Mangrove Ecosystem Conservation Manual

A focus on Kenya

FSPI Mikoko Conservation and resilience of Kenyan mangrove forest - 2021

KENYA Forest Service

REPUBLIC OF KENYA

Institut de Recherche pour le Développement FRANCE
Taasisi ya Ufaransa ya Utafiti kuhu Maendeleo

cirad
AGRICULTURAL RESEARCH FOR DEVELOPMENT

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE
AMBASSADE DE FRANCE AU KENYA

Mangrove Ecosystem Conservation Manual

A focus on Kenya

FSPI Mikoko Conservation and resilience of Kenyan mangrove forest - 2021

KENYA Forest Service

REPUBLIC OF KENYA

Institut de Recherche pour le Développement FRANCE

Taasisi ya Ufaransa ya Utafiti kuhusu Maendeleo

cirad AGRICULTURAL RESEARCH FOR DEVELOPMENT

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE
AMBASSADE DE FRANCE AU KENYA

Citation

Prosperi J., Musili P., Lang'at K. S., Komu H. M. and Williamson D. 2021. Mangrove Ecosystem Conservation Manual - A focus on Kenya. FSPI Mikoko Conservation and resilience of Kenyan mangrove forest.

Published by: Mikoko Project team

Cover picture: *Rhizophora mucronata*, Mida creek, Kenya. ©Juliana Prosperi

Preface

Mangrove forests occur in sheltered areas including bays, creeks, deltas and protected lagoons along the 536km coastline of Kenya. The mangrove ecosystem covers approximately 61,170 ha, which is < 2% of forest cover in Kenya. Lamu mangroves account for 61% of the mangrove cover. There are nine (9) mangrove species in Kenya, with the dominant species *Rhizophora mucronata* (Mkoko) and *Ceriops tagal* (Mkandaa) making 70% of the formation. Mangroves in Kenya display typical zonation pattern of the mangroves in Eastern Africa, with the seaward side being occupied by *Sonneratia-Rhizophora*-giant *Avicennia* community. This is followed by *Rhizophora-Bruguiera-Ceriops* in the mid zone and dwarf *Avicennia-Lumnitzera-Xylocarpus* complex on the landward side. All the mangrove forests in Kenya are gazetted as government forests and are managed by Kenya Forest Service, and co-managed with Kenya Wildlife Service where they occur in marine parks and reserves.

Mangroves provide goods and services essential for human well-being and environmental integrity. These include provision of raw materials such as wood products, support to fisheries, coastal protection, carbon sequestration, absorption of waste, sediment stabilization and source of nutrients and organic carbon to adjacent ecosystems such as seagrass beds and coral reefs. Mangrove ecosystems are regarded as one of the most efficient carbon sinks; storing approximately ten (10) times more carbon per unit area than the terrestrial forests.

The mangrove formations occurring outside protected areas had been the only natural forest in Kenya where logging was permitted until 2018 when the government placed a ban on all forests including them. The ban was lifted for Lamu County where mangroves are essential for the livelihoods of the local communities. The mangrove ecosystems in Kenya have been subjected to degradation and loss due to a number of issues, including but not limited to population pressure, coastal development, and weak governance and enforcement system. The main threats to mangroves are over-exploitation

and illegal wood harvesting, encroachment (especially in urban centers like Mombasa City), pollution and solid waste dumping, sedimentation arising from inappropriate agricultural activities, reduction of freshwater input from damming of rivers upstream, climate change effects such as sea-level rise and natural calamities such as El Nino.

These threats have contributed to degradation of the mangrove ecosystems thereby affecting their functionality and health of associated marine ecosystems. This has led to depletion of quality wood products, reduced fisheries production and degradation and loss of seagrass beds and coral reefs. The annual rate of mangrove cover loss in Kenya is 0.7%, which is higher than those of other forest formations.

With the realization of the importance of mangroves to the sustainability of the blue economy and the need to combat degradation and loss of the mangrove ecosystem, the Kenya Forest Service, working with other relevant agencies and stakeholders, has made significant steps in mangrove ecosystem management. The greatest milestone is the development of the National Mangrove Ecosystem Management Plan (NMEMP) 2017-2027. Secondly, mangroves have been integrated as one of the ocean climate actions incorporated into the updated Kenya's NDC submitted on 28th December 2020 to UNFCCC in accordance with the Paris Agreement.

Capacity building and stakeholder involvement in participatory mangrove ecosystem management is critical for the implementation of the NMEP and the achievements of mangrove related targets in the NDCs. Cognizance of this fact, KFS with key partners initiated capacity building and training on sustainable mangrove conservation and management for key stakeholders, in particular forest managers and community based organizations. This training manual is the product of such training and will go a long way in enhancing mangrove conservation in Kenya.

Mr Julius Kamau
Chief Conservator of Forests
Kenya Forest Service

The Mikoko project

The Mikoko Project « Conservation & Resilience of Kenyan Mangrove Forests » is an FSPI [1] project in Higher Education, Research and Professional Training. Mikoko is a 2-year project, started in 2019, whose main objective is to restore and conserve mangrove forests in Kenya to improve socioeconomic well-being and ensure environmental sustainability especially in the context of climate change.

The Mikoko project aims to meet the challenge of managing the Kenyan mangrove ecosystem with and thanks to the cooperation between organisations in Kenya: Kenya Forest Service (KFS), Institute for Climatic Change & Adaptation (ICCA), National Museums of Kenya (NMK), Kenya Marine & Fisheries Research Institute (KMFRI), Kenya Forestry Research Institute (KEFRI), Kenya Wildlife Service (KWS), Egerton University (Nakuru), Kenya Forestry College (Londiani), The National Environment Management

1] FSPI: Solidarity Fund for Innovative Projects, Civil Societies, Francophonie and

Authority of Kenya (NEMA), Lamu County Government and France (IRD and CIRAD) possessing unparalleled experience in meeting this demand.

Mikoko project training on mangrove ecosystem held in the National Museum of Kenya, Gede, February 2020.

The first training of the Mikoko project took place at the National Museum of Kenya at Gede, in Kilifi County. The training brought together key stakeholders such as local community leaders, KFS ecosystem conservators from the coastal zone of Kenya, and lecturers from the Londiani College of Forestry. Trainers came from a wide variety of institutions: Egerton University, NMK, KFS, KEFRI, KMFRI and KWS. It was designed to build the capacity of KFS frontline staff and local communities to work together and ensure the conservation of mangrove ecosystem.

One of the outcomes of this event was to develop a mutually agreed training manualtargeting foresters and the local communities.

Mikoko project training on mangrove ecosystem held in the National Museum of Kenya, Gede, February 2020.

Human Development. French Ministry for Europe and Foreign Affairs.

Table of Contents

List of Acronyms

AEP	Atlantic East Pacific
BMU	Beach Management Unit
CBO	Community Based Organization
CERRP	Coast Eco-Region Research Programme
CFA	Community Forest Association
CGL	County Government of Lamu
CIRAD	French Institute of Agricultural Research and Development
CMC	Mangrove Management Committee
EBM	Ecosystem-Based Management
EIA	Environmental Impact Assessment
FAC	Forest Association Committee
FCM	Forest Conservation and Management
FLMC	Forest Level Management Committee
FMA	Forest Management Agreement
FSPI	Project in Higher Education, Research and Professional Training
GPS	Global Positioning System
HOC	Head of Conservancy
ICCA	Institute of Climate Change Adaption
IDAO	Plant Identification System
IRD	Institute of Research for Development
IWP	Indo-West Pacific
KEFRI	Kenya Forestry Research Institute
KFMP	Kenya Forestry Master Plan
KFS	Kenya Forest Service
KMFRI	Kenya Marine and Fisheries Research Institute
KTB	Kenya Tourism Board
KWS	Kenya Wildlife Service
LAPSSET	Lamu Port Southern Sudan Ethiopia Transport

NEMA	National Environment Management Authority
NMEM	National Mangrove Ecosystem Management Plan
NMK	National Museums of Kenya
NMMC	National Mangrove Management Committee
NRM	Natural Resource Management
PFM	Participatory Forest Management
PFMP	Participatory Forest Management Plan
PLWDs	People Living With Disabilities
PNRM	Participatory Natural Resource Management
SEKU	South Eastern Kenya University
SHGs	Self Help Groups
TCBFM	Traditional Community Based Forest Management
VDC	Village Development Committee
WGs	Women Groups
YGs	Youth Groups

Acknowledgements

The Mikoko project was funded by the Solidarity Fund for Innovative Projects, Civil Societies, Francophonie and Human Development (FSPI) of the French Ministry for Europe and Foreign Affairs. The authors address a special acknowledgement to the French Embassy in Kenya and especially HE Aline Kuster-Menager, Ambassador, and Cyril Gerardon , Head of cooperation and cultural affairs department. The authors also express their warm thanks for the support from their institutions: KFS and the Chief Conservator of Forests Julius Kamau, together with Nicholas Munyau and Mathenge Gitonga; Institute of Climate Change and Adaptation at University of Nairobi and its directors Profs Shem Wandiga and Dan Olago; KMFRI and Drs Jaqueline Uku and James Kairo; KEFRI; Egerton University; NMK; Pwani University; KWS; NEMA, and the French institutes IRD and CIRAD.

In addition, the authors address their warmest thanks to all local community-based groups involved in mangrove activities, most especially from the County of Lamu. This manual is first dedicated to them. Special thanks to Zulfa Hassan (Mtwangawanda), Fatma Athman and Nadhir Hashim (Pate), Nuzla Misbahu (Kizingitini), the Patte Marine Community Conservancy and its technical supports and funding from Northern Rangeland Trust (NRT) and Hassan Yusuf, and The Nature Conservancy (TNC).

Special thanks to Bainitus Alenga (Digital Process Works Ltd) and Dali Mwagore (proof-reading and Kiswahili translation) for their support in the final realization of this manual.

Sonneratia alba

CHAPTER I
Mangrove Ecosystem

1 Mangrove Ecosystem Overview

Bernard Kirui, Egerton University - bkkirui@egerton.ac.ke
Kipkorir Sigi Lang'at, KMFRI - kisigilang@yahoo.com

1.1 Introduction

Mangroves are defined as assemblages of salt tolerant trees and shrubs that grow in the intertidal regions of the tropical and subtropical coastlines. The word mangrove comes from the Portuguese word *mangue* for "tree" and the English word grove for "a stand of trees," referring to the dominant trees and to the entire plant community.

They provide a range of goods and services of immense value to the coastal communities including wood products and coastal stabilization. In addition mangroves serve as nursery grounds for fisheries, sinks for carbon dioxide and habitats for fauna including crabs, molluscs and birds. They are also known to extract a large amount of carbon dioxide (CO_2) from the atmosphere owing to their high photosynthetic ability, and release a large part of the fixed carbon into the forest floor in the form of leaf litter.

However, the global coverage of mangroves is rapidly reducing at a rate of between 1-2% per annum. Mangroves are threatened by habitat loss from coastal development activities related to population increase from the landward side as well as surface elevation adjustments from the seaward side because of sea level rise.

Public awareness regarding mangroves and their conservation is on the rise in Kenya (Fig 1). Concerted efforts by key stakeholders led by relevant government agencies, local communities and other key actors have increased conservation of mangroves. The current policy and legislative framework emphasises participatory approach in forest management.

Figure 1. First workshop of *Mikoko* project (Conservation and Resilience of Kenyan Mangroves) in Lamu, September 2019.

1.2 Mangrove Distribution

Mangroves are generally found between 30°N and - 30°S latitude.

Two distribution areas in the world

- Atlantic East Pacific (AEP) Mangroves/New World, hosting around ten plant species
- Indo-West Pacific (IWP)/Old World is the most diverse and hosts more than 60 species of plants

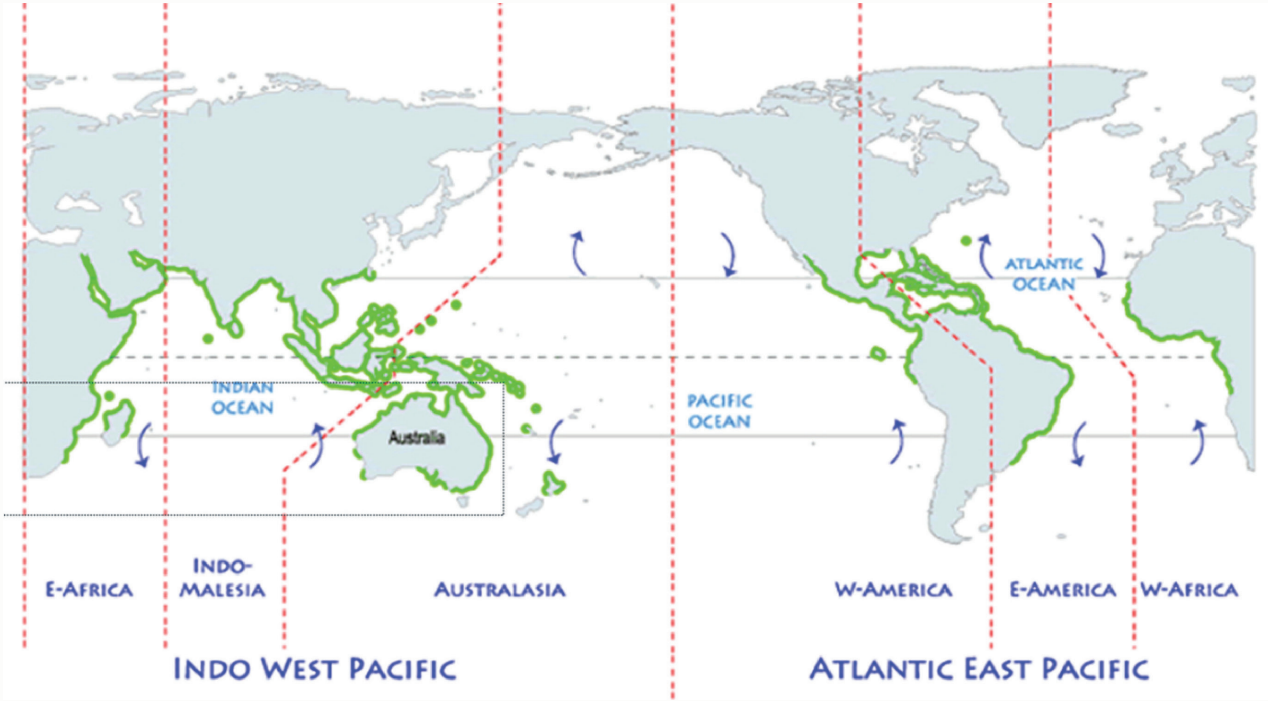
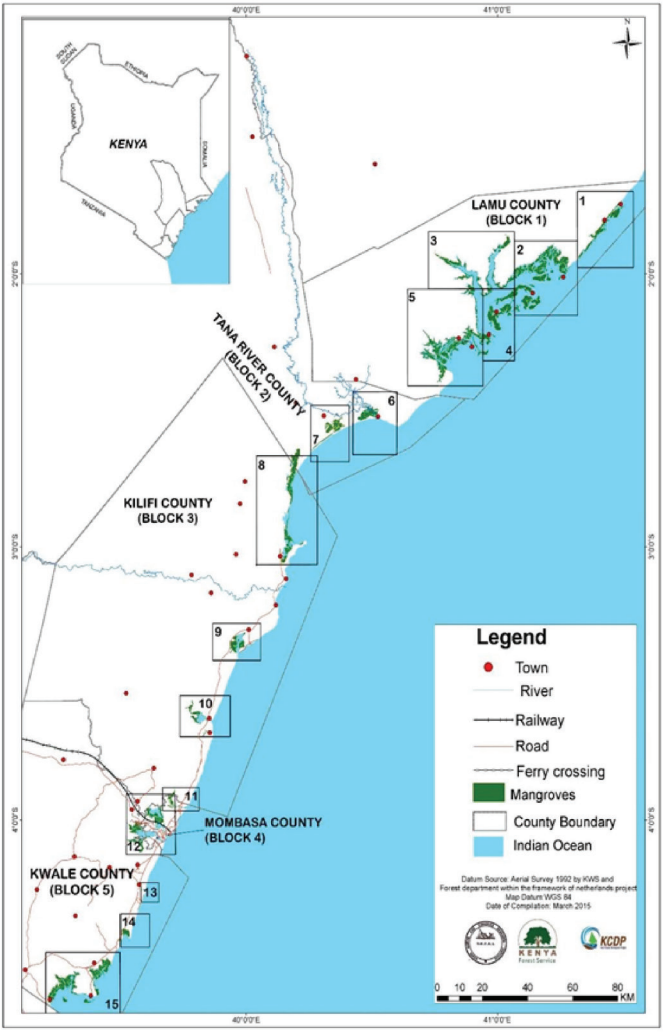


Figure 2. Global mangrove distribution map. Source: Mangrove Watch Ltd. (2013) http://www.mangrovewatch.org.au/index.php?

The mangroves along the Kenyan coast



In Kenya, mangroves cover approximately 61,000 ha, most of this area is in Lamu and Tana River counties (Figure 3).

Figure 3. Mangrove distribution within the five counties (Kwale, Mombasa, Kilifi, Tana River and Lamu) along the coastal strip: The mangrove blocks labeled 1-15 are Northern Swamps, North Central Swamps, Mongoni and Dododori Creek Swamps, Pate Island Swamps, Southern Swamps, Kipini, MtoTana, Ngomeni, Mida, Kilifi, Mtwapa, Mombasa, Ukunda, Gazi, Vanga-Funzi, in that order.

https://www.kmfri.co.ke/images/pdf/National_Mangrove_Management_Plan_Summary_for_Policy_Makers_Final.pdf

1.3 Conditions for mangrove development

Mangroves thrive in unique environment characterised by fluctuating marine conditions. The most important environmental factors that influence mangrove growth and development include:

- Temperature - average temperature above 20° with seasonal range max 5°
- Protection - thrive in environments with low wave energy
- Salinity - saltwater with freshwater intrusion
- Tidal range - competition, dispersal of detritus, seeds and propagules
- Muddy substrate - optimal development in muddy soils

1.4 Adaptations

Aerial/ breathing roots	- Prop/stilt roots in *Rhizophora* species - Buttressed/ cable roots in *Xylocarpus* and *Heritera littoralis* - Knee roots in *Bruguiera*, *Ceriops* and to some extent in *Lumnitzera* - Pneumatophores in *Avicennia* and *Sonneratia*
Salt exclusion	Salt exclusion through negative hydrostatic pressure.
Salt excretion	Salt excretion through epidermal glands in the leaves, development of tissue succulence to retain water (e.g. *Rhizophora* and *Sonneratia*) and a waxy cuticle on the leaf epidermis at least on the upper leaf surface.
Viviparity	Viviparity. In some of the species by producing propagules (looking like green beans in *Rhizophora*, *Ceriops*, *Bruguiera*, and like a flattened green olive in *Avicennia*) that germinate while still on the parent tree so that they can become established more easily.

Figure 4. *Rhizophora* stilt roots (Mizizi ya hewani)

1.5 Mangroves of Kenya

Mangroves are found in patches along the 536 km Kenya coastline, covering about 61,000 ha with 61% being in Lamu. There are 9 mangrove species in Kenya, with the dominant species *Rhizophora mucronata* and *Ceriops tagal* making 70 % of the formation (Table 1). Mangroves in Kenya display typical zonation pattern of the mangroves in Eastern Africa (Figure 5). The seaward side is occupied by *Sonneratia-Rhizophora*-giant *Avicennia* community. This is followed by *Rhizophora-Bruguiera-Ceriops* in the midzone and dwarf *Avicennia-Lumnitzera-Xylocarpus* complex on the landward side. Other plant species associated with mangroves include *Pemphis acidula* and *Barringtonia racemosa*, which have mistakenly been referred to mangroves in some countries in the region.

Table 1. Mangrove distribution in Kenya

County	Coverage Area (ha)	Proportion
Lamu	37,350.00	60.96%
Tana River	3,260.00	5.32%
Kilifi	8,535.00	13.93%
Mombasa	3,771.00	6.15%
Kwale	8,354.00	13.63%
Total	**61,270.00**	

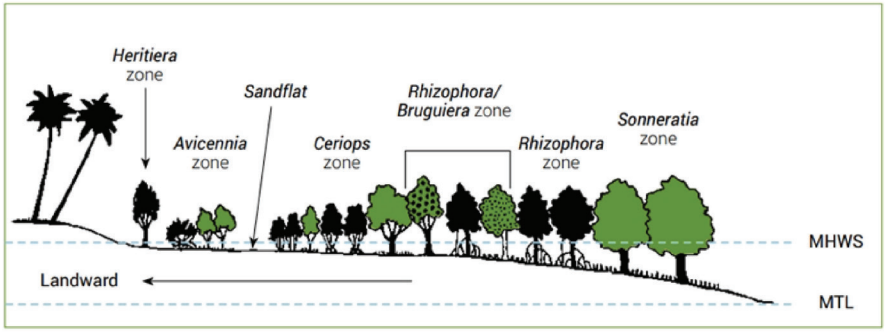


Figure 5. Typical mangrove species zonation in WIO region.© Nairobi Convention 2020.

1.6 Mangrove species and their uses in Kenya

Table 2. Mangrove species and their uses in Kenya

Species name	Local name	Uses
Avicennia marina	Mchu	Firewood, poles, timber, dug-out canoes, dhows ribs, carts, roots for fishing stings, sap for shoots for wounds leaves as fodder
Bruguiera gymnorhiza	Msinzi/mwia	Poles, firewood, charcoal, timber, fishing stakes tannin from bark for fish nets fruits for eye medicine
Ceriops tagal	Mkandaa	Poles, firewood, charcoal, timber, tannin for fish nets, mats bark infusion for haemorrhages
Heritiera littoralis	Msikundazi	Timber, poles, boat mast, firewood, charcoal, boat-building
Lumnitzera racemosa	Kikandaa/mkandaadume	Fencing poles, firewood, tincture of leaves for mouth infectious
Rhizophora mucronata	mkoko	Poles, dye, firewood, fencing, charcoal, timber, fish traps, fishing stakes, tannin for nets, mats, insect repellent, infusion from wood to cure diarrhoea
Sonneratia alba	mlilana	Boat ribs, poles, firewood, timber, boat building roots as fish net floats
Xylocarpus granatum	mkomafi	Furniture/carving, poles, firewood, timber, boat-building, dhow masts, carts, seed to cure diarrhoea, fruit pulp for ointment
Xylocarpus moluccensis	Mkomafidume	Fencing poles, firewood, dhow masts, timber very rare occurrence

Source: Lang'at & Kairo 2008

1.7 Legal status of mangrove forests

Through Proclamation No. 44 of 30th April 1932, mangroves were declared government forest reserve. Under this "Gazette Notification for Mangrove Forests in Kenya", all land between high water and low water marks is described as mangrove areas. These forests are currently managed by the Kenya Forest Service (KFS) either alone; or with KWS when they fall in the marine protected area.

2 Mangrove Fauna

Matthias M. Mwavita - KWS - mmmwavita@gmail.com

2.1 Introduction

Mangrove ecosystems are highly productive habitats for a variety of fauna such as birds, fishes, reptiles, amphibians, mammals and aquatic as well as terrestrial invertebrates. Mangrove fauna consist of both vertebrates and invertebrates.

- Vertebrates: animals with spinal cord surrounded by cartilage or bone; include birds, fish, amphibians, reptiles, and mammals. Those that are not vertebrates are invertebrates.
- Aquatic invertebrates such as insects, molluscs, i.e. gastropods (snails) and bivalves (mussels), crabs, shrimps, oysters, sponges, barnacles, and polychaetes (worms).

Mangrove fauna can be divided into three inhabitants (i) aquatic animals, i.e., fishes, amphibians, (ii) semi-aquatic animals (i.e., reptiles, amphibians and birds) and (iii) terrestrial animals based on their living behaviour, (i.e., mammals and birds). These animals use mangrove areas for their daily activities such as foraging, breeding, and loafing

2.2 Importance of mangroves forests to Fauna

A wide variety of mangrove fauna use mangroves forests as

- Homes/shelter
- Breeding site
- Roosting site
- Feeding site
- Hiding sites

The occurrence of higher diversity of fauna is mostly due to richness of food resources and diversity of vegetation, i.e. they provide ideal foraging and breeding sites and also shelter for these wide array of animals.

2.3 Mangrove Fauna

Avifauna

Mangrove areas are a favourable habitat for a variety of waterbirds (i.e., bird species that entirely depend on water for a variety of activities such as foraging, nesting, loafing and molting) as well as terrestrial birds (i.e., bird species that do not entirely depend on water but may visit some time in search of food, shelter and perch).

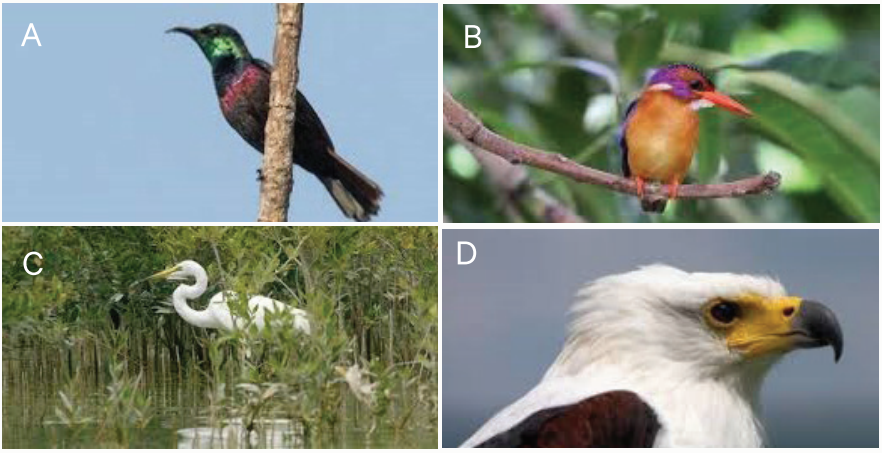


Figure 1. A) Sunbirds get nectar from mangroves and are good in pollination. B) Kingfisher. C) Egret. D) African fish eagle.

Aerial Feeders (Birds)

The bird species that catch their prey on wing i.e. Fish Eagles and Kites (Accipitridae), Wood Swallow (Artamidae), Swallows (Hirundinidae), Bee-eaters (Meropidae) Kingfisher (Alcidinidae) and Swiftlet (Apodidae) always hovers on mudflats and mangrove areas in search of food such as fishes, birds, snakes, and insects (Figure 1).

Amphibians

Only a few species of frogs (Figure 2) occur in mangrove forests including Giant Toad (*Bufo marinus*), Tree Frog (*Osteopilus septentrionalis*) and Mangrove Frog (*Fejervarya cancrivora*).

Figure 2. Frog.

Mammals

Baboons, vervet monkeys, hyenas, bats, wild pigs, squirrels, jackals and other land animals have been sported in the East African Mangroves (Figure 3).

Mammals are a major source of food for a variety of animals such as raptor birds, snakes, crocodiles, and a significant component of mangrove ecosystems. Frugivorous mammals such as monkeys, squirrels, and bats are also important as seed dispersal agents.

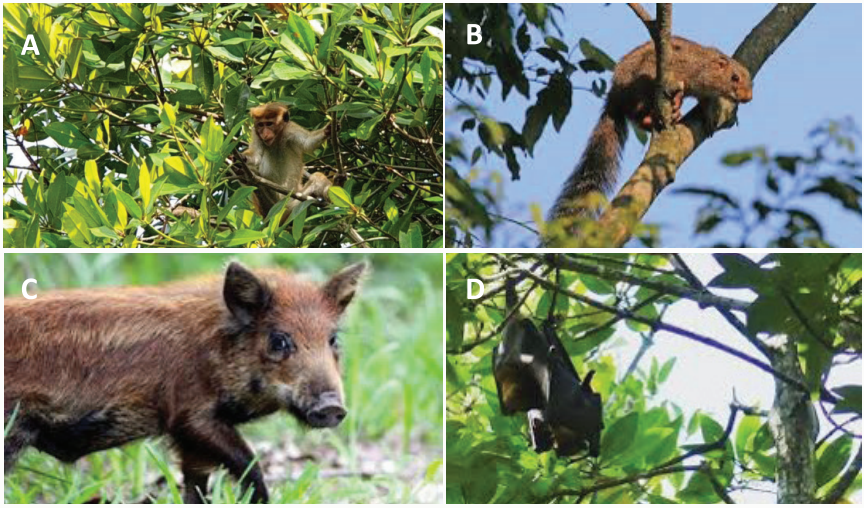


Figure 3. A) Vervet monkey. B) Squirrel. C) Pig. D) Bat.

Fishes

Fish are not only food for human being, but also sources of food for a variety of wildlife species such as birds, reptiles and amphibians, mammals, carnivore fishes and invertebrates

Figure 4. Mangrove red snapper.

The fish fauna of mangrove areas include mudskippers, carangids, clupeids, serranids, mullets, hilsa, seabass, eels and milkfish.

Reptiles

Mangroves are an ideal habitat and are rich in reptile fauna, such as snakes, turtles, crocodiles and alligators (Figure 5). The turtle species found in mangrove ecosystems include:

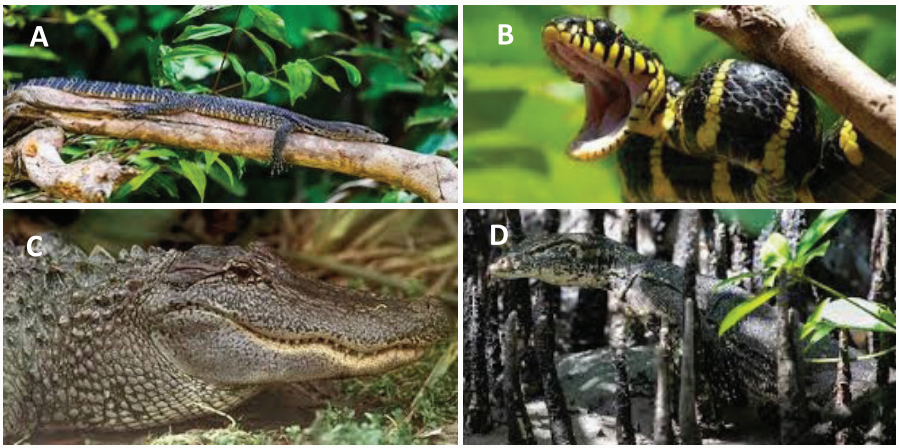


Figure 5. A) Lizard. B) Mangrove snake. C) Crocodile. D) Monitor Lizard.

loggerhead turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*) and leatherback turtle. These turtle species utilize mangrove areas, estuaries and creeks for foraging and breeding owing to the richness and diversity of plankton and benthic food resources. They use undisturbed sandy beaches for breeding, for instance the Mkokoni sandy beach in Kiunga subdivision. Turtles are illegally hunted by fishermen for food and for medicinal values.

Invertebrates

- Mangrove vegetation has attracted diverse insect species such as butterflies, bees, beetles, ants, mangrove cricket. These insects play an important role in the mangrove ecosystem such as pollination and are a major source of food for birds, fishes and amphibians.
- Mangroves are also ideal habitats for a variety of crustaceans, e.g., prawn species and edible crabs.
- Aquatic invertebrates are a major source of food for different animals such as monkeys, birds, snakes, fishes, and even for humans (oysters and mussels).

Crustaceans

Crustaceans such as lobsters, crabs, crayfish, shrimps and barnacles. (Figure 6) very important in nutrient recycling and for community livelihoods. Crustaceans are a source of nutrients such as proteins, fats and minerals to aquatic life and human beings. Because mangroves act as nurseries, they harbor high juvenile population of many aquatic organisms.

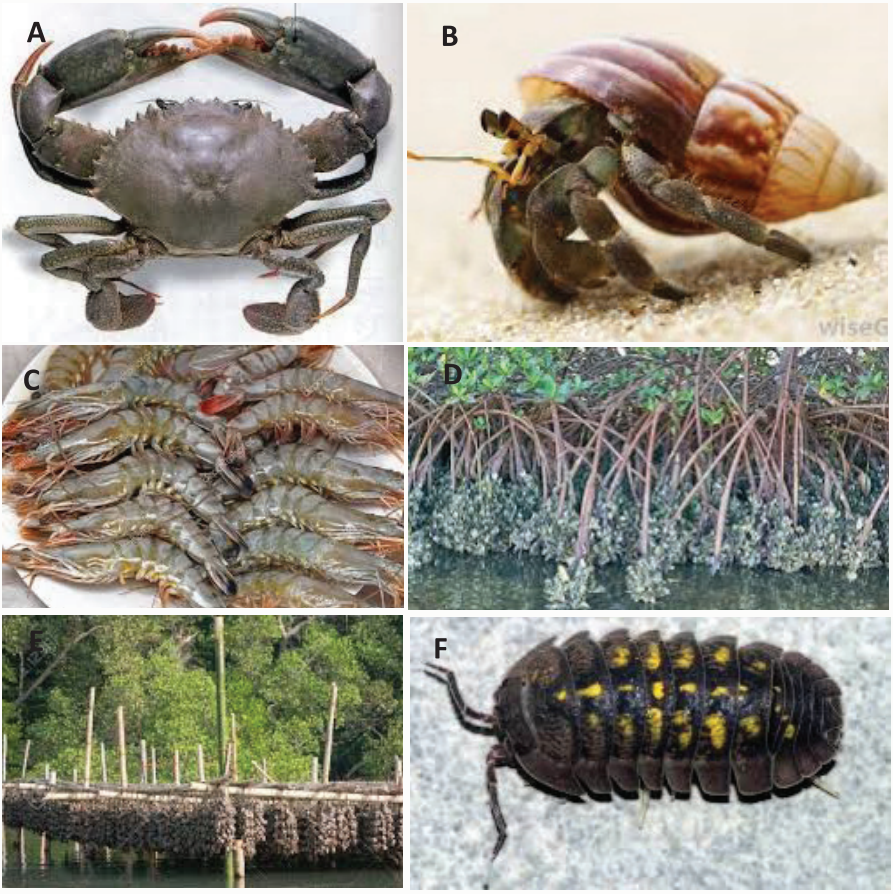


Figure 6. A) Crab. B) Hermit crab. C) Shrimps fetches high market prices in local tourist hotels. D) Mangrove oyster is very common on the roots of mangroves. E) Oyster farming is reduces disturbances and damage to mangrove roots. F) Woodlouse.

2.4 Threats to mangrove fauna

Habitat loss is the main threat to mangrove fauna.

- Urban development; mangrove wood is resistant to rot and insects, making it extremely valuable and is in high demand for construction materials. Indigenous communities in coastal areas heavily rely on this wood for construction material and for fuel.
- Conversion of mangrove habitats to salt farms, aquaculture etc. seriously affects wildlife species particularly birds.
- Destruction of mangroves destroys nursery grounds for several species of fauna, affecting their populations and distribution.

2.5 Non-consumptive exploitation of mangrove Fauna

Communities can benefit from the presence of mangrove fauna without necessarily damaging the habitat through non-consumptive exploitation such as:

- Eco-tourism development,
- Mangrove honey production.

References

Rajpar M. N and Zakaria M (2013) Mangrove Fauna of Asia. Faculty of Forestry, Universiti Putra Malaysia.

https://wwf.panda.org/our_work/oceans/coasts/mangroves/mangrove_importance/

3 Mangrove, water, climate:

A flagship socio-ecosystem for adapting to climate change

David Williamson[1], George Tarus[2,5], Anthony Mbatha[3], Christine Omuombo[4], Lydia Olaka[4], Bernard Kirui[5], Dan Olago[4], James Mwang'ombe[2]

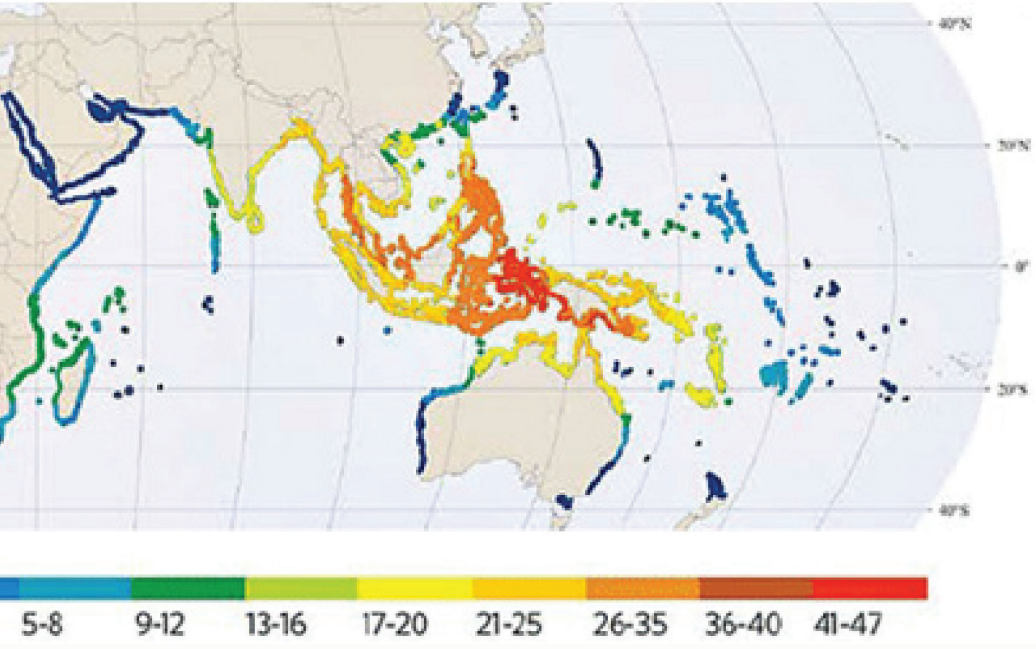
[1]IRD - david.williamson@ird.fr
[2]KFS - tarus2014@gmail.com, jmwangombe@kenyaforestservice.org
[3]Embu University - mbatha.anthony@student.embuni.ac.ke
[4]ICCA - omuomboatieno@gmail.com, lydiaolaka@uonbi.ac.ke, olagodan@gmail.com
[5]Egerton University - bkkirui@egerton.ac.ke

3.1 Introduction

Mangrove is becoming a "flagship" ecosystem for climate hazards and climate change adaptation. This should not come as a surprise: since the beginning

Figure 1. The world map of the mangrove distribution zones and the

of navigation and maritime transport, the mangrove forest has been a natural shorefront refuge for human habitations against meteorological and climate hazards. Today, the mangrove ecosystem hosts all the most populated coastal cities of the tropics, including in tropical Africa. Indeed, the mangrove forest occupies sheltered intertidal zones, between the terrestrial and marine coastal environments, providing a **natural defense against two major evidences of climate change**: the destructive impacts of sea-level rise, and the more frequent occurrence of devastating tropical storms. Moreover, with its huge biomass (frequently more than 400 t C/ha), the mangrove forest is a considerable asset to sequester carbon and to balance greenhouse gas emission especially carbon dioxide, thus reducing the global warming trend of the atmosphere. The carbon production rates are equivalent to those of tropical humid forests, but mangroves store proportionally more carbon belowground, and have higher below- to above-ground carbon mass ratios than terrestrial trees.



number of mangrove species along each region (Deltares, 2014)

3.2 What are the climatic boundaries for mangrove?

Mangrove is a salty environment, regularly flooded by tides. Mangrove forests are freeze-sensitive and generally located along sheltered tropical and subtropical coasts across the world, where favorable substrates are found (Figure 1).

In the southern and northern latitudes end-members (East America, East Asia, southwest Australia), the relatively warm sea waters help mangroves to survive during winter, but mangroves do not survive where the temperatures drops below -7°C, and where mean annual rainfall is under 400 mm.

3.3 How is climate changing in Kenya and in the intertropical regions?

In the warmer intertropical region, mangroves can grow in any suitable sheltered area, but the input of freshwater by rainfall and rivers determines the increase in biomass, as well as the diversity of mangrove forests.

On the Equator and in Kenya, there are two intervals of maximum sunshine during the year, leading to two tropical "summer rains". The latter roughly coincide with the equinoxes of March 22 and September 22. The "short" rains season takes place between September and November (vuli), and the "long rains" season between March and May (masika). These rainy seasons supply water to soils and rivers, **but they are very irregular from year to year**. This is an important feature of the East African climate, called *inter-annual variability*. It represents about 20% of the annual rainfall, enough to limit the life or death of many tropical plant species, thus leading to frequent droughts and floods conditions. The survival and multiplication of trees depend mainly on the presence of water in the soil and on the ability of trees to use this water. Terrestrial trees are adapted to collect fresh water from the ground, especially at the edge of rivers, like in the "gallery" forests of arid zones. **Only mangrove trees support significant salinities,** up to ~3 times sea water salinity. Thus, mangrove trees can persist under high

evaporation conditions, and are adapted to the impact of climate change on the salinity of water, such as along the arid coasts of the Arabian Peninsula, where rainfall does not exceed 500 mm per year.

3.4 What will be the impact of climate change on mangroves?

The ongoing global warming originated almost 200 years ago with the industrial era, when the consumption of fossil biomass (oil, coal, gas) to produce energy resulted in the emission of greenhouse gases (most especially CO2, CH4) and in the warming of the atmosphere.

In spite of international efforts such as the Paris Agreement (2015) to reduce greenhouse gas emissions, this warming trend will be maintained in the next decades, supporting the melting of ice sheets from the North pole and South pole areas, and the rise in global sea-level (Figure 2).

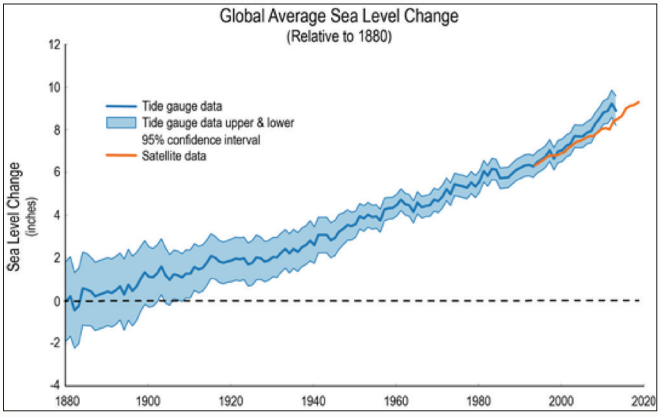


Figure 2. The global rise of sea level (from the US Global Change Research program

The warming and the seal-level rise will likely support the expansion of mangrove trees in the subtropical regions and in the newly flooded coastal areas.

But the changes in rainfall associated with global warming and the supply of freshwater from rivers and groundwater reservoirs, will still be decisive in supporting mangrove growth in tropical regions (Figure 3).

Figure 3. Three sources of fresh water support the growth of mangrove trees: Rivers (tall tree, high biomass), ground water (intermediate tree size and biomass), and of course, rainfall (small tree size and biomass)

In this context, Kenya and East Africa, are potentially favorable regions for the development of mangrove, because of their extended intertidal areas, together with the predicted increase in rainfall over the next decades. Coupled with an outstanding capacity to sequester carbon, it is most likely that mangrove forests will be strongly supported politically and economically and will thus considerably extend in the future.

3.5 In between rains and tides, a path for adaptation to climate change?

Mangroves directly intercepts at least 20% rain, trapped by the dense foliage of the trees. But mangroves develop better when the stress linked to salinity and seasonal drought is reduced: this is the case at the mouths of rivers, and in contact with other natural freshwater reservoirs where rainwater has infiltrated emerged reefs, dunes, coastal sedimentary deposits. In these reservoirs, rainwater, less dense than salted water, remains in the upper part of the underground reservoir. The tides remobilize part of this water while ensuring the periodic flooding of the mangrove trees. The tides thus support the circulation of suspended matter, nutrients. The amplitude of the tide and the area covered between low and high tide define the "tidal prism", which is the total amount of water mobilized by the tide. This water is a mixture of sea water and fresh water (river, aquifer). At ebb tide, the water current is slowed down by the friction of the water on the soil, the roots of the mangrove. This mechanism ensures not only the oxygenation of the soil but also the deposit of the finest sediments, on which the mangrove can grow. Twice a month, during the new moon and full moon, but also during the equinox tides of March 22 and September 22, the tides rise higher and further inland, thus contributing to increase in the salinity of soils and aquifer. Only few mangrove trees such as *Avicennia* spp are adapted to these salt pan conditions.

3.6 Conclusion: how to re-shelter the coast under climate change?

Due to climate change, as already explained, rehabilitating or increasing the surface of mangrove forests is becoming a key ecological, political and economical challenge. How will the coast be re-shelterd?

Three major assets support the health and productivity of mangroves, and further provide support strategies for users and local communities to rehabilitate estuaries and tidal zones:

i) **Access to land and to freshwater**: Using knowledge exchange tools (such as the Mikoko digital platform), an integrated community of actors (local, national, international) and articulating policies will favor the development of mangrove, based on the needs of mangrove user communities;

ii) **Mangrove tree species adapted to local salinity gradients** and freshwater inputs, either temporary (rains) or perennial (rivers or diffuse inputs by subsurface waters of the coastal aquifer);

iii) **A regular renewal of light, water and nutrients by tides, and support to areas of low hydraulic energy** (clayey sand to silty-clay deposition), starting from the edges of existing mangroves (edge-re-sheltering). Such asset is supported by rational logging and by human infrastructures (canals, ridges/dikes).

References

C. Giri, E. Ochieng, L. L. Tieszen*et al.*, 2011. Status and distribution of mangrove forests of the world using earth observation satellite data *Global Ecol. Biogeogr.* (2011) 20, 154–159

Matthew A. Hayes, Amber Jesse, Nina Welti, BasamTabet,David Lockington, Catherine E. Lovelock, 2018. Groundwater enhances above-ground growth in mangroves. *J. Ecol.,*DOI: 10.1111/1365-2745.13105

Michael J. Osland, Laura C. Feher, Kereen T. Griffith *et al.* , 2017. Climatic controls on the global distribution, abundance, and species richness of mangrove forests. *Ecological Monographs*, 87(2), 2017, pp. 341–359

4 Threats to Mangrove Ecosystem in Kenya

Kipkorir Sigi Lang'at - KMFRI - kisigilang@yahoo.com

4.1 Introduction

Similar to most parts of the world, mangroves ecosystems in Kenya are endangered (Figure 1). Threats to mangrove ecosystems comprise human-induced activities, climate change and natural threats.

Figure 1. Clear-cut mangrove for chalk making, Manda Island, Lamu. © KS Lang'at.

These threats include (Figure 2):

i) **Over-exploitation and illegal cutting** – over-cutting has reduced the availability of quality poles from most mangrove areas, causing the degradation of the ecosystem.

ii) **Conversion of mangrove areas to other land uses** – conversion of mangrove areas for pond culture is localized in Ngomeni. Mangrove forests have also been converted to saltworks; such as between Ngomeni and Karawa, which is responsible for underground seepage of high saline water that seriously affects neighbouring mangroves.

iii) **Urbanization and Large-scale development infrastructure** – the ongoing development of Lamu Port South Sudan Ethiopia (LAPSSET) project has posed a number of threats to mangrove ecosystems. Some mangroves areas have already been cleared with more areas projected to be affected upon completion of the project. The dredging and construction of berths has resulted in increased sediment load in the adjacent coastal and marine ecosystems.

iv) **Terrestrial land-use activities** – inappropriate land-use activities upstream and areas adjacent to the coastal areas lead to transport of sediments to coastal and marine areas including mangrove areas, thereby killing mangrove trees. Damming of major rivers draining to the coast for agricultural, water supply and electricity generation reduces the input of fresh water into the mangrove ecosystem, affecting their productivity.

v) **Coastal erosion and sedimentation** – degradation of marine ecosystems such as coral reefs and the seagrass beds leads to coastal erosion and sedimentation, thereby affecting the mangrove ecosystem.

vi) **Pollution** – mangrove ecosystems adjacent to the city of Mombasa and urban settlements are highly polluted by sewerage systems and solid waste. Plastic pollution is emerging as a major threat to coastal and marine ecosystems, worldwide. In addition, oil spills from docking ships have resulted in mangrove dieback of mangroves in areas adjacent to the port of Mombasa.

vii) **Natural phenomena** – The El Nino phenomenon contributes to dieback of mangroves due to prolonged water logging and sedimentation. The El Nino rains experienced in 1997/98 caused destruction of mangroves due to prolonged water logging and sedimentation in areas such as Gazi Bay, Mwache,Tana Delta and Kiunga.

Figure 2. Over exploitation and conversion of mangrove areas.

4.2 Root causes of mangrove degradation

i) **Poverty and economic development** –Some of the highest rates of poverty (>70%) are recorded in the coastal region of Kenya, leading to high dependence on primary resources with limited alternatives. Increasing coastal development has also precipitated environmental and mangrove degradation. For example, dredging, port expansion and development have led to mangrove degradation in Mombasa

ii) **Weak governance**–the following aspects have contributed to 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.

iii) **Inadequate knowledge and awareness** – In many cases, there is lack of awareness on the extent of ecosystem degradation due to limited survey and mapping data. Lack of spatial-temporal data may impair management decisions and even policy decision-making.

Heritiera littoralis

CHAPTER II

Mangrove Ecosystem Socio-economic Values

1 Economic importance of mangroves

1.1 Introduction
1.2 Valuation of Mangrove Resources

2 Mangroves and Fisheries

2.1 Importance of Mangroves to Fisheries
2.2 Fisheries in Mangroves
2.3 Impacts of mangrove degradation on fisheries

3 Mangrove Wood Value Chain in Kenya

3.1 Introduction
3.2 Mangrove Wood Value Chain Actors and Activities
3.3 Inbound Logistics and Operations for Production
3.4 Outbound Logistics
3.5 Marketing and Sales

1 Economic importance of mangroves

Samuel Muriithi[1], Linus Wekesa[2] and Sigi Lang'at K[3].
[1] **KFS -** smuriithi2000@yahoo.co.uk
[2] **KEFRI-** weknus@yahoo.com
[3] **KMFRI-** kisigilang@yahoo.com

1.1 Introduction

Mangroves play a critical role in the livelihoods of local communities and development of the economies through provision of services and goods of economic importance. The mangroves contribution is through provision of forest resources including; wood-based products, and non-wood products. Mangrove wood-based products include the timber, poles and firewood which are very valuable resources to local communities (Gasanaet al., 2004; Kairo and Carolyne, 2006). The non-wood-based products include honey, tannins and traditional medicine (FAO, 1992; Kokwaro, 1985; Kairo 2001). Indirect importance of mangroves includes acting as breeding and nursery areas for fish and prawns, carbon sequestration, and ecotourism (FAO, 1994). There are various tools that applied in valuing mangrove resources as explained in Table 1. The value of these resources in the country is as indicated in Table 2.

1.2 Valuation of Mangrove Resources

Table 1: Tools used for valuing mangrove goods and services.
Source: Kairo et al. 2009.

Type of Goods and services	Examples of good/service	Type of values	Valuation method	Data source
Wood/ Timber products	Building poles Fuelwood	Direct	Market price	Field inventory, review of inventory literature
Supporting	On site fisheries	Direct	Market price	Catch data and literature review
Regulatory	Carbon sequestration	Direct		Carbon stocks & sequestration data/ literature
	Shoreline protection	Indirect	Avoided cost	Cost of protection infrastructure e.g. seawalls
Cultural services	Education and research	Indirect	Research funds and education expenses	Data from research and education funding programs
	Recreation - ecotourism	Indirect	Market price	Data on Number of visitors to the sites

Table 2: Valuation of mangroves goods and services in Kenya. Kairo *et al* 2009: http://dx.doi.org/10.1080/10549810902791523.

Products and services	Value (USD/ha/year)
Building poles	361
Fuelwood	19
On site fisheries	113
Tourism	9
Education and research	770
Carbon sequestration	44
Shoreline protection	1,587
Total	2,903

The poles are the most valuable economic products from mangroves. The poles are used for example in house construction, fencing and furniture making (Figure 1) among others. The poles come in different sizes categorized into fito, pau, mazio, boriti and vigingi, and are utilized for various purposes (Table 3, Figure 3). Mangrove poles are valued at USD/ha/yr 361 (Table 2). Mangrove wood is also used as source of energy in form of firewood collected as dry wood on the landward sides. The value of fuelwood from mangrove ecosystem is estimated to be US$ 19/ha/yr.

Figure 1. Traditional house under construction composed virtually of mangrove poles. (© J. Lang'at).

Table 3. Mangrove pole size classes and their uses: Rm: *Rhizophora mucronata*, Ct: *Ceriops tagal*, Bg: *Bruguiera gymnorhiza, Am: Avicennia marina, Xg: Xylocarpus granatum, Sa: Sonneratia alba.* Source: Langat & Kairo 2008.

Utilization class	Diameter (cm)	Uses	Preferred species
Fito	2.5 – 4.0	Wall filling, fish traps,	Rm, Ct
Pau	4.1 – 6.0	Roof filling, fencing, furniture making	Rm, Ct
Mazio	6.1 – 9.0	Walling, roofing, fencing, furniture making, boat mast	Rm, Ct, Bg, Am, Xg, Sa
Boriti	9.1 – 13	Walling, scaffolding, fencing, boat ribs	Rm, Bg, Xg, Sa
Nguzo	13.1 – 20.0	Ceiling and roof supports, fencing	Rm
Vigingi	20.1 – 35.0	Ceiling and roof supports, dugout canoes, fencing	Rm, Am

Figure 2.
A Licensee. B Jahazi owners. C Loaders. D External loaders.

Figure 3. Mangrove wood use in making local furniture: a local bed (mwankisu); stands are made of "*mchu*"-*Avicennia marina* and side-frame are made of "*mkoko*"- *Rhizophora mucronata*. ©M. Kubwa.

Global estimates of mangrove fishery ranges from 90 kg/ha/yr to a maximum of 1000 kg/ha/yr (Kapetsky, 1985; Dixon, 1989). In Kenya the annual catch for fin fish (excluding shell fish) from mangroves is estimated at about 100 kg/ha/yr with a net income of US$ 113/ha/yr (Table 2)

The mangrove ecosystem present very good opportunities for ecotourism through presence of the diverse flora and fauna. The tourists enjoy bird watching and canoeing in mangrove areas with little or no damage to the ecosystem. The unique nature of the mangrove ecosystem, introduction of board walks and tree-planting activities have made the mangrove sites attractive to local tourists particularly institutions including school and colleges, and companies or organized groups of guests to the coast. Mangrove ecotourism has been valued at US$ 9.30/ha/yr (Table 2).

The mangroves play an important role in carbon sequestration. Scientists have demonstrated that mangroves sequestrate more carbon than any other ecosystem, which is at US$ 44.42/ha/yr. This does not include the value of carbon buried in the below-ground roots and the sediment estimated at 24.9 t/ha, representing 19% of the total biomass (Kairo et al., 2008).

2 Mangroves and Fisheries

Gladys Okemwa – KMFRI - gladysokemwa@gmail.com

2.1 Importance of Mangroves to Fisheries

Mangrove ecosystems play a critical role in the maintenance of fisheries resources in all tropical regions worldwide. Lagoons, bays and estuaries containing mangroves provide a source of food and numerous hiding spaces which protect young fish and invertebrates such as crabs, shrimps and molluscs from predators. The mangrove ecosystem is also strongly inter-connected with coral reef and seagrass ecosystems providing resting, feeding and breeding habitats. Many coral reef fish use the mangrove environment during the juvenile phase and then move seaward to seagrass beds and coral reefs as they mature (Figure 1).

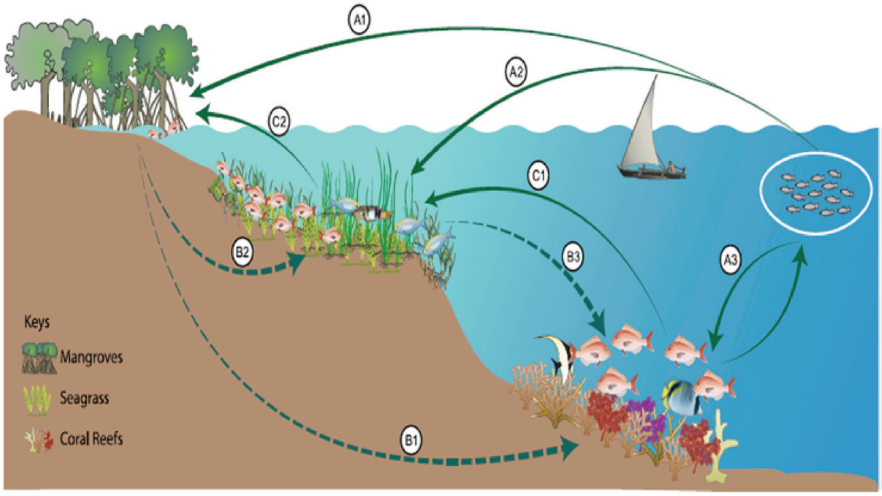


Figure 1. Illustration of the nursery function of mangroves and connection with seagrass and coral reef habitats. A 1-3 shows the movement and settlement of fish larvae into the three habitats; B 1-3 shows the movement of sub-adults and adults; C 1-2 shows daily or tidal movements; C2 shows feeding movements among the habitats (Source: Kimirei *et al* 2016).

Species that use mangroves include (1) those that spend their entire life cycle such as crabs, (2)those that spend at least one life stage within the mangroves (3) and those that move in temporarily into the mangrove environment for food or shelter during high tide and move back to deeper waters during low tide. An example is that of prawns which can be found highly concentrated in offshore areas such as the Malindi-Ungwana bay in Kenya. The early juvenile stages are found inshore within mangrove habitats, while adult phases are found further offshore. Thus, the presence of mangroves can strongly influence the community composition of fish in neighbouring seagrass and coral reefs. Some mangrove/seagrass associated species of commercial importance is presented in Figure 2.

Research scientists have reported that at least 50 fish families and 128 different fish species are found in mangroves many of the fish are commercially important(Table 1). The scientists also observed that almost 70% of the fish that were found in mangroves occurred as juveniles while about 30% also occurred as adults. Therefore, when mangroves are destroyed, some fish species may actually disappear and a reduction in the daily catches of fishers may occur over time resulting in loss of income. Conservation efforts should therefore focus on protecting mangroves to maintain fish populations that depend on them for survival.

Table 1: Common fish families of commercial importance that are found within mangrove habitats.

Family Scientific Name (Common name)	Local Name (Kiswahili)
Ariidae (sea catfishes)	Fumi
Carangidae (king fishes)	Kolekole
Acanthuridae (surgeonfishes)	Kangaja
Chanidae (milkfish)	Mwatiko
Balistidae	Kikande
Clupeidae (sardines)	Simusimu
Gerridae (mojarras)	Chaa, Tae
Haemulidae (rubberlips, grunts)	Fute
Labridae (wrasses)	Pono
Lutjanidae (snappers)	Tembo
Mugilidae (mullets)	Mkizi
Mullidae (goat fishes)	Mkundaji
Plotosidae (eel catfishes)	Tondi/Mtozi
Lethrinidae (emperors)	Changu
Serranidae (groupers)	Tewa
Synodontidae	Goromwe
Siganidae (rabbitfishes)	Tafi
Scaridae (parrotfishes)	Pono
Sphyraeinidae (barracudas)	Tengesi/Kisumba
Scombridae (seerfish/mackerels)	Nguru
Scombridae (tunas)	Jodari/Kiboma
Hemiramphidae	Chuchungi/Mkeke
Crabs	Kaa
Shrimps	Kamba

Among the most common species found in the mangroves are Gerridae (*Chaa/Tae*) (*Gerresoyena*, *G. filamentosus*), Leiognathus species (*Korokoro*) and Terapon species (*Tende*). Other reef fish species commonly found in mangroves as juveniles include *Lutjanus fulviflamma*, *Lethrinus harak*, *L. lentjan*, *L. variegatus*, *Siganus sutor* and *Sphyraena barracuda*. The juveniles of mudcrabs (*Scyla serrata*) are also commonly found on mudflats or inside mangroves while larger adult sizes are found in mangrove channels.

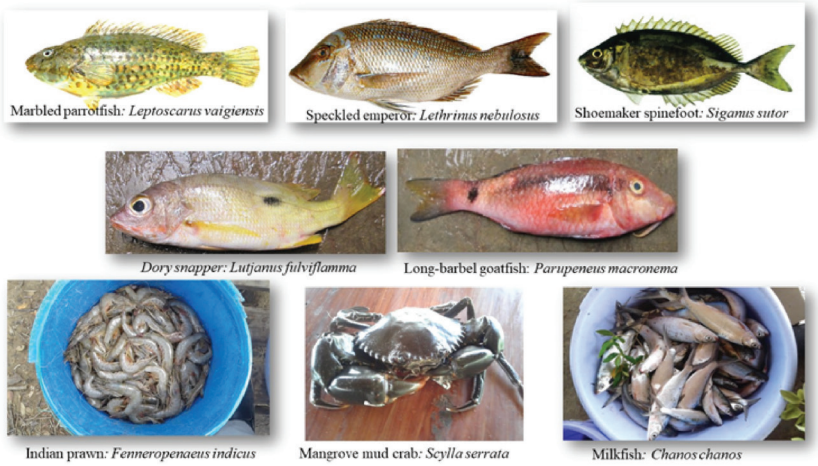


Figure 2. Some mangrove/seagrass associated species of commercial importance.

2.2 Fisheries in Mangroves

Fishing is an important economic activity that directly supports the livelihoods of over 13,000 fishers who fish within shallow areas that include mangroves (Figure 3). Approximately 24 metric tonnes of fish are harvested annually. It has been estimated that one hectare (ha) of mangrove ecosystem has the potential to generate 1.0 - 11.8 tons of fish catches per year in a healthy system. Fishermen use sharpened sticks to collect mud crabs and oysters which burrow in the mud, roots or stems. They also catch fish and prawns using various types of gears such as handlines, seine nets, small gillnets and traps. Mangroves also support other non-fishery products in

the fishing industry such as the wood that is used for building fishing boats and paddles. Over 90% of the fishing vessels are made of wood, and most of the planked vessels are made of mangrove wood.

Figure 3. Fishing within mangroves, seagrass and coral reef habitats. ©Gladys Okemwa.

A number of mariculture activities occur within mangrove environments. Pond culture of milkfish, brackish waterprawns, brine shrimp (artemia), and cage culture of mud crabs has been successfully done, and this has generated much interest concerning empowering local communities (Figure 4). The techniques used in the mangroves are considered environment friendly whereby juvenile stages are collected and fattened in pens and cages.

Figure 4. Culture of milkfish and mud crabs in pens and cages within mangroves. ©James Mwaluma.

2.3 Impacts of mangrove degradation on fisheries

Despite the important role mangroves play in fisheries production, they are intensely harvested to supply wood products for fuel, house and hotel construction. Clear-cutting for salt making is also prevalent in the northern coastline. Mangroves are also threatened by environmental pollution such as oil and sewage, which deteriorates the water quality. High levels of mangrove degradation can lead to environmental changes in the food-web in addition to the flow of nutrients which leads to a decline in primary and secondary production. Declining in secondary production can then lead to loss of prey for the fish. A result of such degradation is the reduction of good quality habitats to support the fish populations. This implies that am uncontrolled loss of mangroves will lead to a reduction in fish abundance. Therefore, it is important that we ensure that mangroves are conserved and sustainably utilized to minimize ecosystem degradation to support the species that are dependent, as this will have an impact on fisher livelihoods as well as the food security of coastal communities.

3 Mangrove Wood Value Chain in Kenya

Linus Wekesa - KEFRI- weknus@yahoo.com

3.1 Introduction

The value chain (VC) approach is a valuable decision support tool for development of enterprises, sectoral development and for achievement of sustainable development goals. The VC is a set of activities that a business performs in order to deliver a valuable product (i.e., good and/or service) for the market. The activities of steps that bring a product from conception to distribution including procuring raw materials, manufacturing functions, and marketing form a VC. Businesses strive to maximize their margins by optimizing profit difference between input and output). In the country, efforts are being made to develop tree-based commodity value chains for enhanced socio-economic and ecological benefits. Among such VCs is the mangrove wood value chain.

The VC activities are often categorized as primary and support activities. Primary activities are directly related to the creation of a good or service, while support activities act as facilitators in enhancing efficiency and work to obtain a competitive advantage (Figure 1).

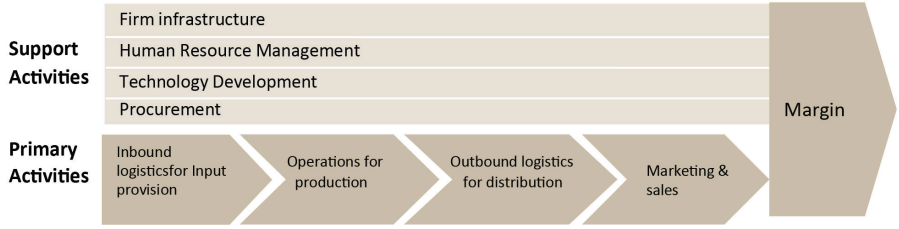


Figure 1. Value Chain Activities.

3.2 Mangrove Wood Value Chain Actors and Activities

A typical wood value chain would involve the following actors:

- Producers including conservators, cutters and processors
- Merchants including yard/warehouse operators, transporters, retailers, brokers and exporters
- Government and other agencies involved in research, management and regulation including research, management/protection, advocacy and capacity building agencies

Since mangrove wood harvesting in Kenya employs selective cutting of poles from the natural forest (Figure 2), which doesn't require establishment of a plantation. However, planting in degraded mangrove areas is usually carried out by various actors.

Figure 2. Mangrove poles being harvested in Lamu.

The actors are involved primary and support activities that form the value chain. The primary activities include; inbound logistics, operations for production, outbound logistics, and marketing and sales as elucidated in Figure 3.

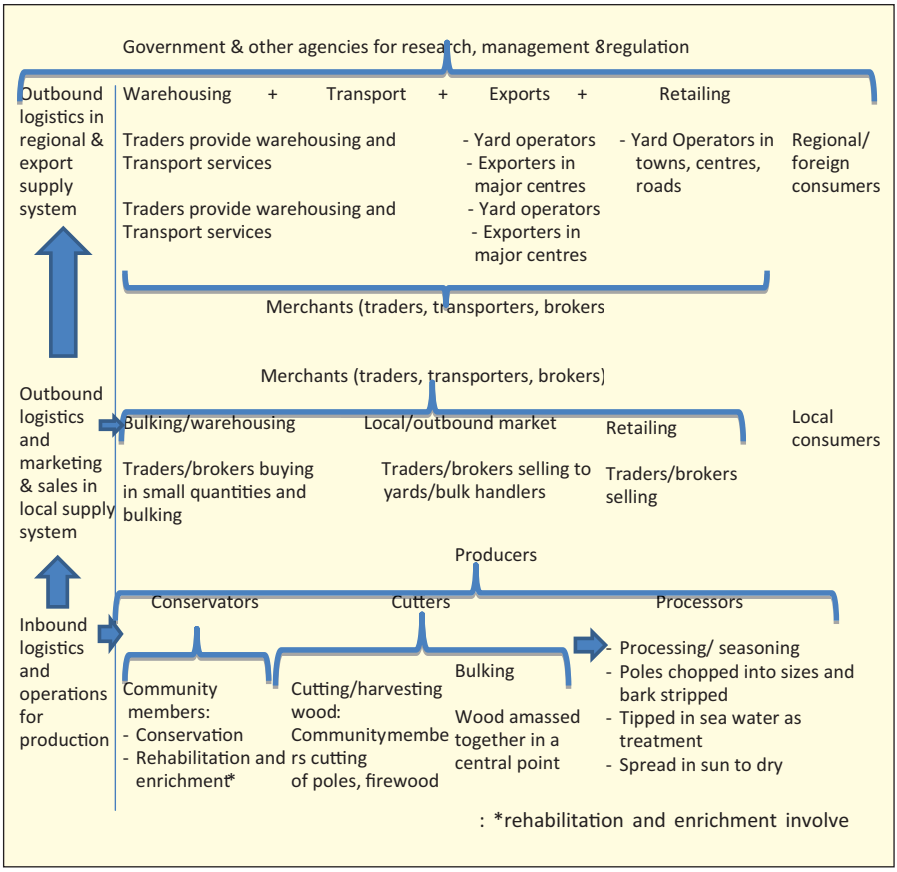


Figure 3. Mangrove Wood Value Chain Activities: *rehabilitation and enrichment involve raising of seedlings in a nursery/collection of propagules and planting in degraded areas by key actors.

3.3 Inbound Logistics and Operations for Production

The inbound logistics and operations for production covers;

- identification of harvesting sites
- cutting/harvesting poles
- transportation and bulking
- enrichment planting in degraded sites (raising of mangrove seedlings/ collection of propagules, planting and their protection)

Figure 4. Mangrove seedlings.

The identification and cutting of the poles is undertaken by pole cutters contracted by licensees. The cut poles are often processed by trimming, stripping the bark and seasoning before selling to customers (Figure 5).

Figure 5. Harvesting mangroves. ©Juliana Prosperi.

3.4 Outbound Logistics

The outbound activities cover warehousing and transport to local, regional and export markets. The warehousing of the mangrove wood is undertaken in yards where the wood is arranged in stakes of varied sizes (Figure 6).

Figure 6. Harvested mangrove poles.

The cutters transport their wood using boats and canoes from cut areas within mangrove forests to sea shores where they do bulking to required quantity for sale or transfer to the next agent. The wood is then carried by cutters either on their shoulders/heads, boats/canoes and/or donkeys to where they are needed by the next level of actors including traders, brokers and constructors.

Transport costs per trip from mangrove forest to the shore is estimated at KSh. 600 per canoe. One cutter can make up to 30 canoes. The price per pole varies depending on the size class. The poles are sold in bundles of 20 pieces called Korija (scores). The merchants participating in the regional and export market supply systems may use heavy trucks, boats (Figure 7) and even ships to transport the wood. The local market supply system traders rarely transport their mangrove wood to the market. In most cases buyers

come over to their yards to buy the wood. However, in some rare cases, the local market supply system traders may use pick-ups, lorries and/or boats to transport the wood to the points of sale of the wood.

Figure 7. Transporting mangroves wood on boat.

3.5 Marketing and Sales

Mangrove marketing and sale undertaken by licensed merchants who include traders, brokers and transporters. Some traders operate in kiosks or open places where they sell wood to customers. Poles for firewood are sold to firewood traders and individual customers both domestic users and food kiosks traders. The merchants transport the wood using pick-ups, canters, lorries and trucks to their customers. The transport costs incurred within urban set-ups is KSh. 5000 to KSh. 10,000 per pick-up trip.

Kairo, J.G, Wanjiru, C., Ochiewo, J., 2009

https://www.tandfonline.com/doi/abs/10.1080/10549810902791523

CHAPTER III

Mangrove Conservation and Management Interventions

1 Botanical Conservation Aspects of Mangroves

1.1 Mangrove taxonomy
1.2 Mangrove Maps
1.3 Mangrove conservation using plant science
1.4 Herbarium specimens' collection, processing and data

2 Mangroves Plant identification tool

2.1 Introduction
2.2 The identification process
3.3 What can we learn from the identification of a species?
2.4 Other functionalities of the Mangrove App

3 Kenya's Mangrove Participatory Knowledge Platform

3.1 Introduction
3.2 The process of building the participatory knowledge platform
3.3 Participatory knowledge platform description
3.4 Stakeholders of the Participatory Knowledge Platform
3.5 Be part of this initiative!

4 Mangrove restoration interventions

4.1 Introduction
4.2 Restoration guidelines
4.3 Mangrove nurseries
4.4 Why restoration interventions may fail?

1 Botanical conservation aspects of Mangroves

Mutuku Musili - NMK - pmutuku@museums.or.ke

1.1 Mangrove taxonomy

Plant taxonomy is a word used to describe identification (understanding identity), naming (giving names) and classifying (assigning them to groups) plants. There are nine mangrove species that are locally recognized in Kenya

1.2 Mangrove Maps

- You can use herbarium specimens' data to know which and where Mangroves species are found.
- You can also use maps to know which species of mangrove is common.
- You can also use maps to know where you need to go and find them for research.
- To identify gaps of information.

Example of such map in Figure 1.

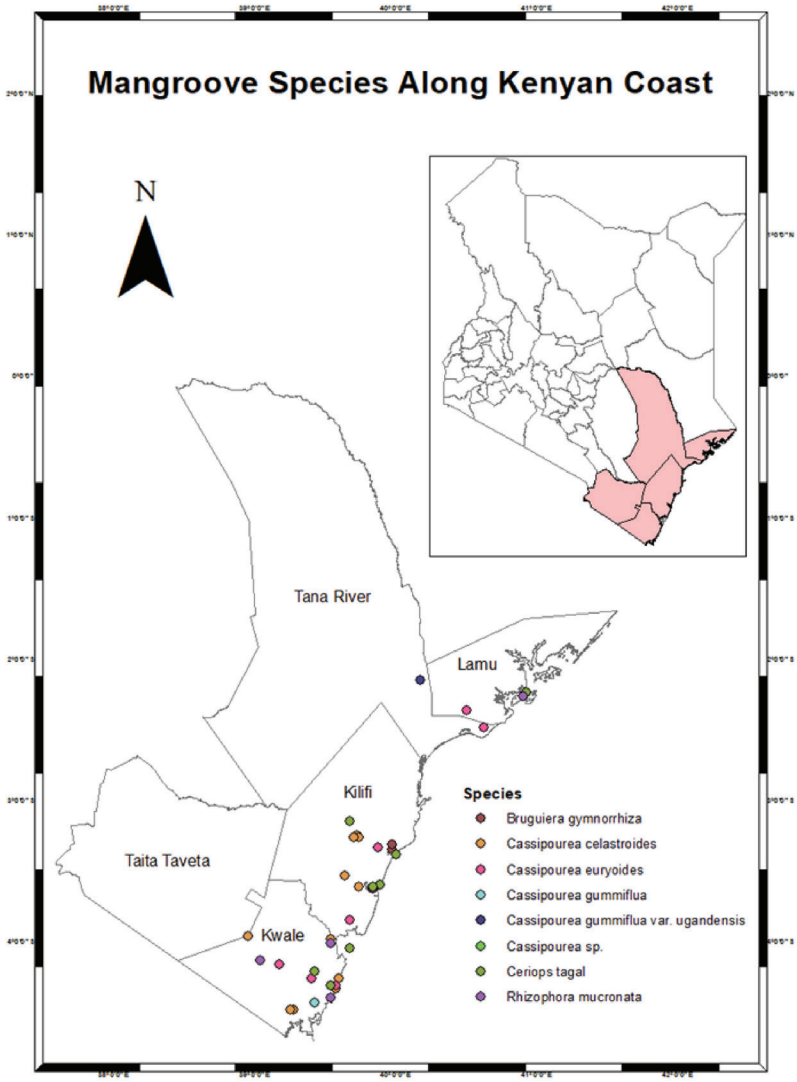


Figure 1. A map on the distribution of the Mangroves and associated species, along the coastal strip. Note: This map is based on the data from herbarium specimens only, the collection gaps can be filled in future as more collections are made.

1.3 Mangrove conservation using plant science

1.3.1 Use of botanical knowledge

- Plant sciences provide information for knowledge of the conservation status of targeted mangrove species and help to plan and monitor conservation action.
- Mangrove forms part of marine wetlands, so this knowledge is needed for conservation.

1.3.2 Botanic gardens

There are no mangrove botanic gardens in Kenya, but their establishment can be used as:

- Genetic store for mangroves
- Restoration of mangrove species through developing seedlings
- Conservation Research for mangroves
- Educational site to learn about natural heritage

1.3.3 Mangrove research

Successful mangrove conservation will require:

1. Data use
2. Community involvement (social research, traditional knowledge)
3. Conservation tools: conservation handbooks, protocols, Apps and other software on mangroves germplasm development.

1.4 Herbarium specimens' collection, processing and data

1.4.1 Natural collections

- Natural collections are 'dead' plants and animals (Figure 2) that are prepared and preserved for future reference.
- An estimated 2–4 billion specimens are contained in natural history collections worldwide

Examples of collections:

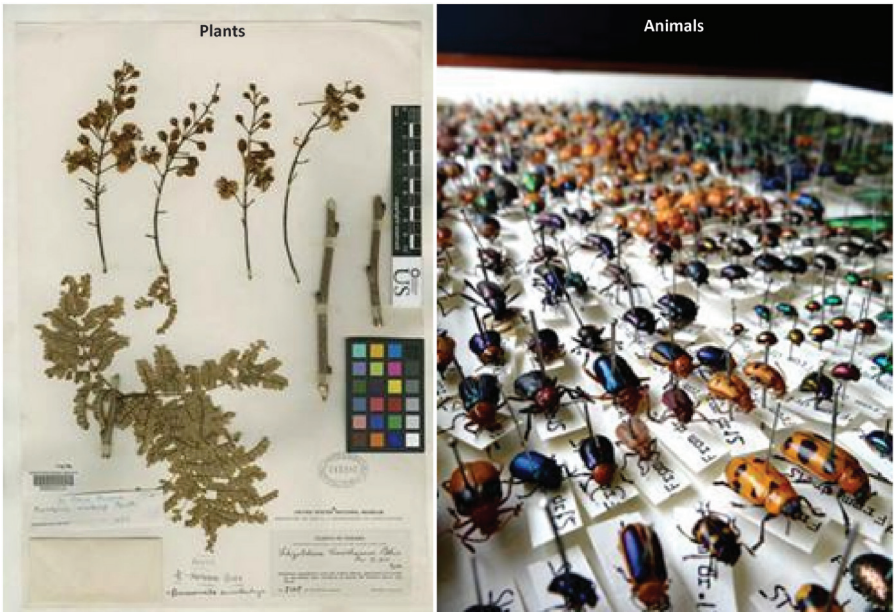


Figure 2. Major natural collection types in the world.

1.4.2 Collecting in the field

- Every collected plant material should have the data as shown in Figure 3.

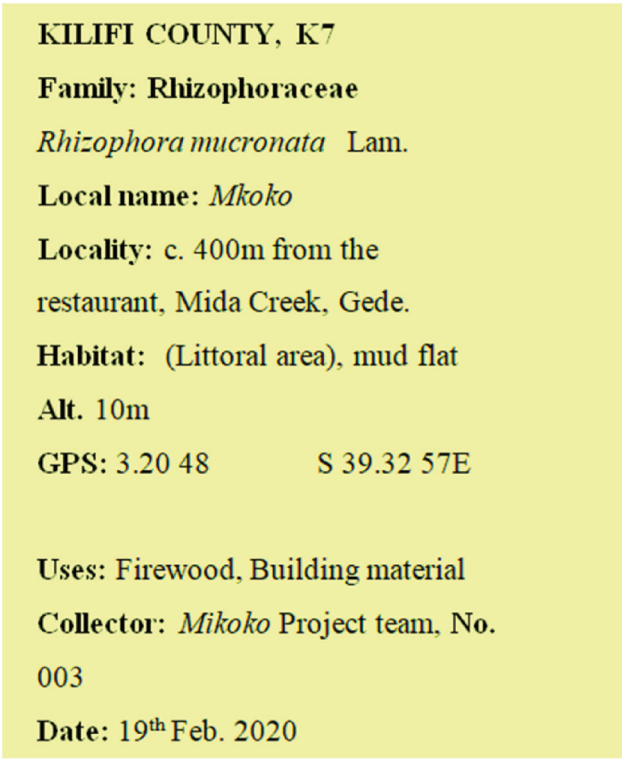


Figure 3. Standard specimen field data. **Sources**: *Mikoko project collection series.*

- The plant materials are then pressed, using old newspapers, corrugated sheet, board and straps.
- Pressing (to keep the shape of the specimen intact) (Figure 4) should be done as soon as specimens are collected and a tag number attached (each specimen should have one).

Figure 4. Taxonomist pressing the freshly collected specimens in the field

- The pressed materials are dried (to remove moisture) for 48 hrs then frozen (to kill any pest) for 3 days.
- They are then mounted (Figure 5) in a standard sheet using glue, brushes, gum Arabica, label, mounting sheet.

Figure 5. A technician mounting specimen at Nairobi herbarium.

A complete mounted specimen looks like this (Figure 6); and ready for preservation in the herbarium cabinets (Figure 9):

Figure 6. A mounted specimen of *Rhizophora mucronata* Lam. ready for preservation in the herbarium. **Sources:** *Mikoko project collections.*

1.4.3 Specimen identification

- Every specimen should be given the correct scientific name.
- To do this we use: Keys, other books (Figure 7) about that specimen,

exchanges with other herbaria, send material to specialists of each Family for identification verifications, we can also compare the specimen with the known one and they match then we give it the same name

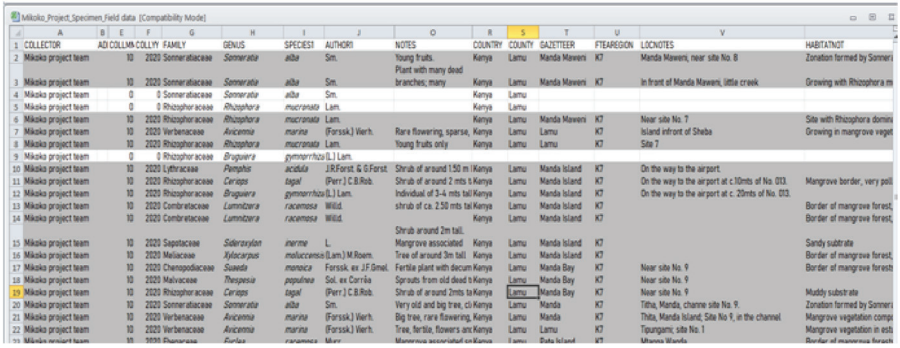
Plant Species	Families	Genera	Species
Pteridophytes	8	10	16
Gymnosperms	1	1	1
Angiosperms	86	293	652
(Monocotyledons)	(23)	(104)	(214)
(Dicotyledons)	(63)	(189)	(438)
Totals	95	304	669

TABLE 2
Comprehensive list of Pteridophytes including 8 families, 10 genera and 16 species

Figure 7. Some literature (tools) used to identify specimens in the herbarium.

1.4.4 Data entry and retrieval

- Data from the label of each specimen is finally entered into computer software for easy retrieval, sharing and continued research (Figure 8) on species distribution, uses, etc.


Mikoko_Project_Specimen_Field data [Compatibility Mode]

	A	B	E	F	G	H	I	J	O	R	S	T	U	V	
1	COLLECTOR	ADI	COLLNU	COLLYE	FAMILY	GENUS	SPECIES1	AUTHOR1	NOTES	COUNTRY	COUNTY	GAZETTEER	FTEAREGION	LOCNOTES	HABITATNOT
2	Mikoko project team		10	2020	Sonneratiaceae	*Sonneratia*	*alba*	Sm.	Young fruits. Plant with many dead	Kenya	Lamu	Manda Maweni	K7	Manda Maweni; near site No. 8	Zonation formed by Sonner
3	Mikoko project team		10	2020	Sonneratiaceae	*Sonneratia*	*alba*	Sm.	branches; many	Kenya	Lamu	Manda Maweni	K7	In front of Manda Maweni, little creek	Growing with Rhizophora m
4	Mikoko project team		0	0	Sonneratiaceae	*Sonneratia*	*alba*	Sm.		Kenya	Lamu				
5	Mikoko project team		0	0	Rhizophoraceae	*Rhizophora*	*mucronata*	Lam.		Kenya	Lamu				
6	Mikoko project team		10	2020	Rhizophoraceae	*Rhizophora*	*mucronata*	Lam.		Kenya	Lamu	Manda Maweni	K7	Near site No. 7	Site with Rhizophora domin
7	Mikoko project team		10	2020	Verbenaceae	*Avicennia*	*marina*	(Forssk.) Vierh.	Rare flowering, sparse,	Kenya	Lamu	Lamu	K7	Island infront of Sheba	Growing in mangrove veget
8	Mikoko project team		10	2020	Rhizophoraceae	*Rhizophora*	*mucronata*	Lam.	Young fruits only	Kenya	Lamu	Lamu	K7	Site 7	
9	Mikoko project team		0	0	Rhizophoraceae	*Bruguiera*	*gymnorrhiza*	(L.) Lam.							
10	Mikoko project team		10	2020	Lythraceae	*Pemphis*	*acidula*	J.R.Forst. & G.Forst.	Shrub of around 1.50 m	Kenya	Lamu	Manda Island	K7	On the way to the airport.	
11	Mikoko project team		10	2020	Rhizophoraceae	*Ceriops*	*tagal*	(Perr.) C.B.Rob.	Shrub of around 2 mts t	Kenya	Lamu	Manda Island	K7	On the way to the airport at c.10mts of No. 013.	Mangrove border, very poli
12	Mikoko project team		10	2020	Rhizophoraceae	*Bruguiera*	*gymnorrhiza*	(L.) Lam.	Individual of 3-4 mts tall	Kenya	Lamu	Manda Island	K7	On the way to the airport at c. 20mts of No. 013.	
13	Mikoko project team		10	2020	Combretaceae	*Lumnitzera*	*racemosa*	Willd.	shrub of ca. 2.50 mts tal	Kenya	Lamu	Manda Island	K7		Border of mangrove forest,
14	Mikoko project team		10	2020	Combretaceae	*Lumnitzera*	*racemosa*	Willd.	Shrub around 2m tall.	Kenya	Lamu	Manda Island	K7		Border of mangrove forest,
15	Mikoko project team		10	2020	Sapotaceae	*Sideroxylon*	*inerme*	L.	Mangrove associated	Kenya	Lamu	Manda Island	K7		Sandy subtrate
16	Mikoko project team		10	2020	Meliaceae	*Xylocarpus*	*moluccensis*	(Lam.) M.Roem.	Tree of around 3m tall.	Kenya	Lamu	Manda Island	K7		Border of mangrove forest,
17	Mikoko project team		10	2020	Chenopodiaceae	*Suaeda*	*monoica*	Forssk. ex J.F.Gmel.	Fertile plant with decum	Kenya	Lamu	Manda Bay	K7	Near site No. 9	Border of mangrove forest
18	Mikoko project team		10	2020	Malvaceae	*Thespesia*	*populnea*	Sol. ex Corrêa	Sprauts from old dead t	Kenya	Lamu	Manda Bay	K7	Near site No. 9	
19	Mikoko project team		10	2020	Rhizophoraceae	*Ceriops*	*tagal*	(Perr.) C.B.Rob.	Shrub of around 2mts to	Kenya	Lamu	Manda Bay	K7	Near site No. 9	Muddy substrate
20	Mikoko project team		10	2020	Sonneratiaceae	*Sonneratia*	*alba*	Sm.	Very old and big tree, cli	Kenya	Lamu	Manda	K7	Titha, Manda, channe site No. 9.	Zonation formed by Sonner
21	Mikoko project team		10	2020	Verbenaceae	*Avicennia*	*marina*	(Forssk.) Vierh.	Big tree, rare flowering,	Kenya	Lamu	Manda	K7	Thita, Manda Island; Site No 9, in the channel	Mangrove vegetation comp
22	Mikoko project team		10	2020	Verbenaceae	*Avicennia*	*marina*	(Forssk.) Vierh.	Tree, fertile, flowers and	Kenya	Lamu	Lamu	K7	Tipungami; site No. 1	Mangrove vegetation in est

Figure 8. Data made to usable form through various softwares. **Source**s *Mikoko project specimen database.*

- The specimens are finally stored in the cabinets (Figure 9).

Figure 9. Herbarium cabinets where specimens are stored.

2 Mangrove Plant identification tool

Juliana Prosperi – CIRAD - juliana.prosperi@cirad.fr

2.1 Introduction

Identifying a plant, that is giving it a name and distinguishing it from others plants, maybe complicated. It is however, its identity that you will have to start with if you want to know more about the plant; for example to know where and how it grows, if its fruits are edible, if the leaves, roots or stems have medicinal properties, and if so how to use them. Knowing the plant name, we can find a lot of information useful to our lives.

Plant identification generally requires basic scientific knowledge, because it is necessary to know what to observe in a plant in order to identify it.

alternate leaves

opposite leaves

One of the easiest characteristics to observe and acquire useful information for identification is the arrangement of the leaves on the stem; whether they are alternate (one leaf per node) or opposite (two leaves per node).

Botanical expertise is being lost, in part because of the lack of academic training. In addition, the traditional methods of identifying plants (eg. Dichotomous keys) are not flexible to allow multiple options, which may lead to errors. They also mainly emphasize the use of flowers more than others plant organs, but the flowers are not always present or if they are, they can be inaccecessible (high in the tree tops). Finally, the use of technical terms in identification process poses a challenge for non-specialists.

It is in this view that a team in CIRAD has been working for several years on Plant Identification System named IDAO (French acronym: Identification Assistée par Ordinateur) to address challenges encountered in plants identification.

The originality of this software lies mainly in the use of an **identikit**[1] (user graphic interface) which reconstructs the plant using simple graphic representations. A specific identikit for mangrove plant identification was developed.

In the framework of *Mikoko* project, an Internet-based application was developed to facilitate identification of about 50 mangrove species. This application is also available for use in mobile devices like smart telephones or tablets.

The navigation page contains simple drawings representing a theoretical plant (the Identikit) and a menu with different functionalities on the right side of the screen.

The Mangrove Identikit is organized around 3 main zones (or drawings) where the user can interact with the app; they represent different botanical characters (Figure 1): the tree with roots on the left of the interface, the stem with leaves in the center and a detail of the leaf on the right side of the interface. The drawings are simple to facilitate the understanding of the users and theoretical enough to evoke a given organ without corresponding it to a particular species.

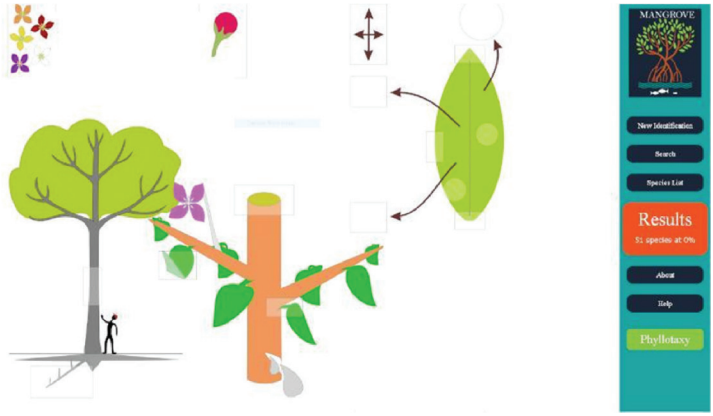


Figure1: Mangrove Identikit or user graphic interface.

[1]Identikit: because at each click the interface will be modified in order to represent the plant the user is looking for.

The user can choose any plant character (eg. type of roots, leaf type, type of fruit, color of the flowers) to start the identification process. Then by a simple click on the frames of the identikit, or on the different drawings, the user can choose the botanical characters available in the software that match with the plant under observation.

When the user slides the cursor on one of the drawings or frames, a window appears the name of the botanical character.

2.2 The identification process

To start the identification the user can choose any kind of botanical character, i.e. it is a multi-entry application.

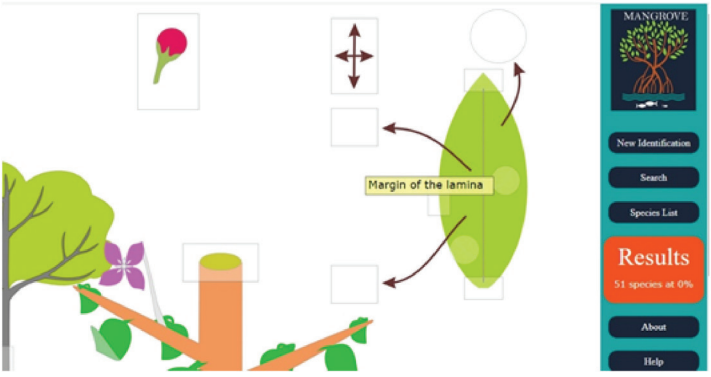
It is preferable to choose a small number of characters, of which you are sure. Remember that quality of the identification depends on keenness of your observation.

As the user goes through the identification, the orange "Results" button shows you how many species match the choices made by the user.

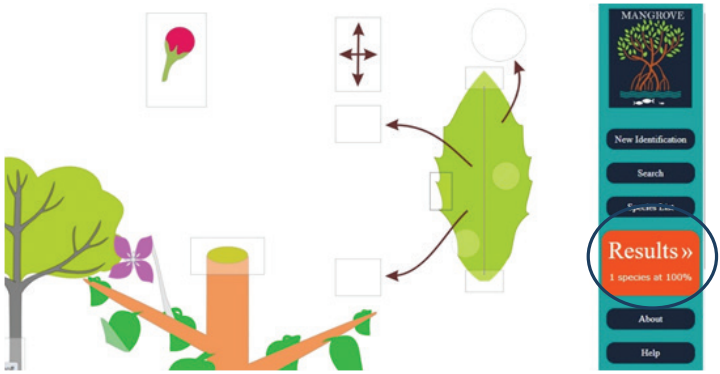
Example 1: Identification with few characters

Some characters common to only a few species (e.g., spiny leaf margin, particular berry fruit) can quickly give the identification (1 species at 100%).

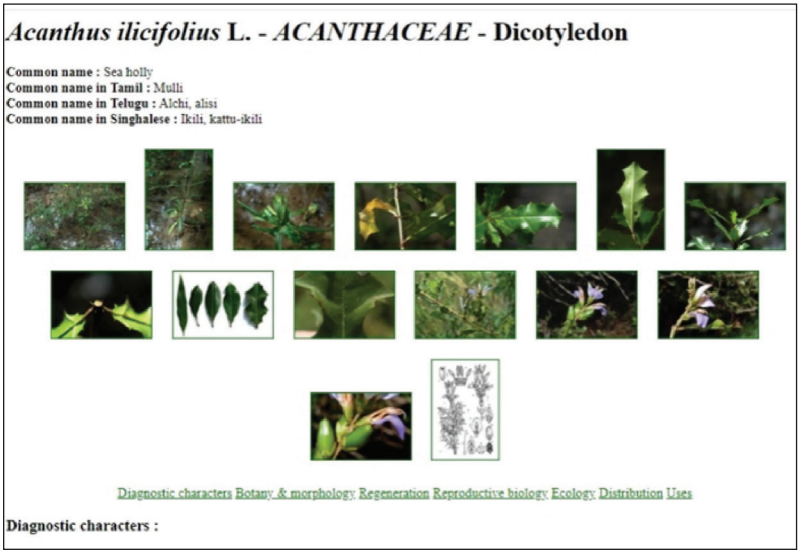
1. Choose "Margin of the lamina"



2 The orange "Results" button shows 1 species at 100%. The user arrives at the identification! Click on "Result" button and in this case is *Acanthus ilicifolius*.



A new window appears with the description of this *Acanthus*.



Example 2: Identification with many characters

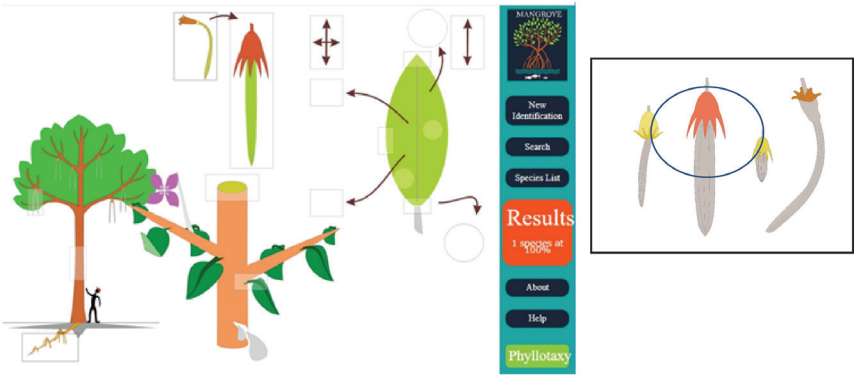
1) Choose **shape of the plant** by clicking on the whole plant; choose a **tree**. Remark the following changes:

- The chosen type of plant appears in the identikit interface and
- The number of species (orange button) pass from 51 to 29 species.

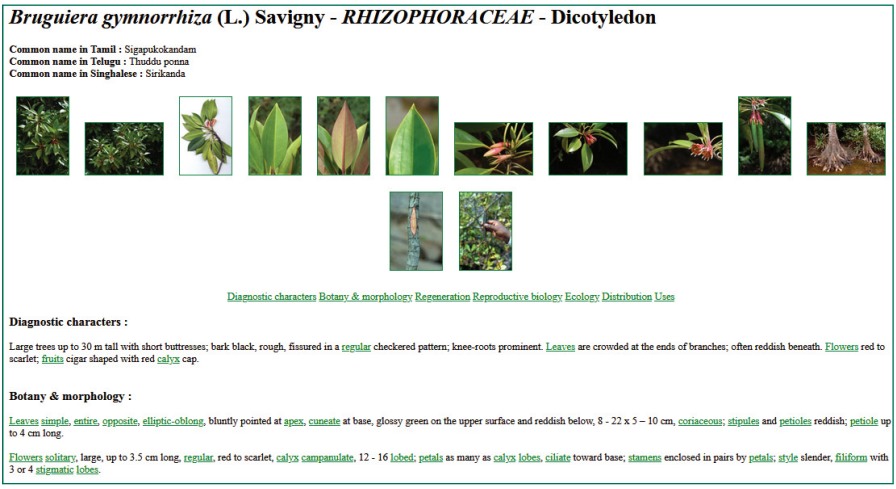
2. Then select another character, for example type of **leaf**; choose a **simple leaf;** then 25 species are trees with simple leaves. The number of species pass from 51 to 25 species.

3. Select type of **pneumatophore**; choose **knee pneumatophore;** then only 7 species are trees with simple leaves and knee pneumatophores.

4. Select type of **fruit**; chose propagule with red calyx



The user gets the identification of 1 species at 100%, in this case *Bruguiera gymnorhiza*. This implies that only one species matches with the combination of the characters chosen. By clicking on the results button, the user accesses the list of species ordered by a decreasing percentage of similarity, being *B. gymnorhiza* at the top of the list.



***Bruguiera gymnorrhiza* (L.) Savigny - *RHIZOPHORACEAE* - Dicotyledon**

Common name in Tamil : Sigapukokandam
Common name in Telugu : Thuddu ponna
Common name in Singhalese : Sirikanda

Diagnostic characters Botany & morphology Regeneration Reproductive biology Ecology Distribution Uses

Diagnostic characters :

Large trees up to 30 m tall with short buttresses; bark black, rough, fissured in a regular checkered pattern; knee-roots prominent. Leaves are crowded at the ends of branches; often reddish beneath. Flowers red to scarlet; fruits cigar shaped with red calyx cap.

Botany & morphology :

Leaves simple, entire, opposite, elliptic-oblong, bluntly pointed at apex, cuneate at base, glossy green on the upper surface and reddish below, 8 - 22 x 5 – 10 cm, coriaceous; stipules and petioles reddish; petiole up to 4 cm long.

Flowers solitary, large, up to 3.5 cm long, regular, red to scarlet, calyx campanulate, 12 - 16 lobed; petals as many as calyx lobes, ciliate toward base; stamens enclosed in pairs by petals; style slender, filiform with 3 or 4 stigmatic lobes.

When this percentage does not reach 100%, it means that the combination of characters chosen does not exactly correspond to any species listed in the application.

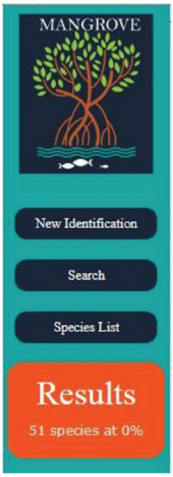
2.3 What can we learn from the identification of a species?

When the user arrives at 1 species at 100%, and clicks on the “Results” button, a new window gives the following information:

- The scientific name of the species along with family name,
- The list of synonyms and the common names in other languages
- The pictures of different plant organs,
- A detailed botanical descriptions,
- The major aspects of the species biology, ecology, distribution, uses,
- And the list of accessible bibliographical references on mangrove species.

2.4 Other functionalities of the Mangrove App

The « New Identification » button. This button serves to initiate a new identification; it puts the user interface at zero.

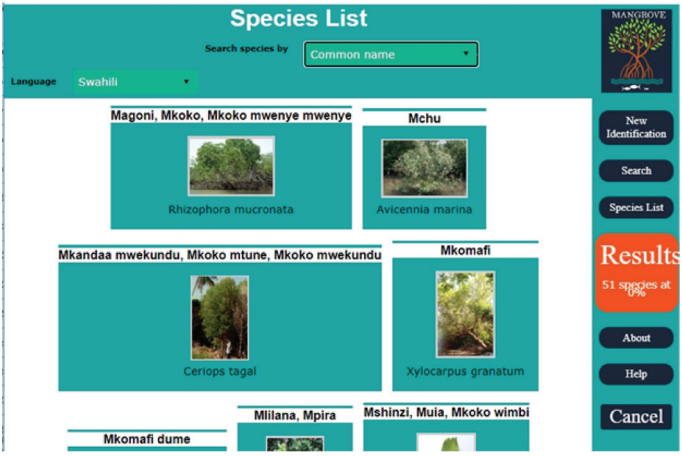


The **"Search" button.** The "Search" button may help the user to differentiate two similar species. If not able to differentiate the two species the software allows further search using different botanical characters until the user gets to one species at 100%.

The **"Species list" button.** If the user does not want to identify, he can directly access the species list by

- Scientific names listed in alphabetical order
- Plant family's names
- Plant common names
- Graphical View of Species (Listed in Alphabetical order)

These different options can be very useful when you want to quickly get more information for a species that you already know the identity.



This digital application offers a "trip" into the vegetal world of mangroves through an interactive approach. Without any knowledge of botany, you will be able to identify mangrove species of the Indian Ocean.

3 Kenya's Mangrove Participatory Knowledge Platform

Juliana Prosperi[1] & Prabhakar[2] R.
[1]**CIRAD -** juliana.prosperi@cirad.fr
[2] **Strand Life Sciences -** prabha.prabhakar@gmail.com

3.1 Introduction

Traditional "top down" approaches are unlikely to achieve the necessary changes for a sustainable mangrove ecosystem management and conservation. Instead, using a participatory knowledge platform, involving frontline stakeholders, will play a key role in ensuring acceptance of change and in creating the conditions for foresters and community based organizations to make effective contributions to their environment management.

In this perspective, a mangrove participatory knowledge platform was developed via a "social network" approach in the framework of *Mikoko* project, to facilitate sharing of knowledge and information among all stakeholders involved in mangrove conservation. In addition, it allows every stakeholder to contribute and build a database on mangrove ecosystem.

3.2 The process of building the participatory knowledge platform

To build a participatory knowledge platform it was necessary to communicate with the main *Mikoko* project stakeholders, (KFS, NMK, KMFRI, KEFRI, ICCA, CGL and local community) consulted and deliberated on the objectives, contents, structure and main functionalities of the platform. Two working groups were therefore, created to support the platform development:

1. Working group 1: devoted to the **platform content, data collection and curation** on the various studies done on the Kenyan mangroves. This group comprised representatives from KFS, NMK, KMFRI, KEFRI, ICCA, CGL and local community.

2. Working group 2: devoted to **technology development**. This group comprised of representatives from KFS and NMK, supported by experts from French Institute of Pondicherry and Strand Company in India recognized for their expertise in the field of information technology for biodiversity assessment. The platform is generic and extensible to other ecosystems. The program code is open source.

3.3 Participatory knowledge platform description

The participatory knowledge platform will gather and exchange relevant data and knowledge on mangrove socio-ecosystem, providing a reliable and sustainable mangrove management tool in Kenya. It is composed of 3 interconnected modules:

The Mangrove ecosystem module is a key module covering the biodiversity of mangrove with pages describing plants and animals occurring in the Kenya Coast. The structure of the species pages gather information on varied subjects as taxonomy, synonyms and common names in other languages, a detailed descriptions related to major aspects of the species biology, ecology, distribution, uses and a list of accessible bibliographical references used as sources on mangrove species descriptions. A set of pictures illustrating various aspects of species is also available.

This module also hosts a graphical tool to help identify plant species of mangrove ecosystems.

The Livelihoods module is devoted to diversity of socio-economic activities. The structure of this module has the flexibility to receive various information from bibliographic sources, from scientific partners involved in the management of mangrove resources and enriched with knowledge from local users. This module also covers the extent

or the importance of certain uses and their possible methods of harvests as well as their markets and demands.

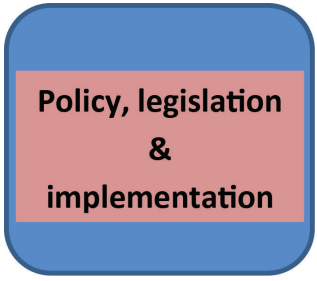
The **Monitoring Module** is essentially based on the compilation and analysis of maps offering a visual spatial and temporal representation, observations (photos), field data on different thematic categories including (mangrove forest, mangrove plantation, degraded mangrove, villages, infrastructures, aquaculture...).

What is interesting to monitor? Land occupation, evolution of tree planted, destructive activities, rehabilitation methods and techniques used in Kenya (and in other regions of the world). Best practices and challenges are highlighted to learn from experiences of different initiatives on protection and restoration of mangroves for continual improvement.

3.4 Stakeholders of the Participatory Knowledge Platform

The platform to be implemented are anchored under the National Mangrove Ecosystem Management Plan 2017 - 2027 of Kenya whose implementation spearheaded by **Kenya Forest Service** (KFS), along with other key actors such as State Department of Fisheries and Blue Economy, **Coastal County Governments,** Kenya Wildlife Service, research institutions, and local Communities along the coast.

The contribution of main stakeholders to the platform are identified as follows:



The policy and legislative frameworks that guide the implementation processes are led by the following government agencies including; the **National Environment Management Authority**

of Kenya (NEMA), KFS, KWS, SDF&BE, **Coastal County Governments.** The Ministry of Lands, Physical Planning, Housing, Urban Development, Infrastructure and Energy are involved in providing planning, ICT expertise and data.

Local communities who are involved in the participatory management framework of the mangrove resources are the first and the ultimate stakeholders of the *Mikoko* participatory platform. The community may be organized in groups with different interests, knowledge and practices. This plays a key role in knowledge exchange, use and promotion of the participatory platform on the mangrove ecosystem.

The research institutions contribute scientific knowledge to this platform. The institutions include: Kenya Marine and Fisheries Research Institute (KMFRI) provides scientific data and information for sustainable exploitation, management and conservation of Kenya's marine resources.

Kenya Wildlife Service (KWS) contribute in assessment of wildlife biodiversity in marine ecosystem.

The **Kenya Forestry Research Institute** (KEFRI) with the Coast Eco-Region Research Programme (CERRP) is mandated to conduct research and provide information and technologies for sustainable development and management of forestry, which includes mangroves and other terrestrial forests.

National Museums of Kenya (NMK) contribute with biodiversity and bioinformatics data and reconstruction of the past changes in mangrove.

Institute of Climate Change Adaptation (ICCA-University of Nairobi) and **South-eastern Kenyan University** (SEKU), provide data on climate change issues, policy conservation, community participation and biophysical and ecological aspects.

CIRAD & IRD provide financial, scientific and technical capacity to the platform. In addition, they provide mentorship and training to reinforce local capacities.

3.5 Be part of this initiative!

https://portal.mikoko.co.ke/?lang=en

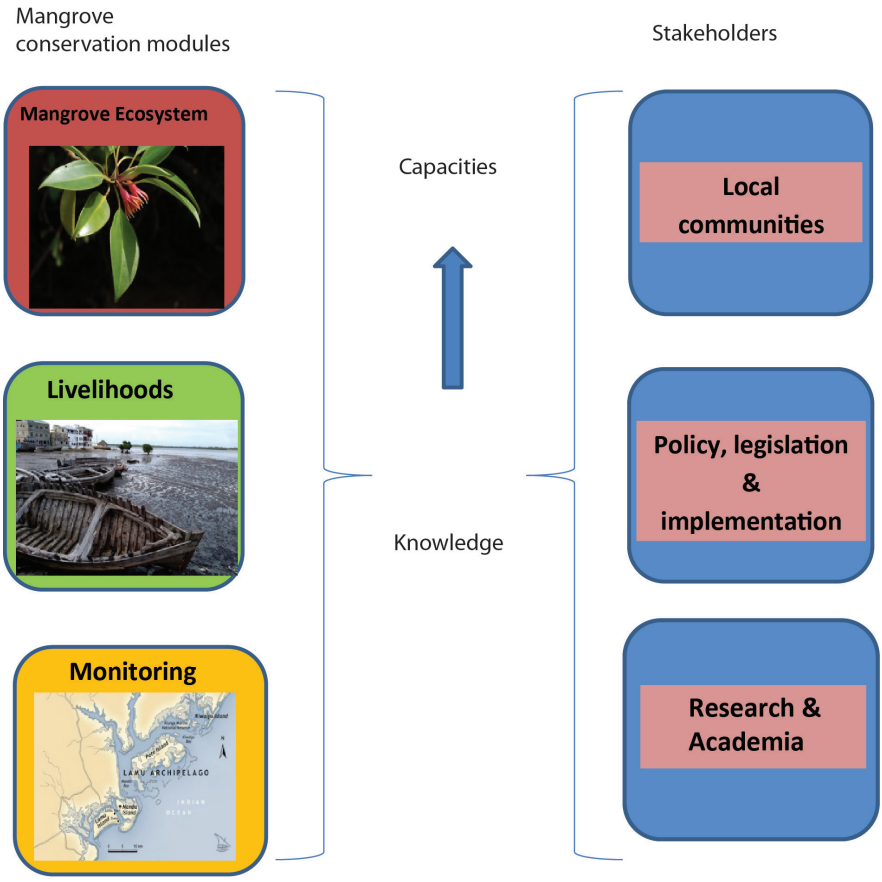
The platform facilitates communication processes among the stakeholders, enables community engagement, serves as an instrument to cooperate, stay up to date and promote positive changes.

Stakeholder engagement and participation is essential for effective conservation and management of mangrove ecosystem.

Sharing compiled data, such as indicators, changes in forest cover, vulnerabilities, socio-economic priorities, among others, could be very useful for governance and participatory management decisions.

The platform counts on your participation and contribution for its sustainability!

Participatory knowledge platform diagram



References

Buckingham S., Aberer K., Schmidt A., *et al*. 2012. Towards a global participatory platform: democratising open data, complexity science and collective intelligence. European Physical Journal Special Topics, 214(1), pp. 109–152.

Herringshaw V. 2018. Increasing citizen voice and government responsiveness: what does success really look like, and who decides? Making All Voices Count Programme Learning Report, Brighton:IDS

Kusters, K., Buck, L., de Graaf, M. *et al*. 2018. Participatory Planning, Monitoring and Evaluation of Multi-Stakeholder Platforms in Integrated Landscape Initiatives. Environmental Management 62, 170–181 (2018). https://doi.org/10.1007/s00267-017-0847-y

Maxwell J., Allen S., Brooks T., *et al*. 2018. Engaging end-users to inform the development of the global standard for the identification of key biodiversity areas. Environmental Science & Policy. Volume 89, November 2018, Pages 273-282; https://doi.org/10.1016/j.envsci.2018.07.019

Montana J. 2017. Accommodating consensus and diversity in environmental knowledge production: Achieving closure through typologies in IPBES. Environmental Science & Policy. Volume 68, February 2017, Pages 20-27. https://doi.org/10.1016/j.envsci.2016.11.011

Vattakaven T., George R., Balasubramanian D., *et al*. 2016. India Biodiversity Portal: An integrated, interactive and participatory biodiversity informatics platform. Biodiversity Data Journal 4: e10279. https://doi.org/10.3897/BDJ.4.e10279

4 Mangrove restoration interventions

Henry M. Komu - KEFRI – henrymwaka@gmail.com

4.1 Introduction

Restoration and rehabilitation are integral part of 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 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. The two are closely related in terms of basic practices, therefore reference can be made for either depending on the forestry management goals.

4.2 Restoration guidelines

Mangrove restoration can be either through natural regeneration or through aided/artificial regeneration. Natural regeneration relies on natural succession processes mediated by biophysical factors. Where natural regeneration is not feasible, human interventions are required to initiate recovery of any degraded site. This entails addressing drivers of degradation and further active interventions to correct abiotic damage and trigger biotic recovery process (Plate 1).

The following steps are essential for effective implementation of a restoration project:

1. Understand both mangrove species and site ecology - patterns of reproduction, propagules distribution, seedling establishment and site history
2. Understand the site hydrologic regimes - this is responsible for controlling distribution and successful establishment and growth of targeted mangrove species
3. Establish drivers of degradation hampering natural secondary succession - this should also involve the local knowledge of communities depending on the mangroves
4. Select the appropriate restoration site based on the information gathered in step 1-3
5. Design the restoration program - the focus should be to restore or create normal hydrology, or remove or reduce stress/degradation drivers to aid natural revegetation. If natural regeneration fails after the initiated interventions, then planting of mangroves is prioritized
6. Preparation of planting - this will entail selection of appropriate mangrove species, populations and individuals for planting, sourcing of planting materials and mobilizing labor for the actual planting. The sources of seeds/propagules for planting of mangrove include: direct planting of collected propagules, transplanting of wildlings and seedlings raised in nurseries.
7. Monitoring of planted sites - Monitoring is fundamental in determining whether objectives of reforestation have been achieved. Aspects like growth rate, mortality rates, new recruitment and other environmental variables are recorded from time to time; a monitoring schedule will be prerequisite for this matter. This will also inform site improvement management decisions in case the objectives are not met.

Figure 1. Mangrove restoration activities in degraded areas.

4.3 Mangrove nurseries

Establishment of mangrove nurseries is essential where natural regeneration is unreliable due to: unfavorable soil conditions, absence of nearby seeding trees and seeding patterns fail 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. Mangrove nurseries can be categorized into two

- **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 permanent nursery in design and its work intensive
- **Flooded mangrove nursery** - It's established in low intertidal zones with regular flooding of sea water. It is a temporary nursery that provides seedlings for one or two years and doesn't require a lot of efforts to establish and maintain.

When establishing the nurseries (Plate 2), emphasis should be given to:

Site selection

Site selection is an important first step in mangrove nursery establishment is the first important step in nursery construction. The choice of the site influences the survival rate of the established seedlings, and consequently the success of restoration programs. An ideal site for mangrove nursery is characterized by:

- Relatively flat land
- Close to planting site
- Ease to access
- Good drainage
- Protected from disturbances e.g. strong waves, livestock

Nursery set up

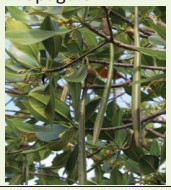
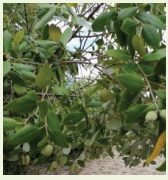
This entails preparation of soil, seedbed, potting and arrangement of the filled tubes in the seedbed. After site selection, the area needs to be cleared off any debris to create space for setting up seedbeds and soil potting. The size of the nursery will depend on the target number of seedlings being raised. The seedbeds are dug up to a depth of about 20cm and 1m width separated by a footpath of 30cm wide. Small ditches are also dug to provide good drainage and irrigation in the seed beds. The potting soil is usually collected from nearby areas where the specific species are growing. Once the seed beds are ready, potted tubes are arranged in an orderly manner, with about 2/3 of the tube beneath the soil surface. The tubes are also

reinforced along the boundaries of the seedbed using wooden bars to avoid being swept by tidal waters.

Seed collection for various mangrove species

The various mangrove species display different flowering, fruiting and seeding patterns which may not guarantee availability of propagules/seeds throughout the year. Therefore, nursery establishment should coincide with the peak seeding season of the specific species to maximize on planting materials availability. Therefore it is essential to understand the nature of the planting material, indicators at maturity, peak collection period and storage conditions if planting is not taking place immediately. The table below gives an overview of these parameters for five common mangrove species in Kenya

Table 2. Overview of main parameters considered for planting common mangrove species in Kenya.

Species-Local Swahili name (scientific)	Type of seed/Planting material	Indicators of maturity	Peak availability period (May vary from site to site)	Storage conditions
Mkoko (Rhizophora mucronata)	Propagule 	Turns from dark green to pale green, Ring like mark below the cap Yellow collar, Length >30cm	March - June	Cool and wet, for maximum of 30 days
Mchu (Avicennia marina)	Propagule 	Seed coat changes from green to light yellow, Seed coat becomes wrinkly and often opens, Weight of 100 seeds >150g	April - May	Cool and wet, for maximum of 5 days
Mkandaa (Ceriops tagal)	Propagule 	Light yellow collar, Body changes from green to brown, Ring like mark below the cap Length >20cm	February - March	Cool and wet, for maximum of 15 days
Mlilana (Sonneratia alba)	Fruit 	Fruits turn shiny or yellowish and soft Float in water, Fruit diameter >4cm	September-November	Cool and wet, for maximum of 5 days
Muia (Bruguiera gymnorhiza)	Propagule 	Green propagules turns to Reddish brown and drops without the cap, Length >15cm	April - July	Cool and wet, for maximum of 10 days

Seed sowing

Propagules are planted upright at the centre of the tube with almost 1/3 of the propagule beneath the soil, while seeds are sown directly in the tubes.

Nursery management (Plate 3)

- **Shading:** Shade is necessary to protect young seedlings from strong sunlight or heavy rainfall. Shade structure should be at least 1.5m above the ground to ensure easy access while maintaining the seedlings. Shade nets, leaves and other materials can be used to provide the shade at the initial stages of growth which can be completely removed after three months.
- **Weeding:** Weeding is done regularly to reduce competition from weeds.
- **Rooting management:** the potting tubes are rearranged once every three months to prevent roots from penetrating deeply into the soil.
- **Nursery requirement:** The nursery requires regular monitoring by visiting at least 2-3 times weekly to ensure that the plants remain upright, healthy, receive regular watering and are protected from pests and stray animals.

Figure 2. Mangrove nursery activities ©PMCC

4.4 Why restoration interventions may fail?

A restoration project is considered successful when the survival rate of at least 85% is attained. At this state, the mangroves may regain functionality similar to natural stands when left to grow undisturbed. However, some of these initiatives do fail due to the following technical and bio-geophysical factors (Plate 4):

- Poor site/habitat selection
- Poor species site matching
- Inadequate knowledge and information on mangrove functionality
- Inappropriate selection of mangrove planting material
- Planting along water channels
- Improper depth of planting propagules
- Adverse changes of environmental conditions
- Failure to eliminate human-induced site stressors
- Inadequate monitoring after planting seedlings
- Failure to involve communities and other stakeholders

Poor site selection

Figure 3. Inappropriate restoration activities.

CHAPTER IV

Policy and Governance Frameworks in Mangrove Ecosystem

1 The Kenya National Mangrove Management Plan

1.1 The Evolution of mangrove forest plans in Kenya
1.2 Why the National Mangrove Ecosystem Management Plan 2017-2027?
1.3 Steps in the Preparation of the plan
1.4 Strategy in development of the plan
1.5 Contents of the plan
1.6 The management programs of the plan
1.7 Implementation of the plan

2 Participatory Forest Management Process: Experiences

2.1 Introduction
2.2 Forest Management Regime Trend Outline
2.3 Main steps in PFM process
2.4 Lessons learnt

3 Formation of Community Forest Associations

3.1 Introduction
3.2 Governance Structure of CFA

4 Community based organizations in Lamu County

4.1 Introduction
4.2 Beach Management Units
4.3 Community Forest Association

1 The Kenya National Mangrove management plan

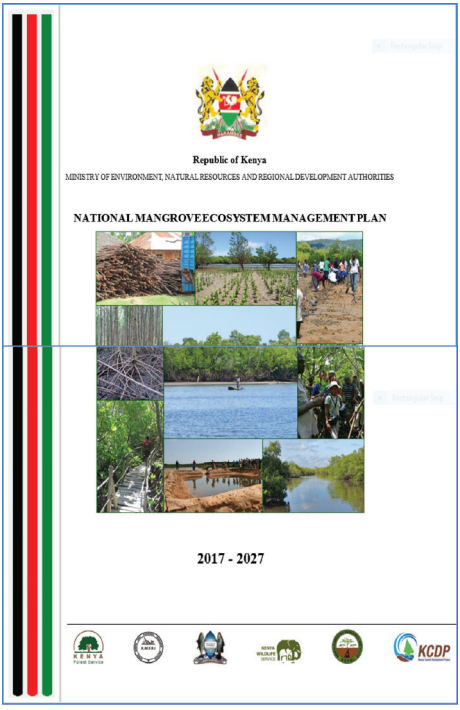
Judith Okello - KMFRI - judith_okello2003@yahoo.com

Forest management plans are prepared to ensure effective management of forest resources by offering adequate management prescriptions. While terrestrial forest ecosystems in Kenya have had management plans, which are reviewed and renewed over prescribed periods of time, mangroves have not been given such considerations. Cognizant of this fact, the KFS together with other stakeholders formulated a ten-year (2017 – 2027) National Mangrove Ecosystem Management (NMEM) Plan of Kenya, which covers all mangrove forests in Kenya.

1.1 The Evolution of mangrove forest plans in Kenya

For a long time, mangrove forest resources were believed to be inexhaustible. At that time there existed the custom of freedom to exploit and use by all who could access it. In the 1940's however, the colonial government took strict controls of exploitation by granting concessions to private firms and monitoring their activities. This was put as a measure to ensure some level of sustainable harvesting of the wood and wood products. The colonial government later in 1951 introduced the first working plans for the mangroves of Lamu. These plans were focused only on reducing cutting pressure, targeting specific mangrove sites along the coast. Mangrove exploitation was thus based on a quota system; whereby the Kenya Forest Service approved the quantity of mangrove poles to be removed from a particular area relying on subjective assessment of forest conditions. Lamu mangroves had a first ever thorough inventory conducted in 1967, and later repeated in 1982 giving rise to the current 5 blocks. Later, in 1993 the entire mangroves of Kenya were surveyed again; but no management plan was developed.

1.2 Why the National Mangrove Ecosystem Management Plan 2017-2027?



Despite all the efforts described above, the problems of mangrove deforestation intensified and spread throughout the coast; including within Marine Protected Areas. While the previous plans were focused only on reducing cutting pressure, the NMEM Plan 2017-2027 is the first in Kenya to consider the entire mangrove ecosystem. It was drawn in compliance with the legal requirement under section 35 of the Forest Conservation and Management Act (2016), which provides for preparation of management plans for all State forests. It addresses the lack of ecosystem-based management approaches for mangroves in Kenya, and supports sustainable utilization of mangrove resources while enhancing biodiversity conservation and ecosystem integrity. It marks the beginning of a journey towards sorting out issues identified in the Kenya Forestry Master Plan (KFMP) of 1994, including deforestation and degradation of forests, problems which are still with us today.

These issues are also reflected in the Forest Conservation and Management Act (2016) and Kenya's Vision 2030.

1.3 Steps in the Preparation of the plan

- The development of this plan entailed the following:
- Constituting a National Mangrove Task Force – this comprised government institutions: Kenya Forest Service (KFS), Kenya Wildlife Service (KWS), Kenya Marine and Fisheries Research Institute (KMFRI), Kenya Forestry Research Institute (KEFRI), and State Department of Fisheries. A member from the Forest Conservation Committee (FCC) was also co-opted in the committee to represent community interests.
- Reviewing literature and consulting with expert groups and agencies
- Carrying out field surveys to collect data
- 24 consultative meetings and workshops held between Aug 2012- Sept 2016
- Circulation of draft to internal and external experts for reviews
- National stakeholders' workshop to review and validate the final draft plan.
- Launch of the plan

1.4 Strategy in development of the plan

This management plan seeks to balance the needs of the people of Kenya with opportunities for rehabilitation, conservation, and sustainable utilization of mangrove resources. As such, the Ecosystem-Based Management (EBM) approach was used to guide the Plan development (*Convention on Biological Diversity*) anchoring on the fact that ecosystems must be managed within the limits of their functioning. The Plan has taken cognizance of other existing policies relating to land and land use, tenure, agriculture, fisheries, energy, environment, mining, wildlife, and water. It also embraces collaborative and participatory approaches in natural resources governance that leads to ownership of the initiatives by the stakeholders.

Data Sources

- Vegetation structure, community composition, & utilization.
- Information generated through GPS mapping (correction of vegetation boundary)
- Reviews of stocking & regeneration rates.

1.5 Contents of the plan

The management plan has eight chapters. The first four chapters provide background information mainly obtained from review of existing literature. Chapter 5 provides a county-by-county situation analysis of the mangroves including information on cover, species, stocking rates, merchantable volume, and natural regeneration. Additionally, issues on utilization and major threats as ranked by the local community as well as actions specific to each mangrove area are outlined. Chapters 6 to 8 prescribe actions that ought to be taken to effectively manage the mangroves of Kenya.

Contents of the plan

1.6 The management programs of the plan

The Plan prescribes actions for management of mangroves in all the counties through six programs as outlined below and their respective objectives:

Management Programs	Objectives
Mangrove forest conservation and utilization	Retain status of protected areas for Climate change mitigation Promote sustainable harvesting of mangrove wood products by ensuring that felling plans availed to the five counties Rehabilitate degraded mangrove forest areas, by increasing replantation efforts, encourage natural regeneration and establish nurseries for continued supply of planting stock Improve policing and protection of mangrove areas from illegal human activities through availing surveillance equipment and deploying rangers to strategic out posts
Fisheries management	Identify and map degraded fish habitats for restoration so as to prioritize them for rehabilitation Promote adoption of silvofisheries in mangrove areas to ensure food security while reducing forest degradation Promote active participation of communities in fisheries resources management through improved co-management in fisheries
Community	Strengthen local institutional capacity in mangrove management and conservation Promote nature based enterprises and networking for livelihood improvement thus reduce pressure on mangrove ecosystem Develop and implement community awareness strategies and training programs Strengthen community participation in formulation and implementation of relevant policy and legislative processes Develop conflict resolution mechanisms to address emerging disputes

Research and education	Promote research and education on conservation and management of mangrove and associated ecosystem
Tourism development	Develop an effective tourism plan and infrastructure through increased tourism infrastructure and activities Develop and enhance marketing strategies Improve and diversify tourism products including culture and ecotourism Enhance community capacity in tourism entrepreneurship by establishing community owned tourism enterprises Develop and implement stakeholder benefit sharing strategy taking into consideration gender equity
Human resource and operations	Provide and maintain adequate infrastructure and equipment in key institutions Develop and maintain adequate and competent human resource thus improved service delivery Strengthen institutions involved in mangrove management and promote collaboration among stakeholders

1.7 Implementation of the plan

A number of institutions will be involved in the implementation of the Plan including but not limited to:

- Kenya Forest Service
- County Governments
- Kenya Wildlife Service
- Community Forest Associations
- Kenya Marine and Fisheries Research Institute
- Kenya Forest Research Institute
- Kenya Tourism Board
- State Department of Fisheries and Blue Economy.

As per the Forests Conservation and Management Act 2016, KFS Directorate is the highest office for management plans implementation. The existing structures will be integrated in the proposed implementation structure of the plan (Figure 1) with some additions to address mangrove ecosystem issues. A national mangrove management committee (NMC) will be constituted to serve as an advisory organ to the Head of Conservancy (HOC) who will also serve as the secretary for the NMC. Each county will have its own mangrove County Management Committee (CMC) headed by the ECs. Membership of CMC will include technical persons from the County Government, KWS, SDF; as well as CFAs/community representatives and the Private sector. CMC will also guide the development and implementation of the operational plans, in compliance with the National Management Plan frameworks. The CMC will have the power to incorporate the user groups and other stakeholders concerned with the mangrove ecosystem resources.

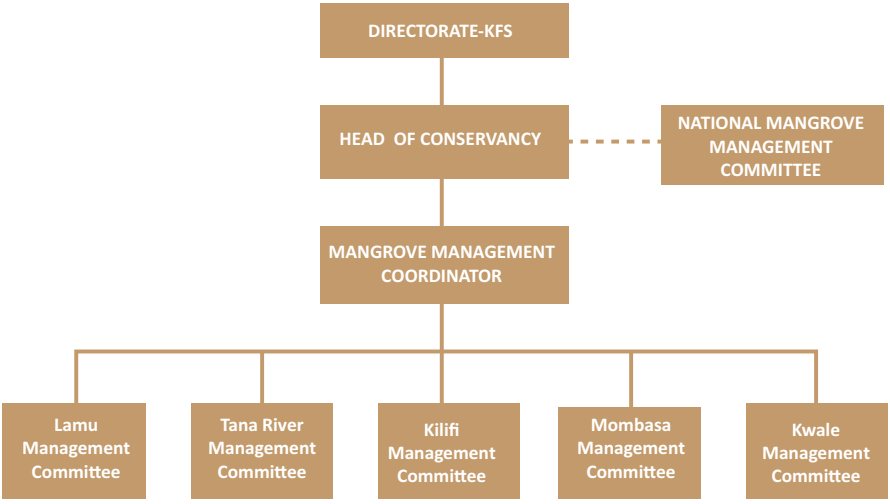


Figure 1. Implementation Structure for the Mangrove Management Plan. Source: GoK (2017), National Mangrove Ecosystem Management Plan. Kenya Forest Service, Nairobi, Kenya.

2 Participatory Forest Management Process: Experiences

Musingo T. E. Mbuvi -KEFRI - mtembuvi@gmail.com

2.1 Introduction

Forestry sector in Kenya has undergone major policy reforms. Prior to 1891 forest and natural resource use was controlled through a system of traditional rules & regulations with no formal policy and were enforced by a council of elders through sanctions and fines. The first forest legislation, in 1891, which focused on the protection of Mangrove swamps of Vanga Bay, was extended to protect mangroves throughout the coast in 1900. The Sessional Paper No. 10 of 1965 on African Socialism and its application to planning in Kenya was the first policy document to recognize the need to conserve natural resources for all future generations and expressed concern about the quality of the environment. The government has progressively reserved and meticulously conserved forest resources. This has led to displacement of local communities and/or their exclusion from access and usufruct rights to land, forests and forest resources. This was sustained by forest legislations notably the Forest Act 1968 (CAP 385) that did not allow community to participate in forest management.

Global practices that supported multi-stakeholder participation in forest management led to a repeal of the CAP 385 to the Forests Act 2005 which was supported by adequate consultation and expert guidance and provided for community and other stakeholder participation in forest management. The Forest Act 2005, was repealed to align with the Kenya Constitution 2010 to Forest Conservation and Management (FCM) Act 2016. This has supported decentralization and devolution of forest management as required by the constitution 2010 which also obligates the state to ensure that communities participate and benefit from natural resources. In Kenya community and other stakeholder participation in forest management

is being implemented through Participatory Forest Management (PFM). Participatory Forest Management was initiated as a pilot alternative management approach in Arabuko Sokoke forest in 1997 before it could be applied nationally in almost all forest station in Kenya. It was perceived that it could lead to better resource management because it promotes local participation, accountability at the level of resource users and empowerment of communities.

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. This approach is guided by several principles as listed below:

- Sustainability
- Participation
- Negotiation
- Dynamism and flexibility
- Strategic and operational planning
- Indivisibility
- Accessible information
- Community participation
- Accountability
- A process approach based on learning by doing
- Appropriate representation & responsibilities
- A supportive policy and legal framework
- Building capacity for long-term change
- Partnerships and networking

2.2 Forest Management Regime Trend Outline

Forest management in Kenya has evolved for over 100 years as outlined in figure 1.

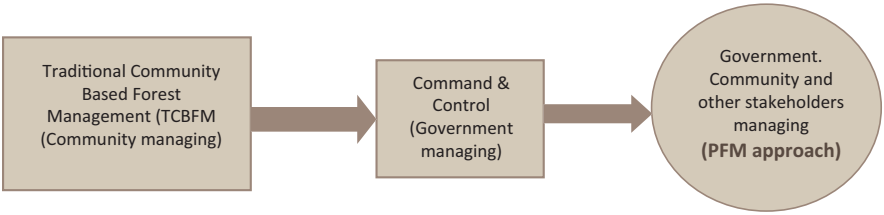


Figure 1. Development of forest management in Kenya.

2.3 Main steps in PFM process

These steps do not always have to be followed in a progressive manner due to the iterative nature of PFM[1] implementation process and include:

1. Identify community and resources

- Visit the area and talk with local residents and opinion leaders
- Assess feasibility (undertake viability in forests where PFM is being implemented) of implementing for PFM and other activities
- Form a representative local planning team
- Agree on the information to be collected
- Stakeholder analysis

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

- Keep the general public informed throughout the entire process.
- Form or facilitate the development of a new organization as per existing social systems and regulations.
- Identify if there are any groups and assess the possibility of re-forming it. If none are available facilitate the formation of a new

[1]http://www.kenyaforestservice.org/documents/pfm/PFM%20Guilines%20Final%202016.pdf

one CFA as per existing regulations. Community Forrest Associations in Kenya has evolved from a Village Development Committee (VDC) during the pilot to the present community organization that has been developing to accommodate emerging changes.

Table 4.1 Changing face of CFA (1997 to 2020).

Village Development Committee (VDC) in 1997	**to CFA in 2020**
• VDC 1997 • Community mobilization • Formation of organizations and guidelines • Forest conservation and live-lihoods • Awareness • Rural development • Forest development **Get our forest back**	• CFA 2020 • Environmental • Biodiversity • Conservation, livelihoods, industrialization (wealth creation) • Sustainability • Politics and elite capture • Investment inside and outside the forest Governance **Joint management of the forest**

- Consider aspects of fair representation and literacy level of representatives
- Create awareness on various NRM legislation, CBO guidelines, CFA formation guidelines, Societies Act etc
- Provide technical and management advice to the community
- Capacity building of all stakeholders

3. Assessing the Forest Area and Communities

This step determines the status of available resources, the demand for forest products and services required by the society and the supply that the forest and surrounding areas can provide.

This will also facilitate the development of mechanisms to meet extra demand or utilize excess supply. The key steps include:

- Undertake socio-economic surveys.
- Undertake participatory resource assessment in the community and forest areas.
- Analyse and write up the findings.
- Organise public meetings at community level to share the main findings.

4. Preparation and Launch of a Forest Management Plan

This is a critical step since it deals with the five practical questions: who, what, when, where, how? The process will lead to development of a plan. A forest management plan refers to a systematic programme that shows all activities to be undertaken in a forest for a period of time. The activities include: Conservation/Protection; utilization; silvicultural operations; infrastructural development, human and financial resources required to implement the plan and develop the area. This will also identify appropriate income generating activities that could be undertaken in the area. The key planning steps include:

- Developing and agreeing on a common vision and main management objective(s)
- Zonation identifying clear external as well as internal physical boundaries.
- Negotiating and agreeing on the main roles and responsibilities of each stakeholder.
- Presentation of the draft plan to the public for comments and endorsement
- Approval by responsible body

It is very important to recognize the planning levels that could include:

a) Master plan that sets national goals (County goals)
b) Strategic Forest Management Plan
c) Landscape forest restoration plans
d) Operational site specific plan and could be for one forest station
e) Work plans that are activity based

5. Negotiating and Signing Forest Management Agreement

- Preparing a draft resource management plan as outlined in the Forest Management Agreement (FMA) guideline
- Present the agreement at all levels for information and consensus building
- Signing of the agreement preferably in the village
- Starting PFMP implementation for the target resource

6. Implementation of the Plan

- Developing implementation mechanisms
- Demarcating the target resource into management zones
- Operationalize the plan through holding regular meeting, keeping records, good flow of information, conflict management etc.
- Making an annual presentation of progress and work plan
- Undertaking experiential sharing activities
- Enhancing costs and benefits between the stakeholders with special consideration for communities and members of forestry Community Forest Association
- Issuing or managing new licenses, leases and sub contracts

7. Review and Revision of the Plan

- Review progress against achieving plan objectives
- Data collected during the year should be analysed to identify trends and changes within the target resource
- Recorded and catalogued data from each activity/resource by the responsible body like KFS for forests and fisheries for fish.
- Encouraging responsible body like KFS together with Forest Associations to publicise and document lessons and experience

8. Impact Monitoring of PFM

- In-building a participatory monitoring system with clear indicators in the PFM process
- Publicise the results through radio, newspapers, magazines, TV and other forms of public media
- Assess if PFM is improving forest conservation, productivity and peoples' livelihood.
- Assess impacts of PFM on target resource and other commonly held resources
- Assess the value of expanding PFM to other areas.

2.4 Lessons learnt

- Implementation of PFM in Mangroves of Kenya would learn from the following lessons'
- PFM is a process guided by principles, laws, guidelines, plans and manuals
- PFM leads to joint forest management and not community ownership of the forest
- Know yourself, the resource and the landscape
- PFM requires formation of teams and partnerships
- PFM incomes are low and alternative livelihood sources have to be developed for sustaining community participation
- The CFA has to manage expectations and community and other stakeholder needs and interests
- Capacity building has be continuous
- PFM process requires flexibility due to the continuous changes in organizations and Institutions

3 Community Forest Association formation

Josyline Thambu - KFS - josylineg@yahoo.com

3.1 Introduction

Community Forest Associations (CFAs) are community-based organizations established with the aim of co-managing forest resources with central and local government institutions, following the introduction of Participatory Forestry Management (PFM) in Kenya from 1997. The recognition of CFAs as a legal entity was entrenched in the subsequent forest legislations.

Community Forest Association (CFAs) formation and registration guidelines 2009, PFM guidelines 2015 and Participatory Forest Management Plans development guidelines provide further elaboration for community participation in forest management. The country has witnessed enormous development of CFA organization with; 255 CFAs registered out which 156 CFAs have had their Participatory Forest management Plans approved with 99 of those plans having had their Forest Management Agreement signed. The country also has 2 Concessions for Kibwezi and Ngare Ndare where CFAs are partners. Overall 79.3 % of the CFAs are active (PFM Field report 2019).

In order to have CFAs continue engaging effectively in forest management they require Capacity Building (Strategic Plan 2014-2017) and CFA should practice good governance, which is supported by their formation process and their governance structure.

3.2 Governance Structure of CFA

The CFA organizational development process steps are defined in the CFA formation and registration guidelines 2009 as outlined below;

a) Identification and negotiation stage
b) Scope of activities for the CFA
c) Establish CFA rules and regulations

d) Organize and facilitate transparent and fair elections for CFA
e) Capacity Building for the CFA and Forest Committee
f) Form a forest level management committee

The typical CFA governance structure should include:

1. CFA Executive and management roles,
2. Oversight functions organized into
    a) Structures and Financial,
    b) Human resource and procurement
    c) Conflict resolution
    d) Any other function agreed upon from time to time

The CFA being established should ensure:

a) Local community commitment to protect the forest
b) Institutional growth and sustainability
c) Democratic governance
d) Open and inclusive membership
e) Resource access by non-members and other stakeholders
f) Cheap membership registration
g) It controls the organization been captured by self-seekers ("my association") or formed by an individual (or a few) or formed for personal gain

Sustained CFA development will depend on:

a) Availability of forest resource
b) Level of forest dependency by community
c) Available community livelihood options
d) Strong local leadership
e) Response of KFS
f) Community responsiveness
g) Co-operation within the community and other stakeholders
h) Existence of other supporting and facilitating institutions and organizations

The formation and sustainability of CFA require clear defined roles of each stakeholders. The role of KFS as a key stakeholder include:

1. Identification of existing community structures:
    - If they exist, it is advisable to help the community to restructure to comply with forest act
    - If no suitable existing structures exist it is advisable to assist in formation of CFA
    - Develop membership recruitment criteria if none exist
    - If the area is large it may be necessary to form more than one CFA
    - If there is more than one CFA operating in an area an umbrella organization may be formed
2. Provision of technical and management advice could be done through
    - Spending more time with community explaining the Government policy and relevant environmental and forestry legislation
    - Assisting the community to prepare rules and regulations
    - Preparing the community for a public event to elect members of forest association committees which should be guided by constitution
    - Deciding and agreeing on criteria for elections. Make sure that the committee is representative of the main users and interest groups
    - Taking into consideration gender and disadvantaged members of the CFA
3. Organizing and facilitating transparent and fair elections for community members to be elected to sit on FAC realizing that
    - The forest association committee will be responsible together with other named stakeholders for management and conservation of the forest
    - Prior to the election those nominated are clear on the roles and responsibility that each committee member is expected to undertake once elected

4. Provision of capacity building to committee members on site where possible through training in
    - bookkeeping, monitoring and recording of activities
    - Leadership training
    - Public speaking and presentation of information
    - Conflict Management and negotiation skills
    - Communication
    - Delegation and supervision

5. As appropriate initiate formation of forest level management committee
    - One or more members of the FAC may be a member of FLMC
    - In state forests is likely to comprise Foresters, KWS warden, CFA chairman and any other locally important stakeholder

The roles for each partner and stakeholder would need to be reviewed from time to time to accommodate changing PFM implementation scenarios and demands.

- The following recommendation will enhance CFA performance
- Regular updating of CFA records.
- Regular monitoring of CFA performance/progress
- Capacity assessments and gap-filling (capacity building
- Adherence to applicable laws, guidelines and manual

CFA in other parts of the country are facing challenges that the Lamu CFA need to be wary of that include;

- Political and elite capture which interferes with activity implementation
- Wrangles and conflicts
- Inadequate implementation of the plan
- Lack of succession planning leading to election wrangles
- Non-adherence to constitution and FMAs

4 Community based organizations in Lamu County

Mohamed Kubwa – Office of the Lamu County Woman Representative m.kubwa2018@gmail.com

4.1 Introduction

The county has several community based organizations (CBOs) and Self Help Groups (SHG) located in the two constituencies of Lamu County. In Lamu East there are three Wards and Lamu west has seven Wards. The Ministry of Social Services, Lamu County has registered community groups categorized as follows:

1. Community Based Organizations (CBOs)
2. Self Help Groups (SHGs)
3. Women Groups (WGs)
4. Youth Groups (YGs)
5. People Living With Disabilities Groups (PLWDs)

The county has approximately 12,000 registered groups, of which about 3,500 are in Lamu East and 7,500 in Lamu West. The representation of various group categories is outlined in Table 1.

Table 1. Representation of Community Groups in Lamu County

CBOs	SHGs	WGs	YGs	PLWDs
7%	40%	30%	20%	3%

The Community Based Organizations are involved in diverse activities including;

1. Advocacy/Human Rights
2. Livelihood Support
3. Educational Support
4. Gender Based Violence/Child Protection
5. Environmental Conservation
6. Counter Violence Extremism
7. HIV/AIDs Awareness

The other groups (SHGs, WGs, YGs AND PLWDs) are involved in the following activities;

1. Environmental Conservation
2. Peace Building and Conflict Resolution
3. Fishing
4. Farming
5. Poultry and Cattle Rearing
6. Bee Keeping
7. Table banking / Savings and Loans
8. Small Business Enterprises.

Some of the activities of the various groups are shown in Figures 1 and 2.

Figure1: Mangrove restoration activities. A) Pate Women Group mangrove nursery. B) PRATI members preparing seedlings for nursery. C) Established nursery. D) Mangrove plantation with fresh seedling. ©PMCC.

Figure 2. Pate Resources and Tourism Initiative (PRATI): Ambergris beach house. ©M. H. Kassim.

4.2 Beach Management Units

Fishing is a key economic activity in the county and the community have organized themselves in Beach Management Units (BMUs). Some of their activities are shown in Figures 3 to 5.

These organizations are registered under the Fisheries Management and Development Act, 2016. Fisheries is a devolved function to County Governments in line with the Kenyan Constitution 2010. The county has 32 registered BMUs spread across the entire county with Faza and Ndau zone having 10 BMUs while 8 are in Kiunga and Kiwayu. The BMUs in addition to fishing, have the following Sub Committees; Finance, Environment, Hygiene, Patrol and Conflict Resolution.

Figure 3. Shanga Ishakani Fishers Women Group after the Octopus (PWEZA) Harvest. ©PMCC.

Figure 4. Pate Marine Community Conservancy Rangers are inspecting the catch. The by-catch, young turtle and small fish are taken back to the ocean. ©M· H· Kassim.

Figure 5. BMU Faza (Pate Island) in annual general meeting (AGM). ©PMCC.

4.3 Community Forest Association

There are estimated 30,000 households in Lamu County that depend on mangrove cutting for their livelihoods. Mangrove cutting is most common in Lamu East Sub-county in Ndau, Kiwayu, Faza, Kizingitini, Pate, Siyu and Manda villages. The community is in the process of forming Community Forest Associations (CFAs) to formally engage with Kenya Forest Service (KFS) in joint management of Mangroves through Participatory Forest Management (PFM), as stipulated in the Forest Conservation and Management Act, 2016.

Avicennia marina

Websites:
www.mikoko.co.ke
https://en.ird.fr
https://www.cirad.fr/en
https://portal.mikoko.co.ke

KEFRI
K.M.F.R.I.
NATIONAL MUSEUMS OF KENYA
WHERE HERITAGE LIVES ON
KENYA Forest Service
Pwani UNIVERSITY

www.portal.mikoko.co.ke