lead to natural recovery where soils have not been damaged and where there is a healthy abundance of propagules for regrowth
- **Assisted regeneration** – Where sites require the active removal of ecological or biophysical barriers, such as the reinstatement of tidal flows, reshaping aquaculture ponds, or controlling invasive species so natural regeneration may take place
- **Direct intervention** – Where damage to landscapes is high, once suitable conditions have been established, active interventions may also involve additional direct replanting of mangroves if there is insufficient availability of mangrove propagules for natural recolonization.

These techniques are points on a continuum where sites may need a mix of more than one technique. No matter the technique required, if there are ecological or biophysical barriers which are undesirable in the wider landscape, or are long-term and difficult to overcome, such as persistent flooding (e.g., from inappropriate infrastructure) and/or erosion, then the likelihood for success is low without larger-scale management interventions.[21] The success of restoration projects will be enhanced by assessing biophysical and socioeconomic conditions (both opportunities and barriers) in evaluating the feasibility of restoration and establishing clear goals and objectives on which to develop intervention activities.

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Figure 4

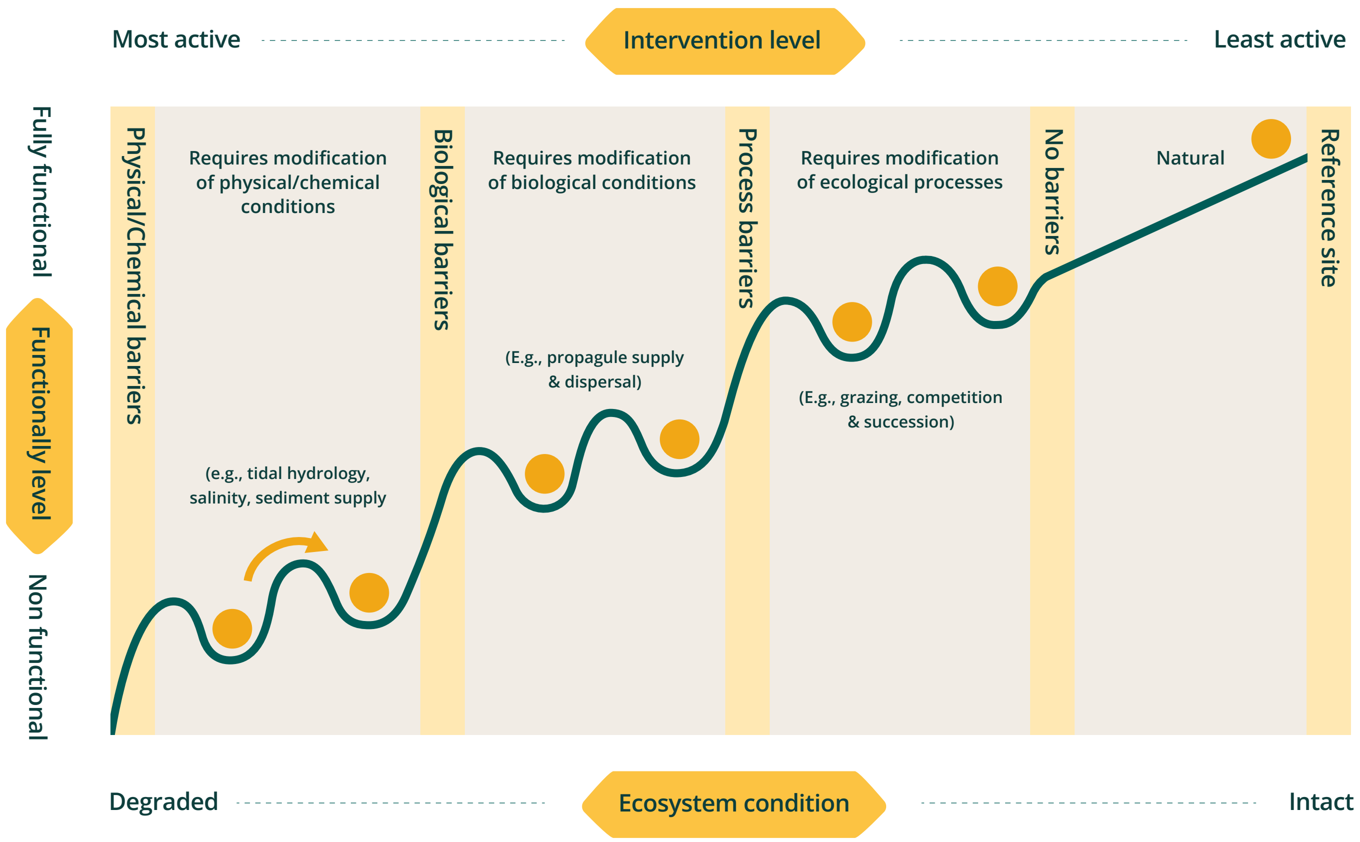


Figure 4. *Conceptual restoration continuum showing the level of intervention required to assist in the recovery of an ecosystem as a function of its level of degradation. Adapted from SER (2021).[22] Originally based on Whisenant, 1999.[35]*

2.2.5 Making the decision

The highest priority factors in determining feasibility will be whether there is likely to be stakeholder support for a restoration project, and no legal barrier to project implementation.

Having identified the different stakeholder groups using or living in the project site and adjacent areas, plus having a clear record of changes in mangrove cover and condition in the project area, it should now be possible to assess the potential for restoration within the context of site-specific pressures.

Multistage decision trees can be useful tools to support site feasibility assessments. They can be adapted by inputting specific issues relevant to your site context and project goals. The example below can be used for assessing biophysical restoration conditions (Figure 5).

Figure 5

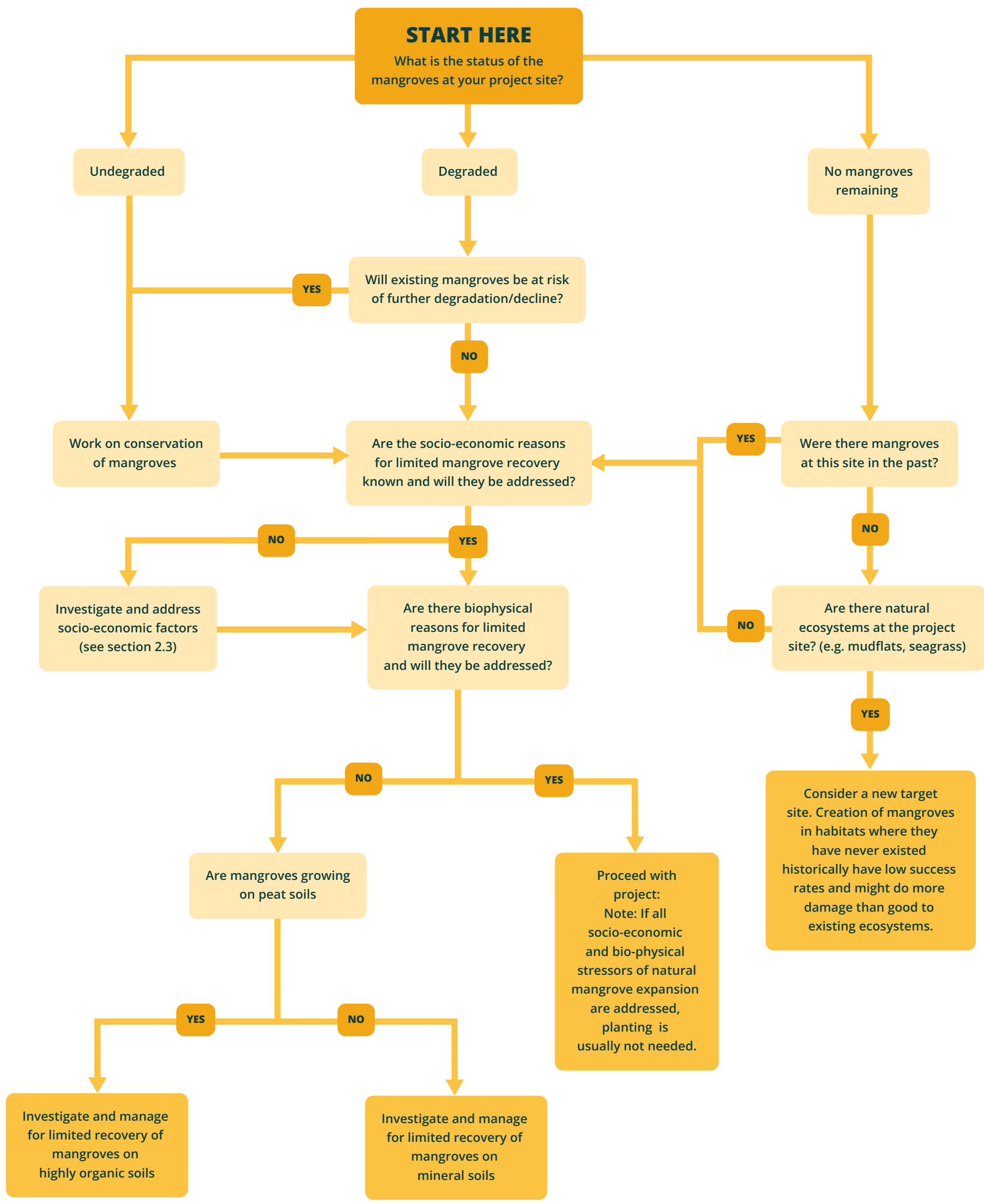


Figure 5. *Assessing site suitability for mangrove restoration.*[23] *The basics are shown here but a project manager can add more questions customized to their site or working environment (e.g., related to political willingness and available funding, see Sections 3.3.2 and 4.3).*[23]

Alongside determining feasibility based on the historic presence of mangroves, stakeholder agreement, and ownership clarity, it will be important to consider how this project fits into the larger landscape and how future conditions under climate change will impact success.

2.3
The wider context

My site looks good – what else do I need to think about?

While most guidance is focused on delivering successful mangrove restoration at site level, a deeper understanding of how environmental, socioeconomic, and policy conditions at regional or national levels interact with your project site can be strongly beneficial.[10,16,20]

2.3.1 Considering the landscape

Even the best projects using the best techniques can fail if the wider landscape is not considered.

Two tools that are available to assist in designing feasible projects within the context of a wider landscape are the 4 Returns Framework and the Restoration Opportunities Assessment Methodology (ROAM).

4 Returns Framework

The 4 Returns Framework is a tool for evaluating restoration feasibility at landscape scales (e.g., >100,000 ha) and for assessing how smaller projects fit within the landscape.[24] This conceptual and practical framework helps stakeholders to achieve returns in four areas – social returns, natural returns, financial returns, and inspirational returns. The framework follows five process elements:

1. Landscape partnership
2. Shared understanding
3. Landscape vision and collaborative planning
4. Taking action
5. Monitoring and learning.

The elements are implemented within a multifunctional landscape (including natural zones, economic zones, and combined zones) over realistic time periods (indicative: minimum 20 years). Multiple restoration projects across several ecosystem types must go through an alignment and planning process that may take up to two years.

Restoration Opportunities Assessment Methodology (ROAM)

ROAM offers a guide to identify forest landscape restoration opportunities at the national or sub-national level using a combination of stakeholder engagement and analysis of available data.[25] It outlines well-defined tools that can be used to address the following topics:

- Stakeholder prioritization of restoration interventions
- Restoration opportunity mapping
- Restoration economic modeling and valuation
- Restoration cost-benefit modeling
- Restoration diagnostic for the presence of key success factors
- Restoration finance and resourcing analysis.

Additional to the original ROAM guidance is specific guidance on navigating governance arrangements to support planning for restoration.[26]

4 Returns and ROAM address different stages of restoration and require different levels of detail, making the two approaches complementary. ROAM provides guidelines focussed on the planning stages for restoration (pre-implementation), with detailed guidance on how to do economic, financial and governance analyses. The 4 Returns Framework covers the stages of restoration from planning to implementation across all sectors operating in the landscape through creating a common language among sectors to achieve restoration outcomes. For example, you might use the 4 Returns Framework to conceptualize the complete process of restoration in each landscape, while ROAM tools might be used to analyze economic and financial returns or governance structures prior to implementation.

While site level work may eventually be integrated into landscape scale initiatives (jurisdictional approaches and national scale programs), this will take several years in most instances and timelines are highly variable. Currently, it is up to the project manager and partners to determine how best to align project goals and objectives with those of any future landscape scale approach.

2.3.2 Considering the changing climate

Whether at the site or landscape scale, mangrove restoration efforts must consider the impacts of climate change and its role in the long-term success of projects.[27,28]

How does climate change impact restoration, and how can I mitigate those impacts?

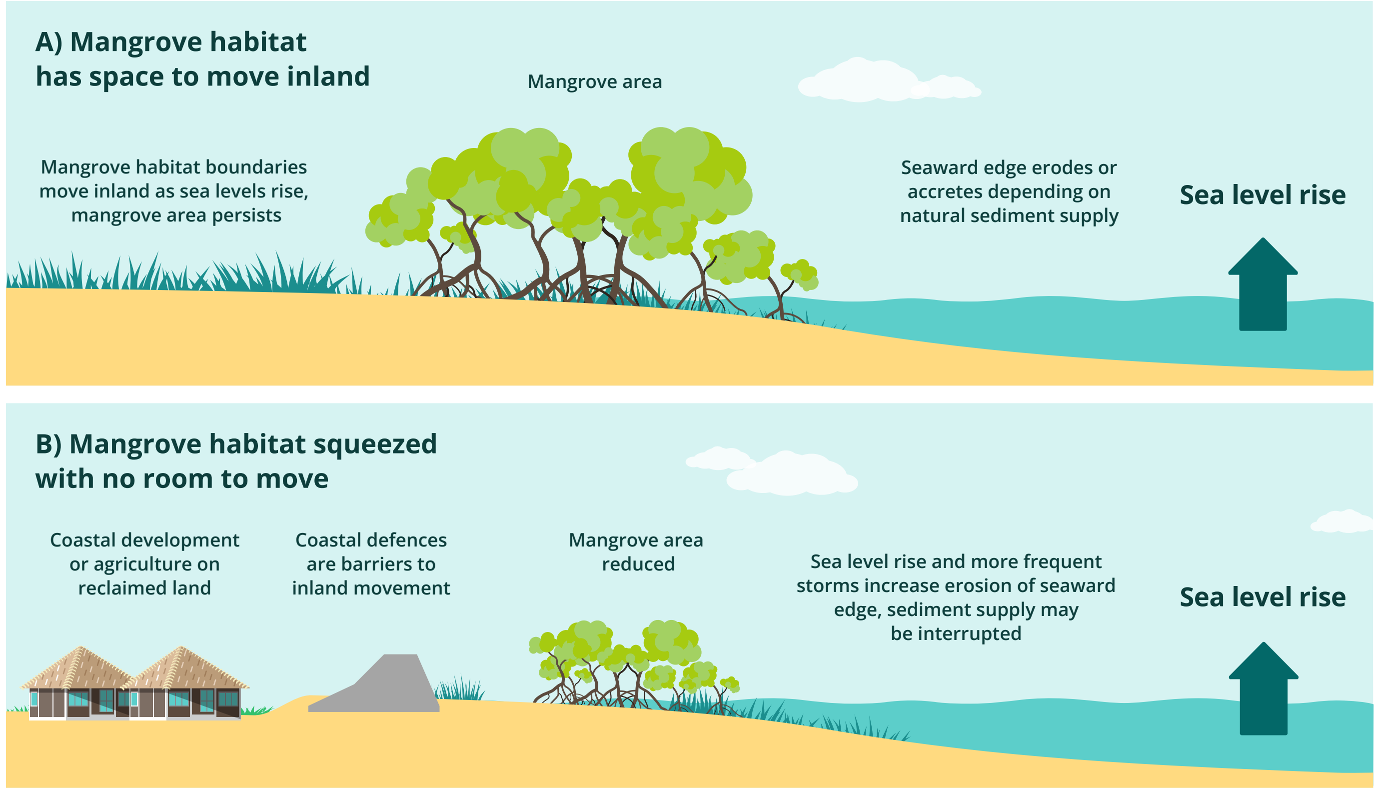
Although degradation of mangroves in the last century has mainly been caused by direct human actions, there is a growing threat of loss from severe flooding, extreme drought, reduced or unpredictable freshwater or groundwater flows, and erosion or sedimentation changes caused by storms and extreme precipitation.[28,29,30] Climate driven threats to mangroves are expected to increase,[2] and it is not clear how mangroves will respond. Mangroves may respond by changing distributions (e.g., expansion in latitude and/or elevation) or species composition. Individual mangroves may respond by adapting root, branch, or stem anatomy.[31,32]

Mangrove restoration projects should consider climate-smart criteria, such as prioritizing sites that are sheltered from high wave activity[33] and are less vulnerable to increasingly frequent extreme storm events. Adaptation strategies should also be considered, for example selecting sites for restoration that can allow for landward migration of mangroves under different sea-level rise scenarios (see Box 3) or planting native species with low sensitivity and/or high adaptive capacity to climate stressors.[34]

Box 3: Coastal squeeze

Around half of the world's population live within 100km of the coastline. As populations grow and the need for living space and food production increases, humans might develop land right up to the margins of intertidal ecosystems, or convert them to other uses, such as aquaculture ponds, grazing, or beachfront accommodation. At the same time, the joint pressures of erosion and rising sea levels may drive intertidal systems to retreat inland as the seaward margin is lost (Figure 6). In locations where development has pushed up against or overlapped into systems such as mangroves, there is no room left for ecosystems to migrate inland, and instead, coasts are squeezed between human development and the rising sea (compare Figure 6a and b).

Figure 6



There are established processes for evaluating the vulnerability of sites to climate change threats.[36] Standard methods usually evaluate the exposure to climate threats at the site (e.g., trends in patterns of rainfall, sea level or extreme events)[37] and the sensitivity of the site to those climate threats.[38] Sites differ in their sensitivity to climate change threats depending on their characteristics,[39] for example:

- Whether the site is on an exposed coastline with greater exposure to wind and waves
- Whether the site is low or high in the intertidal zone which would give rise to differing sensitivities to sea level rise
- Whether there is infrastructure on the landward boundary that might limit landward expansion with sea level rise.

The more non-climate stressors that can be managed to improve the condition of the site, the greater the likelihood of acclimation to and recovery from climate stressors. At a global scale, the Mangrove Restoration Potential Map uses measures of historic and future sea levels to identify locations where mangroves are at higher or lower risk of inundation due to sea level rise. This can be used to assess potential restoration sites, but detailed understanding of local-scale coastal geomorphology, hydrology and other risks will still be required to ensure project locations are 'climate-smart'.

The timing of threats from climate change that are likely to have negative impacts on the site should also be considered in the project design process so management and mitigation actions can be effectively prioritized. For example, a restoration site may be high in the intertidal zone and thus sea level rise may not have a direct effect on the site for decades. However, there may be barriers to landward migration identified (e.g., a road) that may take years to negotiate solutions. Therefore, management of the site may include investment in stakeholder engagement to begin the process of negotiating with infrastructure managers before the situation becomes urgent. In contrast, a site may already show signs of erosion after storms, and thus community consultation to gather information and discuss immediate options would be a higher priority. Potential actions include increased intensity of monitoring, modeling whether sediment delivery to the site has reduced, investigating engineering solutions to reduce waves and currents, identification of options for landward site expansion, and testing the efficacy of replanting within the damaged mangroves areas.

Thailand, © Siriporn Sriaram, IUCN / MFF

2.4

Next steps

It should now be possible to determine that the restoration site meets basic feasibility criteria:

- There are clear initial project objectives
- There are no legal barriers to mangrove restoration
- Stakeholders appear to be aligned (even if only at a high-level)
- Current land uses affecting the site have been identified and assessed
- The restoration site has a reasonable likelihood of success based on initial observations
- There is understanding of how the project interacts with the broader landscape
- Immediate or future threats to the project site have been identified.

The next step will be to dig deeper into the specific biophysical, social, and financial requirements for successful restoration and design an in-depth project plan. Once the project design has been drafted, it is then possible to begin estimating costs for implementation and monitoring (Chapter 3).

3
Project design


© Sean Chinn, Ocean Image Bank

This chapter provides guidance on how to design a project for long-term success. After identifying all relevant stakeholders, agreeing on the goals and objectives for restoration, and completing the basic feasibility phase, the project moves into a design phase where everything that was learned previously is considered and activities are designed to address the specific needs of the project.

There are many excellent publications which provide guidance for mangrove restoration, including manuals with specific regional applications. Chapter 3 is not meant to replicate the wealth of information that is available but to highlight key points that practitioners may find helpful. Please review the manuals listed in Appendix B for more detailed descriptions and steps on how to carry out the suggested assessments.

Key messages

- Historically low rates of success should not be linked to general uncertainty around what it takes to design a project that works but to a lack of communication around what is best practice
- A good project design document should be co-created with the stakeholders and partners identified during the feasibility phase
- Project managers should spend significant time prior to restoration activities ensuring local owners of the project are well informed and engaged in decision-making from the outset. Communicate the benefits of restoration with clear evidence
- The potential to restore mangroves depends largely on the degree of degradation, its geomorphic setting, and the willingness and capacity of the landowner
- Ensure that the restoration design corrects hydrological, hydrodynamic, sedimentation, and propagule availability issues and replicates natural reference sites. To achieve this, local ecological knowledge and/or measurements of hydrological variables in natural and restoration sites can be used.

FAQs

Why think holistically about restoration?
Section 3.1

What should be included in a project design document?
Section 3.2

How do I design a project to limit the social constraints that could hinder my success?
Section 3.3

What is physically happening at the restoration site? And how can it be fixed?
Section 3.4

What will I need to spend money on?
Section 3.5

Reading list

Ecological Mangrove Rehabilitation – A field guide for practitioners https://blue-forests.org/wp-content/uploads/2020/04/Whole-EMR-Manual-English.pdf	Fundamental text on the design and practical implementation of mangrove restoration.
Free Prior and Informed Consent https://www.fao.org/indigenous-peoples/our-pillars/fpic/en/	All projects must at complete a Free, Prior and Informed Consent process before any kind of work begins.
The cost and feasibility of marine coastal restoration https://esajournals.onlinelibrary.wiley.com/doi/full/10.1890/15-1077 The data base is available at: https://datadryad.org/stash/dataset/doi:10.5061%2Fdryad.rc0jn	The research assembled costs of restoration to 2016, finding higher costs in more developed economies than less developed economies and lower restoration costs for mangroves than other coastal ecosystems.
Sediment flow in the context of mangrove restoration and conservation https://wwfasia.awsassets.panda.org/downloads/wwf_mcr_sediment_flow_in_the_context_of_mangrove_restoration_and_conservation_v6_5_web.pdf	A rapid assessment of sediment dynamics in mangrove sites and an explanation of why this is necessary.
Hydrological Classification, a practical tool for mangrove restoration https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0150302	A detailed technical explanation, with case studies, on how to assess hydrological status of mangrove restoration sites.
Social and ecological outcomes of conservation interventions in tropical coastal marine ecosystems: a systematic map protocol https://link.springer.com/article/10.1186/s13750-020-00193-w	A summary of different conservation actions which can inform planning of mangrove restoration projects.
ARSET - Remote sensing for mangroves in support of the UN Sustainable Development Goals https://appliedsciences.nasa.gov/join-mission/training/english/arset-remote-sensing-mangroves-support-un-sustainable-development	A training course (with videos) aimed at policy makers but which provides guidelines on remote sensing of mangroves and instructions using the Google Earth Engine to map mangrove sites and measure site area.
CASE STUDY: Community Based Ecological Mangrove Rehabilitation (CBEMR) in Indonesia https://journals.openedition.org/sapiens/1589	A detailed account of the process of mangrove restoration at a site in Indonesia highlighting a wide range of activities and adaptive management.

3.1
Designing a successful restoration project

Why think holistically about restoration?

While there is strong desire to implement the restoration and rehabilitation of mangrove ecosystems, the process of coastal restoration is nuanced and complex, with many projects around the world resulting in failure.[5,40] However, this historically low rate of success should not be linked to general uncertainty around what it takes to design a project that works but to a lack of communication around what is best practice. Specifically, poor restoration outcomes are often due to project designs that fail to consider and plan for how biophysical, social, financial, governance, and land ownership factors will interact with each other.[17,41] Project designs that consider the wide range of factors influencing restoration have better project outcomes (Figure 7).

The process of coastal restoration is **nuanced and complex**, with many projects around the world resulting in failure.[5,40]

Jitambue bee keeping group member at Mchinga, Tanzania, © Elizabeth Wamba, Wetlands International East Africa

Figure 7

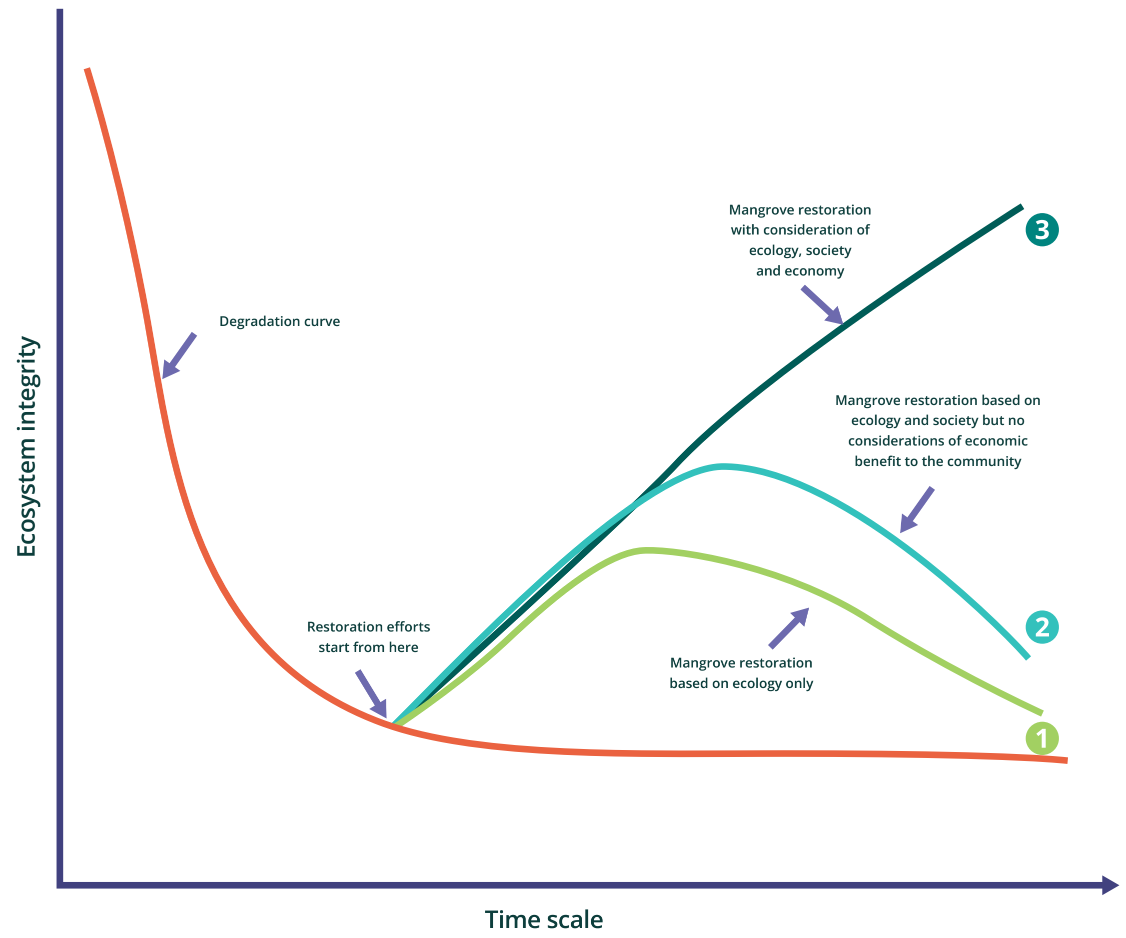


Figure 7. *Hypothetical impacts of addressing (or not addressing) the underlying reasons for mangrove degradation on restoration success. [1] Consideration of ecological reasons only: short-term success followed by rapid degradation due to opposition from people or activities of people. [2] Consideration of ecological and societal reasons: good initial success, but unsustainable in medium-/long-term due to failure to consider economic benefits. [3] Consideration of ecological, societal, and economic reasons: sustainable restoration outcome (successful in the long-term). Modified from Biswas et al. (2009).[42]*

Chapter 2 of this guide looked at goals, objectives, and overall feasibility. Through that process you identified the people that will be critical to the design process of your project, as well as the various ecological, social, and financial issues that need to be included in the project design. Designing projects that meet all the needs of all those involved is unlikely, but the goal is to design projects that meet most of the needs for the most people. The design process allows for cooperative planning such that when the project starts there are clear roles and responsibilities, expectations are met, and everyone involved has the opportunity to weigh in on decisions and is aware of how those decisions will affect the project.

3.2
Components that result in good design

What should be included in a project design document?

A good project design document should be co-created with the stakeholders and partners identified during the feasibility phase. It should be a document that provides general information about the project and restoration strategy, such that anyone involved in the project can pick it up and clearly understand the goals, required actions, decision points, and finance needs required to be successful. The main components are listed here but there may be additional categories that should be considered based on specific project needs.

3.2.1 Project context

- **Project location –** Describe where the project is located (country, region, department etc.), the size, and geographic boundaries of the project area. If possible, include a relevant map of the area and any coordinates
- **Biophysical characteristics** – Provide information on the main biophysical characteristics of the project and surrounding area: elevation, slope, climate, vegetation types, biological resources etc.
- **Barriers to carrying out restoration** – Describe the barriers and underlying causes that may hinder restoration efforts.

3.2.2 Stakeholders and implementation partners

- **Communities, land, and resource use in the project area** – Provide information onthe communities living in and/or around the project area e.g., number of families/individuals and important socioeconomic data, such as poverty and income levels, education, and sanitation information, including main livelihood and economic activities. What are the main types of land use in the project area associated with these livelihood activities? Describe how they use the resources from the project area. Provide relevant maps if available (e.g., land use maps, settlements etc.)
- **Stakeholders involved in the project –** This section should provide an assessment of the local stakeholders and an engagement plan. Identify the key stakeholders that have influence on and are/will be affected by the project and, if pertinent, validate the project approach with them. This section also should answer the following questions: Who is developing the project? What roles are being filled by which partners? How will stakeholders be engaged?
- **Capacity for implementation –** Implementing a restoration project is a long-term commitment in terms of both time and resources. In the short-term, who would be the central project partner overseeing the entire project development phase (2-4 years), and who could manage implementation in the long-term (30+ years). This section should provide an analysis of the strength and weaknesses of the available partners in the region and their capacities to implement and commit to such a project.

3.2.3 National context and governance

- **National policy and legal context** – Identify the legal ownership and any laws involving land use that may be relevant and describe how the project will work within these limits
- **Land tenure and use rights –** This section should describe the land tenure of the project area, basically answering the question: Who owns the land in the project (and surrounding) area? Are there any legal titles to the land? Are there any customary rights attached to the lands in the restoration area? Are there any official management plans/categories regulating land use in the project area? In addition, does the project implementer have the ability/right to manage the restored area and implement monitoring activities as required?

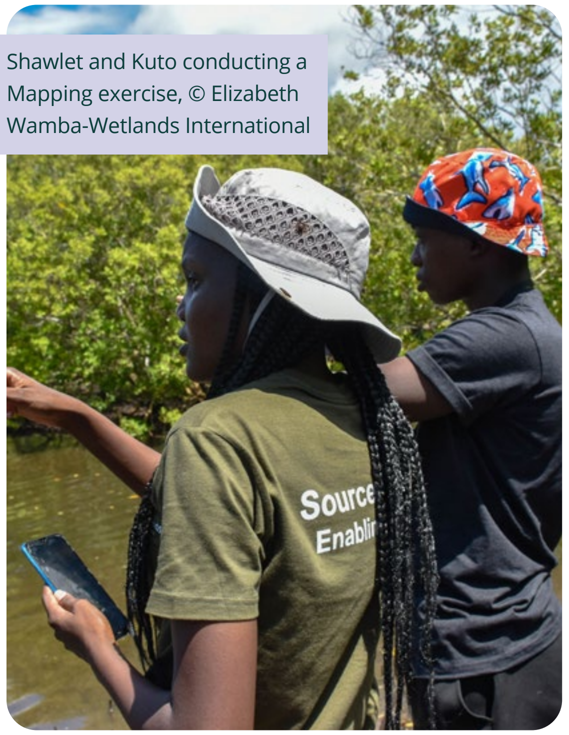

Mikoko Pamoja community monitoring, © Tony Ochieng

3.2.4 Project idea and scope

- **Actions to achieve restoration** – Given the context provided in the previous sections, this section should provide a detailed and clear description of the project strategy in the project area
- **Potential environmental and social co-benefits** – What ecosystem services and biodiversity benefits do we have to take under consideration that are relevant in the region (e.g., important watersheds, endemic/threatened species distribution etc.)? How does the project impact local communities (positive and negative)? How does the project impact biodiversity/other services (positive and negative)?
- **Governance structure** – It is critical that the process for making decisions, who needs to be informed of decisions vs who needs to participate in making decisions is clear and transparent. This section should also describe how differences in opinions will be handled.

3.2.5 Financial analysis

- **Costs overview** – This section should provide an estimation of the project costs, at least for the first 10 years of operation
- **Potential revenue streams** – Describe any source of potential revenue that the project might generate, including revenue from ecosystems services (e.g., tourism, carbon), grants or philanthropic donations, or profits from products (e.g., non-timber forest products). This section might include fundraising and revenue strategies from broader landscape or regional strategies.



Shawlet and Kuto conducting a Mapping exercise, © Elizabeth Wamba-Wetlands International


Senegal, © Dom Wodehouse, Mangrove Action Project


© IUCN / MFF

3.2.6 Preliminary risk assessment

- **Risk identification** – All projects have some degree of risk. This section should highlight potential factors that might pose risk to the project, including political and legal, economic/financial, environmental, social, policy and compliance, reputational, health, safety, and security risks.

3.2.7 Final considerations

- **Proposed timeline** – Highlighting the key activities and strategies to be implemented as part of the project development (e.g., project design document) and implementation (e.g., conservation agreements, biodiversity, and community monitoring plans). The work plan should cover at least 5 years
- **Information gaps** – What kind of critical information can be obtained but is currently missing for moving the project forward? Are there any assumptions made during this process that need to be revised in the next phase?
- **Opportunity identification** – This section should describe any opportunity that would increase the impact of the project. Is there any opportunity to scale up the project? Or potential matching funding, grant, or any prospective financial support from another source? Is there any governmental program that could leverage the impact of the project?

Depending on the individual project circumstances it may not be necessary to answer each one of these questions, but it is useful to at least think through each question to make sure that everyone on the team feels well informed and understands why certain decisions are being made. Once you have this information you can begin to dig deeper into the activities that need to happen for successful mangrove restoration.

3.3 Designing for socioeconomic issues

Inclusive approaches to project design are key to success

The social, economic, institutional, legislative, and governance context of mangrove areas is complex and dynamic. It brings together different communities of direct and indirect resource users that may have very different social, economic, and institutional needs and priorities. The dynamics of these communities, the way they make decisions, combine different strands of their livelihoods, and the formal and informal institutions they participate in, may all be quite different. Designing projects that engage these communities and groups may be a challenge and adequate time is needed to understand and design the project appropriately.

An example of social, economic, and governance issues affecting restoration outcomes occurred in South-East Asia.[17] Over the last decade in the Philippines, many mangrove restoration projects involved the conversion of seagrass meadows or adjacent mudflats to mangrove plantations, an activity that carries a high failure risk.[43] These types of activities, and the lack of successful restoration, had less to do with understanding the ecological requirements of mangrove restoration and more to do with socioeconomic constraints on the project. In the case of the Philippines, short-term funding for mangrove restoration, pressure to produce impacts quickly, and the inability to resolve complicated land-use and land tenure issues in the brief periods often required by funders led to project designs that were fast, cheap, and avoided difficult issues. Similar pressures will often lead to mass row planting of mangroves on unsuitable land too low in the intertidal zone[17,41] (see Section 3.4), because planting in those areas is typically the most straightforward option given costs, rights, and ownership.

In addition to social and economic drivers of the restoration activities themselves, successful restoration will depend on a comprehensive understanding of the social and economic drivers that may have led to the degradation and loss of the mangrove area in the first place, and social and economic reasons behind any apprehension to restoration. In the case of a community mangrove restoration project in Marismas Nacionales, Mexico, a restoration design which included addressing socioeconomic barriers was key to achieving project goals.

Socioeconomic issues can be enablers as well. Examples of design components that have been reported to positively affect the success of mangrove restoration projects include:

- Intentionally designing for high levels of community support and incorporation of local knowledge[44,45]
- Planning for and identifying key times when large sources of funding are required vs. when sustainable long-term finance is needed to maintain, monitor, and report on the project[46,47]
- Mapping out land tenure or access rights within the project area and designing interventions that specifically address those unique circumstances in a way that local communities can agree on[41,48]
- Designing a project that prioritizes quality of life and reducing human poverty.[19,49]

Appendix C identifies some critical issues that should be considered in a restoration design, why they are essential, and highlights approaches that can be used to assess and address socioeconomic factors.

3.3.1 Designing for community participation, co-creation, and engagement

Most mangrove ecosystems are homes, foraging and fishing grounds, places of cultural or historical significance, and more to the people who live in or close to them. As such, they can be considered social-ecological systems rather than purely wild habitats.[53] This distinction means genuine engagement and co-creation in the design and implementation with local communities before and during mangrove restoration projects is essential.[54] Strong involvement of communities in mangrove restoration aligns with the concept of climate justice highlighted in the preamble to the Paris Agreement, which states that those most affected by climate change (and who are least responsible for it) deserve priority in the design of nature-based solutions – such as mangrove restoration projects.

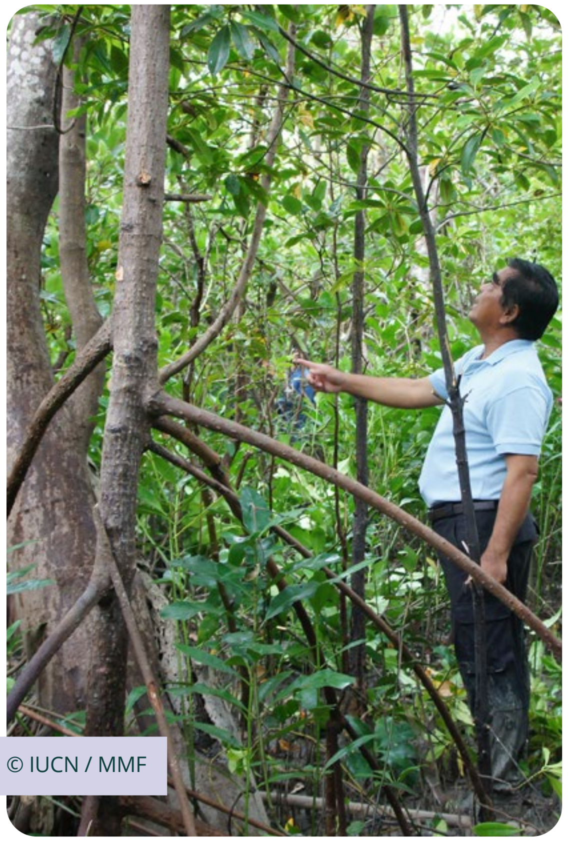
These ethical arguments for genuine local participation align with three practical reasons for project developers to design projects with community participation in mind.

- Most government institutions require evidence of community consultation before the management of public forest resources can be changed
- Even when mangroves are protected by law, enforcement may need to be stronger or more present. Hence, long-term management of the mangroves to avoid reversion of the restored area to previous land-uses will likely require community support
- An effective project must understand and address the core drivers of mangrove loss and degradation and the critical barriers to restoration. These will usually be primarily or partly socioeconomic in origin, and local people have the expertise to help identify the problems and co-design the solutions.[6,21,25,55]

3.3.2 Designing for government and political support

It is essential to understand governance arrangements when designing mangrove restoration projects. Project design should be sensitive to:

- National laws related to land tenure rights and the protection status of land areas, flora, and fauna
- Where mangroves fall within legislation and which government body is responsible for their management. For example, if they fall under terrestrial or marine laws – or fall between the gaps
- Customary rights, such as established patterns of access and management that could contribute to project success or could be contributing to ongoing loss and degradation
- Projects that use payments for ecosystem services to benefit local people may require a demonstration of tenure over the relevant resource. This requirement presents a critical initial challenge for most mangroves since governments often own mangrove land. However, relevant legal instruments may allow the tenure of mangrove resources. For example, in Kenya, The Forests Act (2005) facilitates the tenure of mangroves by user groups to a range of forest goods and services
- Long-term arrangement options to ensure mangrove restoration activities are sustained (i.e., land purchase, land lease, owner agreement, integration into government management plans).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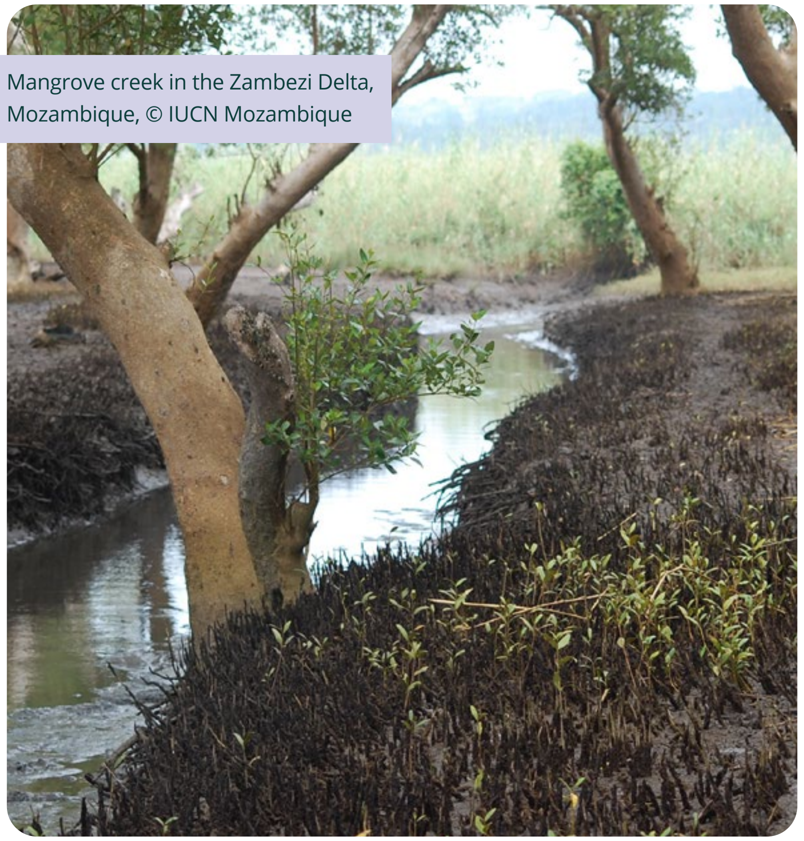
Mangrove creek in the Zambezi Delta, Mozambique, © IUCN Mozambique

Community-based mangrove restoration projects may also require governance structures tailored to local needs, including:

- Democratic representation of local people in project management
- Precise mechanisms for sharing benefits of project outcomes
- Transparent complaints procedures
- Adaptability to allow for changes in design and implementation
- Explicit descriptions of roles and responsibilities (e.g., data collection, reporting, verification, organizing committee meetings, retaining minutes, etc)
- Integration of different forms of knowledge to make restoration successful (e.g., peer-reviewed cience, traditional knowledge)
- In the case of plantations, post-plantation follow-up of planted species including floristic succession, biodiversity, and environmental processes compared to natural areas.[56]

Remember that institutional change can be a long-term process and may require action involving multiple agencies and institutions on many fronts. Legislative change is also likely to require the mobilization of resources of political capital that may not be available for some mangrove restoration projects. Governance arrangements that provide a viable framework for management (e.g., for community forestry) may take time to establish and be accepted, particularly if they differ significantly from existing arrangements.

However, ensuring the sustainability of governance arrangements and their possible extension to more expansive areas will also allow the establishment of longer-term community-led restoration projects.

Resources for analyzing institutional capacity and subsequently understanding and working on improving the legislative context (where required) are provided in Appendix C.

3.3.3 Designing to improve Incomes and livelihoods

One of the greatest threats to mangrove restoration is the return to exploitative and damaging activities because no long-term alternative options for local people were established. A focus on developing alternative livelihoods can be a crucial component of successful restoration projects, mainly where unsustainable exploitation of mangrove resources is important for the livelihoods of communities.

For example, where selling firewood collected from mangroves supports the incomes of community members, reducing the pressure on mangroves from firewood collection requires developing alternative livelihoods for firewood collectors and sellers.

Some of the alternative livelihoods developed in mangrove restoration projects include the production of honey, novel products like fruit drinks, dyes, and soaps, sustainable harvest of crabs and small-scale aquaculture, and tourism enterprises.[57] Payments for ecosystem services, such as carbon sequestration, nutrient processing, habitat for biodiversity, or fisheries, can also enhance livelihoods within conservation and restoration projects.

Module 1: Blue carbon, further elaborates on utilizing carbon finance to support communities and enhance livelihoods. A broader valuation of mangroves' economic services can provide a more robust social and economic argument for mangrove restoration.[45,54]

3.4 Designing for biophysical issues

What is physically happening at the restoration site? And how can it be fixed?

Mangroves are excellent colonizers of intertidal areas. If mangroves are not already growing at the restoration site and there are mangroves nearby (seed sources), then underlying biophysical issues must be identified and addressed. Diagnosing the causes hindering regeneration may require several assessments.

Best outcomes will come from combining local ecological knowledge with quantitative assessments of baselines, hydrology, hydrodynamics, and propagule availability. The first step in understanding what needs to be done to restore the area is to understand what the area would be naturally.

3.4.1 What are you trying to restore back to?

A baseline assessment of biophysical conditions in your site compared to a nearby healthy reference site will help to identify differences that need to be addressed (Figure 8). In general, site assessments should consider the biophysical processes influencing mangrove ecosystem development, including mangrove species ecology (reproduction, dispersal, seedling establishment, growth), the hydrological patterns controlling seedling distribution and establishment, and human modifications that may be preventing natural colonization by plants and other organisms.[58,59] The reference site provides a benchmark against which the restoration site's performance can be measured. By comparing key ecological indicators and parameters between the two sites, it becomes possible to assess the effectiveness of the restoration efforts.[8]

If mangroves are not already growing at the restoration site and there are mangroves nearby (seed sources), then **underlying biophysical issues** must be identified and addressed.

In addition, monitoring and comparing changes in various ecological parameters between the reference site and restoration site over time can help identify trends and deviations, and point out places where adaptive management practices may need to be implemented. If the restoration site is not progressing as expected, the reference site can inform changes to techniques and interventions to improve outcomes. Through these comparisons, it may be possible to differentiate between natural variability, the impacts of restoration efforts, as well as the effectiveness of specific restoration methodologies that could be refined for future projects.

Figure 8

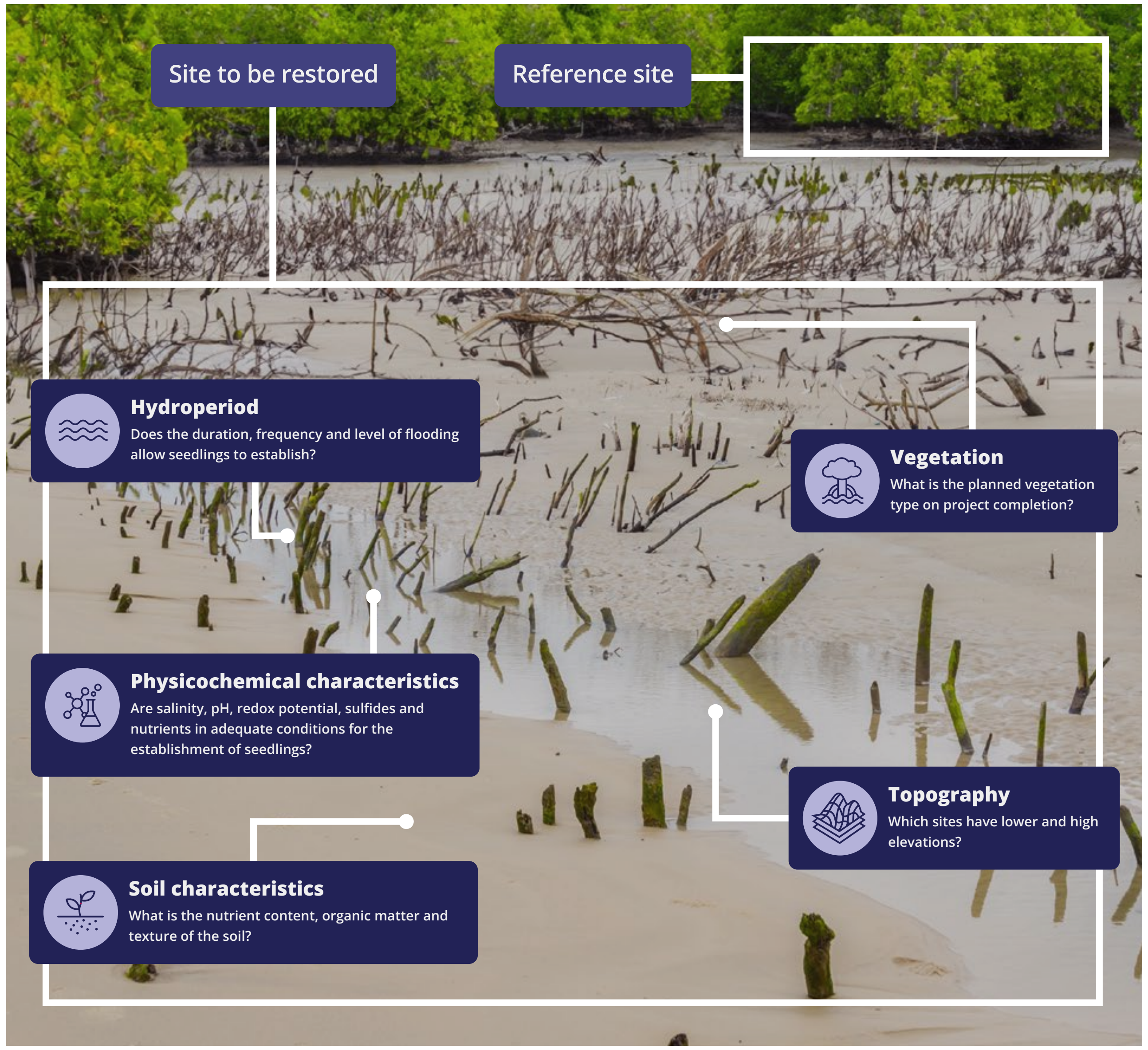

Figure 8. *An overview of biophysical considerations for mangrove restoration projects. Adapted from Teutli-Hernandez et al. (2021).*[16]

3.4.2 Local knowledge on history and current use of the area

In understanding why a mangrove area is not regenerating, it is essential to consider the site's history. A complete understanding of site-specific conditions and history may only be known by Indigenous and local people.[61] Local knowledge is an important aspect of designing effective mangrove restoration projects.[10] It may include information on spatial and temporal changes in species within the mangrove area, changes in mangrove ecosystem structure, species presence/absence, and observable impacts from climate change.

In most cases, Indigenous and local communities have already diagnosed problems with inundation, altered hydrology, or recruitment, and are taking **measures to compensate for changes related to mangrove loss** that should be built upon and inform the restoration design.

In most cases, Indigenous and local communities have already diagnosed problems with inundation, altered hydrology, or recruitment, and are taking measures to compensate for changes related to mangrove loss that should be built upon andinform the restoration design. In addition to understanding the history of the site, it is critical to understand the current uses and needs that the area is providing to communities.

Project designs should build on traditional management strategies that prioritize cultural practices and larger societal needs (e.g., food security and employment). If local knowledge is shared, it is important to follow processes of free, prior, and informed consent (FPIC). All assessments and conclusions should be shared with the local communities in a transparent and timely manner. More information on engagement with local communities and other stakeholder groups can be found in Chapter 4.

3.4.3 What is the starting condition of the site?

The current state of the site, the soil type, and the location of the area can all influence the strategies and likelihood of successful restoration. Below is a very high-level overview of the types of site characteristics and situations in which mangrove restoration commonly is needed. Appendix B lists many resources that go into much more depth on the specific restoration techniques, but as you design your project these are key questions to ask and design solutions for.

What happened to the site?

Deforested – In this case the trees have been removed but the fundamental conditions for mangroves growth and survival may still be intact. It may therefore be likely that the mangrove will recover on its own. If it is not, it could be that the area is suffering total loss (sometimes seen after severe weather events) or that the area does not have access to a supply of propagules and therefore planting with native species may be appropriate.

Drained – In some cases barriers are in place that prevent water flow into the area, or the water has been removed or diverted (eg., freshwater is diverted. to water agricultural fields). Mangroves found on rich organic soils that have been cleared and drained (exposing the soil to the air) may increase the aerobic decomposition of organic matter and subsequent CO_2 release. The loss of organic matter and carbon to the atmosphere reduces the mass of the soil and results in subsidence.[61] These areas can be challenging to restore; if subsidence is severe, the elevation may need to be restored to re-establish the proper tidal ranges, and it may not be practical to do so. In this case, strategies for recovery may require a strong conservation component of remaining mangroves, thereby preventing further soil losses, subsidence, and CO_2 emissions.

Eroded – Mangrove areas susceptible to wind and waves can limit potential for restoration unless engineered structures are used, such as semipermeable structures that can reduce wave energy and trap sediment. In Demak, Indonesia, on the seaward edge of the mangrove, erosion and wave exposure were the most common reasons for mangrove degradation, impacts that were exacerbated by sea level rise and increases in storm frequency and intensity. However, the mangroves improved when built structures that enhance sediment trapping and wave energy reduction were used as an intervention method.[62]

What type of soil does the site have?

Organic – Sites with mangrove-peat or organic-rich soils store a lot of soil organic matter (up to 80% of soil content), usually built up by mangroves through the accumulation of dead roots and the deposition and burial of wood and leaves. The organic matter deposited in mangrove areas is maintained because the salinity of saltwater restricts microbial decomposition. As a result, more material is always being added but not decomposed, leading to soil build-up over long periods. If the soil is exposed to the air, the carbon in the soil may be oxidized and enter the atmosphere as CO_2, and therefore restoration of these sites may have added mitigation value above other types of sites.

Mineral – Mangroves growing on mineral sediments (e.g., sediments delivered in rivers or from marine environments), are present across a wide range of tidal regimes but are mostly found in mangroves with higher tidal ranges.[61] Mangroves on mineral soils occur in deltaic floodplains and estuaries and have been sites of mangrove conversion to agriculture and aquaculture. The dynamic sediment levels in these systems (and high sedimentation rates in some locations like active deltas) give rise to lower carbon storage per volume of soil than in peat-based mangroves, but soils can be very deep.[63] Environmental conditions in mineral soil areas can be suitable for rapid growth and high biomass accumulation, if hydroperiods are appropriate.[64]

Where does the restoration need to occur?

Landward – Landward restoration occurs on the back edge of the mangrove farthest away from main water sources like the ocean or river and right before the dominant vegetation switches to terrestrial species (see Figure 9). These sites will often experience loss of hydrological connectivity and reduced availability of propagules.

Seaward – Seaward restoration occurs along ocean and river fronts (see Figure 9). These sites are often experiencing wind, wave energy, or river currents that are too high for propagules to thrive, increase erosion, or add to issues related to increased inundation from sea level rise.

Figure 9

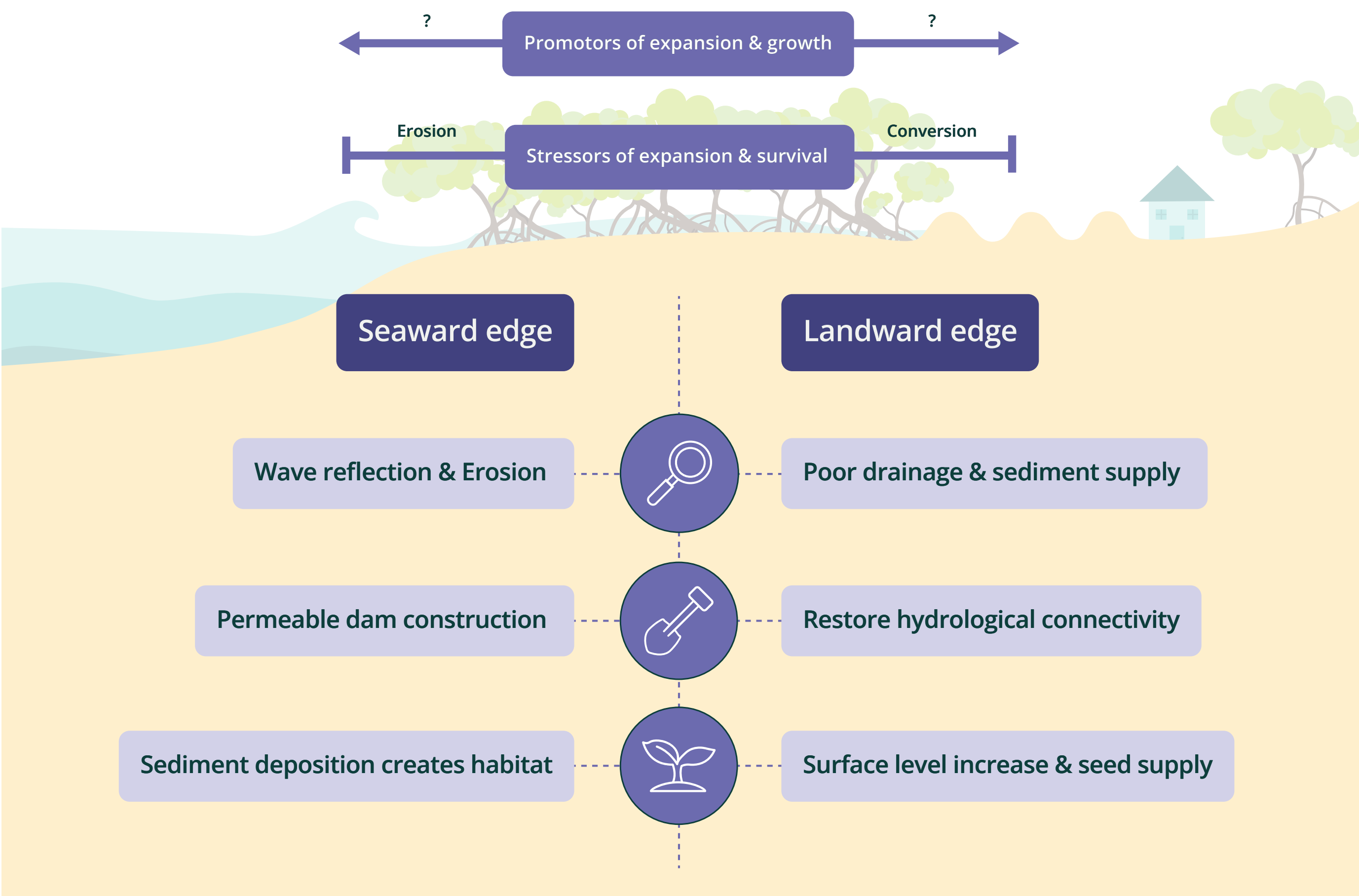

Figure 9. *Common biophysical challenges (top panel with pictures) at the seaward edge and landward edge of minerogenic mangroves and interventions (middle panel) that can lead to successful ecological mangrove restoration (bottom panel). Based on original figure by Celine van Bijsterveldt.*

3.4.4 What is the problem at your site?

Once you have an idea of what you are starting with and any challenges related to soil type and location, you can start to tackle any fundamental issues at the site. There are many reasons why mangrove restoration may need human intervention. Here we focus on the most common reasons that mangroves in the project area are not regenerating on their own. However, there may be additional complexities at your site that need to be considered.

Possible problem #1 – The hydrology is wrong

Hydrology relates to the brackish nature of the environment in which mangroves thrive and to the duration of time the mangroves spend flooded. Mangroves that have reduced tidal flow due to barriers (e.g., roads that run between the mangroves and the open ocean) may become too fresh due to an imbalance of water brought in via rivers. In these instances, mangroves can still survive but may be outcompeted by other vegetation. However, blocking tidal flow may have the opposite effect due to reduced tidal flushing leading to trapped pools of brackish water that evaporate, becoming hypersaline and causing dieback. Hypersalinity can also be an issue when the freshwater input is reduced, for example when river flow is diverted to water crops. Tools to measure salinity levels are easy to operate and relatively cheap.

The other hydrology issue is related to the frequency and duration of tidal inundation at the site. Mangrove species can only thrive in areas where inundation levels are appropriate. Most species cannot establish themselves if the inundation period is more than 50% of the time. Prolonged inundation can adversely affect growth rates and even result in the death of propagules and saplings. For instance, planting mangroves below mean sea level, such as on top of mudflats or seagrass meadows, may severely impact their growth. Generally, the time that mangroves spend inundated by the tides tends to decrease as the distance from the sea increases. However, local conditions at specific sites can deviate from this pattern due to emerging groundwater, levees, or channels. Various methods are available to estimate the range of inundation in restoration and reference sites. These methods differ in terms of cost and benefits, and the choice of method depends on the specific requirements of the project (Table 1 provides an overview of these methods).

CBEMR Training in Tanzania & Kenya, © Dom Wodehouse, Mangrove Action Project

Oyster farming in the mangroves, © Rockyatou, Wetlands International West Africa

Table 1. *Approaches to assessing hydrology and hydroperiod of prospective restoration sites.*

Method	Description	Benefits	Issues	Cost	Source
Consultation	Talking with local communities and looking at historic maps.	Cost effective and involves community engagement.	Has the potential for low accuracy and best at a scale.	Low	Lewis and Brown, 2014[59]
Elevation/ inundation	Comparison of elevation in restoration and reference sites.	Cost effective and can involve community engagement.	Can be low resolution and has potential for low accuracy. Small scale.	Low	Lewis and Brown, 2014[59]; Oh et al., 2017[65]; Teutli-Hernández et al., 2020[14]
Model – Lidar/ Digital Elevation Model (DEM)	Compare elevation of restoration sites to elevation of natural mangroves using Lidar DEM data using appropriate software (e.g., ARC GIS or similar). A catchment elevation map can help identify restoration opportunities.	Data available at large spatial scales at moderate to high resolution for site bathymetry/ elevation with minimal on-site effort required. Can be large scale.	Limited data availability for many priority restoration areas. Involves complex analysis requiring specialized programs and expertise. Expensive to acquire if not freely available.	High	Maher et al., 2013[66]
Mini buoys	Tilt sensors housed in a small float (mini buoy) to monitor inundation, tidal currents, and wave action at restoration site. Non-vented pressure sensors to measure water levels only.	Accurate integrated and cost-effective hydrological and hydrodynamic monitoring in shallow water.	Assessing local hydrology and hydrodynamics prior to restoration against local references. Small scale.	Low/Mid	Balke et al., 2021[67]

Potential solutions to this problem include:

- **Managing hydrological modifications** – If the target site is inundated too frequently (e.g., it is behind a levee, either natural or built) and the site is waterlogged, or inundated infrequently and is dry and hypersaline, mangroves will not naturally establish and planting attempts will typically fail.[61] Hydrological improvement via reintroduction of tidal flows (e.g., breaching of dike walls) can facilitate hydrological exchange and thus improve soil conditions. If the site is too frequently inundated, then increasing the level of soil surface to reduce inundation can be an option. Permeable structures (e.g., fences made of various permeable materials) have been used for this purpose.

Possible Problem #2 – The hydrodynamics are wrong

Mangrove trees are sensitive to waves and currents, with varying sensitivity at different life history stages. For example, seedling establishment is dependent on calm conditions with low wind and wave energy so that the seedlings can take root in the sediment; thus, the best restoration sites should have current, wave, and tidal dynamics suitable for mangrove establishment and survival.[68] Hydrodynamic monitoring and modeling can determine the local wave height, velocity, and inundation characteristics.[69] For example, restoration sites along seaward locations are particularly vulnerable to hydrodynamics, where uprooting of seedlings caused by strong waves during storms has been identified as a significant challenge to restoration. Understanding hydrodynamics can inform the seasonal (or interannual) 'window of opportunity' where environmental conditions are most suitable for recruiting mangrove seedlings.[68]

Potential solutions to this problem include:

- Reducing exposure to wind and waves – If mangroves are showing landward retreat due to wave attack on the shoreline, then restoration may be challenging. Ocean front shoreline restoration activities that change concave shore profiles into convex profiles can aid in restoration.[70] Shoreline modification can be done through sediment nourishment in sandy environments,[71] and by permeable structures in muddy environments.[62]

Mangrove forest, Caravelas, Brazil, © Conservation International

Possible problem #3 – No good source of propagules

For ecological mangrove restoration and natural recovery, mangrove re-establishment relies on the availability of propagules from nearby healthy mangrove areas. Dispersal of mangrove propagules requires tides and river flow to carry them from one location to another; however, those same tides and waves, if too strong, may also dislodge propagules.[58] After propagules are securely anchored, they may still be buried during storms (smothered by sediment) or excavated during erosion events.[72] Surveys of seedling and propagule availability in the targeted restoration area can help evaluate seedling survival rates compared to undisturbed mangrove reference sites. Modeling how local hydrodynamics affect seed transport and dispersal can further support understanding of propagule availability at different sites.[73]

Possible solutions to this problem include:

- **Enhancing propagule availability –** If the site is propagule limited, and a natural seed-source is available nearby, improving hydrological connectivity so propagules are delivered in high tides could be the solution. If seed availability is low, artificial seed dispersal or planting seedlings can also be a solution.[74] When doing this, selection of appropriate species for that environment can aid restoration, which can be based on local knowledge of species composition from natural reference sites.

Possible problem #4 – The sedimentation rates are wrong

Natural processes such as riverine input and tidal action typically regulate sedimentation rates. However, human activities – such as dam construction, deforestation, and coastal development – can disrupt these natural processes and lead to sedimentation imbalances. Sedimentation rates that are either too high or too low can have significant impacts on mangrove ecosystems, affecting their health, growth, and overall ecological functioning. When sedimentation rates are too high the mangroves may experience overload that buries and smothers the roots, leading to dieback.[75]

Common Greenshanks in flight in the Rufiji Delta, © Menno de Boer, Wetlands International

© IUCN / MFF

Excessive sediment may also modify water flow patterns in the intertidal zone, potentially causing shifts in the distribution of mangrove species and affecting the overall ecosystem structure. However, sedimentation rates that are too low are also problematic and may cause mangroves to suffer reduced nutrient input, which can limit the growth and productivity of mangroves. Mangroves also depend on sediment accumulation to keep pace with rising sea levels. If sedimentation rates are too low, mangroves may struggle to maintain their elevation relative to sea level, making them more vulnerable to drowning and ultimately leading to habitat loss. If a mangrove ecosystem has low sediment availability and is subsiding or is exposed to other conditions that are not positive for mangrove growth, then mangrove restoration may not be possible and other sites should be evaluated.

Possible solutions to this problem include:

- Restoring natural hydrological patterns to improve water flow and tidal exchange within the mangrove system. Removing or modifying artificial barriers like dams or dikes can facilitate the natural movement of sediment and water, promoting a more balanced ecosystem
- In severely impacted areas, manual removal of excess sediment may be necessary or, in cases of low sedimentation rates, sediment can be trapped or added.[62] However, negative ecological consequences of sediment additions could result, related to high turbidity that could threaten seagrass or other organisms found on the seafloor
- Select and plant native mangrove species that are more tolerant of high sedimentation rates. Some species may be better adapted to survive in such conditions and reintroducing them can improve the overall resilience of the ecosystem.

Community involvement in management and rehabilitation of mangrove resources at Maintirano, © WWF Madagascar

Figure 10

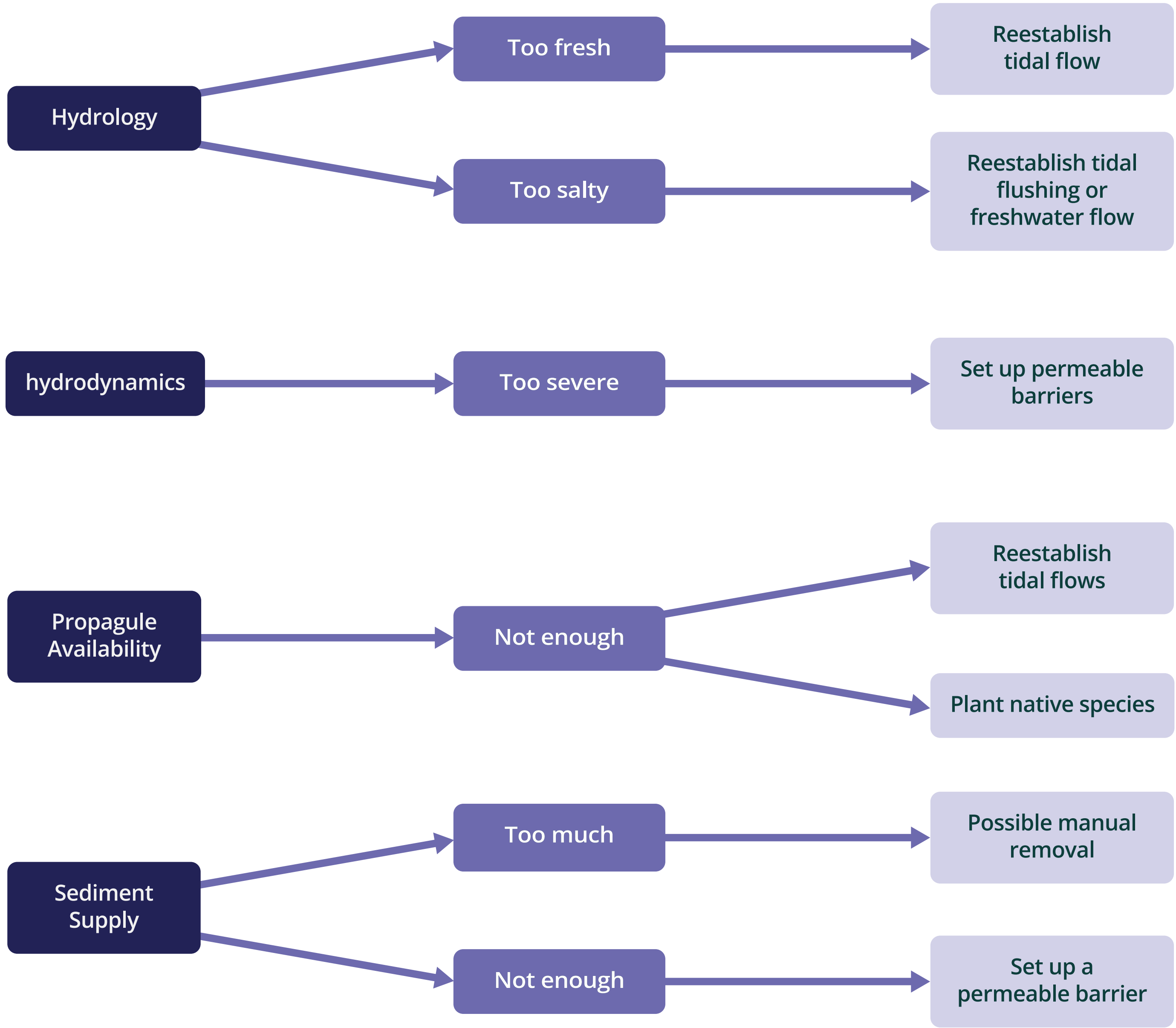

Figure 10 *Examples of biophysical problems which directly affect restoration success, and potential activities to address them and improve restoration outcomes. Note this is not exhaustive and project managers should refer to the most relevant restoration guidance for your region or circumstances (Appendix B).*

3.5

Resource issues

What will I need to spend money on?

The budget should include a contingency buffer to cover unforeseen cost overruns.

Any project design must be developed within the boundaries of available resources. Resources may include project personnel, materials, and machinery depending on the project scale, activities needed to meet goals, and location. Ensuring there are sufficient resources and funds to do high-quality restoration is critical. Starting a project and realizing that the needed assessments cannot be conducted, technical staff needs to be hired, or equipment needs to be purchased can increase risks and lead to poor outcomes. Resourcing is needed for but is not limited to:

- Baseline assessments
- Consultations and staff time
- Project implementation (e.g., physical restoration works)
- Monitoring.

Table 2 provides guidance on the items to consider when devising a project budget. The budget should include a contingency buffer to cover unforeseen cost overruns. Contingency is usually budgeted at 10% of total project costs and is a vital component of any project budget but is often forgotten or not included. For mangrove restoration projects which aim to develop carbon credits, a part of project costing may be the need for specialized equipment (e.g., GHG flux analyzers, surface elevation tables) to accurately assess carbon stocks and fluxes (if required by the carbon market method). Budgets may also need to include validation and verification costs, typically conducted by an independent third party (see Module 1: Blue carbon).

Mangrove restoration projects, including hydrological repair activities, can be more expensive, as some sites may require the hire of heavy machinery to restore initial hydrological conditions (e.g., knocking down or leveling pond walls), as well as elevation surveys to develop plans for modifying elevation of the site. The supporting information provided in Bayraktarov et al. (2016)[76] provides a useful database which breaks down reported costs for mangrove restoration projects and can be found within **the Dryad data repository**.

Table 2. *Examples of budget lines based on broad cost categories for mangrove restoration projects.*

Cost Category	Example
Project Personnel	Project manager
	Administration/finance
	Field team leader – project implementation
	Field team members – project implementation
	Community liaison personnel
	Analyst for Geographic information systems/remote sensing
	Community members e.g., to carry out restoration works (e.g., hydrological modification or replanting of propagules)
	Liaison officers (e.g., government liaison)
Disbursements	Heavy machinery
	Vehicles
	Field visits – Flights to bring experts to the site (and other transport expenses)
	Accommodation
	Meals, food and drinks, and miscellaneous expenses
	Office equipment Nursery for mangrove propagule cultivation For carbon projects additional costs may include but are not limited to: Field equipment (soil augers, measuring tapes, spades/shovels, sample bags)
	Laboratory costs for soil analysis Specialized carbon monitoring equipment (GHG flux analyzers, Surface Elevation Tables [SETs])
Consultants	Technical lead for carbon monitoring/assessment
	Technical lead for biodiversity monitoring/assessment
	Technical lead for community/livelihoods assessment
	Technical lead for hydrological studies Auditing and verification costs (if project involves carbon credits)

3.5.1 Different plans cost different amounts of money

Several factors will influence the overall cost of a mangrove restoration project, particularly where the restoration is occurring, labor costs, the starting condition of the site being restored, and whether engineering or earth-moving activities are required.[77] Here we are focusing on the fixed one-time costs (i.e., capital costs) involved in restoration as a way to compare different restoration approaches. Table 3 breaks down the significant costs into categories, including planting, maintenance, engineering, labor, and transport. Note that the low cost of monoculture planting, with minimal monitoring or maintenance costs, is likely to represent a false economy as such projects typically have a high rate of failure. Additional expenditures may include planning, permitting, mapping, stakeholder engagement, hiring and managing employees, monitoring, and government oversight.

Table 3. *Examples of reported costs in USD per hectare for four types of restoration projects. *The number in parentheses indicates number of studies included, adjusted for PPP. Note the small sample sizes. This study by Su et al., (2021)[78] highlights the difficulty in accessing reliable cost data for project budgets - e.g., EMR can cost under $500ha but this data is not publicly available. The note below provides additional definitions.*

Activity	Type of mangrove restoration project			
	EMR / hydrological repair(2)*	**Monoculture planting(3)***	**Mixed species planting(10)***	**Coastal protection / engineering(1)***
Average restoration size (ha)	322 ha	301 ha	31 ha	0.2 ha
Planting	-	864	14,691	-
Maintenance	-	232	7,903	-
Engineering	1,296	234	16,172	184,167
Labor	442	18	4,138	153,169
Transport	-	26	91	-
Total cost per ha (average)	**2,759**	980	32,050	337,336

***Note**

EMR: Ecological Mangrove Rehabilitation.
Plantation: Cost of nursery set up and transplanting, cost of seedlings.
Maintenance: Cost in maintenance phase, including monitoring and replanting.
Engineering: Cost in engineering preparation, includes construction and monitoring of breakwater, bamboo pole, pit digging, etc.
Labor: Labor payment (government employees, volunteer labor for planting and monitoring).
Transport: cost in transportation.
Sum of the costs: sum of the cost quoted above.
Total cost per ha: average of total costs reported in the reviewed articles.

In addition to fixed capital costs and general management costs, there are also opportunity costs to consider. Opportunity costs relate to the difference in financial gain or expenses that might be experienced because the area was restored (and thus only certain activities may be able to take place there) compared to what could have been done on the land (for example, building waterfront property). Tools like cost-benefit analysis and triple bottom line assessments can help you make decisions and allocate resources.

Figure 11

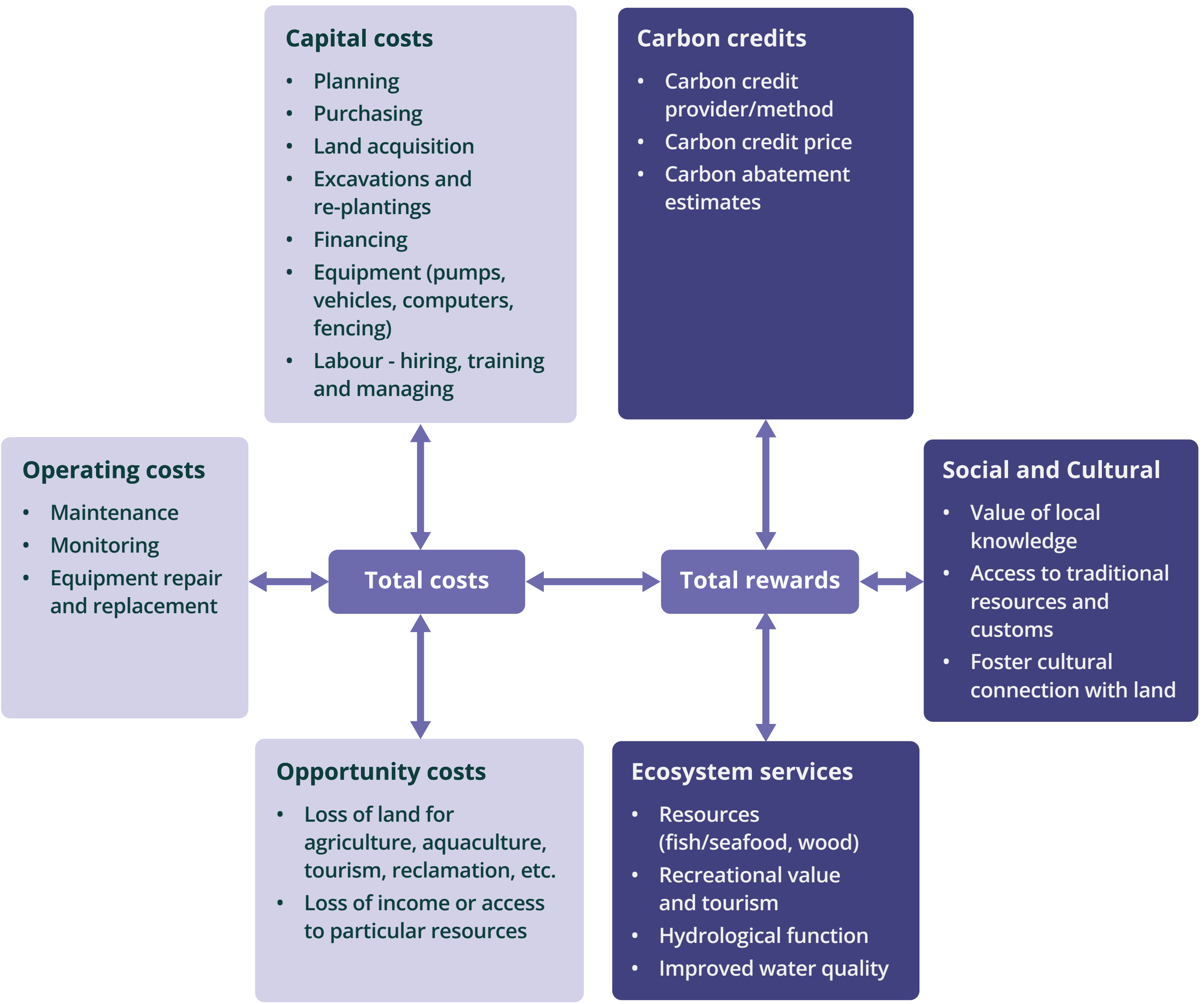

Figure 11. *Summary of costs and benefits to consider for restoration projects.*

3.6

Next steps

You now have a relatively complete idea of what it is you are trying to do at the restoration site and all partners and stakeholder should have a clear idea of:

- Roles and responsibilities of everyone involved
- What specific activities are needed
- How decisions will get made
- How information about the project will be socialized
- How much it will cost.

The next step will be to take all this information and begin implementation. This will require developing work plans, in-depth budgets, and initiating broader community engagement at various levels (Chapter 4).

Case study

Marismas Nacionales, Mexico

A holistic approach to mangrove restoration

Marismas Nacionales is a nature reserve and designated Ramsar Wetland of International Importance located on the north-western Pacific coast of Mexico. It contains about 15% of Mexico's mangroves. Governance of the reserve is primarily community-driven within Marismas, however community activities such as shrimp farming are also the main cause of mangrove degradation.

Communities are dependent on shrimp and oyster farming to sustain livelihoods, but excess nutrient loads, altered hydrology, and clearing for farm production has degraded the mangroves.

For example, the artificial opening of channels to support shrimp production has created hypersaline conditions which has contributed to mangrove dieback. Restoring water flows to the mangrove is therefore challenging, as there are economic and social costs associated with closing channels.

In addition, artisanal fishing techniques such as artificial fish fences (generally built using mangrove timber) deployed in creeks and channels have led to dramatic changes in hydrology and sediment flow,[50] negatively affecting mangroves. Pollution from upstream agricultural practices has facilitated the expansion of a woody vine (*Cissus* sp., "Buzzard Gut"), which also contributes to mangrove tree mortality.[51]

The complexity of permit requirements within protected areas for any restoration activities, such as improving hydrology, makes it challenging to implement restoration activities in Marismas Nacionales. Complexity in the permitting processes for restoration diminishes community support. Understanding trade-offs and the cultural and historical importance of current activities to the local communities and local tourism are key to identifying and prioritizing suitable sites for restoration which can support improvements in the permitting process.

Community acceptance of restoration is often based on evidence that restoration actions will lead to better outcomes. For example, for projects facilitating restoration through changes to hydrology, evidence of potential changes in average shrimp and oyster production is important (e.g., hydrological change may result in losses in yield in the short term, but improvements in the long term).

Therefore, strategies can be developed to compensate for any potential short-term losses in shrimp or oyster production of restoration. In addition, freshwater is extracted upstream to support local agriculture, and therefore any proposed changes to extraction would need to be accompanied by strategies to gain farmer support (e.g., through incentives, or capacity building to increase efficiency of use of extracted water).

Historical mangrove planting efforts occurred in areas with poor biophysical conditions but with good site access for local communities. Current restoration efforts are changing site selection processes in Marismas to account for biophysical feasibility, local community perception and willingness to partake in restoration.

In these sites, communities are actively involved in mangrove restoration and protection under payments for ecosystem services schemes. These collaborative mangrove restoration efforts include the participation of scientists, the local government, and local NGOs to find biophysically suitable sites to restore that are also socioeconomically feasible.[52]


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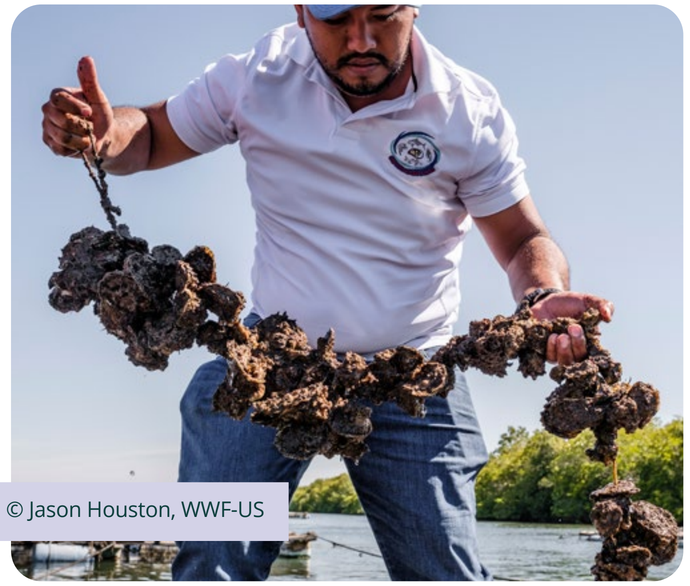
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Case study

Working with communities to enable mangrove regeneration, Myanmar

Collaborating for success

French NGO ACTED, supported by USAID, asked Mangrove Action Project (MAP) to run a Community-Based Ecological Mangrove Restoration (CBEMR) workshop in Rakhine State, Myanmar in January 2017. The participants were local NGO staff, government officers and local community conservation group leaders.

CBEMR was developed by MAP's former technical director, Roy 'Robin' Lewis, and focuses on mitigating mangrove stressors, increasing freshwater input if possible, and creating the conditions necessary to facilitate natural regeneration or to improve the health of existing mangroves.

MAP's training therefore takes participants through the basics of mangrove biology, ecology and the CBEMR process to better understand how a natural mangrove ecosystem works and what it should look like.

MAP's teaching also stresses the importance of working with local stakeholders to build their capacity and generate a strong sense of local ownership of any project.

ACTED had kept aside some seed funding to start small projects in the three communities that had received the training. Working with one of these communities, MAP held several community-wide discussions about their desire to restore areas near them. Working through the CBEMR process, the participants and community identified a suitable site, agreed that it was appropriate – with good hydrology, plenty of fresh water and seeds / propagules available – but in this case failed to naturally regenerate due to grazing and trampling (as seen on the next page).

Left image - Local water buffaloes grazing on the side of the river. Right image - Training participants and comunity members installing fencing around the proposed area to exclude grazing animals but to allow seeds and propagules to float through the gaps and onto the site.

MAP and community members discussed this mangrove stressor with the water buffalo owners, and having received their agreement, the community decided to use ACTED's funds to install fencing that excluded grazers (Above). The images below from Google Earth show the site before the training and currently in 2023 where a mix of planting for community engagement and natural regeneration has successfully brought the mangroves back (Below left and below right).

Google Earth image of the site, 2014

Google Earth image of the same site, 2023

The success of this restoration site demonstrates the importance of talking to communities about current land use and site history as an integral part of project planning, and the effectiveness of community capacity building, decision-making, and local leadership.

4

Engagement and implementation

© Lorenzo Mittiga, Ocean Image Bank

After identifying and agreeing on project objectives, and completing the feasibility and design phases, the project moves into the planning and implementation phase. It would be assumed that:

- The reasons for mangrove degradation have been identified
- The external factors influencing the restoration project have been identified (e.g., marine spatial planning, governance, industries, project partners and stakeholders etc.)
- The potential success of a restoration project is deemed high enough to proceed.

The most successful projects are often those where a lot of thought, consideration, and work has gone into planning and engagement before activities on the ground are undertaken. Chapter 4 guides the reader through the elements required for successful implementation.

Key messages

- A step-by-step implementation plan with actions broken down into explicit tasks provides the direction needed to achieve the project goals and objectives
- Implementation plans consist of several component parts, communicating what needs to be done, when each action should be carried out, and who is responsible for each task
- Tracking implementation progress is critical for projects to remain on track and on budget
- Stakeholder engagement at all levels is important throughout implementation and monitoring
- There are many potential sources of funding for mangrove restoration projects, and for large or high impact projects it may be possible to blend finance options.

FAQs

There's so much to be done... how do I make this more manageable?
Section 4.2

What do we do when things go wrong?
Section 4.2.1

How do I build adaptive management into my project implementation plans?
Section 4.2.2

What can I do to improve funding success?
Section 4.3.1

What kind of funding is best suited to my project?
Section 4.4

I want to make sure the community is fully involved... where do I start?
Section 4.5.1

Reading list

Capitalizing on the global financial interest in blue carbon https://journals.plos.org/climate/article?id=10.1371/journal.pclm.0000061	Journal article discussing the financial landscape for accessing funds for mangrove restoration projects.
The Ocean Finance handbook https://www3.weforum.org/docs/WEF_FOA_The_Ocean_Finance_Handbook_April_2020.pdf	Provides a detailed overview of sustainable financing, funding sources and investment models.
Common success factors for bankable nature-based solutions https://www.wwf.org.uk/sites/default/files/2022-08/Common-success-factors-for-bankable-NbS-report.pdf	Although primarily aimed at investor due diligence, this report can also act as guidance to successfully secure funding for NbS projects – including mangrove restoration.
Completing the Picture: Importance of Considering Participatory Mapping for REDD+ Measurement, Reporting and Verification (MRV) https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0166592	Study which compares the results of remote mapping – carried out as a preliminary site assessment - and participatory mapping. Highlights the importance of local knowledge to project planning and understanding land use.
Participatory planning of a community-based payments for ecosystem services initiative in Madagascar's mangroves https://www.sciencedirect.com/science/article/abs/pii/S0964569118307518?via%3Dihub	Describes participatory approaches to project design, mapping, zonation.
IUCN Gender Analysis Guide https://portals.iucn.org/union/sites/union/files/doc/iucn-gender-analysis-guidance-web.pdf	Technical tool to ensure environmental programs are gender responsive at community scales.
Gender analysis toolkit for coastal management practitioners http://www.mangrovesforthefuture.org/assets/Repository/Documents/Gender-Analysis-Toolkit-for-Coastal-Management-Practitioners.pdf	Methods to ensure gender balance in social data collection and analysis.

4.1

Implementation planning

How to implement effective mangrove restoration varies from region to region and with the unique conditions of each project site.

An introduction to biophysical restoration is given in Chapter 3. For more detail, there are many excellent manuals that provide detailed step-by-step instructions on biophysical mangrove restoration techniques, including several which are region-specific. A comprehensive list is provided in Appendix B, with links to each resource.

Other critical elements such as stakeholder inclusivity, project management, and financial resourcing generally fall outside the scope of biophysical restoration manuals and so are covered here.

Taking a transdisciplinary and holistic approach and developing project implementation plans which integrate biophysical techniques with stakeholder engagement provides a framework for effective project management.

The Mangrove Restoration Tracker Tool (Box 4) can also be used alongside project implementation plans to record and track project progress and inform biophysical intervention choices.

Community-Based Ecological Mangrove Restoration training, Lamu, Kenya, © Dom Wodehouse, Mangrove Action Project

Box 4: The Mangrove Restoration Tracker Tool

The Mangrove Restoration Tracker Tool (MRTT) is an application to record and track outcomes from mangrove restoration projects. Developed by the University of Cambridge and WWF on behalf of the Global Mangrove Alliance in collaboration with conservation practitioners and scientists from around the world, the MRTT has a flexible structure designed to capture field and desk-based data on mangrove restoration projects in a standardized format. The MRTT data entry portal and global restoration project database is hosted on the Global Mangrove Watch platform.

The tool is designed to aid the mangrove conservation community in quantifying how specific conservation actions lead to outcomes for biodiversity, mangrove resilience, management effectiveness, communities, and governance. In turn, this will help improve mangrove conservation implementation and build a community to support more effective mangrove restoration projects. The MRTT has three overarching sections to record information through the lifetime of a mangrove restoration project: (i) site background and pre-restoration baseline, (ii) the restoration interventions and project costs, and (iii) post-restoration monitoring that incorporates both socioeconomic and ecological factors. Each of the three sections has several subsections that make up the MRTT. The MRTT is designed to capture multiple monitoring events, allowing users to track their project throughout its lifetime.

Register & link to organization → Create a landscape → Add your site → Enter project data → Export data

The MRTT is able to record both historical and current restoration projects. If historical project data is being entered then all sections can be completed at once, with additional monitoring periods being added when required. For current or upcoming projects, the MRTT is designed for the user to enter data into section 1 (site background and pre-restoration baseline) before restoration interventions begin. Section 2 (restoration interventions) can then be populated as the intervention actions are completed. Section 3 (post-restoration monitoring) can then be completed multiple times at different time intervals to track project outcomes. The tool can also be viewed as a guide to the type of data that should be collected to plan and monitor mangrove restoration projects efficiently and effectively.

When the user has finished entering data, it can be exported to standard field reports (CSV/Excel) and can be used to create graphs or other reports. This can be used to help inform decision-makers and other stakeholders to plan, conduct and track key performance indicators for the success of mangrove restoration interventions. In addition, data entered into the MRTT will be visualized on the Global Mangrove Watch platform. This will allow future restoration projects to identify the restoration techniques used in areas with similar environmental and socio-economic settings and build them into their own restoration plans. At a larger scale, the tracking of mangrove restoration projects across the globe gives crucial insight into factors underlying project success, which can be used to improve future global restoration outcomes.

4.2

Planning for Success

There's so much to be done... how do I make this more manageable?

As the project approaches the point of progressing from planning to implementation, the project manager and stakeholders should by this stage have a clear and mutually agreed vision of project goals and objectives (Chapter 2), and the actions required to achieve them (Chapter 3). The next stage is to translate this shared vision into a step-by-step implementation plan, explicitly linking actions to create a pathway to achieving each project objective. Developing an implementation plan involves defining the actions, roles, responsibilities, accountability, and communication norms that will not only ensure that projects are done on time and to a high quality, but that they result in the desired social and ecological goals. Identifying the correct actions will require consultation with all stakeholders involved in the project. Involving communities in the identification and execution of restoration actions is important in achieving desired outcomes.[79, 80] The process of engaging stakeholders and collaboratively defining causal pathways that describe how restoration actions can lead to desired social and ecological outcomes is outlined in Figure 12a. An example causal pathway for a mangrove restoration crediting project is provided in Figure 12b.


CBEMR Training in the Rufiji Delta, Tanzania, © Dom Wodehouse, Mangrove Action Project


Fishing boats in the mangroves of Ambilobe, Madagascar, © WWF

Figure 12

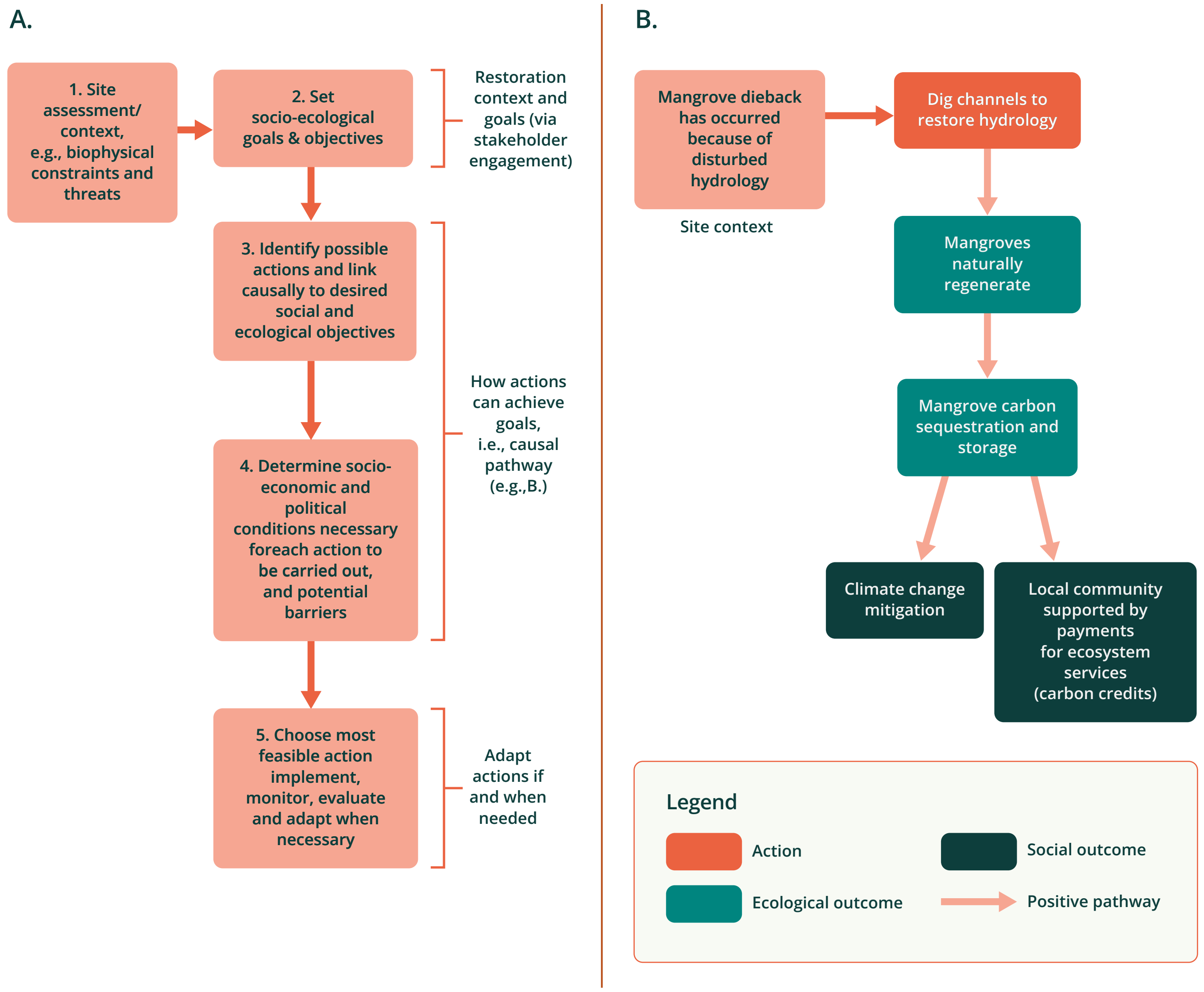

Figure 12. Establishing viable causal pathways for how restoration actions can achieve social and ecological goals and objectives. A) Process for identifying actions and defining causal pathways and B) Example causal pathway for mangrove blue carbon restoration projects (Figure by Christina Buelow, based on Qiu et al., 2018).

The key to successful implementation planning is in translating a complex project into a series of simple tasks. The implementation plan is where you create and communicate that simplicity, breaking each action into component tasks, identifying the order in which the tasks take place, which tasks are reliant on others to be completed before they can be started, and the financial and social support required. The implementation plan can then be organized into distinct phases based around the time taken to achieve set objectives, and the resources required to get there (Iterative planning, Section 4.2.2). Inevitably, there will be challenges requiring the addition of extra tasks to overcome, or not all actions may produce the desired outcome. This uncertainty can be addressed through the use of adaptive management techniques (Section 4.2.2).

To develop the implementation plan, the following questions need to be answered:

What are we doing?

- Identify actions that will lead to social and ecological goals and objectives of the restoration project
- Identify key outputs and deliverables linked to each action related to the restoration project's goals
- Identify potential barriers (if any) to implementing restoration actions (these can be social, economic, technical, logistical, political) within the timeline set for achieving goals and objectives of the project. Include solutions for overcoming barriers as additional actions.

How are we going to do it?

- Identify resources (financial, human) needed for restoration implementation, monitoring, and evaluation
- Ensure resources are sufficient for the entire length of the restoration project, including monitoring and evaluation of long-term goals.

Local people are a critical source of ecological information (C) Ana Grillo

How will we know it's going well?

- Establish how indicators that measure progress towards restoration goals and objectives will be monitored and reported
- Ensure indicator monitoring can inform adaptation of the work plan if necessary
- Define how learnings from monitoring and evaluation of the restoration project will be shared with stakeholders and other restoration practitioners.

What are we doing? Is covered effectively by Chapters 2 and 3.

How are we going to do it? This chapter addresses securing the required social support (Section 4.5) and financial resources (Section 4.3).

How will we know it's going well? Selecting appropriate monitoring indicators and applying adaptive management techniques are discussed in Chapter 5.

Appendix E also provides a worked example of actions, resource needs, and monitoring and evaluation actions aligned to goals and objectives.

The purpose of the implementation plan is to provide a model of the project that clearly outlines what will take place, when, and by whom within the time, cost, and scope of the intervention. Once the questions listed above have been answered, the next step is to organize that information into easy-to-understand formats which allow the project manager and team members to track project progress along all implementation pathways.

Implementation plans may consist of the following components:

- **Schedule** – A series of actions and steps that shows the order of events that need to occur, what activities can be occurring concurrently, and how long each activity is expected to take (Gantt Charts are a classic example)
- **Risk Plan** – Any points where there could be issues that slow down the entire project are identified, and steps are outlined to overcome those risks. Doing this before risks manifest allows the project team to respond to issues as quickly and efficiently as possible
- **Monitoring, Evaluation, Accountability, and Learning (MEAL) Plan** – Decide on the indicators of success that need to be tracked, who will do that, the methods that will be used, and the frequency that the indicators are assessed
- **Communication and Stakeholder Engagement Plan** – Decide on when stakeholders, not engaged in the day-to-day management of the project, need to be communicated with and decide on the best ways to do that. Specifically, plan any communication around milestones or reporting so that the stakeholders are among the first to know about progress and challenges
- **Responsible, Accountable, Consulted, Informed (RACI) Chart** – This chart provides clear guidance on roles and responsibilities amongst the team, describing who makes decisions, and how to keep everyone informed
- **Resource and Budget Plan** – This plan describes what expertise, materials, equipment, etc. are needed at what point in the project lifetime, how resources will be managed, and the budget for the resources. In some cases, funding may be coming from multiple sources so it can be useful to decide early what expenses are charged to which funding source and if there are any restrictions on how funds can be spent.

4.2.1 Iterative planning

Iterative planning is an agile and adaptive approach that establishes the project plan in stages rather than trying to plan for the entire project all at once. In relation to the adaptive management principle, this provides the opportunity for "decision gates" to be built in after (and sometimes within) each of the stages so that an analysis can be done that explores what needs to happen during the next stage of the project. Data and information from the monitoring and accountability systems should be fed into the decision gate process, providing justification for taking the project forward as is or making changes based upon the data, information, and tolerances of the project team.

What do we do when things go wrong?

Emergency Decision gates

Part of adapting to a changing environment might mean that it becomes clear that the project is no longer relevant or able to operate within the current context. This is where Emergency Decision gates come into play. While this scenario is not desired or ideal, the reality is that it may happen and it may be best for stakeholders to close the project down rather than continue to the end.

For example, a mangrove restoration project that is based on reducing mangrove logging by providing an alternative livelihood that can't scale or be easily accessed may leave local communities without a viable livelihood alternative, despite one having been planned. In this case the emergency decision gate might be "can community members have a comparable (or better) livelihood with restoration". If the answer is "no" then the project may need to be shut down until another, more feasible option can be found. The decision to close a project is likely going to be a larger stakeholder group decision but the project manager will be involved in providing information and their opinion. The project manager will also likely be responsible for communicating the decisions to stakeholders.

Issues and Change

The impacts of "issues" (meaning factors internal or external to the project that affect the project) lead to change and may offer insights into gaps in the project. Issues most certainly require that the response to the issue adapts to the context it happens in. For example, restoration projects that have foreign funding will be influenced by changes in currency exchange rates. While this might not be a problem in some situations it might result in the need to rearrange budget allocations or the timing of project activities. For some issues the project team and manager can consider the root cause of the issue to make sure it doesn't take place again, or that there are plans to accommodate it (e.g., contingency funds, or other funding sources) – incorporating that understanding into the lessons learned.

Lessons Learned

One of the best ways to use lessons learned is through adaptive management strategies, decision gates, or other formal processes where set times throughout the project are scheduled to conduct a reflective learning process with project team members and stakeholders. These sessions should be well-documented so that the learning can be incorporated into any iterative planning for the project and/or future project designs.

4.2.2 Adaptive Management

How do I build adaptive management into my project implementation plans?

Adaptive Project Management

Adaptive project management is the umbrella under which a variety of different tools fall that allows adjustments in project implementation. In adaptive management:

- The project is divided into short, fixed time stages
- Cost of resources is fixed
- The scope of activities is variable. The project focuses on the highest priority requirements, with the expectation that the scope will evolve as the project progresses.

There is a decision gate at the end of each stage to re-prioritize existing requirements, to consider any new ones as the project moves forward, and to plan the next stage. It's a form of rolling-wave planning. The aim is to deliver the most important requirements within the budgeted cost and time, but maybe not all the requirements. For this process to work, it must be highly collaborative. It's essential that project stakeholders are closely involved.

With this approach, donors and stakeholders will be more confident approving the project because costs and schedules are defined up front and the overall risk is lower. Hopefully, donors and stakeholders will accept that they can't have everything, but what they do get will meet the main objectives of the project. So ultimately, the agile approach to project management can result in a more successful outcome.

The essential element is to be able to prioritize the project's requirements into four categories of importance:

- Must have – these requirements are guaranteed to be delivered
- Should have
- Could have
- Won't have at this time.

Adaptive management focuses on small incremental changes. The challenge can be that the bigger picture can become lost, creating uncertainty amongst stakeholders. Building consensus takes time and challenges many norms and expectations. Resource costs can be higher – for example, co-locating teams or investing in infrastructure for them to work together remotely.

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4.3
Funding for implementation

Understanding funding needs at each stage of the project

Typically, projects have three main funding phases: the initial feasibility and design phase, the planning and implementation phase, and the monitoring and long-term management phase, which is expected to continue for years to decades. Each phase requires funding, but the level, duration, and source often varies.

Costs associated with the initial feasibility and design phase may include but are not limited to: site selection assessments, proposal development, baseline analysis, legal assessments of tenure and carbon rights, establishing models and projections, stakeholder identification and consultation.[76]

Costs associated with the planning and implementation phase may include but are not limited to: implementation plan development, implementation of restoration activities, stakeholder communication and socialization, developing monitoring indicators and a methodology to measure them, data collection and dissemination, and staffing.[83] This is often the most expensive phase.

Costs associated with long-term project monitoring and management may include but are not limited to: permanent staffing (e.g., for protection, monitoring, and maintenance), repeated communication and social engagement efforts, and ongoing data collection.

These three phases stem in part from the need for feasibility data and risk assessments to be provided to funders in order to secure the larger amounts of funding required for implementation. An initial funding application might cover only the estimated amount required to create a clear evidence base for further investment. This is particularly true of mangrove restoration projects which aim to produce carbon credits as part of their funding structure.[84] Phase one may be funded by a philanthropic grant, resulting in feasibility data which enables corporate investment into phase two, while phase three is subsidized with income from credits (see Module 1: Blue carbon).

4.3.1 Key considerations for securing project finance

What can I do to improve funding success?

Securing funding for mangrove restoration projects can be competitive, demanding, and slow. There are a number of factors you can consider and address in advance in order to facilitate successful funding:

Data requirements and technical assessments

Common practice requires a mangrove restoration feasibility report to be completed before investment is made. Few investors have the in-house capacity to interpret technical information on project design or implementation, and initial feasibility reports may run into hundreds of pages. The burden of both providing and communicating evidence may therefore be placed on the project.

Collecting social, legal, technical, and cost data, (in some cases including carbon baseline projections), and writing a full-length report incurs variable and sometimes high costs. The time and resources associated with data collection create a situation where initial funding is needed to produce the feasibility reports required to secure higher levels of financing. Capital invested in producing feasibility reports is considered high risk, so commercial funding for feasibility reports may come with conditions attached. For early-stage finance, philanthropy, grant funding, or corporate environmental sustainability goals (ESG) sources may provide better options than private finance.

Business model and plan

Whether funded purely for social/environmental returns, or for profit, each project needs to have a clear business model and plan. A private investor wants to know when they will see a return on their investment, whether that is financial or in terms of impact. A donor wants to know what will happen when their funding support ends (for example, after a 3-5 year period), especially for restoration projects with long operational lifespans tied to socioeconomic change, or multi-year site monitoring and maintenance.

Project development deals

In some instances, projects may have needs in addition to funding. Expertise, implementation capacity, political engagement or other support may be required. Project development companies may enter a shared ownership partnership with the project manager and take on the tasks of project funding, design, implementation, and shared management. However, this may also come at a cost.

For example, in the case of mangrove restoration projects designed for carbon markets, a project developer might expect ownership of all the project's credits over the project lifetime, and pays a percentage of any profit to the initial project proponent. The percentage share varies, and there are many reports of exploitative terms being offered. In some cases, deals/arrangements with project developers can provide an equitable alternative, facilitating projects that may otherwise struggle to move forward.

De-risking investment

The project manager should identify risks associated with project implementation, communicate them to prospective funders, and describe how risks have been mitigated. For example, confirming that land tenure issues are resolved, provisions for alternative livelihoods have been made in consultation with community groups, or that, for carbon projects, a government MOU securing the right to sell credits has been signed. This approach enables financiers to complete their risk assessments and facilitates successful investment.

Key considerations for funders, investors, or credit buyers include financial and reputational risks.

In the case of projects aiming to produce carbon credits, financial risks may include:

- Project activities failing and no credits being issued
- Inaccurate modeling resulting in fewer credits being issued
- Legal or political circumstances affecting project implementation
- Legal or political circumstances affecting the issuance and sale of credits.

Reputational risks may include:

- The purchase or retirement of credits with questionable scientific or social integrity
- Association with project activities having negative consequences for local stakeholders
- Poorly designed projects causing environmental harm
- Projects operating outside of legal frameworks.

Blending commercial finance with successful grant funding reduces the investment required from a commercial partner and, therefore, the amount of capital at risk. Securing multiple financial partners, each having completed their own due diligence and risk assessment, reduces perceived risk to individual partners.

© African Wetlands

© Conservation International

4.3.2 Money isn't always the problem

There is more money now for nature conservation and restoration than there has ever been. However, often there are problems in accessing funding. Developing projects and programs that are very large, have a high enough return, and in areas with clear tenure and political will is a daunting task that takes significant expertise, start-up funding, and time.

This has resulted in a mismatch between the needs and expectations of funders, project managers, and stakeholders,[85] with project implementation activities often limited by the amount of financial resources available, the time period resources are available for (and for what phases of the project), and donor-prescribed restrictions related to how any funding can be spent. Funds that are linked to results that must be obtained within a short time period often drive perverse incentives to plant monocultures in inappropriate areas because those strategies are the cheapest and easiest to implement within the opportunity available. **Without funds for long-term monitoring or maintenance, failed activities often go unreported, and the donor may mistakenly believe their funding was effective.**

In addition, funding priorities are still biased against support for or the development of policy, capacity building, and science, yet these are critical to successful restoration outcomes. Delivering funding to projects can involve several different organizational layers between project implementers and funding sources, and effective communication within and between levels may be limited. This has often resulted in funders basing their decision-making on misinformed or poorly designed criteria or funding being disproportionately directed to areas with the best communication strategy instead of the highest need or impact.

By the mangroves, © Tony Ochieng

An example of misalignment might involve a situation where the goal is to halt mangrove loss and enhance mangrove cover but the expectations around implementation and outcomes do not align (Figure 13).

Figure 13

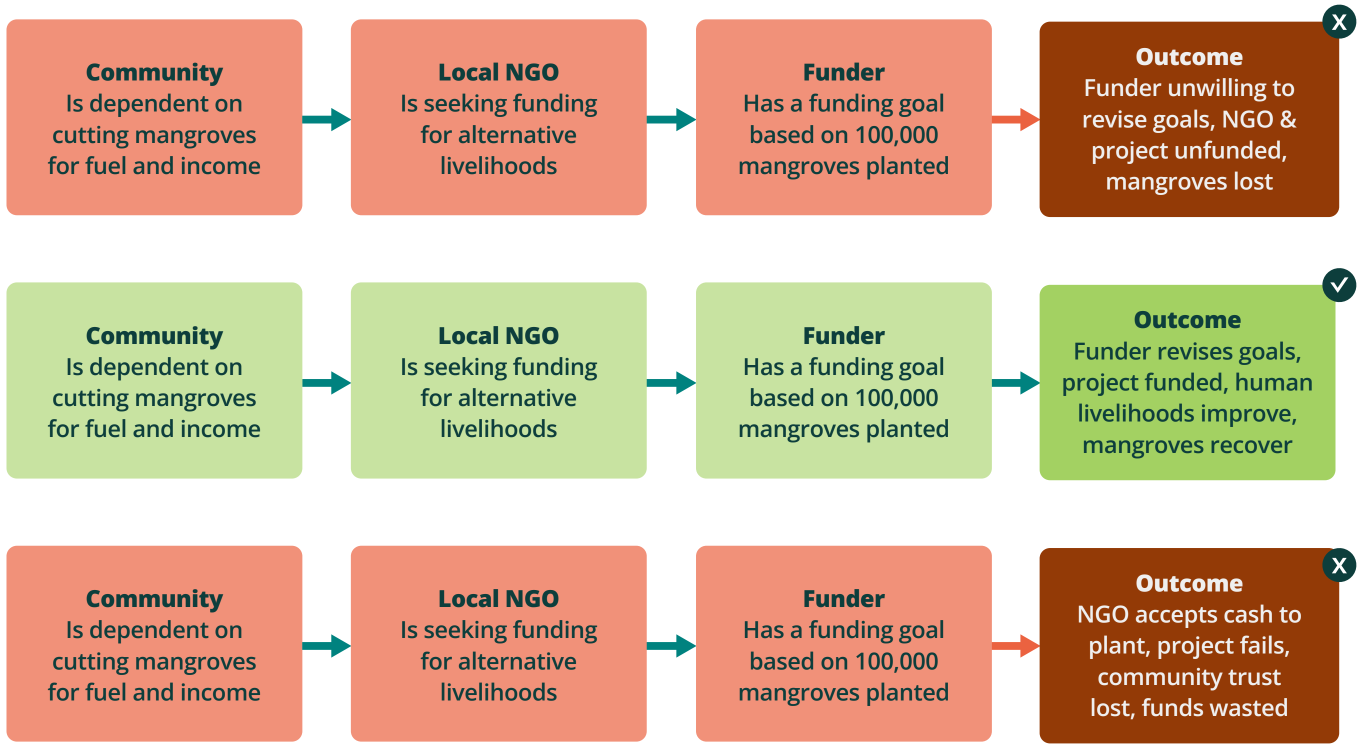

Figure 13. *Observed positive and negative outcomes from mismatches between funder goals and project funding needs. Funding goals based on number of trees planted are rarely applicable to ecosystem restoration goals.*

Mangrove restoration projects therefore must consider how to align the requirements of communities with those of donors and investors. Many donors do still insist on popular but flawed measures of impact reporting, such as the number of trees planted as a result of funds granted (described above). Educating potential donors and encouraging them to update their metrics for measuring or communicating project success is difficult as it carries the risk of missing the funding opportunity. Short executive summary style resources such as "To plant or not to plant" can be useful to support funding applications which are mismatched with donor expectations.

The UN Sustainable Development Goals are widely recognized and can be used to communicate the potentially wide range of impacts of mangrove restoration projects and support the design of improved impact reporting metrics (Figure 14).

Figure 14

Figure 14. *Out of the 17 Sustainable Development Goals, mangrove restoration projects are frequently aligned to 6 (line 1) and less often to a further 6 (line 2). Identifying how your project outcomes align with SDGs can enable easier communication of project impacts within a recognised framework.*

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4.4

What funding sources are available?

Figuring out what's a good match for your project

There are several funding sources and models available to finance mangrove restoration projects, ranging from grants to market-based instruments. Grants can come from government programs at national or international levels, philanthropic support, and from industry, for example from private corporate sustainability initiatives, including Corporate Social Responsibility (CSR) and Environmental, Social, and Governance (ESG) programs.

Concessional finance, such as international development loans, seed funding, and technical assistance facilitation can be the first steps towards entering market conditions and can provide opportunities for private sector investments (e.g., via blended finance, carbon or biodiversity credit markets, or sustainable commodities lined trading).

If restoration projects are in publicly-run marine protected areas (MPAs) or are a part of other effective area-based conservation measures (OECMs), public budget allocations can be of equal importance, although they are often limited as to how they can be used, and levels of resourcing may be low. Before selecting a funding source to pursue, two questions need to be answered:

- What can my project offer/achieve and who would find that valuable?
- What are the financing options available to the project?

Figure 15 outlines a suite of funding mechanisms and investor needs, ranging from no financial return needed (right hand side) to the market type financial model (on the left) which requires low risk and high financial returns.

Figure 15

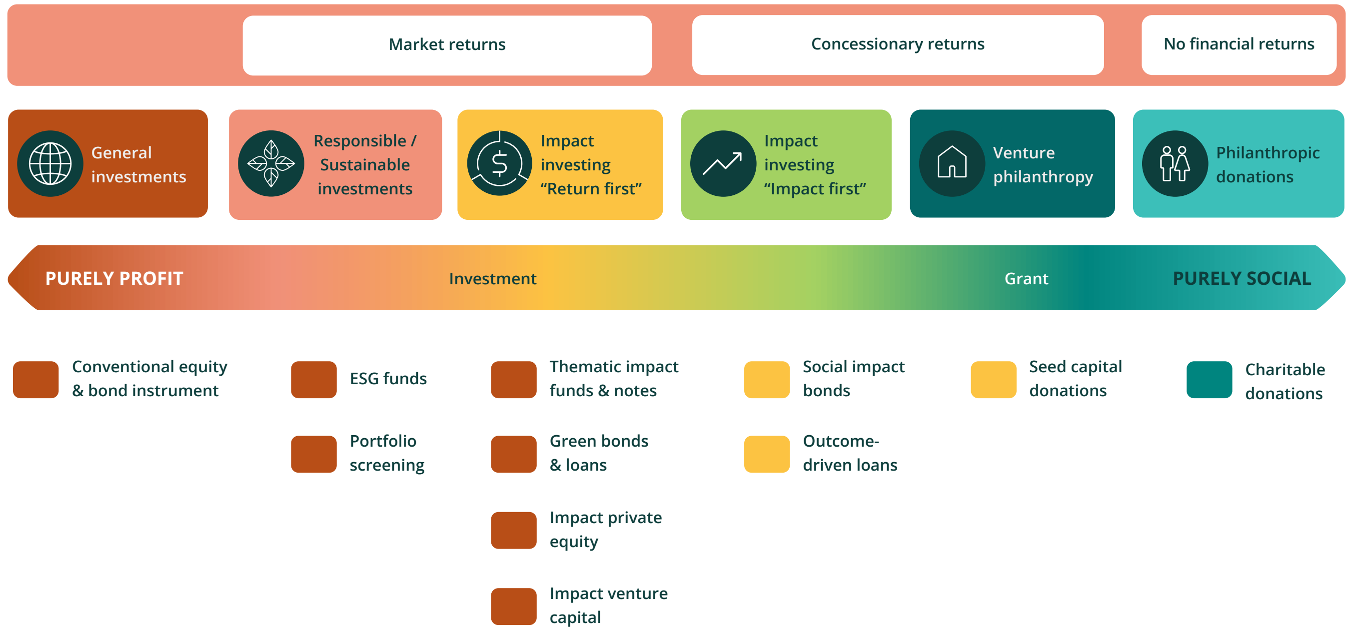

Figure 15. *Types of funding for Nature-based Solution projects. Sourced from: WWF: Bankable Nature Solutions*[86]


© IUCN / MFF


Gazi Bay, © Julia Jung

What kind of funding is best suited to my project?

Potential funding sources for mangroverestoration include:

4.4.1 Private finance/investments in Nature-based Solutions

What this is? – IUCN Definition of Nature-based Solutions (NbS). Investing in natural capital with the goal of halting destruction and restoring what has been lost, with an expectation of a return beyond environmental and social impacts. The return may be purely financial, in which case investors can choose from a wide range of instruments to invest in nature. They include direct purchases of real assets such as forests or agricultural land, private and listed equity in companies supporting natural capital, and mitigation offsets for water, biodiversity, and greenhouse gas emissions. Direct investments by companies may include engaging in carbon or biodiversity crediting markets, green-gray infrastructure investments, or investments in activities within a private company's own supply chain. Returns may also be non-financial, and include investment in resilience, supporting the development of the blue economy, or restoration of mangroves and other wetlands as public goods.

Institutions such as the Blue Natural Capital Financing Facility (BNCFF), the Blue Carbon Accelerator Fund (BCAF), and other incubators and accelerator programs are vital for developing a business case for mangrove restoration and other NbS projects. Information for project developers wishing to explore private finance options can be found at:

- Blue Natural Capital Financing Facility
- Blue Carbon Accelerator Fund
- Blue Action Fund
- Althelia Sustainable Ocean Fund

Pros – In 2019, the private sector invested over USD 20 billion into nature-based activities and that number is expected to increase dramatically over the next decade. Finance flows to NbS were USD 154 billion per year in 2022, less than half of the USD 384 billion per year investment in NbS needed by 2025, with only around 17% from the private sector.[87] Private sector investment is expected to increase dramatically, and mangrove restoration is starting to prove to be an area of interest and demand.

Cons – Many for-profit investors are looking to invest in large scale projects which can be difficult to develop if the focus of the investor is only on mangroves, rather than mangroves within a broader land and seascape. Other investors may be hesitant to invest if they are not confident that the impact of their investment can be adequately assessed (e.g., there is a lack of data). Additionally, large investments at a landscape scale require working with local and national governments which can be complicated.

4.4.2 Blue bonds

What this is? – A blue bond is a relatively new form of a sustainability bond, which is a debt instrument (e.g., governments can take out a loan) that is issued to support investments in a healthy ocean and blue economies. Blue bonds earn income from investing in blue economies and sustainability projects and can be used to finance mangrove restoration, yielding economic benefits that range from climate adaptation, carbon sequestration, fish stocks replenishment, and tourism.

Pros – Bonds are one way for countries, cities, and governments worldwide to raise the necessary funding for investments in nature- and climate-positive activities. They are a popular way to source the significant amounts of capital needed for investments that address sustainable development priorities.

Cons – There are often large transaction costs associated with blue bonds. Bond issuers are required to track, monitor, and report how the proceeds are used, and recipients must develop a complex set of performance indicators to determine whether the results achieved are sufficient to trigger repayments to investors. This increases the cost for countries, who need to source technical expertise, and often means obtaining co-financing/credit guarantees. Borrowing is never without some risk and issuers must have the cash flow to repay the loan and interest.

4.4.3 Insurance

What this is? – The insurance sector has been engaging in ecosystem restoration in a variety of ways, including:

- Offering protection for the ecosystem itself via traditional-style insurance policies covering against drought, storm, and flood damage. The insurance sector can deliver parametric or index-based insurance solutions to optimize budgets allocated to environmental planning and conservation. Index-based solutions provide prompt payouts after an event, which facilitates fast action to support restoration
- Providing incentives to traditional insurance holders in coastal locations to sustainably develop and restore nature as a means of lowering their own climate risk, for example via restoration of mangroves as protection from flooding. This reduces the likelihood of loss and damage to the insured buildings or infrastructure, therefore reducing the likelihood of large insurance payouts.

Pros – Insuring the restoration site helps to reduce risk and make investment more attractive for investors. Parametric insurance can support quick payouts and thus restoration efforts – for example with reef insurance in Belize.

Cons – Taking out an insurance plan adds to the costs of a restoration project (though ideally this is less than what it would cost to recover a system without it) and in most cases insurance will only cover threats related to "acts of God" such as flood, fire, and drought, but not other threats like political change, social unrest, or the reversion to destructive practices.

4.4.4 Carbon markets

What this is? – There are two main types of carbon market: compliance and voluntary. Further information is provided in Module 1: Blue carbon.

Compliance markets are implemented at regional, national, or sometimes state level and enforced with corresponding legislation. They commonly take the form of cap and trade or emissions trading schemes, which may be paired with emissions reductions targets. The European Union, Australia, South Korea, China, California and several other countries have their own established or emerging emissions trading schemes. Some nations such as Australia, have clear processes in place for generating mangrove carbon credits through voluntary activities and trading them on the compliance market. Credits produced on the compliance market may sometimes be traded and used for voluntary reductions, but credits produced on the voluntary carbon market are rarely accepted for use to meet compliance requirements.

The Voluntary Carbon Market (VCM) is a collection of independent private organizations who quantify and sell climate mitigation services to purchasers seeking to offset their carbon footprints. This is relevant to mangrove restoration and/or conservation projects as the GHG benefits of successful project implementation may be measured, verified, and issued as tradable certificates called carbon credits. Each carbon credit represents one metric tonne of CO_2e in avoided emissions or removals from the atmosphere. Rules on how credits can be produced and traded differ between nations, and the policy landscape is evolving rapidly.

Preparation of mangrove restoration interventions in Cacheu Mangrove Natural Park, Guinea Bissau © Menno de Boer, Wetlands International

Pros – Mangrove conservation or restoration projects designed to produce carbon credits are a multi-decadal commitment and can generate income over a long time period, with increased positive socioeconomic outcomes. In landscapes where local stakeholders are reliant on mangrove resources for income or subsistence needs, project developers will often need to integrate alternative livelihoods, local capacity building and other community needs to enable the project to go ahead or to avoid the risk of future damage to the site. As a result, projects with an integrated approach may benefit from strong community support and protection and meet a wider set of goals.

Cons – The process of generating and retailing carbon credits is long, complicated, and expensive.[85] Project design must adhere to strict scientific methodologies which may require specialist support to complete, driving project costs up further. Sites must be maintained and monitored over the long term for credits to be issued. Credit prices are subject to fluctuation so predicting long-term financial return can be difficult, and income from credit sales alone may not be enough to support implementation and maintenance. Different countries may not have policy or clear legal procedures in place to support carbon trading on the VCM or may count mangrove carbon in national GHG inventories and require corresponding adjustments to be made to national totals before credits can be sold internationally (see Section 6.3.2). Some nations may not permit the export of credits but instead may have growing domestic voluntary markets.

Gazi Mangroves, © Tony Ochieng

Sukuma herdsmen in the Rufiji Delta, © Priscilla Kagwa, Wetlands International

4.4.5 Philanthropists and foundations

What this is? – Grant-making organizations seeking to invest funds into projects and activities which align with their own targets and values. Philanthropists and foundations tend to measure their returns on investment in terms of impact or progress towards their own or shared goals.

Pros – A financial return on investment is rarely required, which allows philanthropists and/or foundations to fund proof of concept or research projects which may be seen as unviable for organizations focused on profits. Philanthropy may prioritize long term project development, incorporating research, capacity building, and humanitarian goals.

Cons – Variability. Each individual philanthropist or foundation will have their own set of criteria for fund allocation, which may not always be feasible for projects to meet. Many grants will be short term and desired outcomes may be based around out-of-date metrics (e.g., planting certain numbers of trees). Competition for funding can be fierce and in some cases project managers may be subject to constantly changing impact goals depending on conservation trends or individual whims.

4.4.6 Public funding

What this is? – Governments and overseas development agencies (ODAs) release funding that may be used to address a variety of conservation needs, such as research, fish and wildlife surveys, species restoration, habitat management, climate mitigation and adaptation, and monitoring. Some governments administer payments for ecosystem services (PES) schemes which provide results-based funding for ecosystem conservation, restoration, or climate mitigation outcomes.

Pros – Funding amounts can be large and are often distributed over longer periods of time (5+ years).

Cons – The funding is usually highly restricted in how it can be used, comes with high levels of reporting requirements, and the application process may be competitive and slow.

4.5 Engaging with people…

Ensuring all stakeholders are included

Where relevant, adequate participation by stakeholders in mangrove restoration can be one of the most successful approaches to ensure long-term sustainable outcomes.[13,48,88,89,90] If properly executed, participation can offer involvement and empowerment in resolving environmental, social, and economic issues.[89,91]

Participatory approaches promote a sense of ownership (securing user rights) and transparency in mangrove restoration management (through shared governance) while valuing and strengthening existing traditional knowledge and local people's ability to identify and enact solutions.[90,92] However, engagement strategies will be different for different groups.

4.5.1 …at the community level

Involving local communities (including village leaders, elders, local "champions" and women) or other local stakeholders in mangrove restoration and co-management is considered "best practice" and involves their active engagement, representation, and leadership in planning, goal setting, decision-making, implementation, and monitoring and evaluation.[93]

The process of participatory community planning should be iterative so that unforeseen issues, the interests of stakeholders absent from initial meetings, or new information can be incorporated, and adjustments made. The time invested in establishing community interest, support, and participation will vary across geographical and socioeconomic contexts, and project planning timelines may need to have some initial flexibility. Community engagement is critical when addressing sensitive issues,[60] such as:

- Perceptions and understanding of the comparative benefits of intact mangrove ecosystems compared to conversion of mangroves to other uses
- Legal recognition of the rights to access and use mangrove resources
- Land use governance.

You may be able to work with pre-established community-level institutions such as a mangrove conservation committee, a village environmental conservation committee, or a village development committee as forums for sharing information and getting feedback on the project.

I want to make sure the community is fully involved... Where do I start?

Locally based organizations can play a key role in facilitating the development of implementation plans through use of community participatory planning tools, for example, participatory mapping.[94]

Participatory mapping

One approach of participatory mapping is to use visual tools, such as printed (satellite) maps of the area, on which community members can be asked to draw. To aid in the discussion the group can be split into smaller subgroups where one group can focus on historic mangrove occurrences, another on resource use (such as fishing grounds) and another group on threats. The findings from the subgroups are then presented back to all, after which a complete picture of the context emerges.

For more information on tools to support participatory processes, Blue Ventures have published methods for completing participatory mapping (see Appendix B), and further resources are provided in Appendix C.

The use of participatory tools can encourage community analysis and understanding based on the local context, increase community capacity for planning and leadership, strengthen village organizations and governance, mobilize resources, and collaborative development of implementation plans. Participatory activities also offer opportunities for transparent discussion of expectations regarding voluntary participation (e.g., planting) and financial compensation for local labor (nursery, seed collection and post-plantation surveillance) which need to be agreed and communicated prior to implementation.[30]

Participatory approaches to mangrove restoration have also been successfully integrated with capacity building and novel finance mechanisms, with the aim of empowering people via both access to training and the cash resources to make changes to their livelihoods. An example of this kind of approach is the Bio-rights approach (Box 5).

© Dom Wodehouse, Mangrove Action Project

Lilian taking a core, © Tony Ochieng

Box 5: What is the Bio-Rights approach?

Bio-rights is an innovative system for giving communities financial and technical support to develop more sustainable livelihoods, in return for their active engagement in environmental conservation and restoration.[95]

In the Building with Nature project in Demak, Indonesia, 268 people from ten community groups participated in Wetlands International's trial Bio-rights program, supported by field facilitators who lived in the district throughout the landscape restoration process. Through coastal field schools that lasted a full cropping season, communities learned about the ecology of coastal waters, the functions of mangroves, and pond ecology and management.

Participants were paid in advance in the form of small loans, in return for tasks such as constructing, maintaining, guarding, and inspecting permeable structures that trap mud and sediments and for converting degraded ponds into sediment catching basins, where mangroves then regenerated naturally. The payments are conditional loans that are written off when more sustainable livelihood approaches have been adopted and mangrove restoration efforts have been successfully demonstrated.

The participants spent the funds they received on improving aquaculture or creating alternative livelihoods and other projects of benefit to communities. Some bought equipment to make fish food or fertilizer for their ponds from organic waste such as straw and leaves. Others purchased livestock, created vegetable gardens, produced flour from crab shells, bought boats for rental, harvested non-timber forest products to make handicrafts and honey, and explored ways to cultivate green mussels. The project also supported farmers with equipment to harvest wild fish from in and around the resurgent mangroves. More than 80 per cent of fishers report better near-shore catches, with incomes now as good as those from aquaculture.

Community ownership has been essential for adaptive management because interventions such as the permeable structures need continuous maintenance in the face of storms and other wear and tear. This will continue until the mangroves behind the structures are sufficiently developed to take over their function, recreating a natural defense against further erosion.

The team monitor both biophysical and socio-economic indicators, ranging from rates of sedimentation and mangrove re-establishment to aquaculture pond harvest rates and incomes, with regular monitoring and evaluation conducted by local communities. Monitoring and evaluation are used by the project team to inform an adaptive management approach to seize opportunities and address risks. Community participants also use this monitoring to inform their aquaculture and mangrove management decisions. The system for adaptive management allowed the team to raise awareness of the issue locally and to empower communities to join dialogues with stakeholders at both local and national levels.

While the use of up-front payments can be effective in facilitating change and support for restoration, associated risks include making sure that the time spent working on restoration activities in lieu of loan repayments equates to a fair wage. Schemes like this rely on effective recording and communication of work done, and work objectives which are achievable within the advance amount paid, or the understanding that regular wage payments will begin after an appropriate time.

4.5.2 ...at the local and regional level

Authorities at the township, district, provincial, state and regional levels often have strong influence over mangrove restoration projects. Understanding the institutional context for mangrove restoration requires analysis of a range of institutions – formal and informal, structured and unstructured. Many approaches can be used for analyzing institutions (see "Enhancing the integration of governance in forest landscape restoration")[26] and a selection of resources are provided in Appendix C.

Engagement with local and regional government stakeholders can be achieved through a variety of approaches:

- Informal discussions
- Formal multi-stakeholder forums
- Technical working groups
- Stakeholder coalitions and co-management committees.

Combinations of top-down (government and institutions) and bottom-up (community) approaches can sometimes be effective[44] by ensuring adequate representation of stakeholder and community groups and appropriate government involvement to provide coordination and negotiate user rights and long-term management responsibilities. In addition to government agencies, non-government organizations and the private sector can support the interests and needs of local communities. In some countries with developing economies, governments often have limited resources for conservation and restoration, and their engagement is often limited to granting permissions for land use rights and land ownership. Beyond that, technical and financial resources usually come from the non-governmental and private sectors. An example of a non-government group that aims to support mangrove conservation and restoration is the Global Mangrove Alliance.

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Gazi mangroves, © Julia Jung

In any project, participants and stakeholders may come to the table with unequal or asymmetric relationships, or differences in capacity, power, or ideologies, which can lead to deficiencies in project design and implementation.[96,97] These asymmetries can be overcome through long-term commitments to funding, capacity building and monitoring, stronger collaborations between the funders and individuals/communities carrying out the restoration projects, and resolution of conflicts between bottom-up (local) environmental initiatives and top-down (governmental) legislation.[97,98]

4.5.3 ...at the national level

The engagement of national level stakeholders may be the most challenging part of a restoration project. It can depend on the political context and turnover of decisions and decision makers post-elections. For nations where most land suitable for restoration is state-owned, changes in national priorities can impact the availability of lands for restoration. For example, prior to an election the government may be prioritizing meeting climate targets and after an election the new government may prioritize economic growth – priority shifts may complement or conflict.

Government agencies responsible for mangroves may include the Ministry of Forestry or the Ministry of Environment, and the resources within a mangrove could be managed by Fishery Agencies or Climate Agencies, all of which may have overlapping jurisdictions and managerial responsibilities which can lead to conflict or slow progress, or with mangroves left without clear management.[99,100] Delegation of clear roles and responsibilities for government agencies and/or high-level coordinating bodies can be formed by the leading authority.[101] Coordinating agencies can bring together all stakeholders at the national level to clarify guidelines and address the unresolved conflicts at the local and regional levels (e.g., through Integrated Coastal Zone Management approaches, this video example is from Indonesia). An example of effective capacity building in El Salvador (pages 123 & 124) demonstrates how supporting communication and collaboration across community, local, and national bodies can result in transformative change.

Institutional arrangements created between national agencies and other stakeholders can provide financial sustainability and scalability to mangrove restoration programs. Government (and governmental agency) involvement in restoration can enhance evaluation of the fulfillment of goals, facilitate dissemination of outcomes, enhance funding renewal, and support development of new projects.[97] Government agencies can also facilitate sharing of experiences in mangrove restoration (learning from both successes and failures, pilots and ideas) through support of national symposia, workshops and study tours, that can be instrumental in inspiring restoration initiatives elsewhere. One example of governments actively sharing information is the International Partnership for Blue Carbon.

4.6

Next steps

Chapter 2 covered outlining project goals and understanding if a project is feasible.

Chapter 3 covered forensic ecology, identifying site issues, and designing project activities - what you need to do

Chapter 4 looked at how you are doing it, and you should now have a strong foundation to work from, having:

- Reviewed the existing technical guidance referred to within these guidelines, identified approaches relevant to your region or specific restoration challenges, and finalised your project design
- Created a project management work plan and clear roles and responsibilities
- Shared project design with different stakeholders at community, local, and national levels as required, encouraged and listened to feedback
- Revised your project design to ensure it is inclusive of local needs and feedback received and considered how to make sure project governance is inclusive and responsive
- Considered potential funding sources and how to approach them

The next step is to monitor and evaluate project implementation, referring back to the project targets and objectives and recognising that as you implement biophysical restoration you may also be creating socioeconomic changes.

Consistent monitoring records progress of implementation, effectiveness of actions taken, and effects of restoration – including cultural and socioeconomic effects. Project impacts can then be reported to funders as required, and adaptive management decisions may be taken based on robust monitoring data (Chapter 5).

Community-led hydrological restoration in a community-based mangrove restoration project in Indonesia, © Ben Brown

© Ben Brown

Case study

Collaborative conservation: Mangrove restoration

An important lesson in community participation

Bay of Jiquilisco, El Salvador

The Community-Based Ecological Mangrove Restoration (CBEMR) initiative in the Bay of Jiquilisco, El Salvador, showcases a remarkable case of successful collaboration between local communities, government agencies, and NGOs. By engaging with people at all levels, the 2011 CBEMR training workshop organized by Asociación Mangle (AM), FIAES, EcoViva, and Mangrove Action Project (MAP) had a transformative impact, which laid the foundation for subsequent restoration efforts.

This case study highlights the progress made in restoring the mangrove ecosystem, the incorporation of CBEMR into national policies, and the importance of ongoing monitoring and assessment for long-term commitment to mangrove conservation.

In July 2011, after previous failed attempts to restore mangroves in the Bay of Jiquilisco, a national forum on mangrove restoration was organized by AM, FIAES, EcoViva and MAP drawing attention to the environmental challenges faced by the mangrove forests of the Bay of Jiquilisco and surrounding areas. Following the forum, a four-day restoration training workshop was conducted, targeting local communities, wetland rangers, environmental organizations, and government officials. The training introduced participants to the CBEMR approach, equipping them with skills and knowledge in mangrove restoration.

The success of the 2011 workshop led to significant developments in mangrove restoration in El Salvador. El Salvador's Ministry of Environment and Natural Resources (MARN) recognized the importance of an ecological approach and engaged with AM to lead mangrove restoration efforts in the country. Consequently, AM, EcoViva and their local partners initiated the restoration of the mangrove ecosystem in El Llorón, contributing to tangible conservation outcomes.

These efforts have propelled ecological restoration to the forefront of El Salvador's national mangrove conservation strategy, and FIAES, the largest environmental fund in El Salvador, identified CBEMR as the primary method for its mangrove restoration work.

To evaluate the progress of mangrove restoration work, MAP conducted a follow-up visit to El Salvador in February 2023. The results of this follow-up show that over 1,000 people in El Salvador have now been taught the principles of CBEMR and are using the methods to restore mangroves. Over 70 km of channels have been excavated, and without the need to plant any trees, hundreds of hectares of mangrove forest have been restored. Authorities at MARN have now incorporated the principles of CBEMR as the national policy for best practices in mangrove restoration.

The case study of ecological mangrove restoration in the Bay of Jiquilisco, El Salvador, exemplifies the power of engaging with people at community, regional, and national levels to bring about collaboration and successful conservation outcomes. The initial CBEMR training workshop in 2011 served as a catalyst for subsequent restoration efforts and the integration of these best practices into national policies.

Ongoing monitoring and assessment will continue to refine and enhance the restoration practices, establishing the Bay of Jiquilisco as a regional model for promoting the benefits of the CBEMR process. This case study highlights the significance of collaborative approaches, capacity building, and knowledge-sharing in achieving sustainable mangrove conservation.

Persian Gulf, Iran, © Saeed Hadipoorsalestani, TNC Photo Contest

5
Monitoring and evaluation

Protected mangroves from above, Colombia, © Mariana Rivera-Uribe, Mangrove Photography Awards 2021

This chapter guides you through the process of monitoring mangrove restoration outcomes and evaluating them against set targets and objectives. It explains why you should monitor project outcomes, what you should monitor, and, based on the results, if the implementation or management plan needs to be adapted.

Key messages

- Monitoring is essential for validating project success, guiding adaptive management, and for reporting of outcomes to stakeholders
- Monitoring specific indicators is essential to gauge the relative success of mangrove restoration projects
- A major challenge for mangrove restoration projects is securing the resources needed to continue monitoring beyond a project's funding lifespan
- Adaptive management can be used to adjust the implementation plan in response to unforeseen developments.

FAQs

There's a lot changing on my restoration site… how do I know what to monitor?
Section 5.2

What are reference sites, and how are they used?
Section 5.2.1

How can I visualize, compare, and communicate progress towards multiple goals?
Section 5.2.3

How long do I need to monitor my project site for?
Section 5.3

I want to change my data collection methods after a few years… why is this a bad idea?
Section 5.3


Thailand, © Ana Grillo, IUCN / MFF

Reading list

International standards for the practice of ecological restoration (2nd Edition) https://www.ser.org/page/SERStandards	This lengthy guide is not specific to mangroves, but covers how to use the SER recovery wheel to design an appropriate monitoring strategy.
Indicators of coastal wetlands restoration success: a systematic review https://www.frontiersin.org/articles/10.3389/fmars.2020.600220/full	This comprehensive paper ties together use of the SER recovery wheel with appropriate indicators for mangrove restoration monitoring.
The SWAMP toolbox https://www2.cifor.org/swamp-toolbox https://www2.cifor.org/swamp-toolbox/presentations/theme-d/d2-monitoring-reporting-verification-mrv-wetlands/	Section D2 provides specific advice on monitoring, reporting and verification of mangrove projects.
Manual for mangrove monitoring in the Pacific Islands Region https://www.researchgate.net/publication/326332324_Manual_for_Mangrove_Monitoring_in_the_Pacific_Islands_Region_Manual_for_Mangrove_Monitoring_in_the_Pacific_Islands_Region_SPREP_LibraryIRC_Cataloguing-in-Publication_Data_Secretariat_of_the_Pacific_Re	This guide provides practical guidelines and methods for local communities wanting to monitor the health of mangroves.
Rapid assessment protocol for terrestrial vertebrates https://link.springer.com/article/10.1007/s10531-020-02001-w	This method describes sampling strategies to characterize terrestrial vertebrates in mangroves that can be used to monitor changes in biodiversity.
Queensland data collection protocol https://www.daf.qld.gov.au/__data/assets/pdf_file/0006/63339/Data-collection-protocol.pdf	An example of a locally developed (to address local interests) list of characteristics (and their states) used for monitoring mangroves.
CIFOR field guide to Adaptive Collaborative Management https://www.cifor.org/knowledge/publication/5085/	Practical guidance and examples of how to apply ACM methods in communities and how to teach those methods to others.

5.1

Why monitor?

The importance of tracking your project

Monitoring of intervention outcomes – both biophysical and socioeconomic - is an essential tool to understand progress towards project goals and objectives, to see where adaptive management decisions need to be made and implementation plans revised, and for reporting to communities and other stakeholders.[3,8,102,103]

Monitoring is often required by donors, investors, and crediting bodies – many of which will have their own methods and indicators that they will ask projects to monitor and report against.

Lack of monitoring of mangrove restoration projects has been a driver of high failure rates as funders or implementing bodies were unaware their restoration projects, and the techniques used, were ineffective.[104,105]

5.1.1 Adaptive management: change happens and that's OK

Change happens – it is how you approach and respond to change that makes the difference between a successful or unsuccessful mangrove project.

You also don't want to make changes to projects in an ad-hoc manner. There should be a structure and assessment that determines which changes should be made, how they should be made, and the impact they have on projects.

Data from the monitoring of the project provides you with real-time information as to the project status. Adaptive management (Section 4.2.2) can then help to identify adjustments or corrective measures needed to achieve project success.

It involves periodic review of the project and adjusting management plans to optimize management strategies and actions.

Indicators can be integrated into an adaptive management plan to identify thresholds for interventions.[3] Figure 16 provides an example of adaptive management for active replanting.

CBEMR Training in Tanzania & Kenya, © Dom Wodehouse, Mangrove Action Project

Figure 16

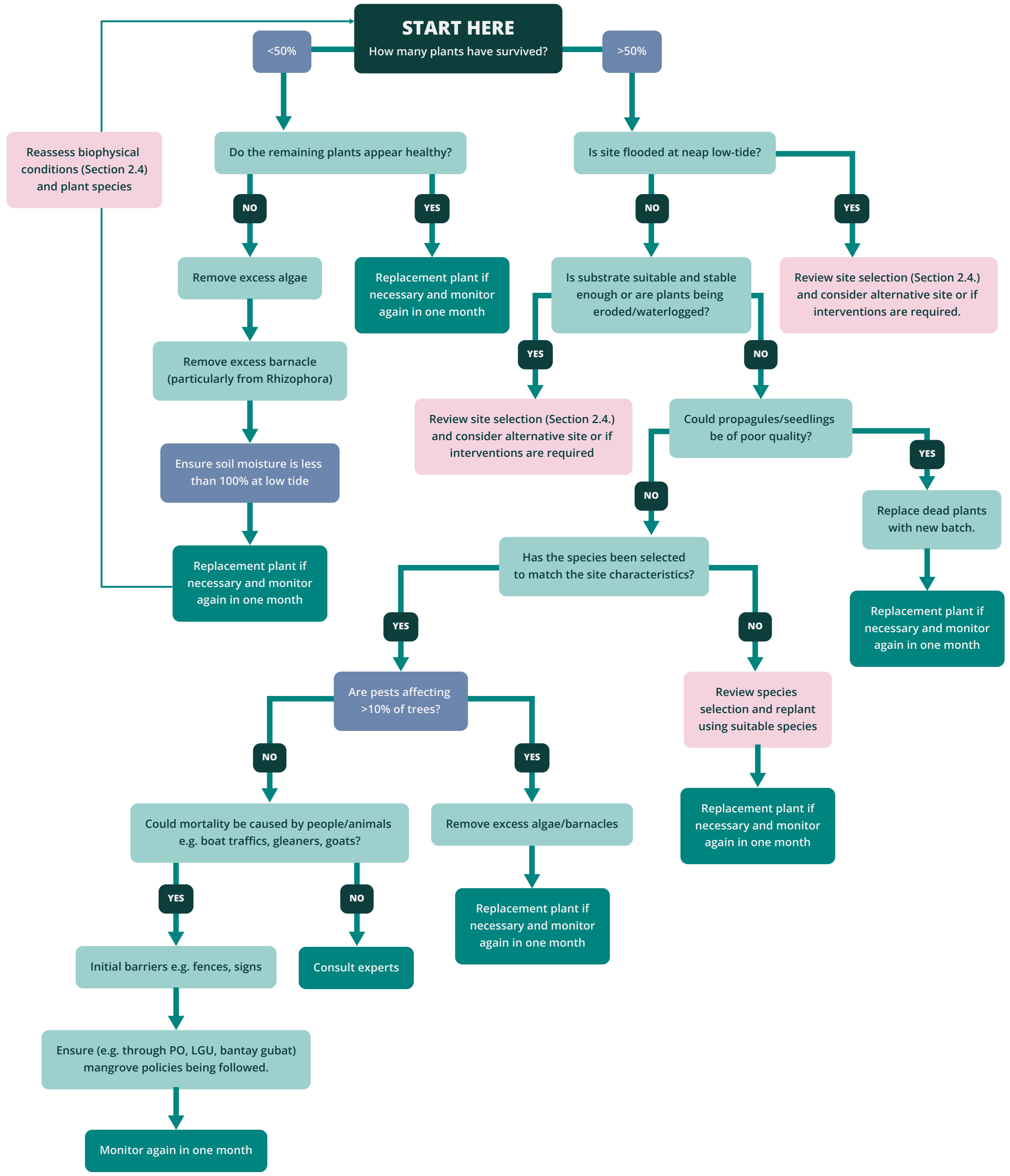


Figure 16. *Example of adaptive management options for mangrove restoration projects involving plantings (adapted from Primavera et al., 2012a)[20]. Blue boxes indicate KPI's for the project and pink boxes indicate adaptive management actions required.*

© Wetlands International

CBEMR Training in the Rufiji Delta, Tanzania, © Dom Wodehouse, Mangrove Action Project

5.2

What to monitor?

There's a lot changing on my restoration site... how do I know what to monitor?

The choice of monitoring indicators should reflect the project's restoration goals and objectives, the ecosystem being restored, and the specific circumstances of the project site.[8,104,106]

The use of commonly used indicators (Section 5.2) to assess coastal wetlands restoration projects can facilitate a clearer and comparable assessment of outcomes.

Accurate monitoring and reporting rely on:

- Clear project goals and objectives
- Using relevant indicators of project success
- Designing a monitoring plan specific to the reporting framework
- Maintaining consistent data collection.

When developing a monitoring plan, it is important to consider the following questions:

- What are the common base set of indicators used to assess coastal wetlands restoration projects?
- Are additional indicators needed to monitor for the specific goals of your project (e.g., for carbon, biodiversity, or water quality)?
- What methods are recommended for monitoring various indicators, are they feasible in your context (affordable, safe, etc.)?
- What is the degree of confidence in the method used to monitor the indicators? (Scientific peer-reviewed methods would be high confidence, while using visual cues derived from personal knowledge would be lower confidence).

Thailand, © Siriporn Sriaram, IUCN / MFF

Mudskipper © Yus Rusila Noor, Wetlands International

The use of relevant indicators of restoration success can produce an accurate estimation of project outcomes[103] and inform adaptive management decisions.[3] There are a large range of indicators used across projects worldwide for measuring mangrove restoration outcomes, which can make it difficult to choose appropriate indicators and to compare across projects, as the use of one indicator over another can result in different conclusions.[105] Further information and examples of commonly used indicators for mangrove restoration monitoring can be found in:

- Indicators of coastal wetlands restoration success: a systematic review
- Priorities and Motivations of Marine Coastal Restoration Research
- Challenges in marine restoration ecology: how techniques, assessment metrics, and ecosystem valuation can lead to improved restoration success.

Whichever indicators are selected, the method used to collect monitoring data should remain consistent throughout the monitoring period. If data collection timing, location, indicators, equipment, or method changes significantly during the monitoring period then results may cease to be relevant or comparable to each other, and any measurement of progress invalidated or unverifiable.

A goal of some mangrove restoration projects could be to report within the framework of the System of Environmental Economic Accounts (SEEA) which can be used to report on national commitments to the Convention on Biological Diversity. If this is the case, then it is important to align indicators with the SEEA framework.

5.2.1 Developing a before-after control-impact approach and monitoring strategy

Indicators selected for monitoring and reporting undertaken within the project site should be measured against a reference or control area in order to gauge progress towards the desired restored ecological state, and/or away from the undesired unrestored state. The before-after control-impact (BACI) monitoring framework[107] is a simple study design which enables you to assess the overall benefits resulting from the project and to evaluate restoration sites against natural reference sites.

Thailand, © Ana Grillo, IUCN / MFF

The net difference the project makes is calculated by assessing indicators between control (typically healthy, unimpacted reference sites where no restoration activities take place) and intervention sites (where restoration occurs). Using a BACI approach, assessments of indicators are done both before (often called the baseline condition) and after activities have taken place (Figure 17). This enables an evaluation of whether detected changes can be attributed to the intervention (restoration) activities or are due to natural processes that are occurring over the whole landscape (e.g., the impact of floods or other climate events) or to external human disturbances.

Figure 17

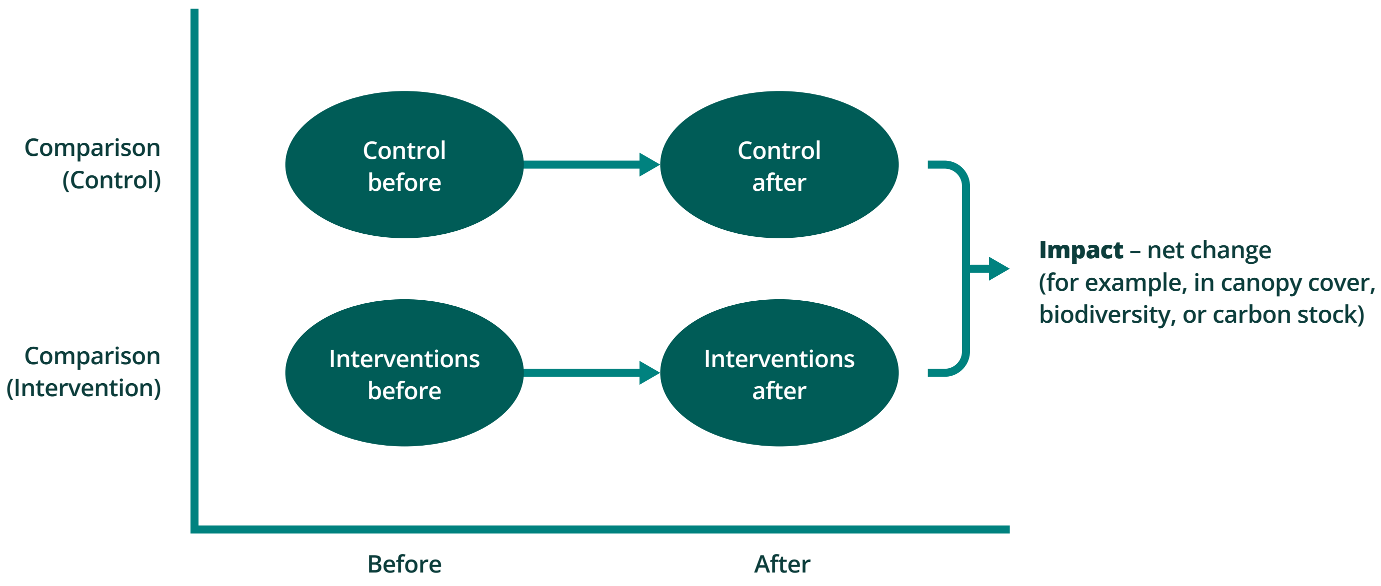


Figure 17. *Schematic of BACI project design for carbon projects adapted from Poortinga et al. (2018).*[107]

What are reference sites, and how are they used?

Choosing appropriate control (reference) sites is important for comparison with the restoration site. Reference sites are typically a healthy natural mangrove with similar ecological and biophysical conditions to the intervention (restoration) site. Having one or more appropriate reference sites provides a clear depiction of goals of the restoration project and a development state to evaluate against.[108] In the absence of suitable intact ecosystems near the restoration site, proxies based on historic data, information from local stakeholders about the ecosystem, or from modeled outputs can be used instead.[106]

5.2.2 Choosing Appropriate Indicators

The starting point for developing indicators is to reflect on the project's stated goals. In the past, the goal of most mangrove restoration projects was to restore vegetative cover with indicators related to a percentage increase in canopy coverage.[109] However, goals can also include restoring ecosystem function, ecological processes, and ecosystem services.[110] Setting project indicators requires consideration of how different parameters are expected to change over time with mangrove development. For example, whilst most structural attributes of vegetation (cover, extent, density) can often be achieved by restoration within a relatively short time frame (<5 years), it can take several decades for ecosystem services to reach those of natural stands.[56]

Indicators should be clearly defined in the project planning phase and linked to realistic and measurable goals and objectives.[110] Consistent definitions and classifications of indicators, including social indicators, deliver reporting that is transparent and acceptable to all stakeholders. Table 4 provides a framework for establishing indicators for a typical mangrove restoration project.

CBEMR workshop for Bonefish and Tarpon Trust and Waterkeepers Bahamas, © Dom Wodehouse, Mangrove Action Project

Table 4. *Examples of indicators for mangrove restoration projects. Adapted from Cadier et al., (2020).[8]*

Attribute category	Sub-attribute category	Indicator
Structural diversity	Vegetation community structure	Percentage of the site covered by natural recruitment after hydrological restoration, or percentage of planted trees that have survived.
		Number of plant species compared to reference sites.
		Natural recruitment of trees occurring within the project area with seedling density at or above levels in reference sites.
	Faunal community structure	Number of faunal species and density of individuals of species (species richness and abundance) compared to reference sites.
	Bacterial community structure	Bacterial diversity and distribution comparable to reference sites.
	Algal structure	Algal diversity and distribution comparable to reference sites.
Ecosystem function	Provisioning ecosystem services	The levels of natural resources being generated from the project area (e.g., alternative livelihoods developed, fish stocks and biodiversity values increasing).
	Carbon storage and primary productivity	The level of carbon storage in sediments and biomass is increasing at the target rate.
	Nutrient levels	Nutrient levels are within natural ranges found in reference sites.
	Sediment dynamics	Erosion rates are comparable to reference sites.
Species composition	Vegetation diversity and distribution	Number of vegetation species present, percentage area cover, and distribution of species, compared to reference sites.
	Fauna diversity and distribution	Fauna species richness/diversity compared to reference site, threatened species presence.
	Bacterial diversity and distribution	Bacterial genetic diversity.
Physical conditions	Soil	Soil physiochemical conditions are similar to reference sites.
	Water	Water physiochemical variables are similar to reference sites.
Absence of threats	Pollution	Pollution levels are comparable to reference sites.
	Biological	Biological threats (e.g., invasive species, pathogens) are absent from the restoration area.
	Exploitation by people	Extraction of resources is sustainable compared to the baseline or reference sites.
External exchanges	Linkages and connectivity for hydrology and tidal inundation.	Hydraulic connectivity has been restored and is similar to reference sites.

5.2.3 Using indicators to track progress

Progress towards achieving your project goals can be tracked by creating key performance indicators (KPIs) linked to explicit objectives. For example, for a mangrove restoration site which has the goal of being returned to a state of natural biodiversity, objectives could include the presence of desirable plant and animal species, and the absence of undesirable species, with the indicators being the number of those species present or absent compared to the number of species on the reference site.[8]

How can I visualize, compare, and communicate progress towards multiple goals?

You may be required to use a specific monitoring framework prescribed by a funder or crediting program, or may choose to devise your own that's customized to your particular project goals. Tools to support project monitoring and reporting include the Mangrove Restoration Tracker Tool (Section 4.1) and the Society for Ecological Restoration (SER) "Recovery Wheel" (Figure 18).

Figure 18

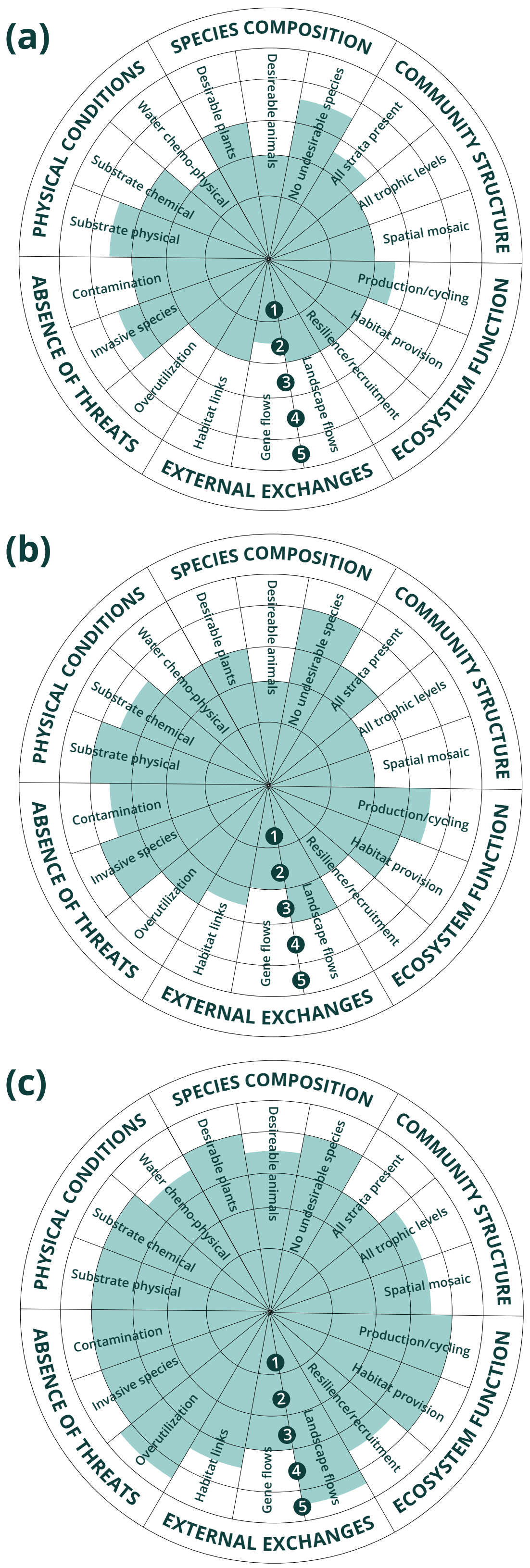


Figure 18. *A theoretical example of how the "recovery wheel" may be applied to track restoration success. Each coloured section shows successful progress towards achieving project objectives. (a) shows a site baseline before restoration has begun, with most indicators in a poor state. (b) shows the results of monitoring the selected indicators on the same site 1 year after restoration has begun. Progress toward removing threats is largely completed, however external exchanges, species composition and community structure have not shown much improvement. This indicates that adaptive management is needed and project design needs to be revised to take a different approach to achieve these objectives. The project team identify that targeting improvement of external exchanges may facilitate improvement across all three goals. (c) shows the monitoring results of the same site again after two years. The adaptive management approach has been successful and there is marked improvement in external exchange, species composition and community structure.*

Recovery wheels can also be used to create a visual comparison of the status of indicators on the reference site with the project site, as a way of indicating overall restoration success (Figure 19).

Figure 19

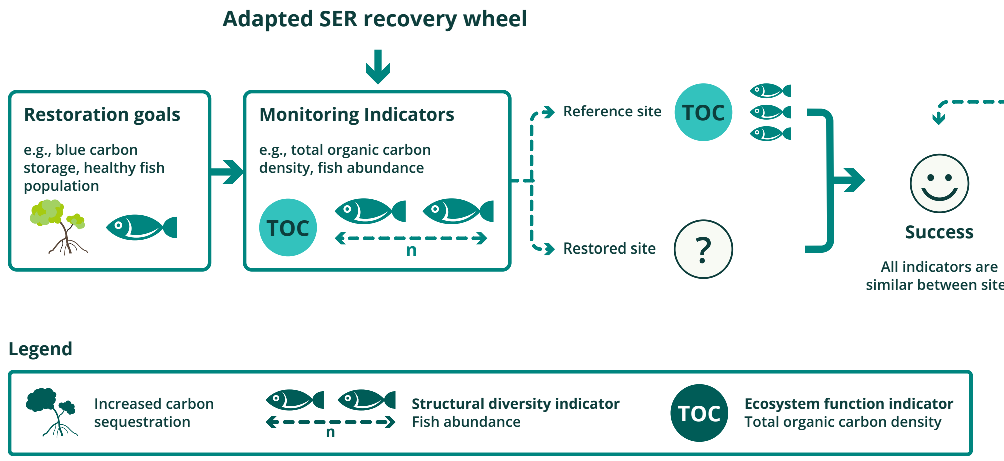
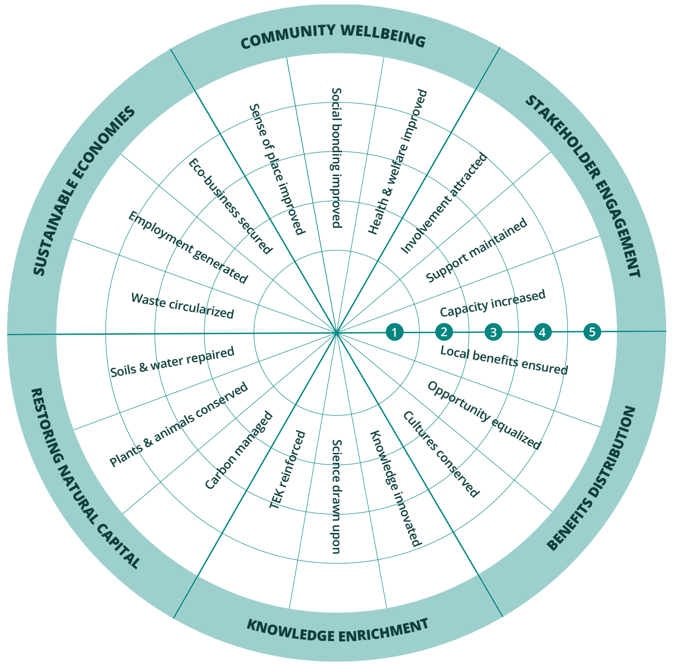


Figure 19. *Example of a monitoring and restoration outcome adapted from (Cadier et al.,2020).*[8]

Figure 20



The SER recovery wheel can also be used to track social, economic, or other benefits of restoration against a range of indicators.

Indicators can address a range of goals, including stakeholder engagement, benefits distribution, knowledge enrichment, natural capital, sustainable economics, and community wellbeing (Table 5, from Gann et al., 2019).[6]

A scoring system (Figure 20) for social indicators can be combined with a recovery wheel that can be used to visualize progress of indicators toward achieving goals.

Figure 20. *Example of a recovery wheel design for monitoring combined socioeconomic benefits from an ecosystem restoration project. Reproduced from Gann et al., 2019.*[6]

Table 5. *Sample social five-star system for evaluating progress toward social goals in a restoration project or program. Social goals will be many and varied. Not all elements in this table will be relevant to all projects. The Social Benefits Wheel (Figure 20) can be applied to small or large-scale projects, with scale used as a multiplier of outcomes, rather than being itself an attribute. Reproduced from Gann et al., 2019.*[6]

Attribute	*	**	***	****	*****
Stakeholder engagement	Stakeholders identified and made aware of project and its rationale. Ongoing communication strategy prepared	Key stakeholders supportive and involved in project planning phase	Number of stakeholders support, and involvement increasing at start of implementation phase	Number of stakeholders support, and involvement consolidating throughout implementation phase	Number of stakeholders support, and involvement optimal, and self-management and succession arrangements are in place
Benefits distribution	Benefits to local communities negotiated, ensuring equitable opportunities and reinforcement of traditional cultural relationships to site	Benefits to local communities starting and equitable opportunities maintained. Traditional cultural elements integrated as appropriate into project planning	Benefits to locals at an intermediate level and equitable opportunities maintained. Any traditional cultural elements well secured within project implementation	Benefits to locals at a high level and equitable opportunities maintained. Substantial integration of any traditional cultural elements, increasing reconciliation prospects	Benefits to locals and equitable opportunities very high, with optimal integration of any traditional cultural elements substantially contributing to reconciliation and social justice
Knowledge enrichment	Relevant sources of existing knowledge identified and mechanisms for generating new knowledge selected	Relevant sources of existing knowledge (and potential for new knowledge) informing project planning and monitoring design	Implementation phase making use of all relevant knowledge, stakeholder feedback, and early project results	Implementation enriched by all relevant knowledge as well as from trial and error arising from the project itself; results analyzed and reported	Implementation enriched by all relevant knowledge and results from the project disseminated widely including to other with similar projects
Natural Capital	Land and water management systems to reduce overharvesting and restore and conserve natural capital being put in place on site	Land and water management systems resulting in low level recovery and conservation of natural capital of the site	Land and water management systems resulting in intermediate level recovery and conservation of natural capital (including improved carbon budget)	Land and water management systems resulting in high level recovery and conservation of natural capital (including carbon neutral status)	Land and water management systems resulting in very high level of recovery and conservation of natural capital (including carbon positive status)
Sustainable economics	Sustainable business and employment models (applicable to the project or ancillary businesses) planned	Sustainable business and employment models commenced	Sustainable business and employment models in testing phase	Trials of sustainable business and employment models showing success	Sustainable business and employment models with strong level of success
Community wellbeing	Core participants identifying as stewards and likely improving social bonding and sense of place	All participants identifying and likely benefiting from improved social bonding and sense of place	Many stakeholders likely benefiting from improved social bonding, sense of place, and return of ecosystem services including recreation	Most stakeholders likely benefiting from improved social bonding, sense of place, and return of ecosystem services including recreation	Public identification of the site as having wellbeing benefits from local participation and return of ecosystem services including recreation

5.2.4 Ecological indicators and data collection methods

Important parameters that may be integrated into indicator monitoring and reporting include:

Hydrological connectivity – Monitoring and reporting may include flooding frequency, duration, and level of inundation (water depth at mean tide). Detailed methods on reporting these parameters can be found in:

- Hydrological classification, a practical tool for mangrove restoration
- Natural regeneration of degraded mangrove sites in response to hydrological restoration.

Biophysical conditions – Monitoring and reporting on biophysical conditions may include parameters such as porewater salinity, pH, and soil redox (oxygen availability in soil)

- Vegetation and soil characteristics as Indicators of restoration trajectories in restored mangroves
- Detailed methods can also be found in the Queensland data collection protocol.

Structural diversity – Parameters can include aboveground and belowground biomass, DBH, canopy cover, tree density, seedling/sapling density, and dead and downed woody debris. These indicators can also be used to inform measures of carbon sequestration via conversion of biomass to carbon stocks, and to inform the potential of fauna being present. Detailed guidance of how to implement these monitoring processes can be found in:

- The Blue Carbon Manual
- Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests.

Biodiversity – Parameters such as species richness, composition, and diversity indexes can be used as metrics for ecosystem function. Targeting specific species (e.g., culturally important, vulnerable, endangered, or invasive species) may also be beneficial. Species that are often monitored include birds (easy to monitor if present), bats, crabs (important for bioturbation processes), and commercially important species (prawns, fish, crabs, etc.). However, locally threatened or invasive vertebrate fauna are less often considered, as are keystone/indicator species for ecosystem health, such as worms that live in mangrove soils. For guidance on monitoring and reporting for biodiversity parameters see:

- A baseline study of the diversity and community ecology of crab and molluscan macrofauna in the Sematan mangrove forest
- Tackling the tide: A rapid assessment protocol to detect terrestrial vertebrates in mangrove forests
- More than Marine: Describes the critical importance of mangrove ecosystems for terrestrial vertebrates
- The role of vegetated coastal wetlands for marine megafauna conservation.

Presence or absence of threats – Most threats to mangrove forests are land-based, and when not managed, can lead to ecosystem loss and degradation. It is therefore important that external influences are captured and addressed in mangrove restoration management plans, and monitored regularly, to ensure effective long-lasting success of the restoration effort. Indicators of threat within mangrove ecosystems include terrestrial pests, invasive plants, erosion (for example, from sea level rise or sand dredging), illegal fishing practices, wildlife poaching, infrastructure development, agricultural encroachment, and pollution. Guidance on monitoring and reporting on these parameters can be found in:

- The Shoreline Video Assessment Method (S-VAM): Using dynamic hyperlapse image acquisition to evaluate shoreline mangrove forest structure, values, degradation and threats.

Habitat connectivity – This can include connectivity with adjacent ecosystems in the marine and terrestrial environments. Marine connectivity supports the movement of juvenile fish which may spend part of their life cycle in other habitats (e.g., adjacent mudflats, saltmarsh, coral reef, and seagrass habitats), and their presence indicates connectivity with mangrove ecosystems. Connectivity with terrestrial habitats is often less considered but is important for species that periodically access mangrove resources. While there are few obligate terrestrial vertebrate fauna species (e.g., species that solely use mangroves), there are a range of taxonomic groups (e.g., birds, mammals, and herpetofauna) that use mangroves facultatively (e.g., as a dispersal route between primary habitats, as a feeding ground, or as a refuge when adjacent terrestrial habitat has been disturbed by human influences). Fauna from adjacent connected terrestrial ecosystems can also provide services supporting mangrove growth, such as pollination.[99]

Monitoring for these indicators of habitat connectivity (e.g., migratory fish and birds, insects, mammals and herpetofauna which utilize mangroves) can be done through underwater observations (e.g., setting up underwater remote video stations), the use of camera traps, hair traps, artificial ground or tree covers, small mammal traps, audio recorders, or visual encounter surveys of individual animals or their tracks. Methods range from easily applicable to requiring more specialized skills or training and can be found in:

- Tackling the tide: A rapid assessment protocol to detect terrestrial vertebrates in mangrove forests.

Ecosystem function – This can be challenging to monitor, and analysis is usually more costly than structural diversity indicators. These relate to regulating services such as erosion prevention and climate regulation. For information on monitoring these processes see:

- Global estimates of the value of ecosystems and their services in monetary units.

5.2.5 Monitoring and reporting for landscape-scale projects

Landscape-scale restoration projects comprise whole regions or watersheds. They require all stakeholders (government, business, and communities) to work together to deliver a common goal for a landscape. Landscape projects provide benefit through coordinated management of factors in wider areas that influence mangroves (e.g., river flows, people's access to energy sources), however they can also be highly complex. Landscape-scale restoration projects often require long time frames (20+ years) to develop and are complicated by the large variation that can occur in environmental and social attributes.

Monitoring and reporting on landscape scale projects relates to the project's progress on achieving the goals and objectives established in Section 2.1. Like smaller scale projects, if goals are not being met it is important to use adaptive management options (see Sections 4.2.2 and 5.1.1) to allow the project to adapt and respond to challenges. Due to the long-time frames and large areas of landscape scale restoration projects, tools such as the Mangrove Restoration Tracker Tool (Section 4.1) are ideal for tracking progress. Global products that evaluate variation in mangrove cover over time can also be useful. Examples include:

- The Global Mangrove Watch
- The Global Intertidal Change tool

Restoration projects may be reported in National Environmental Economic Accounts (e.g., as commitments to the Convention on Biodiversity, post 2020 indicators), and reporting for the Ramsar Convention and UNESCO World Heritage sites.

In Guinea Bissau, local farmers help to break dikes to restore hydrology, fostering ecological mangrove restoration, © Menno de Boer, Wetlands International

5.3

Monitoring success through and beyond the project's lifetime

How long do I need to monitor my project site?

The establishment of a monitoring time frame usually depends on requirements imposed by funders or other stakeholders (e.g., annual donor reports), by GHG crediting programs (e.g., the Verra carbon standard requires a monitoring report every credit issuance), and by the natural changes in a system (e.g., giving vegetation and soil sufficient time to accrue a measurable change in condition between monitoring periods). Not all indicators need to be monitored at the same time. For example, in the case of carbon crediting projects monitoring soil carbon will likely only show measurable changes every 5+ years, but fisheries improvements, hydrological function or reductions in threats may show significant changes rapidly or within a few years.

Funders often do not understand the need for long term monitoring of restoration sites beyond achieving short-term goals. A major challenge for mangrove restoration projects is securing the resources needed to continue monitoring beyond a project's funding lifespan. On average, mangrove restoration projects are monitored for less than 5 years[8,102] which is generally not sufficient for mangroves to reach maturity. However, blue carbon crediting programs require monitoring for the lifetime of the crediting period (20-40yrs) and in some cases beyond to ensure permanence of any carbon removals claimed, with the expectation that carbon finance be used to cover those costs (Module 1).

No matter how often monitoring is required or how many indicators need to be assessed, monitoring often requires technical expertise, field effort, and long-term commitment. Some options to address these challenges include:

Overcoming high costs for expertise – Engaging with universities and turning monitoring/reporting assessments into student research projects. This is a usually low-cost option to gather useful data while at the same time providing educational opportunities. The effectiveness of this approach can be sporadic (depending on the commitment of individuals) and of variable quality.

Overcoming field challenges – Using remote sensing data to capture changes in metrics such as extent, structure (e.g., height and potentially species composition) and condition. However, such approaches still require technical expertise, ground truthing, and have limited use for capturing biological or socioeconomic indicators.[112]

Overcoming risk of lack of long-term commitment – Engaging the local coastal community in the monitoring of a basic set of parameters.

I want to change my data collection methods after a few years... why is this a bad idea?

Longer-term monitoring can be achieved if a standardized monitoring strategy is included and budgeted for during the planning phase of the project. If methods are not kept consistent over time the monitoring data will not be able to make conclusions on the long-term success of a project.[105] For example, if the methodology for monitoring soil carbon data used sampling within particular strata for several monitoring periods, after which definitions of strata are changed, this could result in a change in the sampling areas. Soil carbon data would then not be comparable through the time series. Thus, you would not be able to verify claims of soil carbon stock improvement because of differences in assessment before and after the methodology change.

Local fisherman mending his nets in the mangroves at Maintirano, Madagascar, © WWF

Circumference measuring of mangrove trees, © Conservation International

Case study

Building with Nature

Demak, Indonesia

The Building with Nature Indonesia initiative developed by Wetlands International built a stable coastline with reduced erosion risk in Central Java by integrating mangrove restoration and sustainable land use projects. This resulted in avoiding further coastal flooding and erosion, and a long-term perspective for sustainable economic development for local communities.

The program (2015-2021) focused on the shoreline of Demak district where sea level rise is projected to cause flooding 6 km inland by 2100 – inundating 14,700 ha and affecting over 70,000 people – and the loss of 6,000 ha of aquaculture ponds.

The problems largely resulted from the removal of mangrove belts for aquaculture development, unsustainable coastal infrastructure, and groundwater extraction. In some places several square kilometers of land had already been taken by the sea and entire villages lost. Many people experienced major loss in income, up to 60-80% in some villages. Hard infrastructures to protect the coastline exacerbated erosion, were unstable, expensive, and failed to deliver vital services such as fisheries that the original mangroves provided. Without action, the area would fully flood by 2030.

Technical measures included the construction of permeable dams made of brushwood that capture sediment and help to establish a healthy sediment balance. Once the near shore bed level had sufficiently risen, mangroves regenerated naturally, developing a natural defense against flooding and further erosion.

Figure 21

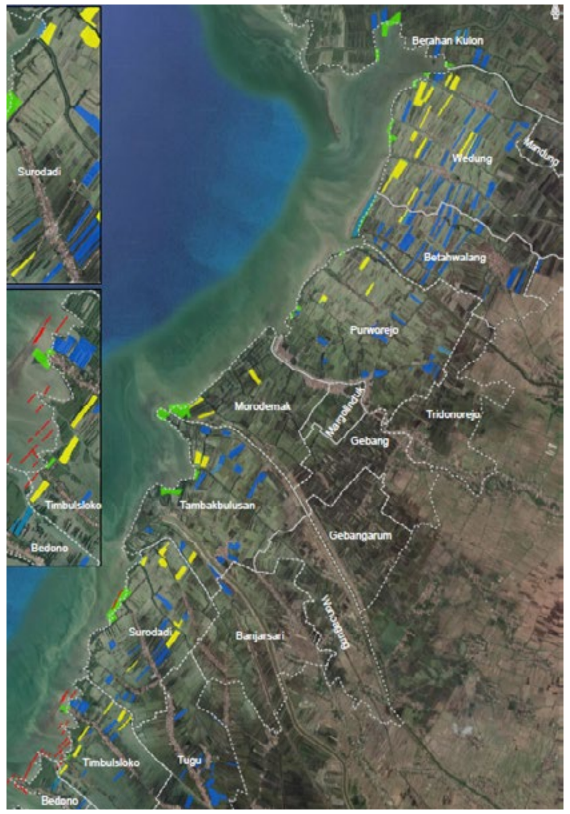


Figure 21. *Overview of the implemented measures in the Building with Nature Indonesia project in Demak, Central Java. Image: Witteveen+Bos.*

Specific lessons from the project

By putting in place a model for sustainable aquaculture, the project addressed the root causes of the erosion problems. The project introduced a model for sustainable aquaculture that provides space for mangrove restoration, for example by giving up unproductive coastal ponds or part of riverine ponds to mangroves. In return for letting mangroves regenerate, shrimp farmers were trained in sustainable techniques that have increased their shrimp production, resulting in greater prosperity, self-reliance, and hazard resilience. The measures have been rooted in community development plans and government master planning for sustainable development.

The key to success is collaboration across disciplines and sectors. To be effective, mangrove restoration needs to be part of integrated coastal management and supported by policy, planning, and strong local governance. Community involvement is key. The program showed that farmers will give up ponds for mangrove restoration if there is intensive stakeholder engagement and improvement of production in new ponds.

Coastal field schools were critical to both mangrove restoration and increasing production from sustainable aquaculture. The trained villagers also passed on their insights through new training in other villages, giving a multiplier effect. Participants also acquired soft skills that enabled them to be more creative in adapting to change and empowered them in policy dialogues.

Challenges

Permeable structures were installed as a temporary measure to allow mangroves to recolonize. Depending on the durability of available materials and exposure to extreme weather, they may suffer damage and require regular maintenance. Further research on material durability and structural design should help perfect the approach in the future. Unfavorable conditions such as significant land subsidence or reduced sediment input decrease their effectiveness. Such local factors need to be considered when deciding where and how to use them.

Sustainable solutions require a combination of technical and socioeconomic measures that address the root causes of the problem. Although the interrelatedness of measures challenged the design process, in the end it led to a more resilient outcome.

Mangrove restoration with permeable structures and through pond conversion is low-tech, but requires a sophisticated design based on comprehensive understanding of coastal processes, continuous monitoring, and adaptive management. However, the approaches can be adapted and replicated widely.

Throughout the program, achieving gender balance was a challenge due to local customs. The project's female teachers therefore recruited a women's group for two coastal field schools. A gender strategy should be developed in the early stages.

The Building with Nature Indonesia project won the UN Flagship award in 2022.

Case study

Vellar Estuary Mangrove Restoration Project, India

Involving young people in restoration efforts

Mangrove restoration in the Vellar Estuary began as a teaching project for students studying mangrove ecology. Students selectively collected mature propagules of local mangroves, which were planted along intertidal areas of the Vellar Estuary, replicating the zonation pattern of nearby natural mangrove reference sites. *Rhizophora* species were planted on the lower intertidal, whereas *Avicennia* species were planted on the upper intertidal. Between the planted sites an area was left unplanted to enable fishers access to the estuary.

Figure 22

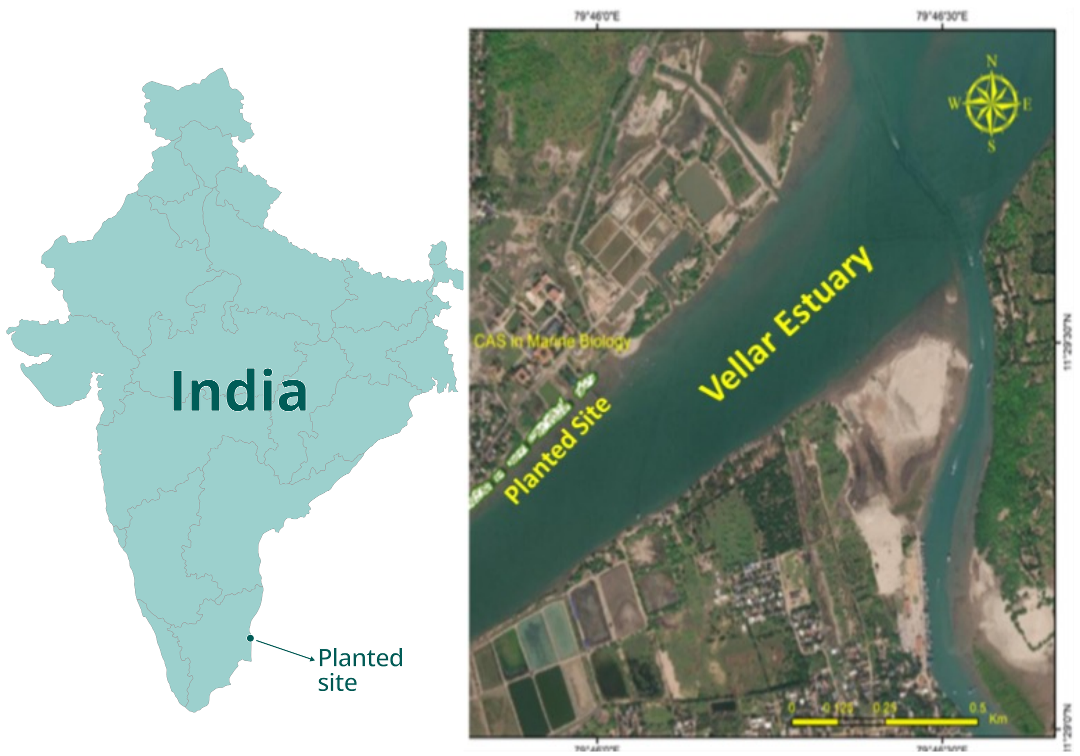


Figure 22. *Kathiresan Kandasamy, CAS in Marine Biology, Annamalai University, India*

Social and cultural considerations

When only male students were involved, the restoration was a failure. When both male and female students were included, it generated greater interest among the students. The students invited the local people (especially women) to participate in the mangrove restoration. There was a large increase in fish resources because of mangrove restoration, especially shrimps and crabs. Due to these changes the local people started respecting the students for their service, and a better understanding between them was established.

Project benefits

The disastrous tsunami of December 26, 2004, occurred 13 years after restoration began. Many of the people living behind the restored mangroves were protected by the mangrove vegetation. This led to further research after the tsunami in 18 coastal villages which, for the first time, documented the benefits of mangroves in buffering the impacts of tsunamis and storm surge, and highlighted the importance of restoration for coastal protection.

Risks to restoration and adaptive management responses

The following risk factors were identified during monitoring, and appropriate remedial measures were undertaken:

Algal growth – Overgrowth of filamentous algae such as *Enteromorpha* and *Chaetomorpha* covered the leaves of seedlings and tipped them into the water. This situation occurred during summer and post-monsoon seasons. This was prevented by hand picking and erecting bamboo fencing for support.

Water hyacinth – This aquatic weed accumulated heavily during the monsoon season through freshwater inflow and impacted seedlings. This was removed by hand.

Infestation by barnacles – Sometimes, a heavy load of barnacles became attached to the stems of seedlings during summer. It was prevented by scraping and carefully removing with a knife without damaging the seedlings.

Infestation by insects – Mangrove seedlings, especially the genus *Rhizophora*, sometimes exhibited pest problems with moth worms and other insects, particularly the scale insect *Aspidiotus* destructor. This was controlled using organic pesticides.

Siltation – Occurred during the monsoon period and the silt deposited on leaves and stems which led to death of some plants. Seedlings were rinsed with seawater.

Cattle grazing – Cattle trample young seedlings. This was prevented by erecting fences for mangrove protection.

Trash – Solid waste materials that were dumped in the water clogged the mangrove habitats. This was prevented by erecting bamboo fences and water gates to trap the trash at entry points.

Currents, waves, and wind – Plants were impacted by currents, waves, and wind. To reduce impacts planting was done in earthen pots, and/or supported with bamboo poles.

Monitoring project outcomes

After restoration, students collected data for percentage survival, plant height, number of leaves and aerial roots per plant, length of aerial roots, and total leaf area per plant at the regular interval of every month. The students also collected data from local fishers about the catch of commercial finfish and shellfish and the income accrued. The data revealed that mangrove-rich areas provided higher catches of fishes and yielded greater fishery income, (approximately 12-fold higher) compared with mangrove-poor areas. This reiterates the value of maintaining mangroves to ensure better fishery resources and to support coastal economies.

Students also collected data of carbon stocks and sequestration rates in planted mangrove stands of different age groups (16-27 years), plus data on vegetation and soil. Carbon storage was 22-fold higher in soil and 56-fold higher in both tree biomass and soil in mangrove stands than in non-planted control sites without mangroves. Carbon sequestration was 90-fold higher in soil and 9,890-fold greater in both tree biomass and soil than the control site. Carbon sequestration and storage increased with increasing levels of silt, clay, moisture, and nutrients in the mangrove soil. In contrast, carbon sequestration and storage reduced with increasing levels of temperature, pore-water salinity, pH, bulk density, and sand in the mangrove soil.

The project led to the training and expert development of approximately 250 young people from 28 countries, who were trained in the conservation and management of mangroves for 15 years since 2001 through 15-day international training programs, sponsored by United Nations University.

Local women and children involved in planting activities in the Vellar Estuary, India. Photo: Kathiresan Kandasamy

Module 1
Blue carbon


© Matt Curnock, Ocean Image Bank

The term "blue carbon" refers to the carbon sequestered or emitted from marine ecosystems, while "blue carbon ecosystems" are those for which there is a large body of research and evidence that proves they generally sequester more carbon than they emit. At the time of writing, this definition includes vegetated coastal and shallow water ecosystems such as mangroves, tidal marshes, and seagrass. As research continues, it is likely that the definition will expand to include macroalgae such as kelp, and some mudflat and soft sediment ecosystems.

Conservation of blue carbon ecosystems can reduce GHG emissions from degradation and destruction, while restoration can contribute to carbon removals through plant growth and soil carbon accumulation. The opportunities for avoiding emissions and increasing carbon storage make blue carbon a highly effective natural climate solution.

Module 1: Blue carbon provides information on the process of producing carbon credits for sale on voluntary carbon markets, plus guidance geared towards aligning your project with national climate change mitigation targets.

Key messages

- Measuring the climate mitigation impact of mangrove restoration projects for National Greenhouse Gas Inventories (NGHGIs), Nationally Determined Contributions (NDCs), and Reducing Emissions from Deforestation and Forest Degradation (REDD+) programs require specific monitoring and reporting procedures to be followed to ensure consistency.
- Depending on national legal and policy conditions for mangroves and carbon trading, not all mangrove restoration projects will be eligible to produce carbon credits.
- There are specific technical monitoring requirements for mangrove restoration projects designed as carbon crediting projects.
- Successfully producing carbon credits is a complex process with added administrative, technical, and monitoring costs. Smaller sized restoration sites will not be financially feasible based on projected credit income alone.
- There is the risk that carbon revenues can incentivize disbenefits. While leading standards attempt to prevent this, project managers should repeatedly evaluate the risk and adaptively manage the project if necessary.

FAQs

What units of measurement do we use for carbon?
Section 6.1

How are NDCs relevant to mangrove restoration projects?
Section 6.2

What is REDD+ and how is it relevant to mangrove restoration projects?
Section 6.2.2

What is Article 6, and does it affect my project?
Section 6.3.2

What are standards and methodologies, and what are the differences between them?
Section 6.4.2

How do I know if I can do this, and does it make sense for my project?
Section 6.4.5

What is additionality, and how do I know if my project qualifies as additional?
Section 6.4.5

What funding options are available to mangrove carbon projects?
Section 6.4.6

Can I produce carbon credits from a mangrove restoration project which has already been carried out?
Section 6.4.8

CBEMR workshop for Bonefish and Tarpon Trust and Waterkeepers Bahamas, © Dom Wodehouse, Mangrove Action Project

Reading List

Blue Carbon Manual https://www.thebluecarboninitiative.org/manual	Provides blue carbon measurement protocols, including field sampling of vegetative and soil carbon pools in coastal ecosystems.
Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests https://www.cifor.org/publications/pdf_files/WPapers/WP86CIFOR.pdf	Describes approaches to accurately measure, monitor and report species composition and structure, aboveground biomass, and carbon stocks of mangrove ecosystems.
The Science and Policy of the Verified Carbon Standard Methodology for Tidal Wetland and Seagrass Restoration https://link.springer.com/article/10.1007/s12237-018-0429-0	This article is fundamental and referred to several times in this section. Although not open access, it is widely available from different sources.
Coastal Wetlands in National Greenhouse Gas Inventories https://bluecarbonpartnership.org/wp-content/uploads/2021/11/Coastal-Wetlands-in-National-Greenhouse-Gas-Inventories.pdf	Provides advice to incorporate coastal wetlands into national greenhouse gas inventories, including mangrove restoration and management.
Guide to Including Nature in Nationally Determined Contributions https://international.nwf.org/wp-content/uploads/2019/09/Guide-to-Including-Nature-in-NDCs_2019-09-27-2.pdf	Provides an overview of incorporating nature-based solutions across all ecosystems within NDCs.
The Smithsonian Environmental Research Centre: Carbon data visualisations across the globe https://serc.si.edu/coastalcarbon/outreach-and-training	Coastal Carbon Research Coordination Network resources including records of mangrove carbon data.
The Wetlands Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories https://www.ipcc.ch/publication/2013-supplement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories-wetlands/	Provides technical guidance to estimate GHG emissions and removals from key activities in coastal wetlands.
Blue Carbon and Nationally Determined Contributions: Guidelines on Enhanced Action https://www.thebluecarboninitiative.org/policy-guidancec1337f2d/1596425746332/BCI+NDC_ExecSum_Final_singles.pdf	Provides policy advice for incorporating blue carbon ecosystems into NDCs.
High-Quality Blue Carbon Principles and Guidance https://merid.org/high-quality-blue-carbon/	Provide a consistent and understandable approach to guide the development and management of blue carbon projects that are equitable, fair, and credible.

6.1 What is the goal?

Can blue carbon add value to your project?

In the context of climate mitigation, healthy mangroves effectively sequester carbon dioxide from the atmosphere, meaning coastal wetlands have tremendous quantities of carbon stored in the vegetation and soil that gets released when the system is degraded or destroyed.[63,113] Mangrove restoration can contribute to national commitments to reduce GHG emissions and be reported within both the NGHGI and NDC.[47,114] Amendments to the scope of REDD+ allow for the inclusion of restoration, rehabilitation, or improved forest management activities – and may include mangroves where they qualify under national definitions of forests. Carbon sequestered and GHG emissions avoided through mangrove restoration may also be quantified and traded on carbon markets.

Including a blue carbon goal into your mangrove restoration project will influence the level of site information needed, the project monitoring needs, the governance of the project, the operational and implementation budget, and most importantly, stakeholder expectations. For more information on project goal setting, see Section 2.1.

The three goals addressed in this module relate to carbon benefits of mangrove restoration for:

1. **Nationally Determined Contributions** – National climate action plans to cut emissions and adapt to climate impacts. Every five years countries are expected to review and enhance their NDCs and submit more ambitious actions for reducing GHG emissions
2. **National GHG inventories** – An estimate of emissions and removals of GHGs from given sources or sinks, from a defined country in a specific period, used to report NDC progress
3. **Carbon markets** – National or regional regulated compliance markets or decentralized international voluntary markets where private actors buy and sell carbon credits or allowances that represent certified removals or reductions of GHG in the atmosphere.

Ecosystem management practices that achieve a reduction of GHGs emissions by sources, or increased sequestration of carbon by sinks, compared to a baseline of what would have happened had the project not been implemented (the business as usual, or BAU, scenario), are considered carbon mitigation activities (Figure 23).[45]

As discussed earlier, coastal wetland management activities meant to restore mangroves range from rewetting and water management activities to revegetation/reforestation and water quality enhancement efforts. However, in the broadest understanding, mitigation activities – as well as climate change adaptation and conservation activities – can also include national capacity building or awareness raising efforts (e.g., enabling stakeholders to use mangroves in a sustainable manner), support for setting up institutions, development and implementation of sectoral policies, enforcement of changes in national legislation, and engaging stakeholders.

While there are various terms used to describe carbon abatement or mitigation outcomes, this guide will generally refer to "emissions reductions and removals" or ERRs.

Figure 23

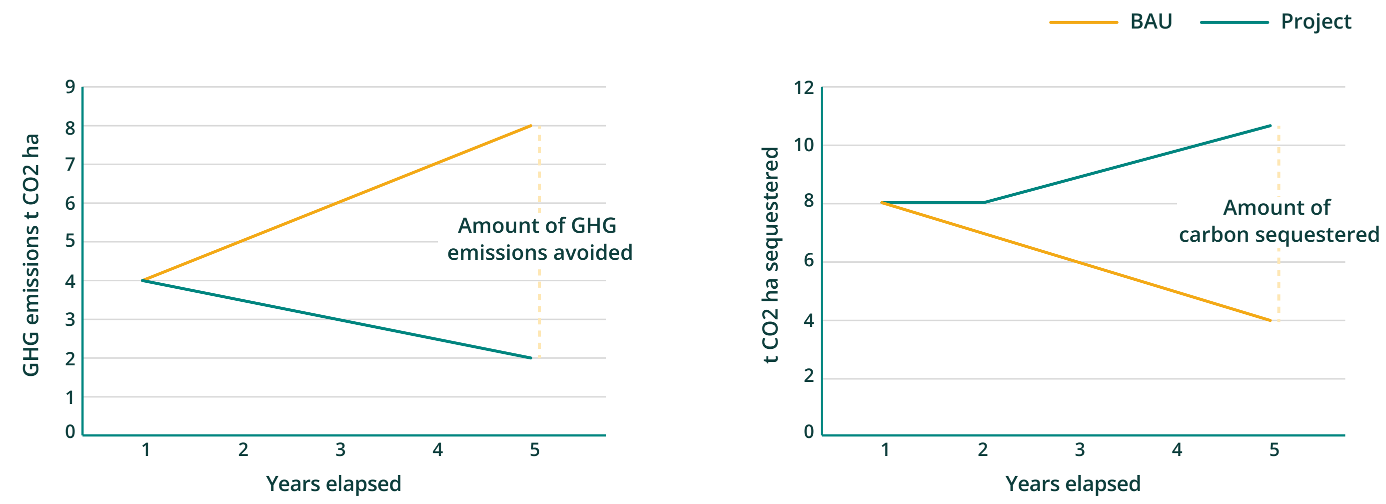


Figure 23. *The difference between the GHG emissions in the business as usual (BAU) scenario, and the avoided GHG emissions in the with project scenario represents the additional carbon eligible to be counted as credits from protecting a mangrove from destruction (left). The difference between the reduction in carbon sequestration with the BAU scenario and the increase in carbon sequestration in the with project scenario represents the additional carbon eligible to be counted as credits by reducing degredation and reforesting a mangrove site (right).*

What units of measurement do we use for carbon?

Carbon stocks are reported as tonnes of carbon dioxide equivalents per hectare (t CO_2e/ha), while emissions reductions and removals are reported as tonnes of carbon dioxide equivalent per year (t CO_2e yr^{-1}), or per hectare per year (t CO_2e/ha yr^{-1}). Megagrams of CO_2e, expressed as Mg CO_2e, have recently begun to be used in scientific literature to avoid confusion between metric tonnes, and American or Imperial tons. One megagram (Mg) is equal to 1,000 kilograms or one metric tonne and one carbon credit is usually equivalent to 1 t CO_2e.

Although this module will primarily focus on mangrove restoration for carbon markets, it is important to note that not all mangrove restoration projects are suitable as market-based carbon projects.

Although this module will primarily focus on mangrove restoration for carbon markets, it is important to note that not all mangrove restoration projects are suitable as market-based carbon projects. There are several reasons for this:

1. They may not fulfill all carbon market requirements (e.g., additionality)
2. Governance and policy settings may not support market-focused projects
3. Market-focused carbon projects may not be culturally or socially acceptable
4. Projects may not be economically feasible (e.g., because they are small, or expensive to implement)
5. Technical capacity to correctly apply a carbon crediting methodology may be limited.

Projects that do not participate in markets may alternatively measure their mitigation outcomes for inclusion in national GHG inventories (if countries include coastal wetlands in their inventories), or to contribute to national restoration or mitigation targets for an NDC or other national initiative.

Mangrove carbon projects may also be privately funded or owned, as an increasing number of funders look for impact to be measured and reported in terms of carbon sequestration, or wish to count privately generated ERRs against their own GHG reduction strategies or net zero targets. You should consider the latter approach as comparable to participating in a carbon market, undertake a similar assessment process (Section 6.4.4), and advise the funder appropriately before accepting any funding.

6.1.1 Maximizing carbon benefit – location matters

If climate mitigation outcomes are the primary objective for mangrove restoration, then site selection may focus on degraded mangroves located in settings with high potential for carbon stock recovery. When assessing whether to include carbon objectives in restoration plans for an existing site, you should also consider your site location and geomorphic setting.

Project sites most conducive to net carbon accumulation are primarily located in sites that are protected from wind and wave energy but that fringe the edge of water bodies, often low in the intertidal zone.[115] Here both soil carbon accumulation rates and the standing biomass of predominant mangrove species (e.g., *Sonneratia* and *Rhizophora* spp.) are higher than more landward mangrove communities where scrub mangroves (<2m tall) typically occur. However, the high potential carbon gains in fringing sites could be countered if the site is highly exposed to wind and wave impacts and sea level rise.

Carbon stocks of mangroves also vary geographically and among different geomorphic settings. Estuarine mangroves that occur in deltaic (both small and large), tidal and lagoonal environmental settings (see definitions in Figure 24) and include extensive landward zones traversed by rivers, streams, and creeks[116,117,118]; tend to have higher carbon stocks (biomass and soils) than open coastal settings.[119,120] Estuarine mangroves typically have higher productivity and growth rates than mangroves in other environmental settings (e.g., open coasts and embayments) and therefore have higher potential for carbon sequestration. This is driven by factors such as the availability, supply, and influx of freshwater and suspended sediments via riverine and tidal inputs.[121] An overview of how different geomorphic settings influence mangrove structure and biomass is presented in Figure 24.

Site selection can be further prioritized using cost-benefit analyses that include the financial benefit from mitigation outcomes of different restoration sites as well as the maintenance costs and the forgone income (opportunity cost) from ceasing current land use[122,123]

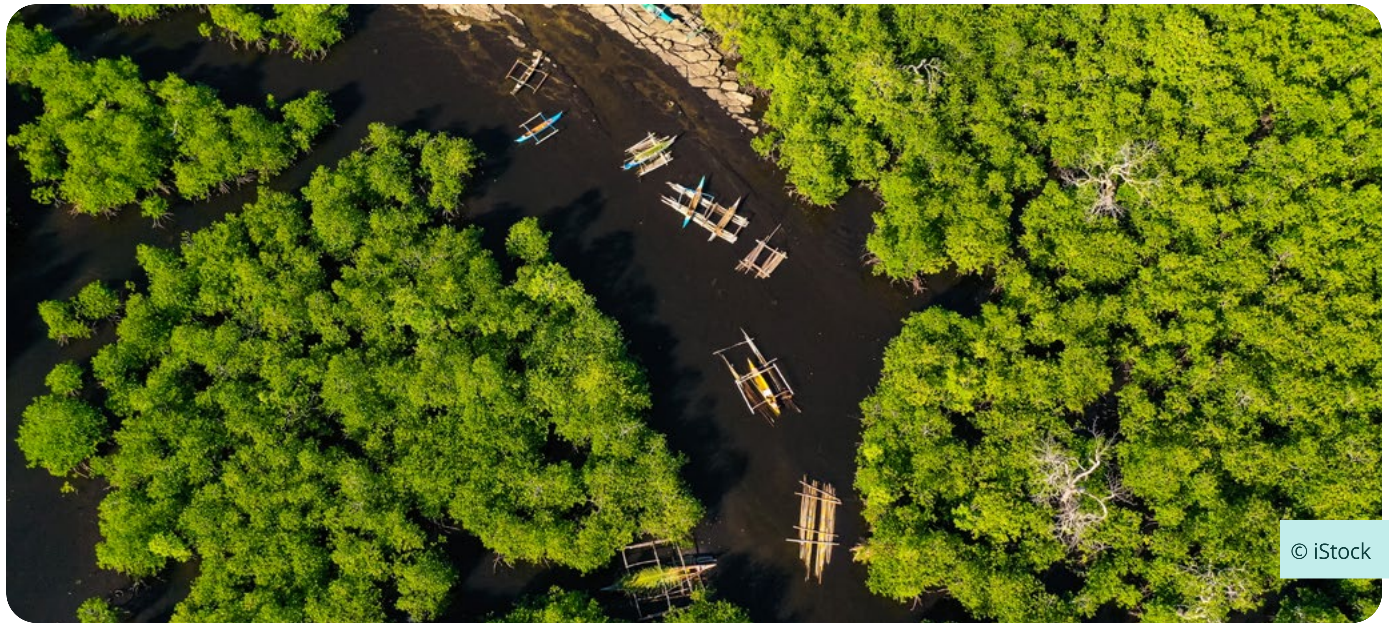


Figure 24

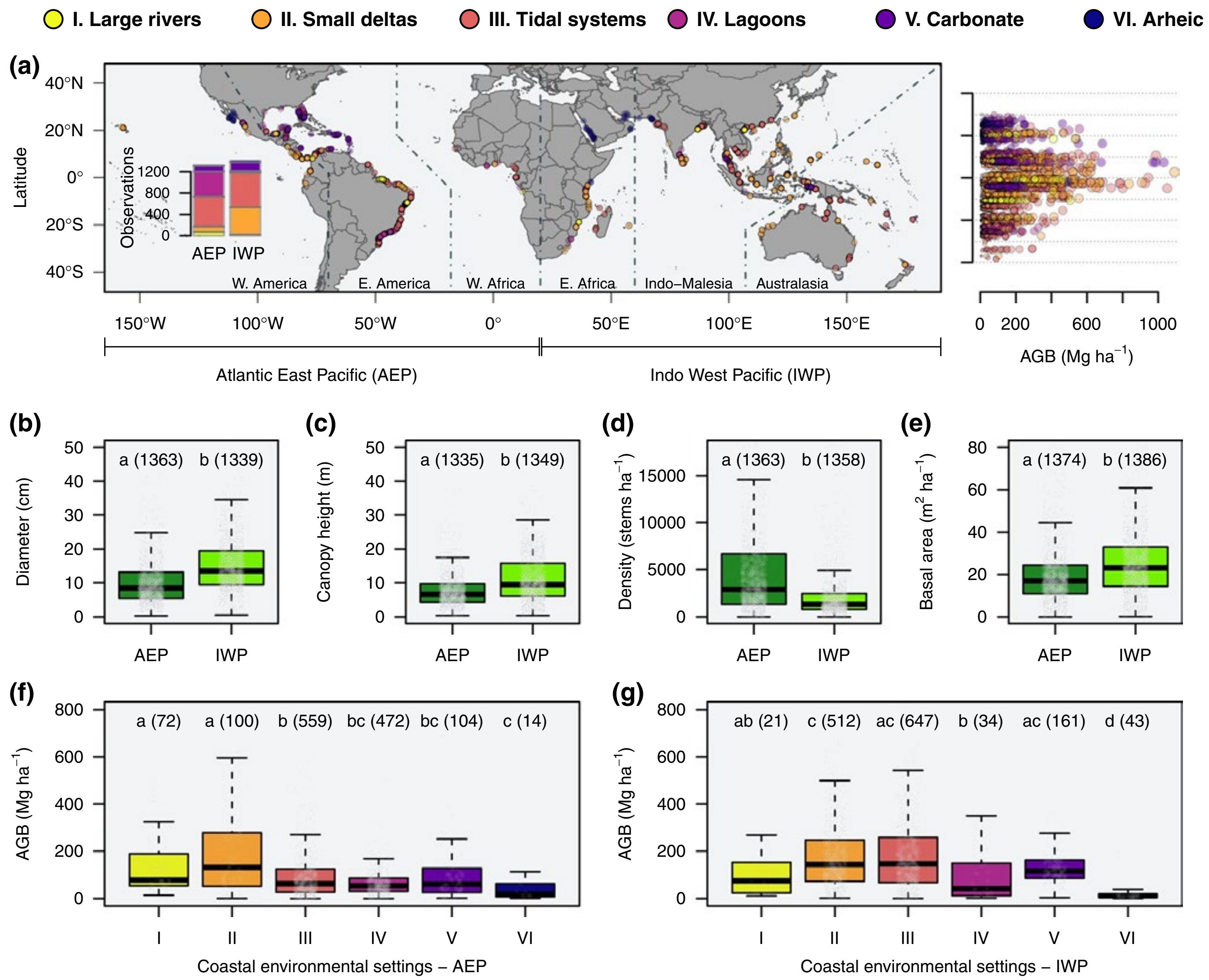


Figure 24. *Distribution of mangrove structural attributes and aboveground biomass (AGB) across biogeographical regions, latitude, and coastal environmental settings.* **(a)** *The total number of observations for AGB is distributed evenly between Atlantic East Pacific (AEP) and Indo-West Pacific (IWP) biogeographical regions but varies across distinct coastal environmental settings. The highest AGB values are generally found in the low tropics, but tall, well-developed stands also occur near subtropical zones.* **(b–e)** *Tree diameter, height and basal area are higher in IWP mangroves, but density (shown only up to 18,000 stems/ha to enhance visualization) is higher in AEP. Different lowercase letters on top of groups and numbers within brackets denote the statistical difference ($p < .05$) and number of observations for each group, respectively.* **(f, g)** *Mangrove AGB decreases:* **(f)** *from river-dominated to carbonate and arheic coastlines in the AEP, and* **(g)** *from river- and tide-dominated to arheic coastal environmental settings in the IWP. Reproduced from Rovai et al. (2021).*[124]

6.2 Aligning mangrove carbon projects with NDCs

How are NDCs relevant to mangrove restoration projects?

By understanding how mangroves are included within an NDC, and the processes used to quantify and report on climate mitigation (carbon) outcomes, it is possible to align project goals, objectives, and monitoring and reporting strategies with national targets. Doing this may then provide access to domestic or international funding streams intended to support countries in implementing the activities outlined in their NDC, for example, through payment for ecosystem services schemes[1] or REDD+ programs.

6.2.1 Nationally Determined Contributions

The value of coastal wetlands for climate change mitigation and adaptation are recognized by the United Nations Framework Convention on Climate Change (UNFCCC) under the Paris Agreement.

Under the Convention, countries set emissions reductions targets and report their progress towards achieving these targets every five years through a Nationally Determined Contribution (NDC) document. While NDCs are intended for communicating mitigation targets and planned actions, countries may also choose to communicate adaptation targets and actions within their NDCs.

Each country must develop specific pathways and actions for achieving their NDC targets, which are sometimes communicated in the NDC itself, in an accompanying implementation plan, or through the national regulatory framework.

NDC implementation actions often include policy incentives such as establishing subsidies for low-emissions practices or technologies, or for developing financial interventions such as carbon taxes and emission trading schemes,[125] which are designed to drive private sector investment in low carbon activities and technologies.

NDCs can include actions which address land use and land use change, which is the sector under which mangrove protection and restoration fall within the UNFCCC framework. The Agriculture, Forestry, and Other Land Use (AFOLU) and Land Use, Land-Use Change and Forestry (LULUCF) sectors are a portion of a country's emission sinks and sources and are inclusive of mangroves, although this is dependent on how a country defines its wetland and forest categories.[126]

Box 6 provides context as to how forests are defined. To include quantitative GHG targets in their NDCs for mangroves, countries should include mangroves and wetlands in their National Greenhouse Gas Inventory (NGHGI) to ensure consistent reporting and to enable reporting of progress at a national scale (Section 6.3).

Box 6: The United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Framework Convention on Climate Change (UNFCCC) defines a forest as "an area of land spanning more than 0.05 ha with tree crown cover (or equivalent stocking level) of more than 10% with trees with the potential to reach a minimum height of 2-5 meters at maturity in situ". Actual definitions can vary from country to country as the Kyoto Protocol permits countries to specify the precise definition within these parameters to be used for national accounting of emissions.[127] For example, in Brazil a forest is defined as an area of land greater than 1 ha, with more than 30% canopy cover and a minimum tree height of 5 meters. By contrast, Ghana defines a forest as an area of land greater than 0.1 ha, with more than 15% canopy cover and a minimum tree height of 2 meters.[128]

Definitions of "forest" influence the inclusion of different mangrove types within the forest category. Mangroves can form extensive scrub ecosystems where tree height can be less than 2 meters, even at maturity. These scrub mangroves can be included in the "wetlands" category in GHG Inventories. Scrub mangroves occur in arid regions, in regions with low nutrient availability and in areas with extended inundation.

Thailand, © Siriporn Sriaram, IUCN / MFF

The number of countries including mangroves within their NDCs as mitigation and/or adaptation actions increased with the submission of Second NDCs. The upcoming NDC revision cycle (2025) enables countries to submit more ambitious commitments in their NDC, including their ambition for coastal wetland conservation as a climate mitigation and adaptation solution. This should create funding pathways for mangrove conservation and restoration projects which contribute to national targets in an increasing number of countries. If a country is setting a GHG target related to mangroves, then emissions from mangroves need to be specified within the National Greenhouse Gas Inventory (NGHGI). The NGHGI is the main tool for reporting progress towards achieving NDCs within a country's Biennial Transparency Reports (BRT), which need to include relevant GHG information for each sector's GHG targets. Progress on the inclusion of mangroves or blue carbon targets within NDCs may be tracked via Global Mangrove Watch or the blue carbon in NDCs map.

While most countries have not yet specifically included wetlands within their national GHG inventories, there are opportunities to include mangroves within non-GHG quantitative and qualitative targets (e.g., reduce deforestation of mangroves by a certain percentage or restore a percentage of cover lost or degraded) to help drive action on the ground prior to establishing national GHG emissions reduction targets. If another metric is used (e.g., percentage reduction in mangrove clearance), the NDC needs to specify the methodological approach used and then be able to use that approach to monitor progress within the Biennial Transparency Reports. For countries to include and report emissions reductions for mangrove ecosystems, there needs to be either a description of the drivers of mangrove loss that can be avoided[131] or description of the opportunities to restore degraded mangroves.

Thailand, © Ana Grillo, IUCN / MFF

© Byelikova Oksana

6.2.2 REDD+

What is REDD+ and how is it relevant to mangrove restoration projects?

REDD+ programs provide national policy and financial support for the conservation and sustainable management of forests and enhancement of forest carbon stocks in developing countries. More than fifty countries with active REDD+ programs have explicitly referred to REDD+ in their first NDC as a part of their strategy to meet targets within the AFOLU sector.[129] If your project is in a country where mangroves are included in REDD+ activities, there may be opportunities to secure funding as part of a national program.

The UNFCCC Warsaw Framework and the Forest Carbon Partnership Facility (FCPF) Carbon Funds Methodological Framework include mangroves in the REDD+ framework in some circumstances.[125] For instance, the incorporation of mangroves in REDD+ is dependent on whether they are included in a country's definition of "forest" (see Box 6). Given that soil organic carbon is typically the largest carbon pool in mangroves it can be important to account for this in REDD+ programs which include mangroves; however in some developing countries there is limited technical capacity to assess soil carbon stocks, and since terrestrial forests typically have mineral soils which store less carbon, the soil carbon pool is often omitted from REDD+ project accounting.

For mangrove carbon projects, the "enhancement of forest carbon stocks" part of REDD+ is relevant to restoration activities – for example, restoring degraded mangroves for sustainable timber harvesting where such activities lead to an overall enhancement of carbon stocks. There is also the potential to incorporate mangrove restoration projects within a wider landscape of national REDD+ activities through 'nesting' of projects.[129,130] Examples of the incorporation of mangroves within REDD+ are described in the CIFOR Global Comparative Study on REDD+. The UN-REDD Programme maintains a list of partner countries with summaries of their national REDD+ programs.

6.3 Inventories

Reporting project contributions to climate goals

Methodologies for measuring carbon emissions for inclusion in national GHG inventories are published by the Intergovernmental Panel on Climate Change (IPCC). In 2013, the Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Wetlands Supplement)[132] was adopted. This set the stage for internationally agreed guidance on emission factors and carbon accounting methodologies specific for coastal wetlands. Reporting following the Wetlands Supplement allows countries to capture emissions reductions and removals from mangroves, tidal marshes, and seagrass meadows in their forest land categories (for mangroves that are defined as forests) and in the wetlands category (for shrub mangroves, tidal marshes and seagrass) within the Agriculture, Forestry, and Other Land Uses (AFOLU) and Land Use and Land Use Change and Forestry (LULUCF) section of a national inventory.

Where mangrove areas meet the definition of forest (Box 6) they can be included in REDD+ Forest Reference Emissions Level (FREL) / Forest Reference Level (FRL). However, shrub mangroves, which are extensive in many countries, can be included in the Wetland category of the inventory. Several countries have begun implementing the Wetlands Supplement in their inventory reporting, including Australia, the USA, Japan, and Canada. Inventories assist countries to better understand the dynamics of their coastal wetland ecosystems and to develop policies accordingly, as well as demonstrate enhanced ambition by actively maintaining the most updated data, and inclusion of all sinks and sources.[126] To enhance adoption of the Wetland Supplement, advice on incorporating Coastal Wetlands in National Greenhouse Gas Inventories has been developed.[114]

For mangrove restoration projects to count their emissions reductions towards national GHG inventories, measurement and monitoring approaches should align with the published IPCC guidance.

6.3.1 Monitoring approaches consistent with national inventories

An understanding of the requirements for national reporting (e.g., for GHG Inventories or REDD+) can inform the planning for monitoring of mangrove restoration projects, to ensure approaches in restoration projects are consistent with national requirements.

In national GHG Inventories there are three main approaches to determine changes in carbon stocks and fluxes which could be considered by mangrove restoration projects (as a proxy for CO_2 emissions) and which can also be used in NDCs and REDD+ programs.

1. **Stock-difference method** – This method estimates the difference in carbon stocks measured at two points in time. The results from such approaches may be considered as an IPCC Tier 3 estimate of emissions, which are those that are more complex and demanding.[113]
2. **Gain-loss method** – This method estimates the difference in carbon stocks based on emissions factors for specific activities (e.g., plantings, drainage, rewetting, deforestation) derived from the scientific literature and country activity data. This approach often uses IPCC Tier 1 (global) and Tier 2 (national) emission factors.[132]
3. **Flux method** – This method estimates the GHG flux between the soil and vegetation and the atmosphere/water column through direct measurements or by modeling. This approach may be considered as Tier 3, reflecting the high level of complexity in the measurements and calculations.[133]

Figure 25

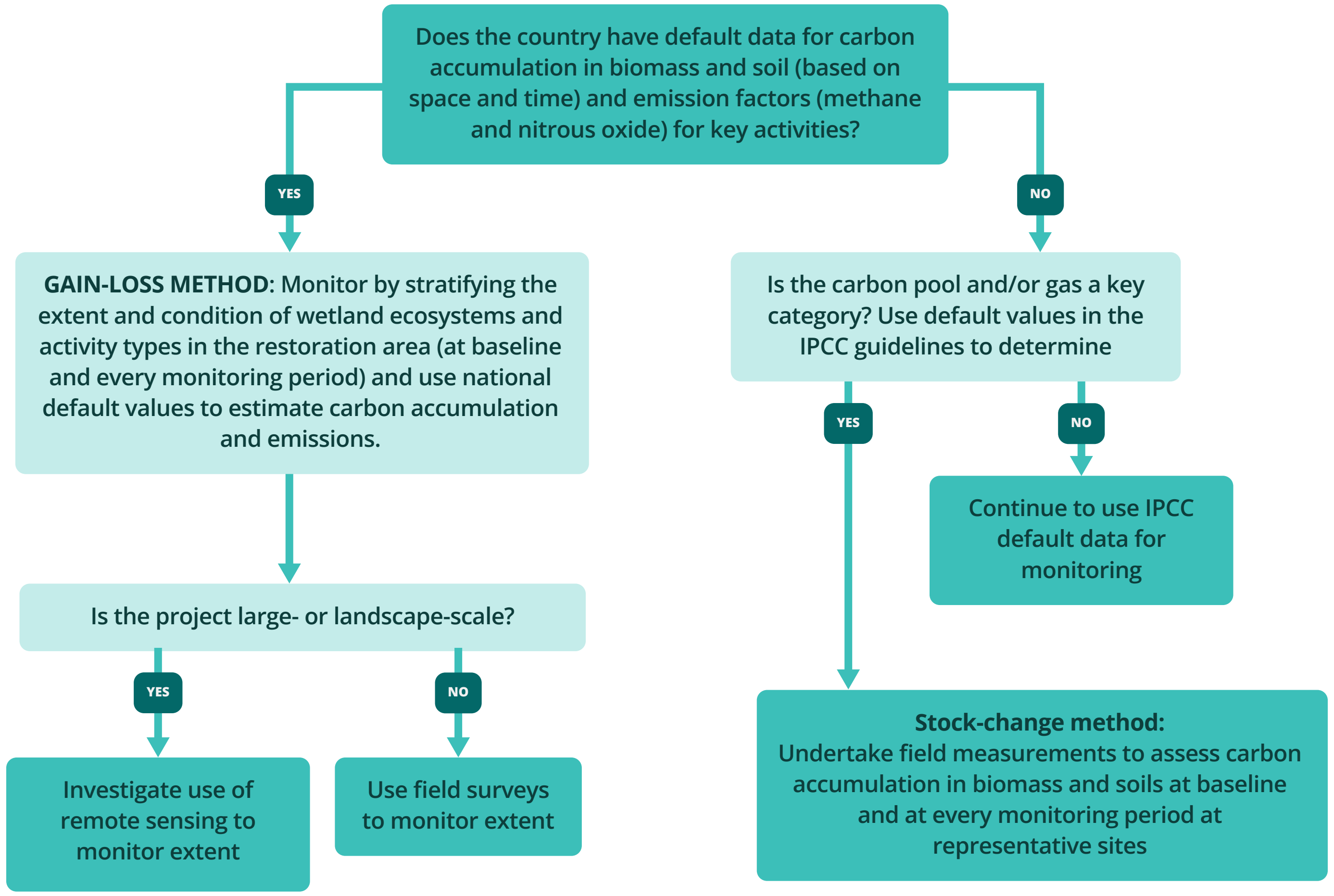


Figure 25. *Decision tree for deciding on the monitoring approach.*[134] *Created by Valerie Hagger for this publication.*

The approach selected will be based on the needs of the project, the resources available, and the level of accuracy required. Approaches chosen depend on the availability of national default data for carbon accumulation and emissions in mangroves and baseline land-uses, and whether the carbon pool or gas is considered a key category in that country.

Collation of carbon and GHG data from mangrove restoration projects can help improve national level reporting by improving national emission factors and supporting the development of national models (Tier 3 approaches).

Reprting of mangrove restoration projects should be sufficient to support complete, consistent, and transparent national inventory reporting. The 2013 Wetlands Supplement lists information specific to reporting of Wetlands in national inventories.[132] The guidelines related to reporting are summarized in Table 6. In designing monitoring for restoration projects knowledge of how countries are addressing the topics in the table can help with alignment of data streams. For example, documenting the previous land use, or stratifying the project in a way that is consistent with national definitions of land types, could make it easier for national inventory compilers to include restoration projects in the inventory, and could help in developing national policies for restoration of mangroves.

Table 6. *Recommended considerations to be included when reporting for national inventories.*

Information to document	Considerations
Methods for identifying restoration activities and land areas	Document your decisions on land representation, land-use/land cover definitions, stratification protocols, datasets, and auxiliary datasets.
Indication if emissions/ removals are associated with land that are not included in the total land extents	Provide explanation of land representation, including seaward and landward limits and how this relates to emission/removal estimates from adjacent ecosystems e.g., seagrass or other forested or agricultural land. It is important to understand the overall impacts of a restoration project.
Stratification protocols	Disaggregated activity data and emission factors/parameters used by important modifying variables e.g., elevation, climate regime (temperature, precipitation), nutrient status, ecosystem type and activity/system, as relevant, and the level at which the emissions/removals were estimated. A detailed description of the stratification applied to the project area and the associated activity data and emission factors will assist with communication of decisions made to calculate emissions and removals. A clear description of disaggregation will assist in transparency, which is important for national inventories and REDD+, if relevant. Documenting the activities reported as occurring in mangroves (or other coastal wetlands) can assist national inventories to identify and justify the selection of applied emission factors.
Details of country-specific emission factors applied	When country-specific emission factors or other parameters are used, documentation and references justifying their use enhances transparency including demonstrating that the adoption of country-specific emission factors/parameters result in an improvement in the accuracy of the estimates.
Results of key category analysis as the basis for explaining methodological choice for each carbon pool or GHG flux	List the criteria by which each GHG or carbon pool was identified as key e.g., level, trend, or qualitative, and the method used to conduct the quantitative key category analysis.
Quality control and archiving procedures	Documenting all system procedures e.g., in a series of standard operating procedures, assists in ensuring consistency in developing estimates each inventory period. Such documentation also assists in maintaining institutional knowledge. Evidence of implementation of the procedures, such as completed QC checklists, also assists in transparent reporting, and can provide increased confidence in the estimates during technical review. The 2006 IPCC Guidelines (Volume 1, Chapter 6, Annex 6A.) include useful generic checklists that can be applied at the subcategory level. Projects can also develop their own specific checklists to suit their needs.
Explanation of any data gaps	For data gaps, it is good practice to clearly report where reporting presents measured or monitored results and where it presents model output. Data gaps in estimations are common. Projects should fully document the splicing techniques applied to address such gaps.

6.3.2 Article 6

What is Article 6, and does it affect my project?

Article 6.2 of the Paris agreement lays out the framework for international GHG trading between countries or groups of countries through bilateral agreements. Governments may trade carbon between national inventories, in the form of ITMOs (Internationally Transferred Mitigation Outcomes). Like most carbon credits, each ITMO is equal to 1 t CO_2e and should satisfy additionality requirements.

Article 6.4 is concerned with replacing the Clean Development Mechanism carbon crediting program with an updated sustainable development mechanism which facilitates carbon trading under the oversight of a UN supervisory body and international registry. UN accreditation may provide an alternative to the VCM for some mangrove carbon projects.

Article 6.8 proposes a framework of non-market approaches for countries to voluntarily cooperate and collaborate to achieve NDC goals without GHG trading. Article 6.8 activities may include capacity building, technology, developmental aid, or other finance mechanisms.

Priority areas include "Mitigation actions to address climate change and contribute to sustainable development", which could include investment in nature-based solutions.

At the time of writing much of the operational infrastructure for Article 6 is still in development, with clear rules and guidance on how blue carbon projects may be supported at local or national scales by different countries not yet available. However, when designing mangrove restoration projects which include measurable climate mitigation goals it's important to look out for emerging opportunities created by Article 6 activities.

Mangrove carbon projects with international investors that intend to use ERRs generated by the project to offset emissions in another country need to evaluate the impacts of Article 6 GHG trading rules during project planning. It's critical to check if blue carbon is included in national GHG inventories or otherwise counted towards NDC goals, and whether corresponding adjustments are required.

Mangrove field data collection and drone training in Senegal as part of the Mangrove Watch Africa Project, © Lammert Hilarides, Wetlands International

© EcoPic, iStock

Corresponding adjustments

Article 6 of the Paris Agreement includes requirements for government authorization and application of a corresponding adjustment to national greenhouse gas inventories. This is to ensure there is no double counting of carbon credits towards both national GHG inventories and towards the climate mitigation targets of the buyer.

Corresponding adjustments are required whenever carbon credits from any sector are transferred internationally for use:

- Towards an NDC
- For international mitigation purposes other than the achievement of the NDC (e.g., for industry offsets)
- For other purposes defined by the host country.

Through a corresponding adjustment, the country that produces the ERRs and transfers them can no longer count those emission reductions towards its NDC commitments and subtracts them from its GHG inventory. Corresponding adjustments are mandatory for the transfer of any ITMOs between countries, but it is a national prerogative to decide whether the voluntary carbon market is subjected to the Article 6 rules. Some buyers of carbon credits will assign a higher value to credits which have a corresponding adjustment, as having this in place removes any risk of exposure to double counting claims. In any scenario, there should be transparency in the way the use of the carbon credits is communicated.

6.4

Designing mangrove projects for carbon markets

An opportunity for long-term income

While blue carbon is currently a small slice of the carbon market "pie," blue carbon finance has the potential to grow overall investment in coastal and ocean nature-based solutions and resilience.[135] Mobilizing private and public-sector finance toward the protection and restoration of blue carbon ecosystems is a significant opportunity, to secure funding for high-quality carbon credit projects that catalyze achievement of climate targets while protecting people, respecting and accounting for local knowledge and tenure rights, and securing biodiversity benefits.

While credit sales can provide an additional long-term income for project operations, this will most likely need to be combined with other funding streams for initial project development.

The generating of income from carbon credits should not be the primary objective of any project, but rather should be regarded as any other funding stream – a means to achieving long-term social or ecological objectives.

Many restoration efforts fail because sustained funding is not secured beyond the life of early project phases, or because short term funding grants are linked to ineffective restoration activities such as mass planting without long term monitoring. This is one reason why carbon markets offer such promise for mangrove conservation and restoration, as revenue from the sale of carbon credits is dependent on successful restoration and tied to long-term monitoring requirements. For coastal communities, carbon projects could supply long-term income streams that are more reliable than other sources, such as ecotourism. In the case of the Mikoko Pamoja project (see Case Study at the end of Module 1 Blue carbon), selling carbon credits has met expected targets for ten years and demand for credits is high and expected to increase.[135]

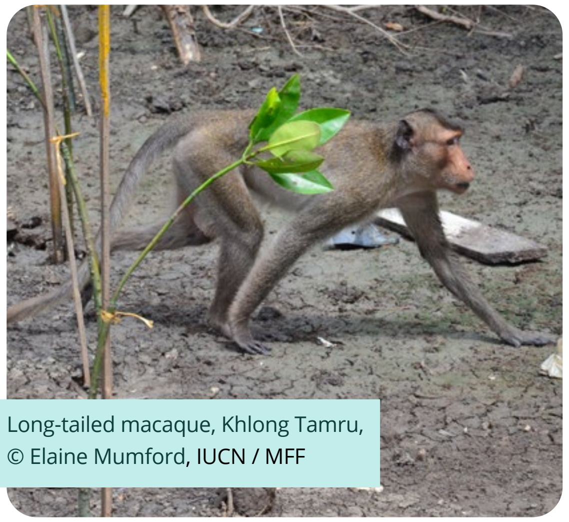
There are two main types of carbon credit markets: the voluntary carbon market (VCM) and compliance market.

Compliance markets are created by national or regional programs governed by individual countries or international agreements which regulate GHG emissions. In order to enable compliance with regulatory requirements, emissions may often be traded in the form of credits or other allowances. National or regional compliance markets generally have strict rules on the type of credits which may be traded, how they are produced, and which GHG crediting programs or equivalent organizations are permitted to issue them. Projects with the goal of producing and selling credits into a compliance market will need to be certain the credits meet market requirements.

The voluntary carbon market (VCM) includes national or international carbon markets where carbon credits may be purchased by any individual or organization, either for onward trading or for use to achieve their own net zero or emissions reductions targets outside of compliance regulations. There are an increasing number of GHG crediting programs issuing different types of credits, and it may be challenging for both project managers and credit buyers to identify which are appropriate for their needs.

As the VCM grows and evolves, there is a recognised need for clear guidance on which GHG crediting programs adhere to best practices and have a sound basis in robust science. The International Carbon Reduction and Offset Alliance (ICROA) and the Integrity Council for the Voluntary Carbon Market (ICVCM) are independent bodies which assess GHG crediting programs and standards. To produce credits for international trading on the VCM, you should select a GHG crediting program which is certified or endorsed by one or both organizations.

Individual countries may also regulate VCM activities within their borders, restrict international transfer of some credit types produced in that country (Section 6.3.2), or administer their own national standards for voluntary use. Examples include the Peatland Carbon Code in the United Kingdom, the Thailand Voluntary Emission Reduction Program, or the Australian Carbon Credit Unit (ACCU) scheme, which includes a domestic methodology for producing mangrove carbon credits (BlueCAM).[136]



Long-tailed macaque, Khlong Tamru, © Elaine Mumford, IUCN / MFF

Van Oord at Quelimane, Mozambique, © Dom Wodehouse, Mangrove Action Project

While the voluntary carbon market is a potential source of reliable funds, achieving accreditation – the process of measuring and verifying ERRs for the purpose of issuing credits – often requires at least two years of costly work. Once established, your project will need the resources to market, sell and administer credits that are generated. These are specialist roles that need expertise and skills, often requiring investments in capacity building.

Privately funded mangrove restoration projects which are aiming to quantify ERRs for funders to claim against their own "net zero" goals avoid the need for full accreditation, as they do not need to sell credits. However, for any claimed ERRs to be credible, and to avoid accusations of greenwashing and reputational risk, privately funded mangrove carbon projects should also use a methodology accepted by an ICROA or ICVCM certified GHG crediting program or, where appropriate, national or regional compliance markets. Where cost and capacity limit this option, only highly conservative ERR claims should be made, based on IPCC or regional default values and applying a risk adjustment/buffer pool similar to those used by GHG crediting programs. Funders of private mangrove carbon projects should also require, and be prepared to pay for, third party verification of their claimed offsets; the following sections are therefore also applicable to inform the design of private projects of acceptable quality.

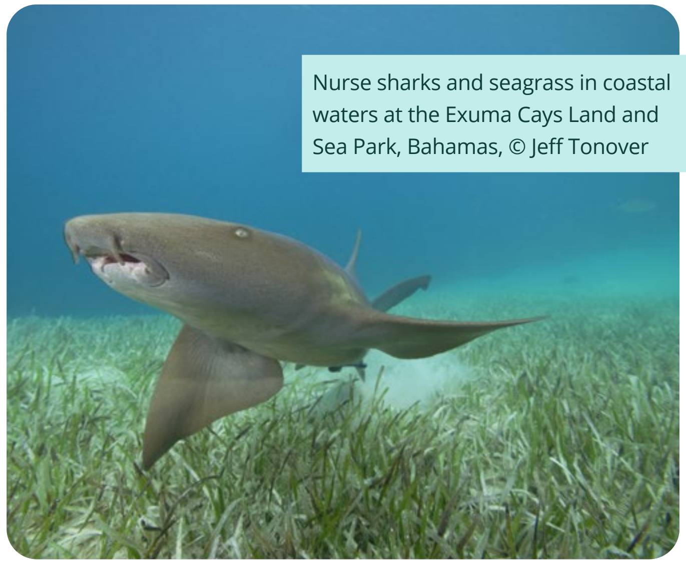
At the project level, to reduce potential risks to communities and the environment from the expanding interest in mangrove carbon credits, the High-Quality Blue Carbon Principles and Guidance and the Global Standards for Nature Based Solutions should be used to guide project development and inform ethical financing decisions.

6.4.1 High-quality blue carbon principles and guidance

Carbon projects that aim to bring benefits to people and the climate can be discredited by association with poor project developers and public perceptions of greenwashing. In an effort to learn from terrestrial forestry carbon projects, the blue carbon community has produced The High-Quality Blue Carbon Principles and Guidance which aims to provide a consistent and accepted framework which defines "high quality" blue carbon credits for project developers, investors, suppliers, and credit purchasers, and can form the basis of a more informed due diligence process.

The key principles are:

- Safeguard nature
- Empower people
- Employ the best information, interventions, and carbon accounting practices
- Operate locally and contextually
- Mobilize high-integrity capital.



Nurse sharks and seagrass in coastal waters at the Exuma Cays Land and Sea Park, Bahamas, © Jeff Tonover

These principles and guidelines address knowledge gaps and mismatched expectations between project developers and investors by laying out a set of ethical buying and funding considerations for blue carbon credit buyers. Aligning your project design to the points outlined in the blue carbon buyers' principles can ensure the project meets buyers' definitions of high quality, fulfills their due diligence requirements, and facilitates access to corporate finance. Financers who commit to a principled approach to blue carbon investment should be considered a preferred source for project financing.

6.4.2 Steps to producing verified carbon credits

This section provides an overview of the verification process for emission reductions and removals (ERRs) from mangrove restoration projects and the issuance of carbon credits.

What are standards and methodologies, and what are the differences between them?

To produce carbon credits, mangrove restoration projects register under an accepted GHG crediting program. Each GHG crediting program has a strict set of rules called a standard, governing project eligibility, accepted activities, and project design. The measurement and recording of ERRs achieved by the project, and any emissions caused by project activities, must follow set technical methodologies. A third-party audit is used to validate that the project adhered to the standard requirements, and to verify the amount of ERRs measured in accordance with the selected methodology. Once the claimed ERRs have been verified, the GHG crediting program issues a corresponding number of tradable certificates – credits – on behalf of the project. Credits issued are recorded in a publicly accessible registry administered by the GHG crediting program.

For example, Verra is a GHG crediting program, the Verified Carbon Standard (VCS) is the standard they administer, and the VM0033 is their methodology for measuring GHG fluxes in blue carbon projects.

Somewhat confusingly, GHG crediting programs are often colloquially referred to as "standards", with the term being used to refer to both the organization and the standard they administer.

Third-party verification of mangrove restoration projects and the ERRs that they achieve under a recognized blue carbon standard/method ensures that projects meet accepted quality standards for trading carbon credits in voluntary or compliance carbon markets. A simplified step-by-step to the carbon accreditation process is outlined on page 176. Although there are some differences among each of the GHG crediting program requirements, methodologies, and verification processes, most include the following steps in the third-party verification process.


© Srikanth Mannepuri / Ocean Image Bank

1. **Pre-feasibility** – Initial investigation of the potential site, confirmation that there is a route for land tenure and carbon rights to be secured (Module 1), stakeholder identification and basic mapping of site area (Section 2). Confirm that the project team has access to sufficient technical capacity for GHG data collection and modeling, and review which GHG crediting programs and methodologies are appropriate.
2. **Feasibility** – All the information required to understand if the project is viable is gathered into a report which lays out goals and objectives, site ecology and restoration strategy, details of initial community and stakeholder interactions, and supporting data (Section 3). It is logical to base the project feasibility report on the first stage documentation required by the selected GHG crediting program, ensuring data collected aligns with the data required at the next stage of development, although at this stage carbon values and other cost-prohibitive data points can be based on local averages rather than site-specific measurements. Most grant makers or investors will require a feasibility study before agreeing to fundany further work.
3. **Draft project description document (PDD) or project idea note (PIN)** – Depending on the GHG crediting program selected, the project developer submits a draft project description document (PDD) or project idea note (PIN), which includes basic project information (e.g., project location, area and start date), application of the methodology and estimates of the ERRs the project activity will achieve, and any information about stakeholder engagement or environmental safeguards.
4. **Validation and verification audits** – Validation is the third-party audit of the project design against the standard of the GHG crediting program and applied methodology. Typically, a validation audit consists of a desk-top review of the project description and any supplementary information or calculation spreadsheets. The auditor may also conduct a site visit to the project area to confirm the information included within the project description and conduct interviews with local stakeholders and any project partners. Throughout this process, the auditor may issue findings that the project developer must address before finalizing the audit. Typically, these findings fall into one of the following categories:
    1. Clarification requests for additional information or questions about the information included within the project description
    2. Corrective action requests for updates that must be made to the project design or documentation in order to comply with the GHG program standard
    3. Forward action requests for changes to the project that should be implemented prior to the next audit (e.g., before the next verification audit).

Some GHG crediting programs do not include a separate validation step and the process described here and the validation audit is carried out during the first verification audit (see point 5 below).

5. **Project registration** – After successfully completing the validation audit, projects can register under the program. Note that most GHG crediting programs will conduct a separate review of project and audit documentation before officially registering a project. Validating, verifying, and registering projects incurs a separate cost for each step of the process.
6. **Activity implementation and monitoring** – Project developers implement activities and monitor the project over the project lifetime. Periodically, the project developer will complete a monitoring report (or equivalent reporting document) to report on the measurements of the project's benefits and to quantify the ERRs achieved during a specified time period. Chapter 5 provides an overview of project monitoring.
7. **Verification audit** – Verification is the third-party audit of a project's ERRs detailed in a monitoring report (or equivalent reporting document). Like a validation audit, typically a third-party auditor will first conduct a desk review of the monitoring report and all supporting documentation (e.g., data and calculation spreadsheets). The third-party auditor will also conduct a site visit to confirm activity implementation and project measurements and conduct interviews with project participants. They may issue findings which the project developer must resolve before the verification can be finalized. Funds to cover the cost of verification should be allocated during project planning.
8. **Carbon credit issuance** – After successfully completing a verification audit, projects can issue the verified ERRs as carbon credits. Most GHG reporting programs will conduct a separate review of project and audit documentation before issuing the credits. Each crediting project also undergoes a risk assessment and a percentage of ERRs are not issued as credits, but are rather held in a buffer pool to compensate for any differences between predicted and actual emissions reductions and removals, and for any damage to the project site, for example by hurricanes or illegal cutting.
9. **Periodic verification and credit issuance** – Carbon projects are required to monitor and report on implementation success, any damage to the site or unforeseen emissions, adjustments to project baselines and carbon models, and ERRs achieved throughout the project lifetime. For credits to continue to be issued, projects are subject to repeat third-party verification audits at set periods, typically every three or five years. Credits are also issued periodically, and the volume issued is adjusted accordingly, while any failure to adhere to the rules of the accrediting standard may result in non-issuance of credits, and review of the project by the GHG crediting program. The year credits are issued is commonly referred to as the credit vintage.

© Joeri Borst, Wetlands International

6.4.3 Pick a standard and methodology

If a restoration project is suitable as a carbon project, the next step is to align project activities to a carbon standard and a specific carbon methodology.[138]

Each GHG crediting program administers its own standard, and will usually accept one or two methodologies for assessing carbon stocks and monitoring ERRs. Methodologies may incorporate monitoring criteria for multiple intervention types – for example avoided deforestation, improved forest management, or ecosystem restoration – or multiple accepted methodologies may have to be used in order to report on each activity in accordance with standard requirements.

Most GHG crediting programs will only accept the use of methodologies which they publish and update themselves, or via specialized scientific consultancies. A few may accept the use of methodologies developed by other academic or international bodies. For example, the Verified Carbon Standard (VCS) administered by Verra requires ERRs to be quantified using their own published methodologies, VM0007 and VM0033, while The Plan Vivo Foundation currently permits mangrove projects to use the AR-AM0014 methodology published by the UNFCCC Clean Development Mechanism (CDM) program. At the time of writing, Plan Vivo are also set to publish a dedicated mangrove carbon credit methodology, and have active test projects for an innovative biodiversity crediting methodology.

Of the 19 publicly visible mangrove carbon projects that had been developed or were undergoing development in early 2022, most (14) used the Verra VCS as the standard while VM0007 (REDD+ Methodology Framework) and AR-AM0014 (afforestation and reforestation of degraded mangrove habitats) were the most used methodologies. Some projects used a mix of both restoration and conservation activities.

Blue Water Mangroves on Mansuar Island. The lack of wave action combined with clear water allow corals to grow very near the surface in this unique environment, © Conservation International

At the time of writing, it is expected that Verra will revise their VM0007 and VM0033 methodologies and consolidate the requirements for blue carbon projects within a single accepted methodology, VM0033.

In addition to measuring and reporting ERRs, there are standards which include reporting requirements for the socioeconomic impacts of mangrove carbon projects, and for monitoring effects on biodiversity. For example, Verra administers the Climate, Community and Biodiversity Standard (CCB).

This standard provides a framework to report on verifiable benefits such as job creation, access to health services, or protection of endangered species, and may be applied to mangrove restoration projects either independently of or in addition to VCS certification.[125] Verra also administers the Sustainable Development Verified Impact Standard (SD VISta) standard, while the Gold Standard has developed the Gold Standard for Global Goals (GS4GG). SD VISta and GS4GG both issue tradable credits that represent project contributions to the United Nations Sustainable Development Goals, and both may be applied as either standalone or additional certification for mangrove restoration projects.

The Plan Vivo standard incorporates mandatory reporting on community and biodiversity impacts, and also applies strict requirements on inclusivity, transparency, and equitable benefit sharing, with a set minimum of 60% of income from carbon credits to be assigned to community programs.

It is important to note that if mangrove carbon projects quantify the full range of benefits provided (e.g., biodiversity, food provisioning and water quality benefits) and are certified to holistic schemes such as the CCB Standard or the Plan Vivo Standard, this may attract a premium from potential private and public sector carbon project investors and carbon credit purchasers.

This can mean that even relatively small-scale projects can be economically feasible.[139] There is significant variation in price among different project types and standards. Plan Vivo, for example, had the lowest share by volume in the voluntary market in 2021 (0.7m credits issued compared to 125.6m for Verra) but attracted the highest purchase price on average, USD 11.58 per credit compared to USD 4.17 for Verra. Recent sales of Verra blue carbon credits with additional CCB certification have attracted a much higher price of USD 18-29 per VCU. This is comparable to the recent value of Plan Vivo blue carbon credits which retailed for around USD 25 average in 2022-23.

The voluntary market standards and methodologies relevant for mangrove restoration and conservation projects are summarized in Appendix F and Appendix G, while Appendix H summarizes examples of mangrove carbon projects from around the world.

Decisions on which methodology is appropriate for a project depends on many factors that include location, national laws, scale of the project, cultural preferences, human capacity, finance, and others.125,138 For those intending to use the VCS methods, Figure 26 provides a decision tree to help guide you to select the most appropriate VCS methodology.

Mangrove crab fisherwomen, © Blue Ventures

Figure 26

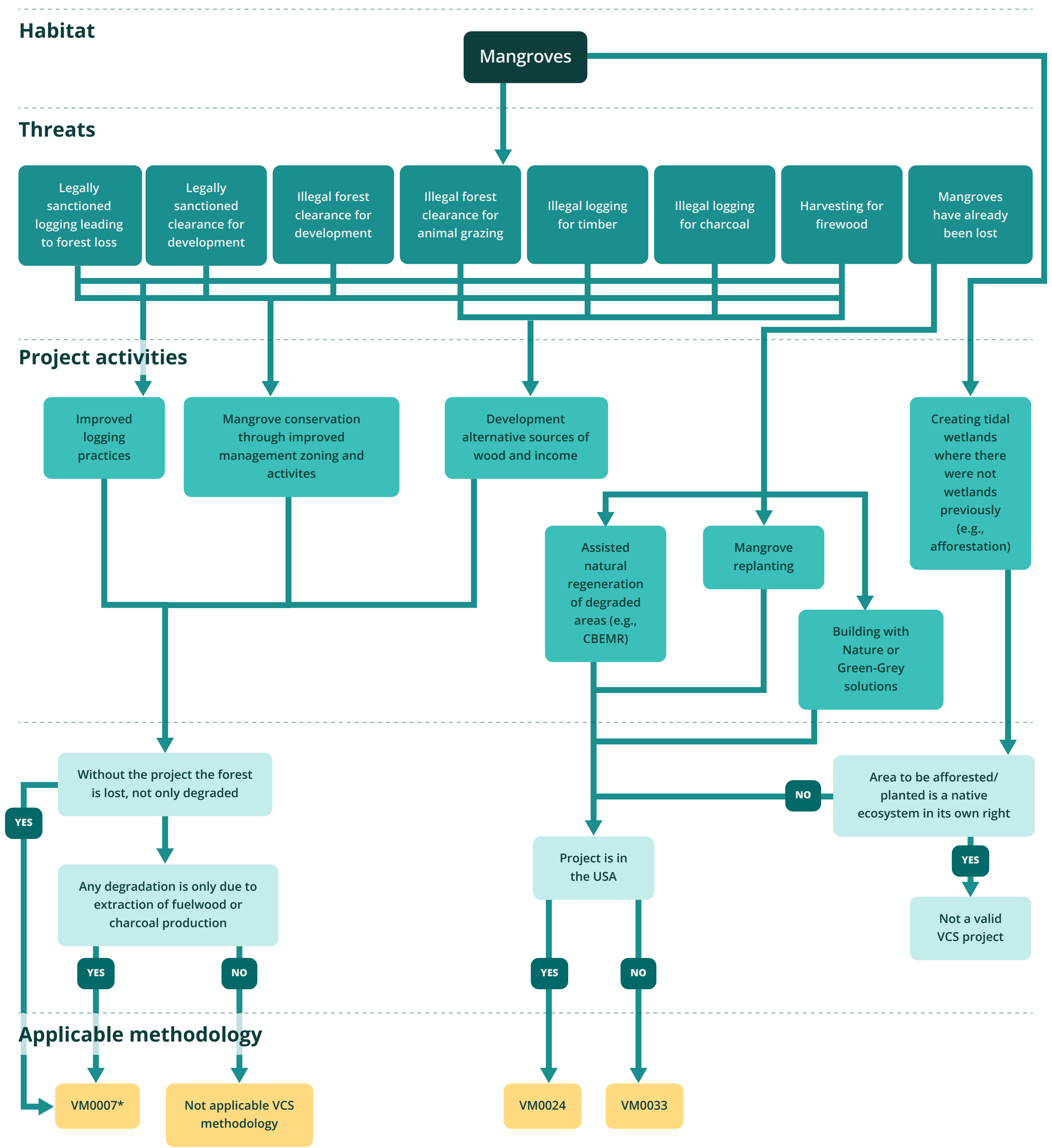


Figure 26. *Selecting the correct methodology for different project types under the Verra VCS Standard. Leah Glass, Sylvestrum Associates.*

Harvesting from the mangroves in Demak, Central Java, Building with Nature Indonesia initiative, © Wetlands International @Nanang Sujana

6.4.4 Developing project design documents/ project idea notes for carbon projects

Once the type of carbon project category and standard/methodology that is most appropriate has been selected, the next step is to assess feasibility, informed by the procedures for registration, additionality, and in some instances benefit sharing and governance described by the standard, and the data required to develop the project design documents (PDD). In most instances, the PDD (or PIN) template can be used as a framework to assess feasibility.

Some common requirements of these documents include:

- Demonstrating additionality
- Addressing requirements for permanence and leakage
- Estimating the volume of project derived carbon credits while ensuring an appropriate buffer pool (or reserve) of credits are set aside to mitigate risk.

These requirements are common to all nature-based carbon projects and are briefly outlined in Table 7 with specific examples of their application to mangrove restoration projects.

Table 7. *Outlines of required assessment criteria for mangrove carbon projects.*

Criteria	Outline
Baseline scenario (or without-project scenario)	The baseline scenario is a projection of what would occur in the absence of the restoration project activity. For mangrove restoration projects, the baseline scenario is usually defined as a continuation of existing land use (e.g., agriculture or degraded land). The specific methodology used for a project will set out procedures for projects to determine and justify the chosen baseline scenario. Baseline emissions are the GHG emissions and carbon stock changes that are expected under this scenario.
Project scenario	The project scenario is a description of what occurs when project activities are implemented. For mangroves, project emissions include any GHG emissions (e.g., CH_4 and N_2O emissions from restored wetland soils) and carbon stock changes (e.g., in aboveground biomass, belowground biomass, and soil organic carbon) that occur in the project scenario. Methodologies establish procedures to estimate and monitor the GHG emissions and carbon stock changes achieved by the project.
Additionality	For carbon projects, management interventions that develop certifiable carbon credits need to pass a test of "additionality" to determine whether an emissions reduction or removal would have occurred in the absence of the intervention[140,141] and therefore is not a continuation of "business as usual". For example, under an avoided deforestation scenario there needs to be a specific driver of deforestation (e.g., logging) which can be alleviated to avoid on-going emissions. In the case of reforestation, interventions must increase CO_2 capture through regrowth above what would normally occur. If there is no driver of loss to avoid and forests remain largely intact (i.e., little evidence of either historical or on-going mangrove loss from harvesting), projects would be unable to meet this requirement. Additionality is commonly demonstrated using an investment or barrier analysis, to show that there are financial or other barriers to implementing the project activities. Mangrove carbon projects registered under Verra and using the VM0007 and/or VM0033 methodologies may use a "positive list" method, where projects that implement activities on the "positive list" are automatically deemed as additional and do not need to further demonstrate additionality. Positive lists are created for regions based on potential uptake (activity penetration), finance available and income streams[141] (see https://verra.org/wp-content/uploads/2018/03/VCS-Guidance-Standardized-Methods-v3.3_0.pdf for details)

Table 7. *Continued...*

Criteria	Outline
Permanence	Permanence in carbon projects refers to the need for the carbon sequestered or GHG emissions avoided in a carbon project to be achieved permanently, which is usually defined as being achieved for a minimum of 100 years. Carbon credits are usually issued in the first 20-30 years of the project, but permanence criteria apply for long after this crediting period. Because of the permanence criteria, projects are intergenerational, requiring particular attention to land tenure arrangements, planning for long-term livelihoods, and consideration of climate change impacts on the project, including those of sea level rise (see Section 2.3.2 and Box 5 below). Carbon credits from most types of natural climate solutions projects are at a risk of non-permanence (or "reversal") because the carbon stored in ecosystems could be released due to human actions (e.g., poor management or over harvest) and natural events (e.g., flooding or storms). All GHG crediting programs have mechanisms to ensure the permanence of carbon credits issued from projects. Many require projects to set aside a percentage of the carbon credits they verify into a risk buffer account, which can be used to compensate for any carbon stock losses that may occur in the future.
Leakage	Leakage refers to any increase in GHG emissions outside of the project area which can be attributed to project implementation (e.g., via a shift in the location of deforestation or degradation activities to outside of the project boundary), resulting in no net change in global emissions because emissions continue to occur. Although mangrove restoration projects are at a low risk of leakage, it can occur due to activities moving to new areas (e.g., agriculture or fuelwood removal) or to activities such as changes to hydrology negatively affecting areas that are hydrologically connected (e.g., terrestrial forests). To reduce the risks of leakage, some projects (e.g., Mikoko Pamoja) have included the planting of terrestrial tree species as an alternate fuel wood supply. Methodologies for mangrove restoration include specific procedures for projects to measure or estimate any emissions from leakage.
Estimating carbon credits generated by the project	At a high level, ERRs achieved by mangrove restoration projects are calculated as the difference in GHG emissions and carbon stocks in the baseline and project scenarios, minus any emissions from leakage. When projects are registered, project managers estimate the amount of ERRs that are anticipated by the project. Each methodology has instructions on how to estimate the ERRs that are expected to be achieved by the project over time, based on the best available scientific data (Appendix F). The changes in carbon stocks and GHG emissions are projected over the life of the project. Projections of ERRs achieved by a mangrove restoration project can be used to estimate the value of the project, assuming a price for carbon credits. Projections can be used to evaluate the financial and economic feasibility of the project using approaches like cost-benefit analyses. These kinds of approaches can aid in decision making. For example, the value of carbon sequestered over the lifetime of a project as well as the value of other benefits were used in a cost-benefit analyses to compare benefits from aquaculture and that from mangrove restoration projects in the Philippines.[142]

Box 7: Climate risks to blue carbon projects – understanding climate risks

Climate change poses a risk to blue carbon projects, but the level of risk depends on a wide range of factors. Section 2.3.2 provides guidance on how to do a vulnerability assessment for a restoration site and some of the factors to consider when devising management actions to reduce a projects sensitivity to climate threats.

For blue carbon restoration projects, the risk of CO_2 emissions is related to disturbances to the project that are likely to lead to remineralisation of organic carbon see (Figure 27, Lovelock et al., 2017).[143] Disturbances could be damage by storms that lead to loss of aboveground biomass or erosion of shorelines, both of which would release stored carbon (in biomass and soils) so that it would be decomposed on either the soil surface or coastal waters and emitted to the atmosphere.

Risk matrices are a useful way of conceptualising levels of risk. In sites with low carbon stocks most disturbances, including those from climate change, are likely to have low risks of CO_2 emissions, while sites with high carbon stocks the risks of CO_2 emissions with disturbance are much greater.

Disturbances vary in their potential to cause mineralisation of stored carbon. For example, thinning canopies for firewood may have a low potential for CO_2 emissions, while disturbances with high potential for emissions would include excavation of soils for ponds. Disturbances due to climate change could include increases in inundation with sea level rise[39] that result in declines in aboveground biomass (that might occur over decades in a high intertidal estuarine site), while climate disturbances that have a high potential for emissions would include intense storms that lead to erosion of shorelines (liberating stored soil C), or extended flooding or drought that results in mortality of aboveground biomass.

Mangrove fisher in Nevis, Eastern Caribbean, © Mark Spalding

Figure 27

		Soil carbon stock				
		Low C_{org} stock (<50 mt ha $^{-1}$)	Low-moderate C_{org} stock (50-100 mt ha $^{-1}$)	Moderate C_{org} stock (100-250 mt ha $^{-1}$)	Moderate-high C_{org} stock (250-500 mt ha $^{-1}$)	High C_{org} stock (>500 mt ha $^{-1}$)
Descriptions of potential for reminerализation	**Relative scores**	1	2	3	4	5
Low	1	1 (Low)	2 (Low)	3 (Low)	4 (Low)	5 (Mod)
Moderate	2	2 (Low)	4 (Low)	6 (Mod)	8 (Mod)	10 (Mod-high)
Moderate-high	3	3 (Low)	6 (Mod)	9 (Mod)	12 (Mod-high)	15 (High)
High	4	4 (Low)	8 (Mod)	12 (Mod-high)	16 (High)	20 (Very high)
Very high	5	5 (Mod)	10 (Mod-high)	15 (High)	20 (Very high)	250 (Very high)

Notes: Mt = metric tons. The relative rise of CO2 emissions varies from low (blue, scores 1-4); moderate (green, 5-9); moderately high (yellow, 10-12); high (orange, 15-16); to very high (red, 20-25). Final scores (from 1, low likelihood to 25, very high likelihood) were obtained by multiplying the scores related to likelihood of remineralization and the magnitude of Corn stocks.

Figure 27. *Risk matrix of CO_2 emissions with varying size of soil Corg stock and relative rate Corg remineralization. Reproduced from Lovelock et al 2017.*[143]

6.4.5 Project feasibility for blue carbon credits

How do I know if I can do this, and does it make sense for my project?

There are several steps to determine whether a project is feasible for carbon crediting. All the feasibility criteria for mangrove restoration projects described in Sections 2.2 and 3.2 apply, but the quantification and trading of ERRs introduces additional legal, technical, social and financial complexities to consider.

While in practice, technical, social, and financial steps may be completed concurrently, assessing the legal and policy conditions surrounding carbon credit trading should always be carried out first.

Political and legal feasibility

The demand for blue carbon credits has increased rapidly in the last two years,[135] encouraging more NGOs and aspiring project managers to explore the potential to produce and sell carbon credits in different geographies. It is not uncommon to discover that policy in your country of operation has not yet been updated or expanded to fully accommodate the legal operation of crediting projects in coastal marine ecosystems[126,141,144]. Many countries are currently in the process of defining rules for national and international carbon trading, and it is critical to watch this process closely to ensure compliance with future legislation.

Checking the registries of GHG crediting programs to see if nature-based credits are produced and available to purchase in the host country is a logical first step to establish if there is already a potential pathway for legal operation in place. If there is no clear discoverable policy basis for trading carbon credits either domestically or internationally then exercise caution, be prepared to engage with the relevant government agencies to clarify the situation, and budget an appropriate time cost into project plans. At the time of writing the national policy landscape for blue carbon and carbon trading in general is progressing fast.

It is important to determine whether the host country defines mangroves as terrestrial (forest), marine, or wetland ecosystems, if they are included in actions targeting LULUCF or AFOLU categories within a country's NDC, and especially if mangrove carbon stocks and emissions factors are included in national GHG inventories. Whether corresponding adjustments are required to correct instances of double counting for ERRs traded as credits on the voluntary carbon market is at the discretion of each individual country (see Section 6.2.1).

The intention to produce credits for the voluntary carbon market brings added complexity to navigating laws determining land tenure and usage or management rights. In addition to establishing the right to carry out restoration activities (Section 2.2.1 and 3.2.2), you will also need to establish the right to claim the ERRs resulting from the carbon project as a tradeable asset. This is generally known as establishing "carbon rights". You should not assume that securing ownership or land management rights for the mangrove restoration site includes carbon rights by default.

In some countries, as with securing land tenure, legally recognized community resource management groups such as forestry or fishery organizations may provide a viable route to securing carbon rights as a community resource, which can also support integrating community leadership and inclusive governance into project management structures.[26]

Ecological feasibility

All nature-based carbon projects measure emissions against a "baseline" scenario, which is an assumed "business as usual" (BAU) scenario that would occur in the absence of the project. In a REDD+ project, for instance, the BAU scenario involves emissions resulting from continuing forest loss or degradation, and the carbon benefit results from emissions avoidance (i.e., halting loss and degradation through, for instance, canceling logging rights) and from restoration. In a mangrove reforestation project developed on abandoned aquaculture ponds, the carbon benefits result from carbon sequestration in vegetation and soils and lowered emissions compared to the BAU.[125,139]

The process for assessing the volume of carbon credits from restoration can be summarized as:

1. Determine a realistic BAU scenario for assessing on-going emissions (e.g., abandoned aquaculture ponds which emit CO_2 to the atmosphere).
2. Estimate the amount of GHG emissions that the project avoids, reduces, and sequesters (Section 6.5), as well as any GHGs emitted from project activities (e.g., fuel used in transport). Guidance for estimating ERRs from mangrove restoration projects can be found in The Blue Carbon Manual.[133] The recently released Australian Blue Carbon Accounting Model (BlueCAM) provides an easy-to-use spreadsheet for calculating the amount of GHGs a project abates and emits for a range of Australian coastal wetlands in multiple climate zones


© Srikanth Mannepuri, Ocean Image Bank

3. Implementation of project activities (e.g., mangrove restoration) followed by monitoring, reporting, including independent verification of carbon abatement (see Section 6.4.2) as the project proceeds.[125]

For blue carbon projects, there are two principal categories through which GHG emissions reductions and removals (ERRs) could be achieved:

- **Avoided or reduced emissions via ecosystem conservation.** Examples include:
  - Protecting a mangrove area from conversion to aquaculture
  - Preventing illegal logging
  - Improving mangrove management to reduce the amount of vegetation clearing
  - Restoring hydrology to reduce CO_2 emissions from soils (Worldview International Foundation manages multiple VCS certified mangrove blue carbon projects in Myanmar).

These activities protect against degradation and emissions caused by the removal of vegetation or the loss and/or oxidation of wetland soil carbon.[145]

- **Sequestration of carbon via ecosystem restoration.** Examples include:
  - Breaching the walls of disused or degraded aquaculture ponds to restore tidal flow, combined with assisted regeneration using species suitable to site conditions
  - Clearing channels blocked by sediment after storm surges, enabling mangroves to naturally recover
  - Installing culverts or bridges under roads that divide mangrove sites, restoring hydrology and enabling natural or assisted regeneration
  - Reducing hypersaline soil conditions by reinstating landward freshwater inputs and improving seaward drainage, enabling natural or assisted regeneration.

These activities restore mangrove vegetation which quickly begins to capture and store carbon in biomass and soils. In some cases, projects that increase sequestration can also lead to reduced GHG emissions as restoring mangroves may reduce emissions of methane and nitrous oxide associated with conversion to alternative uses, e.g., reinstating saline conditions can reduce CH_4 emissions.[145]

What is additionality, and how do I know if my project qualifies as additional?

On top of the ecological feasibility criteria for mangrove restoration projects described in Sections 2.2.4 and 3.4, nature-based carbon projects also need to demonstrate additionality. For project activities to qualify as additional, projects must prove that their claimed mitigation outcomes would not have occurred in the absence of their intervention, and that their intervention was reliant on credit income to take place.[141] Project activities must have a measurable and verifiable effect (e.g., lowering of GHG emissions) compared to the BAU. Processes to prove additionality vary between GHG crediting programs, and it is essential to carry out additionality assessments according to the selected standard.[125]

> For project activities to qualify as additional, projects must prove that their claimed mitigation outcomes would not have occurred in the absence of their intervention, and that their **intervention was reliant on credit income to take place.**[141]

Social feasibility

In addition to the social feasibility and engagement processes presented in Chapters 2, 3 and 4, when considering feasibility of carbon projects, you will need to consider the increased social risks associated with potential income generation, and how to mitigate them through effective community engagement and inclusive management.

For example, there is a risk that benefits from a project, such as revenue from the sale of credits, may not meet community needs or expectations, causing resentment or the resumption of activities which degrade the project site. Where revenue is successfully generated, there are risks surrounding distribution of project benefits, including disproportionate income being allocated to investors or commercial project operators (i.e., funding does not end up with communities), allegations of exclusion of some community members from benefit sharing schemes, and failure to provide sufficient support for stakeholders who have had to modify their behavior or had their access to mangrove resources reduced or lost as a result of project implementation. Social feasibility assessment and project design must consider the capacity of the project to provide the expected benefits, and to administer fair and equitable benefit sharing.

Other social disbenefits from mangrove carbon projects include project development or land management agreements where, to access carbon credit income, local people cede management of their lands to external entities. For mangrove carbon projects which prioritize return on investment, disbenefits have manifested in some locations in the form of plantations of fast-growing monocultures (typically *Rhizophora* spp.) or non-native mangrove species which accumulate carbon faster but don't provide the full suite of ecosystem services to local communities.

Some of these risks and potential disbenefits can be avoided with strong community involvement in project planning, including integrating local ecological knowledge into project design (see Chapter 3). Mangrove carbon projects that do not follow adequate social safeguards may contribute to further societal injustices.

Financial feasibility

Mangrove restoration projects designed to produce carbon credits attract significant data collection, design, and operational costs.[142] This is in addition to the project costs discussed in 3.2.5 and 3.5.1, including the sum of capital costs, operating costs, in-kind costs, and any expense directly related to the establishment and operation of a restoration project. Additional costs for mangrove carbon projects include the sampling, measurement, and reporting of carbon pools and GHG fluxes (Section 6.5) plus administration costs paid to the GHG crediting program and repeat third party verification of reported ERRs. The fee schedule for VCS projects, including inter alia account opening, registration, and VCU issuance levy fees, can be accessed here and the fee schedule for the Plan Vivo Standard can be viewed here.

While income from carbon credit sales may be sufficient to cover operational costs, provide the intended community benefits, and enable the project to be sustainable over the long term, mangrove carbon projects are rarely a lucrative proposition. Although carbon funding from the voluntary carbon market and through national and international climate finance is buoyant and growing, there is also the risk of uncertainty in the future, for example because of market fluctuations in the short term. Costs are also heavily front-loaded, and most extant projects have required external funding from national governments, NGOs, and philanthropic donations (Section 4.3.2), or have secured up-front funds from investors requiring a financial return, or credit buyers seeking to secure a supply of credits for a price cheaper than the open market (Section 6.4.6).

For carbon projects in sites which are used by local stakeholders, each use will need to be assessed to understand if stakeholder activities are impacting carbon sequestration or emissions, (for example cutting for charcoal production, or damage by livestock) or if they are sustainable and can continue or be enhanced by project implementation (for example, harvesting shrimp or fishing).

By the mangroves, © Tony Ochieng

Ocean Image Bank, © Matt Curnock

Often, mangrove resources are essential for the well-being of community users and alternative livelihoods will need to be developed and included in project cost (see Section 3.3). Enabling the use of mangrove forest products while assuring carbon neutrality can be a challenge.[60,146]

The opportunity cost and risk borne by community stakeholders should also be assessed. The opportunity cost of mangrove restoration projects is often related to the potential income for stakeholders generated by alternative land uses that might replace mangroves. For example, the opportunity costs of cutting mangroves for timber. In an ideal scenario, income streams generated by mangrove carbon projects and associated alternative livelihood programs should be able to compete with the opportunity cost,[21,142] however other project benefits may also be considered, including the flood protection and increased food security offered by intact mangrove areas. A wider valuation of the ecosystem services mangroves provide (e.g., social and cultural values, biodiversity, fisheries, and coastal protection)[123] can deliver a stronger social and economic argument for encouraging mangrove restoration.[45,54]

It's feasible… now what?

If there is funding available to cover upfront costs, the revenue from carbon credits has the potential to cover long-term costs (after any potential return owed to investors is removed) and the project will provide more social and ecological benefits than disbenefits – the project becomes feasible. Once feasibility is confirmed, the project manager can register the mangrove project under the selected GHG crediting program, use the feasibility study as a basis to develop project design documents (Section 6.4.4), and can move ahead with securing funding (Section 6.4.6) and the collection of site-level GHG data (Section 6.5).

Gazi Mangrove Boardwalk, © Julia Jung

6.4.6 Designing funding arrangements (the "deal")

What funding options are available to mangrove carbon projects?

Mangrove projects which aim to produce carbon credits for sale on the voluntary carbon market may be able to access additional commercial sources of finance for project implementation.[135] The critical consideration is understanding where alignment between available finance and project needs occur and in filling the funding gaps.[85,86] Corporate buyers or investors, for example, may provide funding to secure an exclusive supply of credits, cheaper credits, or realize a return on their investment. They may be acting as speculators, brokers, or meeting net-zero goals.

Where the focus is on carbon credit supply or financial return, smaller restoration sites are unlikely to be considered feasible as they will not be able to meet the volumes of credits required by these funders. Funding "deals" tend to be transactional rather than grant-based and are entered at the project proponent's own risk. Deal structures vary considerably and can include:

- Implementation loans, with varying amounts of interest or other conditions/obligations
- Advance purchase of carbon credits at either a fixed price or fixed discount
- Providing funding in exchange for a percentage share of project income
- Providing funding for feasibility studies, usually with conditions attached
- Carrying out feasibility studies at no cost to the project with the obligation that the developer has an exclusive option to work with the project manager to implement the project
- Offering to implement the project from feasibility onwards including providing all funding, which is usually accompanied by high levels of obligations to the funder.

This is a highly competitive space. Some organizations will be focused solely on securing carbon credits for the lowest possible price. Given the lack of transparency in the marketplace, it may be difficult to assess whether an offered deal represents good or bad value, as there is minimal data available for comparison.

Advance purchase deals

Projects aiming to produce carbon credits may be able to receive funding via the advance sale of credits. However, the price of blue carbon credits is not stable and thus projects may sell credits for lower than is eventually possible. One observed deal structure is that a fixed price per credit for a minimum volume of credits to be delivered over several years is offered.

Box 8: Forward Sale Considerations

For example: a commercial organization offers a forward purchase price of $8 per credit for five years. A set amount is paid in advance to enable project implementation to proceed.

At the time of the offer:

- Peer-reviewed literature regularly uses dated values of $5 per credit to create models for blue carbon
- Records of blue carbon credit sales from a few years ago show a price of $12 per credit
- The actual selling price from some blue carbon credits may be $36 per credit
- Onward trading of high-quality blue carbon credits may already exceed $44 per credit.

Given that carbon prices are difficult to access,[85] a project manager needing early-stage investment may agree to this deal structure based on the first two values, unaware that credits may already be traded for over $40. If the project manager accepts a fixed price deal and the retail price of blue carbon increases over five years to $80 per credit, under this deal structure, the project is still only receiving $8 per credit. Therefore, the project is receiving 10% of the actual value of each credit while project running costs increase with inflation. It is up to the project manager to decide whether this trade-off is worth it to secure funding.

Not all advance purchase agreements set a fixed price throughout the project period. Some agreements proposed by project developers allow for projects to benefit from predicted carbon price increases.

For example: a project is offered a forward purchase price of $8 per credit for five years. The investor proposed a deal where the price difference between the advanced credit price and the price at issuance is split between the investor and the project. This deal structure is known as "sharing the upside" and allows both the project and the investor to realize the desired return. Similar proposed models which facilitate more equitable investment include ratcheting mechanisms which increase the price per credit above the floor price as the retail price increases.

Another model sets advanced purchase prices based on a percentage discount, with the difference in value, or a portion of it, payable on delivery of the credit.

For example: an investor offers to provide early-stage funding tied to the option of forward purchase of credits at a 30% discount. The current market value is $12, so the investor pays $8 per credit. When the project is implemented and credits are issued two years later, they are valued at $36, discounted to $24. The investor pays the difference between $8 and $24 upon receipt of the credits, retaining their 30% discount.

Due to the private nature of funding and purchasing agreements, there is no confirmation available of whether models proposed by developers looking for equitable solutions have been put into practice or not. While equitable deals and models exist, early exposure to exploitative deals may cause project managers to be hesitant to enter these kinds of investment deals. Instead, projects may prefer philanthropic or grant funding.

Certified "future credits"

The Plan Vivo and Verra crediting programs have been exploring the possibility of issuing tradeable advance credit certificates, which would be replaced with a valid carbon credit when credits are issued. Advance certificates cannot be retired (i.e., cannot be used to offset any emissions), and the volume issued would be limited to a conservative portion of the project's expected credit production. Plan Vivo approved their future credit mechanism in 2022, enabling projects to secure early income by offering future credits on the open market and retaining control over the amount offered, when they are offered, and the sale price.

Bundling/aggregating project sites

Another important aspect of planning mangrove restoration projects designed for generating carbon credits is to consider whether aggregating or "bundling" sites is possible. Aggregation may give rise to economies of scale and cost efficiency which decreases verification costs per credit. UNEP and CIFOR (2014)[145] provide the following guidance on aggregation of sites/projects:

"Transaction costs incurred from carbon cycles, market participation and consulting and legal fees can add considerable amounts to the project costs. Such costs may be recoverable, however, through international (public) donors.

Notably, carbon standards often come with the option to upscale intervention throughout a country or even beyond. A set of smaller initiatives may be designed and managed as a grouped project, providing opportunities for a gradual roll-out and flexibility in timing of validation. Size will lower relative costs, and project managers should always consider whether economies of scale can be activated. Close cooperation between the different initiatives is also a key to lowering costs so that capacity can be shared, and mistakes avoided. On the flip side, however, scaling up can present its own issues, such as when the initial developer lacks the capacity to operate the project on a much larger scale."

When aggregating sites or projects, social engagement, inclusive governance, and equitable income dispersal may become increasingly complex for grouped projects which include multiple communities. However, in addition to sharing costs across project sites, for funders looking for a return on their investment, grouped projects with competent management represent a less risky investment opportunity. If one site within the group of sites encounters unforeseen barriers to implementation or suffers damage, their investment and returns are protected by being spread over multiple sites. Grouping sites can de-risk investment in some cases by creating a more significant financial buffer for unforeseen circumstances.

6.4.7 Use of project income and profit

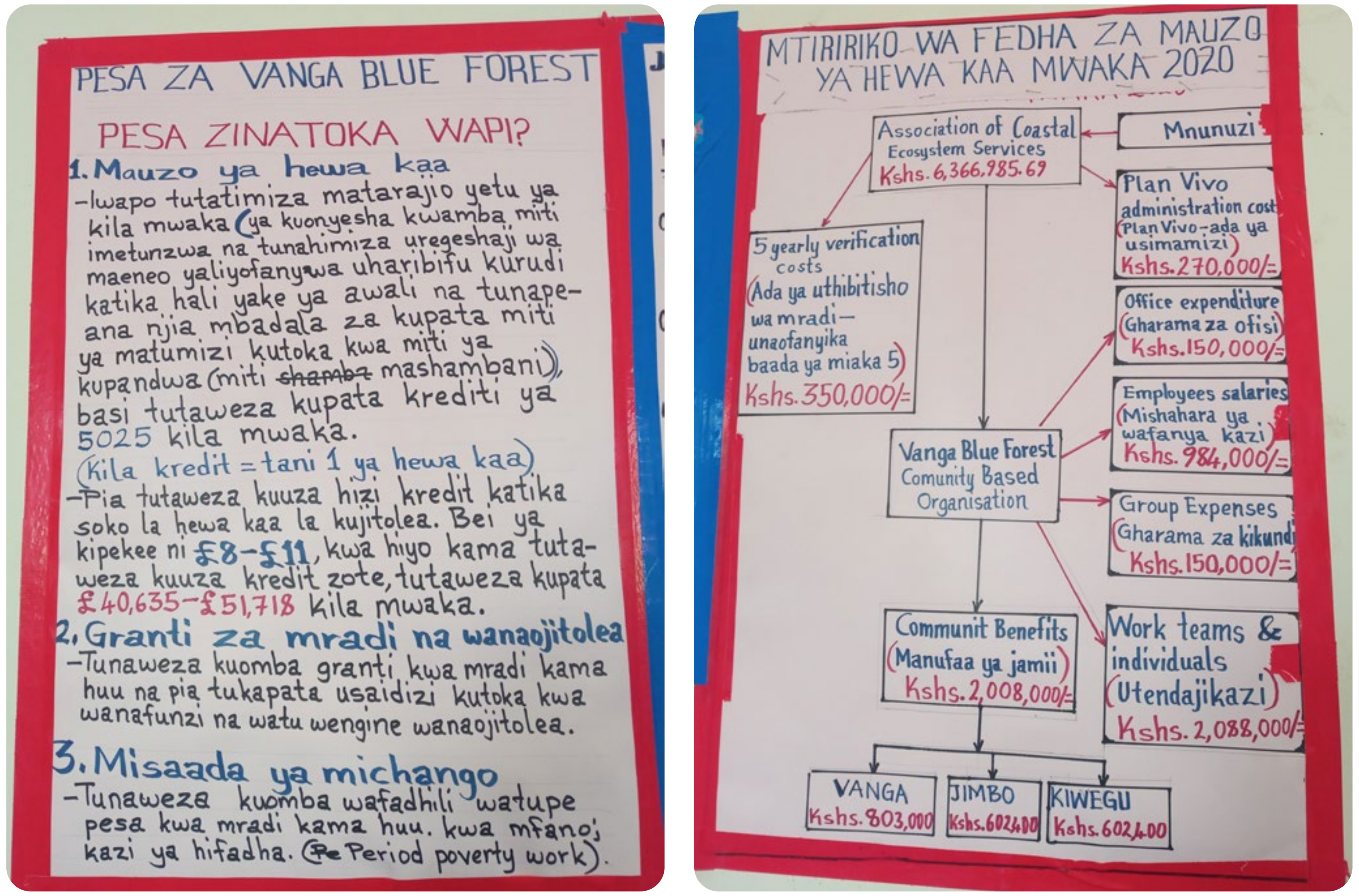
The income from selling blue carbon credits on the voluntary market can be used to repay initial project development and implementation costs (e.g., if financing was secured in the form of a loan such as the World Bank sponsored Mangroves for Coastal Resilience Project),[147] secure financing for on-going project management requirements (e.g., maintenance and monitoring of restored sites), subsidize alternative livelihoods for communities affected by project implementation, and, importantly, provide a usually small but significant funding stream for community use.

The allocation of project incomes to the community is often not transparent, and thus income allocation to communities within existing projects is often not known. Depending on the GHG crediting program or standard, projects may not be required to publish what share of project income is allocated to residents and other stakeholders, while claims of providing employment are often phrased as a benefit to the whole community, although the benefit may in practice only extend to several individuals in a large population. To increase transparency, projects can be encouraged to publish clear income dispersal and allocation records accessible to community members and other stakeholders (see image facing page). This level of transparency can also be achieved through equitable project governance structures that make clear and democratically decided decisions on project activities and income allocation.

Community-based approaches that integrate benefit-sharing mechanisms and the equitable dispersal of payments may result in poverty alleviation and promote sustainable development,[148,149] while governance that involves local stakeholdzers and community members, including women, provides the foundation to disperse income to community needs and the equitable dissemination of benefits to community members.[10]

The Plan Vivo Standard provides an example of how transparency in benefit-sharing and project governance can be ensured through the integration of community and livelihoods. All projects verified under the Plan Vivo Standard must allocate at least 60% of the income from credit sales to the project participants and stakeholders. Additionally, the dispersal of funds and other benefits under the benefit-sharing system must be reported and clarified to the standard and to the community. Project managers can and should aim to replicate this level of reporting, regardless of which GHG crediting program or standard they are working with.

In landscapes with large human populations or those that directly utilize mangrove resources, evidence suggests that risks of damage, leakage, project impermanence and loss of community support can be managed via meaningful investment of project income into initiatives that meet the needs of local people. It is, therefore, in the best interest of investors to assess risk in terms of equitable benefit sharing within the project.[149] Investors, project developers, and stakeholders often overlook community control over income and project activities as a factor when assessing risk, yet inadequate planning for income dispersal can increase other risk factors.



At a local level, transparent publication of project finances, income dispersal and benefit sharing can be as simple as a set of publicly accessible posters. Those pictured are handwritten and regularly updated by the Vanga Blue Forests team in Gazi Bay, Kenya. Image credit: Mwanarusi Mwafrica.

Building the capacity of aquaculture farmers with innovative sustainable practices through Coastal Field Schools © Boskalis

Government legislation and income dispersal

Nationally developed community forest management frameworks vary in scale, their rules, requirements, and reporting standards.[97,126] Ensuring high levels of community participation and decision-making can sometimes be aided by national legislation on community forestry management that may be obligatory for projects in some regions.

Forestry management systems run by local and indigenous communities for restoration, conservation, or sustainable use, often called community forest associations (CFA), have been integrated with mangrove restoration projects with significant success (Appendix C and Section 2.2.1), and may also provide a pathway to securing carbon rights (Section 6.4.5 and 6.6.2).

Community forestry practices may be championed as a route to achieving NDC targets and promoted at the state level through legislation and policy focused on formulation of community associations, revenue generation, governance structures, and the equitable dispersal of income. For example, countries such as Myanmar and Mexico have developed community forestry rules that concentrate rights to CFAs with the specific objectives of increasing employment and forest cover, and addressing mitigation and adaptation to climate change. In Myanmar, laws also stipulate that CFAs must be equitable in their composition and decision-making power to allocate funds as local income, community development, and re-investment in project activities.[48] Assigning control and management over the ecosystem and fund allocations allows the community itself to address specific issues, such as education and access to water or forest resources, and places a focus on inclusive governance for mangrove carbon projects set up in partnership with a CFA.

No fee is required to register a community forestry project in Myanmar; however, many countries may charge registration fees or require a portion of the income generated by community forestry projects to be given to the government. Guidance for development of community forests is available from the FAO (2006).

6.4.8 Accessing credit income from established projects

Can I produce carbon credits from a mangrove restoration project which has already been carried out?

Sometimes restoration project managers find out too late that certain requirements of carbon standards were not met, which results in the project being ineligible to produce carbon credits.[145] For instance, the development of a dedicated carbon project may have been a secondary goal and only received minimal attention. By the time the project manager focuses on the carbon component, the project is too far along in the design and implementation process to make the necessary adjustments. If a project's stated goals include generating carbon credits, it is important to make sure that proposed project activities qualify for a carbon crediting program before actively carrying out interventions such as planting or hydrological restoration.

A standard and methodology for projects intending to generate credits should be selected at the concept and planning stage, and additionality criteria should be assessed against the chosen standard before work begins. Carbon baseline data will need to be recorded before significant alterations to the ecosystem are made. With the exception of the Plan Vivo standard, data collection on biodiversity, socioeconomic impacts and other metrics are not mandatory to successfully issue carbon credits. However, documenting and reporting on project performance across these metrics may be necessary to secure funding or to demonstrate the credits or mitigation outcomes achieved are of high quality and subsequently are of high market value.

While existing restoration projects may wish to pivot to carbon credit income as a source of funding after their inception, the prerequisite for carbon projects to meet additionality requirements may be a significant challenge. For example, if a project is already implemented, to meet the criteria of "additionality" there may need to be demonstrated changes in circumstances surrounding project financing, implementation, or permanence for which income from carbon credits is the best or only solution to achieve mitigation.[141]

From a technical perspective, creating a business-as-usual carbon baseline may not be plausible on project sites where interventions have already been carried out. This is because it may no longer be possible to model site regeneration rates or loss without the influence of the project. Without measuring CO_2 removal and carbon storage services against a robust baseline, it may not be possible to issue carbon credits. Assuming project design and data collection meet the criteria of the selected standard, activities carried out for up to three or five years before project registration are eligible for inclusion and credit issuance.

6.5 Monitoring and Reporting

Measuring emissions reductions and removals

Accurate monitoring and reporting of outcomes for mangrove carbon projects is essential to verify any emissions reductions or removals achieved.[8,103] This section provides guidance for mangrove restoration projects on how to measure different carbon pools and GHG fluxes.

Monitoring and reporting for mangrove carbon projects is specific to the climate mitigation outcomes desired, the methodology used, and the reporting requirements for the relevant government mitigation or adaptation program,[114] or GHG crediting program.[125] Links to blue carbon credit methodologies are provided in Appendix F and Appendix G and discussed in Section 6.4.3.

Many methodologies require the measurement of carbon pools and fluxes in the monitoring process to develop a carbon inventory.[138,141] Project managers need to be able to assess carbon stocks (total amount of carbon stored within the project area) and monitor the net project mitigation outcomes (ERRs), which includes the changes in carbon stocks and fluxes of GHG emissions over time (Figure 28). Methodologies which do not use direct site measurements can require the monitoring of change in vegetation area over time, from which mitigation outcomes are modeled.[150] Some methods can use mixes of direct measurements of carbon pools (e.g., aboveground biomass) and the use of indicators from which some components of mitigation outcomes are modeled – for example, the use of aboveground biomass to estimate belowground biomass or soil carbon accumulation, or the use of salinity to estimate methane emissions.[141]

Carbon stock in blue carbon methodologies can include four major carbon pools (see Figure 28):

1. Aboveground living plant biomass (woody plant mass)
2. Belowground living plant biomass (plant roots)
3. Aboveground dead plant biomass (dead wood and leaf litter)
4. Soil carbon.

Changes in carbon pools are usually measured against a “baseline” or pre-restoration scenario. The growth of mangrove vegetation via restoration efforts increases the amount of carbon stored in biomass and soil carbon pools. Carbon accumulation rates in the baseline scenario may be negative (i.e., a net emission of CO_2 from the soil) or positive (i.e., soil acts as a net sink of CO_2). For example, a shift in land-use from baseline scenarios where soil organic matter is oxidized due to drainage, disturbance, or excavation of soils, to one in which disturbance of soils does not occur can provide significant CO_2 mitigation outcomes in some restoration projects.[141] Factors that influence rates of decomposition can control the direction and magnitude of soil fluxes and are influenced in part by changes in inundation and moisture content of soils, temperature regimes and nutrient levels, as well as the amount of physical soil disturbance in the baseline scenario.[136]

Greenhouse gas fluxes are considered in most methodologies. These can include estimates of baseline emissions that would have occurred in the project area in the absence of any restoration activity, and greenhouse gas emissions from mangrove soils and water after restoration has commenced (See Figure 28). Greenhouse gasses commonly included are:

- **Carbon dioxide (CO_2)** has a global warming potential (GWP) of 1 and is emitted from the decomposition of organic matter in plant litter and soils. Carbon dioxide emission rates are influenced by oxygen availability and are lower in low oxygen, waterlogged soils and more rapid in aerated soils under freely draining conditions. The removal or mortality of mangrove vegetation also releases carbon dioxide as plant biomass decomposes[151]
- **Methane (CH_4)** has a high global warming potential (x27.2 over 100 years; IPCC, 2021) and is produced by bacteria in wetland soils when organic matter is present, and oxygen is not present (anaerobic). This occurs when soils are inundated with water. The production of methane is also limited in the presence of sulfate, which occurs in seawater. Because of this, methane production tends to decrease in waters and soils with high salinity, often above 18 ppt[152]
- **Nitrous oxide (N_2O)** has very high global warming potential (x273 over 100 years; IPCC, 2021) and can be produced under both aerobic and anaerobic conditions. The factors which influence nitrous oxide production in soils are carbon concentration, nitrogen concentration and soil moisture content. The inundation of land areas with seawater can cause nitrous oxide production from nitrification (a microbial process by which reduced forms of nitrogen, often ammonia, are sequentially oxidized to nitrite and nitrate). However, denitrification (the process that converts nitrate to nitrogen gas, removing nitrogen and returning it to the atmosphere) can still occur if nitrogen is available from ongoing nitrogen inputs (e.g., from pollution, animal waste etc.) and therefore restoration can result in reduced N_2O emission.

Greenhouse gas emissions from mangrove soils and waters can partially reduce the mitigation outcomes in a project and may be measured or modeled in blue carbon accounting. Baseline emissions provide an estimate of the greenhouse gas fluxes that would have occurred in the absence of the project (BAU). This can include emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O),[141] depending upon the method and the baseline land use.

Figure 28

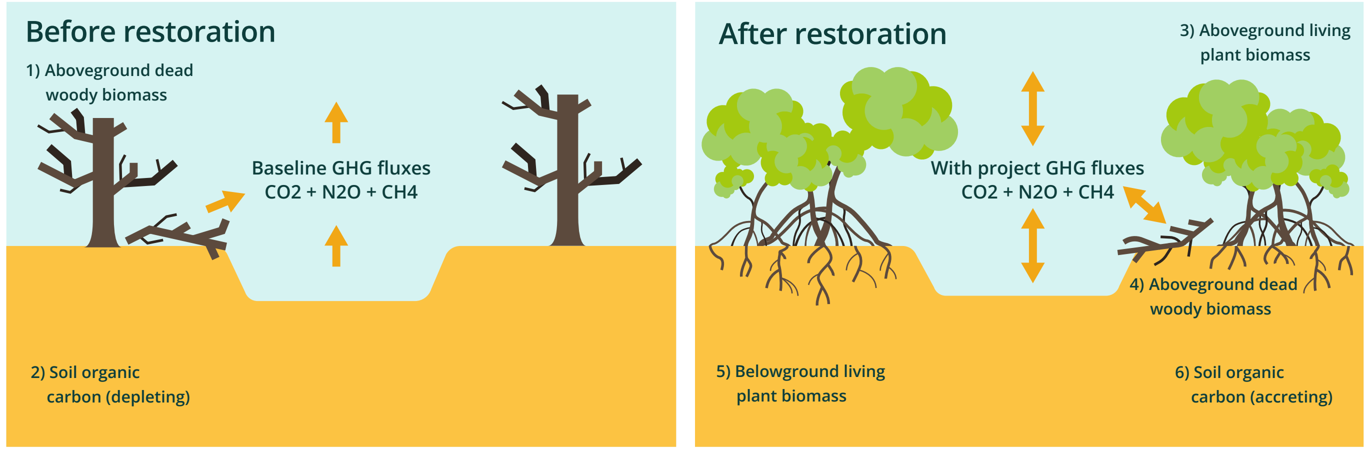


Figure 28. *Carbon pools and fluxes often included in blue carbon methodologies. "Before restoration" is the baseline state or BAU. "After restoration" is after the project has been implemented.*

6.5.1 Methods for assessing carbon stocks

There are many available techniques for the assessment of blue carbon pools and fluxes. The specific requirements of different methods/standards vary. Detailed methods for assessing blue carbon stocks and calculating greenhouse gas fluxes can be found in the Blue Carbon Manual. This document provides details on the planning and design of sampling approaches, guidance on field sampling of different carbon pools, sample preparation and laboratory analysis, and calculations for scaling up carbon stocks and fluxes to the project area.

Here we provide brief descriptions of these techniques which are described in greater detail in the Blue Carbon Manual and specific carbon credit standard/method guidelines. Some important components of carbon stock assessments include:

1. **Aboveground living plant biomass (woody plant mass) –** Data is recorded for all individual mangrove trees (based on a standard tree size) in a plot and often includes the identification of species. Mangrove tree biomass is calculated using main stem diameter at breast height (dbh). Measurement of tree height can improve estimates of tree biomass and is included in some allometric equations (standard equations that can be used to determine tree biomass based on the trees dimensions - see The Blue Carbon manual[133] for a list of allometric equations).
2. **Belowground living plant biomass (plant roots) –** Belowground biomass is often estimated using allometric equations that calculate the belowground biomass based on the measured aboveground biomass values. Although laborious, belowground biomass can be determined on a site-by-site basis by direct measurements.
3. **Aboveground dead plant biomass (standing dead and downed trees, woody debris) –** Within each sampling plot, all trees that are dead and standing should be recorded and analyzed as a separate carbon pool. The degree to which the tree has decayed will determine how its biomass is calculated. Downed woody debris can be a large component of total ecosystem carbon stocks and can be characterized using the transect method (see Blue Carbon Manual).
4. **Soil carbon –** To accurately quantify the soil carbon pool, soil cores are collected, subsampled, and analyzed for a specific depth (usually 1m). Subsamples are analyzed for bulk density and organic carbon content.

6.5.2 Methods for assessing greenhouse gas fluxes

Some blue carbon projects may choose to measure greenhouse fluxes which can enhance the value of the project. Measurements of gasses require specialized equipment and therefore in some projects fluxes of methane and nitrous oxide are omitted or estimated from proxies or indicators, such as salinity for methane.[141] Some methods/standards have options for directly measuring gas fluxes, while some methods will allow for using carbon stock change as a proxy for CO_2 gas fluxes - this is called a stock difference method. Assessment methods for analyzing greenhouse gas fluxes are described in Table 8.

Gazi Mangroves, ©Tony Ochieng

Table 8. *Benefits and challenges of different ways to measure greenhouse gas fluxes.*

Flux estimation methods	Benefits	Challenges	Relative Costs	Guidance
Static chambers - using soil or water chambers linked with a greenhouse gas analyzer (e.g., LICOR greenhouse gas analyzer). The rate of gas flux is determined by measuring changes in chamber headspace concentration over time.	Accurate estimates of greenhouse gas emissions from soils and water. Depending upon the greenhouse gas analyzer, the method can measure carbon dioxide, methane, and nitrous oxide fluxes.	Requires field expertise, expensive equipment, and complex calculations to determine flux rates. Annual emissions are estimated from measurements made at limited time points.	Mid/high	Howard et al. (2014),[133] Sidik and Lovelock (2013).[154]
Vial measurements - Collecting gas emissions from soil or water chambers using syringes and vials. These can be collected and analyzed in laboratories. The rate of gas flux is determined by measuring changes in headspace concentration over time.	Samples can be taken and sent to external laboratories for analysis, reducing costs. Can be accurate with an adequate number of samples taken. Depending upon the greenhouse gas analyzer, the method can measure carbon dioxide, methane, and nitrous oxide fluxes.	Requires field expertise and access to laboratory analysis of greenhouse gas concentrations. May not provide highly accurate flux estimates. Annual emissions are estimated from measurements made at limited time points.	Moderate	Howard et al. (2014),[133] Iram et al. (2021).[155]
Flux estimation methods	Benefits	Challenges	Relative Costs	Guidance

Table 8. *Continued...*

Flux estimation methods	Benefits	Challenges	Relative Costs	Guidance
Eddy covariance	Whole ecosystem gas exchange. High precision measurements over longer time periods than static chambers. Can identify daily, seasonal, and annual changes in fluxes from the whole ecosystem. The method can measure carbon dioxide, methane, and nitrous oxide fluxes.	Highly complex systems requiring expertise for installation and management. Large and complex data sets requiring expert analysis.	High	Aubinet et al. (2012),[156] Burba (2013).[157]
Stock difference method. This method estimates the difference in carbon stocks measured at two points in time.	Can provide an estimate of carbon dioxide fluxes without expensive equipment.	Larger degree of error than other methods. This method does not include methane or nitrous oxide fluxes, but focuses on vegetation biomass and sometimes soils where changes in soil carbon against a baseline BAU scenario can be assessed.	Low	Kauffman et al. (2014).[113]

Assessing baseline greenhouse gas fluxes

Reporting of baseline greenhouse gas emissions is specific to each method/standard. It may require direct measurement of greenhouse gas fluxes from soil before the project commences using the methods described in Table 8 and/or greenhouse gas flux rates may be linked to the type of land use before the commencement of the project and the extent of different land use types within the project area. Estimates of greenhouse gas fluxes from different land uses may use IPCC Tier 2 approach [123,132] or use default values specific to the carbon credit method/standard used.

Mapping the extent of vegetation types

Changes in vegetation extent is a key component for monitoring of all restoration projects. In fact, some methodologies/standards (i.e., the Australian Tidal Restoration of Blue Carbon Ecosystems method) do not require measurement of carbon stocks or fluxes, instead they model change in greenhouse gas fluxes and carbon accumulation linked to changes in ecosystem extent.[150] Monitoring of changes in ecosystem extent may be achieved through high resolution mapping of extent and imagery for ground truthing (such as georeferenced, time stamped photos).[158] In mangroves, one common practice is to take four photos with one in each cardinal direction (N, S, E, W) from the center of an established monitoring plot.[159,160]

Reporting greenhouse gas emissions

Greenhouse gas fluxes include fluxes from baseline land uses before the commencement of a restoration project, and fluxes from mangrove soil and water after the commencement of a restoration project. Fluxes of greenhouse gasses other than CO_2 (i.e., methane and nitrous oxide) are converted to CO_2e by multiplying by each gas type's global warming potential (GWP). Methane and nitrous oxide have GWP of 27.2 and 273 times that of CO_2 respectively. This means that 1 t of methane is equal to 27.2 t CO_2e and 1 t of N_2O is equal to 273 t CO_2e.

- Flux estimate measurements from mangroves are specific to the method used for the project (detailed in Table 8). For detailed explanation of the flux methods and calculations see Chapter 5 in the Blue Carbon Manual[133]
- Baseline flux estimates depend upon the specific conditions of a baseline setting and vary between reporting methods. Refer to the carbon credit method/standard used for the project for guidance on calculation of baseline emissions.

Reporting overall project mitigation outcomes

Total ERR calculations are specific to the method/standard used for the project. Net mitigation outcome calculations can include any or all the following parameters: the sum of the carbon sequestered in mangrove biomass and soils, minus the greenhouse gas emissions from mangroves and any other land use types in the project area, plus avoided emissions from baseline land-use, minus any carbon accumulated in the prior land uses and other emissions such as any fuel use associated with the project activities (Figure 29).

Figure 29

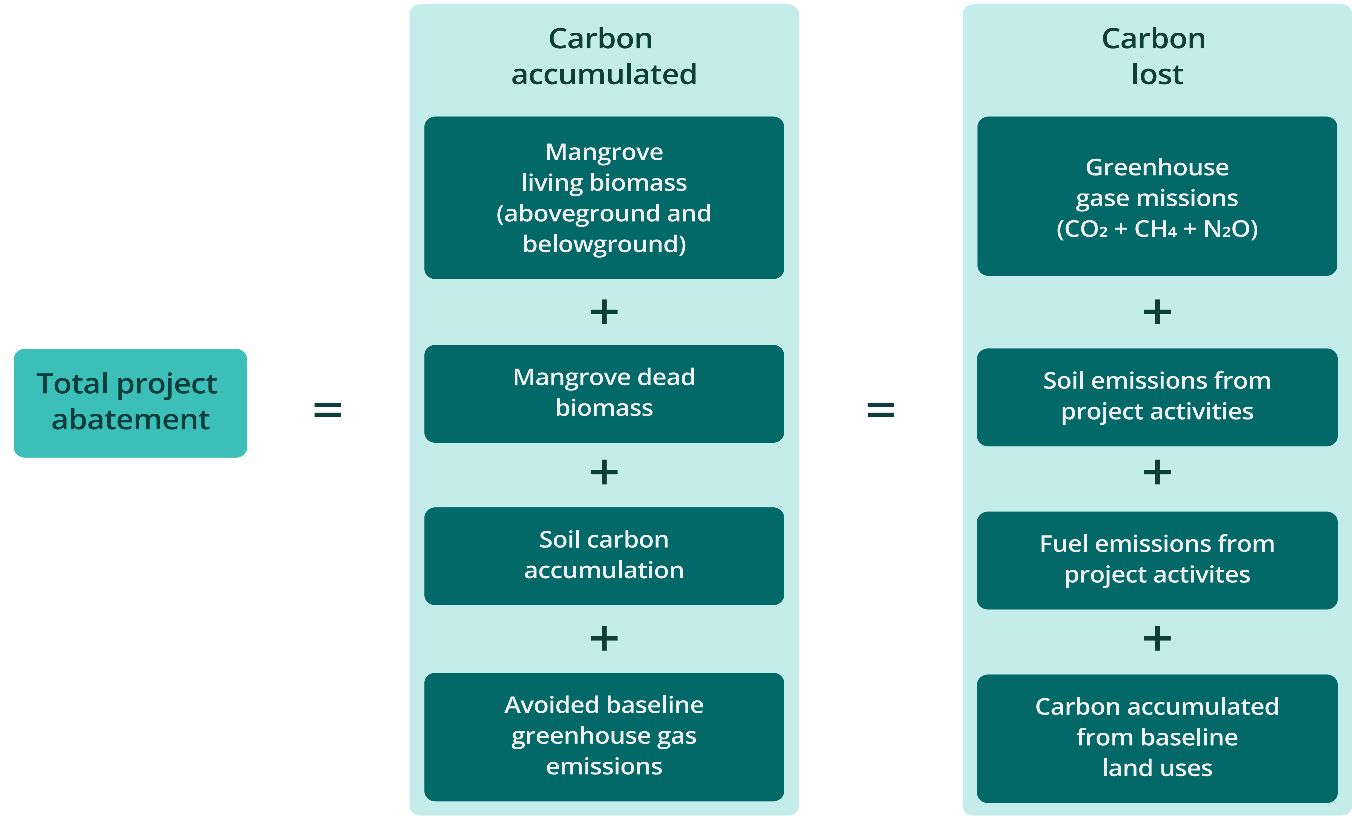


Figure 29. *Project mitigation outcome calculations are specific to each carbon credit methodology, including the sum of parameters in carbon accumulated minus the parameters of carbon added to the atmosphere.*

Mangrove living in Zhanjiang, protects a coastal population of approximately 4 million people, © Conservation International

Case study

Mangrove Carbon Crediting Projects

An important lesson in community participation

Tahiry Honko, Madagascar

Lalao Aigrette (Blue Ventures) and Leah Glass (Blue Ventures)

Overview

Tahiry Honko is a community-led mangrove carbon payment for ecosystem services (PES) project in the southwest of Madagascar which was developed to generate carbon credits from project activities. The Plan Vivo standard was used to certify the climate benefits from Tahiry Honko as it provides a support framework for smallholders and rural communities to manage their natural resources more sustainably. Local communities from ten villages are partners in the project and were involved from the early stages of project design and implementation. The community members decided on the activities that would be implemented in their area and led the project activities, including local law enforcement, mangrove replanting and patrols. All people, including marginalized groups such as women and young people, were included using a participatory approach.

Figure 30

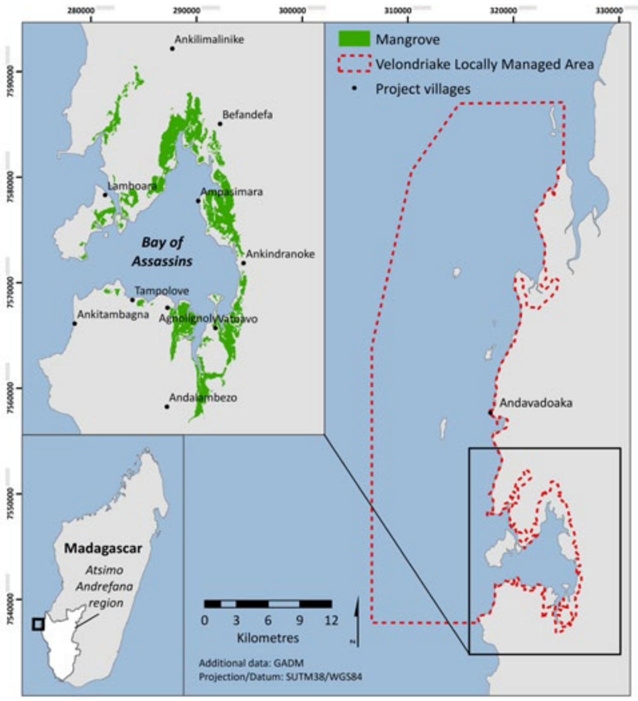


Figure 30. *Map of the area - Tahiry Honko.*

The breakdown of monetary benefits from the sale of carbon credits follows national legislation and Plan Vivo requirements, which are 20% for the central government to ensure the governance of the carbon project and 80% for project activities, the national risk buffer, and community payments. The communities decided to use the funds to subsidize school fees for children in the project and have also prioritized a list of needed infrastructure projects to invest these funds including school building, wells, and health clinics.

Challenges

While payments for ecosystem services schemes present a financial incentive for community-led mangrove preservation and restoration, there were considerable challenges encountered in implementing the Tahiry Honko project. A long period of time occurred between the introduction of the concept of the carbon project to the community and the first income from carbon revenue. This time lag negatively influenced community participation and engagement in the project. Additionally, given that a legal framework plays an important role for successful community-led mangroves management, the lack of regulations specific for mangroves was challenging in Madagascar.

Specific lessons from the project

1. A participatory approach is well-suited to the planning and development of community-led carbon projects that restrict or change access to common resources such as mangroves. This approach promotes engagement for all community members, regardless of gender. However, management of community interaction is important to create safe and comfortable spaces for the voiceless and marginalized groups to avoid domination by certain groups in decision-making.
2. Even though a participatory approach enables community empowerment, this requires a large effort in community engagement such as the organization of multiple village meetings. We learned that careful planning of village meetings is crucial to avoid community fatigue and ensure continued participation throughout the process. Some meetings, training events, and workshops could be consolidated to reduce and streamline the total number of engagement events required.
3. As carbon projects may impact access to resources for forest-dependent community members, it is important to obtain a true representation of a community and to receive adequate community consent. This can be achieved through an effective and inclusive approach to allow the full range of community members to provide their consent.

GPS training

Mikoko Pamoja, Kenya

Jared Bosire and Mark Huxham (Edinburgh Napier University)

Overview

Mikoko Pamoja ("mangroves together" in Swahili) was the world's first community-led mangrove conservation and restoration project funded by carbon credits. The project is situated within the mangrove area of Gazi Bay, southern Kenya, with around 5,400 residents living in the two local villages of Gazi and Makongeni. The project is registered under the Plan Vivo standard, chosen because of their focus on community-based conservation, their long track record of supporting communities in the Global South, their ability to support relatively small projects and because they are based in Edinburgh, Scotland, where the UK partners (ACES) are also based.

Mikoko Pamoja belongs to the people of Gazi Bay. The project is represented by a community-based organization run by an elected committee and local people were involved in project development and decision making from the inception of the project. The Mikoko Pamoja committee is advised and supported by the Kenyan Marine and Fisheries Research Institute (who give guidance on forestry and practical conservation) and the Association for Coastal Ecosystem Services (ACES - a charity established to facilitate the marketing of credits and administration of funds and accreditation). All revenue raised through carbon sales is used for running the project or supporting community development.

Figure 31

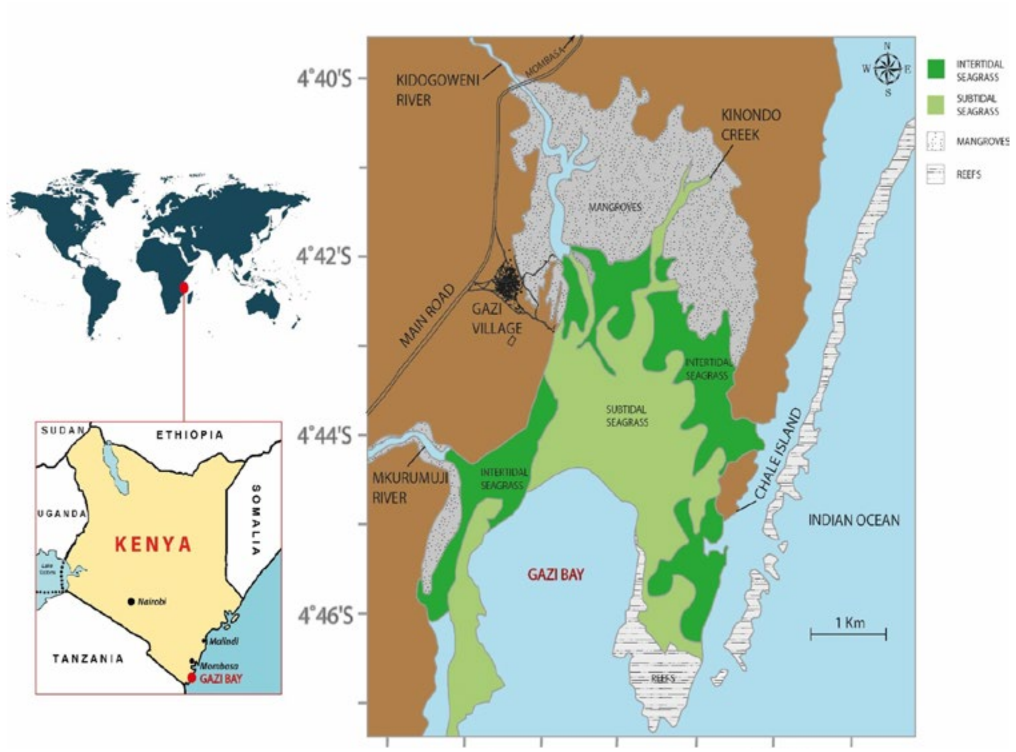


Figure 31. *Mikoko Pamoja – ACES.*

There are no profits made and no returns given to investors. The project relies heavily on voluntary contributions of time and support, from the local committee members, from Kenyan and international scientists and from ACES trustees and supporters. Approximately 80% of income is returned to Kenya. This income is used to employ project staff, run project operations (such as planting), and contribute to a community fund. Decisions on how to spend the community fund are made through village meetings which are open to all. The remaining 20% of income is used to support the costs of administration, marketing, and accreditation in the UK.

Challenges

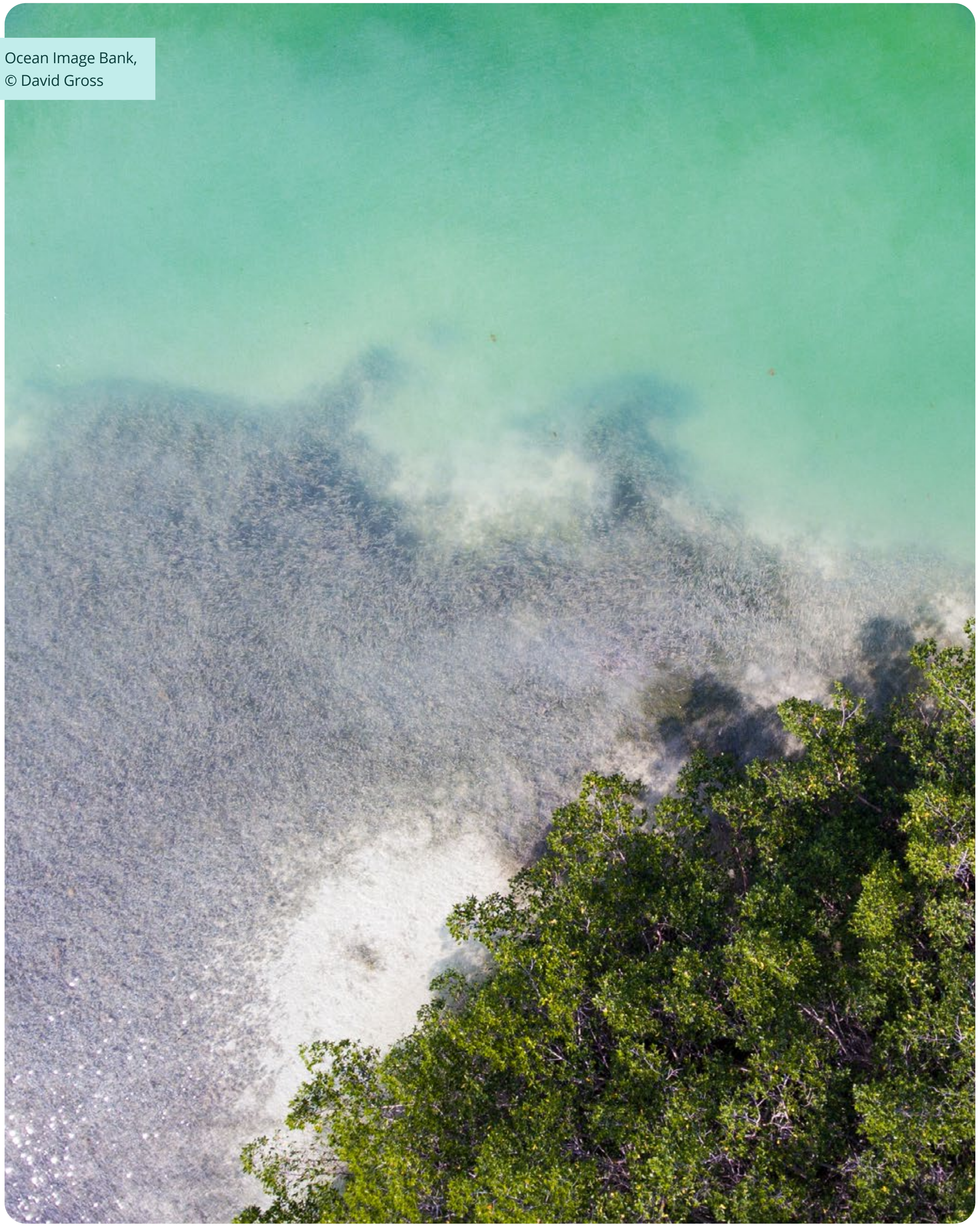
The dominant theme that describes both the challenges and the lessons is: "It's all about the people." Building trust, engagement and ownership were essential in launching and maintaining the project and this takes time and commitment. Mangroves in Kenya are socioecological systems, in which people and nature are intimately related and co-dependent. Focusing on scientific precision, finance, marketing, or rapid reporting to funders at the expense of spending time ensuring that the local owners of the project really understand and support it would lead to failure.

Specific lessons from the project

- Make benefits obvious and rapid. People need to see returns on their efforts. We were able to arrange confirmed sales for our first credits which meant money was guaranteed for the first year
- Ensure political support. Make sure key players in local and national politics are aware of and support the work
- Have a marketing plan. Credits do not sell themselves. You need an organization that will sell the credits, administer the money and deal with annual and five-year reporting
- Be wary of mass planting. Trees planted into areas that really need restoration often suffer mass mortality. If planting is needed, then try to balance that through forest protection and restoration activities
- Keep communicating. Explaining carbon offsetting is very complicated and it is easy for people to get confused or suspicious about where the money comes from and where it goes. You need to keep communicating this with maximum transparency
- Offsets can help fund conservation and livelihoods and are a small contribution towards a net zero world. However, working with major polluters who do not have credible plans to reduce their emissions could undermine the legitimacy of your projects and of the whole sector. More information on ethical offsetting can be found at https://aces-org.co.uk/the-3-ps-of-carbon-offsetting/

Community water dispersal taps installed through the Mikoko Pamoja Project, © Grid Arundel

Mikoko Pamoja community monitoring, © Tony Ochieng



Ocean Image Bank, © David Gross

Thor Heyerdahl Climate Park, Myanmar

Toh Aung

Overview

This project falls under the ARR (afforestation, reforestation, and revegetation) category of the Verified Carbon Standard (VCS). The project has been implemented across 2,146.5 ha of degraded mangroves within the Ayeyarwady Delta of Myanmar. The lands restored under the project belong to the Magyi, Thabawkan and Thaegone villages and restoration has resulted in a healthy mangrove ecosystem. The objective of the project is to establish and maintain a sustainably managed mangrove ecosystem for carbon sequestration, natural disaster risk reduction and poverty reduction, generating sustainable livelihoods within coastal communities. A vital component of the project is the conservation of biodiversity and the establishment of the first mangrove gene bank in Myanmar.

Social and cultural considerations and project benefits

Reforestation of mangroves was undertaken with the participation and involvement of local community members who act as plantation laborers. They earned an income from undertaking planting activities between 2015 to 2020, while a portion of profits from the sale of carbon credits are shared between local communities which is directed towards village development projects.

© TNC, Jamaica

Project challenges and outcomes

The project site is next to a clean sandy beach which is a tourist attraction. During the project period the hotel encroached on the project area which was a major challenge faced in project implementation. Project success required ensuring land use rights and the participation of all relevant stakeholders which are some of the key lessons learned from the implementation of the project. For the sustainability of restored mangroves and long-term protection of restoration sites, project activities need to focus on raising community awareness and strengthening management capacity.

A key finding of this project is that the direct sowing of mangrove propagules saved a lot of resources in comparison with planting nursery-raised seedlings and resulted in a higher survival rate.

Women engaged in mangrove restoration activities at project sites in Myanmar.

Appendices

River, Colombia
© Bridget Besaw

Appendix A: Key messages and FAQs

Chapter 2: Setting goals and assessing feasibility

Key messages	How to implement key messages and links to sections in the Manual
• Establishing clear goals and measurable objectives helps to communicate and set expectations with stakeholders and provides an early opportunity to integrate shared goals into project design.	• Set clear, time-specific goals and measurable objectives (via indicators) that are relevant for your site (Section 2.1).
• Restoration is a social enterprise and local leadership is key. Projects often fail without sufficient community and political support to sustain management in the long-term.	• Plan time and budget for community involvement that moves beyond consultation and instead integrates community needs with project goals. Remember that mangrove restoration can directly affect people's lives and wellbeing. (Section 2.2.2)
• Building trust, engagement, skills, empowerment, and ownership are essential for launching and maintaining mangrove restoration projects, and this takes time and commitment by project managers.	• Project developers should spend significant time prior to restoration activities ensuring local owners of the project are well informed and engaged in decision making from the outset. Communicate, with clear evidence, the benefits of restoration. (Section 2.2.2).
• Mangrove restoration typically fails in sites with prolonged inundation (e.g., in seagrass beds or mudflats that are low in the intertidal zone) or otherwise unsuitable conditions where mangrove seedlings cannot survive for long.	• Instead of planting over bare sites, question why mangroves are not already growing there, and use that information as the basis for assessing project feasibility. (Section 2.2.4).

Chapter 3: Project design

Key messages	How to implement key messages and links to sections in the Manual
• Historically low rates of success should not be linked to general uncertainty around what it takes to design a project that works but to a lack of communication around what is best practice.	• Monoculture plantations are not the same thing as ecosystem restoration. You need to understand site conditions and work with the landscape/seascape to enable restoration success. (Section 3.1)
• A good project design document should be co-created with the stakeholders and partners identified during the feasibility phase.	• People who have lived near a restoration site for decades can tell you more about site history and changing conditions than satellite images. Co-creating project design can increase restoration success and community understanding/support. (Section 3.4.2)
• Project managers should spend significant time prior to restoration activities ensuring local owners of the project are well informed and engaged in decision-making from the outset. Communicate the benefits of restoration with clear evidence.	• Section 3.2 provides guidance on conducting stakeholder analysis, while Sections 3.2.1 to 3.2.3 outline how to implement engagement at the community, local/regional, and national levels.
• The potential to restore mangroves depends largely on the degree of degradation, its geomorphic setting, and the willingness and capacity of the landowner.	• There are different types of mangrove sites with different recovery potential. Identify what you are working with and be certain the landowner or governing entity is clear on what restoration looks like. (Section 3.4.1)
• Ensure that the restoration design corrects hydrological, hydrodynamic, sedimentation, and propagule availability issues and replicates natural reference sites. To achieve this, local ecological knowledge and/or measurements of hydrological variables in natural and restoration sites can be used.	• Understanding site conditions and drivers of change is the basis of project design. (Section 3.4.4)

Chapter 4: Engagement and implementation

Key messages	How to implement key messages and links to sections in the Manual
• A step-by-step implementation plan with actions broken down into explicit tasks provides the direction needed to achieve the project's goals and objectives.	• Appendix E provides an example of a work plan linking goals, objectives, actions, milestones, deliverables, resources required and monitoring activities. It also outlines how causal statements can be defined and linked (Section 4.2).
• Implementation plans consist of several component parts, communicating what needs to be done, when each action should be carried out, and who is responsible for each task.	• Project management is as essential a skill as ecological understanding of restoration or social engagement processes. (Section 4.2.1)
• Tracking implementation progress is critical for projects to remain on track and on budget.	• A selection of project tracking and management tools are described in Section 4.2.
• Stakeholder engagement at all levels is important throughout implementation and monitoring.	• Section 4.5 provides guidance on conducting stakeholder analysis, while Sections 4.5.1 to 4.5.3 outline how to implement engagement at the community, local/regional, and national levels.
• There are many potential sources of funding for mangrove restoration projects, and for large or high impact projects it may be possible to blend finance options.	• An overview of the funding landscape is given in Sections 4.3 and 4.4 and via reading materials at the beginning of the chapter.

Chapter 5: Monitoring and evaluation

Key messages	How to implement key messages and links to sections in the Manual
• Monitoring is essential for establishing project success, for adaptive management, and for reporting of outcomes to stakeholders.	• Section 5.2 and the chapter reading list provide links to resources and examples which can help design a robust monitoring plan.
• Monitoring specific indicators is essential to gauge the relative success of mangrove restoration projects.	• Assessing the degree to which mangrove restoration projects have achieved specified outcomes allows for reflection and communication on the project's achievements as well as opportunities to identify adaptive management actions to improve outcomes (See section 5.2.3).
• A major challenge for mangrove restoration projects is securing the resources needed to continue monitoring beyond a project's funding lifespan.	• It is important to understand that funders are not ecologists and to be able to effectively communicate the need for long term site monitoring and maintenance. Engaging with universities and turning monitoring/reporting assessments into student projects is an option to reduce long-term costs while at the same time providing educational opportunities and building knowledge and capacity in the global community (Section 5.3).
• Adaptive management can be used to adjust the implementation plan in response to unforeseen developments.	• Resources on adaptive management can be found in Section 4.2.2 and 5.1.1.

Module 1: Blue carbon

Key messages	How to implement key messages and links to sections in the Manual
• Measuring the climate mitigation impact of mangrove restoration projects for National Greenhouse Gas Inventories (NGHGIs), Nationally Determined Contributions (NDCs), and Reducing Emissions from Deforestation and Forest Degradation (REDD+) programs require specific monitoring and reporting procedures to be followed to ensure consistency.	• Mangrove restoration can align with national policies aimed at greenhouse gas (GHG) emission reductions and removals, biodiversity enhancement, and climate change risk reduction, and this provides options to broaden the scope for supporting restoration projects with the capacity to meet monitoring requirements. (See sections 6.2 and 6.3).
• Depending on specific national legal and policy conditions for mangroves and carbon trading, not all mangrove restoration projects will be eligible to produce carbon credits.	• Voluntary carbon markets opened nature conservation and restoration projects to private sector investment, and they can potentially channel much needed finance for mangrove restoration. However, not all mangrove restoration projects are feasible as market-based carbon projects. See sections 6.4.1 and 6.4.5.
• There are specific technical monitoring requirements for mangrove restoration projects designed as carbon crediting projects.	• The technical requirements for mangrove restoration projects designed as market-based carbon abatement projects will differ from the measurement and monitoring required for inclusion in an inventory, NDC targets or as part of a REDD+ program. (See sections 6.3.1 and 6.5).
• Successfully producing carbon credits is a complex process with added administrative, technical, and monitoring costs. Smaller sized restoration sites will not be financially feasible based on projected credit income alone.	• Appendix G summarizes market volumes, geographical and sectoral scopes of the main voluntary market standards (Also see sections 6.4.5 and 6.4.6).
• There is the risk that carbon revenues can incentivize disbenefits. While leading standards attempt to prevent this, project managers should repeatedly evaluate the risk and adaptively manage the project if necessary.	• Appendix F provides an overview of leading carbon standards and methodologies relevant for mangrove restoration projects. Risk of disbenefits may be addressed via effective community inclusion in project design (Section 2.2.2 and 3.3) and via ethical benefit sharing. (Section 6.4.7).

Chapter 2: Setting goals and assessing feasibility

FAQs

How do I set measurable ecological and social goals and objectives for mangrove restoration?
Section 2.1.1

What is land tenure, and how does it affect my mangrove restoration project?
Section 2.2.1

Who do I need to consider when defining project goals and objectives?
Section 2.2.2

What is Community Based Ecological Mangrove Restoration?
Section 2.2.2

What should I be looking for when carrying out a remote assessment?
Section 2.2.3

What is the most important question to ask to understand if a site is suitable for restoration?
Section 2.2.4

My site looks good, what else do I need to think about?
Section 2.3

How does climate change impact restoration, and how can I mitigate those impacts?
Section 2.3.2

Chapter 3: Project design

FAQs

Why think holistically about restoration?
Section 3.1

What should be included in a project design document?
Section 3.2

How do I design a project to limit the social constraints that could hinder my success?
Section 3.3

What is physically happening at the restoration site? And how can it be fixed?
Section 3.4

What will I need to spend money on?
Section 3.5

Chapter 4: Engagement and implementation

FAQs

There's so much to be done... how do I make this more manageable?
Section 4.2

What do we do when things go wrong?
Section 4.2.1

How do I build adaptive management into my project implementation plans?
Section 4.2.2

What can I do to improve funding success?
Section 4.3.1

What kind of funding is best suited to my project?
Section 4.4

I want to make sure the community is fully involved... where do I start?
Section 4.5.1

Chapter 5: Monitoring and evaluation

FAQs

There's a lot changing on my restoration site... how do I know what to monitor?
Section 5.2

What are reference sites, and how are they used?
Section 5.2.1

How can I visualize, compare, and communicate progress towards multiple goals?
Section 5.2.3

How long do I need to monitor my project site for?
Section 5.3

I want to change my data collection methods after a few years... why is this a bad idea?
Section 5.3

Module 1: Blue carbon

FAQs

What units of measurement do we use for carbon?
Section 6.1

How are NDCs relevant to mangrove restoration projects?
Section 6.2

What is REDD+ and how is it relevant to mangrove restoration projects?
Section 6.2.2

What is Article 6, and does it affect my project?
Section 6.3.2

What are standards and methodologies, and what are the differences between them?
Section 6.4.2

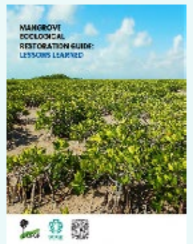
How do I know if I can do this, and does it make sense for my project?
Section 6.4.5

What is additionality, and how do I know if my project qualifies as additional?
Section 6.4.5

What funding options are available to mangrove carbon projects?
Section 6.4.6

Can I produce carbon credits from a mangrove restoration project which has already been carried out?
Section 6.4.8

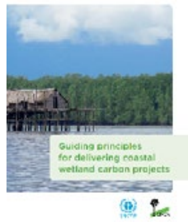
Appendix B: Methodologies and frameworks



Teutli-Hernández C., J.A. Herrera-Silveira, D.J. Cisneros-de la Cruz. and R. Román-Cuesta (2020). Mangrove Ecological Restoration Guide: Lessons Learned. Mainstreaming Wetlands into the Climate Agenda: A multi-level approach (SWAMP). CIFOR/CINVESTAV-IPN/UNAM-Sisal/PMC, 42pp.

Available in English: https://www.cifor.org/publications/pdf_files/Books/2020-Guide-SWAMP.pdf and in Spanish: https://www.cifor.org/publications/pdf_files/Books/2020-Guia-SWAMP.pdf

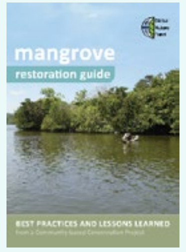
The objective of this guide is to navigate and strengthen the local capacities of anyone interested in recovering mangrove areas. This guide is intended to support the development of proposals, planning, execution, and monitoring of mangrove restoration programs. It sets out, beyond specific methodologies, a strategy that includes the integration of social, economic, and ecological components in the restoration process. The strategy is presented in an orderly and standardized way in three general phases: planning, implementation, and evaluation. The scope of its application includes all types of mangroves and levels of degradation, thanks to its conceptual and technical bases that consider the fundamentals and concepts of species, habitats, populations, communities, ecosystems, and the landscape. Central America and the Caribbean are regions of the planet where there is a significant increase in the intensity and frequency of extreme weather events. Among them, hurricanes, droughts, and floods, with severe effects on the stability of coastal ecosystems and their ecosystem services. The Mesoamerican and Caribbean region includes Small Island States whose ecological, economic, and social stability depends on the well-being of their coastal ecosystems such as mangroves, seagrasses, salt marshes and reefs. The United Nations has declared 2021-2030 as the Decade of Ecological Restoration. This guide is intended to support the window of opportunity to raise awareness of the importance of the restoration of blue carbon ecosystems such as mangroves and their ecosystem services.



UNEP and CIFOR (2014). Guiding Principles for Delivering Coastal Wetland Carbon Projects. United Nations Environment Programme, Nairobi, Kenya and Centre for International Forestry Research, Bogor, Indonesia, 57pp.

Available from: https://www.cifor.org/publications/pdf_files/Books/BMurdiyarso1402.pdf

This document provides knowledge-based guidance for a range of interventions, including policy actions, adjusted management actions or project-based investments that lead to improved coastal wetland conditions for climate change mitigation and adaptation. Drawing on lessons learned and case studies from coastal wetland management and restoration as well as terrestrial carbon projects, guiding principles are identified. In view of the high potential for inclusion of coastal wetland management in climate change mitigation strategies, consideration is given to including coastal wetland management under existing and evolving mechanisms, such as Reducing Emissions from Deforestation and forest Degradation (REDD+), and Nationally Appropriate Mitigation Actions (NAMAs). This guidance supports policy makers, coastal management practitioners and civil society organizations in designing projects and activities in coastal wetlands that synergize adaptation and mitigation objectives. Wetland conservation and restoration can be scaled up to establish multi-use functional landscapes integrating community activities in balance with sustaining environmental conditions.



Primavera, J.H., J.D. Savaris, B. Bajoyo, J.D. Coching, D.J. Curnick, R. Golbeque, A.T. Guzman, J.Q. Henderin, R.V. Joven, R.A. Loma and H.J. Koldewey (2012). Manual on Community-based Mangrove Rehabilitation. Mangrove Manual Series No. 1, London, UK: ZSL, viii + 240pp.

Available from: https://www.zsl.org/sites/default/files/media/2014-05/Manual%20on%20Community-Based%20Mangrove%20Rehabilitation.pdf

The Community-based Mangrove Rehabilitation Project of the Zoological Society of London ran from 2008 to 2012 with the aim of increasing coastal protection, food resources and livelihood income of coastal communities in Panay and Guimaras by rehabilitating abandoned government-leased fishponds to mangroves, re-establishing legally mandated coastal greenbelts, and securing tenure on coastal land through Community-based Forest Management Agreements (CBFMAs). During the CMRP, close to 100,000 mangroves were planted, with the rehabilitation of 107.8 ha (56.3 ha fishponds and 51.5 ha greenbelt) of mangrove forest underway. More than 4,000 people have been actively engaged in the planting, with many receiving intensive training. Six peoples' organizations were established or strengthened, with one of these being awarded a CBFMA and five more in progress. The four years of the project provided many important lessons in mangrove rehabilitation, for both nursery and grow-out phases. This manual presents the lessons learned, culminating in a set of 20 strategic "golden rules" for mangrove rehabilitation.

Global Nature Fund (2015). Mangrove Restoration Guide. Best Practices and Lessons Learned from a Community-Based Conservation Project. Global Nature Fund, Radolfzell, Germany, 60pp.

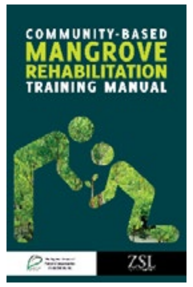
Available from: https://www.globalnature.org/bausteine.net/f/8281/GNF_Mangrove_Handbook_2015.pdf

This guide presents experiences and lessons learned from the project "Mangrove reforestation in Asia – local action and cross-border transfer of knowledge for the conservation of climate, forests and biodiversity". This project was carried out under the partnership of the Germany-based NGO Global Nature Fund in collaboration with five local partners in Sri Lanka, India, Cambodia, and Thailand. Lessons learned from these grassroots mangrove restoration efforts (five local case studies) that restored over 100 ha of damaged mangroves by adopting a Community-Based Ecological Mangrove Restoration (CBEMR) approach, are summarized in this guide. The guide presents the basic principles of CBEMR, its advantages over other restoration methods, when to use planting and CBEMR, and takes the reader through seven basic steps that are considered vital pre-conditions for successful mangrove restoration.

ICRI (2018). Mangrove Restoration: The Key Elements to be Considered in Any Restoration Project. Technical Guide. Pole-Relais Zones Humides Tropicales, 2018, 32pp.

Available in English: https://icriforum.org/wp-content/uploads/2020/05/restoration-guide-eng-WEB-secured%20(1).pdf and in French: https://icriforum.org/wp-content/uploads/2020/05/guide-restauration-web-25.03.pdf

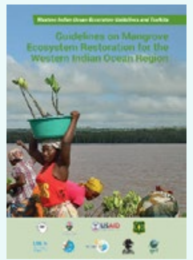
This technical guide on mangrove restoration was produced by the French Tropical Wetlands Network. The report provides a summary of elements that may be considered in any mangrove restoration project based on a review of available literature and practices around the world. There are essentially two different fundamental approaches to ecological restoration: natural colonization and mangrove planting. These two approaches are described and explored in depth in the report. Due to the threats facing mangrove systems, restoration is being increasingly undertaken, often in the form of replanting mangrove stands with seedlings. Despite the efforts involved in these initiatives, the results are often disappointing due to a lack of forward planning. Problems include poor choice of location, mono-specific coverage, or lack of consultation with local stakeholders, all of which can limit the medium- or long-term success of restoration actions, and thus fail to restore a functional mangrove forest. A successful restoration action results in the establishment of a relatively large, diverse, functional, and self-sustaining mangrove forest that can provide environmental and human benefits. The guide therefore recommends a natural colonization approach whenever feasible, based on recommendations from organizations such as Mangrove Action Project (MAP) and Wetlands International.



PTFCF and ZSL (2021). Community-Based Mangrove Rehabilitation Training Manual. Philippine Tropical Forest Conservation Foundation and Zoological Society of London, 68pp.

Available from: https://www.zsl.org/sites/default/files/media/2018-08/Mangrove%20Rehab_Training %20Manual.pdf

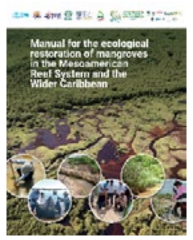
Awareness of the importance of mangroves, particularly for coastal protection and blue carbon, has grown among the general public over the past several years. In turn this has led to numerous planting initiatives by national government agencies, local government units and communities, non-government organizations, schools, and especially the corporate sector. However, most of these programs did not yield positive results mainly due to lack of science-guided protocols. To address this gap, the Philippine Tropical Forest Conservation Foundation, Inc. (PTFCF) has produced this manual for dissemination to groups that undertake mangrove rehabilitation in the Philippines. It is an abridged version of the Manual for Community-based Mangrove Rehabilitation (Primavera et al., 2012a, see above), a documentation of the experience of Zoological Society of London-Philippines in mangrove nurseries and out-planting of propagules. Annexed to the latest version of this training manual is the Guide on Mangrove Damage and Recovery Assessment, which was drafted following the impacts of Super Typhoon Yolanda in 2013.



Kairo, J.G. and M.M. Mangora (2020). Guidelines on Mangrove Ecosystem Restoration for the Western Indian Ocean Region. UNEP-Nairobi Convention/USAID/WIOMSA, 71pp.

Available from: https://www.nairobiconvention.org/CHM%20Documents/WIOSAP/guidelines/GuidelinesonMangroveRestorationForTheWIO.pdf

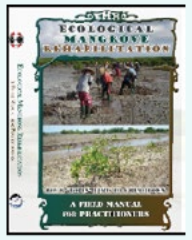
The Guidelines on Mangrove Restoration for the Western Indian Ocean Region analyses, for the first time for the region, the risks and challenges to mangrove restoration projects and points to potential solutions. The guidelines were developed by the member states of the Nairobi Convention with support from UNEP–Nairobi Convention, the Western Indian Ocean Marine Science Association, and the Western Indian Ocean Mangrove Network. They can be used by governments, resource managers, scientists, civil society, and communities at large as they embark on mangrove conservation and management initiatives. With the inclusion of case studies from around the region, the guidelines also enhance and promote shared lessons and best practices across the Western Indian Ocean and beyond.



Teutli-Hernández et al. (2021). Manual for the ecological restoration of mangroves in the Mesoamerican Reef System and the Wider Caribbean. UNEP and Mesoamerican Reef Fund, Guatemala, 114pp.

Available from: https://marfund.org/en/wp-content/uploads/2022/01/Manual-for-Mangrove-restoration.pdf

Mangroves in the Mesoamerican Reef Region (MAR) and the Wider Caribbean are the economic foundation of over 134 million people living in the coastal regions, providing a range of ecosystem services in particular blue carbon storage and protection against floods, storms, and hurricanes, to which the region is highly vulnerable. This manual aims to contribute to strengthening local, national, and regional capacities for the ecological restoration of mangroves in the MAR and the Wider Caribbean region. Within the framework of the Cartagena Convention and the United Nations Decade on Ecosystem Restoration 2021-2030, ecological restoration (ER) of mangroves is considered a Nature-based Solution (NbS) that addresses the effects of climate change and contributing to the United Nations Sustainable Development Goals. This manual offers a high-quality technical restoration guide for Mesoamerica and Caribbean, addressing both passive and active restoration approaches. The manual also provides an extensive list of active restoration groups in the Caribbean region.



R.R. Lewis and B. Brown (2014). Ecological Mangrove Rehabilitation. A Field Manual for Practitioners. Mangrove Action Project, 151pp.

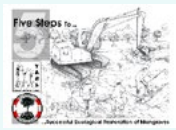
Available from: https://blue-forests.org/wp-content/uploads/2020/04/Whole-EMR-Manual-English.pdf

Over the years, there have been many different attempts to restore mangroves. Some of these efforts have been large-scale, involving several thousand hectares of coastal lands. Other efforts have been small-scale in comparison, with perhaps less than a hectare of mangroves restored. There are many different techniques and methods utilized in planting mangroves. Based on lessons learned from both successes and failures, this field manual aims to present a detailed process of mangrove rehabilitation which has proven successful in its application in various locations at various scales. Ecological Mangrove Rehabilitation (EMR) engages communities to consider social, economic, and ecological factors before undertaking mangrove restoration, and relies on monitoring to inform corrective actions over time. This EMR manual also presents summary descriptions of case studies from around the world, which are representative of both successful and failed attempts at mangrove restoration.

PPA (2020). Mangrove Rehabilitation Guidelines. Report A382466, Pilbara Ports Authority, Port Hedland, 21pp.

Available from: https://www.pilbaraports.com.au/about-ppa/publications/forms-and-publications/forms-publications/guideline/2020/june/mangrove-rehabilitation-guidelines

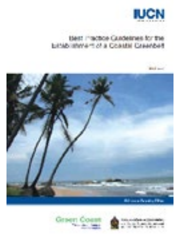
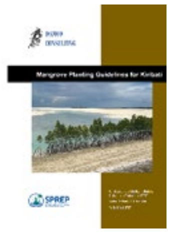
A practical guide that specifically addresses mangrove rehabilitation related to the removal of temporary infrastructure and associated construction envelopes, with a special focus on the semi-arid Pilbara region of Western Australia. The guide discusses mangrove habitats in the Pilbara region, practical considerations for installation and removal (decommissioning) of infrastructure in mangrove habitats, methods for mangrove rehabilitation and offset projects, mangrove reinstatement following removal of temporary infrastructure and access corridors (such as roads, levees, conveyors, pipeline crossings, solar salt ponds, ponds containing dredged spoil), natural recolonisation and planting, completion criteria and monitoring of rehabilitation progress.

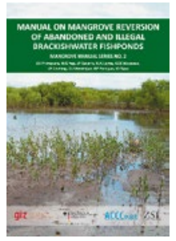
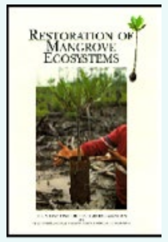


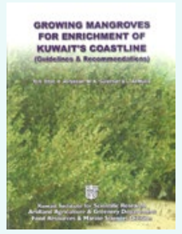
Lewis, R.R. III and B. Brown (2006). Five Steps to Successful Ecological Restoration of Mangroves. Mangrove Action Project, 64pp.

Available from: https://dcrm.gov.mp/wp-content/uploads/crm/5_steps_to_restoration_of_mangroves.pdf

This cartoon-style guidance manual presents five critical steps that are considered necessary to achieve successful mangrove restoration (originally developed by the late Robin Lewis III): [1] understand the autecology (individual species ecology) of the mangrove species at the site; in particular the patterns of reproduction, propagule distribution, and successful seedling establishment; [2] understand the normal hydrologic patterns that control the distribution and successful establishment and growth of targeted mangrove species; [3] assess modifications of the original mangrove environment that currently prevent natural secondary succession (recovery after damage); [4] design the restoration program to restore appropriate hydrology and, if possible, utilize natural mangrove propagule recruitment for plant establishment; [5] only utilize planting of propagules, collected seedlings, or cultivated seedlings after determining (through steps 1-4) that natural recruitment will not provide the quantity of successfully established seedlings, rate of stabilization, or rate of growth of saplings established as objectives for the restoration project. This excellent guide is a precursor of the later Field Manual for Practitioners (Lewis and Brown, 2014).

	IUCN (2007). Best Practice Guidelines for the Establishment of a Coastal Greenbelt. IUCN, Sri Lanka office, 16pp. Available from: https://portals.iucn.org/library/sites/library/files/documents/2007-021.pdf The overall objective of these guidelines is to evolve a systematically designed common approach to restore, rehabilitate and/or recreate a vegetational barrier/buffer (greenbelt) that may be resilient and stable enough to prevent or mitigate the devastating effects of natural disasters such as cyclones, storm surges and tsunamis. The enthusiasm and wide acceptance of the need to rehabilitate or establish afresh, a coastal belt of vegetational cover following the post-tsunami scenario, has in recent times led to unregulated and disoriented rehabilitation works that are likely to have serious negative consequences. These guidelines aim to ensure that well-integrated greenbelts will emerge in conformity with basic standards and policies on coastal conservation.
	ADB (2018). Community-Based Mangrove Planting Handbook for Papua New Guinea. Asian Development Bank, GEF, 86pp. Available from: https://www.adb.org/sites/default/files/publication/479436/png-mangrove-planting-handbook.pdf This publication is an initiative of the government of Papua New Guinea that provides step-by-step guidance on how to rehabilitate mangroves. It aims to help address the impacts of climate change, particularly the coastal flooding prevalent in Papua New Guinea. It is a resource for the planting of mangroves for diverse purposes, including carbon sequestration, nature conservation, support for fisheries, and ecotourism. It offers a set of guidelines for community-based mangrove restoration projects with a focus on planting.
	SPREP (2020). Mangrove Planting Guidelines for Kiribati. DAMCO Consulting, for the South Pacific Regional Environment Programme (SPREP), 15pp. Available from: https://www.sprep.org/sites/default/files/documents/publications/mangrove-planting-guidelines-Kiribati.pdf A practical set of guidelines for mangrove planting in Kiribati. Although the focus of this report is on the planting of Rhizophora stylosa in Kiribati, much of its contents can also be applied elsewhere in the Pacific region. The guidelines are based on a combination of a literature review of mangrove planting efforts worldwide, evaluation of previous achievements in mangrove planting on Tarawa (Kiribati) and the author's personal experience. The guidelines discuss mangroves in Kiribati, rationale for planting, critical steps for success, when to plant, common reasons for failure, nursery establishment, planting methods, low-tech hybrid engineering, community participation, expectations, monitoring, and evaluation.
	Marchand, M. (2008). Mangrove Restoration in Vietnam - Key Considerations and a Practical Guide. Deltares, December 2008, 42pp. Available from: https://repository.tudelft.nl/islandora/object/uuid:98b5ba43-1452-4631-81dc-ad043ef3992c/datastream/OBJ/download This is a summary report on factors contributing to successful mangrove rehabilitation or planting projects, with a particular focus on Vietnam. It can be used as a practical guide to the planning of these projects. The report discusses mangroves in Vietnam and their role in storm and erosion protection, successes, and failures of previous mangrove restoration efforts, five steps for successful mangrove restoration (based on Lewis and Brown, 2006; see above), monitoring and maintenance requirements, and costs.

	Primavera et al. (2014). Manual on Mangrove Reversion of Abandoned and Illegal Brackish Water Fishponds. GIZ-ZSL, 124pp. Available from: https://www.zsl.org/sites/default/files/media/2014-05/Manual%20on%20Mangrove%20Reversion %20of%20Abandoned%20and%20Illegal%20Brackishwater%20Fishponds.pdf This manual offers an extensive resource on mangrove rehabilitation in abandoned shrimp pond areas. This volume is a sequel to the Manual for Community-based Mangrove Rehabilitation (Primavera et al., 2012b; see above) but has a focus on mangrove restoration in abandoned and illegal ponds. Though focused on the Philippines, this is a subject of high relevance to many other South-East Asian nations where it would be equally useful in guiding rehabilitation efforts. The manual is divided into four sections, including [1] a general introduction on mangroves (zonation, species, status) and brackish-water pond aquaculture (including pond abandonment and tenurial systems), [2] inventory of brackish-water ponds (including steps to map and determine tenurial status), [3] biophysical considerations for mangrove growth, and [4] protocols for pond reversion to conditions suitable for mangrove growth.
	Wetlands International (2021). Technical Guidelines Series Building with Nature to Restore Eroding Tropical Coastlines. Series of 5 separate technical guidelines Available from: https://www.wetlands.org/news/technical-guidelines-released-for-restoring-eroding-tropical-coastlines/ A series of five technical, science-based but practical guidelines for restoring eroding tropical mangrove coastlines through nature-based approaches, with detailed attention for both technical and socioeconomic aspects. These guidelines are based on insights and lessons learned during the implementation of a district-scale pilot in Central Java (Indonesia) as part of the Building with Nature Indonesia programme. The aim of sharing the lessons learned in these practical guidelines is to enable replication by government agencies, the water and aquaculture sector and NGOs elsewhere in Indonesia and beyond. It is emphasized that Building with Nature measures should be part of integrated coastal zone management and require a thorough problem understanding and system analysis.
	Wetlands International (2020). Mangrove restoration: to plant or not to plant? Wetlands International, Wageningen, 12pp. (available in English and 10 other languages, including Bahasa Indonesia, Burmese, Spanish, Thai, Vietnamese, Khmer, Malay, Filipino, Chinese and Kiswahili). Available from: https://www.wetlands.org/publications/mangrove-restoration-to-plant-or-not-to-plant/ Mangrove planting has become hugely popular. Most planting efforts are, however, failing. A more effective approach is to create the right conditions for mangroves to grow back naturally. Mangroves restored in this way generally survive and function better. This publication aims to contribute to best practice by exploring the question that everyone involved in mangrove restoration should ask: to plant or not to plant? The focus of this guide is on facilitating natural recovery by restoring the enabling biophysical and socioeconomic conditions and letting nature do the rest. In some cases, planting can assist or enrich the natural regeneration process, but planting in non-mangrove habitats and areas showing natural recruitment is discouraged.
	Field, C. (Ed.) (1996). Restoration of Mangrove Ecosystems. International Tropical Timber Organization (ITTO) and International Society for Mangrove Ecosystems (ISME), Okinawa (Japan), 250pp. Available from: http://www.mangrove.at/mangroveshop/restoration-of-mangrove-ecosystems.html One of the first global guidebooks on mangrove restoration is excellent, although now out of print. It describes the rationale and basic principles for mangrove restoration, along with 13 case study chapters on restoration projects from across Asia, the Americas and Saudi Arabia and a concluding chapter on general guidelines for the restoration of mangrove ecosystems, with details on site selection, selecting species, seed collection, nursery practices, planting, and care after planting.

	Chan, H.T. and S. Baba (2009). Manual on Guidelines for Rehabilitation of Coastal Forests damaged by Natural Hazards in the Asia-Pacific Region. International Society for Mangrove Ecosystems (ISME) and International Tropical Timber Organization (ITTO), 66pp. Available from: https://www.preventionweb.net/files/13225_ISMEManualoncoastalforestrehabilita.pdf This manual provides an overview and guidelines for rehabilitation of mangroves and other coastal forests. The guidelines include the rationale for rehabilitation, choice of species, site selection and preparation, propagation and planting, monitoring and tending, and case studies. The case studies provide useful lessons of success and failure of past and on-going projects in coastal forest rehabilitation. The manual includes introductory chapters on coastal forests (mangrove forests, beach and dune forests, and forests of coral islands), natural hazards (tsunamis, tropical cyclones, coastal erosion, and sea-level rise), and the protective roles of coastal forests. The manual is the final output of the ISME/ITTO Pre-Project on Restoration of Mangroves and other Coastal Forests damaged by Tsunamis and other Natural Hazards in the Asia-Pacific Region.
	Bhat, N.R., A. Al-Nasser, M.K. Suleiman and L. Al-Mulla (2007). Growing Mangroves for Enrichment of Kuwait's Coastline (Guidelines and Recommendations). Kuwait Institute for Scientific Research (KISR), 2nd Edition (2007), 25pp. (In English and Arabic). This practical 25-page booklet offers helpful guidance for mangrove planting initiatives along coastlines in arid areas in the Arabian/Persian Gulf, with a particular focus on Kuwait. It discusses mangroves in Kuwait, rationale for mangrove planting efforts and its benefits in Kuwait, site selection, selection of mangrove species (Avicennia marina) and propagule sources, nursery raising, field planting and growth monitoring. It is also available (from KISR) in Arabic.
Google Earth Engine Mangrove Mapping Methodology	The Google Earth Engine Mangrove Mapping Methodology (GEM) provides an intuitive, accessible, and replicable tool which caters to a wide audience of non-specialist coastal managers and decision makers. Available from: https://github.com/Blue-Ventures-Conservation/GEEMMM The GEM is designed specifically to map multi-date mangrove distributions and quantify dynamics anywhere in their global distribution. While not requiring advanced skills in remote sensing, geospatial analysis, or coding, the tool is designed with the assumption that users have basic computer skills and are familiar with the key steps in mapping mangroves and assessing dynamics.
Community based payments for Ecosystem Services.	Rakotomahazo, C., Ravaoarinorotsihoarana, L.A., Randrianandrasaziky, D., Glass, L., Gough, C., Todinanahary, G.G.B., Gardner, C.J. (2019). Participatory planning of a community-based payments for ecosystem services initiative in Madagascar's mangroves, Ocean and Coastal Management, Volume 175, pp. 43-52. Available from: https://blueventures.org/publications/participatory-planning-of-a-community-based-payments-for-ecosystem-services-initiative-in-madagascars-mangroves/ This peer-reviewed publication details two participatory approaches used in the Tahiry Honko project, Madagascar (See case study). Public participation geographic information systems and concept modeling workshops were carried out with 10 coastal communities to investigate the dynamics and spatial distribution of the mangrove resources they use.

Appendix C: Governance, institutions, livelihoods, and mangrove restoration: some key Issues and tools

Key issues	Why is it important?	Tools for analysis and engagement
Social and economic context.	Socioeconomic factors directly and indirectly influence mangrove restoration. The socioeconomic context includes understanding the actors (e.g., individuals, groups, institutions) and their relationships to each other and the mangrove resource. It includes understanding the values of direct and indirect users of mangrove resources and mangrove areas and other stakeholders who either have an interest in mangroves and their health or whose activities might influence them in some way. Direct users might include those who cut mangrove wood, use it to make charcoal, who make use of the different fisheries resources found in mangrove areas, and those developing aquaculture, agricultural or industrial activities within or adjacent to mangrove areas. Indirect users would include those who exploit fish resources that depend on mangroves for at least part of their life-cycles (as nursery grounds, shelter or feeding areas). Given the importance of mangroves for the life cycles of many commercially important fish resources in tropical coastal waters, the number of indirect users of mangrove resources will often include women, men and children, fishers, fish workers, processors and other people involved in the fish and seafood industries and markets, even if they rarely or never directly access mangroves. A wide range of people living in coastal areas are protected by mangroves and are also "users" in the sense that their life and livelihoods may be dependent on enhanced coastal protection from existing mangroves. "Indirect" stakeholders include a similarly wide range of people whose activities might affect, positively or negatively, mangroves and processes of mangrove restoration. For example, users of up-stream water supplies for mangrove areas, those involved in agriculture and industrial activities that might generate pollution that impacts on mangrove areas and those exploiting or living in forest areas in catchments whose activities will affect run-off and sedimentation in estuaries.	
Identifying mangrove users and understanding their power relationships.	The groups of people who use mangroves and mangrove areas and their characteristics will have a strong influence on the feasibility of mangrove restoration and how it should be implemented. Extractive users whose livelihoods depend on access to, and use of, mangroves will clearly have a more direct interest in restoration work, because of the positive or negative effects it might have on their livelihoods and because they are potential stewards of mangrove resources who have a direct interest in its sustainability. Including female stakeholders and their roles is important (see below).	A stakeholder analysis is an effective method to identify who should be involved in management and restoration activities.[149,162,163] Some tools which can help in this process include: ALNAP Stakeholder Analysis Toolkit FAO tool for facilitating multi-stakeholder processes IIED using stakeholder and power analysis in multi-stakeholder processes WWF stakeholder analysis.

Understanding the direct and indirect role of mangrove and mangrove resources in local livelihoods and the local economy.	Properly analyzing the role that mangroves play (i.e., the resources that are found in mangrove areas, and the use of mangrove areas) in different people's livelihoods is key for mangrove restoration planning. Mangrove areas contain numerous livelihood "niches" that may be used by different social, gender, age, and economic groups in different ways. Similarly, linkages between mangrove resources and mangrove use and the wider economy need to be understood to identify key drivers of mangrove degradation as well as potential opportunities for mangrove stewardship. Analysis of historical trends in mangrove use and the factors driving changes and current trends in local economic, social and technological development are also important. Increasingly, in the context of responses to climate change, this analysis may include wider political issues, including international commitments for protection and conservation as well as pressures from globalized demand for products related to mangrove areas such as farmed shrimp.	Livelihoods analysis for a more detailed understanding of how different user groups might influence and/or be affected by mangrove restoration and management interventions. Links to: DFID Sustainable Livelihoods Guidance Sheets FAO e-learning course on sustainable livelihoods FAO/ILO Livelihood Assessment Toolkit Livelihoods Centre Livelihoods Toolbox.
Understanding the gender and age characteristics of users.	Understanding the gender and age dimensions of community and household members that use or depend on mangroves, and the specific gender and age of mangrove users is particularly important. While some of the more "visible" activities in mangrove areas, such as wood cutting and fishing, may be carried out by men, women and children often directly participate in resource use and resource extraction activities that can play a significant role in household livelihoods and local economy. These can include firewood collection, harvesting of shellfish and molluscs, fishing activity with a variety of active and passive fishing gears in shallow channels and pools within mangroves or along their fringes and gleaning on mudflats at low tide. For example, women and children collect shrimp fry for aquaculture operations using simple push nets in mangrove areas of coastal Bangladesh. These types of use can be considered when developing mangrove restoration projects to better serve all groups in the community. Particular care may be required to understand and map out the institutional arrangements surrounding gender relations and the relative power and influence of women and men, and the power relationships between different age groups.	Gender analysis tools for an in-depth understanding of the gender dimensions of mangrove resource use. For gender analysis, links to: Mangroves for the Future Gender Analysis Toolkit CASCAPE manual on gender analysis tools IUCN Gender Analysis Guide. Guidance for the analysis of the role of children in mangrove resource use. For analysis of children's role, links to: FAO handbook for evaluating child labour in agriculture FAO/ILO guidance on addressing child labour in fisheries and aquaculture.
Institutional context.	The institutional context influences how a mangrove restoration intervention can be designed and its likelihood of success. Institutional context includes both the "organized" institutions (government departments, resource user organizations, local and national legislatures, and representative bodies), institutional norms (such as tenure systems, traditional management arrangements) and the less tangible "rules of the game" in a society (such as ingrained power relations between groups, norms of behavior).164 Any arrangement that persists over time and serves some collectively valued purpose165 can be regarded as an institution that might influence efforts to restore and manage mangroves.	

Analyzing and mapping institutions.	Understanding the institutional context for mangrove restoration requires analysis of a range of institutions - formal and informal, structured and unstructured. Some of these institutions may have a direct influence on how mangroves are used, and this influence may be obvious (for example customary use rights among local communities, local tenure arrangements, government agencies with responsibilities for mangrove protection, or organizations of different user groups such as fishers, local women involved in shellfish collection, firewood collectors, or fish farmers). Other institutions may have an important but less obvious influence. This might include a range of unseen "arrangements" that are widely accepted but not formalized in any way (for example the power exercised by certain influential, but informal, leaders, or informal networks among people from certain backgrounds or age groups). For all of these "institutions", certain key aspects are: what does an institution deal with and how is that determined (mandate and legitimacy)?; what an institution is supposed to do and what it actually does (formal versus informal mandates)?; who is a member of an institution and how is that determined (membership, inclusiveness, and exclusivity)?; what are the rules governing a particular institution, how are they decided and how are they enforced (rules, regulations, norms, and values)?	Many approaches can be used for analyzing institutions. Resources available or institutional analysis and mapping include: IFAD Institutional Analysis Tools World Bank Sourcebook for Institutional, Political and Social Analysis IIED Power Tools for analyzing institutions and policies E. Ostrom (2010) Crafting Analytical Tools to Study Institutional Change UNDP Institutional and Context Analysis Guidance Note.
Working with institutions and catalyzing institutional change.	The process of working with institutions to encourage them to create a more supportive institutional environment for restoration can be particularly challenging. In some cases, mangrove restoration initiatives may require the creation of new institutions or organizations to provide more effective support, but more often restoration projects will need to work with existing institutions and within existing institutional arrangements. It is important to understand whether institutions are "fit for purpose", in other words equipped to perform the roles and tasks relating to mangrove management and mangrove restoration that are expected of them. Based on this understanding, areas of potential institutional change, strengthening and capacity development can be identified, and work undertaken to support mangrove restoration efforts. Various processes can aim to inform and influence institutions, to catalyze change within institutions and to develop their existing capacities and strengths to develop a more "enabling" institutional environment. The time frames involved in bringing about institutional change may be long (decades) but including processes of institutional reform, leadership strengthening, and capacity-building as part of mangrove restoration work can deliver benefits.	For guidance on undertaking processes of informing and influencing institutions for change, links to: The OXFAM Influencing for Impact Guide IFAD Institutional Analysis Tools. For determining institutional capacity and whether they are 'fit for purpose', links to: UNDP Institutional and Context Analysis Guidance Note For developing new institutions, links to: FAO Crafting Institutions for Community Forestry. For institutional capacity development, links to: Effective Institutions Platform. For promoting institutional change, links to: IIED Exploring institutional change.
Legislative context.	The legislative arrangements surrounding mangroves, mangrove management and mangrove restoration will have a fundamental influence on which mangrove restoration interventions are and are not possible.	

Understanding existing legislation, catalyzing legislative change, and permit requirements.	Knowledge of laws and regulations about mangrove use, about fisheries and about the roles and responsibilities of different actors and institutions concerned with mangrove areas is fundamental. Undertaking mangrove restoration activities in coastal environments can trigger government legislation and regulations that require approvals (permits). Permission from communities or landholders may also be required to restore a particular area. Given mangroves occur at the interface between land and sea, multiple government agency permits may be required from fisheries, marine, environment, and planning departments.144 Gaining permits can take months, usually involve an application fee, and requires expertise to complete the approval documentation. Knowledge of the process early in project planning including the costs and resources involved can speed progress. Consultation with the relevant federal, state, and local government agencies and with local communities and Traditional Owners can help identify permits and permissions required. Introducing new legislation will involve often complex and long-term processes and require the mobilization of political support at various levels.	For understanding and working on the improvement of the legislative context, links to: IUCN Legal Frameworks for Mangrove Governance FAO Legislating for small-scale fisheries FAO Policy and Legal Diagnostic Tool for Small-Scale Fisheries. For informing and influencing legislators on the need for legislative change, links to: The OXFAM Influencing for Impact Guidejg0O IFAD Institutional Analysis Tools.
Governance arrangements.	The governance arrangements for mangrove areas are determined by the combination of the institutions involved and how they work, the laws and regulations that are in place and how they are implemented or enforced, and the relationships between different key actors and interest groups. The analysis of mangrove stakeholders and the context within which they live and work (described above) will all combine to help those implementing mangrove restoration interventions to determine what governance arrangements are in place, how they have developed and why they persist, and how they might be changed or managed to enhance restoration of mangroves. Knowledge of governance arrangements can highlight the "fitness for purpose" of different potential management arrangements, indicating for example how mangrove users can take on roles as mangrove stewards and the institutional arrangements that might make this possible.	
Improving governance and creating an enabling environment.	Bringing about change in governance arrangements often depends on generating corresponding changes in the institutional and legislative contexts so that improved governance becomes possible i.e., developing an "enabling" environment. Often these changes may require long-term engagement and processes of institutional development and reform. However, the introduction of better measures for managing mangrove areas will assist the change process by creating pressure for institutional change at higher levels. The promotion of collaborative, co-management approaches that involve a range of stakeholders in decision-making processes and in the implementation of management is likely to be particularly important. Different degrees of collaboration between mangrove users and local authorities, government agencies and other local organizations will be appropriate in different settings, and there is no single template for effective co-management. An adaptive approach is key. The range of sources suggested here include options for improved regulations, rules and governance arrangements for mangroves, forests, and fisheries.	For improving governance arrangements, links to: FAO Code of Conduct for Responsible Fisheries FAO Voluntary Guidelines on the Responsible Governance of Tenure Arrangements FAO Technical Guides on the Governance of Tenure FAO Sustainable Forest Management toolbox FAO Voluntary Guidelines on Securing Sustainable Small-Scale Fisheries. For adaptive management and co-management approaches, whether of mangrove forests or fisheries, link to: CIFOR Field Guide to Adaptive Collaborative Management Low Impact Fishers of Europe Co-Management for Small-scale Fisheries MRAG Research Outputs on Adaptive Learning in Adaptive Fisheries Management

Appendix D: Example of project goals, objectives, and indicators

A worked example of ecological and social goals, objectives and indicators for a mangrove restoration project focused on key ecosystem and social attributes (adapted from the International Restoration Standards).[6]

In this fictitious case, mangrove degradation and loss has occurred due to several threats: 1) altered hydrology (i.e., lack of tidal flow), 2) invasive weeds, and 3) harvesting for timber.

Project vision: "To restore hydrological connectivity, increase mangrove cover, enhance long-term carbon storage, and incentivize reduced harvesting of mangroves through payments from the sale of carbon credits".

Goal type (ecological or social)	Attribute	Goal	Objective	Indicator measured	Desired out-come	Desired magnitude of effect	Time frame (years)
Ecological	Biophysical conditions	Hydrology is restored to the same regime as in the reference model within 2 years	Water salinity at the site increases to 50% of the salinity of the reference model, within 1 year	Water salinity	Water salinity increases	50% of what is required to achieve reference model conditions	1
Ecological	Species composition	The diversity of mangrove tree species is restored to the same as the reference model within 25 years	Mangrove species richness increases to 20% of that required to achieve species richness of the reference model, within 5 years	Mangrove species richness	Number of mangrove tree species increases	20% of that required to achieve reference model conditions	5
Ecological	Species composition	The diversity of mangrove associated keystone and/ or indicator macrofauna species is restored to the reference model within 25 years	The abundance and diversity of mangrove macrofauna keystone and/or indicator species (e.g., worms, crabs, and molluscs) is 80% similar to the reference model and achieved within 5 years	Keystone and/ or indicator macrofaunal species	Abundance and diversity of keystone and/or indicator macrofaunal species increases	80% of that required to achieve reference model conditions	5
Ecological	Structural diversity	The basal area of mangrove trees is restored to reference model within 25 years	Mangrove basal area increases to 20% of that required to achieve basal area of the reference model, within 5 years	Basal area of mangrove trees	Basal area increases	20% of that required to achieve reference model conditions	5
Ecological	Ecosystem function	Carbon stored by mangroves aboveground biomass has increased by 167 Mg C ha^{-1} within 25 years	Carbon stored by mangroves increases to 20% of that required to achieve the overall target, within 5 years	Above and belowground and soil carbon stocks	Carbon stocks increase	20% of that required to achieve overall carbon storage target	5
Ecological	External exchanges	Hydrological connectivity is restored to reference model within 2 years	Tidal inundation depth increases to 50% of that required to achieve tidal inundation depth of the reference model, within 1 years	Tidal inundation depth	Tidal inundation depth increases	50% of that required to achieve reference model conditions	1
Ecological	Absence of threats	Invasive weed species are absent within 25 years	Invasive weed species density reduced by 50% within 2 years	Invasive species density	Invasive species density decreases	50%	2
Social	Sustainable economies	Payments for mangrove carbon credits provide a viable alternative livelihood for local community members, within 5 years	Annual income from payments for mangrove carbon increases community income by 50% within 5 years	Income from payments for mangrove carbon	Proportion of local community income from mangrove carbon increases	50% increase	5
Social	Community wellbeing	Sense of place improved for local community within 5 years	Visitation of mangroves by local community members for recreation increases by 50% within 5 years	Visitation by local individuals	Visitation by local individuals increases	50% increase	5

Goal type (ecological or social)	Attribute	Goal	Objective	Indicator measured	Desired out-come	Desired magnitude of effect	Time frame (years)
Social	Stakeholder engagement	Buyers of carbon credits generated from the mangrove restoration project communicate their involvement and the benefits publicly within 5 years	At least one carbon credit purchaser is advertising their involvement in the project within 2 years	Stakeholder advertising	Stakeholder advertising increases	1 stakeholder	2
Social	Benefits distribution	A governance arrangement is formalized to ensure that local stakeholders are leading mangrove restoration activities and payments from carbon credits are distributed equitably throughout the community, within 5 years	Two local stakeholders are managing restoration activities and distributing carbon payments within 5 years	Number of local stakeholders in formal management positions	Number of local managers increases	2 managers	5
Social	Knowledge enrichment	Knowledge of mangrove ecosystem services is enriched by engaging local community members in citizen scientist events	Number of citizen scientists involved in monitoring carbon storage increases by 50% within 5 years	Number of citizen scientists involved in monitoring carbon storage	Citizen scientist involvement increases	50% increase	5

A framework for practitioners to assess project outcomes from a mangrove restoration project using the above example. The example is restoration of a degraded 150 ha site.

Project assessment phase	Social parameters	Carbon credit parameters	Hydrological and ecological functioning parameters
Project goal	Goal (a): Ensure stakeholders are actively engaged and supportive and build management capacity to secure the long-term, on-going sustainability of the project.	Goal (b): Develop and register the project to a carbon market standard for issue of carbon credits.	Goal (c): Improve hydrological and ecological functioning.
Objectives	Objective (a): Active participation and training in all aspects of project design and implementation, building management capacity.	Objective (b): To develop and register the project with a reputable carbon standard and methodology.	Objective (c): To re-establish hydrological connectivity and improve the ecological functioning across the site.
Milestones and indicators	Stakeholders are actively involved in the setting of short-, mid-, and long-term project milestones with benchmarks to be achieved over time using SMART guidance. Key community members are represented on the projects management board and actively engaged in decision making.	Project application deadlines are met.	The entire restoration area is inundated on spring high tides. Within 6 months of hydrological restoration activities natural mangrove recruitment is evident within the project area. Within 18 months seedlings are growing naturally across the entire project area with a density of > 1 seedling per m^2. Grazing of naturally recruited seedlings by feral animals is reduced by 80% within 18 months. Pest plant density is reduced by 80% within 18 months.
Outcome	Most stakeholders were involved in setting milestones (6 out of 10 stakeholders identified in the stakeholder analysis) and are represented on the projects management board, although participation/engagement in decision making remains limited.	Market application deadlines were met, the project was approved, and restoration activities commenced in line with the applied GHG standard.	Most of the restoration area is inundated, although some landward margins remain dry on spring tides. Natural recruitment is observed within 6 months and seedlings are growing naturally across most (but not all) the project site within 18 months. Grazing of seedlings has been reduced through fencing, but pest plants remain present in landward margins.
Outcome assessment	Partially achieved (6/10).	Achieved (10/10).	Partially achieved (7/10).
Remedial action	Conduct more capacity building workshops/trainings to build management confidence.	N/A	Level landward margins using a mechanical excavator to ensure full inundation which will reduce pest plant density and facilitate recruitment across the entire project area.

Appendix E: Example elements of a work plan and outcome assessment

Project goal	Objectives	Actions	Milestones and KPIs	Product and/or deliverable	Resources required	Monitoring and reporting
Restore a degraded 150 ha site back to mangroves and: Ensure stakeholders are actively engaged and supportive and build management capacity to secure the long-term, on-going sustainability of the project; Develop and register the project to generate carbon credits; Improve hydrological and ecological functioning.	Objective (a): Active participation and training of stakeholders in all aspects of project design and implementation. Build management capacity.	Identify the stakeholders, including community members. Conduct and engage in free, prior, and informed consent (FPIC) throughout the project's design and implementation. Promote and facilitate communication between all stakeholders. Conduct training and workshops where necessary. Involve community members in project management.	Stakeholders are actively involved in the setting of short-, mid- and long-term project milestones with benchmarks to be achieved over time using SMART guidance. Key community members are represented on the projects management board and actively engaged in decision making.	Documents summarizing social, political, and economic characterization of stakeholders. Agreements with communities, other organizations and government bodies agreed upon, signed and formalized. Training and workshop activities undertaken (e.g., how to conduct biodiversity surveys, project management techniques).	Stationery, human resources for consultation, travel, per diem, communications requirements.	Use the SMART framework to provide a quantifiable assessment of stakeholder attitudes to the program.
Restore a degraded 150 ha site back to mangroves and: Ensure stakeholders are actively engaged and supportive and build management capacity to secure the long-term, on-going sustainability of the project; Develop and register the project to generate carbon credits; Improve hydrological and ecological functioning.	Objective (b): To develop and register the project with a reputable carbon standard and methodology.	Develop the projects PIN/PDD in accordance with a reputable standard (e.g., Verra) and methodology (e.g., VM0033) Submit the project application and all supporting documentation to the selected standard and ensure all requirements are met.	Project application deadlines are met. Project is approved prior to restoration work being undertaken.	Project PIN and/or PDD completed and submitted.	Documentation, site assessment details, human capacity to understand and implement the requirements of the standard and methodology used.	Reporting to meet the requirements of the selected standard.

Project goal	Objectives	Actions	Milestones and KPIs	Product and/or deliverable	Resources required	Monitoring and reporting
Restore a degraded 150 ha site back to mangroves and: Ensure stakeholders are actively engaged and supportive and build management capacity to secure the long-term, on-going sustainability of the project; Develop and register the project to generate carbon credits; Improve hydrological and ecological functioning.	Objective (c): To re-establish hydrological connectivity and improve the ecological functioning across the site.	Remove structures and/or barriers to tidal inundation to ensure unimpeded hydrological connectivity across the entire site. Pest plant and animal control activities.	The entire restoration area is inundated on spring high tides. Within 6 months of hydrological restoration activities natural mangrove recruitment is evident within the project area. Within 18 months seedlings are growing naturally across the entire project area with a density of > 1 seedling per m^2.	Technical BA CI reports produced for biophysical, hydrological, and biological indicators.	Resources (human, machinery, technical designs) for removal of barriers to tidal flows. Resources for growing and planting mangrove seedlings in a nursery environment (if planting is in the plan). Fencing materials to reduce grazing by feral animals.	Monitoring of vegetation, biodiversity, and hydrology in comparison with reference (control) sites.

A framework for practitioners to assess project outcomes from a mangrove restoration project using the above example. The example is restoration of a degraded 150 ha site.

Project assessment phase	Social parameters	Carbon credit parameters	Hydrological and ecological functioning parameters
Project goal	Goal (a): Ensure stakeholders are actively engaged and supportive and build management capacity to secure the long-term, on-going sustainability of the project.	Goal (b): Develop and register the project to a carbon market standard for issue of carbon credits.	Goal (c): Improve hydrological and ecological functioning.
Objectives	Objective (a): Active participation and training in all aspects of project design and implementation, building management capacity.	Objective (b): To develop and register the project with a reputable carbon standard and methodology.	Objective (c): To re-establish hydrological connectivity and improve the ecological functioning across the site.

Project assessment phase	Social parameters	Carbon credit parameters	Hydrological and ecological functioning parameters
Milestones and indicators	Stakeholders are actively involved in the setting of short-, mid-, and long-term project milestones with benchmarks to be achieved over time using SMART guidance. Key community members are represented on the projects management board and actively engaged in decision making.	Project application deadlines are met.	The entire restoration area is inundated on spring high tides. Within 6 months of hydrological restoration activities natural mangrove recruitment is evident within the project area. Within 18 months seedlings are growing naturally across the entire project area with a density of > 1 seedling per m2. Grazing of naturally recruited seedlings by feral animals is reduced by 80% within 18 months. Pest plant density is reduced by 80% within 18 months.
Outcome	Most stakeholders were involved in setting milestones (6 out of 10 stakeholders identified in the stakeholder analysis) and are represented on the projects management board, although participation/engagement in decision making remains limited.	Market application deadlines were met, the project was approved, and restoration activities commenced in line with the applied GHG standard.	Most of the restoration area is inundated, although some landward margins remain dry on spring tides. Natural recruitment is observed within 6 months and seedlings are growing naturally across most (but not all) the project site within 18 months. Grazing of seedlings has been reduced through fencing, but pest plants remain present in landward margins.
Outcome assessment	Partially achieved (6/10).	Achieved (10/10).	Partially achieved (7/10).
Remedial action	Conduct more capacity building workshops/trainings to build management confidence.	N/A	Level landward margins using a mechanical excavator to ensure full inundation which will reduce pest plant density and facilitate recruitment across the entire project area.

Appendix F: Summary of GHG crediting programs

Standard	Summary of the standard	Methodologies and relevance for mangrove restoration projects
Verified Carbon Standard (VCS)	The VCS, administered by Verra, was founded by the International Emissions Trading Association, the World Business Council for Sustainable Development, The Climate Group, and the World Economic Forum.[125] Most VCS projects are in renewable energy and forestry. Link: https://verra.org/project/vcs-program/	The VCS has developed several methodologies relevant to mangrove restoration and avoided emissions projects, including: VM0007 REDD+ Methodology Framework (REDD+MF), v1.6 VM0024 Methodology for Coastal Wetland Creation, v1.0 VM0033 Methodology for Tidal Wetland and Seagrass Restoration, v1.0 VM0010 Methodology for Improved Forest Management: Conversion from Logged to Protected Forest, v1.3. Verra are developing a new methodology for biochar which could be applicable for mangrove ecosystems.[166] Verra will also serve as the independent standard setter for a Seascape Carbon Initiative which incorporates other blue carbon ecosystems such as kelp and activities such as sustainable fishing and seabed management.
Gold Standard (GS)	Gold Standard was established in 2003 by WWF and other international NGOs to ensure projects that reduced carbon emissions featured the highest levels of environmental integrity and contributed to sustainable development. In total, Gold Standard has issued 191 million carbon credits from projects based in more than 98 different countries around the world, with the majority (98.2m) of carbon credits generated from Southeast Asia followed by Africa (36.2m).[167] The Gold Standard does not issue carbon credits for REDD+ projects due to concerns about environmental integrity, including the ability to control leakage (when deforestation activities move to another area) and risks for overestimation of credits due to baseline uncertainty. Link: https://www.goldstandard.org	Gold Standard has an approved methodology for the certification of mangrove afforestation/reforestation projects since 2013 which is based on the much broader Gold Standard A/R Requirements. The modifications for mangrove A/R Projects are that 90% of the planting area needs to be planted with mangrove species, and that an additional 1.8 t $CO2$ ha^{-1} $year^{-1}$ can be accounted for soil organic carbon accumulation in the first 20 years. However, there are no identifiable mangrove projects in the Gold Standard registry. Gold Standard are exploring opportunities to develop new methodologies for blue carbon projects, including a Sustainable Mangrove Management Methodology (Forliance is the developer). The methodology will include innovations in the remote sensing and geographic information sectors combined with participatory stakeholder engagement to address sustainable management of mangrove ecosystems. This innovative methodology will incorporate alternative monitoring and reporting approaches to overcome the high complexity and risk associated with on-ground monitoring.[168] https://globalgoals.goldstandard.org/standards/PRE-GS4GG-AF/ar-guidelines-mangroves.pdf

Standard	Summary of the standard	Methodologies and relevance for mangrove restoration projects
American Carbon Registry (ACR)	The American Carbon Registry (ACR), a non-profit enterprise of Winrock International, was founded in 1996 as the first private voluntary greenhouse gas registry in the world. In both the regulated and voluntary carbon markets, ACR oversees the registration and verification of carbon projects following approved carbon accounting methodologies or protocols and issues carbon credits on a transparent registry system. The carbon credit products are specific to ACR's distinct operations in the California compliance market, International Civil Aviation Organization, and the global voluntary carbon market. In the voluntary market, ACR oversees the registration and independent verification of projects that meet ACR's science-based standards and follow ACR-approved carbon accounting methodologies. Link: https://americancarbonregistry.org/	ACR registers carbon projects from a range of project types relevant to mangrove restoration, including: Afforestation and reforestation (A/R) of degraded lands Improved forest management (IFM) Restoration of pocosin wetlands Restoration of California deltaic and coastal wetlands. ACR registered projects do not have to be based in the USA, but, like all other programs, projects need to follow an ACR approved methodology.
Climate Action Reserve (CAR)	CAR began as the California Climate Action Registry, which was created by the State of California in 2001 to address climate change through voluntary calculation and public reporting of emissions. CAR serves as the registry for California's Cap and Trade Program. CAR also operated a pilot emissions trading system in Mexico from 2020-2023. Link: https://www.climateactionreserve.org/about-us/	CAR established the Forest Protocol (FP), which provides guidance for developing forest carbon projects. The FP describes the eligibility and accounting requirements for the calculation of emissions removals and reductions associated with: Improved forest management Avoided conversion projects. Forest Protocol projects must be within the U.S, although Avoided Conversion projects may also be within U.S. Territories (e.g., Guam). CAR have developed the Forest Carbon Protocol for Mexico, and there are two mangrove conservation projects that use this methodology (Manglares Ursulo Galvan and Manglares San Crisanto).

[1] Biochar is a carbon-rich material derived from biomass, such as agricultural and forestry residues, by pyrolysis in a closed container with either limited or no oxygen. The application of biochar in soil creates environmental and ecological benefits, such as reducing greenhouse gas emissions, acting as an environment-friendly adsorbent to reduce nutrient leaching, enhancing nutrient retention, and improving the chemical and physical properties of soils.[166]

Standard	Summary of the standard	Methodologies and relevance for mangrove restoration projects
Plan Vivo	Plan Vivo was developed in 1994 through a desire to help communities plant trees in Chiapas, Mexico. The project, called Scolel'te, was a collaboration between the University of Edinburgh, El Colegio de la Frontera Sur, and other local partners, with the first voluntary carbon markets credits issued in 1997. The Plan Vivo Standard is a set of requirements used to certify smallholder and community projects in countries with developing economies based on their climate, livelihoods, and environmental benefits. It is the longest-standing carbon standard in the voluntary carbon market, with 20 projects actively issuing credits. V5.0 of the Plan Vivo Standard was released in 2022. Among several changes from the 2013 version of the standard are new methodological and verification requirements. One major change is that auditing processes are dependent on the scale of a project. Projects with the capacity to generate climate benefits of less or equal to 10,000 t CO_2 annually are considered microscale. Projects with the capacity to generate climate benefits of more than 10,000 t CO_2 annually are considered macroscale. Macroscale projects must undertake validations and verifications using validation and verification bodies (VVBs), whilst microscale projects can complete validations and verifications through the internal validation and verification process. The objective of this change is to minimize the financial pressure of the auditing process on the smallest of projects, whilst also maintaining high levels of quality assurance to buyers of carbon credits. While Plan Vivo had the smallest share of the voluntary carbon market as a standard as of 2021, it attracts the highest price per carbon credit. This is largely because of its emphasis on co-benefits (aside from carbon) and represents a good option for small scale mangrove restoration projects. Link: https://www.planvivo.org	There are three mangrove projects currently registered with Plan Vivo: Tahiry Honko in Madagascar and Mikoko Pamoja and Vanga Blue Forest, both of which are in Kenya. Mikoko Pamoja (Gazi Bay, Kenya) is the world's first blue carbon project and receives Plan Vivo certificates for the conservation of its mangrove forests (see Case Study). Vanga Blue Forest was inspired by Mikoko Pamoja and has been operating since 2019. Under the new version of the standard, projects may only apply methodologies approved by the Plan Vivo Foundation. For mangrove carbon projects, this is currently the AR-AM0014: Afforestation and reforestation of degraded mangrove habitats (Version 3.0), which was initially approved in 2013 under the (now superseded) Clean Development Mechanism and is still in operation. An updated methodology for mangrove carbon projects is in development and expected to be released for review in 2023.
Architecture for REDD+ Transactions, the REDD+ Environmental Excellence Standard (ART/TREES)	ART/TREES is a standard launched in 2020. ART/TREES formulates and administers standardized procedures for crediting emission reductions and removals from government-sponsored national or large sub-national programs for Reducing Emissions from Deforestation and Degradation Plus (REDD+). ART/TREES is geared to certify large volumes of GHG emission reductions and removals. The first Letters of Intent for transactions involving jurisdictional credits certified under ART/TREES were signed in November 2021.	When ART/TREES is approved it may be used for large scale mangrove restoration projects such as those planned in Pakistan and Indonesia, provided “restoration” fits within the scope of REDD+ via the “enhancement of forest carbon stocks”.

Standard	Summary of the standard	Methodologies and relevance for mangrove restoration projects
Emissions Reduction Fund	The Tidal Restoration of Blue Carbon Ecosystems method was approved in 2022. Projects are specifically for the reintroduction of tidal flows to historically drained coastal land through the removal of infrastructure such as bund gates and seawalls. Projects receive funding for avoided emissions from previous land uses and carbon accumulated during the project. Link: https://www.cleanenergyregulator.gov.au/ERF/Choosing-a-project-type/Opportunities-for-the-land-sector/Vegetation-methods/tidal-restoration-of-blue-carbon-ecosystems-method	Carbon Farming Initiative—Tidal Restoration of Blue Carbon Ecosystems (Australia). There are no registered projects currently with ERF. This method has potential to fund large- and small-scale restoration projects in Australia.

Appendix G: Summary of market volumes

Summary of market volumes, geographical and sectoral scopes of the main voluntary market standards. Adapted from Climate Focus (2022) with data sourced from Ecosystem Marketplace (2022), Plan Vivo (2023), and Fair Carbon (2022).

Standard	Market volume (m = million)*	Market price (USD $)**	Name of credits issued	Geographical scope	Sectoral scope	No. mangrove projects registered or under development
Verified Carbon Standard (VCS)	125.6m	$4.17	Verified Carbon Units	1,792 registered projects in 82 countries. VCS is dominant in developing countries.	Covers all project classes.	14
Plan Vivo	0.7m	$11.58	Plan Vivo Certificates (PVCs)	20 projects registered around the world.	Nature based community projects and biodiversity.	11
Climate Action Reserve	4.9m	$2.12	Climate Reserve Tons (CRTs)	26 projects in the USA.	Covers agriculture and forestry, energy, waste, and non-CO_2 GHG abatement (e.g., methane reductions from livestock).	2
Gold Standard (GS)	5.2m	$3.94	Verified Emission Reductions (VERs)	1,313 registered projects in 80 countries. Credits are purchased especially by buyers in the European Union.	Covers most project classes but excludes project-level REDD+. After 2025, will only cover credits backed by corresponding adjustments.	0
American Carbon Registry (ACR)	2m	$11.37	Emission Reduction Tons (ERTs)	156 projects in the United States.	Covers industrial processes, land use, land use change and forestry, carbon capture, and waste.	0
Tidal restoration of blue carbon ecosystems method	-	$21.83	Australian Carbon Credit Units (ACCUs)	0 registered projects.	Abated GHG emissions from land use and C sequestered in soil and vegetation.	0

**Market volume of registered credits in 2021 (up until August). Sourced from Ecosystem Marketplace (2022).*
*** Average purchase price of carbon credits as of August 2021 (USD $). Sourced from Ecosystem Marketplace (2022).*

Appendix H: Overview of selected case studies

Project overview				
Project overview				
Project name	Tahiry Honko	Mikoko Pamoja	India Vellar Estuary Mangrove Restoration	Thor Heyerdahl Climate Park
Location (country, latitude, and longitude)	Madagascar. -22,21 S, 43.32 E	Gazi Bay, Kenya. -4.42 S, 39.51E	Tamil Nadu, India. Lat. 11029' 19.1-28.3"N; Long. 79045' 51.9-57.3" E	Myanmar, 17.07 N, 94.47 E
Project goal	Establish a sustainable, long-term mangrove payment for ecosystem services (PES) scheme to incentivize community-led mangrove preservation and restoration.	The protection and restoration of natural mangrove forest, the restoration of eroding and degraded shorelines and the support and development of local livelihoods and welfare.	Student Action-oriented mangrove restoration and ecosystem service restoration through teaching-learning process in the field.	Sustainable mangrove ecosystem for carbon sequestration.

Project overview				
Project developer	Velondriake Association and Blue Ventures	Kenya Marine and Fisheries Research Institute/Edinburgh Napier University	Prof. Dr. K. Kathiresan	Suraj A. Vanniarachchy (consultant)
Project proponent	Velondriake Association and Blue Ventures	Association for Coastal Ecosystem Services (ACES)	Annamalai University, India	Worldview International Foundation
Project progress (accredited, accredited and available, under development, undergoing validation)	Accredited and available.	Accredited (in 2012) and available.	Accredited in terms of research publications for wide dissemination of knowledge.	Accredited and available.
Area (ha)	1,230 ha	117 ha	20 ha	2,146.48 ha
Total cost ($)		Total initiation costs are estimated at ~INR $400,000. However, this includes substantial "in kind" support, for example the costs of supporting the Kenyan PhD students who conducted the original research underpinning the project and the time of multiple volunteers.	INR $11,250 ($3,750 for refreshments to students while planting by students and $7,500 for fencing around the planting site).	TBC
Cost per ha ($)		~$4,000 implementation	$562.5	TBC
Time frame for project implementation (years)		Five years	1991 onwards	15th June, 2015, to 14th June, 2035
Government, NGO, or community driven?	NGO	A mix of all three, with government (KMFRI), community, academic (Edinburgh Napier) and NGO (ACES, Earthwatch Institute) support.	Student community-driven.	NGO

Project overview				
Funding source		For initial restoration science, Earthwatch Institute. For governance and carbon science, Natural Environment Research Council UK. Other charitable sources also contributed.	Tamil Nadu State Council for Science and Technology, UGC, Ministry of Environment and Forests (Govt. of India), and UNU-International Network of Water, Environment and Health (Canada).	WIF
Website	https://blueventures.org/tag/tahiry-honko/	https://aces-org.co.uk/mikoko-pamoja-project/	https://registry.verra.org/app/projectDetail/VCS/1463	https://wif.foundation
Baseline setting and activities implemented				
Biophysical baseline setting*	Loss of mangrove forests cover. Approximately 3.18% of mangroves were lost between 2002 and 2014, equal to 0.27% per year.	The natural forest at Gazi was degraded (with extensive illegal cutting) and total mangrove extent across southern Kenya was declining at around 2% per year. There were large areas of former forest that had been cut and failed to regenerate, leading to eroding coastlines.	Physical characteristics of soil: Temperature 340C, pH 7.37, pore water salinity 56 ppt, moisture 20.08%, bulk density 1.1 g/m3, sand 48.85%, silt 42.44% and clay 8.72% in soil of non-planted barren area (corresponding to the values of temperature 300C, pH 6.6, pore water salinity 46 ppt, moisture 38.52%, bulk density 0.78 g/m3, sand 25.69%, silt 52%, and clay 21.95% respectively in soil of the 27 year old planted site).	Degraded and/or severely degraded mangroves.
Dominant mangrove species	*Ceriops tagal*, *Rhizophora mucronata* and *Bruguiera gymnorrhiza*	*Rhizophora mucronata*, *Avicennia marina*, *Ceriops tagal*, and *Sonneratia alba*	*Avicennia marina*, *Avicennia officinalis*, *Rhizophora apiculata*, and *Rhizophora mucronata*	*Bruguiera gymnorrhiza*, *Ceriops tagal*, *Rhizophora apiculata*, *Ceriops decandra*, *Bruguiera cylindrica*, and *Lumnitzera racemosa*

Project overview				
Drivers/ pressures on mangrove ecosystems	Dieback due to natural disaster (cyclone). Harvesting of mangrove wood, used as fuel to produce a seashell-based lime render.	The key pressure is small scale/subsistence cutting, for fuelwood and timber, although larger scale commercial poaching also occurs.	Cattle grazing.	Charcoal production both for local consumption and supply to Yangon city, fuelwood cutting, conversion to paddy fields, fish and shrimp ponds.
Responses to address drivers/pressures: what sort of restoration activities were undertaken?	10 villages tasked with protecting ~1,200 ha Conservation (establishment of protected area, sustainable timber harvesting) Reforestation of mangroves in deforested areas Improved forest management (establishment of alternative timber plantations).	To address illegal cutting and removal of wood, forest patrols were instituted, and woodlots provided to supply alternative timber and fuelwood. Better relationships with Kenya Forest Service were established with new means to communicate with them and assist with their statutory forest protection duties. Seedlings are grown in nurseries and planted into degraded areas.	Fencing has been made for protection of planted sites from cattle grazing and human interference in crab collection.	Planting mangroves associated with livelihood improvement activities.

Project overview				
Monitoring: Which outcomes did you monitor (carbon, community biodiversity)? Did you use a BACI design? What was the monitoring frequency?	Vegetation carbon stock (annually) Survival rate of the mangrove replanting (semester) Biodiversity (every 5 years) Socioeconomic (every 5 years).	We monitor aboveground biomass, natural establishment of new trees, evidence of illegal cutting (stumps and clear-fells), biodiversity (crabs and molluscs) and social outcomes (the latter are determined annually by local decisions, so cannot be predescribed). Measuring of the key monitoring targets is done twice per year and summarized in the annual reports to Plan Vivo. Permanent monitoring plots are used. Data within protected areas has been compared, in independent research, with data taken outside and this shows the effects of protection. However, we have evidence of "positive leakage" (a "halo" effect) in which the forest outside the protected area is also benefiting from increased awareness and conservation activity.	Mangrove growth, carbon and fish catch were monitored by students at regular intervals.	Yearly measurement of voluntary carbon units and in the process of proposing protected public forest.
Carbon outcomes				
Standard	Plan Vivo	Plan Vivo	Proposed Verra VCS	Verra VCS
Methodology	Tahiry Honko technical specifications.	Custom (i.e., developed own original methodology).	Carbon gains in soils and biomass were calculated following Kauffman, J.B., Donato, D.C. (2012). VM0033 is to be used as the methodology during further measurements and reporting.	AR-AM0014.
Carbon crediting period (no. years)	20 years	20 years	27 years (1991-2018)	20 years

Project overview				
Estimated carbon credits from the project: Total t CO_2e (over project lifetime) t CO_2e ha^{-1} (over project lifetime) t CO_2e $year^{-1}$ t CO_2e ha^{-1} $year^{-1}$	27,420 t CO_2e $year^{-1}$ (20 years) 22 t CO_2e ha^{-1} (20 years) 1,371 t CO2e $year^{-1}$ 1.11 t CO2e ha^{-1} $year^{-1}$	To date (2022) there have been 11,923 credits issued (reflecting 13,966 t CO_2e benefits achieved after removal of risk buffers). Hence projections for total over the 20 year lifetime are 31,036 265 2,043 t CO_2e year 17.5	1,971 total t CO_2e over 27 years of plantation in 20 ha 73 t CO_2e per year in 20 ha 98.55 ± 3.24 t CO_2e ha^{-1} over 27 years of plantation 3.65 ± 0.12 t CO_2e ha^{-1} $year^{-1}$	3,680,125 t CO_2e 184,006 t CO_2e 171,485.6 t CO_2e
Actual carbon credits generated (to date) per t CO_2e		For every confirmed t CO_2e we generate 0.85 credits (because of a 15% risk buffer).	Yet to be worked out.	4,971 t CO_2e (2016) 8,154 t CO_2e (2017) 18,619 t CO_2e (2018) 26,615 t CO_2e (2019) 53,369 t CO_2e (2020) 54,137 t CO_2e (2021)
Purchase price (USD per t CO_2e	USD 20 (USD 27,000 per year, 1,300 credits per year).	This has varied from 7-30 USD per tonne, over the years of the project and depending on the buyer (we negotiate with each buyer to fit their needs and to find a fair price).	Yet to be worked out.	

Project overview				
Income dispersal arrangements	23% set aside for the local management association to carry out activities such as replanting mangroves and conducting forest patrols 5% contributes to the national buffer account (i.e., in case protected mangroves are cut down) in addition to the Plan Vivo buffer allocation. 22% Malagasy Government 50% local communities (10 villages). Profits set aside for education of children and infrastructure developments.	There are no profits from Mikoko Pamoja. Income raised from carbon credit sales (and grants and charitable donations to ACES) is used to support the project (the main running cost is salaries of Kenyan staff) and then allocated to the community fund controlled by the committee. In the last year (2021) 82% of income was sent to Kenya for project costs and community benefit.	Yet to be worked out.	TBC.
Carbon stocks assessed: Biomass Dead and downed wood Soil GHG fluxes assessed: CO_2 CH_4 N_2O		Aboveground biomass A small component of total soil carbon CO_2 only (methane was measured during project design and found to be usually below detectable levels).	Biomass and soil (not dead and downed wood as they are not available). CO_2 equivalent was assessed.	Biomass and soil.
Project verification organization	Silvestrum Climate Associates.	https://epicsustainability.com	Yet to be done.	RINA Services S.p.A, TUV SUD South Asia Pvt. Ltd., 4K Earth Science Private Limited.
Verification costs	USD 18,000	USD 8,240 (2018)	Yet to be done.	TBC.

Appendix I: Index of hyperlinks used in this document

Chapter 1

Section 1.1

- Pledged to safeguard and restore mangroves: https://www.unep.org/interactive/ecosystem-restoration-people-nature-climate/en/index.php
- High-Quality Blue Carbon Principles and Guidance: https://merid.org/high-quality-blue-carbon/
- Global Mangrove Alliance: https://www.mangrovealliance.org
- Blue Carbon Initiative (BCI): https://www.thebluecarboninitiative.org/

Section 1.3

- Global Mangrove Watch: https://www.globalmangrovewatch.org/
- The Mangrove Restoration Tracker Tool: https://www.mangrovealliance.org/news/new-the-mangrove-restoration-tracker-tool/
- Mangrove Knowledge Hub: https://www.mangrovealliance.org/our-knowledge-hub/

Section 1.4

- UNEP State of Finance for Nature: https://www.unep.org/resources/state-finance-nature
- The Mangrove Breakthrough: https://www.mangrovealliance.org/wp-content/uploads/2022/11/Mangrove-Breakthrough-_-Leafletv1.3.pdf

Chapter 2

Section 2.2.1

- On the land and in the sea: https://www.cifor.org/publications/pdf_files/reports/6659-report.pdf
- Online resources: https://www.land-links.org/what-is-land-tenure/

Section 2.2.2

- WWF stakeholder analysis guide: https://awsassets.panda.org/downloads/1_1_stakeholder_analysis_11_01_05.pdf
- Ecological Mangrove Restoration: https://blue-forests.org/wp-content/uploads/2020/04/Whole-EMR-Manual-English.pdf
- Mangrove Action Project: https://mangroveactionproject.org/
- Blue Forests - Yayasan Hutan Biru: https://blue-forests.org/en/

Section 2.2.3

- Google Earth: https://earth.google.com/web/
- Global Mangrove Watch: https://www.globalmangrovewatch.org/
- Mapping Ocean Wealth: https://oceanwealth.org/
- Planet: https://www.planet.com/get-started/
- Global Mangrove Watch: https://www.globalmangrovewatch.org/

Section 2.3.1

- 4 Returns Framework: https://www.commonland.com/wp-content/uploads/2021/06/4-Returns-for-Landscape-Restoration-June-2021-UN-Decade-on-Ecosystem-Restoration.pdf
- ROAM: https://portals.iucn.org/library/node/44852
- Specific guidance on navigating governance arrangements: https://portals.iucn.org/library/node/50050

Section 2.3.2

- Evaluating the vulnerability of sites to climate change threats: https://www.ipcc.ch/report/ar4/wg2/assessing-key-vulnerabilities-and-the-risk-from-climate-change/

Chapter 3

Section 3.3.1

- (FPIC): https://www.fao.org/indigenous-peoples/our-pillars/fpic/en/

Section 3.3.2

- Free, prior, and informed consent (FPIC): https://www.fao.org/indigenous-peoples/our-pillars/fpic/en/

Section 3.4

- The Dryad data repository: https://datadryad.org/stash/dataset/doi:10.5061/dryad.rc0jn
- Global Mangrove Watch: https://www.globalmangrovewatch.org/

Chapter 4

Section 4.1

- Mangrove Restoration Tracker Tool
- Global Mangrove Alliance: https://www.mangrovealliance.or
- Global Mangrove Watch: https://www.globalmangrovewatch.org/

Section 4.2

- Project DPro Guide: https://pm4ngos.org/methodologies-guides/program-dpro/

Section 4.4

- WWF: Bankable Nature Solutions: https://wwfint.awsassets.panda.org/downloads/bankable_nature_solutions_2__1.pdf

Section 4.4.1

- IUCN Definition of Nature-based Solutions: https://www.iucn.org/our-work/nature-based-solutions#:~:text=Nature-based%20Solutions%20are%20actions,simultaneously%20benefiting%20people%20and%20nature.
- Blue Natural Capital Financing Facility: https://bluenaturalcapital.org
- Blue Carbon Accelerator Fund: https://bluenaturalcapital.org/bcaf
- Blue Action Fund: https://www.blueactionfund.org/
- Althelia Sustainable Ocean Fund: https://www.eib.org/en/products/equity/funds/sustainable-ocean-fund

Section 4.4.3

- reef insurance in Belize: https://icriforum.org/first-reef-insurance-payout-belize/

Section 4.5.1

- The Bio-rights approach: https://www.wetlands.org/publications/biorights-in-theory-and-practice/

Section 4.5.2

- Enhancing the integration of governance in forest landscape restoration: https://portals.iucn.org/library/node/50050
- Global Mangrove Alliance: https://www.mangrovealliance.org/

Section 4.5.3

- This video example is from Indonesia: https://www.youtube.com/watch?v=1gazBiUOGxI
- International Partnership for Blue Carbon: https://bluecarbonpartnership.org/

Chapter 5

Section 5.2

- Indicators of coastal wetlands restoration success: a systematic review: https://www.frontiersin.org/articles/10.3389/fmars.2020.600220/full
- Priorities and Motivations of Marine Coastal Restoration Research: https://www.frontiersin.org/articles/10.3389/fmars.2020.00484/full
- Challenges in marine restoration ecology: how techniques, assessment metrics, and ecosystem valuation can lead to improved restoration success: https://link.springer.com/chapter/10.1007/978-3-030-20389-4_5
- System of Environmental Economic Accounts: https://seea.un.org/

Section 5.2.3

- Society for Ecological Restoration (SER) "Recovery Wheel": https://seraustralasia.com/wheel/

Section 5.2.4

- Hydrological classification, a practical tool for mangrove restoration: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0150302
- Natural regeneration of degraded mangrove sites in response to hydrological restoration: https://myb.ojs.inecol.mx/index.php/myb/article/view/e2511754
- Vegetation and soil characteristics as Indicators of restoration trajectories in restored mangroves: https://link.springer.com/article/10.1007/s10750-013-1617-3
- Queensland data collection protocol: https://www.daf.qld.gov.au/__data/assets/pdf_file/0006/63339/Data-collection-protocol.pdf
- The Blue Carbon Manual: https://www.thebluecarboninitiative.org/manual
- Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests: https://www.cifor.org/publications/pdf_files/WPapers/WP86CIFOR.pdf
- A baseline study of the diversity and community ecology of crab and molluscan macrofauna in the Sematan mangrove forest: https://www.cambridge.org/core/journals/journal-of-tropical-ecology/article/abs/baseline-study-of-the-diversity-and-community-ecology-of-crab-and-molluscan-macrofauna-in-the-sematan-mangrove-forest-sarawak-malaysia/2C21C33D600716C1AB6DD3BFD928F134

- Tackling the tide: A rapid assessment protocol to detect terrestrial vertebrates in mangrove forests: https://www.researchgate.net/publication/342338109_Tackling_the_tide_A_rapid_assessment_protocol_to_detect_terrestrial_vertebrates_in_mangrove_forests
- More than Marine: Describes the critical importance of mangrove ecosystems for terrestrial vertebrates: https://onlinelibrary.wiley.com/doi/full/10.1111/ddi.12514
- The role of vegetated coastal wetlands for marine megafauna conservation: https://www.sciencedirect.com/science/article/abs/pii/S0169534719301090
- The Shoreline Video Assessment Method (S-VAM): Using dynamic hyperlapse image acquisition to evaluate shoreline mangrove forest structure, values, degradation and threats: https://www.sciencedirect.com/science/article/abs/pii/S0025326X16303903?via%3Dihub
- Tackling the tide: A rapid assessment protocol to detect terrestrial vertebrates in mangrove forests: https://www.researchgate.net/publication/342338109_Tackling_the_tide_A_rapid_assessment_protocol_to_detect_terrestrial_vertebrates_in_mangrove_forests
- Global estimates of the value of ecosystems and their services in monetary units: https://www.sciencedirect.com/science/article/pii/S2212041612000101

Section 5.2.5

- Global Mangrove Watch: https://www.globalmangrovewatch.org/
- The Global Intertidal Change tool: https://www.globalintertidalchange.org/
- The Building with Nature Indonesia project won the UN Flagship award in 2022: https://www.wetlands.org/news/un-recognises-building-with-nature-indonesias-efforts-with-world-restoration-flagship-award/

Module 1

Section 6.2.1

- The number of countries including mangroves within their NDCs
- Global Mangrove Watch: https://www.globalmangrovewatch.org/
- Blue carbon in NDCs map: https://faircarbon.org/content/fc/bluecarboninndcsmap

Section 6.2.2

- UNFCCC Warsaw Framework: https://redd.unfccc.int/fact-sheets/warsaw-framework-for-redd.html
- Forest Carbon Partnership Facility: https://www.forestcarbonpartnership.org/
- Carbon Fund: https://www.forestcarbonpartnership.org/carbon-fund

- CIFOR Global Comparative Study on REDD+: https://www.cifor.org/publications/pdf_files/infobrief/8048-infobrief.pdf
- list of partner countries with summaries of their national REDD+ programs: https://www.un-redd.org/our-work/partners-countries

Section 6.3

- Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: https://www.ipcc.ch/publication/2013-supplement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories-wetlands/
- Coastal Wetlands in National Greenhouse Gas Inventories: https://bluecarbonpartnership.org/resources-2/

Section 6.3.2

- framework for international GHG trading: https://unfccc.int/sites/default/files/resource/cma3_auv_12a_PA_6.2.pdf

Section 6.4

- International Carbon Reduction and Offset Alliance: https://icroa.org/
- Integrity Council for the Voluntary Carbon Market: https://icvcm.org/
- domestic methodology for producing mangrove carbon credits: http://www.cleanenergyregulator.gov.au/DocumentAssets/Pages/Blue-carbon-accounting-model-BlueCAM-guidelines.aspx
- High-Quality Blue Carbon Principles and Guidance: https://merid.org/high-quality-blue-carbon/
- Global Standards for Nature-based Solutions: https://www.iucn.org/theme/nature-based-solutions/resources/iucn-global-standard-nbs

Section 6.4.1

- High-Quality Blue Carbon Principles and Guidance: https://merid.org/high-quality-blue-carbon/

Section 6.4.3

- Verified Carbon Standard: https://verra.org/programs/verified-carbon-standard/
- Verra: https://verra.org/
- Published methodologies: https://verra.org/methodologies-main/
- The Plan Vivo Foundation: https://www.planvivo.org/
- AR-AM0014 methodology: https://cdm.unfccc.int/methodologies/DB/KMH6O8T6RL3P5XKNBQE2N359QG7KOE

- Climate, Community and Biodiversity Standard: https://verra.org/programs/ccbs/
- Sustainable Development Verified Impact Standard: https://verra.org/programs/sd-verified-impact-standard/
- Gold Standard for Global Goals: https://www.goldstandard.org/articles/gold-standard-global-goals
- United Nations Sustainable Development Goals: https://sdgs.un.org/goals
- Core standard: https://www.planvivo.org/standard-overview
- USD 18-29 per VCU: https://blog.opisnet.com/blue-carbon-momentum

Section 6.4.4

- https://verra.org/wp-content/uploads/2018/03/VCS-Guidance-Standardized-Methods-v3.3_0.pdf

Section 6.4.5

- Blue Carbon Manual: https://www.thebluecarboninitiative.org/manual
- Australian Blue Carbon Accounting Model: http://www.cleanenergyregulator.gov.au/DocumentAssets/Pages/Blue-carbon-accounting-model-BlueCAM-guidelines.aspx
- VCS fees: https://verra.org/wp-content/uploads/Program-Fee-Schedule_v4.1.pdf
- Plan Vivo fees: https://www.planvivo.org/costs-fees

Section 6.4.7

- Guidance for development of community forests: https://faolex.fao.org/docs/pdf/cam204405.pdf

Section 6.5.1

- Blue Carbon Manual: https://www.thebluecarboninitiative.org/manual

Case studies

- https://aces-org.co.uk/the-3-ps-of-carbon-offsetting/

Appendix D hyperlinks

- ALNAP stakeholder analysis toolkit: https://www.alnap.org/system/files/content/resource/files/main/Stakeholder-analysis-toolkit-v3.pdf
- FAO tool for facilitating multi-stakeholder processes: https://www.fao.org/capacity-development/resources/practical-tools/multi-stakeholder-processes/en/
- IIED using stakeholder and power analysis in multi stakeholder processes: https://www.iied.org/sites/default/files/pdfs/migrate/G03412.pdf
- WWF stakeholder analysis: https://awsassets.panda.org/downloads/1_1_stakeholder_analysis_11_01_05.pdf
- DFID sustainable livelihoods guidance sheets: https://www.livelihoodscentre.org/-/sustainable-livelihoods-guidance-sheets
- FAO e-learning course on sustainable livelihoods: https://elearning.fao.org/course/view.php?id=166
- FAO/ILO livelihood assessment toolkit: https://www.fao.org/fileadmin/templates/tc/tce/pdf/LAT_Brochure_LoRes.pdf
- Livelihoods Centre livelihoods toolbox: https://www.livelihoodscentre.org/web/livelihoods-centre/toolbox#19428503
- Mangroves for the Future gender analysis toolkit: http://www.mangrovesforthefuture.org/assets/Repository/Documents/Gender-Analysis-Toolkit-for-Coastal-Management-Practitioners.pdf
- CASCAPE manual on gender analysis tools: https://agriprofocus.com/upload/CASCAPE_Manual_Gender_Analysis_Tools_FINAL1456840468.pdf
- IUCN gender analysis guide: https://portals.iucn.org/union/sites/union/files/doc/iucn-gender-analysis-guidance-web.pdf
- FAO handbook for evaluating child labour in agriculture: https://www.fao.org/3/i4630e/i4630e.pdf
- FAO/ILO guidance on addressing child labour in fisheries and aquaculture: https://www.ilo.org/ipec/Informationresources/WCMS_IPEC_PUB_22655/lang--en/index.htm
- IFAD institutional analysis tools: https://www.ifad.org/en/web/knowledge/-/publication/guidance-notes-for-institutional-analysis-in-rural-development-programmes-an-overview
- World Bank sourcebook for institutional, political and social analysis: https://openknowledge.worldbank.org/handle/10986/6652
- IIED power tools for analyzing institutions and policies: https://policy-powertools.org/index.html
- E.Ostrom (2010): Crafting analytical tools to study institutional change: https://www.cambridge.org/core/journals/journal-of-institutional-economics/article/crafting-analytical-tools-to-study-institutional-change/41867B82336261695C4AAEDE65088932
- UNDP institutional and context analysis guidance note: https://www.undp.org/sites/g/files/zskgke326/files/publications/UNDP_Institutional%20and%20Context%20Analysis.pdf
- The OXFAM influencing for impact guide: https://oxfamilibrary.openrepository.com/bitstream/handle/10546/621048/gd-influencing-for-impact-guide-150920-en.pdf;jsessionid=EB9B1176E20BF0B0C83ED05662FCF0F3?sequence=1

- IFAD institutional analysis tools: https://www.ifad.org/en/web/knowledge/-/publication/guidance-notes-for-institutional-analysis-in-rural-development-programmes-an-overview
- UNDP institutional and context analysis guidance note: https://www.undp.org/sites/g/files/zskgke326/files/publications/UNDP_Institutional%20and%20Context%20Analysis.pdf
- Crafting institutions for community forestry: http://www.nzdl.org/cgi-bin/library?e=d-00000-00---off-0aginfo--00-0----0-10-0---0---0direct-10---4-------0-1l--11-en-50---20-about---00-0-1-00-0--4----0-0-11-10-0utfZz-8-00-&cl=CL2.8&d=HASHae418eae7295c27ce4e6e5.1&gt=2
- Effective institutions platform: https://www.effectiveinstitutions.org/en/publications/
- Exploring institutional change: https://www.iied.org/sites/default/files/pdfs/migrate/10763IIED.pdf
- IUCN legal frameworks for mangrove governance: https://www.fao.org/sustainable-forest-management/toolbox/tools/tool-detail/en/c/1331512/
- Legislating for small-scale fisheries: https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1316895/
- FAO policy and legal diagnostic tool for small-scale fisheries: https://www.fao.org/voluntary-guidelines-small-scale-fisheries/resources/detail/en/c/1476470/
- The OXFAM influencing for impact guide: https://oxfamilibrary.openrepository.com/bitstream/handle/10546/621048/gd-influencing-for-impact-guide-150920-en.pdf;jsessionid=EB9B1176E20BF0B0C83ED05662FCF0F3?sequence=1
- IFAD institutional analysis tools: https://www.ifad.org/en/web/knowledge/-/publication/guidance-notes-for-institutional-analysis-in-rural-development-programmes-an-overview
- FAO code of conduct for responsible fisheries: https://www.fao.org/3/v9878e/V9878E.pdf
- FAO voluntary guidelines on the responsible governance of tenure arrangements: https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1151688/
- FAO technical guides on the governance of tenure: https://www.fao.org/tenure/resources/collections/governance-of-tenure-technical-guides/en/
- FAO sustainable forest management toolbox: https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1445081/
- FAO voluntary guidelines on securing sustainable small-scale fisheries: https://www.fao.org/voluntary-guidelines-small-scale-fisheries/en/
- CIFOR field guide to adaptive collaborative management: https://www.cifor.org/knowledge/publication/5085/
- Co-management for small-scale fisheries: https://lifeplatform.eu/wp-content/uploads/2021/02/LIFE-Co-Management-for-SSF-compressed.pdf
- Adaptive learning in adaptive fisheries management: https://mrag.co.uk/adaptive-learning-approaches-fisheries-management

Appendix F hyperlinks

- VM0007 REDD+ Methodology Framework (REDD+MF), v1.6: https://verra.org/methodology/vm0007-redd-methodology-framework-redd-mf-v1-6/
- VM0024 Methodology for Coastal Wetland Creation, v1.0: https://verra.org/methodology/vm0024-methodology-for-coastal-wetland-creation-v1-0/
- VM0033 Methodology for Tidal Wetland and Seagrass Restoration, v1.0: https://verra.org/methodology/vm0033-methodology-for-tidal-wetland-and-seagrass-restoration-v1-0/
- VM0010 Methodology for Improved Forest Management: Conversion from Logged to Protected Forest, v1.3: https://verra.org/methodology/vm0010-methodology-for-improved-forest-management-conversion-from-logged-to-protected-forest-v1-3/
- Seascape Carbon Initiative: https://verra.org/programs/verified-carbon-standard/seascape-carbon-initiative/

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