Innovative Mapping, Assessment and Economic Valuation of Blue Carbon Ecosystems in Kenya for Conservation and Sustainable Livelihoods

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Marine and Coastal Biodiversity Conservation Workshop for Kenya and Tanzania, Pride in Paradise, Mombasa 26th – 30th January 2026

MANDATE

Undertake research on:

- Marine and freshwater fisheries
- Aquaculture (Freshwater and Marine)
- Environmental and ecological studies
- Chemical and physical oceanography and hydrography
- Marine geology, minerology, bio-prospecting
- Socioeconomics



KMFRI
Kenya Marine and Fisheries Research Institute

Presentation Outline

- Blue Cabon in Kenya: Why It Matters
- Innovative Mapping Approaches
- Ecosystem Assessment Methods
- Economic Valuation of Blue
- Conservations and sustainable Livelihoods
- Lessons & Way forward
- Discussion

Blue Carbon Ecosystem

Mangroves



Salt Marshes



Seagrass



Shoreline protection



Carbon storage



Fishery nursery

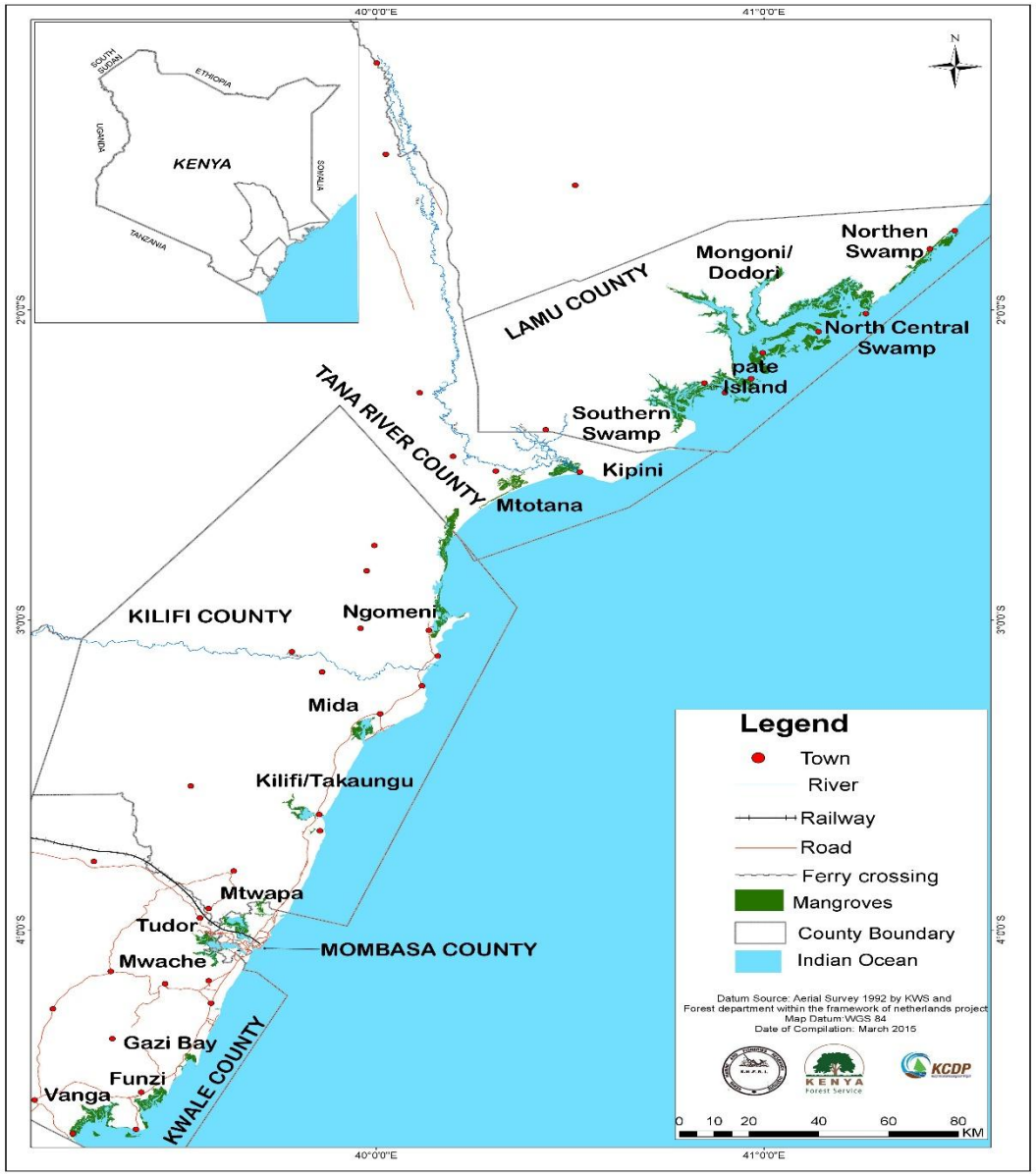


Blue Carbon Ecosystem in Kenya





Mangroves in Kenya



Mangrove coverage in the countries along the Kenyan coast		
County	**Area (ha)**	**% Cover**
Lamu	37,350	61
Tana River	3,260	5
Kilifi	8,536	14
Mombasa	3,771	6
Kwale	8,354	14
Total	61,271	100

ECOSYSTEM SERVICES

The benefits people derive from mangroves



Livelihoods

120 million people living near mangroves[1]

Mangrove ecosystem services

Worth US$ 33,000–57,000 per hectare per year[1] x 14 million hectares[2] = up to **US$ 800 billion** per year

Climate regulation

Carbon storage potential of mangroves is **3–5x higher than that of tropical upland forest** due to strong carbon storage in the soil[3]; CO_2 released by global mangrove loss annually could be as high as the annual emissions of Australia[4-5]

Wood

Its density makes mangrove wood a valued source of **timber and fuel**

Coastal protection

Restoring mangroves for coastal defence up to **5 times more** cost-effective than "grey infrastructure" such as breakwaters[9]

Water filtration

2–5 hectares of mangroves may treat the effluents of **1 hectare of aquaculture**[8]

Tourism

There are over **2,000** mangrove-related attractions globally, such as boat tours, boardwalks, kayaking and fishing[7]

Fisheries

More than **3000 fish species** are found in mangrove ecosystems[6]

Federal Ministry for Economic Cooperation and Development

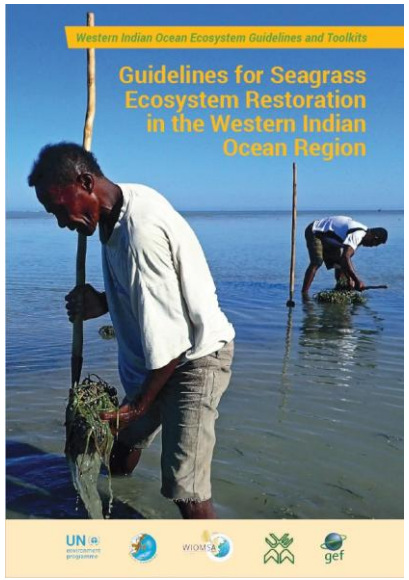
WWF

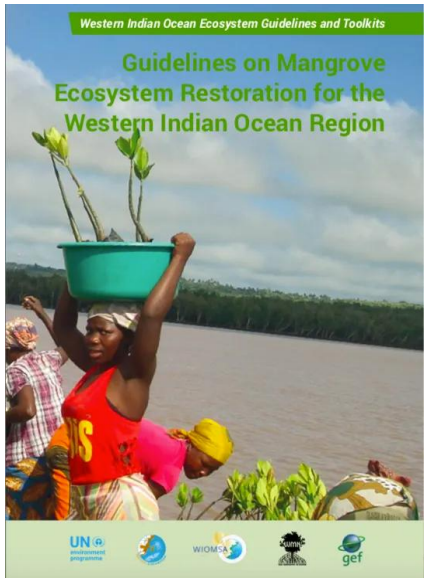
IUCN

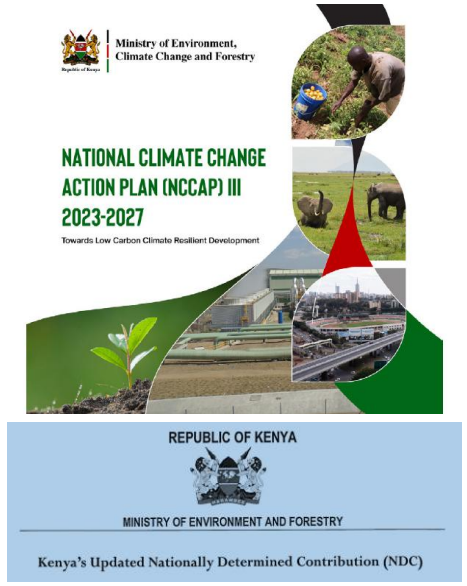
SAVE OUR MANGROVES NOW!

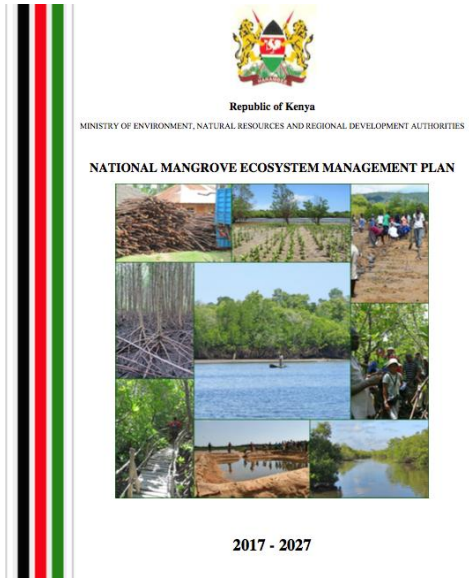
Sources: ❶ UNEP, 2014 • ❷ Giri et al., 2011 • ❸ In the Indo-Pacific region: Donato et al., 2011 • ❹ Up to 450 million t CO_2: Pendleton et al., 2012 • ❺ In 2015: EDGARv4.3.2., 2018 • ❻ Sheaves, 2017 • ❼ Spalding et al., 2016 ❽ Primavera et al., 2007 • ❾ In Vietnam: Narayan et al., 2016

BC policy instruments and management tools









Innovative Mapping

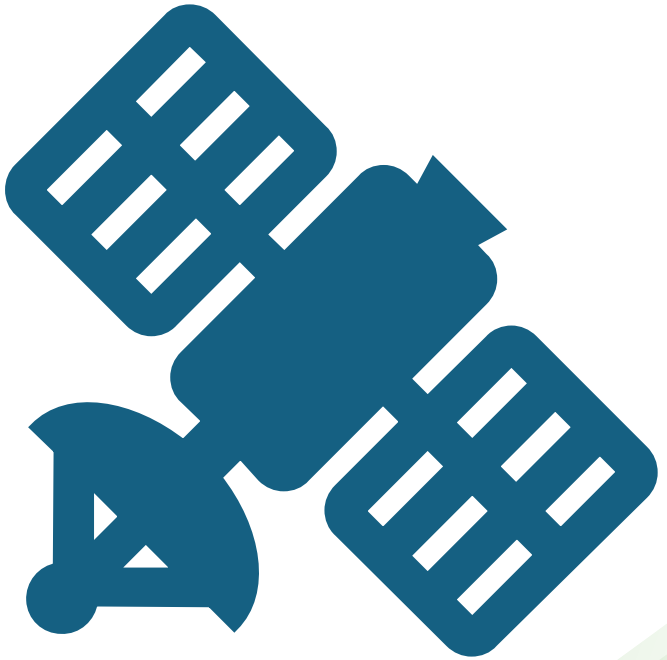
- Remote sensing (Satellite Imagery, drones)
- GIS and Spatial Modelling
- Machine learning and classification
- Ground truthing

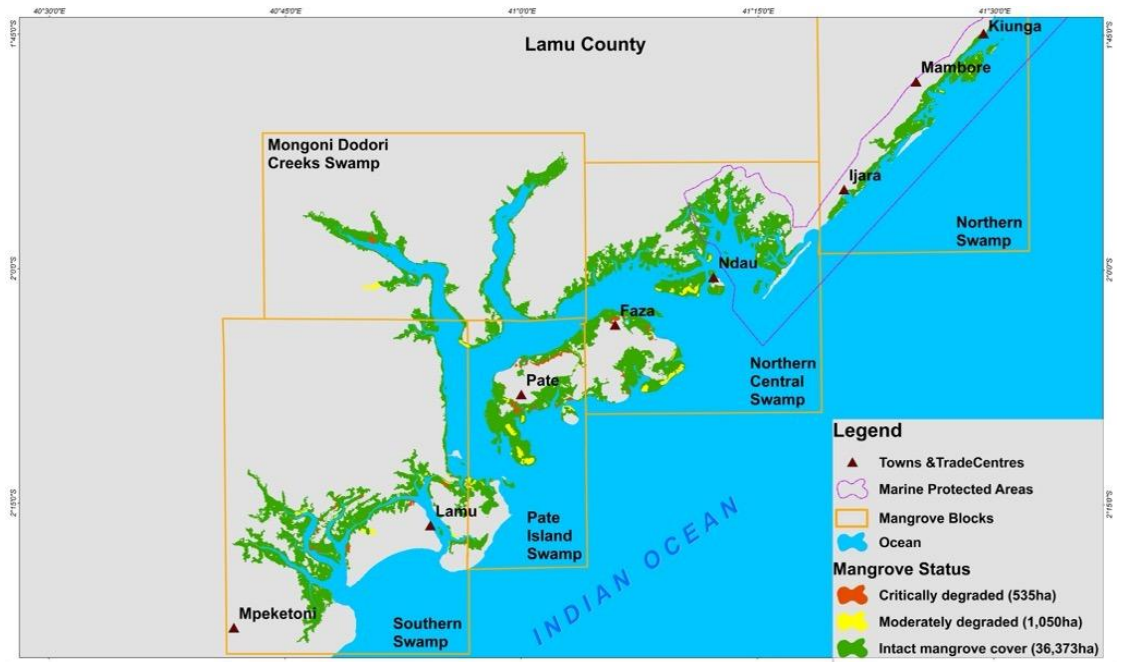
Accurate maps support

- Planning
- Resource allocation
- Monitoring Progress

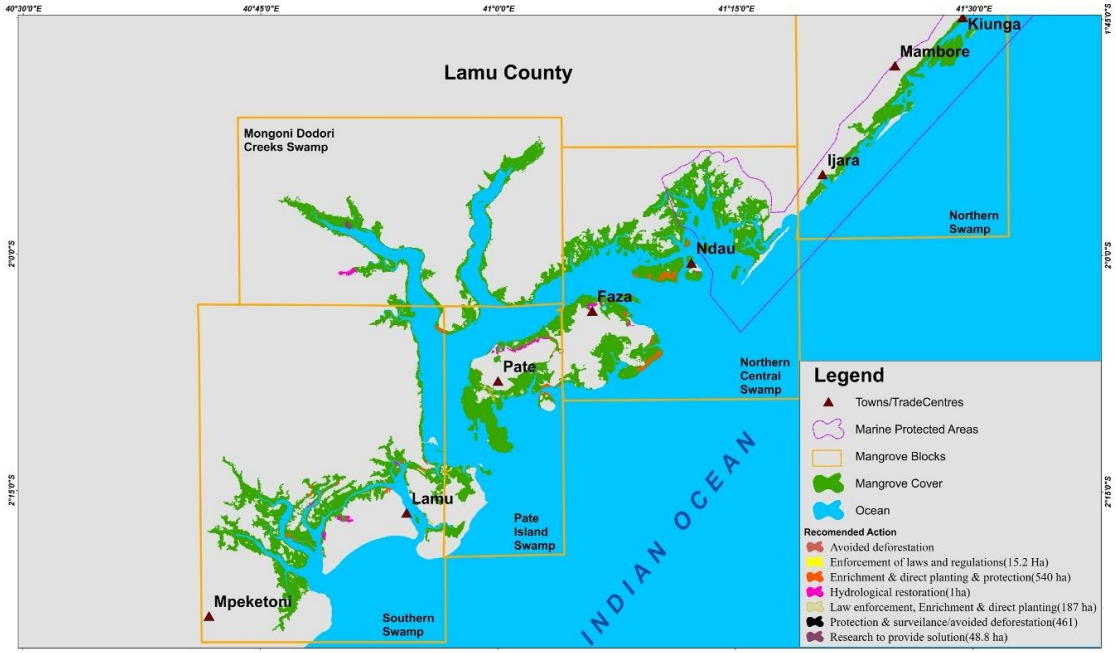
Maps Show

- Where resources are
- Where degradation is happening
- Where restoration is needed





TITLE	SCALE AND DIRECTION	DATA SOURCE	Collaborating & Funding Partners
LAMU MANGROVE LEVELS OF DEGRADATION MAP	Scale; 1:100000 N 0 7 14 21 28 Km	Mangrove cover derived from Worldview imagery 2021 Coordinate System: WGS 1984 UTM Zone 37S Projection: Transverse Mercator Datum: WGS 1984 False Easting: 500,000.0000 False Northing: 10,000,000.0000 Central Meridian: 39.0000 Scale Factor: 0.9996 Latitude Of Origin: 0.0000 Units: Meter 2023/2024	KMFRI, Kenya Forest Service, UN environment programme, The Nature Conservancy



TITLE	SCALE AND DIRECTION	DATA SOURCE	Collaborating & Funding Partners
LAMU MANGROVE DEGRADED & INTERVENTION MAP	Scale; 1:100,000 N 0 6.5 13 19.5 26 Km	Mangrove cover derived from Worldview imagery 2021 Coordinate System: WGS 1984 UTM Zone 37S Projection: Transverse Mercator Datum: WGS 1984 False Easting: 500,000.0000 False Northing: 10,000,000.0000 Central Meridian: 39.0000 Scale Factor: 0.9996 Latitude Of Origin: 0.0000 Units: Meter 2023/2024	KMFRI, Kenya Forest Service, UN environment programme, The Nature Conservancy

Ecosystem Assessment Methods

- Ecosystem Health
- Carbon Stocks (above and Below ground)
- Biodiversity

- Field Surveys
- Soil Sampling
- Biomass measurements
- Intergration with Mapping Data









Why Ecosystem Assessment Matters

- Scientist- Accurate data
- Policy Makers- evidence based decisions
- Communities – Understanding ecosystem conditions and sustainability



Economic Valuation of Blue Carbon

"Putting a monetary value to nature's benefits"

Global Value estimated at 37-57,000/ha/yr

IUCN,2024

- Global value in flood **protection - $US 65 billion**
- **Protects 15million people from flood risks**

(Menendez et al., 2020)

Mean Value of Ecosystem services in USD

(Salem and Mercer, 2012)

Fisheries- **23,613**

Forestry products- **38,115**

Coastal protection- **3,116**

Recreation and tourism- **37,927**

Carbon sequestration- **967**

Non use **values-17373**

Air purification/waste assimilation - **4,748**

Traditional **uses-114**

Kenyan Valuation

Ecosystem service	Valuation Method	Estimated value (US$/ha/yr)
Fuelwood	Market based	22.81
Construction materials	Market based	365.72
Carbon sequestration	Market based	786.08
Fisheries support	Market based	219.65
Coastal protection	Replacement cost and Avoided damage cost	4,603.29
Honey	Benefit transfer	286.4
Medicine	,,	43.46
Biodiversity support	,,	239.46
Fish breeding	,,	702.23
Flood control	,,	851.55
Education support	,,	301.17
Ecotourism	,,	106.82
Existence value	,,	731.9
Total		9,260.54

Possible citation: Kisilu et al., 2026

THREATS

Drivers of mangrove loss

Mangrove loss

35% between 1980 and 2000[1] - the equivalent of losing almost 150,000 annually[2], and **4 times higher** than overall global forest loss[3]

Climate change

Air temperature and rainfall regimes influence global mangrove distribution[4]; abrupt changes in sea level are a primary cause of **local and regional extinctions**[4-6]



Logging

can cause altered species composition, **fragmentation and total clearance** of mangrove forests

Agriculture

Conversion to rice paddies responsible for **88% of mangrove loss** in Myanmar[10]

Aquaculture

causes more than **half of mangrove losses globally**, mostly due to shrimp culture[9]

Pollution

Mangrove's aerial roots, through which they obtain oxygen, can easily be smothered and clogged by **sediment, solid waste and oil**[8]

Coastal development

Urbanisation drives mangrove loss and degradation; human population density in coastal regions **3 times higher than global average**[7]

Federal Ministry for Economic Cooperation and Development

WWF

IUCN

SAVE OUR MANGROVES NOW!

Sources: ❶ Millennium Ecosystem Assessment, 2005 • ❷ 0.66% or 102,000 hectares annually (2000-2005): FAO, 2007 • ❸ Spalding et al., 2010 • ❹ Alongi, 2015 • ❺ Duke et al., 2017 • ❻ Lovelock et al., 2017 • ❼ Small et al., 2003 ❽ UNEP, 2014 • ❾ Valiela et al., 2001 • ❿ Over 2000–2012: Richards & Friess, 2016

Drivers and threats to mangrove forests

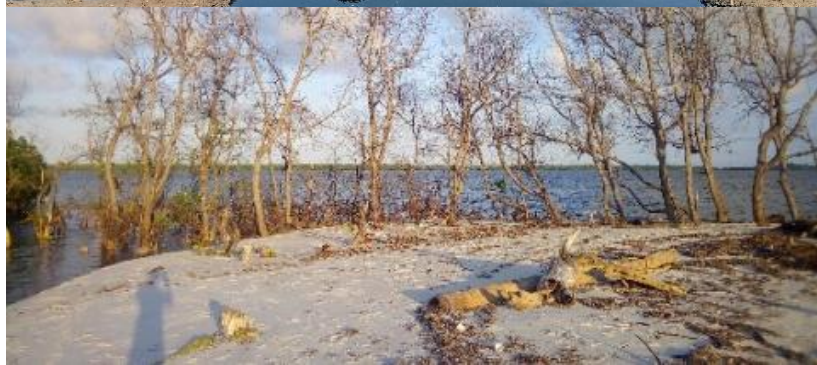
- **Threats**
- Over-exploitation
- Land use change
- Pollution and sedimentation
- Climate change effects

- **Root causes**
- Weak governance
- Poverty and economic dev’t
- Inadequate knowledge and awareness









LOCAL SOLUTIONS

Conservation and Sustainable Livelihood : A case study of Mikoko Pamoja and Vanga Blue Forest projects

Project Details

Item:	Mikoko Pamoja	Vanga Blue Forest
Project Participants:	2 villages	3 villages
Participants	5,400; (1,350 households)	8,736 (2,184 households)
Start date	2013	2020
Project area	117 ha	460 ha
Activities	i. Restoration ii. Avoided deforestation	i. Restoration ii. Avoided deforestation
Annual C removals & emission reduction	2,485 tCO2e	5,023 tCO2e
Certificates issued to date	20,095	18,840
Average annual revenues	US$ 20,000 (Kshs 2.4 million)	US$ 47,000 (Kshs 6 million)

A blue carbon Project

Acting along the SDGs

Mikoko Pamoja

More than 70 % of PES income directly benefits 2 local communities by implementing community development projects

Accredited to sell 3000t CO2 equivalent annually for 20 years

We are the first community based carbon offset project to restore and protect mangroves through the sale of carbon credits

Bought over 600 textbooks for 2 local schools, renovated Classrooms and donated desks to 40 pupils. We also run environmental education programs to students and members of the public

Planted over 10,000 mangrove seedlings so far

Created Partnerships with international institutions such as universities and funding agencies

Provided water for over 3500 people, 2 primary schools , bought a water tank for 1 secondary school and equipped 1 local dispensary with furniture

Mikoko Pamoja is Conserving biodiversity, developing the community and promoting environment conservation

To Make Mikoko Pamoja your offset partner. Visit our website www.aces-org.co.uk

Project impacts

- **Job creations**
- **Enhanced Livelihood**
  - Ecotourism
- **Community services**
  - Education-
  - Water & Sanitation
- **Mangrove reforestation**











Vanga Blue Forest Project

Fast Facts

460ha
of mangrove forest conserved from further degradation and encroachment

To prevent continued emissions by storing

5023 tCO_2

Seeks to improve livelihood of

8700
people living in the project area

To promote long term socio-economic development of communities through an annual income generation of

USD 48713

Project area is home to numerous species of wildlife including marine fauna that are endangered and of high conservation importance. This includes turtles, dolphins & dugong

Vanga Blue Forest (VBF) is a carbon offset project that seeks to sustain the flow of mangrove goods and services by halting further deforestation and degradation. The project is located in the South Coast of Kenya in Kwale County.



To make VBF your offset partner
Visit us on www.aces-org.co.uk

Community

i) Upgrade of science laboratory, Vanga





ii) Construction and electrification of two classrooms, Kiwegu



iii) Period poverty



iv) Storage furniture set donated to dispensary



Global Influence



Royal visit by prince and princess, Gazi



VBF at World Ocean Summit, Lisbon



Parliamentarians from Kenya, Tanzania & Madagascar

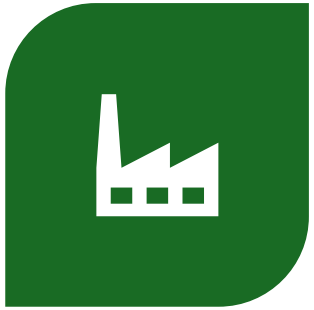


Mikoko Pamoja at COP 26

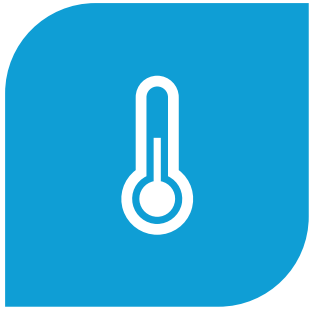
Challenges in Blue Carbon project



VERIFICATION AND CERTIFICATION COST



VOLATILE CARBON MARKET



CLIMATE CHANGE AND NATURAL RISK



LAND TENURE AND GOVERNANCE ISSUES

Assumed cost per hectare for setting up and operating a Blue Carbon Project

Initial investment		Operational expenses	
Type	**2024 US$/ha**	**Type**	**2024 US$/ha/yr**
Preliminary assessment (site selection, historical land use and land cover changes, analysis of agents & drivers of deforestation)	111.28	Verification under Plan Vivo (assuming small-scale project) **	1.06
Carbon assessment (carbon density measurements)	164.82	Administrative fee upon issuance (assuming issuance for < 15000 tCO2e / yr) **	1.77
Project Idea Note (PIN), Project Design Document (PDD)	305.51	Corresponding adjustment fees for Internationally Transferred Mitigation Outcome (assuming 50% transfer) **	35.38
Validation under Plan Vivo (assuming small-scale project) **	150.00	Restoration (seedlings)	500.00
Carbon project application fee (Kenyan citizen) *, **	0.77	Operational expenses associated with conservation & restoration (labour/staff salary, office costs, community development projects)	79.62
Carbon project design document fee (Kenyan citizen) *, **	7.70		
Administrative fee upon approval of the project design document (project with issuance of < 15000 carbon credits/yr) **	11.54		
Total	**752**	**Total**	**618**

* Average carbon project application fee for non-citizens would be US$7.7/ha, while the PDD fee US$15.04/ha ** Please note that for calculating fixed costs that are the same for all small-scale carbon projects, the per hectare costs were received by assuming a project with size of 100 hectares and associated carbon credits obtained.

Lessons Learnt



Community participation is essential



Science must inform policy



Strengthening Community Ownership

Way forward

- Enhance community resilience and livelihoods - Scaling up mapping and BC projects
- Strengthening community ownership of conservation and restoration activities
- Intergrating Blue carbon into National Plans

Food and Agriculture Organization of the United Nations

SWIOFC

Sweden Sverige

UN environment programme

Nairobi Convention