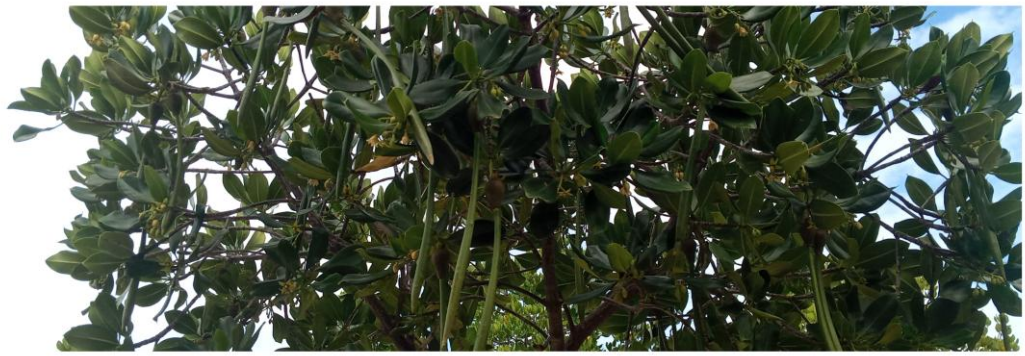
Training Manual for Ecological Mangrove Restoration in Kenya

A Guide for Trainers of trainers



2025

The Swimming Coastal Forests. ***Photo courtesy of KMFRI***

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Cover Image:

<table>
<tr><td colspan="3">A mature mangrove tree (Rhizophora mucronata) canopy with propagules</td></tr>
<tr><td>An encroached mangrove area in Mombasa County. Residents backfill mangroves for building settlement</td><td>An insect pest infested Ceriops tagal tree in Kizingitini, Lamu</td><td>An example of a poorly drained mangrove site in Mida Creek</td></tr>
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Cover images courtesy of Judith Okello

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DISCLAIMER

The designations employed and presentations of materials in this publication do not imply the expression and opinion whatsoever on the part of the management of Kenya Marine and Fisheries Research Institute, Kenya Forestry Research Institute, and Kenya Forest Service. The manual is meant to guide trainers on the subject matter and should not be used as a substitute to seeking professional assistance in restoration of mangroves.

Preface

The development of this Training Manual is the result of a partnership and collaborative efforts of institutions in the field of mangrove conservation, governance and management namely Kenya Marine and Fisheries Research Institute (KMFRI), Kenya Forestry Research Institute (KEFRI), Kenya Forest Service (KFS) and Jumuiya ya Kaunti za Pwani with funding from Plan International Kenya (PIK). The Manual is one of the key deliverables of the *Conservation and Sustainable Management of Coastal and Marine Ecosystems (COSME)* project designed to build knowledge and skills of communities and other stakeholders in mangrove conservation and restoration. It also feeds on to the roles of the National Mangrove Management Committee (NMMC) in spearheading implementation of the National Mangrove Ecosystem Management Plan 2017-2027.

The goal of this Manual is to enhance the capacity of community-based trainers to effectively and efficiently deliver the training content to community members in targeted project areas. It serves as a practical guide for the trainers, fostering experiential learning among the target participants.

Drawing from existing and on-going work on Community-Based Ecological Mangrove Restoration (CBEMR) in the country and experiences elsewhere, the Manual aims to equip trainers, community members, and other stakeholders with relevant knowledge and skills necessary for effective management and conservation of mangrove ecosystems. By enhancing understanding and proficiency, the manual endeavours to promote sustainable environmental conservation and socioeconomic development.

The training manual has seven modules, cutting across the basics of understanding mangrove ecosystems including threats, over conservation and restoration strategies, to issues governance and community engagement. This Manual will therefore be used as the basic reference material by community-based trainers alongside other relevant resources in mangrove conservation and management. With its comprehensive insights and practical guidance, the manual is expected to catalyze a positive change in mangrove conservation efforts in Kenya.

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Acknowledgement

The Ecological Mangrove Restoration Training Manual has been developed through a consultative participatory process led by Kenya Marine and Fisheries Research Institute (KMFRI), in collaboration with Kenya Forest Service (KFS), Kenya Forestry Research Institute (KEFRI) and Kwale County Government, climate change directorate. Financial support was provided by Plan International, Kenya (PIK) under the framework of KMFRI-PIK agreement in the implementation of the *Conservation and Sustainable Management of Coastal and Marine Ecosystems (COSME)* project

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To the many stakeholders and partners from various institutions and/or organisations, and who we may not be able to list by name; your contributions through the series of consultations are highly appreciated. Many thanks to PIK for providing financial support that aided in the successful development of the training manual.

Acronyms

CBEMR- Community Based Ecological Mangrove Restoration

CFAs- Community Forest Associations

COSME- Conservation and Sustainable Management of Coastal and Marine Ecosystems

EMCA- Environmental Management Coordination Action

FAO- Food and Agriculture Organization

GHG- Greenhouse Gases

GOK- Government of Kenya

KEFRI- Kenya Forestry Research Institute

KFS- Kenya Forest Service

KMFRI- Kenya Marine and Fisheries Research Institute

NEMA- National Environmental Management Authority

NGOs- Non-governmental organizations

NGOs- Non-governmental Organizations

NMEMP- National mangrove ecosystem management plan

PFM- Participatory Forest Management Plan

PFMP-Participatory Forest Management Plan

PIK- Plan International, Kenya

REDD+- Reducing Emissions from Deforestation and Forest Degradation in Developing countries

UNEP- United Nations Environment Programme

Definition of key terms

Biodiversity: the variety of life in a specific area, including the diversity of species, genes, and ecosystems.

Climate change: long-term alterations in temperature, sea level, precipitation patterns, and the frequency and intensity of extreme weather events

Degradation: the deterioration or decline in the quality and health of forest ecosystems resulting from various human activities, natural processes, or a combination of both.

Drivers: 'mangrove drivers'" typically refers to the various factors or forces that influence the health, distribution, and dynamics of mangrove ecosystems

Governance: UNEP defines environmental governance as "the framework of social, political, economic, and administrative systems that influence the use and management of natural resources and the environment.

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

Reforestation: to plant trees in an area previously occupied by forest but was cleared.

Rehabilitation: deliberate efforts, encompassing technical, institutional, and socio-economic interventions, aimed at promoting the artificial or natural regeneration of trees in an area that has been degraded.

Restoration: the corrective processes that involve returning an ecosystem back to its original status by eliminating or modifying causes of ecological degradation and re-establishing the natural processes that sustain and renew ecosystems over time

Threats : 'mangrove threats' refer to the specific conditions, actions, or influences that pose risks to the health, survival, or functioning of mangrove ecosystems

1. Introduction

1.1 Background information for the manual

Degradation and loss of mangroves has primarily been attributed to both human activities and natural causes. Towards the end of the twentieth century, about 35% of mangrove forest area is reported to have been lost worldwide (Valiela et al., 2001) and this has led to loss of essential ecosystem services they provide. In regards to this, there has been a significant campaign towards conservation of mangroves in Kenya and beyond with an aim to sustain this resource. As such, restoration has now been recognized as a management strategy to transform degraded mangrove areas into uniform stands of higher productivity. Under the UN Decade of Ecosystem Restoration (2021-2030), restoration of degraded areas has gained momentum over the past years and this is more likely to intensify (Waltham et al., 2020). The demand for extensive restoration is high, amidst massive failures of the majority of the restoration projects (Friess et al., 2022). These failures are a result of extreme changes in site conditions, inappropriate restoration techniques, or failure to involve stakeholders (Lee et al., 2019; UNEP, 2020). This training manual has thus been developed with a view to encourage and propagate the culture of ecological mangrove restoration.

1.2 Purpose of the training manual

This manual aims at equipping mangrove conservation practitioners and Community Forest Association (CFAs) with skills for effective ecological mangrove restoration projects in Kenya.

Overall Objective

- The overall objective is to provide a standard set of training modules that will be used by trainers towards enhancing the capacity of coastal communities in carrying out successful mangrove restoration and conservation projects in Kenya.

Specific objectives

- To increase awareness of the importance of mangrove ecosystems and the need of their conservation.
- To enhance understanding of the causes of degradation, the threats facing mangrove ecosystems, and the intervention measures.
- To strengthen local capacity for mangrove restoration and conservation.
- To understand the interlink between mangroves and climate change adaptation and mitigation actions
- To create awareness about the existing policy and legal frameworks for mangrove management and conservation in Kenya.

1.3 Target users and audience

This manual targets trainers who could be from Government institutions and Non-Governmental Organisations (NGOs) involved in mangrove conservation initiatives, as well as Local community based organisations, and any other relevant interested parties.

1.4 Training Sessions

The training sessions are composed of five modules, each further divided into sub-sessions to ensure effective coverage and in-depth understanding.

Modules

1. Introduction to Mangroves Ecosystems
2. Threats to Mangrove Ecosystems
3. Mangroves and Climate Change
4. Mangrove Ecosystem Restoration
5. Governance and Mangrove Management

Training approaches techniques;

The training will take various approaches depending on the unit, these are defined in each of sections. A facilitator may choose to vary the prescribed strategy depending on need and circumstances

Course Duration: To cover the first 4 modules effectively, the training requires a total of 8 days. Module 5 will require additional 2 days.

Expectations as well as foreseen costs

The cost of the training will include;

1. Venue and equipment to be used i.e Projector, white board and Flipchart stand
2. Stationary (notebooks, pens, flipcharts, permanent markers, sticky notes)
3. Field equipment and materials including mangrove boots
4. Refreshments
5. Accommodation for trainers and participants.
6. Facilitators' fees

2. Module One – Introduction to Mangrove Ecosystems

By Judith Okello and Henry M. Komu

Module 1: Introduction to Mangrove Ecosystems					
Training Objectives; At the end of the module, participants will be able to:	**Contents**	**Methodology**	**Duration**	**Specific Materials**	**Guide for trainers**
Have a general understanding of the basic biology of mangroves	-Define mangrove (as a tree, forest, ecosystem) -Features that make mangroves stand out (adaptations)	Teaching presentation using PowerPoint presentations; brainstorming;	45 minutes	-Laminated diagrams -Flipcharts, marker pens, notebooks	- Provide key terminologies -use pictures to show the features
Clearly describe mangrove formations and identify the various tree species by use of the distinguishing features- leaves, roots, reproductive parts	-Overview of mangrove ecosystem in Kenya -mangrove tree species in Kenya -Zonation	Teaching presentation using PowerPoint presentations; field activity /transect walk	45 minutes 3 hours field	pens, photo guides, maps, notebooks, projector, whiteboard, Computer Flipcharts, marker -Mangrove boots	- Provide key terminologies -Use map to locate the mangrove patches along the coast -In groups, match the leaves to the roots and name species - A walk through transect to identify species and pick phenological samples
Have a basic understanding of the key features that define a natural mangrove ecosystem and the role of hydrology in mangrove	-Mangrove's natural system including stressors -Hydrology as an important feature in mangroves	group field activity	90 minutes A day in the field	pH kit, refractometer, photo guides	-Using glass of salt water demonstrate measuring salinity in class -Visit sites that display the various forms of stressors 'bad' and 'good' hydrology
Outline the importance of mangrove ecosystems	Explain the provisioning, regulatory, support, and Cultural ecosystem services of mangrove	Teaching presentation using PowerPoint presentations, brainstorming	1 hour	Flipcharts, marker pens, photo guides,	-Explain the different categories of ecosystem services -Engage the participants to list known uses and classify into the various categories -Participants to rank the mangrove services

2.1 Basic Mangrove biology

Facilitators' guide: *use pictures, illustrations and images to let learners appreciate the different mangrove tree species, mangrove forest and ecosystem. During a transect walk in the mangroves, guide them identify the species and various biophysical features that make mangroves stand out.*

Definition: The term mangroves could be used to mean a tree, forest or ecosystem. Ecological mangrove restoration emphasises consideration of mangroves as an ecosystem thus it is prudent to understand all the components therein.

Mangrove as an ecosystem constitutes a community of woody plants (forest), the associated biodiversity and the interactions therein, normally occurring in tidal areas within tropical and subtropical coasts. Mangrove tree species are salt tolerant and are adapted to thrive in the rather harsh and highly dynamic environment of the tidal flat facilitated by a number of morphological adaptations.

- Posses breathing roots that appear exposed above the ground as either; Pneumatophores or pencil roots, peg roots, stilt roots or knee roots
- Exclusion of excess salts by filtering off excess salts at the roots through strong negative hydrostatic pressure in the xylem thus facilitating access of fresh water for use in photosynthesis
- Salt excretion through; salt deposition in barks and senescing leaves as well as excretion through epidermal glands in leaves
- Mangrove trees display tissue succulence to retain water, possessing waxy cuticle on the upper side of leaves and hairs on the underside; and in some cases having sunken stomata.
- Vivipary for reproduction and generational success: this is a trait where seeds germinate and develop while still attached to parent tree and
- Complex rooting structures for support thus protecting the trees from being toppled over by the strong waves or sometimes storms (Figure1)

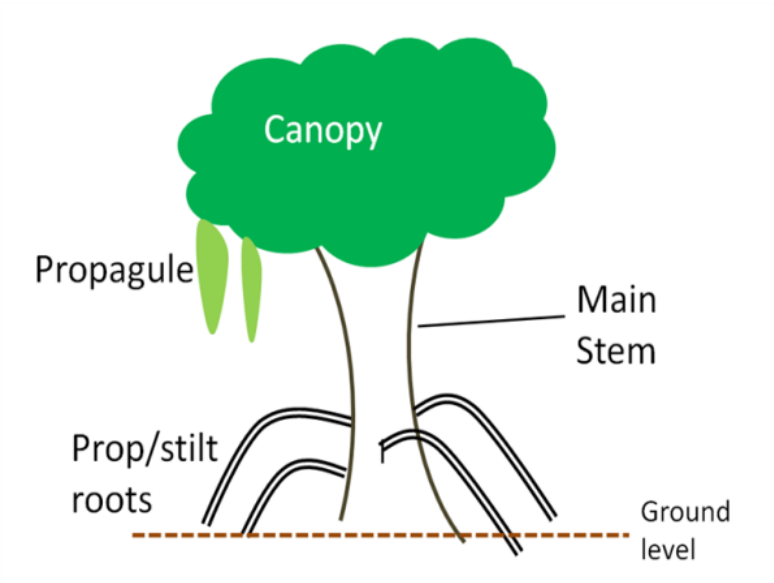


Figure 1: A graphical representation of the components of a mature *Rhizophora mucronata* mangrove tree

2.2 Mangrove formations and tree species of Kenya

Mangroves of Kenya cover an area of 61,271 ha (approximately 3% of the total national forest cover) and grow in different formations (Table 1) (UNEP, 2020). The largest mangrove cover is found in Lamu county and the least being Tana River.

Table 1. Distribution of mangroves of Kenya across the 5 coastal counties and the various formations

County	**Mangrove patches**	**Formations**
Lamu	Northern Swamp, Northern Central Swamp, Pate Island Swamp, Mongoni-Dodori Creek Swamp	Drowned river valleys (Dodori Creek); Reef platforms (Lamu)
Tana River	Kipini and Mto Tana	Delta and estuary (Tana)
Kilifi	Ngomeni, Mida, Kilifi, Takaungu, Mtwapa	Drowned river valleys (Mtwapa, Takaungu); Delta and estuary (Sabaki)
Mombasa	Tudor Creek and part of Port Reitz	Drowned river valleys
Kwale	Mwache Creeks, Kongo River, Gazi Bay, Shirazi-Funzi-Munje, Sii Island, Vanga	Sheltered bays and reef patches: (Vanga, Funzi, Shimoni and Gazi); Offshore Island with managroves (Sii Island)

How many mangrove tree species do we have in Kenya?

Nine species of mangroves occur in Kenya. The most common species are: *Rhizophora mucronata* (mkoko), *Avicennia marina* (mchu)and *Ceriops tagal* (mkandaa). The other types are *Sonneratia alba* (Mlilana), Bruguiera gymnorrhiza (Muia), *Lumnitzera racemosa* (Kikandaa), *Xylocarpus granatum* (Mkomafi), *Xylocarpus molucensis* (Mkomafi dume), and *Heritiera littoralis* (Msikundazi).

2.3 Zonation in Mangroves

Mangroves in Kenya occur in a typical zonation pattern from seaward to landward where Sonneratia-Rhizophora-Avicennia communities occupy seaward side, followed by Rhizophora-Bruguiera-Ceriops in the mid-zone and dwarf Avicennia-Lumnitzera-Xylocarpus complex on landward side (FAO, 2003). *A. marina* is the most widely distributed exhibiting double zonation i.e. on seaward side, it grows bigger compared to landward side where it occurs as a shrub due to harsh environment. *R. mucronata* is dominant in muddy soils, in the zone between *S. alba* and *A. marina* on the seaward side and *C. tagal* on the landward side. *B. gymnorrhiza* is found scattered within stands of *R. mucronata. X. granatum* is found after *R. mucronata* and *C. tagal* stands. *L. racemosa* will be found at the highest landward zone.

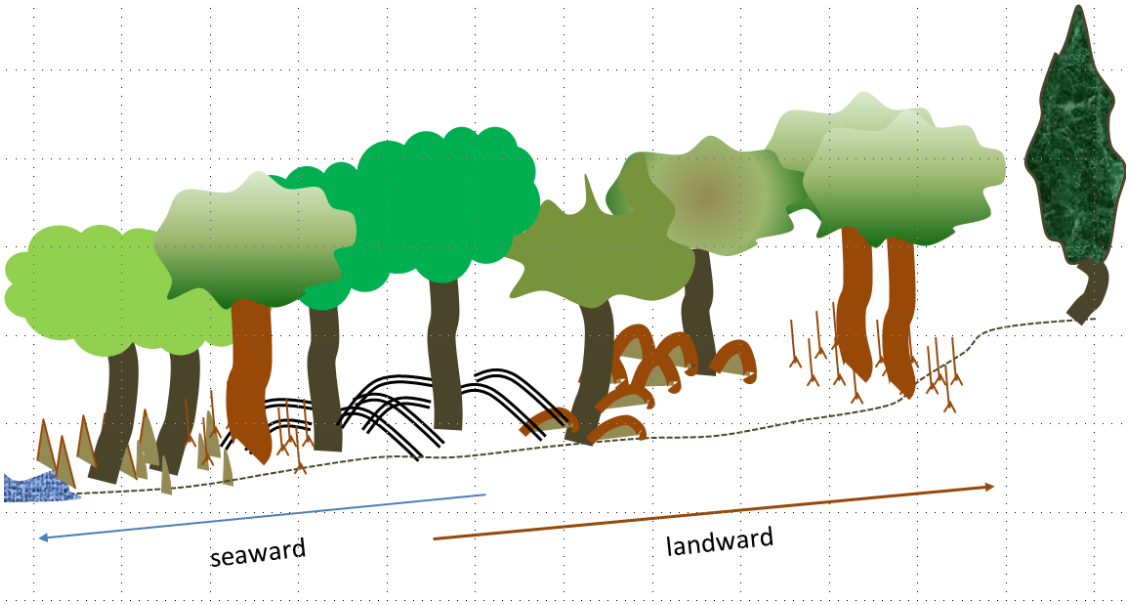


Figure 2. Illustration of typical zonation in mangroves. Mangrove tree species, sometimes but not always, occur in bands parallel to the shoreline

2.4 Mangroves natural ecosystem Key characteristics

- Mangroves are found in the top half of the intertidal zone. While the tidal range normally extends over a wide area, (from Low water- over Average sea level- to high water) mangroves are only restricted to areas between the average sea level and high water level. Within this top half, different species occupy different elevations relative to sea level sometimes forming zones (Duke N.C 2006; Fig 2)
- Terrain is naturally undulating never flat plain
- winding channels sometimes large and extending over large areas
- Variety of densities, canopy heights allowing varying light intensities and enhanced biodiversity
- Low wave energy sites- generally not open ocean facing
- Mangroves good at slowing water but are not good at resisting big waves from the ocean
- Different species have varying abilities in resisting erosion/binding soil e.g. *S. alba* and *A. marina*.
- Pioneer species more appropriate than *R. mucronata* due to cable roots under the soil
- Biodiverse mangrove ecosystem varying number of species from one locality to the other

Mangrove natural system characteristics facilitator's guide: *These characteristics of a natural mangrove system would be appreciated more by the learners through class presentations and making a transect walk in a mangrove area, preferably in an area with an obvious zonation*

A section of mangrove forest during high tide. The pictured tree species (*S. alba*) has suffered severe dieback due to insect pest infestation, a common occurrence along the coast of Kenya

2.5 Stressors in the mangrove system

Let the participants discuss in groups examples of stressors in mangroves after defining what the term applies to. Explain the effect of each of the stressors. The session will also include field work where measurements and observations are made.

Salinity

Salinity refers to the concentration of dissolved salts in the pore water of mangrove sediment. Mangroves are adapted to grow in brackish water, where salinity levels are moderate. However, excessive salinity can stress mangroves by affecting their ability to regulate water uptake and osmotic balance. This leads to physiological stress such as to reduction in growth rates in trees, leaf damage and eventual mortality (Twilley et al., 2005).

Facilitator guiding points: Using a handheld refractometer, take measurements of various salt solutions in a glass. Let the participants appreciate the differences in the readings. In groups, guide the participants to take in situ salinity measurements along a gradient.

Hypoxia/anoxia

Hypoxia/anoxia refer to conditions where oxygen levels in the waterlogged soils or surrounding water become significantly reduced (hypoxic) or depleted (anoxic). In this case, without sufficient oxygen below ground, roots must rely on internal transport of gases to satisfy the oxygen requirements (Alonga 2009). Mangrove species have a number of mechanisms that help them to cope with the fluctuating oxygen levels i.e aerenchyma tissues found in roots, stems and sometimes leaves that facilitate in diffusion of oxygen in aerials parts submerged in waterlogged soils(Kathiresan et al.,2001). However, prolonged or severe hypoxic/anoxic conditions can stress mangroves by inhibiting their ability to

perform aerobic respiration, leading to metabolic imbalances and potentially death of roots and associated microorganisms crucial for nutrient cycling(Alongi 2008).

Strong waves/wave action

The physical force exerted by high energy wave actions can lead to adverse effects on the mangrove ecosystem(Alonga 2009). This include;

- Intense wave action can cause physical damage by uprooting the mangrove trees and seedlings.
- Erosion-high wave action can cause the removal of soil and fine sediments that mangrove grow in. This undermines the stability of root systems making it difficult for mangroves to anchor themselves in soil effectively.
- Strong waves can cause saltwater to inundate areas where mangroves are not typically exposed to high salinity, leading to several mangrove stress-related impacts.

Facilitator additional guide: Visit a site exposed to wave action and let participants document observable features, you could also use photos where available.

Mangrove hydrology

Plants including mangroves need water to facilitate cooling effect (during respiration), it is a media for dissolving and transporting nutrients; maintain cell turgor hence support the plant; helps in waste removal. In the mangroves, the movement of tides ensure the following;

washing out excess salts,

washes away acid toxins from soil particularly emanating from crab burrows and root channels thus improve root growth;

Dispersal of propagules thus deposit seeds in the appropriate places enhancing natural regeneration

help sediment balance,

breathing through lenticels as the pores open up and allow the air to go down into the soil during the low tide as the sediment is drained off;

flushes out organic material -partly a basis of inshore food web; tides bring with it bacteria that help improve soil quality- they take nitrogen from the air and fix it into the soil; allows to connect the vital ecosystems -so fish etc are able to move freely across the ecosystems (to and from coral, seagrass and mangroves).

All these can only be possible with a good hydrology

If an area has an obvious channel, it is important therefore to keep it clear and open, by digging out to improve flow; so do not plant in the channel; note roads can block hydrology ensure in designing, culverts are placed appropriately

Example of hydrology interfered with resulting in blocking water and subsequent mangrove death, in Kililana chanel

2.6 Benefits of mangroves

Mangroves provide a diverse range of goods and services, divided into provisioning, regulatory, support and cultural services. While some of these benefits are ‘obvious’ others in fact majority are less obvious

Provisioning services	Wood products: Fuelwood, timber and poles for construction. Non-wood products: Fisheries, medicine, tannins, fodder and honey.
Regulatory services	Shoreline protection, carbon sequestration, nutrient and sediment filtration.
Support services	Primary production, habitat for marine life, nutrient cycling, breeding, spawning and feeding grounds for fish.
Cultural services	Use of mangroves: as sacred sites (Kaya), for tourism and recreation (e.g. Wasini and Mida), and for educational purposes (e.g. Gazi KMFRI station).

Mangrove Benefits summary:

there are the obvious and the less obvious benefits of mangroves and this answers to the question; why care about mangroves?

Mangroves are home, nursing and feeding grounds for many forms of biodiversity

What do fish or crabs come to do in the mangroves? Crabs eat organic matter; juvenile fish in the tidal pools; *A. marina* seeds and seedlings; propagules

Mangroves aid in climate change mitigation: absorption of CO2 from the atmosphere and carbon storage; retain/hold water; slow water flow; reduce flooding; reducing erosion; buffer against storm surges

Mangroves filter water that pass through them from land; thus get rid of excess sediments, heavy metals, and nutrients that would otherwise affect adjacent critical ecosystems

Trainers guiding point: *facilitate discussions to let the learners understand how mangroves perform the functions listed in the text box above, by explaining in detail with elaborate examples. Use photos and images that depict how systems would fail where mangroves are lost*

3. Module Two – Threats to Mangrove Ecosystems

By Judith Okello, Henry M. Komu and Miriam Vihenda

Module 2: Threats to Mangrove Ecosystems					
Training Objectives: At the end of the module, participants will be able to	**Contents**	**Methodology**	**Duration**	**Materials**	**Guide for trainers**
Identify the local threats to mangroves	-State the qualities of a healthy versus degraded mangrove ecosystem -Identify the drivers of change	Teaching presentation using PowerPoint presentations, Brainstorming	**2 hours**	Flipcharts, marker pens, photos of healthy and degraded ecosystems, notebooks, projector, whiteboard,	-Facilitator to provide a presentation with illustrations -Guide participants to give examples of qualities of a healthy system -Brainstorm on the local threats (categorized as human-induced/natural) and rank in order of importance)
Identify drivers of mangrove degradation	-Key drivers of mangrove degradation	Teaching, PowerPoint presentations	**45 minutes**	Flipcharts, marker pens, computer, projector	Engage the participants in discussing this section; majorly brainstorming combined with group work
	-what do we lose when mangroves are degraded -Some management interventions	Brainstorming	**30 minutes**	Flipcharts, marker pens,	

Facilitators' guide: *Ask participants to list the threats leading to degradation of mangroves from their own understanding. Use pictures to let learners differentiate anthropogenic and natural causes.*

3.1 Healthy verses degraded mangrove ecosystem

In a healthy mangrove ecosystem, there exists a harmonious balance of ecological components that sustain biodiversity, encompassing both fauna and flora, while also fostering sustainable ecosystems. However, in our dynamic and ever-changing world, mangroves encounter many challenges. These challenges are brought about by extensive human activities and climate change (Bosire et al., 2016) that inevitably lead to the tidal forests degradation, resulting in losses in biodiversity, structural integrity, and functional capabilities within the mangrove ecosystem (Vásquez & Gerding., 2018). Human-induced factors such as un-monitored illegal cutting of mangroves (GOK 2017) for fuel energy, conversion of mangrove areas to other land uses and sedimentation through damming of rivers, and plastic pollution, oil spills are the major threats witnessed to cause mangrove degradation. Climate change poses a significant threat to the remaining mangrove areas, primarily due to rising sea levels, sedimentation and El Nino events resulting from changes in precipitation patterns and shoreline dynamics (Bosire et al., 2016)

3.2 Threats to mangroves ecosystem

The table below describes the threats identified in Kwale and Kilifi counties according to the National Mangrove Management Plan (GOK 2017)

Table 2: Some examples of degradation in mangroves across the coastal counties of Kenya

Overexploitation
Plate 1. Mangroves cleared in Mbwajumwali, Pate Island Lamu
Photo credit: *Judith Okello 2023*

Natural causes
Plate 2. Diebacks on trees observed in Mwazaro
Photo credit: Henry Komu

Plate 3. Insect pest-infested *S. alba*
Photo credit: Henry Komu

Plate 4. Clear felled area in Munje
Photo credit: Henry Komu

Soil erosion & Sedimentation from riparian farms
Plate 5. Farm on slopes facing mangrove area in Mtwapa Creek with gulleys demonstrating erosion and potential siltation in adjacent mangroves ***Photo credit:*** *KMFRI,2022*

Encroachment
Plate 6. A mangrove area in Mombasa County has been intruded upon by the local community.
Photo credit: *KMFRI,2022*

Pollution
Plate 7. Plastic pollution observed in Majoreni mangroves
Photo credit: *Nimrod Ishmael 2023*

Grazing in mangrove area
Plate 8. Cows feeding on the saplings in Munje;
Photo credit: Henry Komu

Plate 9. 1997/98 El nino caused mangrove death at Mida Creek. (the area has never recovered since the event);
Photo credit*: Judith Okello, 2023*

Plate 10. Mangrove dieback due to increased sedimentation caused by shoreline change at Kizingitini- Lamu, Kenya;
Photo credit*: Judith Okello, 2024*

3.3 Drivers of mangrove degradation

The following key drivers have led to the degradation of Kenya's mangroves.

1. Poverty – The coastal region of Kenya has been reported to have some of the highest poverty levels, leading to high dependence on primary resources with limited alternatives. Mangroves have been highly relied upon by the adjacent communities for decades, contributing to their decline
2. Economic development - Increasing coastal development has also precipitated environmental and mangrove degradation. For example, road construction, dredging, port expansion and development have led to mangrove degradation in Mombasa and Lamu
3. Weak governance – the following aspects have contributed to the loss and degradation of mangroves: (i) weak enforcement of existing legislations, (ii) sectoral approach to management due to overlapping or conflicting mandates, (iii) lack of effective coastal planning, (iv) inadequate institutional capacities and (v) poor stakeholder or community participation.

4. Inadequate knowledge and awareness – Lack of adequate awareness on the extent of mangrove ecosystem degradation due to limited survey and mapping data (spatial-temporal data) may impair management decisions and even policy decision-making regarding mangrove utilization and conservation

What do we stand to lose when mangroves are destroyed?

The degradation of mangroves leads to several detrimental outcomes through a reduced ability to deliver essential ecosystem services to both local coastal communities and the worldwide population (Duke et al., 2007; Estoque et al., 2018).
These outcomes include;

- A subside in the mangroves' ability to absorb atmospheric carbon, leads to reduced effectiveness in mitigating climate change.
- Coastal communities are also left more exposed to risks like sea-level rise and storm surges due to the diminished protective function of mangroves.
- Moreover, the loss of essential resources provided by mangroves, such as food, fibres, timber, chemicals and medicines, reduces the adaptive capacity of coastal populations.
- This loss affects not only local economies but also industries like fisheries and tourism that rely on the health of mangrove ecosystems.
- The loss of mangroves could also affect interconnected coastal ecosystems, such as coral reefs, seagrasses, and seaweeds(UNEP-WCMC, 2006).

3.4 Some Management interventions

As a manager, you need to understand the factors underpinning degradation to make effective decisions. The table below provides a summary of potential interventions specific to selected threats.

Table 3. Threats to mangroves and potential management interventions

	Threat	Possible management interventions
1	Illegal harvesting and over-exploitation	Preparation of harvesting plans, enforcement, and provision of alternatives to mangrove forest products e.g woodlots for timber and poles, alternative fuel energy sources. This will ensure sustainable utilisation while conserving this critical resource
2	Soil erosion and sedimentation	Soil stabilisation and conservation interventions along the seashores, on the farm, and upstream e.g afforestation and restoration programs, agroforestry
3	Livestock grazing	Provision of alternative fodder and pasture grounds, protection and enforcement. This will allow natural regeneration to take place with minimal disturbances from trampling and foraging livestock
4	Coastal developments and encroachments	Developing coastal and marine spatial development plans and enforcing existing legislation is vital for conserving and maintaining the ecological integrity of mangrove ecosystems.
5	Pests and diseases	Development of integrated pest and disease management interventions. To control the spread and new infestation, which will ensure the existing species thrive
6	Floods and sea level rise	It may not be prevented, but responsible practices on the riparian lands facing the mangrove areas could reduce the impact on mangroves. (discuss further on various practises, including appropriate farming techniques)
7	Droughts and increased salinity levels	Requires a multifaceted approach that combines scientific research, ecological, and community-based strategies and robust policy framework

4. Module Three – Mangroves and Climate Change

By Joseph M. Indo

Module 3: Mangroves and Climate Change					
Training Objectives: At the end of the module, participants will be able to	**Contents**	**Methodology**	**Duration**	**Materials**	**Guide for trainers**
Learn the basics of climate change	Definitions -Concept of Climate change -Sources of greenhouse gases	This is an interactive lecture presentation	**1 hour**	Flipcharts, marker pens, white board/ Black board, Chalk, Pictures	
Understand climate change impacts on critical ecosystems	-Definitions -Impact of global warming	Teaching presentation using PowerPoint presentations Interactive discussions	**1 hour 30 minutes**	Marker pens, Flipcharts, Marker board marker	-Facilitator to provide a presentation with illustrations -Guide participants to give examples of risks/impacts associated with climate change.

Reflect on how climate change has impacted them and their neighbours. Identify adaptation strategies including carbon offsets to enhance their resilience in the face of climate change	-Overview of climate change effects on coastal communities and mangroves -the concept of hazard, exposure and vulnerability -Importance of coastal ecosystems -Mangroves and Climate Change adaptation and mitigation actions	Teaching presentation using PowerPoint presentations Interactive discussions	**2 days**	Flipcharts; Marker pens, Marker board marker	-Facilitator to provide a presentation with illustrations - Brainstorm and propose examples of adaptation strategies and rank in order of importance - Encourage discussions on how carbon offset projects can contribute to resilience in these communities
Learn about mangrove carbon accounting	-Discuss the importance of mangroves as carbon sinks and their role in mitigating climate change. -An overview of carbon accounting standards -Estimating carbon stocks and emissions in mangroves	Teaching presentation using PowerPoint presentations interactive discussions, Group exercises Plenary sessions	**1 hour**	Flipcharts; Markers, white board	-Organise a field trip to a mangrove site where participants can conduct a hands-on carbon inventory. -guide participants on measuring tree biomass, soil carbon content, and other relevant parameters to estimate carbon stocks in the mangrove ecosystem.

4.1 Basic Science of Climate Change

Brainstorm

Allow the participants to describe their understanding of weather and climate. From their description pick out elements of weather and write them on the white board/black board.

Definition of Concepts

Atmosphere - is a mixture of gases that surrounds the Earth. Earth's atmosphere is composed of about 78% nitrogen, 21% oxygen, and one percent other gases.

Carbon Dioxide - a naturally occurring gas, and also a by-product of burning fossil fuels and biomass, as well as land-use changes and other industrial processes. It is the principal human caused greenhouse gas that affects the earth's radiative balance.

Carbon Sequestration - is the process by which trees and plants absorb carbon dioxide, release the oxygen, and store the carbon.

Climate - the weather conditions prevailing in an area in general or over a long period. (30 years) These conditions are most often surface variables such as temperature, precipitation, and wind.

Climate Change - is any systematic change in the long-term statistics of climate variables such as temperature, precipitation, pressure, or wind sustained over several decades or longer. Climate change can be due to natural external forcings (changes in solar emission or changes in the earth's orbit, natural internal processes of the climate system) or it can be human induced: i.e. attributed largely to human activities that increase levels of GHG emissions, especially atmospheric carbon dioxide produced by the use of fossil fuels. Climate change is sometimes referred to as global warming, which specifically refers to the long-term trend of rising average global temperature.

Greenhouse Gas (GHG) - is gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include,carbon dioxide, methane and nitrous oxide, etc

Ocean Acidification - Increased concentrations of carbon dioxide in seawater causing a measurable increase in acidity (i.e., a reduction in ocean pH)

Temperature - is a physical quantity that quantitatively expresses the attribute of hotness or coldness. Temperature is measured with a thermometer.

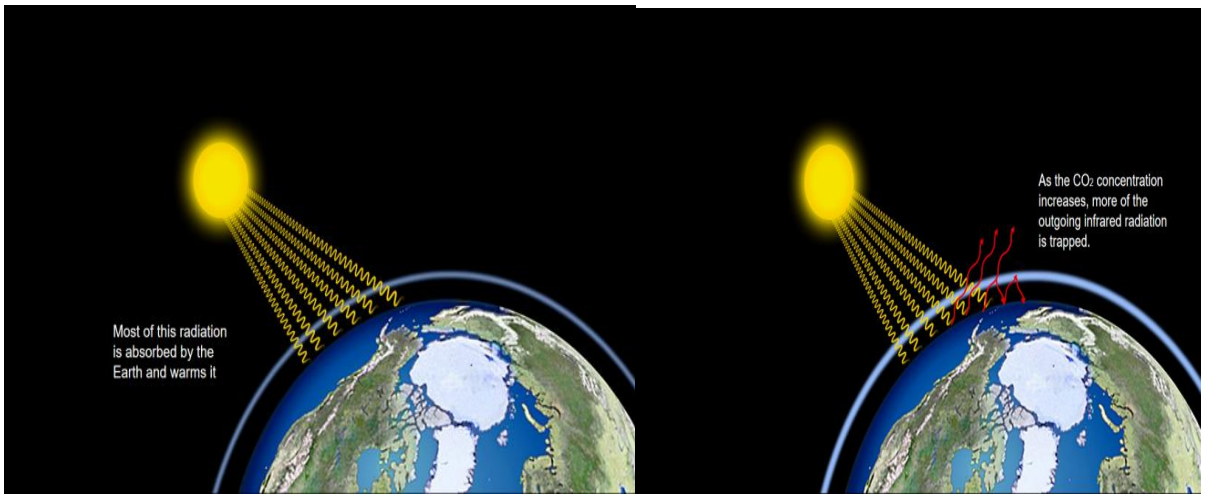
Vulnerability - the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed; its sensitivity; and its adaptive capacity.

Weather - Atmospheric condition at any given time or place. It is measured in terms of such things as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from hour-to-hour, day-to-day, and season-to-season.

Concept of Climate Change

Initiate discussions on the Solar system and let the participants share their understanding of it.

Stars are heavenly bodies that generate their own heat and light while the planets depend on the Sun for light and heat. The Blue line represents the Troposphere.The Troposphere helps to regulate the warming of the Earth through solar radiation.



SLIDE SOURCE(S): https://earthobservatory.nasa.gov/features/EnergyBalance/page6.php

Greenhouse Gas emissions including Carbon dioxide from Human activities have resulted in expansion of the troposphere impacting it's ability to regulate the solar radiation resulting in global warming. Greenhouse gases - The atmospheric gases responsible for causing global warming and climate change. The major GHGs are carbon dioxide (CO2), methane (CH4) and nitrous oxide (N20). Less prevalent but very powerful - greenhouse gases are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and Sulphur hexafluoride (SF6).

Sources of Greenhouse Gases

Figure kk. Graphic representation of major sources of greenhouse gas emissions (Source: Climate Reality Project)

Brainstorm session

Let the participants identify other sources of Carbon dioxide and other Greenhouse Gases from their day to day activities. In addition let the members discuss ways in which they can reduce greenhouse gas emissions from their day to day activities.

4.2 Climate change impacts on critical ecosystems

Begin by defining the following terms:

Adaptive capacity (A) - capacities of the system, sector or group to resist impacts, cope with losses and/or regain functions. This component comprised the following layers community resource maps and access to water and infrastructure.

Disaster: means a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.

Disaster Risk: means potential disaster losses in lives, health status, livelihoods, assets and services, which could occur to a community or a society over some specified future time period.

Disaster Risk Reduction: means concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.

Exposure: the size of the area and/or system, sector or group affected and the magnitude of the stressor. This factor (exposure) was largely defined by climatic layers these included the drought risk, flood risk, long-term rainfall average and long-term temperature average layers which were ranked in accordance to the risk level

Hazard: means a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Sensitivity (S) - the characteristics of a system or population and the governance/market structures that Influence the degree to which it is affected by stressors. This factor (sensitivity) by defined by the following layers: conflict, diseases (Human, Livestock, crop), landslides and land degradation

Vulnerability - The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity

I**mpacts of Climate Change**

Global warming attributed to GreenHouse Gas emissions has resulted in the following Climate change impacts:

- Warmer temperatures increase the frequency, intensity, and duration of high temperatures that have posed health risks particularly for young children and elderly.
- Climate change can also impact human health by worsening air and increasing the spread of diseases and altering the frequency or intensity of extreme weather events.
- Rising sea level threatens coastal communities and ecosystems.
- Changes in the patterns and amount of rainfall as well as changes in the timing and amount of stream flow can affect water supplies and water quality.
- Changing ecosystems influence geographic ranges of many plant and animal species and the timing of their lifecycle events, such as migration and reproduction.
- Increases in the frequency and intensity of extreme weather events, such as drought and floods, pests and diseases can increase losses to property, cause costly disruption to communities.

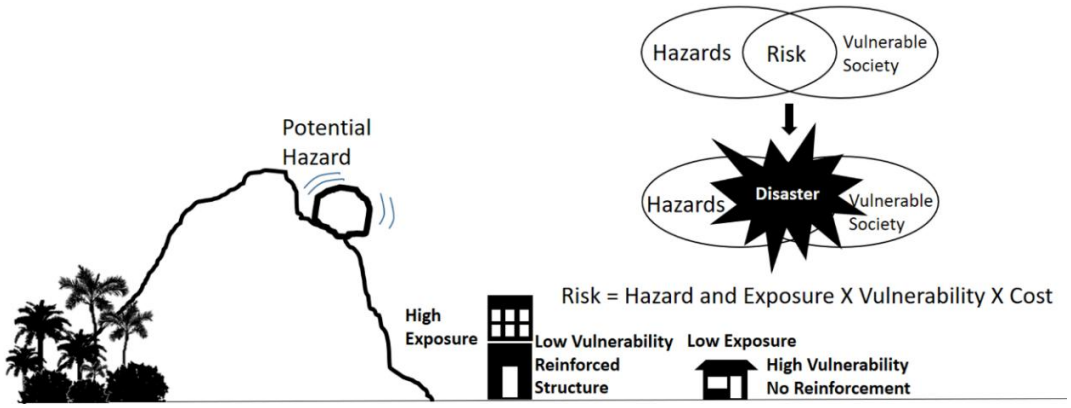


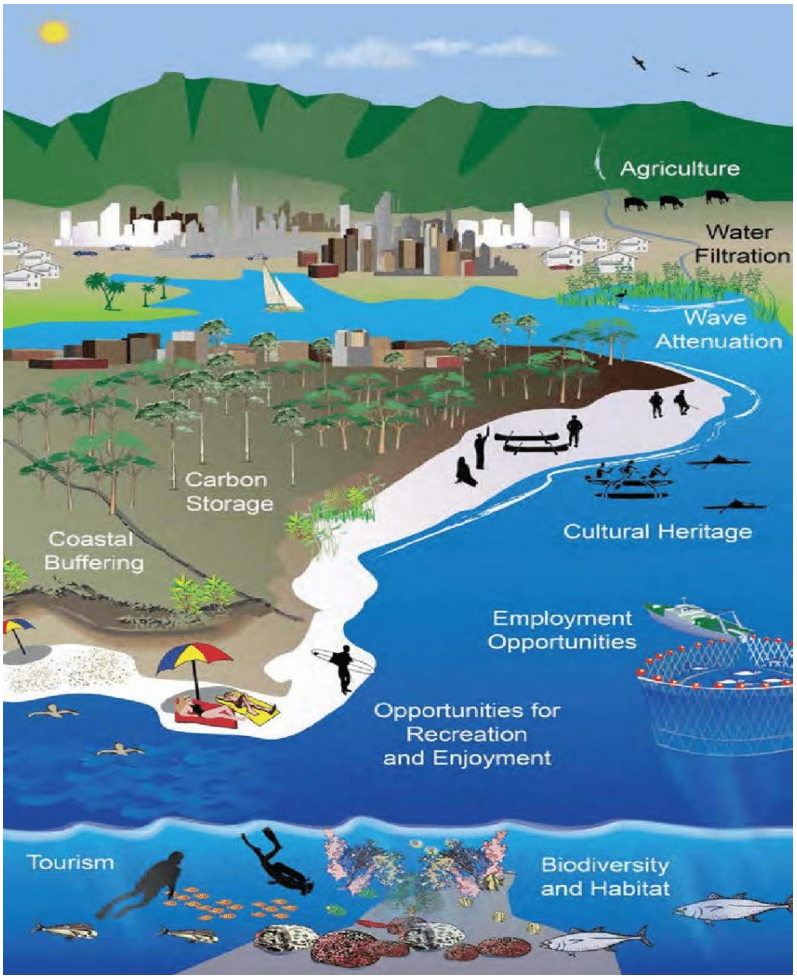
Figure XX Effects of Hazard, Exposure and Vulnerability to Disaster Risks and hazard (figure credit to April Mae Arcaya)

Brainstorm session

Let the participants discuss their observation of the picture and let them relate this to their locality. Let them link their understanding of the concept of climate change to the localised impacts in their locality.

Importance of Coastal Ecosystems

Divide the participants into four groups of adult male, adult females, male youth and female youth and let each group list and draw a resource map of their locality. Based on their grasp of the concept of climate change, let each group overlay climate hazards on their resource maps.Observe the gendered perspectives on resource identification and how their resources are vulnerable to the climatic hazards.[1]



Importance of Coastal Ecosystems

- They facilitate exchange of mass and energy between land, sea, atmosphere and biota.
- Coastal ecosystems consist of remarkable biological productivity and diversity
- Coastal ecosystems produce fish, coral reefs, sea weed and sea grass that are of environmental and socio-economic importance
- Coastal ecosystems store and cycle nutrients as well as filtering of pollutants
- They offer coastal shoreline protection against erosion and storms
- Harbour ports for commerce facilitation transport networks, tourism and recreational activities
- Vulnerability to climate change comprises a set of conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of a climate hazard.

Climate change impacts on critical ecosystems include:

[1] Adapted from Swiderska, Krystyna & King-Okumu, Caroline & Islam, Md. (2018). Ecosystem-based adaptation: a handbook for EbA in mountain, dryland and coastal ecosystems.

- Mangrove ecosystems depend on freshwater streams to balance the salinity along the channels. As a result of increased drought events freshwater flow is inhibited affecting mangrove ecosystems.
- Extreme weather events such as increased rainfall intensity increases flooding resulting in sedimentation that impacts mangrove ecosystems.
- Increased temperature has also increased ocean acidification impacting key biodiversity habitat in marine space.
- Sea level rise has also impacted vulnerable coastal ecosystems through coastal flooding.

4.3 Mangroves and climate change adaptation and mitigation actions

Definitions and concepts of adaptation

Climate Change Adaptation: Refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change.

Mitigation: In the context of climate change, a human intervention to reduce the sources or enhance the sinks of greenhouse gases. Examples include using fossil fuels more efficiently for industrial processes or electricity generation, switching to solar energy or wind power, improving the insulation of buildings, and expanding forests and other "sinks" to remove greater amounts of carbon dioxide from the atmosphere.

Climate Resilience: Closely linked to adaptation, building climate resilience includes reducing vulnerability to climate change, making sure that the impacts of climate change are avoided or cushioned, and enabling people to respond to climate risks.

Risk Assessment: A methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend.

Participatory Climate Risk Assessment

A Participatory Climate Risk Assessment (PCRA) is a process that helps communities identify and prioritize climate risks, and develop strategies to respond to them.

Why should Participatory Climate Risk assessment be undertaken?

- **Identify risks -** The PCRA process identifies hazards like drought, flooding, and deforestation.
- **Prioritize risks -**The PCRA process helps communities prioritize the risks they face.
- **Develop strategies -**The PCRA process helps communities develop strategies to respond to the risks they face.
- **Incorporate local knowledge -**The PCRA process incorporates local knowledge with scientific data to gain a better understanding of local risks.
- **Inform action plans -**The PCRA process informs local action plans to reduce the risks from climate change.

The PCRA process involves administration of 10 tools as shown below:

PCRA tool 1 -Hazard and Resource map

Objectives of the tool

- To identify resources and vulnerable areas;

- To help the community identify the various hazards and risks in their area (mapping out the climate change related hazards and risks)
- To help the community identify the various resources within their area

How to facilitate development of the Hazard and Resource map

- Explain to participants that they are going to draw a map of their area (village)
- Ask them to brainstorm the common boundaries and landmarks and draw a sketch map demarcating the village boundaries and locate the landmarks
- Now ask them to draw the map and locate the various hazards on the map (areas at risk, areas where the hazard/s are most prevalent)
- Ask them to locate the various resources on the map i.e. main roads, rivers, forests, water resources, institutions (schools, health facilities
- Not all the resources will be mapped, let the rapporteur list down all the resources –they will form part of the PVCA report, i.e. schools, both public and private, primary, secondary tertiary institutions etc., all the major water resources i.e. dams, water pans, pipelines, wells and boreholes, major roads and the type i.e. murram, tarmac, Health facilities and their level i.e. dispensaries, health centres, referral hospital, private clinics etc., rivers and streams, forests/shrines/Kayas, livestock facilities i.e. dips, crashes, abattoirs, slaughter slabs etc., major markets and market days and the common commodities sold, etc.

PCRA tool 2 -Historical timeline

Historical timeline is a tool for gathering information about what has happened in the past.

Purpose:

To identify all the events and activities that has left their mark on the growth and development of the community. So that the community will be able to see the pattern links which able to create awareness and influence on making their decisions priorities.

How to Facilitate Historical timeline tool

- Identify areas of interest: define the topics for which you want to collect information. These might include food security, hazards, land distribution or conflicts. (the identified climate changes)
- Selection of participants: younger & older people blend -having the younger generation will be beneficial; opportunity that the younger will learn from older people.
- Start off by asking people if they can recall major events in the community related to the topics selected.
- Capture the information using a timeline which was created by the community as a chart showing the changes over time of key aspects of their lives. A note-taker – a participant, another specified person or the facilitator – should write the events discussed down on a blackboard or large sheet of paper in chronological order, using symbols.

PVCA tool 3 -Seasonal Calendar

Objectives of the tool

- To analyse seasonal changes in activities and periods of stress or scarcity
- To identify important livelihood activities
- To document community observations of changing trends in seasonal patterns

How to facilitate

- Explain to the participants that you would like to develop a calendar to show key events and activities that occur during the year.
- Ask people to list the key seasons, activities and other events that occur throughout the year, and arrange these along the vertical axis. The list could include:
- Seasons (rainy and dry seasons, hot or cold seasons)• Holidays and festivals• Agricultural activities including planting, harvest and marketing • Periods of scarcity of resources, such as food, water, fish or pasture• Times of migration• Timing of climate events such as storms, floods, droughts and heat waves• When common seasonal illnesses occur for people and for livestock)
- The Participants should develop 2 calendars, 1 in how seasons were experienced and how climate change has impacted shifting of the seasons valued by the community.

PCRA tool 4 -Daily clock

Objectives of the tool

- To illustrate the inequality in workloads within the household and how this can undermine resilience and affect the ability to implement the adaptation options
- To show the value of women's work (gender roles)
- To understand how daily tasks and the division of responsibilities shift when a climate-related shock occurs

How to facilitate

- Divide the participants into four groups: Men, Women, Male Youth and Female Youth.
- Using one of the prepared daily clocks, ask them to draw or write all of the tasks that they do throughout a typical day. This should include any overnight activities (such as breastfeeding), paid and unpaid work, leisure and rest time. Give them approximately 20 minutes to do this.

PCRA tool 5 -Household Decision Making Pile Sorting

Objectives

- To explore who in the household has the authority to make important decisions
- To discuss how decision-making could be more equal as a means to increase resilience

How to facilitate

- Explain to the participants that the exercise will explore decision-making in the household. Ask them to brainstorm the critical decisions that are needed at the household level, to meet the family's needs, maintain well-being and plan for the future. Ask them to also consider decisions that are made when the household is affected by climate-related shocks and stresses. Give them approximately 10 minutes to come up with a list. Write (or draw) each decision on an individual card.
- Lead a discussion: Who makes the most decisions? Does this change when the household is affected by a climate-related shock or stress? What types of decisions are made by the man alone? By the woman alone? What types of decisions are made jointly? Why is this the case? Is there any difference based on the age, ethnicity, etc. of household members? Have there been any changes to the ways in which decisions are made in recent years? What has driven these changes? What are the benefits of both partners having an equal voice in important decisions?
- Invite them to turn to a neighbour and discuss : One change that they would like to see in terms of decision-making in their own household for their well-being; One change that they would like to see in terms of decision-making at the household level when it comes to anticipating, absorbing or adapting to climate stresses and shocks

- Ask all group members to reflect individually on one action they can take to move towards the change they would like to see.
- Ask the group if they have any questions, thank them for their participation and explain the next steps.

PCRA Tool 6 -Leaky bucket

Objective

- To analyse household income and expenditure

How to facilitate

- Request the community members to role play and identify the common sources of income and expenditures in the community.
- Identify areas that the communities can intervene to boost their incomes and minimise their expenditures.

PCRA Tool 7 - Vulnerability Matrix

Objectives

- To identify the highest-priority livelihood assets and hazards
- To analyse the degree of impact of hazards and changes on priority livelihood assets

How to Facilitate

- Prepare a matrix in advance. This can be done on the ground, using idea cards or on flip chart paper.
- Ask the group to identify their most important livelihoods assets. These do not have to be resources that they currently have, but those that they consider to be most important in achieving secure and resilient livelihoods. The most important assets will generally come out fairly quickly, so after the initial ideas have come out, move on to the next step.
- Ask the group to identify the four assets that they consider to be most important in achieving well-being and resilience (or five, if they are having difficulty narrowing it down). List these priority assets down the left side of the matrix on the vertical. Use symbols if this will help participants to better understand.
- For each of the priority assets, ask who in the community has access to the assets and who controls decision-making in relation to their use.
- Refer back to the previous discussions and the hazard map and ask the group to identify the four hazards or changes that have the greatest impacts on their livelihoods.
- List the four (or five) most important hazards/changes horizontally across the top of the matrix, again using symbols if necessary. If they do not immediately identify climate-related hazards, try to gently guide them in that direction so that there are at least two climate-related hazards included in the analysis.
- Ask the group to agree on a scoring system for analysing the impacts of the hazards/changes on the livelihood assets, incorporating scores for significant, medium, low and no impact. You can use figures, stones, symbols or different colours of markers (e.g. red = significant impact on asset, orange = medium impact, green = low impact, blue = no impact). Ensure that all members of the group understand the scoring system
- Ask the participants to decide on the degree of impact that each of the hazards has on each of the assets, referring back to the impact chains. This will involve coming to consensus as a group. The note taker should note key points of discussion that lead to the scores assigned and any disagreements on the scores. Use this moment to also ask participants if the hazards are impacting people the same way and who is most affected.

- Ask the group if they have any questions, thank them for their participation and explain the next steps.

PCRA Tool 8 - Venn Diagram

Objective

- To undertake stakeholder analysis in the climate change space
- This tool lists all stakeholders who assist the community and their relationship with the residents. The Venn diagram shows how much both internal and external organizations contribute to the community
- The purpose is to identify perceptions that local people have of the role and significance of various organisations, groups and individuals within the community, to understand which institutions are most important to communities and to assess access to services and availability of social safety nets. It is further used to understand gaps that exist in implementation of resilience projects.

How to facilitate

- Let the group list down all the institutions operating in the village and their roles.

PCRA Tool 9 - Impact Chains

Objective

- To analyse the direct and indirect impacts of climate change in the target community.

How to facilitate

- Explain that the purpose of the session is to analyse the impacts of climate change in their community, which will help them identify options for adaptation.
- Referring back to the hazard map and the discussions around changing trends and increasing uncertainty from previous sessions, work with the group to identify 2–3 climate changes they would like to analyse. These should be changes the community is experiencing or is likely to experience.
- Explain that you will work through the climate changes one at a time. Choose one to start with and write or draw it on the left side of the flip chart or the surface where the chains will be built.
- Ask the group to identify 2–3 of the change or event's most important direct impacts. Write them down on idea cards. Add these direct impacts as the next links in the chain.
- Ask the group to identify 2–3 of the most important indirect impacts, building on the direct impacts. Write them down on ideas cards. Add these indirect impacts to the chain
- Repeat steps 3¬–5 for all of the climate changes.
- Ask if they are happy with the impact chains and make any adjustments needed.
- Ask the group if they have any questions, thank them for their participation and explain the next steps.

PCRA Tool 10 - Adaptation Pathways

Objective

- To identify adaptation options to address identified climate change impacts.

How to facilitate

- Explain to participants that the next step is to identify options to minimize the negative impacts of climate change on their livelihoods.
- Choose one of the impact chains to work on. Ask the group to identify changes they could make to their livelihoods strategies that would reduce the negative effects of the identified impacts, both direct and indirect. Write the strategies on cards (or draw pictures or symbols that represent them if the participants have low literacy).
- When adaptation options have been identified, ask the participants which are the most urgent. At their direction, arrange the cards into a pathway, with the most urgent at one end and the more longer-term strategies at the other.
- Ask the participants which of the urgent strategies they can undertake themselves as individuals or households. Identify these with a symbol or a different colour on the cards. Then ask them what opportunities or existing resources they have that will support them in implementing the strategies.
- Ask the participants which of the urgent strategies would require collective action. Identify these with another symbol or colour on the cards. Ask them how this collective action could be mobilized.
- Ask them what additional information and support they might need to implement the individual, household or collective actions.
- Repeat steps 2–6 for the other impact chains.
- Ask the group if they have any questions, thank them for their participation and explain the next steps.

Forest-based Climate Change Adaptation Mechanisms

While forests are affected by climate change, they also play a key role in adaptation to it. Forests enhance biodiversity conservation by supporting species' adaptation to changing climate patterns and sudden climate events by providing them with refuge and migration corridors.

Forest ecosystems support climate change coping mechanisms by providing goods and services during extreme weather events (droughts and floods), reducing the vulnerability of communities and systems.

Forest based adaptation strategies include:

- Improvement of forest management systems – control of deforestation, reforestation and afforestation
- Creation of conservation hotspots including conservation management areas, biodiversity corridors and protected areas
- Promoting of climate resilient forest tree species
- Assessment of vulnerability of ecosystems to the impacts of climate change
- Monitoring of forest tree species
- Development and maintenance of seed banks
- Adaptation strategies undertaken in the forest buffer zones include:
- Adaptation strategies in agriculture: Agroforestry, changing planting strategies, good agricultural practices, promoting drought tolerant crops and shifting from rain-fed to irrigated agriculture
- Application of indigenous coping and adaptation mechanisms and strategies
- Prepared risk assessments, managed water resources, built settlements in safe zones, developed early warning systems, instituted better building designs, improved insurance coverage, and developed social safety nets.

Forests-based Climate Change Mitigation Mechanism

Forests have considerable potential to sequester carbon. This can be achieved through afforestation, reforestation, forest restoration and minimization or substitution of forest products such as promoting energy efficient cook stoves. The contribution of forests to climate change mitigation is also through the decision to adopt the approach on Reducing emissions from Deforestation and Forest Degradation (REDD+)

Climate Change Mitigation strategies include:

Protection and Conservation of Forests

Sustainable Forest Management

Agroforestry and on-farm tree planting

Urban forestry

Non extractive use of forests e.g. Ecotourism, Beekeeping etc)

Substituting increasing use of forest based products such as fuel wood with energy efficient cook stoves

Low emission farming systems such as organic farming and conservation agriculture

4.4 Accounting for Mangrove Carbon

Definitions and concepts of carbon accounting

Carbon stock refers to reservoirs where carbon has been sequestered, effectively keeping it from being released into the atmosphere. These include aboveground biomass, belowground biomass, deadwood, litter, and soil.

Carbon accounting is the practice of making scientifically robust and verifiable measurements of GHG emissions.

The concepts of payment for environmental services (PES): PES initiatives involve compensating mangrove forest dependants for maintaining and restoring mangrove ecosystems. Conservation organizations, or private companies seek to offset their environmental impact. They often prioritize community involvement and engagement and local communities may receive payments for sustainable mangrove management practices, such as mangrove restoration, sustainable harvesting, and conservation efforts.

Carbon markets provide a mechanism for private finance to support avoided deforestation and forest restoration.

Carbon credits: a method to offset emissions from activities that are currently unable to be completely carbon-neutral. This is achieved by financially supporting projects that reduce or capture carbon in other locations.

Carbon transactions refer to the buying and selling of carbon credits or offsets, which represent reductions in greenhouse gas emissions.

Financing mechanisms: include innovative pricing instruments for REDD+ implementation that aim to increase the efficiency of public finance, mobilize private investment, and support the transition to a zero-deforestation pathway.

Cap-and-trade schemes are regulatory systems that set a limit or cap on the total amount of greenhouse gas emissions allowed within a specific jurisdiction.

Carbon pools: This includes above-ground biomass, below-ground biomass, dead wood, litter, Soil Organic Matter (SOM), harvested wood products. Aboveground and belowground biomass is the living biomass. Aboveground biomass is the living biomass found above the ground level, and includes stems, branches, bark. Below ground biomass is the living biomass in living roots. Dead wood is the dead wood biomass either standing or lying on the ground, while litter is the dead biomass under different degrees of decomposition which are usually deposited on organic soil or mineral i.e. humus, sand, and living fine roots. Organic carbon in soil is the organic carbon in mineral and organic soil.

Determination of carbon stocks in various pools

1. Carbon capture and stocks should be estimated based on the following procedure:
2. Fieldwork measurements and sampling
3. Estimating biomass (dry weight) and organic carbon content through allometric equations or direct measurement in the laboratory.
4. Estimation of carbon stocks as the sum in all the components and carbon capture as the difference of carbon stocks over time.

Verification systems for carbon accounting

Verification is critical to enhance trust in a carbon pricing system.

Payment schemes and benefit sharing

This includes all institutional means, structures, and instruments for distributing finance and other net benefits from REDD+ programs. Equitable and transparent benefit distribution ensures that local communities receive compensation for their efforts in emission reduction initiatives, such as forest conservation and sustainable forest practices.

The benefit-sharing mechanism ensures that the local community directly benefits from the project's conservation efforts and sustainable practices.The initiative channels its revenue from carbon credits into community development projects, with decisions on fund allocation being democratically determined through inclusive community consultative meetings e.g. the Mikoko Pamoja project.

Before the project becomes eligible to receive payments for emission reductions, a benefit-sharing plan needs to be fully developed and transparent. The plan should outline details about the recipients of benefits, the nature of the benefits provided, and the mechanisms through which the results-based payments for verified emission reductions will be distributed.

Regulations on carbon trade and marketing

The Carbon Market Regulations provide guidance in the development and implementation of carbon markets in compliance with international obligations, and provide policy direction on benefit-sharing mechanisms.

4.5 Nature-Based Solutions in Forest Management

Participatory guide: Introduce the concept and put the participants into groups to identify the NbS practices adopted in their localities. Each group to make a presentation.

CBT Notes

Definition of Concepts

- **Nature-based solutions (NbS)** is an environmental and nature conservation concept, which uses ecosystems and ecosystem services to address social, economic, and environmental challenges effectively and adaptively.
- The concept addresses the challenges simultaneously with providing human well-being, ecosystem services, resilience, and biodiversity benefits.
- Societal challenges include climate change, food insecurity, water insecurity, natural disasters, risks for human health, economic and social regression and decline, disaster risk, ecosystem degradation, and biodiversity loss.
- A central feature of NbS is that they can deliver a range of positive outcomes or "co-benefits" alongside their intended outcomes. For example, terraces of trees and fodder crops intended to control soil erosion over steep hillsides also build resilience to landslides, sequester carbon and help increase agricultural productivity.
- A subset of nature-based solutions, called ***"natural climate solutions,"*** are expressly aimed at addressing climate change, either by avoiding or reducing emissions or by removing and storing carbon from the atmosphere. One example would be a forest restoration project that improves the soil quality and tree cover to increase greenhouse gas sequestration. Natural climate solutions can also provide adaptation benefits given their focus on conservation, restoration and improved land management; however, their primary focus historically has been on mitigation.
- These solutions prioritize the restoration and conservation of natural habitats, such as forests, wetlands, and grasslands, to achieve multiple benefits for both people and the environment.

Principles of NbS in Forest Management

- **Ecosystem-based Approach**: Emphasizes the interconnectedness of natural systems and promotes management strategies that mimic natural processes.
- **Biodiversity Conservation**: Prioritizes the protection and enhancement of biodiversity within forest ecosystems, recognizing its essential value and role in ecosystem functioning.
- **Climate Resilience**: Focuses on enhancing the ability of forests to withstand and adapt to climate change impacts through measures such as diverse species composition and habitat restoration.
- **Carbon Sequestration**: Recognizes the crucial role of forests in sequestering carbon dioxide from the atmosphere and aims to maximize carbon storage through sustainable management practices.
- **Water Resource Management**: Highlights the importance of forests in regulating water cycles, maintaining water quality, and reducing the risk of floods and droughts.
- **Community Engagement**: Involves local communities in decision-making processes, ensuring that forest management strategies align with their needs and priorities while fostering stewardship and sustainable livelihoods.

- **Adaptive Management**: Emphasizes flexibility and learning, allowing for adjustments in management practices based on monitoring, research, and changing environmental conditions.
- **Land-Use Planning**: Integrates forest management objectives with broader land-use planning processes to minimize conflicts and optimize the delivery of ecosystem services.
- **Respect for Indigenous Knowledge**: Recognizes the traditional ecological knowledge of Indigenous peoples and incorporates their perspectives and practices into forest management approaches.

Techniques and practices of NbS in Forest Management

1. **Tree Nurseries:** Cultivating seedlings of suitable species for rehabilitation of degraded areas and for sale.
2. **Agroforestry**: Integrating trees and other woody plants into agricultural landscapes to enhance resilience to climate change, improve soil health, and provide additional income sources for farmers.
3. **Payment for Ecosystem Services (PES)**: These are schemes in which landowners or communities are compensated for conserving forests and providing ecosystem services like carbon sequestration and watershed protection.
4. **Conservation agriculture:** This sustainable farming approach aims to protect and improve the environment while maintaining or increasing crop yields. It involves three main principles: ***minimal tillage, permanent soil cover, and diversified crop rotations or intercropping.*** By reducing tillage, using cover crops, and rotating crops, conservation agriculture promotes soil health, enhances water retention, reduces erosion, and minimizes the need for synthetic inputs like pesticides and fertilizers. This approach prioritizes long-term soil fertility and ecosystem resilience, making it a valuable strategy for sustainable food production in the face of climate change and environmental degradation.
5. **Ecotourism**: Ecotourism involves responsible travel to natural areas that conserve the environment and improve the well-being of local people. By engaging visitors with the beauty and significance of untouched landscapes, it fosters an appreciation for biodiversity and the need for its preservation. Through carefully managed activities, ecotourism not only supports local economies but also ensures the protection of fragile ecosystems, making it a vital nature-based solution for sustainable development.
6. **Permaculture:** It is an approach to designing agricultural systems that mimic natural ecosystems, emphasizing principles such as working with nature rather than against it, observing and learning from natural patterns, and promoting biodiversity and sustainability. Permaculture aims to create resilient and regenerative systems that provide for human needs while enhancing the health of the environment.

7. **Biogas:** Biogas is produced through the anaerobic digestion of organic matter such as agricultural waste, animal manure, sewage, and food scraps. This process relies on naturally occurring bacteria to break down the organic material and produce methane gas, which can be captured and used as a renewable energy source. Biogas use is a NbS because it reduces greenhouse gas emissions by capturing methane, which is a potent greenhouse gas, and displaces fossil fuels when used for heating, electricity generation, or transportation. Additionally, the digestion process produces nutrient-rich digestate, which can be used as a fertilizer, thus closing nutrient cycles in agricultural systems. It therefore represents a nature-based solution that can contribute to mitigating climate change, improving resource efficiency, and promoting sustainable development.
8. **Beekeeping**: It involves managing and maintaining colonies of honeybees for various purposes, such as pollination, honey production, and other hive products like beeswax and royal jelly. Beekeeping supports biodiversity by aiding in the pollination of plants, which is crucial for the reproduction of many flowering crops and wild plants. It also promotes environmental conservation by providing bee habitat and encouraging natural ecosystem preservation. Beekeeping can contribute to sustainable agriculture and rural livelihoods, making it a multifaceted nature-based solution with numerous benefits for both ecosystems and communities.
9. **Harvesting Non-timber Forest Products**: Sustainable harvesting of NTFPs can provide livelihood opportunities for local communities, promote biodiversity conservation, and contribute to ecosystem resilience. However, it is essential to ensure that NTFP harvesting practices are carried out sustainably to avoid negative impacts on forest ecosystems and local communities.

Facilitate linkages between groups and government agencies for technical training on NbS/forest based IGAs

Participatory Guide: In an open forum discussion before the training session, let the participants discuss government and Non-government agencies they have worked with previously and the level of interaction with regards to NbS.

CBT Notes

Linkages between community and government agencies help the community organizations keep up with advances in nature-based solutions, and give access to wide-ranging sources of up-to-date information within each area of NbS adopted.

Nature based Solution	Possible agencies to offer technical training

Tree nursery	KFS, KEFRI, County Government
Agroforestry	KEFRI, KFS, County Government
Payment for Ecosystem Services (PES)	KFS, KEFRI, WRA, NEMA, NETFUND, County Government
Conservation agriculture	KALRO, Agricultural Information Resource Center, County government
Ecotourism	KWS, KFS, Kenya Tourism Board (KTB), Tourism Finance Corporation (TFC), Tourism Fund, The Brand Kenya Board, Tourism Research Institute.
Permaculture	Min of Agriculture, KEFRI, NGOs
Use of Biogas	Ministry of Energy
Beekeeping	State Department for Livestock, KALRO, Kenya Beekeepers Association, County Government
Harvesting Non-timber Forest Products	KFS, KEFRI, County Government
Aquaculture	Kenya Fisheries Service(KeFS), KMFRI, County Government
Woodlots	KFS, KEFRI, County Government

5. Module Four- Mangrove Ecosystem Restoration

By Judith Okello and Henry M. Komu

Module 4: Mangrove Ecosystem Restoration					
Training Objectives: At the end of the module, participants will be able to	**Contents**	**Methodology**	**Duration**	**Materials**	**Guide for trainers**
Introduction to Mangrove Ecosystem Restoration Differentiate rehabilitation and restoration	-define both terms; rehabilitation and restoration -Aims of rehabilitation -Factors that may inhibit successful restoration	Teaching using PowerPoint presentations Brainstorming	**2 hours**	Flipcharts, marker pens, photos of healthy and degraded ecosystems, notebooks, projector, whiteboard,	-Facilitator to provide a presentation with illustrations -Guide participants to differentiate a degraded, rehabilitated and restored site -Brainstorm on the benefits of a rehabilitated vs restored site -Brainstorm on factors that may inhibit successful restoration
Why conservation should be prioritised over restoration	-Define conservation -Reasons on why conservation is better than restoration	Teaching using PowerPoint presentations Brainstorming	**1 hour**	Flipcharts, marker pens, notebooks, projector, whiteboard,	-Guide participants to be able to identify different scenarios/examples of conservation -Brainstorm on the benefits of conservation vs restoration

Ecosystem Restoration Approaches -Identify degraded mangrove areas and assess the potential for restoration	-Mapping degraded areas -describing a degraded site -Factors to be considered when selecting a restoration site	Teaching, PowerPoint presentations; field activity which involves transect walk, group work	**45 minutes** **+ 1 Day field visit**	Flipcharts, marker pens, photo guides, maps, notebooks, projector, whiteboard, Computer	- Provide key terminologies -elaborate on the various indicators of degradation - Participants to map out degraded areas in their localities
Clearly understand the different restoration objectives	-what are these objectives -How do you define your objective	Teaching, PowerPoint presentations, group work	**1 hour**	Flipcharts, marker pens, photo guides,projector, whiteboard, Computer	-Define the various restoration objectives and when each applies -In groups, participants to pick a site and help them go through the process of defining their restoration objectives
-Appreciate the importance of hydrology in	-Why hydrology is an important feature in mangroves	Teaching, PowerPoint presentations,	**45 minutes**	-Laminated photos with examples of how hydrology could go wrong	-Refresh participants' minds on what mangrove hydrology entails -Guide them to look at images provided from a lens of what poor hydrology means
-Understand the different restoration approaches and their application	Explain the provisioning, regulatory, support, and Cultural ecosystem services of mangrove	Teaching presentation using PowerPoint presentations, brainstorming	**1 hour**	Flipcharts, marker pens, plant materials, plant photo guides, animal photo guides, notebooks, projector, whiteboard	-Explain the different categories of ecosystem services -Engage the 'class' to list known uses and classify into the various categories -Class to rank the mangrove services

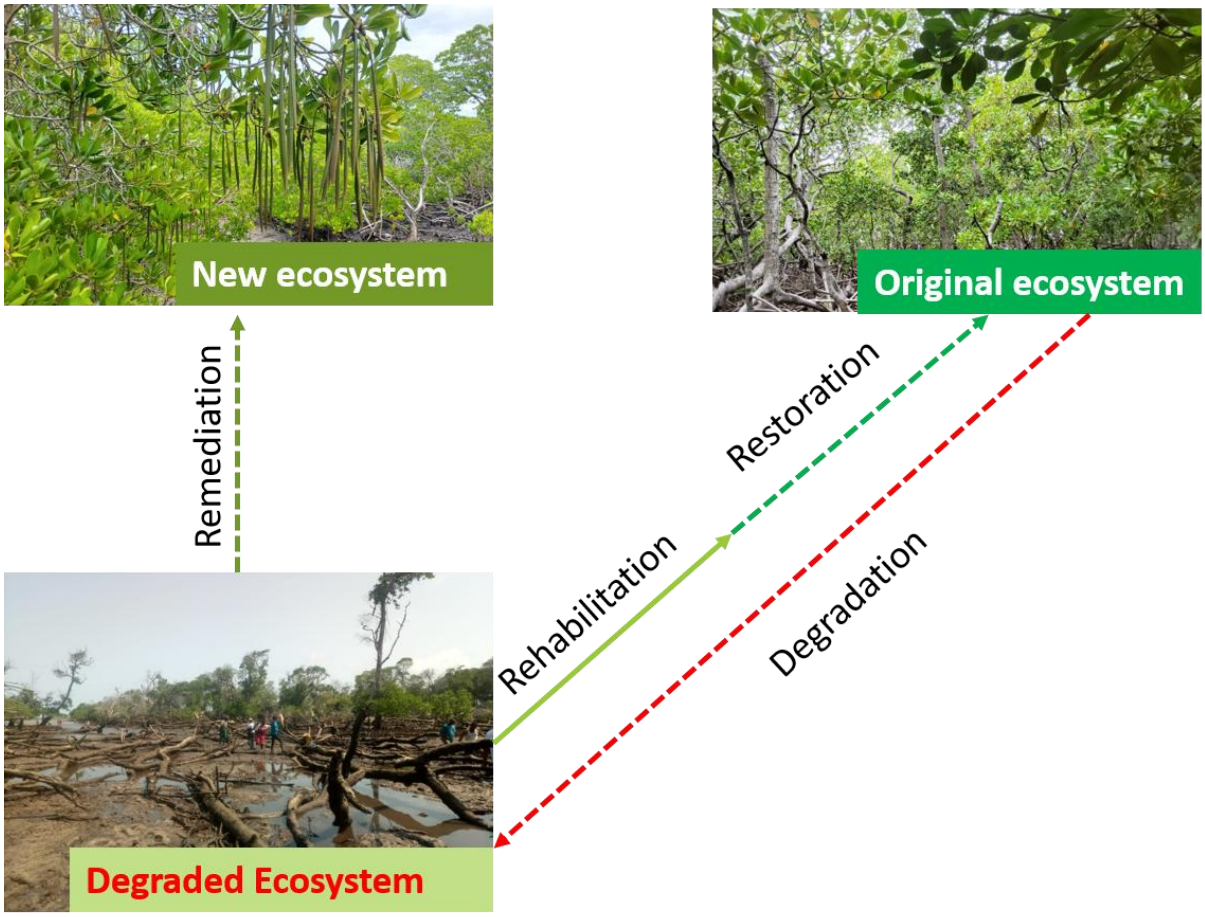
-Define and explain the various steps of Community-Based Ecological Mangrove Restoration (CBEMR)	-why is CBEMR superior over conventional planting		**1 hour**		-Provide step by step narration of the CBEMR approach -Give examples of successful and failed restoration initiatives explaining why in each case -Compare CBEMR and conventional planting
Monitoring and evaluation of restoration projects Have a general understanding of monitoring of restoration project why it is important	Introduction -Definition of terms -Why monitoring and evaluation -Monitoring schedule	Teaching presentation using slides	**1 hour**	Flipcharts, marker pens, photos, projector, whiteboard	Explain using illustrations and photos what mangrove monitoring entails -Explain on importance of baseline data and what it means

Understand the attributes of a successful restoration project	Monitoring indicators -Survival rates -Growth performance -Fauna assemblages -Cover change -Sediment grain size and organic matter	Teaching presentation using slides, field exercises	**1 day**	-projector, whiteboard -Tape measure, vernier caliper, meter rule, sisal/manila rope, binoculars, pencils, data sheet	-Elaborate on each of the indicators -During field exercise, divide the participants into groups and guide them through monitoring process of a given phase within the monitoring schedule

5.1 The concept of rehabilitation and restoration

***Facilitator guide**: Begin by asking participants to explain in their own perspectives how restoration differs from rehabilitation then help them understand by giving examples of each case*

Rehabilitation and restoration are essential forestry management interventions influenced by the increased forest destruction and degradation. Restoration is a long-term process that aims to assist recovery of a degraded forest to its original state (to re-establish the presumed structure, productivity and species diversity of the forest). Whereas, rehabilitation seeks to repair damaged ecosystem functions with the primary goal of increasing productivity (re-establishes productivity of the forest and some, but not necessarily all, of the plant and animal species thought to be originally present at a site). This may opt for another intermediate or alternative state or simplified ecosystem instead of returning to the original ecosystem creating a new ecosystem.



A figure illustrating rehabilitation and restoration concept in a mangrove ecosystem

A key aim of rehabilitation is to ensure the long-term stability of soils, landforms and hydrology required for the site to establish and sustain a natural ecosystem or vegetation. The second main purpose of rehabilitation is to partially or fully repair the capacity of ecosystems to provide habitats for biota and services for people. Full restoration of original plant communities is not always possible due to permanent changes to landforms, soils and hydrology associated with activities that dramatically changed the local landscape.

Mangrove conservation over restoration

Why should *mangrove protection be our primary priority?*

- Many planting projects fail to meet their set objectives. Lots of success stories have been told, but there are also lots of failures
- Only mature mangrove ecosystem can provide the whole set of benefits and if it is to be restored, it will take several years to complete the journey
- Even when planting is successful, it is always less biodiverse than what is seen in natural forests. More than often, individual planting of species is witnessed
- Disturbing mature peat-based mangrove soil releases a lot of CO2 from the decay. Note that upto 90% of that carbon stored by mangroves is in the soil
- Greater impact per budget from conservation over restoration (site-specific)
- By protecting mangrove forests, in essence, we are protecting the quality of the soil: note that Mangrove roots passively suck up water and nutrients: help release oxygen into the soil; carbohydrate and humic acid in to the soil; slowly build up organic material in soil which improves soil structure
- Priority protect fringing mangroves coz once they are lost, it would be almost impossible to return
- Protect small patches and seed trees that appear as stands/ tag them

How would you make mangrove protection to become your primary priority?

- Should you need to build a road through a mangrove area, correctly place culverts under roads to help mangroves survive the development. Ensure you do not trap the water; ensure the culverts are placed at the right elevation so they do not get clogged and allow free water flow
- Ensure there is a policy/law that protects mangroves
- Ensure these policies and governance structures are enforced
- Preserving mangroves by using less mangrove wood, e.g improved cook stoves, improved fish dryers or smoking techniques Alternative sources of fuelwood: Bamboo, casuarinas, woodlots, fuel blocks from compressed sawdust, fuel from oil palm husks, gas, biogas
- Avail alternative building materials to reduce pressure on alternatives, e.g. cement blocks, modern ceilings as opposed to boriti, coral blocks
- Establish a team for community forest management (working with community leaders) to establish: Community wood harvesting rules, community patrols, community sanctions

In Summary: Planting is a risk; only mature mangroves provide full benefits, mitigation planting is often less diverse, disturbing soil releases Co, better use of budget, Existing mangroves improve soil conditions

5.2 Mangrove Restoration Approaches

***Facilitators' guide**: In class, define the factors that determine the choice of a restoration strategy. Follow this by a visit to a pre-identified degraded (spotted through a reconnaissance survey) and guide the participants to assess restoration potential, and design a restoration plan. The participants should be in a position to understand the different restoration approaches and their application (Clearly identify scenarios where planting is required or otherwise facilitated natural regeneration*

5.2.1 Assessing Restoration Potential

Identification and selection of degraded mangrove sites for restoration must always be based on the needs of the community and the ecosystem services to be recovered. It is necessary to involve all the interested groups while selecting the site. The following guiding factors need to be considered while selecting a restoration site to ensure the viability, implementation, and sustainability of restoration outcomes:

- **Nearby existing mother trees**- This will ensure the availability of propagules and seeds to avoid using nursery seedlings, thus reducing restoration costs.
- **Site accessibility** - Consider the time and cost of trips, It should be easy to locate and access, it will save on time and cost
- **Proximity to water source –** the site needs to be close to fresh/saline water sources, well inundated and drained to provide optimal growth conditions for mangroves
- **Benefits to the community –** how the project will directly provide benefits to the community e.g fisheries, wood, apiculture, etc.
- **Resources -**The amount of funds required is related to the accessibility of the site, the area, the extent of damage, equipment, and labour, among others
- **Safety -** Avoid endangering the people's lives during restoration actions at the selected sites.
- **Government permits and community consent –** Ensure you obtain the relevant permits and the local community's consent before starting restoration projects
- **Connection with other projects -** Exchange of experiences and information of implemented projects.
- **Opportunity for science and civic education –** Potential of the site to offerlearning and research e.g. demo site
- **Objective of the area to be restored -**The area must be suitable for the objective to be achieved.
- **The extent of disturbance –** This will determine the resources required and respective remedial actions
- **Anthropogenic stress factors —** Human-induced and social stressors must be considered for the project's long-term viability.
- **Land tenure and protection status -** There must be some kind of legal security that allows the restoration and its benefits to endure

However, consideration of these factors may vary from site and locality of the project.

5.2.3 Defining Restoration Objectives

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. 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

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. In addition, restoration goals and objectives should be set for both ecological and social outcomes. Goals can be short-term or long-term and outline the desired outcome(s) while objectives act as interim guides towards achieving the goals

Table 1. Example of goals and objectives set for mangrove ecological restoration (adopted from Teutli-Hernandez et al., 2021)

Objective of restoration (*What needs to be recovered?*)	**Goal** (*Attributes that the project intends to achieve through the restoration process*)	**Specific objectives** (*Must be expressed as quantifiable indicators to determine if goals are being achieved*)	**Indicator**
Restore 36 ha of degraded mangrove	Establish mangrove seedlings by restoring the hydrology and the reduction of interstitial salinity	Reduce the interstitial salinity to 50% in 18 months	Salinity
		Favor the natural regeneration in 18 month	Number of seedlings
		Synchronise water level variations between the built canal and the reference canal in 6 months	Frequency, level, and duration of the flood

Examples of restoration objectives

Most people plant mangroves for reasons that are not linked to restoration. There is a need to ask yourself what are the reasons for restoring an area. Although one needs to be guided by research, it is important to discuss what we are doing and why we are doing it with the community. There are all sorts of objectives/reasons of restoring a site

- Increase fisheries, climate change mitigation, research and education purposes, ecotourism, legislative compliance, coastal protection and soil stabilization, etc
- The default objective of CBEMR is to restore the entire ecosystem function
- Objectives might change based on initial research questions. After research, project objectives might be noted to be impossible on a given site: e,g sufficient fuelwood production on a highly saline area which means slow rate of growth; some problems may be people-based and so the objective of wood production might fail- eg village leadership
- Set clear objectives since this is the foundation upon which monitoring will be based

5.2.4 Selection of Restoration Approaches

Mangrove restoration involves two main approaches: aided natural regeneration and planting. The approach used will vary from site to site depending on the site's specific needs and the species of mangroves involved. In most cases, mangrove restoration projects can effectively rehabilitate degraded areas and promote the recovery of these vital coastal ecosystems by employing a combination of these methods.

1. Aided/assisted natural regeneration

This approach depends on naturally occurring mangrove propagules (or seeds) to restock degraded sites. It involves regeneration from direct, freely falling and dispersed mangrove propagules. Where natural regeneration is an option to restore a degraded mangrove area, and the availability of propagules and seeds is ensured, restoration planning should first identify and remove any primary stressors preventing natural regeneration. Eminent examples of stressors hindering natural regeneration are blocked tidal inundation and livestock grazing.

a). Protection

The protection of mangroves and the associated environment is meant to enhance natural regeneration. In the National Mangrove Ecosystem Management Plan (2017-2027), under the mangrove forest conservation and utilisation programme, improving policing and protection of mangrove areas from destructive human activities has been emphasised. Some of the proposed activities to enhance the protection of mangroves include:

- Support routine policing patrols by respective government agencies (KFS and KWS)
- Promoting community policing by recruiting and training of community scouts for joint patrols
- Beaconing of mangrove areas
- Fencing of mangrove sites under certain threats e.g. livestock browsing
- Community awareness forums to embrace social fencing

A photo of a cow in the mangroves of Kizingitini, Lamu Kenya. Cattle browsing on mangroves including mature *A. marina* trees poses a threat to the mangroves. ***Photo credit****: Judith Okello, 2024*

The enforcement and compliance measures concerning mangrove forests in Kenya, are vested under the Kenya Forest Service, except in marine protected areas where it falls under the Kenya Wildlife Service. At the county level, through the oversight of County Forest Conservators, the service is responsible for ensuring adherence to regulations and guidelines governing the protection and sustainable management of mangrove forests within their respective counties. Their roles encompass a range of activities, including monitoring for illegal activities such as unauthorized logging or land clearance, conducting inspections, and enforcing penalties for violations. In addition, Community Forest Associations also collaborate with the Service to protect, conserve and manage the forest or part of the forest.

b). Hydrological restoration

Hydrological restoration is the re-modification and re-establishment of the original conditions of the ecosystem including tidal regimes (Turner and Lewis 1996; Kamali and Hashim 2011) while mimicking natural water flow within the target site. Site hydrology determines several factors such as salinity, sediment supply, propagule dispersal and flooding duration crucial to the survival of mangroves. Disruption of tidal flow causes imbalances leading to dynamic shifts in ecosystem biophysical and chemical composition.

Hydrological re-modification entails approaches like the establishment of canals or channels to direct water into a potential restoration site, dyke-breaking for sites with fish ponds or salt pans, and opening channels which have been blocked by deposition of soil or debris. These methods allow tidal flushing and propagate movement within the target site. Where signs of natural recovery are not observed within 6 to 12 months after adjustments of the physical conditions, consideration for undertaking actual mangrove reforestation either through direct planting of propagules collected from the forest or nursery-raised seedlings should be considered and evaluated.

Unfortunately, the hydrological restoration approach has also been inappropriately used to convert sand flats to mangrove growing sites which alters the habitat consequently affecting biodiversity

c. Addressing social drivers/stressors

Mangrove restoration interventions might be predominantly addressing social, rather than biophysical barriers to natural regeneration. Supporting livelihood activities enhances the local community's buy-in and sustainability of mangrove restoration initiatives. Integrating restoration activities with Income Generating Activities (IGAs) in the surrounding communities reduces human overdependence and subsequent pressure on mangrove ecosystems and their resources. Beekeeping, aquaculture (fish farming and crab fattening), mangrove eco-tourism, and the use of energy-efficient stoves should be promoted where appropriate to relieve pressures and safeguard mangroves. In addition, education and awareness at the community level on mangrove conservation will aid reduce pressure on mangroves and promote sustainable utilization and conservation.

2. Planting

Mangroves can naturally regenerate successfully including colonization of newly created mudflats. This is facilitated by the viviparous nature of the trees, producing propagules locally referred to as *milinga* that easily anchor, take root and grow. Planting of mangroves should therefore be done as a last resort following failed attempts to facilitate natural regeneration. Planting is however the most common method of mangrove restoration preferred by project implementors as it produces immediate results that can be documented and publicized. Moreover, the techniques of mangrove planting have not been

perfected for many species with most plantings targeting *Rhizophora mucronata*, *Ceriops tagal* and *Bruguiera gymnorhiza* for their ease of acquisition and propagation.

Planting Densities

The number of propagules or seedlings that are appropriate for planting per unit area will vary from site to site determined by various factors. The densities will depend on site conditions, selected species, and restoration project goals. Therefore, there is no specific density recommended, although some projects choose higher densities for specific areas and lower in others. For example, in areas with high tidal inundation or erosion, planting at higher densities can improve survival rates and speed up canopy closure. On the other hand, lower planting densities may be more suitable for areas with favourable soil conditions or where natural regeneration is promising.

To determine the most appropriate planting density for each restoration site, it is crucial to carry out site assessments and seek advice from experts. Factors such as species diversity, site characteristics, and project objectives should all be considered. Site accessibility and available resources should also be taken into account when deciding on planting densities. Ultimately, the goal is to achieve a balanced approach that maximizes the survival of seedlings, encourages natural regeneration, and contributes to the long-term health and resilience of the restored mangrove ecosystem.

Methods of planting mangroves

Planting may be done in open areas without trees or as enrichment planting which aims to increase the density of trees to an optimum level in an existing forest. Planting involves direct planting using propagules collected from the forest or nursery-raised seedlings.

a. Direct planting

Direct planting involves using propagules and is desirable where the site to be restored is not extremely degraded and the site conditions are ideal for ease of establishment. In such sites, the only factor hindering natural regeneration is the lack of/limited supply of naturally dispersed propagules. Due to its simplistic nature, this method is preferred by many restoration practitioners though sometimes may result in massive failure if the right restoration principles are not applied. Direct planting of propagules is done for mangrove species belonging to the Rhizophoraceae family (*Rhizophora mucronata*, *Ceriops tagal* and *Bruguiera gymnorhiza*). These species produce large and pointed propagules that can be planted directly into the mud. Experience has shown that mature propagules picked from mother trees or those recently fallen have a higher survival rate than transplanted seedlings. This is because the latter leads to disturbance of root balls when removing the seedlings from the potting tube and transporting them. Further, transplanting of seedlings is more expensive than use of propagules

b. Use of seedlings raised in nurseries

Raising seedlings in mangrove nurseries is essential where natural regeneration is unreliable due to: unfavourable soil conditions, attack by pests like crabs, the absence of nearby seeding trees and seeding patterns failing to coincide with optimal planting period. The nurseries also do provide temporary storage for excess seeds and propagules produced during the fruiting season which otherwise would be lost.

Seedlings within a nursery are raised and maintained until they are ready for transplanting. It is an essential part of reforestation programs because it can produce healthy planting stocks and subsequently high survival when outplanted. The seedlings can withstand inhospitable conditions of denuded or degraded and open coastal environments compared to propagules.

Seedling production should also be informed by a restoration plan, which will inform the type and number of seedlings required per specific site. Mangrove seedlings should not be raised with the main goal of earning income, to avoid scenarios of overgrown seedlings in nurseries, when there is no potential buyer.

How to raise seedlings in a nursery

Mangrove nursery sites should be in inter-tidal areas with periodic inundation, easily accessible and close to planting sites to reduce labor and transport costs, shielded from strong wave energy, especially in creeks, well drainage areas, be fenced to minimize disturbance, and should have a good quality propagation stock. Propagule and seedling seasonality varies from site to site and germination will vary with maturity and seed quality. Growing plants in similar environmental conditions to the final planting site minimises mortality rates as seedlings acclimatize to the natural environmental setting. It also serves as a gene bank for different mangrove species.

There are two types of nurseries:

1. **Floating mangrove nursery** - It's established above the highest tidal range and requires frequent watering. This type of nursery is meant to supply seedlings for long-term big afforestation projects. This is a permanent nursery in design and it's work-intensive
2. **Flooded mangrove nursery** - It's established in low intertidal zones with regular flooding of seawater. It is a temporary nursery that provides seedlings for one or two years and doesn't require a lot of effort to establish and maintain.

Nursery layout

An ideal mangrove nursery should have the following components: fence, seed germination beds, potting shed and hardening off beds

A seed germination bed - dugout troughs are made at least ¾ depth of the height of seed pots. These beds protect soil from movement, where the soil is too rocky to be dug out, wooden planks pegged into the ground can be used to secure the seed pots. For ease of operations, at least two sunken beds should be prepared 10m X 1m each, with a 1m path between them.

Potting shed—This is a sheltered area where soil media is aggregated, debris is cleaned off, and potting bags are filled. It should be no smaller than 3m X 4m.

Hardening off beds - This is where the potted seedlings are left to acclimatize them to higher sunlight exposure. The germination beds can double as hardening beds as long as potted seedlings are not moved around until they are ready for outplanting. The roofing shade is removed to expose the seedlings to sunlight a month before outplanting

Fence – The nursery should be protected from external disturbances e.g. livestock

Soil media and filling pots

Soil media should be obtained from within healthy mangroves during low tides; soft muddy substrate is preferred for most species. Remove any debris from the soil media before potting. Different species require different pot sizes. 12.5 X 20cm bags are suitable for small-sized seedlings like *A. marina*, while large seedlings like *R. mucronata* require large bags of 15 X 30 cm or more. These potting bags should be as per the Kenya Bureau of Standards Standard KS ISO 17088:2012 on the specification for compostable bags gazetted in 2019 (GoK, 2019). To ensure maximum germination percentage and survival of potted seedlings, the following should be taken into account:

- Potting bags should be filled firmly to avoid water stagnation at the top

- The pots should be arranged in a dug-out trough; at least ¾ of their height to be below ground to preserve moisture
- Proper drainage to ensure no water stagnation within the nursery bed
- Allow the pots to harden

Collection and transportation of mature propagules

Most mangrove species have specific fruiting peak seasons; therefore, propagules/seed production may not be available throughout the year. It is important to know the peak production seasons for each species. However, the fruiting peak season for each species may also vary annually, influenced by weather patterns. To ease transportation, mature-quality propagules should be collected from the nearest forest to the planting site.

Sorting, treatment and sowing in nursery

After collection, good quality planting materials are sorted out from any unviable material. The planting material should be mature and healthy, i.e. free from disease and pest attack or physical injury. The seeds that recently fell from the mother plant for more than 3 days are not viable e.g. for *A. marina*. Collected seedlings and propagules should be treated to enhance their germination e.g. *H. littoralis* requires soaking in fresh water for 1-2 weeks. Each mangrove species is treated differently and requires different sowing methods. For large propagules (*C. tagal* and *B. gymnorhyza*), hypocotyl should be inserted to a depth of 4-5 cm and 7-8 cm for *R. mucronata* while Avicennia and Xylocarpus seeds, the radicle must be pushed gently into the soft mud (⅓ of the seed).

Nursery management

The nursery requires regular monitoring by visiting at least 2-3 times weekly to ensure that the plants remain upright and healthy, receive regular watering and are protected from pests and any stray animals. The seedlings should be maintained in the nursery for 3-4 months before transplanting. Hardening of the seedlings should be done in the last month to avoid shock after planting in the field

5.2.5 The CBEMR concept

Community-Based Ecological Mangrove Restoration (CBEMR) is a holistic, multi-stage mangrove restoration approach that involves local community and other stakeholders from the outset. It encourages the mitigation of mangrove stressors and the facilitation of natural regeneration where possible. CBEMR works with nature and takes into account mangrove ecology and biology to restore degraded mangroves by mimicking natural processes.

Community involvement is important in mangrove rehabilitation for several reasons:

1. Local knowledge and expertise: The local community often has valuable knowledge about the mangrove ecosystem, including its history, uses, and traditional practices. Their understanding of the local conditions, such as tidal levels and water sources, can greatly contribute to the success of restoration efforts. Involving the community ensures that this knowledge is utilized and integrated into the restoration plans.
2. Ownership and stewardship: When the local community is actively involved in the restoration process, they develop a sense of ownership and stewardship towards the restored mangrove area. This increases the likelihood of long-term sustainability and protection of the restored forest. The community becomes responsible for monitoring and managing the area, ensuring its continued health and productivity.
3. Cultural and economic benefits: Mangroves are often intricately linked to local communities' cultural and economic practices. Involving the community in restoration efforts allows for the

preservation and continuation of these practices. Additionally, restored mangroves can provide various economic benefits to the community, such as sustainable fishing, ecotourism, and carbon offset opportunities. Community involvement ensures that these benefits are maximized and shared equitably.

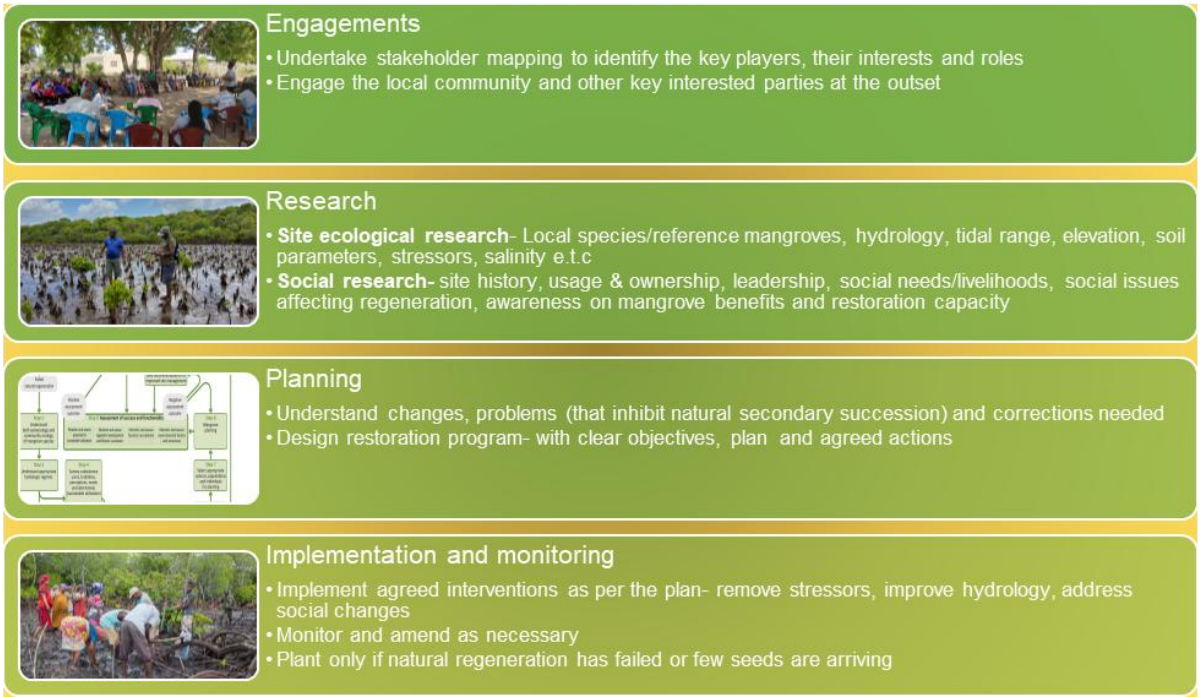
4. Enforcement and regulation: The local community can play a crucial role in enforcing regulations and protecting the restored mangrove area from external threats, such as illegal logging or land encroachment. Their presence and active participation deter such activities and help maintain the integrity of the restored ecosystem.
5. Co-management and collaboration: Collaborating with the community and relevant government agencies can lead to more effective and sustainable restoration outcomes. The community's involvement in decision-making ensures that their needs and perspectives are considered, leading to more inclusive and successful restoration efforts.

Building trust, providing capacity-building opportunities, and ensuring equitable benefits are essential for meaningful community engagement in mangrove rehabilitation.

Additionally, adequate stakeholder engagement from the initial planning stages is critical because of the following:

- To understand power relations and leadership
- Stakeholders expectations and interests are known
- It minimizes future conflicts
- Legal and institutional requirements are taken into consideration from the outset
- The project implementation is made easier

The major steps for Community-Based Ecological Mangrove Restoration (CBEMR) are as follows



Social Research

Opportunity to verify the biophysical research

If there were no mangroves before? If there were, how long has it been lost and for what reasons, find out whether the community has made attempts to rehabilitate the area so you don't repeat the same mistakes

Initial scoping

- Meeting with the local leaders
- Get to understand the local knowledge
- Understand the local leadership and what kind of power they have regarding our proposed engagement
- Relationship with outside groups
- How well the local groups work together
- Talk with the elderly in the community to get real history

Community socio-economics

- Land ownership in the area
- How do the locals use the mangrove area and the mangrove wood and wood products. Not if reliance is high, then you need to help find alternatives
- Is there a shared perception of the mangrove conditions and causes of degradation. Ensure that there is a shared understanding on the causes
- What is the proximity of the local town to the mangroves
- Understanding the poverty levels and income coz natural resources highly benefit the poor
- Understand literacy levels so you know
- Not literacy may not be about how far one has gone with formal education
- Use videos in local language for purposes of awareness

Other potential socio-economic issues

- Is there community management in place?
- Is there support from NGOS, universities, police
- Cattle grazing; uncontrolled, who owns, when

Mapping

Reasons for maps

- Maps can be used by the community even where there is no internet and no electricity power
- Transparency: Even if the villagers have missed a meeting, they can see this on maps. Print out the map of the area of focus on a large canvas and hang in the village

Biophysical Research

This will help understand the ecological conditions of the site and guide in making informed decisions on how to restore. Consider inundation frequency, salinity ranges, species composition, degradation markers (including stumps, sedimentation, die back, insect pest infestation etc),

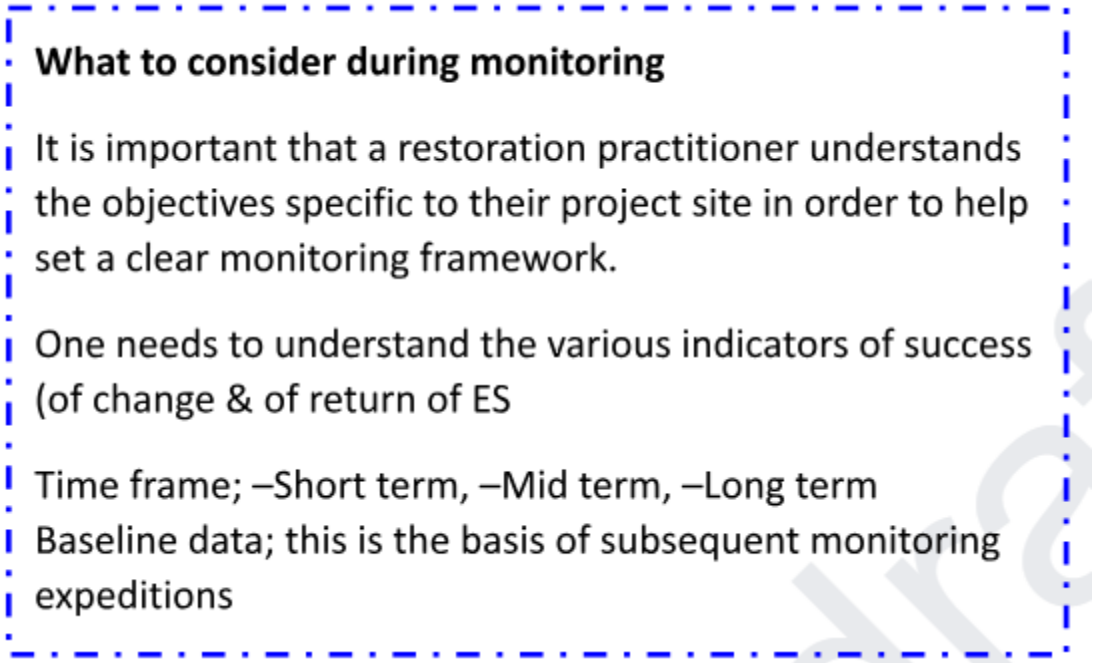
Biological assessments, ecological assessment, local knowledge, analysis of disturbance, social assessment and social capital- all aimed at get a full understanding of your site and village context.

NB: Understanding what nature is telling you will be important in making decisions

5.3 Monitoring under CBEMR

Monitoring in restoration allows for timely progress review of restoration projects, learning and taking timely corrective actions as may be required.

What does ecological restoration entail? Ecological restoration aims to recreate, initiate, or accelerate the recovery of an ecosystem that has been disturbed (Society for Ecological Restoration- SER). Monitoring under the framework of CBEMR takes a holistic approach considering all factors associated with system recovery.



During the monitoring process, a number of indicators are periodically tracked at varying intervals depending on the restoration objectives and the variable in question. These would form the basis best practices, innovations, cases, and unique experiences, which can be documented for subsequent learning and sharing. Further, to evaluate how effective actions applied are, baseline data is required for comparisons. *Baseline data* refers to bio-physical and chemical information regarding the restoration site, prior to restoration actions being applied. In addition, socio-economic settings of the community adjacent to the degraded sites identified for restoration should also be evaluated. It is however important to take note that monitoring should be based on the restoration project objectives.

Permanent sample plots should be established (see standard for establishment of permanent sample plots by Okello et al., 2024), where assessment for vegetation and secondary succession is done.

Vegetation assessment

This refers to assessing seedling performance when in nursery and after out planting. in monitoring, the following variables should be considered

- Survivorship full count: Move in zigzag motions to the left three and to the right three and note how many plants are alive. Calculate a percentage based on the proportion of the surviving plants then repeat after every metre of motion and compute an average for the entire plot.
- General monitoring of growth performance involves assessing:
    - Germination and mortality/survival percentage
    - Average height increment (m)
    - Number of internodes
    - Number of leaves and leaf area (L x W)
    - Number of lateral branches

- Diameter (cm) of the stem at second internode (for *A. marina*, stem diameter is taken at 50% of total plant height)

Other variables to measure

- Biophysical- number of volunteer seeds, plant density, and at later stages biomass increment and canopy cover
- Where the objective is biodiversity, assess species diversity and faunal colonization including crabs and crab burrows, increase in fish, shrimp, Mangrove biodiversity and forest health indicate success of restoration activities. Thresholds assessed are ,
- If hydrology was improved; check channel depth, water flow, salinity for a start to ensure the parameters stabilise before deciding to plant or to let natural regeneration take

Socioeconomic monitoring: This generally involves documenting the local communities' lifestyle and livelihoods before and after restoration project. Depending on the initiative that was put in place to curb degradation, the following could be assessed:

Social agreements in line with conservation or restoration being adhered to; e.g If it was agreed that only a given amount of wood be extracted- are the community members sticking to this? Where a fence was erected; has the fence been maintained or the locals are cutting it away? Are cattle owners keeping their cattle away. Where conservation measures were proposed e.g improved jikos, efficient fish smoking method, alternative fodder-have they been adopted by the local community?

Timelapse photography: Repeated photography of a site/plot over time. Pictures are taken from the same location and from the same direction; ensure- use the same camera/phone, same zoom, same time of the day, away from the sun, same state of the tide, put a mark at that point/spot where the photo will always be taken. Consider using existing features to demarcate your point

You could use Google earth, for instance taking an existing construction/building as a reference

Summary: why monitoring

- Facilitates the assessment of survival and growth performance of seedlings after restoration
- Enables one to determine the possibility of a project achieving restoration goals and objectives.
- Through documentation of challenges and successes, lessons for future restoration projects can be collated.
- Allows timely putting in place of corrective actions including; removal of debris e.g. wrack; Pests and disease attacks can be noted and controlled
- Facilitates surveillance to assess damages after restoration e.g. by crabs, by waves etc.
- Data can be obtained for reporting to the donors/development partners

6. Module Five - Governance and Management of Mangroves in Kenya

By Miriam Vihenda, Victor Mwakha and Santos Ingotsi

Module 5: Governance and Management of Mangroves in Kenya					
Training Objectives: At the end of the module, participants will be able to-	**Contents**	**Methodology**	**Duration**	**Materials**	**Guide for trainers**
Understand Environmental Governance and the right to Clean and Healthy Environment	-Concept of environmental governance -Constitution of Kenya 2010 Article 42, and Article 69. -Bill of rights -land and environment	Teaching presentation using slides, Brainstorming	45min	Flipcharts, marker pens, projector, whiteboard	
Understand mainstream mangrove Governance in Kenya	-Introduction to Forest Governance, -Forest Policy, 2014 -Forest conservation Management (FCM) Act, 2016. -The Community Forest Association (CFAs) and the Participatory Forest Management (PFM) -Understand Mangrove Conservation Governance structure (NMMP 2017-2027)	Teaching presentation using slides, Brainstorming	45min	Flipcharts, marker pens, projector, whiteboard	Facilitator to provide a presentation with illustrations

Understand other existing relevant laws and policies touching on mangrove conservation	-Wildlife Conservation and Management Act, 2013 -EMCA, 2019 -Fisheries Management and Development Act, 2016 -National Museums and Heritage Act, 2006 -Water Act, 2016	Teaching presentation using PowerPoint, Brainstormin g	1hr	Flipcharts, marker pens, projector, whiteboard	The facilitator to provide

6.1 Environmental governance overview

UNEP (United Nations Environment Programme) *defines environmental governance as "the framework of social, political, economic, and administrative systems that influence the use and management of natural resources and the environment.*

Effective governance and management of mangrove forests in Kenya are essential for their conservation and sustainable use.

The government of Kenya has established a legal framework that governs and manages all forests including mangroves. All mangrove forests in Kenya were gazetted vide Legal Notice number 44 of 1932, declaring them as public forests whose management is vested in the state. ie;

- The Forest Conservation and Management Act (2016) provides the legal basis for the conservation, management, and sustainable development of forests, including mangroves.

- The Kenya Forest Service (KFS) is the primary institution responsible for the management of public forests, including mangroves.
- However, other state and non-state agencies, community organizations and private sector players are also involved either directly or indirectly in the conservation and management of mangrove forests in Kenya. This is made possible by the FCMA 2016 that allows for participatory forest management.
- The Kenya Marine and Fisheries Research Institute plays a vital role in mangrove governance and management through research, conservation initiatives, and community engagement.
- Likewise, the Kenya Forestry Research Institute also participates in mangrove governance and management through research and monitoring, community engagement, ecosystem restoration, and policy advocacy.

Participatory Guide: *Ask participants to list other state and non-state players in mangrove governance and management in Kenya and explain their role.*

6.2 Environmental governance and the right to clean and healthy environment

Objective: *Help participants understand the importance of promoting and observing human rights and fundamental freedoms, focusing on the right to a clean and healthy environment provided in the Constitution of Kenya 2010.*

Note for trainers:

- The General Assembly of the United Nations, the main decision-making body, declared human rights as a universal standard for all people and nations.
- On environment, the United Nation Human Rights Council Created the Right to clean and healthy environment as enshrined in the International Bill of rights and the Kenya Constitution 2010.

Chapter 4:Bill of rights

Under article 42 of the Kenyan constitution 2010, gives every person a right to a clean and healthy environment.

Article 69 provides rights to a have the environment protected for the benefit of present and future generations through legislative and other measures whereas;

Article 70 to have obligations relating to the environment.to have obligations relating to the environment.

Chapter 5: Land principles and Obligations in respect to the environment

Article 60(1)e, Provides for sound conservation and protection of ecologically sensitive areas.

Article 69(1) Provides for concerns linked to the environment such as:

Sustainably utilize, manage, and conserve the environment and natural resources while ensuring equitable distribution of the accruing benefits;

Achieve and maintain a tree cover of at least 10% of Kenya's land area;

Protect and enhance intellectual property in, and indigenous knowledge of, biodiversity and the genetic resources of the communities;

Encourage public participation in the management, protection and conservation of the environment;

Protect genetic resources and biological diversity;

Establish systems of environmental impact assessment, environmental audit and monitoring of the environment;

Eliminate processes and activities that are likely to endanger the environment; and

Utilise the environment and natural resources for the benefit of the people of Kenya.

6.3 Mainstream mangrove governance in Kenya

6.3.1 National Level

At a national level other frameworks and legislations that touch on mangrove ecosystems have been provided by the government which include;

Table 4: National legal frameworks applicable for mangrove ecosystems

Frameworks	Year Amended	Mandate
Environmental Management and Coordination Act	2015	Mandates National Environmental Management Authority (NEMA) together with other stakeholders to conduct surveys on coastal zones and compile the state of the Coast report.
Forest Conservation And Management Act	2016	The Act provides for forest conservation and local community participation in decision-making processes in regards to mangrove conservation and classifies forests into public, community, private, or provisional classifications.
Forest Policy 2024	2014	This management plan is prepared in compliance with the legal requirement under section 35 of the Forest Conservation and Management Act (2016), which provides for preparing management plans for all State forests. It seeks to balance the needs of the people of Kenya with opportunities for rehabilitation, conservation, and sustainable utilization of mangrove resources.
National Mangrove Ecosystem Management Plan (2012-2017)	(2012-2017)	The management plan provides guidelines for the management and sustainable use of products and services derived from mangrove ecosystems to contribute to Kenya's economy .In addition the plan also aims to enhance biodiversity conservation and the health of ecosystems
Kenya Forest Service Strategic Plan (2014/2017)	**(2014/2017)**	Through (KFS) the plan provides for sustainable management, utilization and conservation of forest resources for the country's socio-economic development and environmental sustainability.

6.3.2 County level

- County government plays a crucial role in mangrove conservation and management. They provide policies and plans that align with the national frameworks
- These implementation plans include measures to protect ecosystems, manage natural resources, and promote sustainable land use.

- Example for Kilifi and Kwale counties Kilifi County Forest Conservation and Management Act 2021, Kwale County Quarrying Act 2016 respectively.

Other existing relevant laws and policies touching on mangrove conservation are stipulated in Table below

Relevant law and policy	Mandate
Fisheries Act 2016	The Act establishes a framework for fisheries development, management, exploitation, usage, and conservation, and it protects fish breeding and feeding grounds including mangrove forests through subsidiary legislation.
Climate change Act 2016	The Climate Change Act provides policies, strategies, and action plans to protect and coordinate climate change measures through the Climate Change Fund by financing climate-related actions and interventions
Climate change Act no. 9 2023	This Act provides for amending the 2016 Climate Change Act, by introducing new definitions, and replacing sections.The Act defines carbon credits, markets , quantity of greenhouse emissions acceptable at a given time ,nature based solution e.t.c.
Tourism Act 2023	Establishes responsible licensing, classification of tourism activities, regulation, limitation, and control of tourism-related activities and services, as well as natural resource management through climate change adaptation and mitigation guidelines
Community Land Act 2016	This act recognizes and protects the rights of communities living on communal lands, including their rights to manage and conserve natural resources within their territories

6.4 Formation and management of CFA

Participatory Guide: *Ask participants to define CFAs and list some of the CFAs they know and its importance in the community.*

Training Notes

Definition of CFAs

Community Forest Associations (CFAs) are local organizations established to promote sustainable forest management and conservation through the involvement of community members

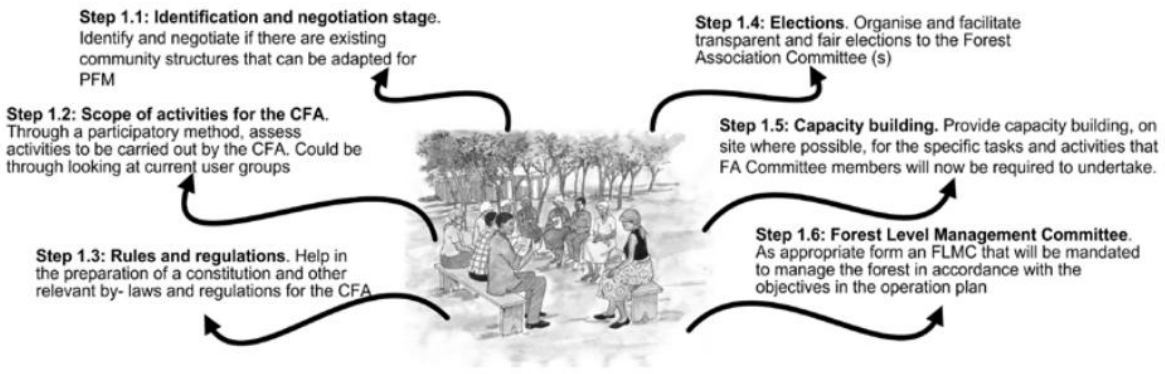
These Community Forest Associations are formed under the Forest Act with an aim of managing community forest resources and ensuring local community participation in the forest related decision making processes.

Key factors about CFAs

- **Community Involvement: C**FAs engage local communities in the decision-making processes regarding forest management, ensuring that the needs and knowledge of the community are considered.
- **Sustainable Management:** These associations focus on sustainable practices that balance resource use with conservation.
- **Benefit Sharing:** CFAs often facilitate the fair distribution of benefits derived from forest resources, including timber, non-timber forest products, and ecosystem services.
- **Capacity Building:** CFAs provide training and support to community members to enhance their skills and knowledge in forest management and conservation**.**
- **Governance:** CFAs help to establish governance structures that promote transparency, accountability, and inclusiveness in forest management.

6.4.1 Steps for formation of CFAs

Figure 1 Steps in formation of a Community Forest Association



Step I: Identification and negotiation stage

Studying community dynamics and identifying entry points often involves assessing social structures and engaging with organized groups, government agencies, and NGOs, utilizing official channels like introductory letters or office visits to gather information and establish connections.

Step 2: Scope of activities for the CFA

The facilitator is required to;

- Support the Community Forestry Association (CFA) through participatory methods in evaluating its constituent groups' activities and aligning them with the Forest Act's provisions.
- Assess necessary conditions for successful execution, including member willingness.
- Encouraging local workshops and stakeholder meetings organized by community groups facilitates consensus-building among the wider community regarding the CFA's activities.

Step 3: Establish CFA rules and regulations

By ;Creating awareness on Forests Act and other environmental legislations stressing on the followings facts about CFAs;

- CFAs are the legal entities through which the community will undertake PFM.
- It is through CFAs that communities will have an opportunity to participate in forest conservation committees.
- It is through the CFAs that they will be represented in the KFS board through Forest Conservation Committees.
- Its through the FCC that CFAs are represented in the KFS Bord

Preparation of Constitution, by-laws and other relevant regulations

- The facilitator coordinates technical advice for the CFA to draft a clear, gender-sensitive constitution and relevant by-laws addressing membership, vulnerability, longevity, conformity with the main Act, stakeholder involvement, and the potential for establishing a separate enterprise for commercial activities.

Lastly, assisting the community to prepare free and fair elections

Step 4: Organize and facilitate transparent and fair elections for CFA

- A CFA executive committee must be elected to manage and lead the association.
- The executive committee then should initiate the process of registration with the Attorney general thereafter registration with KFS for recognition of CFA in PFM
- The Forest Act 2005(Section)provides for the association to register with the KFS
- After approval of CFA by director, both parties can enter into a signed management agreement, which will enable the CFA to perform activities stipulated in the agreement and supported by Section 47(1) of the Forests Act

Step 5: Capacity Building for the CFA and Forest Committee

- To fulfill its obligations effectively, the Community Forestry Association (CFA) should undergo a capacity assessment to identify areas requiring development.
- Basic training needs for many CFAs include; entrepreneurship, resource mobilization, leadership, advocacy, conflict management, and more.
- The facilitator can assist in conducting this assessment and ensure that capacity building becomes an ongoing process within the CFA.

Step 6: Form a forest level management(FLM) committee

This step is crucial to ensure governing structures are in place and helps with compliance in the implementation of the memorandum of agreement (MOA) **.**

Key Functions of the (FLM) committee

- Provide technical assistance to ensure the effective management and operation of community forests.
- Serve as a vigilant overseer to ensure higher bodies, such as the Forest Conservancy committee FCC, deliver services effectively.
- Monitor and evaluate operations of CFA
- Assist to resolve and manage conflicts among CFAs
- Assist to develop work plans and offer guidance to ensure adherence to the same

6.5 Participatory Forest Management

Participatory Guide: *Ask participants to list other state and non-state players in mangrove governance and management in Kenya and explain their role.*

6.5.1 What is PFM, benefits and key components

What is PFM?

PFM is a forest management approach, which deliberately involves the forest adjacent communities and other stakeholders in management of forests within a framework that contributes to community's livelihoods.

Benefits of PFM

Participatory Guide: Ask participants to state the benefits of PFM in management and conservation of mangrove forests

PFM in mangrove forests offers the following benefits

- Empowers local communities by letting them have a say in decisions and take part in looking after their natural resources.
- PFM promotes the sustainable use of mangrove resources, reducing the risk of overexploitation and degradation.
- PFM helps to alleviate poverty in the community by granting them access to mangrove forest resources for jobs, like collecting non-timber forest products, promoting ecotourism, and doing sustainable fishing.
- It enhances biodiversity conservation by increasing the awareness and stewardship of local communities of biodiversity thereby leading to better conservation outcomes.
- PFM can help mitigate conflicts in the community over mangrove resource use by fostering collaboration and dialogue among stakeholders.

Key Components of PFM in Mangroves:

- The following are the main components of PFM in mangroves;
- Stakeholder engagement-All relevant stakeholders, including local communities, government agencies, NGOs, and private sector players are to be involved in mangrove forest governance and management activities.
- Collaborative decision-making- Stakeholders work together to make decisions about mangrove forest management plans and policies.
- Capacity building- Local communities need to be trained and supported to enhance their knowledge and skills in forest management, conservation, and sustainable livelihoods.
- Legal and policy frameworks: For PFM to be successful, clear legal and policy frameworks that support its implementation should be put in place.
- Monitoring and evaluation: Mechanisms for monitoring and evaluating the effectiveness of PFM initiatives, including assessing socio-economic impacts, forest condition, and community participation should be set up.

6.5.2 History and evolution of PFM in Kenya

PFM in Kenya signified an important shift towards involving local communities in forest management. The traditional command-and-control conservation method, focusing on protected areas and regulatory measures, was initially employed by the then Forest Department, but it was found to be counterproductive. In the 1980s and 1990s, there was growing recognition of the limitations of centralized forest management. Various stakeholders, including forest adjacent communities, civil society, and development partners, advocated for a participatory approach.

The Kenya Forestry Master Plan of 1994 emphasized the need to involve local communities in forest management. The pilot project for PFM started in 1997 in a 42km^2 area of the Arabuko Sokoke Forest in partnership with adjacent villages and various stakeholders and it yielded numerous benefits. The Forest Act No 7 of 2005 provided a legal framework for PFM, recognizing community rights to manage and benefit from forest resources. With the Forest Act of 2005, Community Forest Associations (CFAs) emerged as key institutions for implementing PFM at the local level. The Forest Conservation and Management Act No 34 of 2016 further strengthened the role of CFAs in forest management.

Today, PFM is implemented in virtually all forest stations in Kenya including those with mangrove forests, with CFAs actively contributing to forest management.

6.5.3 Achievements of PFM in respect of mangrove forests in Kenya

Participatory Guide: *Ask participants to state the benefits accrued since PFM was implemented in mangrove forests in their respective localities.*

Trainers' Notes

PFM in mangrove forests has resulted in numerous achievements such as;

- Enhancement of physical resources for communities such as the construction of community resource centers, establishment of honey processing units, and development of community ecotourism facilities such as in Mida Creek.
- Improved management of mangrove forest resources as evidenced by a reduction in illegal activities.
- Enhancement of livelihoods for forest adjacent communities (FAC) as evidenced by improved incomes from ecotourism, fishing and sale of carbon credits (e.g Vanga Blue Carbon project)
- Contribution to social change, the development of natural, physical, and human capital, and empowerment of marginalized communities.
- Mangrove forest management through CFAs has significantly contributed to forest rehabilitation and increased multi-sector participation in forest management.
- PFM in mangroves has enlightened FACs that the forest resource belongs to them, resulting in an increased sense of ownership of local forest resources, ensuring long-term sustainability.

6.5.4 Challenges to the Implementation of PFM in mangrove forests

Participatory Guide: *Divide participants into groups of not less than five and let them discuss the challenges to the implementation of PFM in mangroves forests. Give each group an opportunity to present their findings*

CBT Notes

1. Limited Resources: Inadequate financial resources, technical expertise, and capacity at both governmental and community levels hinder effective implementation.
2. Policy and Legal Framework: Inconsistent or inadequate policies, laws, and regulations related to mangrove forest management create ambiguity and hinder community participation and empowerment.
3. Lack of Awareness and Education: Many local communities lack awareness of their rights, roles, and responsibilities in forest management. Education and awareness programs are crucial for fostering community participation and building capacity.
4. Power Dynamics: Power imbalances between different stakeholders, including government agencies, private sector interests, and local communities, sometime undermine participatory processes and decision-making.
5. Resistance to Change: Resistance from entrenched interests, including commercial entities and individuals, at times hinder the adoption of participatory approaches, as they may perceive them as threats to their authority or profits.
6. Climate Change and Environmental Degradation: Increasing pressures from climate change, deforestation, and degradation exacerbate the challenges of sustainable mangrove forest management, requiring adaptive strategies and investments in resilience.
7. Social and Cultural Factors: Some socio-cultural norms, gender dynamics, and traditional practices influence community engagement and decision-making processes, requiring culturally sensitive approaches to participation.

6.5.5 PFMP Preparation Process

Participatory Guide*:* *Let participants attempt to define what a PFMP is.*

CBT Notes

A PFMP is a systematic program developed through a participatory approach involving all relevant stakeholders showing all activities to be undertaken in a forest during a period of at least five years.

The process of developing a PFMP in Kenya is the same for both terrestrial and mangrove forests. It entails 8 steps as below;

Figure 1: Main steps in PFMP preparation

1.Identify the community and the resource

- During this step, the stakeholder initiating the PFMP development process undertakes activities that would help to identify the target community and the forest resource for which the PFMP is being considered.
- The initiator will then build rapport with the forest-adjacent community to understand its history, challenges, livelihoods, forest product use and resource use conflicts.
- A local planning team is then constituted involving representatives from among the forest community, local opinion leaders, KFS, national and county government officials at the local level and other key stakeholders within the area.

2. Facilitate the formation/strengthening of CFA and other relevant community structures

- The applicant will identify existing community structures that will facilitate PFM.
- Identified structures/associations are strengthened to comply with the FCMA 2016.
- Where there are no existing structures, the applicant will help form a CFA in accordance with the applicable guidelines.
- For very large areas, multiple CFAs may be considered, while for small areas with multiple groups, merging may be considered.

Figure 2: *A KFS CFA officer capacity building members of the public on CFA formation. Photo credit: KFS Media Team*

3.Assessing the forest area and communities

- Also called participatory situation analysis.
- Involves conducting socioeconomic surveys and resource mapping conducted by the LPT.
- Most activities here are conducted through community meetings.
- Discussions in this step are done in a language that the majority of the community members are comfortable with.
- The outputs in this step include identification of key issues and challenges for forest management, identification of stakeholders and how they can participate in forest management and the identification and documentation of socioeconomic and institutional set up of the local community.
- Findings are analyzed and written up and shared with the community through public meetings.

Figure 3:*Field officers and community members conducting a socioeconomic survey in Mwache area of Kwale County.*

4.Preparation and approval of a Participatory Forest Management Plan

- The LPT working together with supporting stakeholders and KFS prepare a draft PFMP for the forest.
- The plan should be prepared in line with national aspirations and following the laid down PFMP preparation guidelines.
- Once the plan has been drafted, it is then submitted to KFS for approval.

5.Negotiating and Signing Forest Management Agreement (FMA)

- A forest management agreement is a legally binding contract between the KFS and the community, outlining responsibilities and rights of each party for sustainable forest management and conservation.
- The CFA in consultation with KFS prepares a draft FMA after capacity building on what entails FMA negotiation.
- The FMA specifies parties to the agreement, the name and description of the forest, objectives and purpose, assignment of rights, duration, authorized activities, basic assurances, rights and obligations of the parties, risks and liabilities assignment, termination or withdrawal of user rights and relationship of parties.
- The FMA also establishes a clear dispute resolution mechanism.
- Once the draft FMA has been completed, it is presented and discussed with the CFA membership to get their comments and obtain buy-in.
- Once the FMA has been approved by the KFS and the CFA, it is signed between the two.
- It is then launched at a public gathering to be witnessed by members of the general public.

6.Implementation of the plan

- This is where the CFA implements the PFMP.
- First, the FLMC is constituted to help the CFA implement the PFMP.
- A FLMC is a committee initiated by KFS comprising of Service representatives, the CFA, and other relevant stakeholders to assist the CFA in implementing the FMA.
- The FLMC develops annual joint annual work plans with budgets and clear roles and responsibilities.
- It also develops mechanisms for: protection and conservation, utilization, issuing of licenses and permits, management of monies, sharing of returns, and record keeping and M&E.
- The FLMC also mobilizes resources to support implementation work.

- Also undertakes physical zone demarcation for protection, conservation and utilization within the forest.
- Study tours and visits to other PFM areas may be done during this step to promote sharing experiences and exploring opportunities for income generation and, forest or tree-based enterprise developments.

7.Review and Revision of the Plan

- This step entails reviewing and revising the plan.
- It follows the evaluation done at midpoint and end point which will justify the revision of the plan.
- At the end of each year of implementation, the FLMC together with other stakeholders should review the progress towards attaining the plan's objectives.
- Data collected during the evaluation should be analyzed to identify trends and changes within the forest area. These will be used to modify the plan as well as the conservation and management practices appropriately.
- Based on experiences, lessons learnt and challenges faced, major the stakeholders should be involved in plan revision.

8.Impact Monitoring of PFM

- This outlines activities to monitor the impact of PFM on the forest, community livelihoods, and other sectors.
- Available data is used to assess if PFM is improving forest conservation, productivity and people's livelihood.
- Also, impact on other sectors is evaluated with a view of expanding the PFM into other areas.

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