SOCIO-ECONOMIC ROLE OF MANGROVES

AND THEIR CONSERVATION FRAMEWORK IN KENYA

Hilda Manzi & Viola C. Kirui

SAVE OUR MANGROVES NOW!

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This is a Technical Report done by Geospatial Research International (GRI) for the International Union for Conservation of Nature (IUCN). It aims to provide evidence-based scientific and economic support in policy and decision making with regards to the social and economic roles of mangroves along the Kenyan Coast.

This publication is part of the “Save Our Mangroves Now!” initiative’s work to close existing knowledge gaps concerning mangrove protection. It has been produced with the financial support of the Federal Ministry for Economic Cooperation and Development (BMZ). The contents of this publication are the sole responsibility of “Save Our Mangroves Now!” and can in no way be taken to represent the views of BMZ.

SAVE OUR MANGROVES NOW!

Bringing together governments, conservation specialists and coastal communities, Save Our Mangroves Now! (SOMN) aims to reverse the decline of mangroves to restore biodiversity, protect livelihoods and mitigate against the impacts of the climate crisis. It is a joint initiative by the German Federal Ministry for Economic Cooperation and Development (BMZ), World Wildlife Fund (WWF), the International Union for Conservation of Nature (IUCN) and Wetlands International. SOMN envisions a world with thriving mangrove habitats that work in harmony with local communities. Its mission is to mobilize action by facilitating policymaking, programmes and investments that regenerate mangrove ecosystems, tackle climate change and provide livelihoods, with an ambition to ensure that mangrove ecosystems are conserved, restored and sustainably used to the benefit of people and nature, locally and globally.

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LIST OF ACRONYMS

AGB	Above Ground Biomass
ACES	Association for Coastal Ecosystem Services
AMN	African Mangrove Network
ASF	Arabuko Sokoke Forest
BGB	Below Ground Biomass
BMU	Beach Management Unit
CBA	Cost Benefit Analysis
CBD	Convention on Biological Diversity
CBO	Community Based Organization
CDA	Coast Development Authority
CDC	Center for Disease Control
CFA	Community Forest Association
CIDP	County Integrated Development Plan
CO	Carbon Dioxide
CRBC	China Road and Bridge Corporation
EIA	Environmental Impact Assessment
ELD	Economics of Land Degradation
ESG	Environmental, Social and Governance
ESPA	Ecosystem Services for Poverty Alleviation
EU	European Union
FAO	Food and Agriculture Organization
FCM	Forest Conservation and Management
FGD	Focus Group Discussion
FMP	Forest Management Plan
GECOFA	Gede Community Forest Association
GEF	Global Environment Facility
GMA	Global Mangrove Alliance
GOGACOFA	Gogoni-Gazi Community Forest Association
GoK	Government of Kenya
Ha.	Hectares
ICZM	Integrated Coastal Zone Management
IGA	Income Generating Activities
IUCN	International Union for Conservation of Nature
KEFRI	The Kenya Forestry Research Institute
KeFS	Kenya Fisheries Service
KFS	Kenya Forest Service
KIHBS	Kenya Integrated Household Budget Survey
KMA	Kenya Maritime Authority
KMFRI	Kenya Marine and Fisheries Research Institute
KNBS	Kenya National Bureau of Statistics
Ksh	Kenya Shillings
KWS	Kenya Wildlife Service
LDN	Land Degradation Neutrality
LMMA	Locally Managed Marine Areas
LNG	Liquefied Natural Gas

MA	Millennium Ecosystem Assessment
MOKICFA	Mombasa Kilindini Community Forest Association
MOE	Ministry of Energy
MPA	Marine Protected Areas
MSP	Marine Spatial Planning
MT	Metric Tonnes
MTAKIMAU	Mtwapa, Takaungu, Kilifi, Matsangoni and Uyombo Community Forest Association
NBSAP	National Biodiversity Strategy and Action Plan
NDC	National Determined Contributions
NEMA	National Environment Management Authority
NGO	Non-Governmental Organization
NRT	Northern Rangeland Trust
NWFP	Non-Wood Forest Products
PES	Payment of Ecosystem Services
PFM	Participatory Forest Mangement
PFMP	Participatory Forest Management Plan
REDD	Reducing Emissions from Deforestation and Forest Degradation
SDF	State Department of Fisheries
SDG	Sustainable Development Goals
SGP	Small Grant Program
SEEA	System of Environmental and Economic Accounting
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Value
UNDP	United Nations Development Program
UNCCD	United Nation's Convention to Combat Desertification
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nation's Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States Dollar
USEPA	United States Environmental Protection Agency
VAJIKI	Vanga, Jimbo & Kiwegu
VBF	Vanga Blue Forest
VDFCC	Village Development Forest Conservation committee
WWF	World Wide Fund for Nature

EXECUTIVE SUMMARY

Mangroves are critical coastal ecosystems that are of immense significance ecologically and economically. Despite the vital ecosystem services they provide, the full value of mangrove products is not easily recognized, and they are more often neglected in development planning. It is often concluded that mangrove forests should be converted to uses which generate directly marketable products. As a result, there is an increasing threat to mangrove ecosystems worldwide and their damage has become substantial especially in recent years. The worldwide decline of mangrove forests has instigated a wide range of efforts to estimate the economic values of mangrove ecosystems, and on the other hand, understand the social benefits that local communities draw from them.

The Millennium Ecosystem Assessment has a vision of a world in which people and institutions appreciate natural systems as vital assets, recognize the central role the assets play in supporting human well-being, and routinely incorporate its material and intangible values into decision making. To make meaningful decisions therefore, it is paramount to embed the values of mangrove ecosystems and natural capital as a whole in these people and institutions to bring about change. The key to making informed decisions would be to understand the elements that would motivate change in decisions and behavior, and how such can be included in a conscious process of cultural norm evolution. Presenting decision making institutions with evidence of these values and their beneficial role in their specific activities, alongside the development of feasible plans to incorporate them into existing structures and practices, will provide enabling conditions for mainstreaming and subsequent informed actions regarding the management and conservation of the increasingly threatened mangrove ecosystems.

The focus of this project was to assess the socioeconomic role of mangroves and their conservation frameworks in Kenya through the development of in-depth profiles underpinning the 'Kenyan mangrove case' and identifying the 'key entry points' for mangrove conservation. Further the knowledge gap of valuation studies in Eastern Africa, covering the full suite of ecosystem services, was addressed to provide these estimates at the regional and national levels. This work is part of the "Save Our Mangroves Now!" joint commitment whose main aim it to upscale and focus global efforts to stop and reverse the decrease and degradation of mangrove habitats. The following pertinent findings were documented following a field and desktop study.

Output I: Assessment and documentation of the natural capital drawing from ecosystem services provided by mangroves, and their inclusion in national development planning. An ecosystem service valuation was carried out for 11 mangrove forest formations along the Kenyan Coast namely; Vanga, Funzi, Gazi, Tudor, Mtwapa, Kilifi, Mida, Takaungu, Ngomeni, Ungwana bay and Lamu island. Availability of data was the sole inclusion criteria applied for the selection of the forest formations. The mangrove ecosystem services considered are; fish catch (commercial and substance use), wood products (firewood and charcoal use), Medicinal value, ecotourism, costal protection/ storm control, habitat provision for fish, carbon sequestration and storage, biodiversity conservation and Non- use value (existence value). The analysis and evaluation employed the use of remote sensing data to evaluate the mangrove area for the years 2000 and 2019 respectively, and it was established that the geographical extent of mangroves in Kenya changed significantly between the years 2000 and 2019. A significant increase in forest area was noted for Vanga, Gazi, Mida, Ngomeni and Ungwana bay. On the other hand, a significant decrease in forest area was noted for Funzi, Tudor and Lamu. It was established that the forest changes in terms of area, has an impact on the general value of ecosystem services from mangrove, more so on the value of provisioning goods like fish catch. The year 2019 was earmarked as the study year, and the mangrove area for the year 2019 was used in the ecosystem service valuation. Based on our findings, the combined estimated economic value of the mangrove forest formations evaluated was Ksh 9,375,340,736.63 for the year 2019. The resulting average unit economic value was estimated at Ksh 200,473.93 /ha/year. Generally,

high ecosystem service values were reported for wood extraction followed by shoreline protection, ecotourism, carbon sequestration, habitat provision, Fish catch, non-use value, medicinal use, biodiversity conservation in a descending order. It was further noted that the value of the mangrove ecosystems has decreased overtime in terms of the quantity of goods and services, even though the unit costs of goods has increased over time. In areas where the surrounding communities are engaged in conservation, ecotourism and existence values were high whilst in areas where the community was not active despite the presence of community forest associations, the values were low both in quantity and cost per units.

Further findings from observation and from information collected during focus group discussions held with the communities, showcased a high possibility of an increase in the value of the mangrove ecosystems in the near future. The involvement of the communities in income generating activities like the implementation of sustainable use schemes, the payment for ecosystem services and the introduction of alternative activities that would reduce the pressure on mangrove ecosystems, are some of the avenues sited to have a positive impact on mangrove existence. An example is the introduction of casuarina plantations to meet the wood product demands. It is evident that the potential to increase wood products on a sustainable basis from mangrove ecosystems is very low, and based on this study, alternatives are a more viable option. Areas with potential to increase mangrove value include; apiculture, medicine, tannins, fish, non-destructive recreation and tourism, habitat provision, shore line protection and carbon sequestration. Further, the potential of the mangrove ecosystems to increase the value was observed from remote sensing data, through an analysis of the change in forest densities. Generally, the mangrove forest densities have direct impact on the biodiversity, shoreline protection and carbon sequestration. The mangrove forest densities for the various forest formation evaluated were found to be low especially in forest formations where the mangrove area had significantly decreased. Further, the decrease in the dense forest category was significantly high across all forest formations and especially Tudor where the change was higher. The negative change in forest densities is directly correlated with the negative change in the value of mangroves. This is attributed to low quantities of biomass and soil organic carbon observed from satellite imagery data from (Simard et al, 2019 and Sanderman et al, 2018).

Overall, the evaluation of ecosystem services drawn from the selected mangrove forest formations was an enlightener on the socio-economic benefits of mangrove ecosystems in Kenya as well as on the provision of information on the status of the value both in quantities and cost per unit.

Output II: Assessment of the mangrove conservation frameworks in Kenya. This was achieved through an assessment of four important pointers; an assessment of the legal frameworks governing the conservation of mangroves in Kenya; an assessment of the mangrove conservation governance structure; an assessment of the associated key actors in mangrove management and conservation, and an assessment of the individual conservation frameworks governing the individual forest formations through the respective Participatory Forest Management Plans.

Legal frameworks; Mangroves in Kenya are legally protected as public forests by various legal frameworks including the Forest Conservation and Management (FCM) Act, 2016. It was established that, for a long time, Kenya had limited specific policies on mangrove conservation, and as a result, the mangrove conservation and management models were only based on wood and timber extraction while ignoring other essential services from the ecosystem. Consequently, a National Mangrove Management Plan was prepared for implementation between the years 2017-2027 to enhance mangrove ecosystem integrity and its contribution to the economy through sustainable management and rational utilization. Various studies have revealed that Kenya's mangrove ecosystem conservation legal framework is comprehensive and can effectively battle management ineffectiveness. Further, Kenya is party to various mangrove and biodiversity conservation-related international conventions and treaties, and this emphasizes the fact that the legal frameworks governing the mangrove forest ecosystems in Kenya are adequate. Furthermore, Kenya's constitutional provisions have provided a strong basis for managing and conserving forest ecosystems, including mangroves. A previous review of Kenya's legal framework and constitutional requirements regarding mangrove management and conservation, done by Slobodian & Badoz (2019) ascertained that the Country's environmental laws are progressive. However, the current legislative

framework has multisectoral and cross-institutional mandates, which pose severe coordination and management challenges.

Governance structure; a review of the Governance structure revealed that the management and associated constitutional roles and rights at the regional and local levels are influenced by multiple decisions made at diverse governance levels and stakeholders with varying interests. According to the FCM Act, 2016, mangrove forests administration is handled by the Kenya Forest Service (KFS). The service is managed by a Board of Directors, which is at the top of the forest management hierarchy at the National level. Primarily, National-level management is involved in policy formulation, general management strategies, mangrove resource assessments, and preparing mangrove status reports, among other duties. The Head of Conservancy leads the Regional level, and the Ecosystem Conservator follows in command as the officer in charge at the County level. Each County has to implement National policies, including mangrove management and conservation policies in public lands defined in Kenya's constitution. Finally, the forest managers, forest guards, and the Community Forest Associations (CFA) manage and conserve mangroves and their resources at the local level. A forest manager heads a forest station that may cut across more than one County or shared by various CFAs. Generally, forest managers are responsible for harmonizing KFS's policies and programs at the local level with the assistance of CFAs, NGOs, community members, mangrove product harvesters, and local opinion leaders/politicians. It was also established that the local and regional governance units/systems get management support from other parastatals such as the Kenya Marine and Fisheries Research Institute, the Kenya Wildlife Service, and the State Department of Fisheries. The parastatals have complementary roles and interests in protecting mangrove ecosystems because they are habitats and breeding sites for diverse flora and fauna.

Key actors in mangrove conservation; the myriad of legislative and policy documents on coastal resources, illustrates the diverse range and number of relevant sectors and actors on coastal governance. The National Government is the central actor in mangrove conservation in Kenya. Furthermore, international organizations and NGOs have also increasingly become involved in shaping agendas as well as approaches to mangrove management. The focus remains singularly on mangrove rehabilitation and afforestation but with a shift towards understanding and strengthening community-based management systems to ensure that mangroves will be protected and appropriately managed over the long-term. This report presents a synthesis of the conservation frameworks governing the various key actors and institutions, the objectives of the actors, their successes and the challenges faced in the implementation of the frameworks.

Conservation frameworks governing the individual forest formations through the respective Forest Management Plans; the FCM Act, 2016, promotes Participatory Forest Management (PFM) through co-management of mangroves by the KFS and CFAs. The Act allows CFAs to protect, conserve and manage Forests through structures and programs embedded in their Forest Management Plans (FMPs). Individual management plans must formulate implementable strategies and programs for monitoring development and human activities in the area, enforcing the Act's provisions, identifying changes in forests, and local administration of forest resource utilization. A review of literature shows that the PFM has been embraced in Kenya since its inception in 1997 but has not been effective because of limited local capacity, which has negatively affected various components such as developing suitable PFMPs. Information collected from select CFAs further reveals that, the top-down approach employed in the development of the PFMPs, which to a larger extent excluded the community members, is a major impediment to the adequate implementation of the plans. As a result, communities do not actively participate in mangrove forest conservation and associated activities. Also noted is that, several CFAs have formal agreement registration with KFS with various co-management mandates. On the other hand, some CFAs are operating informally with a limited mandate to organize conservation activities or manage mangrove resources. The lack of full recognition by KFS through the PFMPs was also noted to lower conservation efficiency such that the community lacks the legal authority to manage mangrove resources or prosecute offenders, even at the local Government administrator's offices, neither can their grievances be heard and solved. For example, at the time of this study, the Magarini Mangrove CFA reported that they have had stagnated PFMP preparation and signing since 2015 because they lacked adequate funds and technical guidance. The outcome has been sustained mangrove ecosystem degradation, loss of

biodiversity, and expansion of development activities such as salt farms in mangrove areas. Fundamentally, the CFAs having co-management agreements with the KFS contribute to better conservation because they have structures for identifying threats to mangrove ecosystems and conservation constraints. Further research revealed that, despite the proliferation of CFAs as alternatives to top-down conservation approaches in Kenya's forest ecosystems; there is limited information on factors influencing collective forest conservation efforts. Generally, according to the key stakeholders interviewed, the participatory forest management and utilization process has enlightened local communities and made them appreciate the notion that forests are beneficial to their livelihoods, hence they should manage them as their resource. Sustainable mangrove forest management remains promising with user groups and communities operating as stewards of the resource. The CFAs, opinion leaders, and institutions, who form the main stakeholders in mangrove conservation, highlighted conservation legislative aspects and decision-making inefficiencies contributing to the governance lapses. This background knowledge identified underlying constraints to protection and recommendations for improved conservation and management that have been well captured in this report.

Output III: Assessment and documentation of the 'human development' related to, or derived from, mangroves along the Kenyan Coast. This was documented by assessing three key pointers; the economic benefits that the community draws from the mangrove ecosystems, the human development (attitude and interest) to change in mangrove area and densities, and the link between mangrove dependency and the local communities.

The local communities identified key economic activities where they generated significant revenues. These are; fishing, fuel wood, ecotourism and honey production. Even though the investment costs could not be determined at the time of the study due to limited data availability, a visual representation of the impact of the economic and social benefits on the local communities and the level of dependency attached to mangroves was evident. Firewood scored the highest followed by charcoal, fishing and ecotourism in the order of importance and revenue generation. This was prevalent in all the forest formations, especially in the rural setups namely; Vanga, Gazi, Funzi, Takaungu, Kilifi, Ngomeni and Ungwana Bay. In Mtwapa which has both rural and urban setups intertwined, the highest was firewood, followed by charcoal, ecotourism and finally fishing. In Tudorwhich is purely an urban setup, ecotourism was the highest followed by charcoal, fishing and finally firewood. The assessment of the human development to the change in area and forest densities led to the identification of the role of communities in sustainable utilization of the mangrove ecosystems. It was concluded that attitudes and interest of the local communities are key in the utilization of the mangrove ecosystem benefits. Further, their role is strengthened with the increase in the social-economic benefits realized from the mangrove ecosystems. When communities remain unaware and not concerned, then the efforts of sustainable utilization and increased socio-economic benefits to the communities cannot be realized. The presence of a legal system on its own may not achieve any sustainable economic benefits to the communities, but on the contrary it may be a source of degradation due to constrained or limited availability of benefits. It was evident that the decrease in the area and the associated negative changes in the forest densities were minimal where communities are active and aware of the benefits of the mangrove ecosystems. An exception was however evidenced in Tudor, and it was established that the urban setup played a significant role in the outcomes. The degradation pressure was observed to be higher than the community's efforts in sustainable utilization as well as in restorative measures. The contribution to this was not only a local community problem but also drawn from the many projects that the private sector as well as the Government was undertaking in the area.

The dependency of the local communities to the mangrove ecosystems was done by assessing; the nearness to the mangroves. Communities living closer to the mangrove ecosystem were found to be highly dependent on the mangrove ecosystems compared to those that were far off. The assessment of the cultural understanding of mangrove ecosystems by the local communities led to the conclusion that, communities whose culture is connected to mangrove use are highly dependent on the mangrove ecosystem. Further, communities' activities related to mangroves were mostly connected to their cultural undertakings. The local communities also placed a level of importance to the certain products and services that are associated to mangrove. The communities believe that, the mangrove ecosystems are

responsible for the flourishment of fish, sea weed, firewood, traditional medicine, ecotourism, cultural activities and honey production, as well as a source of employment especially for the youth and women. Finally, the willingness expressed by the local communities to be involved in conservation efforts is a sign that they value the benefits accruing from the ecosystems.

Output IV: Business case development for mangroves along the Kenyan Coast. The assessment was anchored on the realization of the need to integrate environmental, economic, and social concerns in mangrove development processes. The approach adopted two strategic perspectives to develop a comprehensive business case for the conservation of mangrove ecosystems along the Kenyan Coast.

Strategy 1: A Cost-Benefit Analysis (CBA), was performed with a key focus on substantiating the premise that mangroves have a higher economic value than any other alternative and competing land use. This was achieved by highlighting the economic importance of mangrove ecosystems in Kenya as a comparison to rife competing land uses along the Kenyan Coast. Among the various competing land uses identified, rice farming in Vanga area in the Southern Coast was earmarked for assessment as a case study. The general applied principle was to economically compare the undiscounted annualized net economic benefits per hectare of mangroves and the undiscounted annualized net benefits of rice farming, which were established to be Ksh 179,540 and Ksh 36,171 respectively. Based on the results, the mangrove ecosystems can be argued to be of higher economic value as compared to rice farming. It was however recommended that for a more conclusive assessment on the viability of either the mangroves ecosystems and/or conversion of the same into rice plantations, or any other competing landuse, a more intricate and in-depth cost benefit analysis would need to be undertaken, perhaps over 15 – 30 years, and factoring in the seasonality variability in the various parameters among others key economic considerations.

Strategy 2: An evaluation of viable mangrove investment key entry points was done. The key focus was on outlining practical proposals that can be used to mobilize finance for nature-based solutions, both at a National level and at a global scale with a vision is to align global economic development with the value of mangrove ecosystems. The assessment noted the challenge to re- orient the economic incentives that drive investment, production and consumption, and to make natural ecosystems' conservation a viable business proposition in its own right. It was established that, to overcome the challenge, there was a need to build commercial enterprises that generate profits through activities that conserve natural ecosystems, use biological resources sustainably, and share the benefits arising from this use equitably. Four 'benefit areas' where mangroves can provide value to potential investors in Kenya while ensuring that mangrove conservation and restoration is properly implemented were identified and proposed as business models. The benefit areas were earmarked as 'key entry points' for mangrove conservation due to their evident potential in providing exceptionally high disaster risk reduction benefits as well as other valuable ecosystem services. These are; **(i) Asset protection business model**; mangrove ecosystems are known to be very cost-effective structures that can be used for coastal protection against coastal and tidal erosion, storms, and other natural hazards. Studies have shown that the greatest threat to the Kenyan coastline, is the Karthala volcano on Comoros and has a likelihood of causing a tsunami with a probability of reaching Mombasa within 30 minutes. Destructive tidal waves are also very rampant along the Kenyan Coastline. In a bid to protect some of the notable historic sites along the coastline from such natural hazards, the Government of Kenya has in the recent past invested over Ksh 500,000, in building sea walls. Drawing from a study done in the Philippines that considered a 15-year investment period, it was reported that the conservation of mangroves and coral reefs is 50 times more cost-effective in comparison to coastal protection investment by constructing a cement seawall. On the other hand, another study done in Vietnam, showed that the restoration of 8,961 hectares of mangrove forests alongside a 100km dyke line in the Vietnam's most disaster-prone coastal provinces, reduced dyke maintenance by USD 7 million per year. Research has shown that by 2030, property damage due to coastal storm surges and sea level rise is set to increase by a factor of 10, making investments in mangrove conservation increasingly important. These are some of the lessons learnt that can be utilized for the conservation of mangroves along the Kenyan Coast. Evidently, Mangroves are the cheapest restoration option, and literature shows that it would cost an average of 3.6 times less than other coastal ecosystems. Some of the realizable

value metrics that the Government, private investors, and even the communities can benefit from, through the conservation of mangroves include; substantial cost savings from infrastructure construction; substantial cost savings from annual infrastructure maintenance; and finally, reduced insurance costs due to lower exposure to risks. **(ii) Payment of Ecosystem Services business model**; formal markets, some voluntary and others mandated by law, now exist related to carbon, water and biodiversity. In line with this, focused business deals and PES are now being forged to invest in restoration and maintenance of ecological systems and the services that they provide. Carbon trading under the voluntary markets is quickly gaining popularity among the coastal communities living adjacent to the mangrove ecosystems in Kenya. During this study, it was established that the Mikoko Pamoja, a user group in the Gazi mangrove forest formation makes an average of Ksh 1,200,000 in annual revenues from Carbon trading, in what is considered to be the world's first blue carbon project. This is a ripe business entry point that the communities can take advantage of. Indeed, the success story has drawn keen attention from the communities living within mangrove ecosystems across the coastline. Further, research shows that marine ecosystems capture up to 55 percent of biological Carbon, and mangrove forests can store up to five times as much carbon as land-based forests, better still, 40 percent faster. This, in essence, should incentivize even more, the communities living adjacent to the mangrove ecosystems in Kenya to invest their time and energy in the restoration of mangrove ecosystems, with the aim of getting rewards through voluntary markets. Some of the realizable value metrics that the communities, private investors, and even Government can benefit from through the conservation of mangroves include; increased revenues from carbon offsets generated; improved livelihoods for the communities; recognition both nationally and internationally; and finally, tons of carbon sequestered and avoided CO_2 emissions. **(iii) Community development business model**; The recognition of the communities adjacent to forests as key stakeholders and users of natural resources, as provided for in the Kenya Forest Act 2005, is considered vital if successful management of the forests is to be attained. The management plans governing the operations of the communities gives them legal user rights to sustainably utilize the forests through sustainable use schemes like fishing, beekeeping, ecotourism, carbon trading among others. These income generating activities have a potential to improve the livelihoods of local communities through increased incomes, while at the same time conserving and restoring mangrove ecosystems. Despite the ready opportunities for sustainable use schemes that the mangrove ecosystems provide, not much has been actualized across the mangrove forest ecosystems in Kenya. Only Tudor Creek, Gazi and Mida creek forest formations have a record of significant projects with an estimated average annual revenue of Ksh 8,580,000; Ksh 4,020,000 and Ksh 1,595,000 respectively. Among other challenges, the lack of capital to invest in sustainable use schemes was highlighted during this study. Private investors and even Government can therefore use such avenues to form partnerships with the local communities and take advantage of the many opportunities to make profits from the specific investments, while at the same time improving on biodiversity and ecosystem services. Some of the realizable value metrics that the Government and even the private investors can benefit from by investing is income generating activities that enhance conservation efforts in the Kenyan Coast include; improved National economy from increased local community income and value of products; lucrative business opportunities for the private sector through partnerships and other associated donor agreements; business recognition both Nationally and Internationally; increased number of local jobs and enterprises; reduced costs from local community conflicts; and finally National attainment of International commitments e.g. the Paris Agreement, the Sustainable Development Goals (SDG 15), the Aichi Target 5, and the REDD+ efforts. **(iv) Regulatory obligations business model;** the mangrove ecosystem is a cost-effective approach towards nature-based site remediation and restoration, for either Government or private investors, to meet regulatory standards and other strict environmental requirements for, businesses such as infrastructure, extractives, and energy. This is one of the ripe, yet under- utilized business opportunities that potential investors can harness to meet their obligatory requirements, while at the same time enhancing the restoration and conservation of mangrove ecosystems. Even though investors have not explored yet, the mangrove ecosystem along the Kenyan coast has great potential for investors to offset their carbon footprints and other site remediation to meet both national and international regulatory standards. Kenya's ratification to international agreements cuts across agreements like the Paris Agreement, the Aichi target, the SDG 15, the REDD++ strategy, among

others. Therefore, investors dealing in businesses such as energy, infrastructure, and other extractive ventures, must bear the obligation of offsetting their carbon footprints and other nature-based remediation in line with the State's standards. For instance, the China Road and Bridge Corporation (CRBC), an infrastructure company hired to build Kenya's first double-decker expressway, was tasked by the Government through the National Environmental Management Authority, to offset the loss of vegetation by planting trees at all affected public places along the corridor. The same requirements applies to many other investors alike running projects in Kenya. The mangrove ecosystems along the coast have a myriad of cost-effective opportunities that they can invest in to meet their remediation obligations. Some of the realizable value metrics that the Government and even private investors can benefit from by enhancing conservation efforts in the Kenyan Coast include; cost savings from reduced regulatory costs from permits, fines, etc.; cost savings from reduced remediation costs, i.e. the cost-benefit analysis of mangrove conservation and restoration in comparison with other remediation options, shows that the mangrove option is way more cost-effective; and finally investors can improve their operations from increased financial gains that can be attributed to the cost savings and boosted access to the international financing facilities owing to the fulfillment of international investment performance standards.

Finally, an evaluation of the apparent incentives necessary for the successful implementation of the proposed business models was done. The earmarked incentives are; a proper enabling environment, the availability and accessibility of nature-based financing instruments, the involvement of a wide range of stakeholders, the 'bundling and 'stacking' of ecosystem services, and the establishment of a common language between the worlds of business and nature conservation.

It is concluded that, tangible examples of financially viable nature-based businesses and operational markets for ecosystem services are necessary to persuade all stakeholders to come together to conserve natural ecosystems on a sustainable and commercial basis. The time is therefore ripe to start investing in the mangrove ecosystems of Kenya.

1.0: GENERAL INTRODUCTION

Nature matters, not just for its aesthetic and inspirational qualities, but for the other benefits that people receive from it. Ecosystems, fully embedded in nature, have the potential to supply a range of goods and services that are of fundamental importance to human well-being, health, livelihoods, and survival. These goods and services are defined as the direct and indirect contributions of ecosystems to human well-being.

Ecosystem globally are being modified leading to degradation especially in sub-Saharan Africa where the resources are over-exploited and the lands are converted to other uses. A major reason for this is that the economic value of ecosystem goods and services is poorly understood. This has led to the interference, modification and degradation of their resources and their functions, for they are seen to have little or no value as compared to other "developments" which yield more immediate and obvious profits (Emerton, 1998). The MA 2005, observes that one of the significant factors driving loss and degradation of ecosystem services globally is that decision-makers lack the information on the total value of ecosystem services when considering development decisions that would impact on natural ecosystems.

The focus of this project was to assess the socioeconomic role of mangroves and their conservation frameworks in Kenya through the development of in-depth profiles underpinning the 'Kenyan mangrove case' and identifying the 'key entry points' for mangrove conservation. Further the knowledge gap of valuation studies in Eastern Africa, covering the full suite of ecosystem services, was addressed to provide estimates at the regional and national levels. This work is part of the "Save Our Mangroves Now!"[1] joint commitment whose main aim it to upscale and focus global efforts to stop and reverse the decrease and degradation of mangrove habitats.

1.1: THE ECOSYSTEM SERVICE CONCEPT

Everyone in the world depends completely on Earth's ecosystems and the services they provide, (MA, 2005). Ecosystems, fully embedded in nature, have the potential to supply a range of goods and services that are of fundamental importance to human well-being, health, livelihoods, and survival (MA, 2005; TEEB, 2010). These goods and services are called ecosystem services or natural capital and can be defined as the benefits that people obtain from ecosystems (MA, 2005), and the direct and indirect contributions of ecosystems to human well-being (TEEB, 2010). Ecosystems however cannot provide any benefits to people without the presence of people (human capital), their communities (social capital), and their built environment (built capital). These benefits are perceived as a contribution of the natural capital to human wellbeing, which forms only by interaction with human, social and built capital, (Ruskule, et al. 2018). Natural capital is considered to be most vital

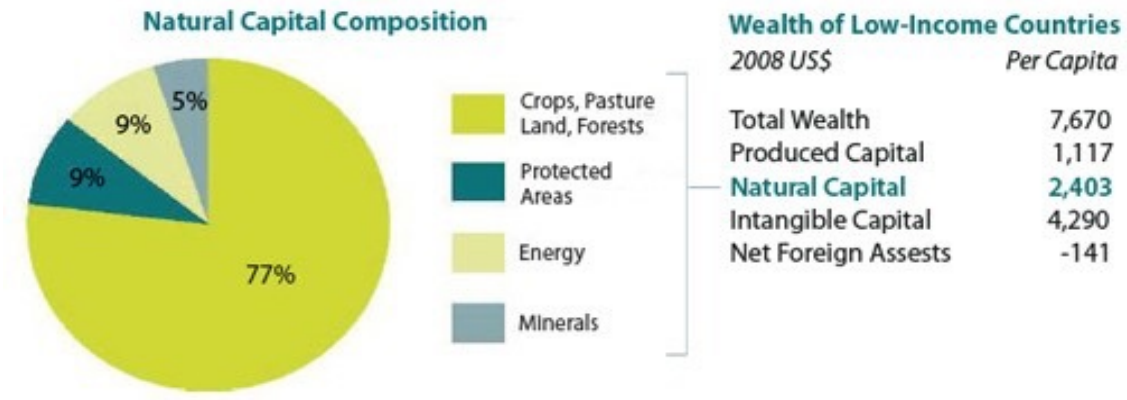


Figure 1-1: Natural Capital in the Developing World

Source: http://www.naturalcapital.vn/

1 https://www.iucn.org/regions/eastern-and-southern-africa/our-work/coastal-and-ocean-resilience/save-our-mangroves-now

because it underpins all other types of capital such as manufactured, human and social capital, and therefore is the foundation on which our economy, society and prosperity is built. The natural environment, in its broadest sense, offers numerous amenities, which can be used to the benefit of people. In essence, natural capital constitutes an irreplaceable provider of prosperity. This is particularly true for developing countries, where about 30% of the total wealth are derived from such capital[2]. Figure 1-2 below depicts a highly summarized list of natural capital (not mentioning biodiversity water resources and marine resources) of low-income countries. This evidently portrays that natural capital is an invaluable asset and plays an important role in the strategy of socio-economic development especially in the developing world. The concept of ecosystem services can therefore be perceived as an interface between people and nature for it makes visible the key role of ecosystem functioning and biodiversity to support multiple benefits to humans. It establishes a link between biodiversity, ecosystem services and human wellbeing in a cascade flow model from the natural to the human world.

1.1.1: CLASSIFICATION OF ECOSYSTEM SERVICE

The ecosystem service framework has several classifications with different typologies and approaches to classify ecosystem services, all with a range of intended purposes. These classifications have been established as guides for comprehensive ecosystem assessments rather than 'blueprints'. The classification of ecosystem services is a precondition for any attempt to measure, map or value them and to communicate the findings in a transparent way, (ELD initiative, 2015; Ruskule et al., 2018). The categorization used by the Millennium Ecosystem Assessment (MA) is one of the most popular, and whose foundation lies within raising awareness in the society about the different benefits that humans gain from the ecosystem, (MA, 2005).

The MA classification system proposes four main ecosystem services categories:

- **Provisioning services**; are the products obtained from ecosystems such as food, fresh water, wood, fiber, genetic resources and medicines.
- **Regulating services**; are defined as the benefits obtained from the regulation of ecosystem processes such as climate regulation, natural hazard regulation, water purification and waste management, pollination or pest control.
- **Supporting services**; are the services necessary for the production of all other ecosystem services such as soil formation, nutrient cycling, and primary production.
- **Cultural services**; include non-material benefits that people obtain from ecosystems such as spiritual enrichment, intellectual development, recreation and aesthetic values.

1.2: MANGROVE ECOSYSTEMS

According to the United States Environmental Protection Agency (USEPA)[3], wetlands are one of the most biologically productive ecosystems known globally. Mangrove ecosystems are a very important category of the wetland systems. They are trees and shrubs that possess a range of features, which make them adaptable to their stressful environment, such that they are salt tolerant, and grow at the harsh interface between land and sea in tropical and subtropical regions. They cover more than 15 million hectares of tropical coastal areas worldwide and are found in more than 123 countries, (Slobodian & Badoz, 2019). Even though they make up only 0.1% of the global landmass, mangrove forests are one of the Earth's most resilient, productive and bio diverse ecosystems[4]. They are rich in biodiversity and their structure and species composition vary considerably in each continent (FAO, 2007).

From global to local scales, mangroves are critical coastal ecosystems of immense significance, both ecologically and economically, to the human population. According to the 'Save our Mangroves Now' initiative[4], more than 120 million people live within a

2 http://www.naturalcapital.vn/

3 https://www.epa.gov/wetlands/why-are-wetlands-important

4 http://www.mangrovealliance.org/save-our-mangroves-now/

Quick Facts

- Mangroves are found in 123 nations and territories, but represent less than 1 per cent of all tropical forests worldwide, and less than 0.4 per cent of all global forests.
- Mangroves are rich in biodiversity. They provide a valuable nursery habitat for fish and crustaceans; a food source for monkeys, deer, birds, even kangaroos; and a source of nectar for honeybees. They support complex communities, where thousands of other species interact.
- Mangroves act as a form of natural coastal defense: reducing erosion, attenuating waves (and tsunamis) and reducing the height of storm surges.
- Mangrove soils are highly effective carbon sinks. They are among the most carbon-rich tropical ecosystems globally, and can contain more carbon per square meter than tropical rainforests. On average, they store around 1,000 tons of carbon per hectare in their biomass and underlying soil.
- Although very complex and resilient to natural disturbances, mangrove ecosystems worldwide are endangered by human activity and are lost at a greater rate than inland tropical forests.
- The management and restoration of mangrove ecosystems is an achievable and cost-effective way to help ensure food security for many coastal communities.

Source: UNEP 2017 (Mangrove on the spot light)

vicinity of 10 km from mangroves and they depend on these ecosystems for their survival. The ecosystems provide important goods and services which include; provisioning, such as a large variety of wood and non-wood forest products (NWFPs) (FAO, 2007); regulating, such as coastal protection against the effects of wind, waves, and water currents; supporting services, such as breeding and nursery sites for fish and crustaceans conservation of biological diversity, including a number of endangered mammals, reptiles, amphibians, and birds as well as the protection of coral reefs and sea-grass beds; and cultural, which include recreation, religious and aesthetic values of the resource (Brander et al., 2012; UNEP, 2006). Mangroves also play an important role in carbon sequestration with their storage averaging 1023 Mg of carbon per hectare, which is several times greater than the carbon density in terrestrial forest systems, therefore having great implications for climate change mitigation (Donato *et al.,* 2011).

Despite their value to humans, throughout history, mangrove ecosystems have largely been seen as wastelands - unproductive and unhealthy areas, and are heavily threatened by a range of anthropogenic pressures. The unsustainable use and the increasing economic development pressure on the mangroves have led to an alarming loss of global mangrove cover such that nearly half of all mangrove forests have disappeared since the mid-twentieth century. Some of the stressors on mangroves include, pollution, habitat loss through conversion to other land uses, climate change, overexploitation and poorly managed dredging and coastal development (Abuodha and Kairo, 2001; FAO 2007; Cormier-Salem, 2006; Van Lavieren et al., 2012). These threats have eroded the culturally and economically important fish stocks population and the structural complexity of various mangrove communities. This has largely contributed to the loss of livelihood for the largely fishing communities that are dependent on mangroves as fish habitat (Fulanda *et al.,* 2009). Owing to this detrimental losses, proper management, conservation and the sustainable use of mangroves is necessary, and this requires the consideration of a range of sectors and jurisdictions at international, national and local levels. The conservation and restoration of mangroves is an important contribution to the achievement of the Agenda 2030 of the United Nations, and the therein defined Sustainable Development Goals (SDGs), and more specifically the SDG 14 on the protection and sustainable use of our oceans and marine resources.

1.3: SOCIOECONOMIC VALUATION OF MANGROVE ECOSYSTEMS

The World's coastal ecosystems are facing significant pressure. A combination of geographical shifts in human settlements coupled with an exponentially increasing population as well as climate change are causing considerable changes in land uses. Owing to this, natural habitats are being converted into agriculture plantations, aquaculture farms, tourist destinations, and other land uses, (UNEP, 2011).

According to MA, 2005, one of the significant factors driving loss and degradation of ecosystem services globally is that decision-makers lack the information on the total value of ecosystem services when considering development decisions that would impact on natural ecosystems. Similarly, to mangroves, this lack of information makes mangrove forests vulnerable when choices have to be made between conservation, development or other ostensibly beneficial land uses. One reason why mangrove forests are threatened is because of the 'public-good' and 'non-market' nature of many of the ecosystem goods and services they provide (Ronnback, P., 1999). Due to the difficulty in estimating the value of the non-market ecosystem services, intact mangrove forests are often undervalued in benefit cost analyses of conservation versus other commercial land uses. Properly accounting for the multiple services provided by mangroves is therefore necessary for making efficient choices between developing mangroves and management alternatives that entail more conservation and less conversion and exploitation of mangroves, (Marwa & Evan, 2012)

The worldwide decline of mangrove forests has instigated a wide range of efforts to estimate the economic value of mangrove ecosystems and this has increasingly been considered essential for environmental decision-making in the recent past. Economists argue that, it is only when people bear the true economic costs of using natural resources, such as mangroves, will they have appropriate incentives to use them efficiently and minimize their degradation and losses. Other scientists too, have in the recent past started to call for the use of economic valuation information to lobby for the conservation of mangroves, since economic valuation information can play, at least theoretically if not practically, in encouraging conservation of mangroves and increasing efficiency in resource use, (Padma Lal, 2003). This is because, economic valuation methods offer a more comprehensive assessment of the many goods and services provided by mangrove ecosystems, and hence may contribute to more informed decision-making.

According to Daily et al., 2009, the main challenge is that, the relative forms of capital, assets embodied in ecosystem are often poorly understood, rarely monitored, and as a result, the ecosystems undergo rapid degradation. Further, the importance of ecosystem services is often recognized only after they have been lost. This therefore calls for the need to understand the elements that would motivate change in decision and behaviours and how such can be included in a conscious process of cultural norm evolution. This can be in the form of monetary rewards, legal sanctions, and approval by peers e.t.c. The integration of conservation into decision making process thus can be aided by;

- Broad discussion and inquiry into what motivate people and how social norms evolve especially in the context of nature
- Incorporating traditional knowledge and practices into modern conservation approaches and developing a broader vision for conservation, and approaches that move from confrontation to participatory efforts seeking a wide range of benefits

In order to take full advantage of the multiple benefits that ecosystems provide, there must be a clear understanding of the values of nature and where they can usefully be taken into account in public and private decisions. Presenting decision making institutions with evidence of these values and their beneficial role in their specific activities, alongside the development of feasible plans to incorporate them into existing structures and practices will therefore provide enabling conditions for mainstreaming. The assessment of ecological values is vital for the management of ecosystem services since it supports quantifying ecosystem services; identifying service providers and users; analyzing temporal changes in services; measuring delivered services in payments for ecosystem services; allocating resources among competing uses of services; decision-making for sustainable land use; and the selection of conservation priority sites, (Baral et al., 2017).

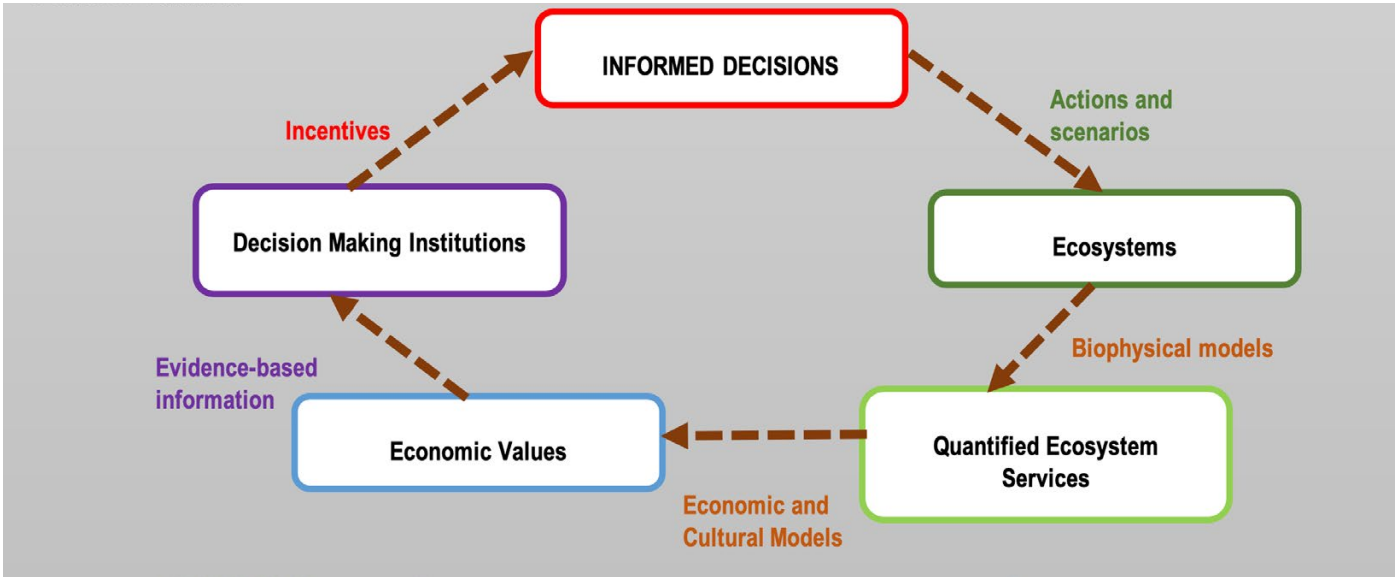


Figure 2-1: Integration of Ecosystem Service Values in Decision Making for Conservation

Source: Daily et al., 2009 (Modified)

Valuations if done well and robustly therefore, can influence policy at the local, regional, national, and international level in very positive ways. These include spurring planning and the development of policies to safeguard ecosystem services of value, determinations of risk, compensation for damage to natural capital, and a greater rationale for more holistic and effective ecosystem-based management. Figure 2-1 below presents a framework of the role that ecosystem services can play in decision making.

1.3.1. DRIVERS FOR SOCIOECONOMIC VALUATION OF MANGROVE ECOSYSTEM SERVICES

Some of the expected benefits accruing from the measuring and valuing of ecosystem services delivered by mangrove ecosystems as portended by Neugarten et al. 2018, include;

1. **For public/policy support;**
   - Valuing of ecosystem services provide additional evidence and justification for the importance of conserving a particular site and even lobbying for commensurate budgetary allocations for their conservation and management from the national accounts
   - Valuing of ecosystem services fosters local awareness of the ecosystem services provided by a particular site
   - Valuing of ecosystem services builds support for the conservation of multiple sites through increased understanding of their wide range of benefits
   - Valuing of ecosystem services links contributed by all sites in a Country to international or national sustainability goals and national policies (e.g. Sustainable Development Goals)

2. **For site management**
   - Valuing of ecosystem services aids in the establishment of the baseline of ecosystem services provided by a site to enable monitoring of changes and support management planning
   - Valuing of ecosystem services reveals synergies and possible trade-offs between ecosystem services and conservation objectives to identify management options for the site and better define conservation objectives
   - Valuing of ecosystem services develops, implements and updates management strategies for the site, building on the understanding of ecosystem services (e.g. integration of ecosystem services into site's management plan or developing a business plan for the site)

3. **For human well-being**
   - Valuing of ecosystem services ensures a good understanding of the ecosystem service values that are important to resident, local and more distant stakeholders
   - Valuing of ecosystem services allows for the assessment of compensation options to

resident and local stakeholders for ecosystem services forgone as a result of biodiversity conservation, and it contributes to discussions about Free Prior and Informed Consent, conflict resolution, etc.

4. **For planning**
   - Valuing of ecosystem services supports spatial and strategic conservation planning and investment by identifying areas of particular importance for ecosystem services
   - Valuing of ecosystem services supports in the assessment of potential consequences of different sectoral (e.g. agriculture, infrastructure etc.) decisions and policies on ecosystem services delivered by sites (scenario comparison)
   - Valuing of ecosystem services supports in the assessment of potential consequences of climate change scenarios on ecosystem services provided by a site
   - Valuing of ecosystem services supports the integration of ecosystem services delivered by sites into land/water/resource use planning at regional, national or sub-national scales through the understanding of implications for management of surrounding areas to improve flows of ecosystem services

5. **For private sector engagement**
   - Valuing of ecosystem services helps businesses manage risks and meet their social and environmental responsibility targets, by identifying possible impacts on ecosystem services and beneficiaries (e.g. Environmental Impact Assessments, corporate sustainability assessments)
   - Valuing of ecosystem services provides incentives for businesses to engage in the conservation of sites by demonstrating the dependence of the businesses on ecosystem services provided by sites (e.g. public-private funding schemes, in-kind support, branding)

6. **For funding and investment**
   - Valuing of ecosystem services attracts Government and donor investment from other sectors concerned with conservation of ecosystem services (e.g. forest management, national security) and/or donors interested in sustainable development
   - Valuing of ecosystem services supports the development of new sustainable finance mechanisms for conservation of the sites, such as Payments for Ecosystem Services (PES) or carbon financing such as Reduced Emissions from Deforestation and Forest Degradation (REDD+)

7. **For knowledge generation**
   - Valuing of ecosystem services informs research on ecosystem services provided by sites locally, nationally, regionally or globally
   - Valuing of ecosystem services informs research on the synergies and trade-offs between conserving biodiversity and ecosystem services, between different ecosystem services, and between different stakeholders.

2.0: MANGROVE ECOSYSTEMS IN KENYA

2.1: BACKGROUND INFORMATION

Mangrove forests in Kenya are found in five coastal counties: Lamu, Tana River, Kilifi, Mombasa, and Kwale, see Figure 1-2. According to the Kenya Forest Service[5], the total mangrove area in Kenya is about 61,271 ha covering over 18 forest formations. These ecosystems are found both in narrow fringing formations and in creeks and estuaries of major rivers. Despite the semi-arid conditions, the most extensive mangroves are found in the north along the complex of creeks and embayment of the Lamu Archipelago and adjacent mainland (Spalding et al. 2010). There are also significant mangrove forests in the Tana River Delta, while smaller mangrove areas are found on Kenya's only other perennial river, the Galana (or Sabaki). The Gazi Bay in the south has a broad and diverse mangrove fringe in a deep embayment with associated seagrasses and coral reefs. Administratively, 61% of the mangroves are situated in the county of Lamu, 14% in each of the counties of Kwale and Kilifi; 6% in Mombasa; and 5% in Tana River.

There are nine species of mangrove trees and shrubs found along the Kenya coast, (Lang'at, 2008). They are; *Rhizophora mucronata* (Lam), locally known as mkoko, *Bruguiera gymnorrhiza* (L) Lam, locally known as muia, *Ceriops tagal* (Perr), locally known as mkandaa, *Sonneratia alba* (Sm), locally known as mlilana, *Avicennia marina* (Forsks), locally known as mchu, *Lumnitzera racemosa* (Willd), locally known as kikandaa, *Xylocarpus granatum* (Koen), locally known as mkomafi, *Xylocarpus molucensis* (Lam.), locally known as mkomafi dume, and *Heritiera littoralis*, locally known as msindukazi, (Kairo, 2001). According to the KFS, the mangroves follow a typical zonation pattern. The *Sonneratia alba* grows closest to the low water line, followed mainly by *Rhizophora mucranata*, then comes *Bruguiera gymnorrhiza*, *Ceriops tagal, Avicennia marina, Lumnitzera racemosa* and *Heritiera litoralis* respectively. The commonest Kenya mangrove species are the *Rhizophora mucronata* and *Avicennia marina* and both are found along the entire Kenyan coast. The *Heritiera littoralis* is found only in a small pure stand at the Tana River estuary near Kipini (UNEP, 1998). According to Fergusson, (1993), Mangrove forests occur within six distinct landscape categories in Kenya; (a) within sheltered bays and reef patches as in the cases of Vanga, Shimoni and Gazi, (b) in drowned river valleys at Mombasa, Mtwapa, Kilifi, Mwachema, Takaungu and Dodori, (c) in bays at the Mida Creek, (d) behind marine influenced barrier dunes in Ngomeni, (e) behind barrier dunes, predominantly estuarine, in Sabaki and Tana deltas and (f) on abrasion reef platforms behind protective outcrops of coral limestone and coquinas in the mangroves of Lamu.

Mangrove in Mida Creek

5 http://www.kenyaforestservice.org/index.php?option=com_content&view=article&id=316:tusker-all-stars-plant-trees-at-karura-forest&catid=223:hict&Itemid=98

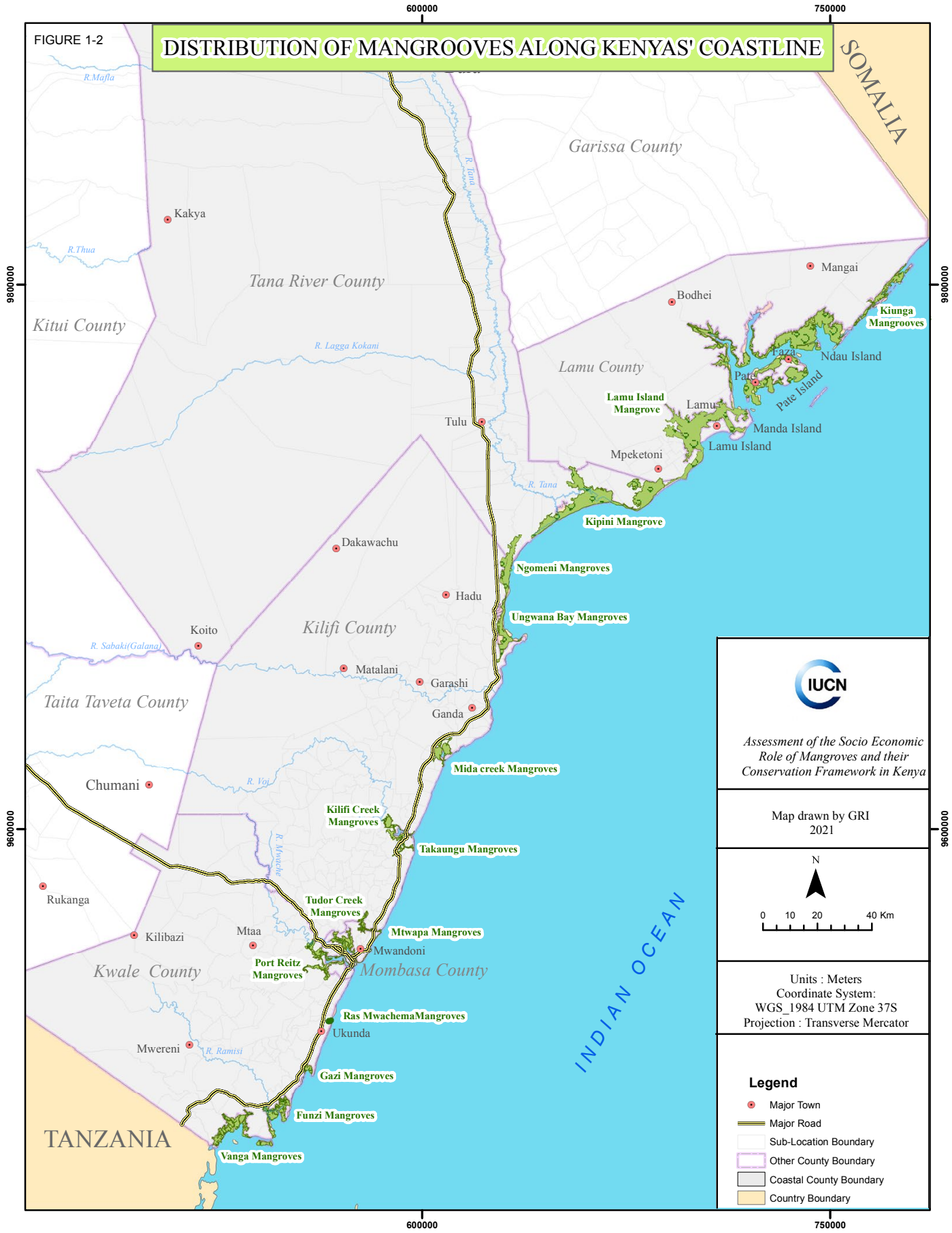


Figure 1-2: Distribution of Mangroves along the Kenyan Coast

2.2: MANGROVES' DIRECT AND INDIRECT CONTRIBUTION TO THE KENYAN NATIONAL ECONOMY

Mangrove swamps are often hot, mosquito-ridden, muddy and almost impenetrable. As a consequence, they are frequently held in low regard and often seen and used as wasteland, (Els Martens, 1996). The mangrove ecosystem provides socio-economic, ecological, environmental, cultural, scientific and educational value to the people in varying degrees. Direct and indirect products from the mangroves form the basis of mangrove-dependent economic activities. Mangrove forests along the Kenyan coast provide goods and services to the coastal people. There is an established tradition on mangrove use in Kenya for wood and non - wood products. Local timber consumption has continued to rise and it is estimated that 70 % of the wood requirement by the coastal people is met by the mangroves (Lang'at 2008). The timber is commonly used for building huts, furniture, boats and fish traps. Mangrove wood is also used for fuel-wood and charcoal. While the ecosystem is valued for the extractable resources it supports, it also provides ecological values and non-consumptive services. For instance, along the Kenyan coast a few mangrove areas are known as sacred forests, e.g. the mangrove kaya on Chale Island. Tourism has also arisen around the Kenyan mangroves; like the 500m boardwalk in Gazi Bay which brings valuable income to the local community, (KMFRI, 2013). Some of the direct and indirect contributions of mangroves to the Kenyan economy are;

i. **Mangrove goods;** Mangrove goods are grouped into products derived from their woody parts i.e. timber products, and products derived from their non-wood parts, i.e. non-timber products.

- **The timber products** along the Kenyan coast are mostly sought after as building material. This is largely because mangrove wood is relatively durable and resistant to rotting and termite attack (Spalding et al. 2010). The extensive export of mangrove poles for building particularly to Arab countries was banned in 1982. This caused a remarkable decline in the exploitation of mangrove forests along the Kenyan Coast, especially in Lamu, however the average yearly harvest along the whole coast remained quite the same (Els Martens, 1996). Other uses for the wood include; boat building and fishing stakes. The timber products are also a main source of fuel for the coastal communities in Kenya, and harvesting of mangroves for fuel wood occurs throughout the Kenyan coast line. According to Baba et al. 2013, some tree species, notably those of the family *Rhizophora,* produce wood that burns with a high calorific value, and because of this, mangroves provide an abundant source of firewood and high quality charcoal. Firewood is particularly important in areas where there are no alternative sources of energy especially for domestic cooking. The timber products are also highly used for wood crafts, because certain mangrove species have timber which is soft enough for sculpture
- **The non-timber products** harvested from mangroves include; tannins. The bark of all mangrove trees, but particularly, those in the family of *Rhizophora* contain large amounts of tannins, which have traditionally been used to prepare leather, cure nets to extend their longevity, and as dyes for cloth. The mangroves are also a source of food for the coastal communities e.g. the provision of fish and other sea animals. Different mangrove plants are also consumed by coastal communities. The nectar of mangrove plants also attracts honey bees, which facilitate apiculture activities in some regions along the Kenyan coast line. Mangrove vegetation is also harvested and used as fodder where both the foliage and propagules are fed to livestock. Mangrove plants are also widely used by the coastal dwellers for bush medicine, since the majority of mangrove areas are inhabited by rural communities who in most case, have limited access to medical facilities.

ii. **Mangrove Services;** the intangible benefits from mangroves are significant, however not always noticed nor measured. Some of the major and valuable ecosystem services from mangroves include;

- **Recreation and Tourism**; because they are located along coastlines and have unique aesthetic and ecological characteristics, mangrove ecosystems provide excellent opportunities for recreation, ecotourism and environmental education.

Figure 2-2: Ecosystem services delivered by mangroves

- **Climate change mitigation**; mangroves are one of the most carbon-rich tropical forests and have extremely high carbon storage rates. They store more carbon per hectare than other vegetative coastal ecosystems
- **Coastal protection;** mangroves play an important role in shoreline protection under normal sea conditions and during tropical storms. Due to their complex structure, particularly their aerial roots, the presence of mangroves can attenuate waves and reduce the impacts of storm surges
- **Bio filtration;** several properties enable mangrove systems to remove excess nutrients and pollutants from contaminated water sources. Mangrove vegetation is highly productive and can filter nutrients from water. Extensive root systems slow the movement of water, promote settlement of particles and bind particles in the substrate
- **Nutrient cycling;** Mangroves play an important role in nutrient cycling in coastal ecosystems. They are often nutrient poor but maintain high rates of productivity through efficient nutrient cycling and nutrient conservation. They produce large amounts of tree litter, and particularly, leaf litter and the decomposition of this litter contributes to the recycling of nutrients within the mangrove as well as adjacent habitats
- **Wild life habitat**; Mangrove forests are unique ecosystems which provide habitat to a broad diversity of plants and animals both large and small. From the leafy canopy, to the muddy intertidal banks, and aerial roots which extend into the water, the forest offers many environments for animals to exploit. The main groups of animals found in the mangrove include sponges, prawns, insects, fishes, amphibians, reptiles, birds and tiny animals which live in and on the sediments. Birds roost in the canopy, shellfish attach themselves to roots, and snakes and crocodiles use them as hunting grounds. Many bird species use mangroves as nesting or roosting grounds, including terrestrial and marine species that may feed in adjacent ecosystems. Other marine species use the complex structure of the mangroves as shelter from predators, spreading quickly through the shallow waters of rising tides into areas where larger predators cannot easily reach. The roots of mangroves provided hard substrate for bivalves, such as oysters to settle on and can be abundant on mangrove roots.

2.2: MANGROVE STRESSORS AND DRIVERS OF THEIR LOSS; A KENYAN PERSPECTIVE

Mangrove forests in Kenya face a number of threats arising from both anthropogenic as well as natural causes. Between 1985 and 2009, the Country lost about 20% of its mangrove cover; translating to about 450 ha of mangrove area per year, (GOK, 2017). Further, a study done by KMFRI shows that from 2000 to 2010, mangrove depletion in Kenya totaled to 1,340 ha (3,310 acres), compared to 4,950 ha (12,230 acres) lost in the eight years prior to that. Generally, according to GOK, (2017) at least 40% of mangroves across the coast are degraded as shown in the Table 1 below. Losses of mangroves are disproportionately higher in urban centers than in rural areas. In Mombasa County, for instance, the loss of mangroves is reported to exceed 80% in the last decade (GOK, 2017).

Table 1-2: County Mangrove degraded proportions

County	Mangrove area(ha)	Degraded mangrove (ha)	% Degraded area
Lamu	37,350	14,407	38.6
Tana River	3,260	1,180	36.2
Kilifi	8,536	3,422	40.0
Mombasa	3,771	1,850	49.1
Kwale	8,354	3,725	44.6
Total (ha)	61,271	24,585	40.1

Source; GOK, 2017

The major proximate causes of threats to mangroves include; cutting for domestic and industrial use, pollution from land-based sources, oil spills from tankers, conversion of mangrove areas to other land uses e.g., salt works and commercial prawn aquaculture in Ngomeni, and infrastructure development around mangrove areas (Kairo 2001). On the other hand, the underlying driving forces that underpin the proximate causes have been identified as population pressure, poverty and inequality, low levels of education, economic development, and poor governance. Poor governance manifests itself in a range of management problems and deficiencies, and generates threats from forest encroachment, overexploitation of resources among other activities, (GOK, 2017)

Degradation pressure is especially severe in Mombasa and surrounding areas due to the high human population in the area. For instance, between 1992 and 2009, the Tudor Creek mangroves in north-western Mombasa lost 86% canopy cover, representing an annual cover loss of 5.1% per year against a national average of 0.7% per year (Bosire et al., 2013). In the same period, Mwache mangroves also in Mombasa, lost 45.4 % cover representing an annual loss of 2.7% per year. Other threats include siltation caused by soil erosion and natural hazards associated with climate change, and which is believed to be responsible for frequent floods and erosion along the coastline, affecting the ecological stability of mangrove areas. Damming rivers also threatens mangroves by increasing salinity during the dry season (Gang et al., 2009). The Kenya Forest Service[6] summarizes the threats facing Kenyan mangroves as outlined below;

1. Reduction in species diversity due to preferential extraction of certain species and of trees of given specification
2. Overexploitation of wood resources for building poles, fencing, fuel wood, fishing stakes, charcoal burning among others
3. Pollution effects including oil spills, solid waste and sewage disposal. Oils are harmful to the

6 http://www.kenyaforestservice.org/index.php?option=com_content&view=article&id=316:tusker-all-stars-plant-trees-at-karura-forest&catid=223:hict&Itemid=98

mangroves since they clog the breathing roots leading to suffocation.

4. Opening up beaches have led to chocking of mangroves through beach sand accumulation.
5. Conversion of mangrove forest areas to other uses including salt mining or even settlement.
6. Over reliance on mangrove products due lack of suitable alternatives
7. Poverty has been outlined as the main contributing factors towards overexploitation of mangrove forests.

Based on the analysis of benefit and threats facing mangrove ecosystem in Kenya, six management programmes were developed to ensure an integrated approach to their management, based on the following objectives (GOK, 2017).

1. To conserve and manage mangrove wood and non-wood resources on a sustained yield basis;
2. To manage and protect mangrove areas for fisheries, erosion control, coastal stabilization and biodiversity conservation;
3. To promote community participation in mangrove resource management for improved livelihoods;
4. To strengthen institutional capacities of the institutions responsible for mangrove management;
5. To promote tourism and recreation in mangrove areas; and
6. To promote research and education on conservation and management of mangrove and associated ecosystem.

3.0 PROJECT OUTPUTS

3.1: OUTPUT 1- ASSESSMENT OF THE NATURAL CAPITAL FROM MANGROVES ALONG THE KENYAN COAST

The valuation of an ecosystem is a complex process that is reliant on the availability of relevant and accurate biophysical data on ecosystem processes and functions and the appropriate applications of economic valuation (Morse-Jones et al., 2011). The economic value of biodiversity and ecosystem services has its place in the policy-making process owing to the substantial economic value, compared with alternative consumptive resource uses, which might not tell us everything we need to know about the value of biodiversity and ecosystem services. Several studies have been carried out on mangrove ecosystem valuation all over the world in a number of different ways. Spaninks & Beukering (1997) indicates that the nature of mangrove ecosystem services valuated and their alternatives vary from one region to another and with the type of mangrove management considered. The underlying ecological linkages also differ and remain inconsistent and this makes it difficult to undertake the comparison of mangrove studies.

Economic valuation attempts to provide an empirical account of the value of services and amenities or of the benefits and costs of proposed actions (projects or policies) that would modify the flow of services and amenities. Further, economic valuation provides a utilitarian account of the contribution to the satisfaction of human preferences. Valuation relies on detailed information from the natural sciences. For instance; one might value an environment as an asset, in which case its value would be the net present value of the services that it provides and will provide. Alternatively, one might evaluate some proposed action (a project or policy); and the value would be the net present value of the change in services that the environment will provide minus the cost of implementing the proposed action. Either way, valuation requires detailed knowledge of, the service flows of the environment; the costs incurred in preparing these services for human enjoyment; and the responsiveness of service flows and costs to human interventions, (Randall, 1987). Ghani (2006) expresses the economic value as the degree to which goods or services satisfy individual preferences and this forms the basis for theory of economic valuation.

Socio-economic valuation involves the use of ecosystem-based approaches that provide information on socio-cultural and economic benefits. Ecosystem-based adaptation is underpinned by the concept of 'ecosystem services,' which describes the links between the natural environment and human well-being. This approach has been there since the 1970s, and was found to build public interest in conservation, (Liu at al 2010; Norgaard 2010). Ecosystem-based approaches to reduce social vulnerability are a promising option for sustainable and efficient management of degraded ecosystems, (Chong, 2014). Ecosystem based Adaptation (EbA) notably is part of the overall adaptation, and takes into account multiple social, economic and cultural co-benefits for local communities. EbA encompasses adaptation policies and measures that take into account the role of ecosystem services in reducing societal vulnerability, through multi-sectoral and multi-level approaches, (Andrade et al., 2011). EbA has been known to be of great help in maintaining and restoring natural infrastructure such as mangroves, coral reefs and watershed vegetation to reduce vulnerability to storm surges, rising sea levels and changing precipitation patterns. It also works to conserve biodiversity and make ecosystems more resistant and resilient, (Andrade et al., 2011). The Total Economic Value (TEV) approach is another way of ascertaining the true value of ecosystem services. Perez (2017) describes the TEV as the value derived by people from natural resources and manmade resources. In Environmental economics, Pant, et al., (2015) defines it as an aggregation of value emanating from a particular ecosystem. In the TEV approach, the desire is to valuate both direct, indirect and non-use values in any given ecosystem. This approach ensures that all the ecosystem services emanating from ecosystem functions are all incorporated in a valuation process.

One of the key purposes for this study is to ***support the integration of ecosystem service values and their needs for conservation within planning and policy-making at both the national and international levels and thus contributing to the fulfilment of national and international environmental policy targets.*** The study incorporated both the TEV and the EbA approaches to implement the socio-economic valuation process while adhering to all the international

Fisherman at the Mida Creek

standards and guidelines for socio-economic valuation. The success of the valuation exercise was highly dependent on the availability of data.

3.1.1: METHODOLOGY

The choice of the approaches adopted for this study took into consideration outputs from a review of the valuation studies that have been done in the past with a special interest to those done along the Kenyan coast. From this, various valuation methods were selected and are presented below;

a. Valuation of fish species associated with mangrove ecosystem in Kenya

There are several species associated with mangrove ecosystem and according to the status of fisheries report by KMFRI 2018, there are 197 fish landing sites along the Kenyan coast. Over the years there has been a decline in fish abundance particularly in the near shore fishing grounds. This report further indicated that the monthly fish catch ranged between 1200 to 3400 MT with an average of 2000MT per month. The Fisheries Sector in Kenya contributes about 0.3% to the Gross Domestic Product (GDP) annually. The sector is considered important in providing informal employment in fish production, processing and marketing. The Fisheries Department's Annual Reports indicate that those directly involved in fish production have increased from about 10,000 in early 1970s to nearly 50,000 currently. About 800,000 people rely on the fishery directly or indirectly for their source of livelihood, either in fish production, processing and marketing or as dependants of people engaged in the fisheries sector. The artisanal fishermen along the Kenyan coast account for 90% of this catch, while the rest are derived from prawn trawlers and only consist of fish catch by catch, (KMFRI, 2018). Wakwabi et al., (2003) estimated the pelagic fishery accounts for 18% of the marine fishery landings, with 80% of the total marine products coming from shallow coastal waters and reefs, and about 20% coming from off-shore fishing. Intertidal shallow aquatic environments such as mangroves, tidal creeks and tidal flats offer conditions which favour the presence of large assemblages of fish (Rozas & Zimmerman, 2000; Vidy, 2000). It has been documented by Little et al., (1988) that there are 86 species belonging to 43 families in Tudor creek and Gobiidae and Gerridae were the dominant families. Further in Gazi bay, Kimani et al., (1999), recorded that 128 fish species belonging to 50 families were using beach seines in Gazi bay where the Gerreidae, Atherinidae and Clupeidae were the most abundant, accounting for 78.5% of the total catches. In Kilifi creek, Oyugi (2005) recorded 95 species belonging to 45 families and found Signathidae and Leiognathidae to dominate using gillnets, handnets and castanets. Studies conducted in Ungwana bay (Mirera et al., 2010) and Mtwapa creek (Mavuti et al., 2004) have also reported similar families and species however with different densities. The studies generally supported the existence of a distinct community of fish species that are closely associated with mangroves and species that migrate freely between the creeks, seagrass beds, sandflats and coral reefs. Only one species according to these studies, the crepuscular feeder *Sphaeraemia orbicularis* (Apogonidae) has been established to be strictly mangrove associated.

The fish species associated with mangrove ecosystems, and were accounted for in this valuation are listed in the table below;

Table 1-3: Fish catch associated to Mangrove ecosystems in Kenya

Common name	Local name	Scientific name
Dermesal and Pelagic Fish		
Rabbit fish	Tafi	*Siganus spp.*
Scavengers	Changu/Tangu	*Lthrinus spp.*
Snapppers	Kiunga	*Lutjanus spp.*
Parrot Fish	Pono/Mwera/Parati	*Callyodon guttatus*
Surgeon fish	Kangaja	*Acathurus spp.*
Unicorn fish	Puju	*Naso unicomis*
Grunters	Pamamba	*Pomadasys operclare*
Pouter	Chaa	*Cephalopholis argus*
Black Skin	Fute/Kufi	*Gateringaterinus*
Goat fish	Mkundaji	*Pseudeopeneus spp.*
Streaker	Mshigashawe	*Aprion virescens*
Rock cod	Tewa	*Epinephelus macrospilus*
Cat fish	Fumme	*Tachysurus dussumieri*
Mixed Dermesal	Fulusi n.k	
Mullets	MKizi	*Mugil Cephalus*
Baracuda	Mizia/Mishio/Papa/Matengezi/ Chungichungi	*Sphyraena japonica*
Cavalla jacks	Kolekole/Kandoizi	*Euthynnus pelamis*
Milk Fish	Mwatiko/Myimbi	*Chanos chanos*
Little Mackerel	Una/Mbono	*Rastrelliges kanagurta*
King fish	Nguru	*Scomberomorus lineolatus*
Queen fish	Pandu	*Istiophorus gladius*
Sail fish	Sulisuli	*Chorinemus tol*
Mariculture		
Crabs	Kaa	*Scylla serrata*
Octopus	Pweza	*Vulfaris Spp*
Lobsters	Kamba Mawe	*Panulirus spp.*
Squid	Ngisi	*Sepia Loligo*
Prawns	Kamba	*Peneaus spp.*
Oysters		

NB: The list is based on Fish catch data for 2019 from County Fisheries departments

The assessment looked into the volume of coastal species in tonnes from the mangrove zones and the surroundings, and catch in mangroves and ontogenic migration (spill over areas around the mangroves). The ecosystem service valuation was calculated based on market prices as follows

$$V = (AxB) - C$$

Where;

V-value of the ecosystem service based on direct market price

A-The quantity of fish harvested in tonnes within a particular base year of ecosystem service assessment.

B-The market price as averaged with the particular base year of ecosystem service assessment

C-Cost incurred in harvesting and transporting the fish e.g., harvesting cost etc.

b. Mangrove wood product valuation

Informal small-scale mangrove wood harvesting has received limited attention, though it is a widespread threat to mangroves in many parts of the tropics. Livelihood activities drive the harvesting of certain species and size classes. Mangrove wood is used mainly for the construction of traditional housing and fencing. About 90% of the mangrove wood is utilised in building and heating. The highly rated species for wood according to the locals is *Rhizophora Mucronata* (mkoko) and *Ceriops Tagal* (mkandaa), (Kairo, 1992; Dahdouh-Guebas et al., 2000). The implementation of the moratorium which banned wood product harvesting in most of the mangrove areas resulted to firewood valuation consumer prospectives for firewood and charcoal, apart from Lamu forest formation where the moratorium was lifted.
The following was considered in the calculation of wood products. The data was obtained from the Energy report of 2019 for Kenya (Ministry of Energy, 2019), and the Kenya National Bureau of Statistics Population Census data for Kenya for the year 2019 (KNBS, 2019).

- Number of households within 10Km radius per forest formation in 2019
- Charcoal use per household annually
- Firewood use per household annually in 2019
- Cost per kg charcoal used annually in 2019
- Cost per kg wood used annually in 2019
- Firewood use at county level
- Charcoal use at county level
- Household firewood use within 10km per forest formation
- Household Charcoal use within 10km per forest formation
- Value of wood from mangrove
- Value of charcoal from mangrove
- Total Value

The calculation used;

$$(Number\ of\ housholds(2019) * firewood\ use\ per\ household) = Total\ Firewood\ use\ in\ Kg$$

$$\%\ charcoal\ use\ per\ county * Total\ firewood\ use\ in\ Kg = Actual\ firewood\ use\ in\ kg$$

$$Actual\ Firewood\ use * Cost\ per\ Kg\ of\ firewood\ in\ 2019 = Value\ of\ firewood\ Use$$

c. Medicinal use

Mangroves have been known to have medicinal value, however data to indicate the amount and the medicinal value are scanty for the Kenyan Coast. Therefore, the cost of treating patients with traditional medicine from mangroves was applied. The value of medicinal plants was estimated as the amount of income made by medicine men from treating people using mangrove extracts. It follows therefore that the assessment of the medicinal value adopted the market price formula as shown below.

$$V = A * B$$

Where;

V- is the medicinal value of mangroves

Number of people treated for various ailments using mangrove extracts

The price of traditional medicine consultation fee especially for those using mangrove extracts

NB. Not all the forest formations reported the commercial use of mangrove extracts as traditional medicine for treatment of community members. This service was only reported for Mtwapa, Tudor, Kilifi and Gazi forest formations.

d. Habitat provision (nurseries for fishes and marine species)

A large number and variety of fish species and other marine species use the mangroves for nursery, spawning and feeding grounds. The main fish, shrimp and crab species available for fishery in the mangrove area include small pelagic fish, snapper (lates calcarifer Bloch), milkfish (*Chanos chanos*), whiteleg shrimp (*Penaeus vannamei Boone*) and mud crab (*Scylla serrata*). The provision of the nursery ground value for fish and marine species can be obtained from the Nutrient productivity of the mangrove ecosystem and related to fish production, (Spaninks & Beukering,1997). The nutrient productivity of the ecosystem is linked to soil organic carbon (net primary productivity) that determines the nutrient richness of the soil. The value of the soil organic carbon (nutrient productivity) is then equated to the value of fish production. Fitri et al., (2018) estimated the litter production in indonensia for certain species of mangroves to be Avecinnia spp 12,318kg/ha/year, Rhizophora spp 19,436.25kg/ha/year and sonneratia spp 10,311.25. kg/ha/year. Establishing the soil organic carbon emanating from the litter discharge by various species determines the mangrove ecosystem habitat provision according to Spaninks & Beukering (1997).

Where;

Habitat provision Value = (Nutrient productivity (kg/ha) X Mangrove area) X the price of Fish per Kg

The data for Nutrient productivity was obtained from the Soil organic carbon mangrove datasets from Sanderman et al., (2018).

e. Carbon sequestration

Field surveys are the most basic ways of getting Above Ground Biomass (AGB) data however the method is time consuming and costly when applied to larger areas, (Hu et al., 2020). In addition, field surveys in mangrove ecosystems are challenging due to the muddy conditions and the nature of the mangrove ecosystems. However, modelling and remote sensing have proven as easier methods for the estimation of AGB. The most popular methods of remote sensing used in estimation of the biomass include passive optical remote sensing, radar and light detection and ranging Lidar, (Wang et al., 2019).

Mangroves are usually highly productive forests and, with a significant fraction of their soil carbon being plant-derived. It is therefore crucial to assess the rates of net primary productivity of mangroves and associated plants, especially the benthic microalgae. Measurement of primary production in mangrove forests is limited by methodological shortcomings, but the best estimates suggest that mangrove carbon production is more rapid than other estuarine and marine primary producers. The calculation of the above ground biomass and below ground biomass is very important for accurate carbon storage within mangrove ecosystems.

Biomass is the sum total of all the components of a tree, below ground as well as above ground, (Hogarth, 1999). Mangroves have higher relative root mass (Saenger, 1982), therefore the calculation of below ground biomass is also important. Allometric equations are very powerful in estimating the carbon sequestration in any green space but where such data is missing remote sensing data is applied. The remote sensing data developed by Sanderman et al., (2018) and Simard et al., (2019) for Soil organic carbon and Above Ground Biomass was used respectively. The estimation of the quantity of carbon stock in terms of $tC0_2$ stored in mangrove ecosystems adopted the following procedure drawn from Salcone et al., (2016).

i. Mangrove ecosystem land cover classification for the years 2000 and 2019 respectively was done.
ii. Above Ground Biomass and Soil Organic Carbon data for year in question was acquired.
iii. The carbon sequestered by the mangrove ecosystem was computed. This was calculated as follows;

$$Carbon\ Sequestration_t = \sum(r_{s,t} + q_{s,t})$$

Where;

r represents the rate of carbon sequestration (according to Salcone et al., (2016), the rate of carbon sequestered per year by mangrove is estimated at 6.3 t Co_2 /Ha/Yr)

q the carbon stored that would otherwise have been lost if the ecosystem is disturbed.

The subscript **s** refers to the species; the subscript **t** refers to the length of time analysed, usually one year.

Data on the rates of carbon sequestration by different ecosystems and the extent of those ecosystems was used to estimate annual quantities of carbon sequestration;

Data on the quantity of stored carbon in different ecosystems and reductions in extent of those ecosystems was used to estimate the annual quantity of carbon prevented from release or decay into the atmosphere.

If an ecosystem was protected, and we assume that the stock biomass and substrate was being destroyed or damaged, the annual value of carbon sequestration was estimated by multiplying the annual rate of sequestration by the value per tonne of carbon, as represented below;

$$Value\ of\ Carbon\ Sequestered_t = \sum(r_{s,t} + q_{s,t}) * Value\ per\ tonne\ of\ carbon$$

i. The carbon released as a result of reduction in the mangrove ecosystem area was then estimated, drawing from Salcone et al., (2016), This was assessed through[7];
ii. Generating the current rates of change in areas of coastal ecosystems (total areas of coastal ecosystems multiplied by the percentage change) the global average is 0.7–2.1% (Murray et al., 2011). The data on current state of change were calculated from the landcover classification.

Total area of mangrove* Global average rate of change

$$Area * 2.1^8$$

The estimated quantity of carbon stored and released to the atmosphere (For mangroves, average biomass carbon ranges from 237–563 t CO2-eq/ha (Murray et al., 2011). Regarding the rate at which biomass carbon is released, it can be assumed that if the mangrove is burned, 75% of biomass carbon of mangroves is released immediately and that the remaining 25% decays with a half-life of 15 years (i.e. a further 12.5% is released within 15 years, a further 6.25% is released within 15 years after that. (Murray et al., 2011).

Biomass carbon released per hectare = (Average mangrove Biomass Carbon* 75% carbon released) + ((Average Mangrove Biomass Carbon * 25% of Carbon that decays with half life of 15 years) / 2)

$$\frac{237tCo2eq}{Ha * 0.75} + ((237tCo2 * 0.25/2))$$

i. The total quantity of carbon stored in soil that is released following removal of the ecosystem using available estimates was then calculated. This was done by looking at the average amount of carbon stored in the top meter of soil beneath mangroves, which is 1060 t CO2-eq/ha for estuarine mangroves and approximately 1800 t CO2-eq/ha for oceanic mangroves (Murray et al., 2011). Regarding the rate at which this is released, it can be assumed that mangrove soil organic carbon has a half-life of 7.5 years (i.e. 50% of the stored carbon is released in the first 7.5 years, 25% in the following 7.5 years, etc.

$$Soil\ Carbon\ released\ per\ Ha = (Average\ Amount\ of\ Carbon\ Stored\ in\ top\ meter\ in\ Eustarine\ Mangrove * Rate\ of\ Carbon\ Release) + Average\ Amount\ of\ carbon\ stored\ in\ top\ meter\ in\ Oceanic\ Mangroves * rate\ of\ carbon\ release$$

7 It is advisable to convert all quantities of carbon to tonnes CO2-equivalent (1 t C = 3.67 t CO2-eq) since prices and damage costs of greenhouse gas emissions are most often stated in US$/t CO2-eq. Keeping all quantities in CO2-eq reduces the chance of mixing up the units in which carbon is measured. An alternative assumption, also from Murray et al. (2011), is that oceanic mangroves release 82 t CO2 eq/ha/yr and estuarine mangroves release 59 t CO2-eq/ha/yr for 25 years following clearance of the mangrove trees.

i. The foregone sequestration benefits over time was then computed. This is where the sequestration benefits would continue in perpetuity if the ecosystem is not degraded, but because future benefits are typically discounted, a finite time span was assumed. (Using a Country's discount rate, future annual benefits fall below 50% of current year benefits in about 15 years such that;

$$\textit{Potentially Avoided tCo2eq per Ha} = \textit{Average rate of change of mangrove carbon} + \textit{Biomass carbon released per ha} + \textit{Soil carbon release per Ha}$$

ii. The total potentially avoided CO2 in the atmosphere was computed by multiplying the quantity of emissions per hectare by the area of predicted loss per year:

$$\textit{Total Potentially Avoided tCo2} = \textit{Potentially avoided tCo2 eq per Ha} * \textit{Area Predicted Loss per year}$$

The data required for the carbon sequestration calculation and storage can be summarized as shown in table 2-4.

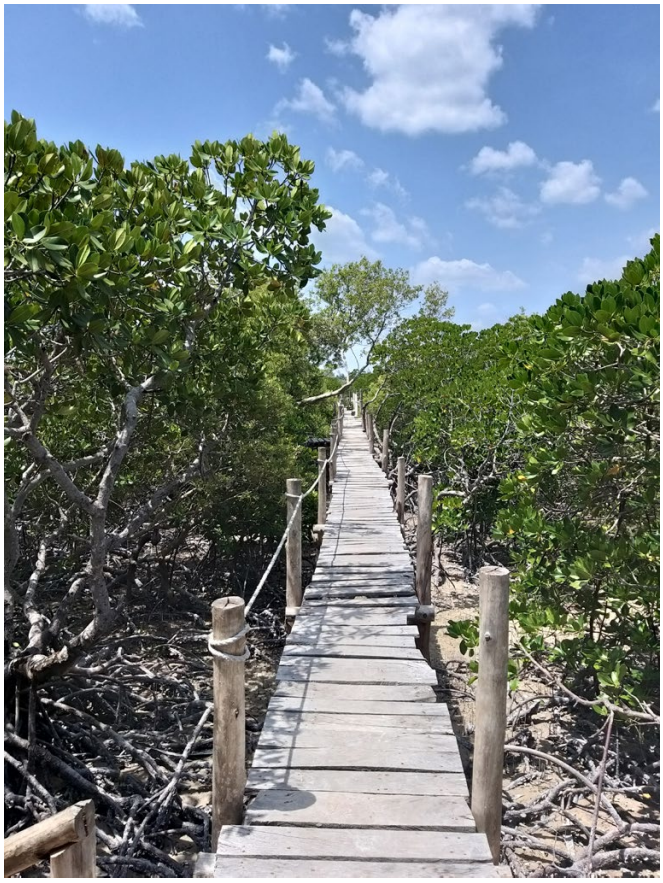
Table 2-3: Carbon sequestration table for analysis: (Salcone et al., 2016)

Item	Units	Value	Source
Mangrove area	Ha		
Annual rate of loss	%		
Annual area loss	Ha		
Carbon Seq. rates	6.3		
Mangrove biomass carbon	tCo2/Ha		
Soil biomass carbon	tCo2/Ha		
Biomass carbon initial release	75%		
Biomass carbo half life	15 years		
Soil carbon (top 1m) half life	15Years		
Carbon release from Biomass(15yrs)	tCo_2 /ha		
Carbon release from soil (15yrs)	tCo2 /ha		
Forgone Sequestration (15yrs)	tCo2 /ha		
Carbon emission (15yrs total)	tCo2 /ha		
Annual carbon release	tCo2		
Market price of carbon	Ksh/ tCo2		
Market value of protecting mangrove per year	Ksh		

f. Mangrove tourism/recreation

Salcone et al., (2016) indicates that, the beneficiaries of marine and coastal tourism and recreation services are diverse. The methods for estimating tourism and recreation values are generally similar regardless of the beneficiary, therefore very important to explicitly identify, collect data, and estimate values for different beneficiary groups where relevant. He further indicates that the benefits from marine and coastal tourism accrue to tourism providers (producers) and tourists (consumers). The producer surplus of a tourism activity is the service providers' revenue from tourists' expenditures, minus the costs of providing the service. Producer surplus is represented by the profit (revenue, net of all costs) of tourism providers. It is difficult to separate one ecosystem from another when visitors access a particular site and therefore, in this study, ecotourism only run by the communities/ CFAs, was valued. The project did not target marine protected areas. The formula used for the calculation of the ecoutoruism revenue was as follows;

$$\textit{Producer Surplus} = (\textit{Total Toursim Revenue} - \textit{Tourism Industry Cost}))$$



Board Walk at the Mida Creek

g. Coastal protection/flood control

The estimation of the value of flood control by mangrove ecosystems relied more on the replacement cost methods for the mangrove. This method has been used to value the coastal protection ecosystem service of the Caribbean (Burke et al., 2008) and the New Caledonian reefs (Pascal, 2010) among other coastal ecosystems.

This was calculated by estimating the cost of putting up a sea wall as a protective measure, and equating the same to the value of the natural ecosystems, e.g. in areas like Bamburi where walls have been built for storm surge protection. The cost of the construction of the sea walls varied between urban and rural settings. An average cost of 8,500 Ksh/Km for urban areas and 5200 Ksh/Km for Rural areas run (adopted from the department of Planning estimations) was adopted for this computation.

V= A X B;

Where;

$$Value\ of\ coastal\ protection =$$

$$Cost\ of\ wall\ construction\ X\ the\ distance\ of\ \ mangroves$$

h. Biodiversity conservation

The recognition of the value of biodiversity has grown substantially even though it remains extremely difficult to quantify and value, Salcone et al, (2016). One method to quantify the value of biodiversity is to evaluate the amount of public funds that are redistributed to help protect bio diverse areas, which is called the revealed price method. The unique biodiversity found in marine and coastal environments attracts investment in research and conservation from around the world. Furthermore, these bio diverse ecosystems offer education opportunities to students of all ages, and investment from schools and universities. This interest in studying and protecting biodiversity attracts grants, scholarships, and aid from overseas.

The boundaries of our analysis being at the Country level, the team was able to assess the estimated budget that were set aside in 2019 for conservation as well as research/education in mangroves ecosystem for the various forest formations. The budgetary estimates were obtained from institutions such as KEFRI, KFS and KMFRI. The domestic Governmental expenditures on biodiversity considered as economic values were also assessed. This is normally considered to be internal transfers or redistribution of resources, and not new economic values.

The international and NGO expenditures on aid and grants, including aids for research, training and education were directly targeted but little information was found concerning mangrove conservation in Kenya.

i. Sediment trap

Mangroves regulate sediment movement, especially the rate of sediment deposition (Salem & Mercer, 2012; Spurgeon, 2002; Ronnback, 2001). Sediment regulation occurs in two dimensions where; one, mangrove assist in filtering terrestrial sand and preventing it from being blown along the shore which reduces the rate of sand deposition and prevents fringing of the reefs. Secondly, the mangroves reduce the speed of sediment laden waters through their complex rooting system during flash floods. This enables the settling of sediments within the mangrove environment (Spurgeon, 2002). This process is very important and of high economic value to the functions of the coral reefs since it prevents the sediments

from corroding the shoreline. In Kenya, there are two major drainage basins, namely Tana and Sabaki-Galana-Athi basin which drain into the Indian Ocean. The Tana River discharges about 3 million tonnes of sediment per year whilst the Sabaki River discharges 2 million metric tonnes of sediment annually into the southern Ungwana bay through Sabaki estuary north of Malindi, Gwada et al., 2019.

There are also a number of semi-perennial and seasonal rivers such as the Mwache, Kombeni, Tsalu, Nzovuni, Umba, Ramisi, Mwachema and Voi, all of which drain into the coastal region from arid and semi-arid catchments. The Ramisi River, which arises in the Shimba Hills forested area, discharges 6.3 million m3 of freshwater and 1,500 tonnes of sediments annually into Funzi - Shirazi Bay in the southern part of the Kenyan Coast. The Umba discharges 16 million m3 of freshwater into Funzi - Shirazi Bay while the Mwachema and Mwache rivers discharge 9.6 million m3 and 215 million m3 of freshwater annually, respectively. Other small streams such as Mto Mkuu, Tsalu, Sinawe, Kombeni, etc, have not been gauged. The Kenyan Coast inshore waters receive nutrients via river systems that drain into it from various catchment areas that extend into the Kenyan Highlands where agricultural activities are dominant. There is also an outwelling of nutrients from mangrove areas. Thus, mangrove fringed deltas, estuaries and tidal creeks that receive significant freshwater input such as Tana, Athi-Sabaki, Mwache, Tudor, Funzi and Shirazi are characterised by high nutrients levels as compared to the offshore waters (Marine, 2015).

For this study, the estimation of the economic value of mangroves in providing the function of storm buffering and sedimentation control was not achieved since secondary data documenting nutrient richness of the sediment loads released into the Indian ocean was not available.

j. Cultural services (Non-use Value/existence value)

Understanding socio-cultural perceptions about human-nature relationships is essential to promote collective responses for sustainable ecosystem management, (Yang, 2019). Pascual et al., (2017) defines the cultural services as those that target cultural identity, spiritual interactions and sense of place. Simply defined, cultural services are the intangible and non-material benefits that the ecosystem provides. In most cases these aspects of the cultural services are difficult to assess and quantify and they include; ecotourism, religious or other non-use values. The valuation of ecotourism according to (Spaninks & Beukering, 1997) represents a potential value of preservation rather than an observed value. Since we cannot rely on actual tourist visits to value this function, the valuation relied on contingent valuation since this was the only method that could value hypothetical goods. Chen et al., (2012) has documented cultural services as difficult to quantify and suggested two approaches towards their valuation, i) the assessment of the cultural ecosystem services, and ii) the involvement of stakeholder views which can be evaluated through non-monetary values such as ranking and weighting. The monetary valuation according to Pascual et al., (2017) can be valuated through indirect revealed preferences which can be done through contingent valuation.

For this study, the ecotourism service was valued based on the Contingent Valuation method as was established from focus group discussions. The subject question focused on time use values for leisure activities related to mangrove ecosystems. The interest was on the willingness of the communities to preserve the mangrove ecosystem due to the cultural services they get together with other benefits. Further, in order to bring out a broader understanding of the cultural ecosystem services from mangroves, non-monetary approaches such as social-cultural valuation which assesses preferences and user characteristics in the ecosystems as drawn from Schmidt et al., (2017) were applied. These included; participatory system mapping which looked at the conceptualization of the stakeholder perception of the ecosystem services, mainly the aesthetic, spiritual and cultural heritage values. To accomplish this, narrative-based methods by key informants using ethnographic approaches was applied. Focus group discussions with members of CFAs were also conducted and the application of causal loop diagrams as drawn from Lopes & Videira (2015) was also done. This was augmented by household interviews, done within the surrounding villages. This was done along with the assessment of the social-economic role of mangroves as later discussed in this chapter.

3.1.2: FINDINGS: NATURAL CAPITAL FROM MANGROVES ALONG THE KENYAN COAST

Valuation of 9 selected ecosystem services was done using the methodologies as decribed in the preceding chapter. The year 2019 was set as the assessment year, and requisite datasets were captured from the field and also from secondary data. The ecosystem service valuation was carried out for 11 selected forest formations along the Kenyan Coast i.e., Vanga, Funzi, Gazi, Tudor, Mtwapa, Takaungu, Kilifi, Ngomeni, Ungwana Bay and Lamu.

The ecosystem service valuation results for each forest formation are presented below;

1. Mida Creek Forest Formation

Mida Creek is located approximately 100 Km northeast of the city of Mombasa, between geo-coordinates 3°23'S, 39°56' E in the south and 3°18' S, 39°59' E in the north, see maps below in Figures 1-3, 2-3 and 3-3. The total area of the forest formation as at the year 2019 was 1814.67Ha, whilst in 2000 it was 1778.43Ha. Mangrove species found in the forest formation include; *R. mucronata*, *C. tagal*, *A. marina*, *S. alba*, *B. gymnorrhiza*, *X. granatum* and *L racemose*. Threats to the Mida Creek mangrove forest include; firewood harvesting, pollution from plastics and faeces, pollution from oil spills, overharvesting for building materials and encroachment for settlements. Biodiversity present in the forest include; species of birds, reptiles including crocodiles, mammals (monkeys), a number of prawns (Penaeus indicus, P. monodon, P. semisulcatus, Matapenaeus monoceros), crabs (Scylla serrata, Uca spp., Sesarma spp. and Birgus latro), mollusca (oysters such as Brachydontes spp. and Crassostrea cucullata and cockles, Donax spp) and insects; while terrestrial flora mainly comprises of fungi, lichens and mistletoes.

The communities around the creek, estimated as about 10,000 people, are actively involved in fishing, subsistence farming and small businesses (Kihia et al, 2015). Uyombo is the only registered landing site that can be associated with the Mida creek Mangrove ecosystem.

Mwashote et al., (1999) investigated the relationship between physical hydrodynamic processes and nutrients dynamics in Mida creek, for the year March 1996 and May 1997. In his investigation he established that nutrient concentrations vary with the tide and that, though there was no river drainage, they were of the same magnitude as in mangrove creeks, however with substantial river runoff. Mida Creek is an important feeding and development area for juvenile green and hawksbill sea turtles. Coral heads and the rich seagrass beds provide food in a sheltered area away from large predators.

The ecosystem service valuation of the Mida Creek forest formation is presented in Table 3-3 below.

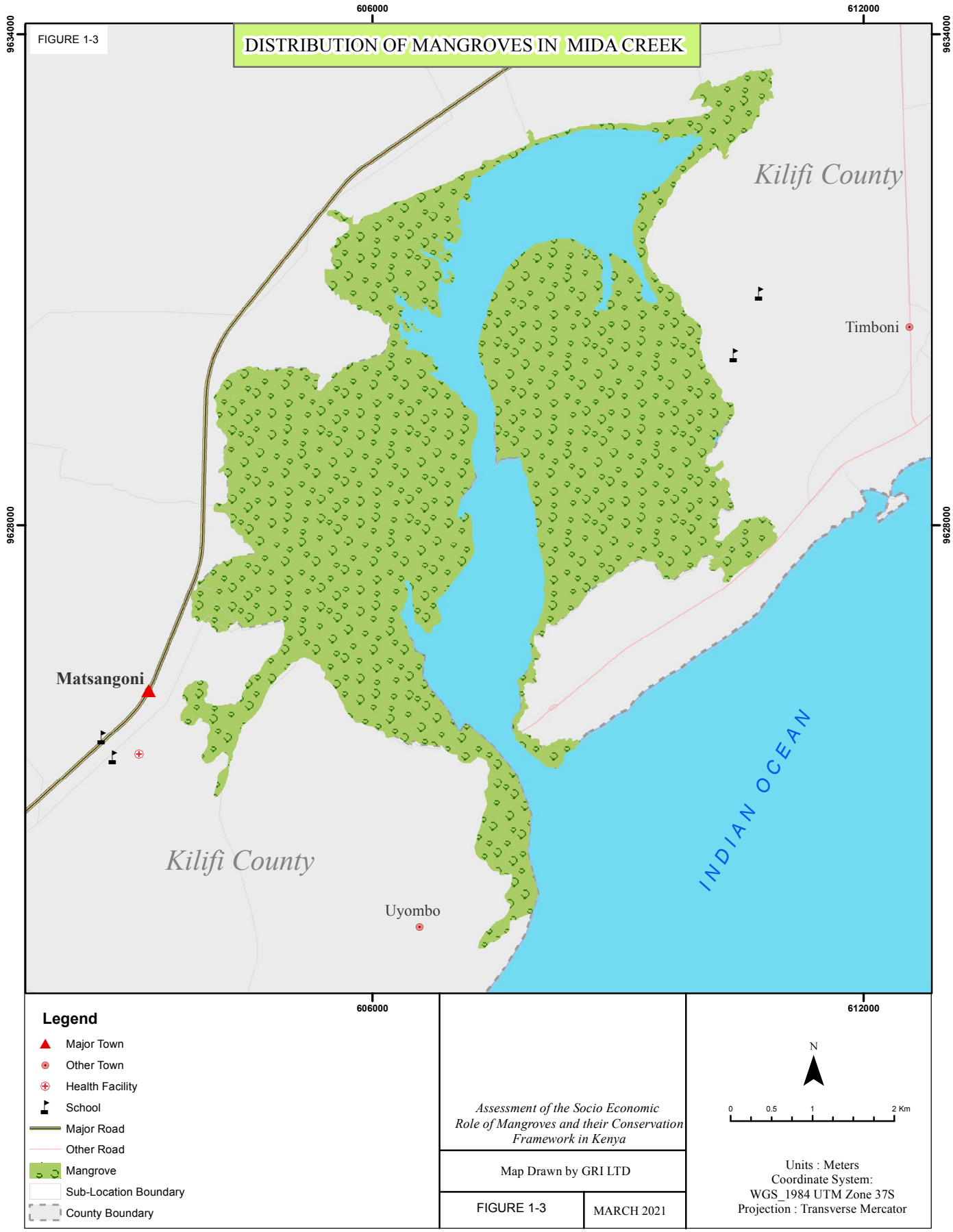


Figure 1-3: Distribution of Mangroves in Mida Creek

Figure 2-3: Mida Creek Landcover Classification Year 2000

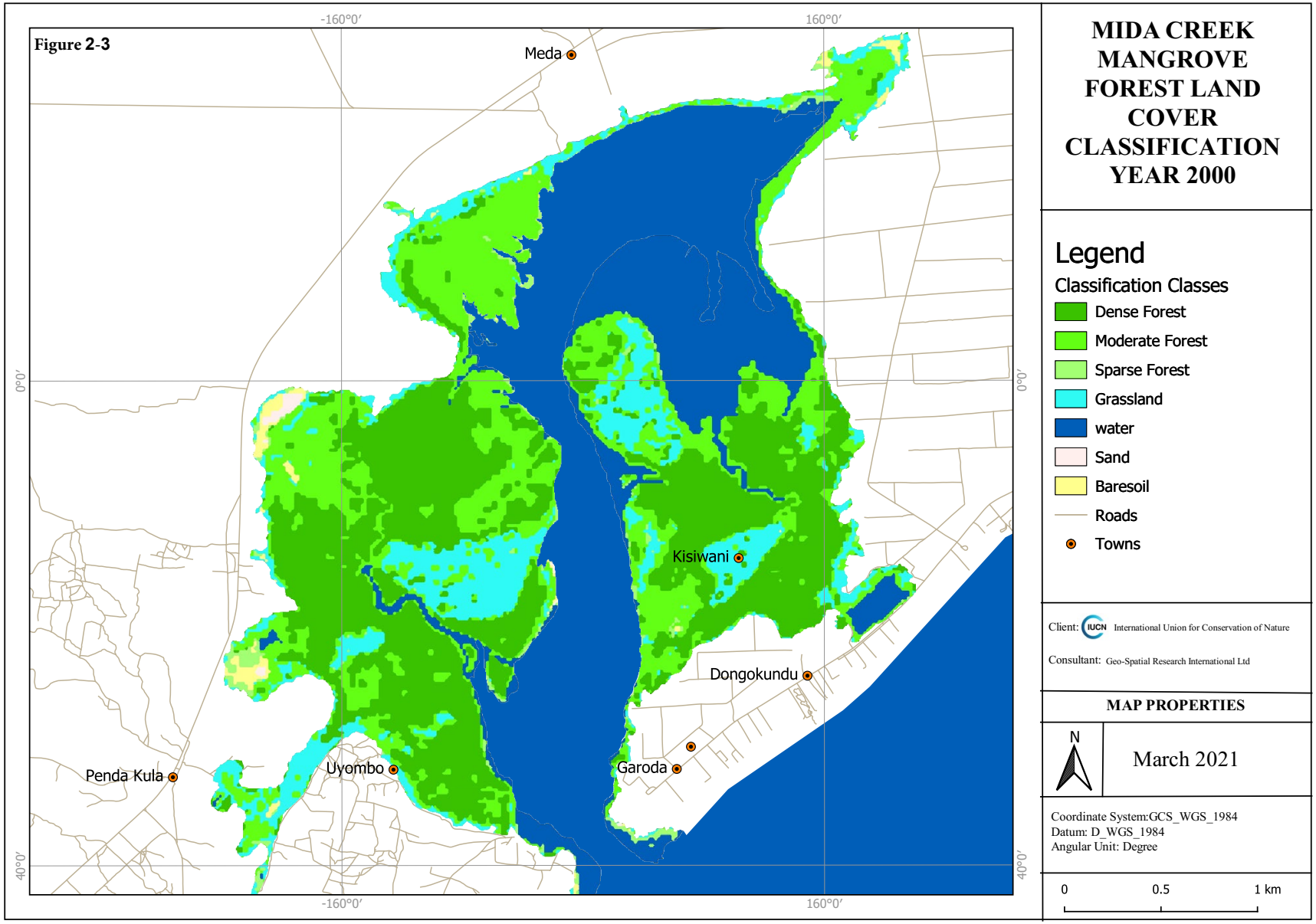


Figure 3-3: Mida Creek Landcover Classification Year 2019

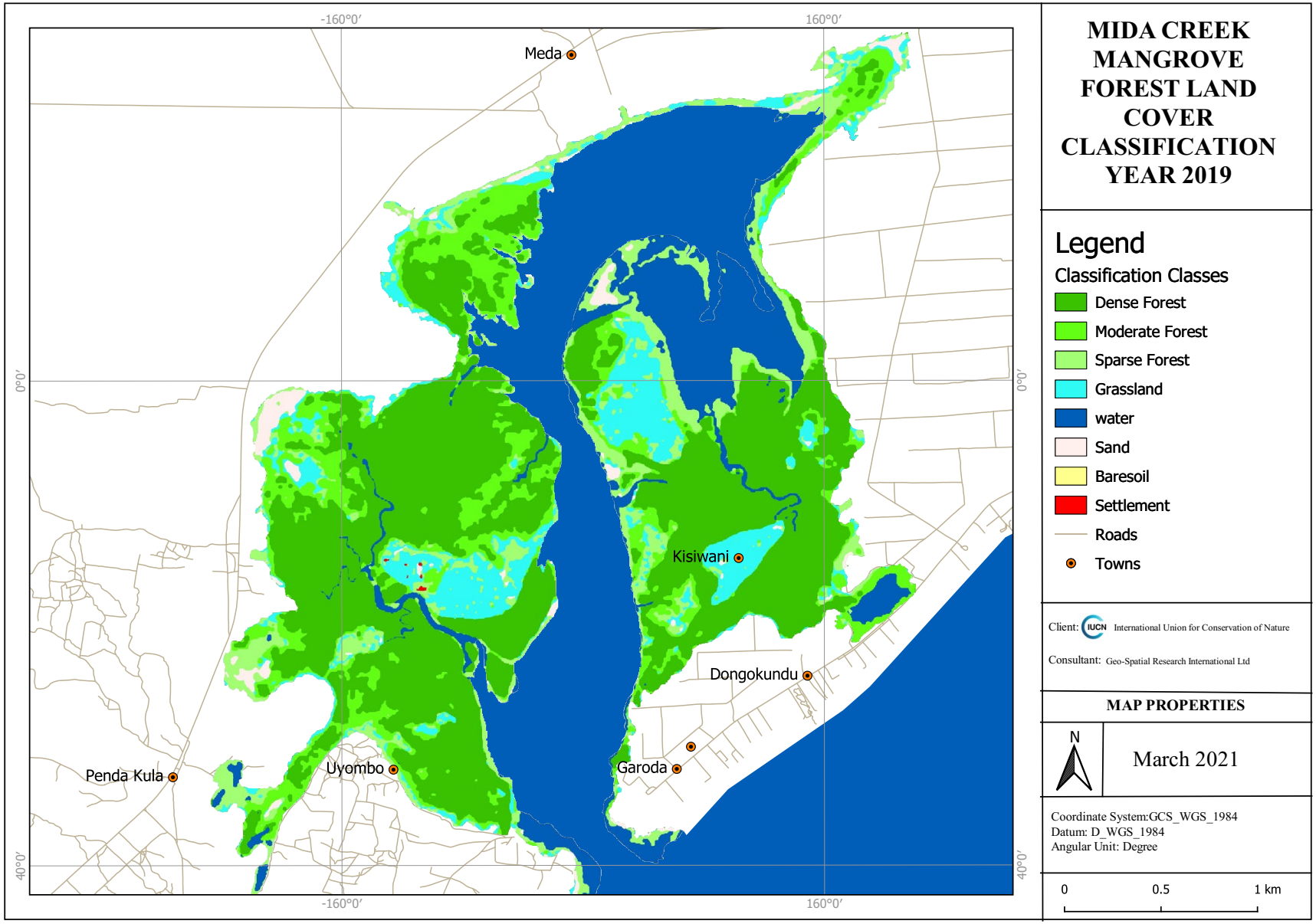


Table 3-3: Mida Creek Ecosystem service Valuation for 2019

Ecosystem services	Service quantification/ year	Average Cost/ Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Food (Subsistence fisheries)	71, 559 Kg/year	Ksh 226.52	Ksh 16,209,858	Ksh8935.97	Mangrove zones and the surroundings, based on the government registered landing site, Uyombo.	Final consumer prices	County government ministry of fisheries	The value is calculated from the total fish catch where the % role played by mangrove in the fish habitats is applied as cited by UNEP (2011). According to Arbuto Oropreza, 2008, the contribution of mangrove to fisheries is 31.7%. 90% of the marine fishing is done by artisanal fishermen in Kenya, (Ahmed, 2017). Each fish species was calculated based on the specific consumer price and overall average price was obtained. The data was obtained from the department of Fisheries, Kilifi county.
Wood extraction	Consumption of firewood and charcoal at Household level	Ksh 30-firewood Ksh 45 - Firewood	Ksh 203,130,115.20 – Firewood Ksh 35,180,021.78 - Firewood	Ksh 111,937.77 Ksh 19,386.46	Households living within 10km radius	The final consumer quantities and prices	KNBS 2009 population data projected to 2019 KNBS-KIHB 2015/2016 MOE report 2019	Calculated from firewood consumed by households within 10km radius of the mangrove ecosystem Consumer prices based on Ministry of Energy 2019. Consumption per household for charcoal and firewood @ 1Kg and 1.6Kg respectively. % firewood and charcoal use per county are based on KNBS-KIHB 2015/2016 report. This was used to get the number of households using firewood and charcoal for the counties in question within 10Km radius for each forest formation.
Medicinal use	Volumes of active ingredients extracted per type of use	0	0	0	Mangrove zone	Market Price	KFS	There is no user group or medicine men involved in traditional medicine as a commercial entity even though the user right exists. Most community members collect medicine for personal use.

Ecosystem services	Service quantification/ year	Average Cost/ Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Tourism/ recreation	No. of visits to specific mangrove sites and the cost per visit	Ksh 500	Ksh 6,000,000	Ksh 3307	Mangrove zone	Price of services taking place in tourism sites	CFA/ Community	Local tourism is rife with over 10 eco-tourism sites within the forest formation including boardwalks, crab farms etc. A visit per site is charged at ksh 500 Estimated visitors is to the ecotourism site is 5-10 person per day.
Coastal protection/ flood /storm control	The mangrove protective area 14,773.31Meters	Ksh 5200	Ksh 76,821,212	Ksh 42,349	Coastal protection zone	Replacement cost method	Ministry of planning and development (Valuer based in Mombasa) Engineer estimate on building and maintaining the protective wall	Calculated based on engineers' estimate of the cost of building the protective wall. The estimate was done at ksh5200/ metre. The estimated mangrove protected area is 14,773.31 Meters
Sediment trap /coastal erosion control	Quantification of sediment charge and nutrients in it	0	0	0	Mangrove zone	Replacement cost or damage cost on tourist activities	None	No sediment charge calculation was done due to data unavailability There are no studies that have established the nutrient content of sediment charge to aid in calculation.
Habitat provision (nurseries for fishes and marine species)	The nutrient productivity of the Mangrove area	Ksh 226.52	Ksh 19,073,656.55	Ksh 10,514.69	Mangrove zone	Final consumer price	Remote sensing data by Sanderman et al., 2018.	The role that the mangroves play in habitat provision for fishes and mariculture is calculated from soil organic carbon nutrient productivity in Kg/ha.

Ecosystem services	Service quantification/ year	Average Cost/ Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Carbon sequestration	Quantification of carbon annual sequestration and carbon storage reported in tC02 = 171,172.76tC02 equivalent to 96.25tC02 per Ha.	Ksh 1000	171,172,761.23	Ksh 94,362	Mangrove zone	Social Cost of Carbon	Remote sensing Biomass data for 2019 from Simard et al., 2014 and Sanderman et al., 2018	Annual sequestration rate 6.3% from Murray et al., 2011 Biomass initial release at 75% from Murray et al., 2011, Biomass half life at 15years based on Murray et al., 2011 Soil carbon (top 1m) half life at 7.5 years Murray et.al 2011. The price of carbon is adopted from price Plan VIVO to GAZI CFA @ 10USd at conversion rate of 1 dollar to KSh 100.
Biodiversity conservation	Specific biodiversity indicators (revealed prices of money spent on conservation)	Ksh 5673	10,296,320	Ksh 6435.20	Mangrove zone	Revealed price for conservation	KFS 2018-2022 strategic plan Seedling bought by KEFRI for Mida Creek.	Calculated based on the money set aside for conservation of forest in the KFS 2018-2022 draft strategic plan. Calculated also based on 200,000 seedlings bought by KEFRI for restoration of Mida Creek. Not all money given or budgeted or utilised for conservation efforts may have been captured.
Non-use value (existence value)	Socioeconomic indicators 610 CFA members	Ksh 400	Ksh 976,000	Ksh 538	Settlement near the mangroves, tourists/ urban inhabitants	Expenditure cost/ contingent valuation	Field data collection	The willingness to pay for conservation is calculated from population estimation captured through dasymetry mapping which allows for apportioning of population. According to the field study all members of CFA were considered to be willing to pay for conservation. Mida has 21 user groups with a membership estimated at 30 members per group hence a population of about 610. CFA members were willing to pay ksh 400 per person per week for conservation
Mangrove education and research	Education visits and grants given for education and research in mangrove	0	0	0	Mangrove zone	Payment for services offered	KMFRI KEFRI KFS	No data was available at the time of the project.

2. Vanga Forest Formation

The Vanga mangrove ecosystem is located in Kwale County in the south coast of Kenya near the Kenya-Tanzanian border, see maps below in Figures 4-3, 5-3 and 6-3. It is located at 4.663°S and 39.215°E. This mangrove complex is the largest in the south coast of Kenya. Following a land use land cover classification, the forest area was estimated to be 3,879.86Ha as at the year 2019, while in the year 2000, it was estimated to have been 3,632.89 Ha. Mangrove species found in the forest formation include; *Rhizophora mucronata*, *Sonneratia alba*, *Xylocarpus granatum, Avicennia marina*, *Bruguiera gymnorrhiza* and *Ceriops tagal*. Threats to the ecosystem include; increased sedimentation from land use practices in the surrounding areas of the mangrove forest formation, increasing population, dredging to deepen ports/navigation channels and over-exploitation. Biodiversity present in the ecosystem include; fish, crabs and sea grass.

The Vanga forest formation is home to Vanga town and other smaller villages such as Jimbo and Kiwegu. The Digo ethnic group accounts for about 72% of the people living close to the forest formation (Omwenga, 2009). The major economic activity in the area is artisanal fishing contributing to more than 80% of the local economy inclusive of other fishing related activities such as boat making and fish vending (Omwenga, 2009; Ochiewo, 2004). There are four landing sites associated with the ecosystem namely; Jimbo, Vanga, Majoreni, Kibuyuni and Shimoni. Other income generating activities include crop farming (mainly rice), small business enterprises and casual labour, in house construction. Tourism is minimal in the area.

Most of the houses in the area are semi-permanent and about 6.8% of the households use firewood as the main fuel for cooking, (KNBS, 2013). Sanitation is relatively poor in the area with 87.15% still using unimproved sanitation methods such as uncovered pit latrines, bucket, and use of bushes. There is also a lack of adequate waste disposal facilities. Only 24.5% have access to portable water (KNBS, 2013). Generally, the level of education is low with 40.5% of the population having no formal education.

The table 4-3 below shows the mangrove forest ecosystem services values for Vanga as at 2019;

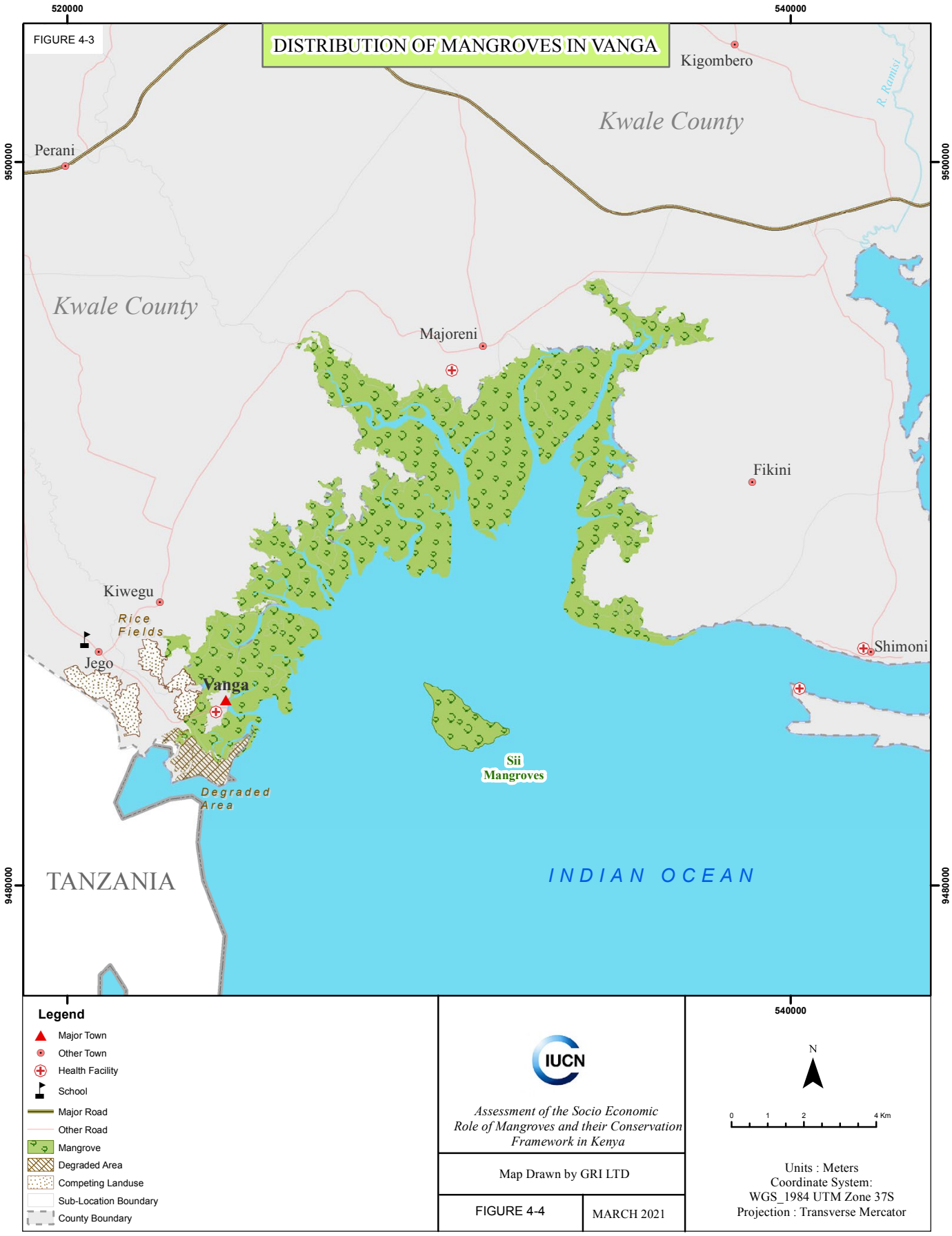


Figure 4-3: Distribution of Mangroves in Vanga

Figure 5-3: Vanga Landcover Classification Year 2000

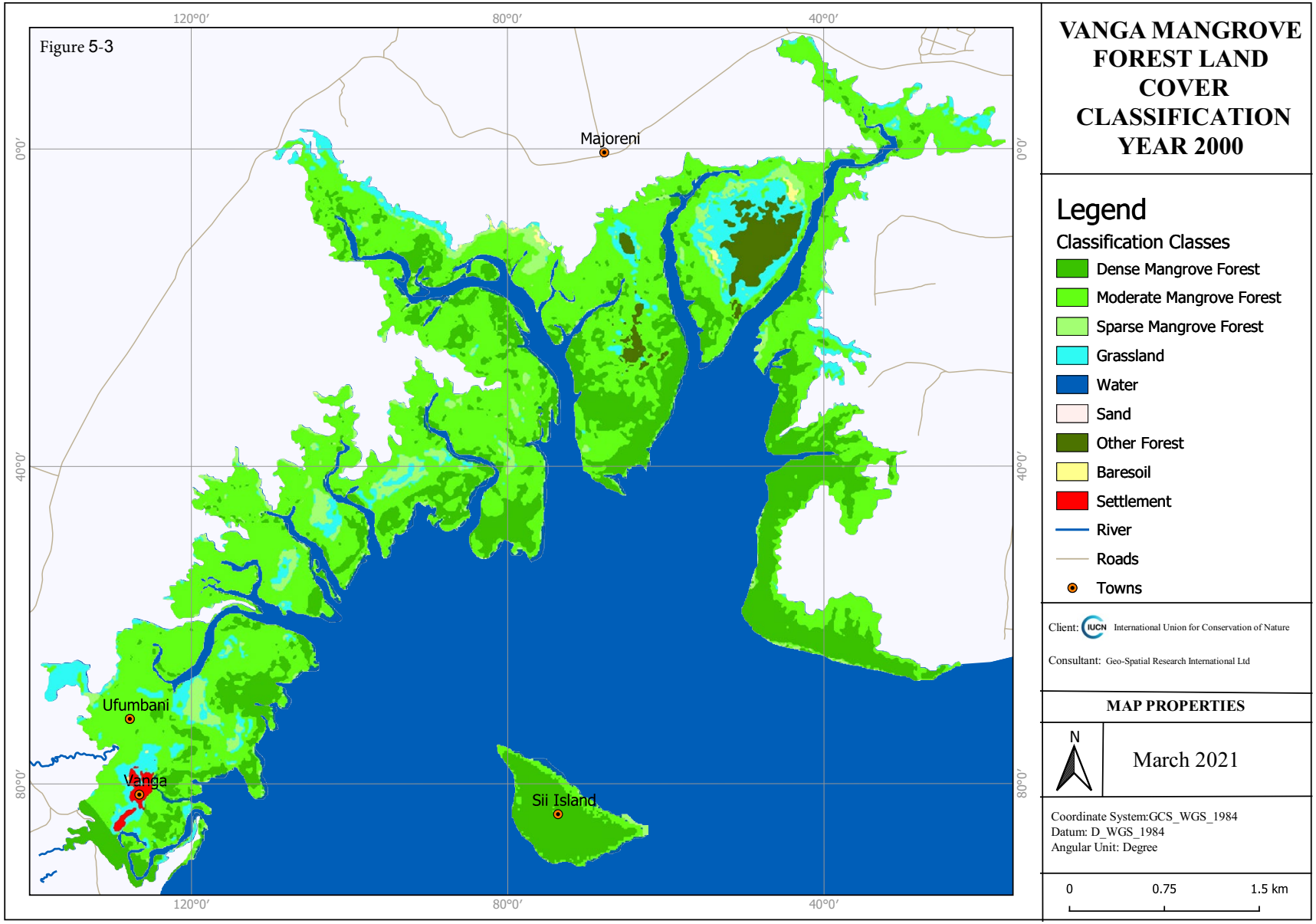


Figure 6-3: Vanga Landcover Classification Year 2019

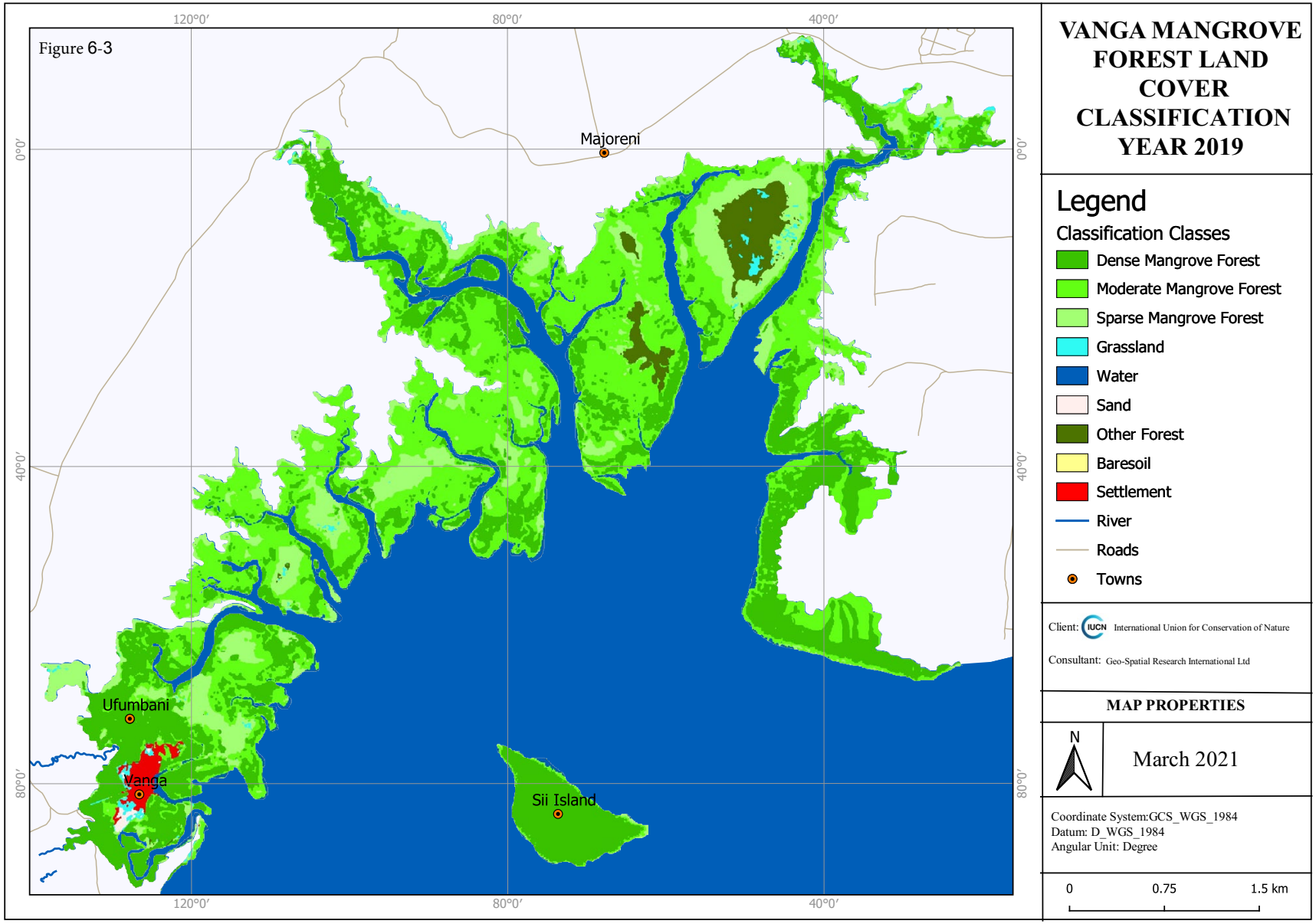


Table 4-3: Vanga ecosystem service Ecosystem service Valuation for 2019

Ecosystem services	Service quantification/ year	Average Cost/ Unit in Ksh	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Food (Subsistence fisheries)	48,425 Kg/year	Ksh 195	Ksh 8,867,054	Ksh 2285.41	Mangrove zones and the surroundings, based on the government registered landing sites; Jimbo, Majoreni, Kibuyuni and shimoni	Final consumer prices	County government ministry of fisheries	The value is calculated from the total fish catch where the % role played by mangrove in the fish habitats is applied as cited by UNEP (2011). According to Arbuto Oropreza, 2008, the contribution of mangrove to fisheries is 31.7%. 90% of the marine fishing is done by artisanal fishermen in Kenya, (Ahmed, 2017). Each fish species was calculated based on the specific consumer price and overall average price was obtained. The data was obtained from the department of Fisheries, Kwale county. There are 4 landing sites used for this calculation are; Jimbo, Vanga, Majoreni, Kibuyuni and shimoni
Wood extraction	Consumption of firewood and charcoal at Household level	Ksh 45- charcoal Ksh-30 for firewood	Ksh 212,918,025.60 Ksh 36,875,785.99	Ksh 54,877.76 Ksh 9,504.41	Mangrove zone	Market price	Ministry of Energy Report KNBS-KIHB report	Calculated from firewood collected within 10km radius of the mangrove ecosytems. Households within 10km radius were obtained through dasymetric mapping, on 2009 KNBS data projected to 2019. Data on value of charcoal & firewood, consumption per day is based on the 2019 Ministry of energy report titled Kenya Cooking Sector study report. Data on percentage of household using charcoal and Fuelwood in coastal counties is based on the Kenya Integrated Household Budget Survey by KNBS-KIHB 2015/2016 report.
Medicinal use	Number of patients accessing traditional medicine and the cost per patient	0	0	0	Mangrove zone	Market Price	KFS	There is no user group or medicine men involved in traditional medicine as a commercial entity. Most community members collect medicine for personal use.

Ecosystem services	Service quantification/ year	Average Cost/ Unit in Ksh	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Tourism/ recreation	No. of visits to specific mangrove sites	Ksh 500	Ksh 1,344,000	Ksh 346.40	Mangrove zone	Price of services taking place in tourist sites	CFA/Community	Local tourism is done but has not picked very well within the forest formation. There is 1 ecotourism sites within the forest formation. A visit to the sites is charged at ksh 500 per person. There are estimated 5-10 visitors per day accessing the sites.
Coastal protection/ flood /storm control	Length of protective wall that should be put up in place of mangroves. This is estimated at 10,076M	Ksh 5200	Ksh 52,395,200	Ksh 13,504	Coastal protection zone	replacement cost method	Ministry of planning and development (Valuer based in Mombasa)	Calculated based on engineer's estimate of the cost of building the protective wall. The estimate was done at ksh5200/ metre. The meters of protection at Vanga forest is estimated at 10,076 Meters.
Sediment trap	Quantification of sediment charge and nutrients in it	0	0	0	Mangrove zone	Replacement cost or damage cost on tourist activities	None	There are no documents with information on sediment loads/charge for the calculation of the value. River Umba deposits 16 million M3 of fresh water into the ocean via the mangrove ecosystem.
Habitat provision (nurseries for fishes and marine species)	Soil organic nutrient productivity in Kg/ha	Ksh 195	Ksh 41,888,531.37	Ksh 10,796.40	Mangrove zone	Final consumer price	Remote sensing data by Sanderman et al., 2018	The role that the mangroves play in habitat provision for fishes and mariculture is calculated from soil organic carbon nutrient productivity in Kg/ha. It is also calculated based on price of fish catch.
Carbon sequestration	Quantification of carbon annual sequestration and carbon storage reported in tC02 = 348,000tC02 is equivalent to 957tC02/ha	Ksh 1000	118,417,168.14	Ksh 30,520.99	Mangrove zone	Social cost of carbon	Remote sensing Biomass data for 2019	Annual sequestration rate of 6.3% from Murray et al., 2011 Biomass initial release at 75% from Murray et al., 2011, Biomass half life at 15years based on Murray et al., 2011 Soil carbon (top 1m) half life at 7.5 years Murray et.al 2011. The price of carbon is adopted from price Plan VIVO to GAZI CFA @ 10USd at conversion rate of 1 dollar to KSh 100.

Ecosystem services	Service quantification/ year	Average Cost/ Unit in Ksh	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Biodiversity conservation	Specific biodiversity indicators (revealed prices of money spent on conservation)	Ksh 1608	Ksh 73,360	Ksh 18.91	Mangrove zone	Revealed price for conservation	KFS 2018-2022 strategic plan	Calculated based on the money set aside for conservation of forest in the 201/Ha8-2022 draft strategic plan that targeted 500,000ha nationwide. Mangrove cover loss is estimated at 450ha/year (Bosire et al., 2013). The loss in Vanga is estimated at 12ha/ year averaged between the years 2000 and 2019. Conservation cost per ha from the budget is ksh 1608/Ha. Estimated area for conservation in 2019 was 45.6ha
Non-use value (existence value)	Socioeconomic indicators 107 registered CFA members	Ksh 500	Ksh 9,630,000	Ksh 2484	Settlement near the mangroves, tourists/ urban inhabitants	Expenditure cost/contingent valuation	Field data collection	The willingness to pay for conservation is calculated from population estimation captured through dasymetry mapping which allows for apportioning of population. According to the field study all members of CFA were considered to be willing to pay and spend time for conservation. The approximate time as collected from the field is 3hrs a day per person, 5times a month, at a labour cost of ksh 500/day. The monthly willing expenditure was estimated at ksh 7500 per person. The CFA has 107 registered membered actively involved in mangrove conservation.
Mangrove education and research	Education visits and grants given for education and research in mangrove		0	0	Mangrove zone	Payment for services offered	KMFRI KEFRI KFS	No data was found for this particular service

3. Tudor Creek Forest Formation

The Tudor creek, borders Mombasa Island on the northwest and extends10 km inland, see maps in Figures 7-3, 8-3 and 9-3 below. The creek has two main seasonal rivers, Kombeni and Tsalu, draining an area of 550 km², with an average freshwater discharge estimated at 0.9 m³s-1 during the inter-monsoon long rains (Nguli, 2006). The mangrove forest is mainly composed of *R. mucronata*, *A. marina* and *S. alba*. (Mohammed *et. al.* 2008). The basin has an area of 6.37 km² at low water spring and 22.35 km² at high water spring. Following a land use land cover classification, the mangrove forests occupied 767.39 Ha of the creek as at the year 2019 while in 2000 it was computed to be 1244.24 Ha. The floristic composition of mangroves of Tudor creek has been described by SPEK (1992), that the dominant mangrove species are *A. marina w*hich occupies the landward zone, and *R. mucronata* mosaic which covers the middle zone. Wherever present, *S. Alba* occupies the seaward margin, but is replaced by tall *A. marina* and *R. mucronata* along small creeks.

The Tudor creek mangrove ecosystem has been exposed to raw sewage intensively for more than a decade. The sewage runs through the mangrove forest in canals and is discharged into the Tudor creek waters mainly from Mikindani, Tudor and the Old Town settlements. The mangroves are periodically dozed with sewage every tidal cycle, with the loading exponentially reducing with distance from source (PUMPSEA, 2007). Sediments of Tudor creek are predominantly muddy and some parts are covered with sand. The land surrounding the creek beyond Mombasa Island is mainly agricultural, largely small-holdings and coconut plantations with rough grazing land further inland, while the immediate slopes bordering the mangrove creek have in the recent past been intensively cleared of vegetation to create space for informal settlements and subsistence farming. Other threats are; sedimentation from the agricultural fields, concentrated population and creation of informal settlements at the immediate slopes bordering the mangrove creek.

The Tudor creek is directly surrounded by Tudor, Junda, Birikani, Miritini and Kwa shee areas. These villages form most of the informal settlements adjacent to the forest formation. The socio-economic activities carried out in the area include; tourism, fishing and trading in both large-scale and small-scale businesses. With support from the Global Environment Facility (GEF), Small Grant Program (SGP) implemented by the United Nations Development Program (UNDP), Mombasa Kilindini Community Forest Association (MOKICFA) is currently engaging with the Kenya Forest Service (KFS) and other partners to provide for the sustainable use of the Mombasa County Mangrove.

The Table 5-3 below presents the ecosystem service values for the Tudor Creek mangrove forest for the year 2019.

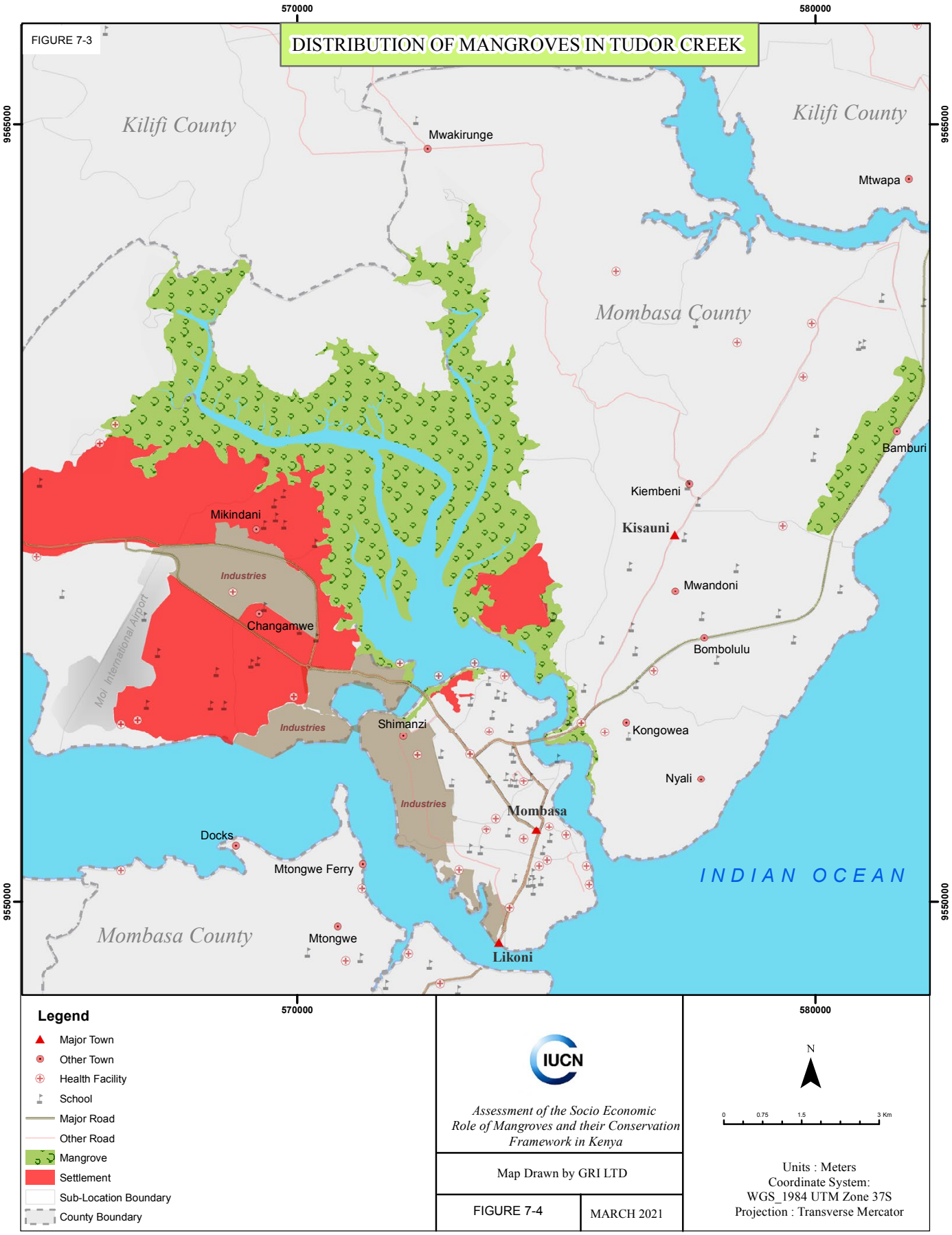


Figure 7-3: Distribution of Mangroves in Tudor

Figure 8-3: Tudor Landcover Classification Year 2000

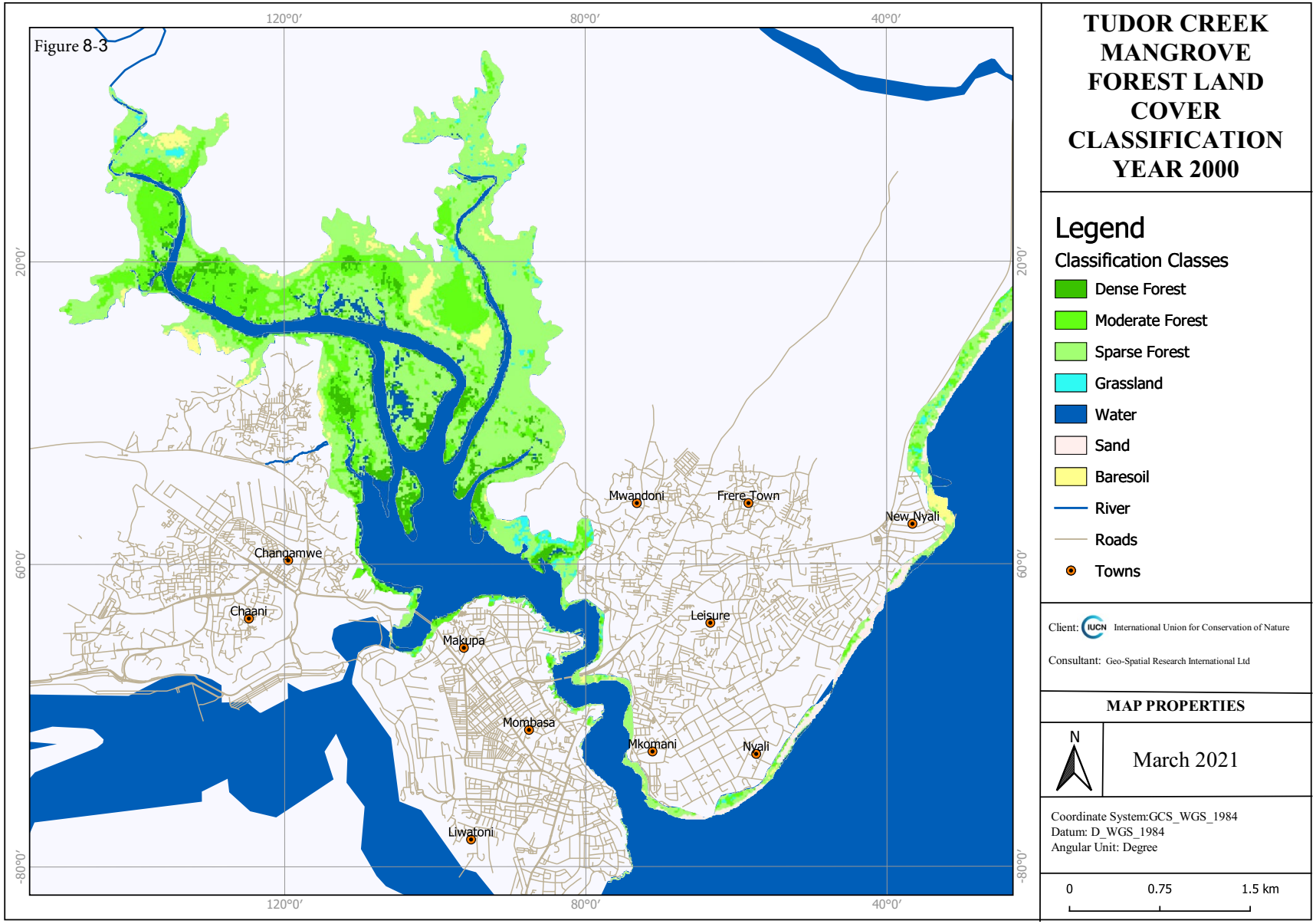


Figure 9-3: Tudor Landcover Classification Year 2019

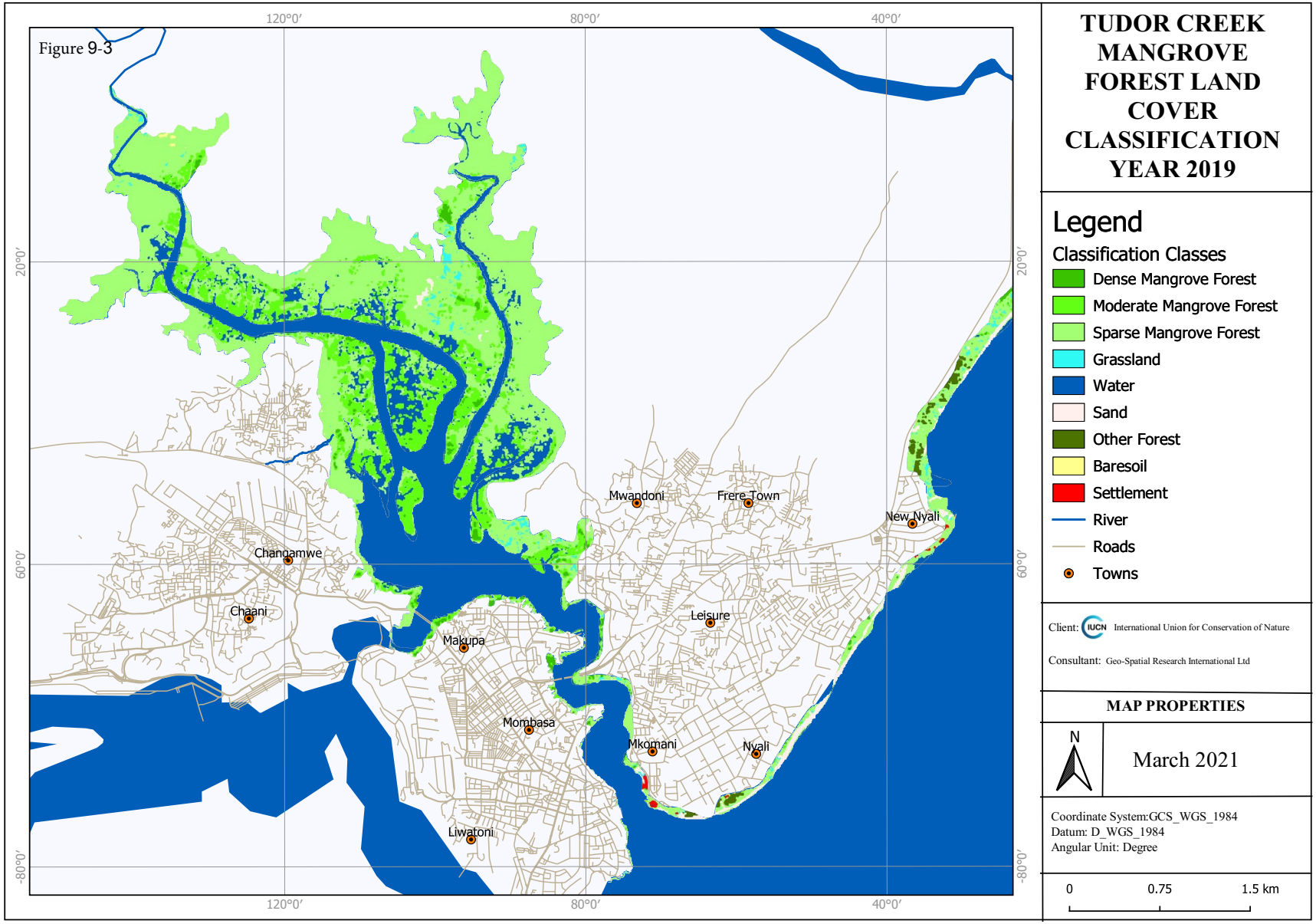


Table 5-3: Tudor Creek Forest Formation Ecosystem Service Valuation for 2019

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Food (Subsistence fisheries)	71,908.28 Kg/ year	Ksh 308.44	Ksh 22,179,963.78	Ksh 28,903	Mangrove zones and the surroundings, based on the government registered/ unregistered landing sites of, Mshomoroni, Mkomani, Bamburi, Utange, old Port, Tudor, Nyali, Marina, Kidongo, Mkupe and Kitanga Juu	Final consumer prices	County government ministry of fisheries	The value is calculated from the total fish catch where the % role played by mangrove in the fish habitats is applied as cited by UNEP (2011). According to Arbuto Oropreza, 2008, the contribution of mangrove to fisheries is 31.7%. 90% of the marine fishing is done by artisanal fishermen in Kenya, (Ahmed, 2017). Each fish species was calculated based on the specific consumer price and overall average price was obtained. The data was obtained from the department of Fisheries, Kwale county. There are 12 landing sites used for this calculation and are associated to Tudor creek mangroves.
Wood extraction	Consumption of firewood and charcoal at Household level	Ksh 30- Firewood Ksh 45 - Charcoal	Ksh 4,775,291.21 Firewood Ksh 28,082,890.70 Charcoal	Ksh 6222.77 firewood Ksh 36,595.33 charcoal	Mangrove zone within 10km radius	Final consumer prices	Ministry of Energy Report KNBS-KIHB report	Calculated from firewood collected within 10km radius of the mangrove ecosytems. Households within 10km radius were obtained through dasymetric mapping, on 2009 KNBS data projected to 2019. Data on value of charcoal & firewood, consumption per day is based on the 2019 Ministry of energy report titled Kenya Cooking Sector study report. Data on percentage of household using charcoal and Fuelwood in coastal counties is based on the Kenya Integrated Household Budget Survey by KNBS-KIHB 2015/2016 report.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Medicinal use	Number patients treated with mangrove related extracts Cost per patient for the treatment	0	0	0	Mangrove zone	Market prices	KFS	There is no registered user group or medicine men involved in traditional medicine as a commercial entity even though the user right exit. Most community members collect medicine for personal use.
Tourism/ recreation	No. of visits to vendors situated at the mangrove front	Ksh 500	Ksh 840,312,000	Ksh 1,095,025.	Mangrove zone	Price of services taking place in kiosks at the mangrove front and tour guiding in areas in close proximity	CFA/Community	Open business premises on the mangrove fronts are the main tourist attractions. Estimated over 100 open kiosks (vendors) in mangrove fronts, operating an estimated 50 visitors per day in peak seasons only. Estimated expenditureper visitor is Ksh 500. Ecotourism is also practiced where the CFA charges Ksh 500 per visitor and the frequency of visitors to mangrove sites ranges between 11-15 people per week.
Coastal protection/ flood /storm control	Length of wall that should be built in place of mangroves; 6448.68 Metres	Ksh 8500	Ksh 52,879,176	Ksh 68,904.83	Coastal protection zone	Replacement cost method	Ministry of planning and development (Valuer based in Mombasa)	Calculated based on engineers' estimate of the cost of building the protective wall. The estimate was done at ksh8500/metre. The meters of protection at Tudor creek are estimated at 6448.68 Most areas along the tudor creek where mangroves were removed, already have the concrete wall. The cost of setting this wall per meter as at 2019 was used in this calculation
Sediment trap	Quantification of sediment charge and nutrients in it	0	0	0	Mangrove zone	Replacement cost	None	There is no documentation on sediment loads/charge for the calculation of the value. There is no documentation on the amount of nutrient that can be deposited in sediments. River Kombeni and Tsalu are associated with Tudor creek depositing 0.6m3 and 0.2m3 of fresh water respectively.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Habitat provision (nurseries for fishes and marine species)	Soil organic nutrient productivity in Kg/ha	Ksh 308	Ksh 6,872,517.70	Ksh 10,160.58	Mangrove zone	Final consumer price	Remote sensing data by Sanderman et al., 2018 and simard 2019	The role that the mangroves play in habitat provision for fishes and mariculture is calculated from soil organic carbon nutrient productivity in Kg/ha. Calculated based on price of fish catch.
Carbon sequestration	Quantification of carbon annual sequestration and carbon storage 118,400tC02 and 95.78tC02/ ha	Ksh 1000	Ksh 4,773,179.14	Ksh 6,220.02	Mangrove zone	Social cost of carbon	Remote sensing Biomass data for 2019	Annual sequestration rate 6.3% from Murray et al., 2011 Biomass initial release at 75% from Murray et al., 2011, Biomass half life at 15years based on Murray et al., 2011 Soil carbon (top 1m) half life at 7.5 years Murray et.al 2011. The price of carbon is adopted from price Plan VIVO to GAZI CFA @ 10USd at conversion rate of 1 dollar to KSh 100.
Biodiversity conservation	Specific biodiversity indicators (revealed prices of money spent on conservation)	Ksh 2278	Ksh 546,720	Ksh 712.44	Mangrove zone	Revealed price for conservation	KFS 2018-2022 strategic plan	Calculated based on the money set aside for conservation of forest in the KFS 2018-2022 draft strategic plan that targeted 500,000ha nationwide. Mangrove cover loss is estimated at 450ha/year (Bosire et al., 2013). The area for rehabilitation according to MOKICFA CFA for 2017-2019 was 240 Ha. BigShip, a CBO operating in the area has a project on adopt a site where various stakeholders have adopted areas for rehabilitation. There is an estimated 2 ha of already adopted sites by various private, NGO and GOK entities

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Non-use value (existence value)	Socioeconomic indicators 80 registered CFA members		Ksh 3,900,000	Ksh 5082	Settlement near the mangroves, tourists/ urban inhabitants	Expenditure cost/contingent valuation	Field data collection	The willingness to pay for conservation is calculated from population estimation captured through dasymetry mapping which allows for apportioning of population. According to the field study all members of CFA were considered to be willing to pay for conservation. The approximate time as collected from the field is 2hrs a day per person, 3times a month, at a labour cost of ksh 500 per day. The CFA has 50 registered memberes actively involved in mangrove conservation. Another group, brain youth indicated their willingness in spending 5hrs for 5 days a week. The group has a membership of 30 people.
Mangrove education and research	Education visits and grants given for education and research in per day mangrove		0	0	Mangrove zone	Payment for services offered	KMFRI KEFRI KFS	No data was found for this particular service

4. Funzi Bay Mangrove Forest Formation

The Funzi bay Mangrove forest formation is located at the far Southern edge of the Kenyan coastline, between geo-coordinates 4°38'S, 39°24' E in the south and 4°30' S, 39°26' E in the north, see maps in Figures 10-3, 11-3 and 12-3 below. Following a land cover classification, the total area of the forest formation was estimated as 1305.61 Ha for the year 2019 and 2009.169Ha for the year 2000. Mangrove species found in the forest formation include; *Avicennia marina*, *Bruguiera gymnorrhiza*, *Ceriops tagal*, *Rhizophora mucronata*, *Sonneratia alba* and *Xylocarpus granatum*.

The threats to Funzi bay mangrove Forest formation include; settlements, uneven cutting pressures/ over-exploitation, increasing population and pollution from the surrounding community. The biodiversity within the forest include; fish, crabs and sea grass.

Funzi bay is directly surrounded by Funzi and Shirazi settlements. The socio-economic activities carried out in the surrounding include; tourism, hospitality, wood extractions and agriculture.

The table 6-3 below gives the ecosystem service valuation of Funzi forest formation for the year 2019.

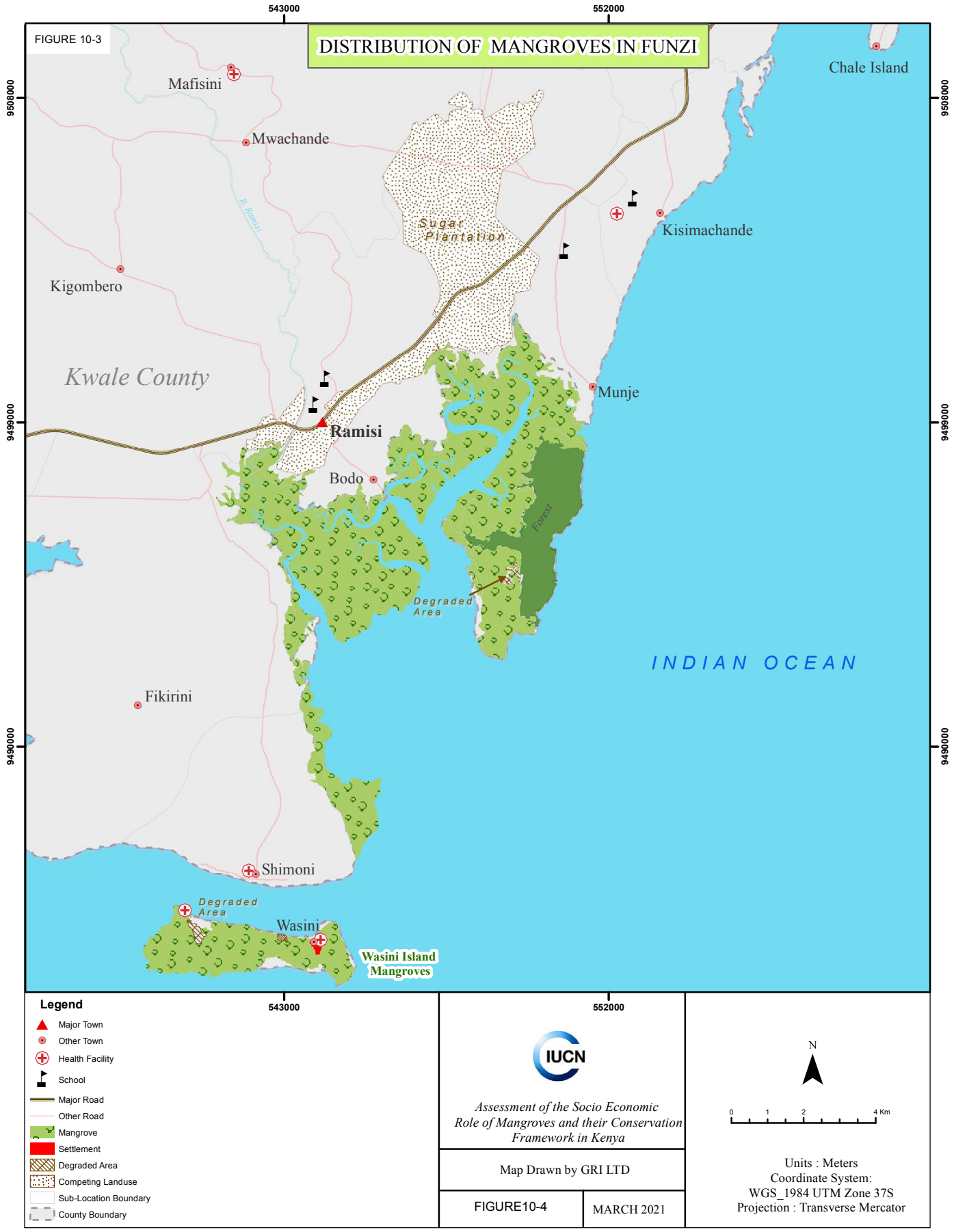


Figure 10-3: Distribution of Mangroves in Funzi

Figure 11-3: Funzi Landcover Classification Year 2000

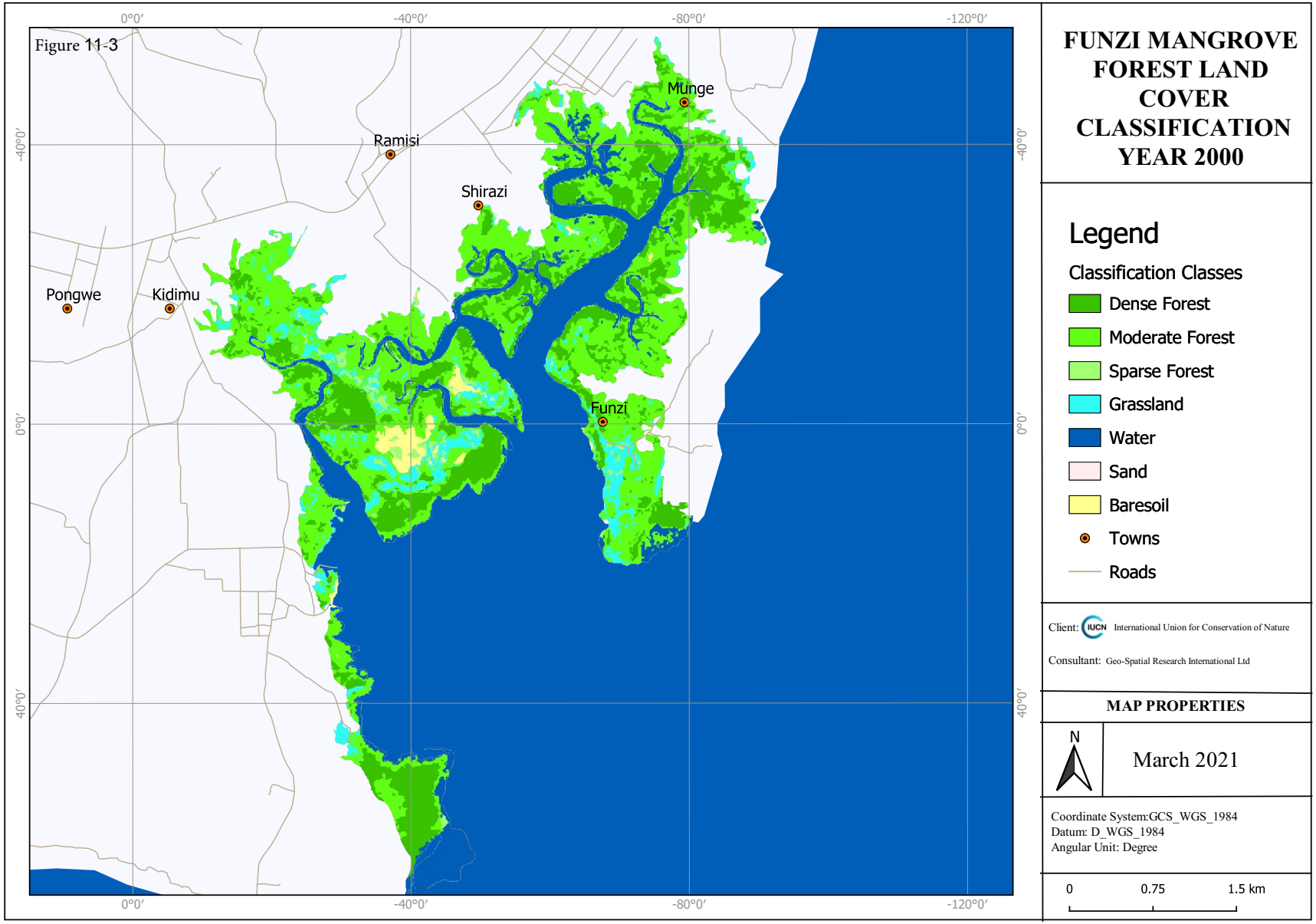


Figure 12-3: Funzi Landcover Classification Year 2019

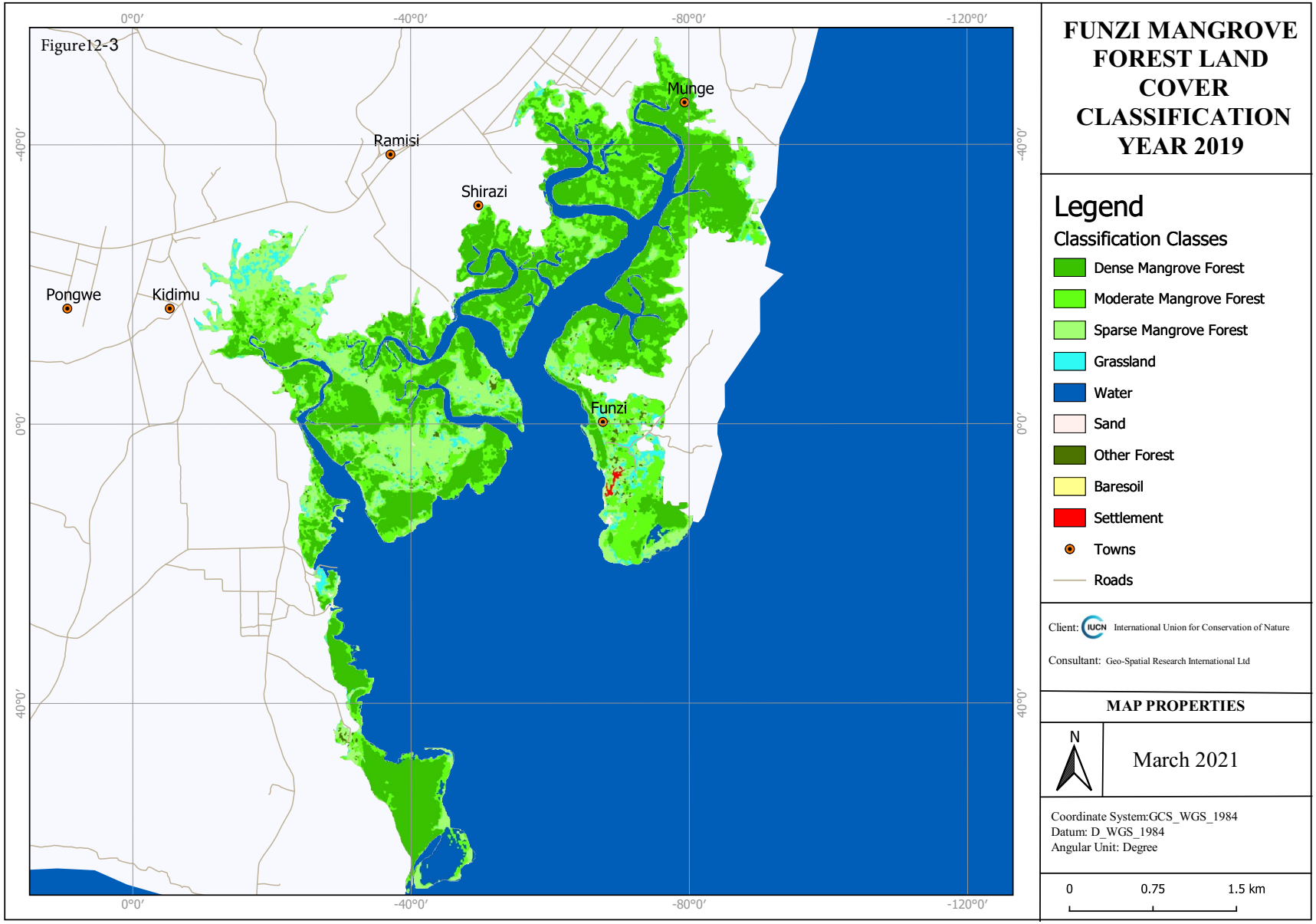


Table 6-3: Funzi Forest Formation Ecosystem service Valuation for 2019

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Food (Subsistence fisheries)	1765 Kg/year	Ksh 178.99	Ksh 315,909	Ksh 242.08	Mangrove zones and the surroundings based on the government registered landing site, Bodo, Funzi and Munje	Final consumer prices	County government ministry of fisheries	The value is calculated from the total fish catch where the % role played by mangrove in the fish habitats is applied as cited by UNEP (2011). According to Arbuto Oropreza, 2008, the contribution of mangrove to fisheries is 31.7%. 90% of the marine fishing is done by artisanal fishermen in Kenya, (Ahmed, 2017). Each fish species was calculated based on the specific consumer price and overall average price was obtained. The data was obtained from the department of Fisheries, Kwale county. There 3 landing sites used for this calculation and are associated to Funzi mangroves.
Wood extraction	Consumption of firewood and charcoal at Household level	Ksh 30- Firewood Ksh 45- Charcoal	Ksh 158,526,979.20 Ksh 27,455,222.86	Ksh 121,420.042 Ksh 21,028.69	Mangrove zone	Final consumer prices	Ministry of Energy Report KNBS-KHIB	Calculated from firewood collected within 10km radius of the mangrove ecosytems. Households within 10km radius were obtained through dasymetric mapping, on 2009 KNBS data projected to 2019. Data on value of charcoal & firewood, consumption per day is based on the 2019 Ministry of energy report titled Kenya Cooking Sector study report. Data on percentage of household using charcoal and Fuelwood in coastal counties is based on the Kenya Integrated Household Budget Survey by KNBS-KIHB 2015/2016 report.
Medicinal use	Volumes of active ingredients extracted per type of use	0	0	0	Mangrove zone	Market Price	KFS	There is no user group or medicine men involved in traditional medicine as a commercial entity. Most community members collect medicine for personal use.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Tourism/ recreation	No. of visits to mangrove sites	Ksh 500	Ksh 192,000	Ksh 147.05	Mangrove zone	Cost of accessing tourist sites by tourists	CFA/Community	An ecotourism site is run by Mwazaro BMU which charges Ksh 500 per person and receives 5-10 visitors per week.
Coastal protection/ flood /storm control	Length of wall that should be built in place of mangroves; 26,000.22	Ksh 5200	Ksh 135,314,400	Ksh 103,635.19	Coastal protection zone	Replacement cost method	Ministry of planning and development (Valuer based in Mombasa)	Calculated based on engineer's estimate of the cost of building the protective wall. The estimate was done at ksh5200/metre. The meters of protection at Funzi are estimated at 26022.00 Meters.
Sediment trap	Quantification of sediment charge and nutrients in it	0	0	0	Mangrove zone	Replacement cost or damage cost on tourist activities	None	There are no documented sediment loads/charge for the calculation of the value. There is no data either on nutrients richness of the site.
Habitat provision (nurseries for fishes and marine species)	Soil organic nutrient productivity in Kg/ha	Ksh 308	Ksh 18,199,278.22	Ksh 13,938.54	Mangrove zone	Final consumer price	Remote sensing data by Sanderman et al., 2018 and simard 2019	The role that the mangroves play in habitat provision for fishes and mariculture is calculated from soil organic carbon nutrient productivity in Kg/ha. It is also calculated based on price of fish catch.
Carbon sequestration	Quantification of carbon annual sequestration and carbon storage 192,000tC02 and 95.55tC02/ha	Ksh 1000	Ksh 191,969,842.16	Ksh 147,026	Mangrove zone	Social cost of carbon	Remote sensing Biomass data for 2019	Annual sequestration rate of 6.3% from Murray et al., 2011 Biomass initial release at 75% from Murray et al., 2011, Biomass half life at 15years based on Murray et al., 2011 Soil carbon (top 1m) half life at 7.5 years Murray et.al 2011. The price of carbon is adopted from price Plan VIVO to GAZI CFA @ 10USd at conversion rate of 1 dollar to KSh 100.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Biodiversity conservation	Specific biodiversity indicators (revealed prices of money spend on conservation)	Ksh 1608	Ksh 226,084	Ksh173.64	Mangrove zone	Revealed price for conservation	None	Calculated based on the money set aside for conservation of forest in the KFS 2018-2022 draft strategic plan that targeted 500,000ha nationwide. Mangrove cover loss is estimated at 450ha/year (Bosire et al., 2013). The loss in Funzi is estimated at 35ha/year averaged between the years 2000 and 2019. Conservation cost per ha from the budget is ksh 1608/Ha. Estimated area for conservation in 2019 was 140.6ha
Non-use value (existence value)	Socioeconomic indicators 50 registered CFA members	Ksh 500	Ksh 796,800	Ksh 610.26	Settlement near the mangroves, tourists/ urban inhabitants	Expenditure cost/ contingent valuation	Field data collection	The willingness to pay for conservation is calculated from population estimation captured through dasymetry mapping which allows for apportioning of population. According to the field study all members of CFA were considered to be willing to pay and spend time for conservation. The approximate time as collected from the field is 2hrs a day person, 2 times a week. At a labour cost of ksh 500 per day. The CFA has 50 registered membered actively involved in mangrove conservation.
Mangrove education and research	Education visits and grants given for education and research in mangrove	0	0	0	Mangrove zone	Payment for services offered	KMFRI KEFRI KFS	No data was found for this particular service

5. Mtwapa Creek Mangrove Forest Formation

The Mtwapa Creek is situated 25 km north of Mombasa between geo-coordinates 3°57'S, 39°44' E in the south and 3°53' S, 39°42' E in the north, see maps in Figures 13-3, 14-3 and 15-3 below. It receives freshwater from River Luadini, a seasonal river, with an annual mean discharge of 0.3 m3 /s (Magori, 1997). The creek is relatively eutrophic with evidence of seasonal contamination attributed to river discharge, surface runoff and raw sewage disposal (Mwangi et al., 2001). Mangrove forests, mainly dominated by *R. mucronata* occupy the extensive mudflats along the edge of the creek. Following a landcover classification, the total area of the forest formation was estimated as 597.096 Ha as at the 2019 whilst in the year 2000, it was 538.73Ha. The Creek is occupied predominantly by *R. mucronata* with other species including *Xylocarpus granatum* (mkomafi) and *Avicennia marina* (mchu) being quite rare within the mangrove swamp. Threats to Mtwapa Creek mangrove forest include; illegal harvesting of mangrove, overexploitation of mangroves, encroachment of mangrove areas for farming, encroachment of mangrove areas for settlement, Increased Sedimentation and sewage & litter disposal. Biodiversity present within the creek include; fish and crabs.

Mtwapa creek is directly surrounded by Shimo la Tewa, Kidutani-Mwamba, Mwakirunge and Shanzu urban centres. The ethnic people living in the area are predominantly the Mijikendas. The socio-economic activities carried out include; farming, trading in small scale businesses, hospitality, fishing, masonry and charcoal production (although the majority of the charcoal produced is not used locally).

The Table 7-4 below provides the ecosystem service valuation for Mtwapa Creek for the year 2019.

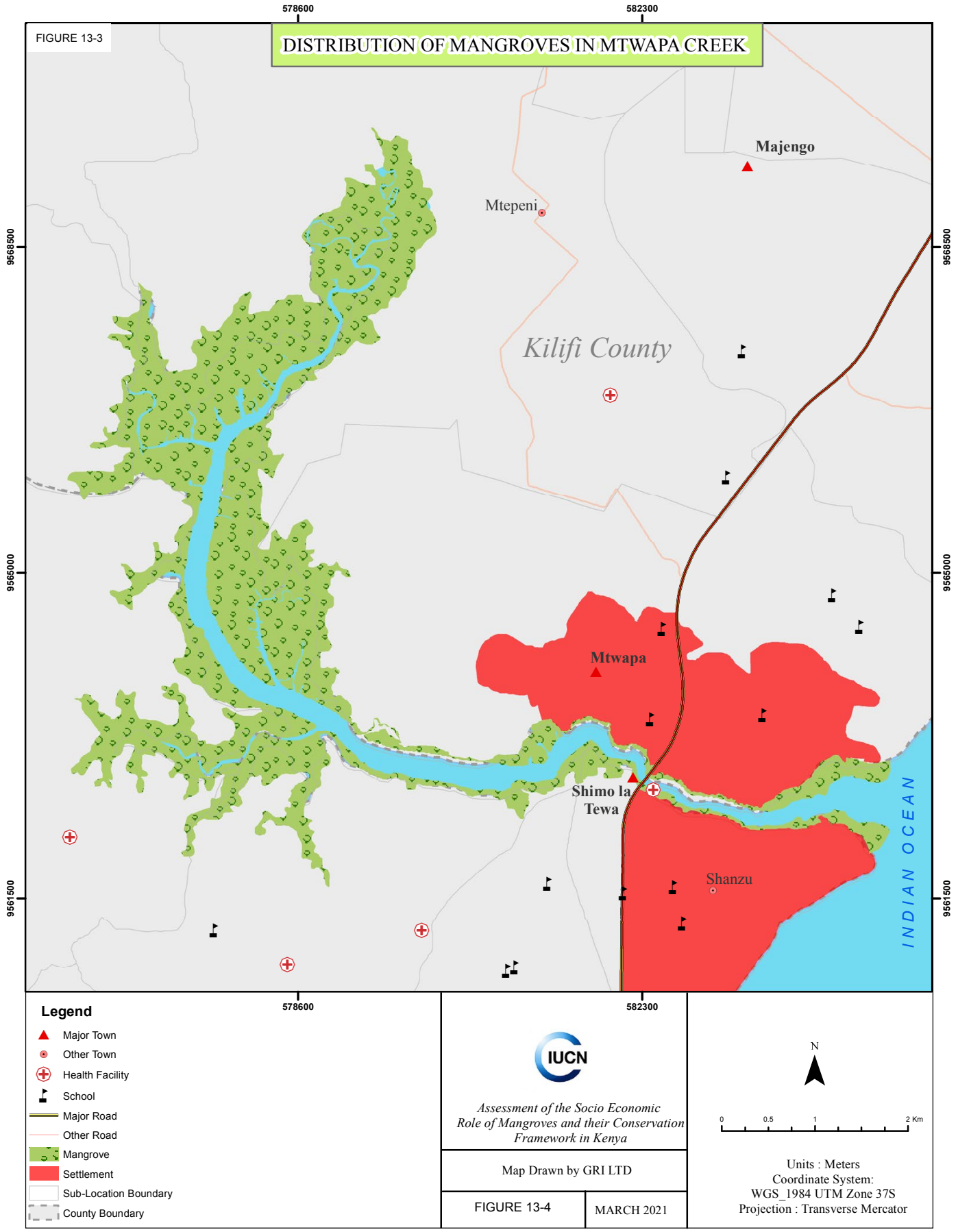


Figure 13-3: Distribution of Mangroves in Mtwapa Creek

Figure 14-3: Mtwapa Creek Landcover Classification Year 2000

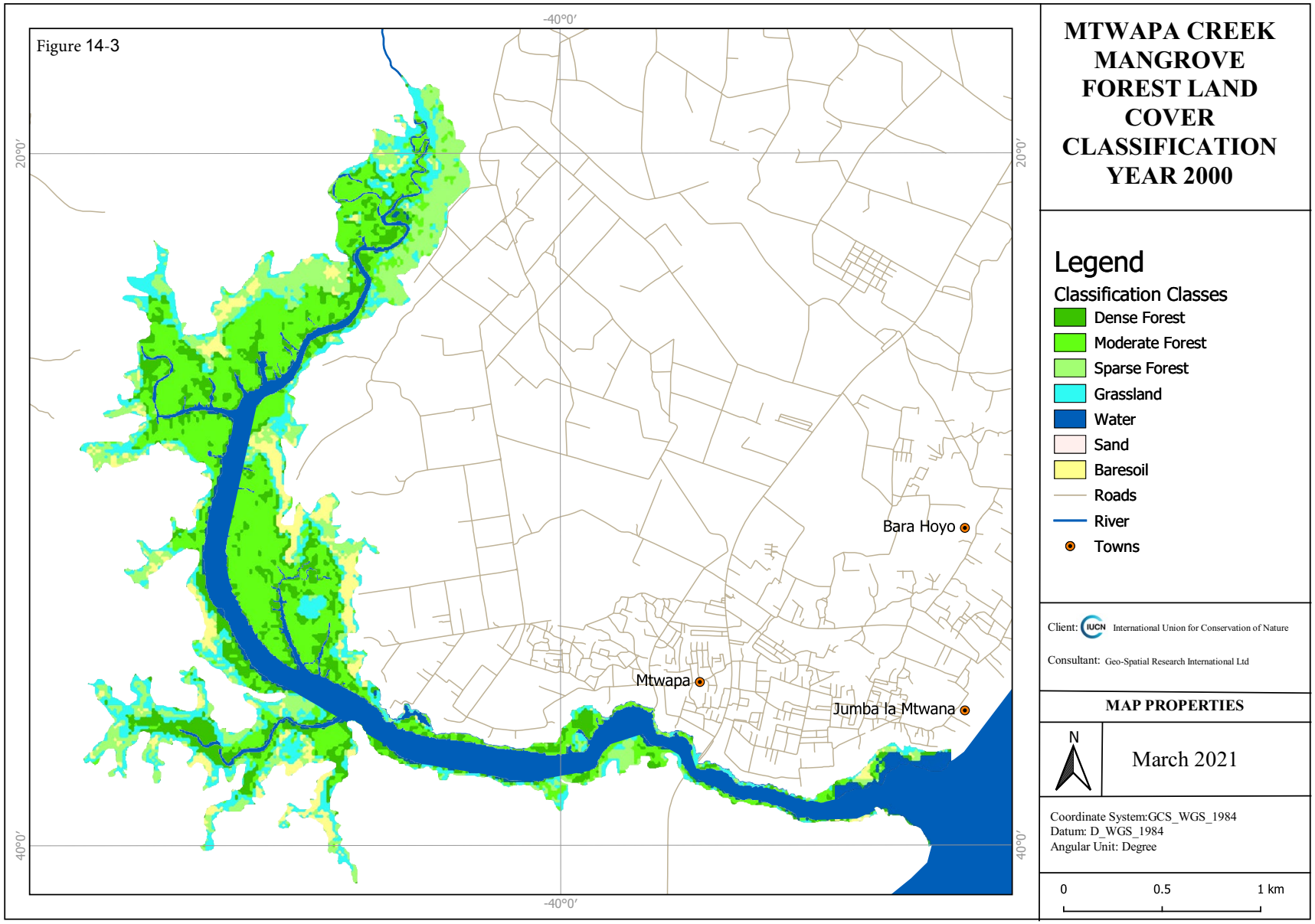


Figure 15-3: Mtwapa Creek Landcover Classification Year 2019

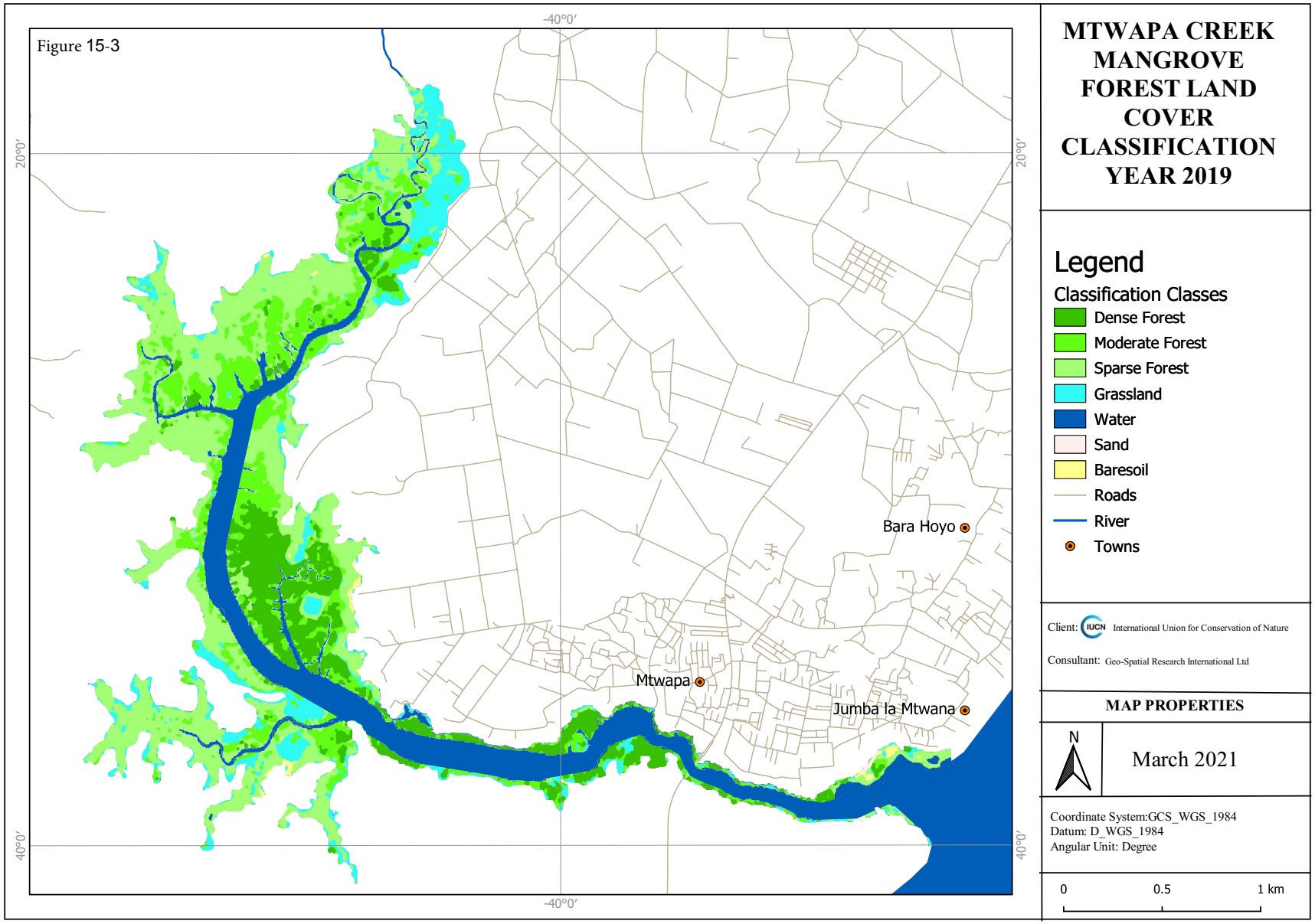


Table 7-3: Mtwapa Forest Formation Ecosystem service Valuation for 2019

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Food (Subsistence fisheries)	19,401 Kg/year	Ksh 221	Ksh 4,288,762.96	Ksh 7172.32	Mangrove zones and the surroundings based on the government registered landing sites; Mtwapa and Kanamai	Final consumer prices	County government ministry of fisheries	The value is calculated from the total fish catch where the % role played by mangrove in the fish habitats is applied as cited by UNEP (2011). According to Arbuto Oropreza, 2008, the contribution of mangrove to fisheries is 31.7%. 90% of the marine fishing is done by artisanal fishermen in Kenya, (Ahmed, 2017). Each fish species was calculated based on the specific consumer price and overall average price was obtained. The data was obtained from the department of Fisheries, Mombasa county. There 2 landing sites used for this calculation and are associated to Mtwapa creek mangroves.
Wood extraction	Consumption of firewood and charcoal at Household level	Ksh 30-Firewood Ksh 45- Charcoal	Ksh 359,174,580.83 Ksh 214,834,985	Ksh 601,535.73 Ksh 359,799.74	Mangrove zone	Final consumer prices	Ministry of Energy Report KNBS-KIHB report	Calculated from firewood collected within 10km radius of the mangrove ecosytems. Households within 10km radius were obtained through dasymetric mapping, on 2009 KNBS data projected to 2019. Data on value of charcoal & firewood, consumption per day is based on the 2019 Ministry of energy report titled Kenya Cooking Sector study report. Data on percentage of household using charcoal and Fuelwood in coastal counties is based on the Kenya Integrated Household Budget Survey by KNBS-KIHB 2015/2016 report.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Medicinal use	Volumes of active ingredients extracted per type of use	Ksh 1500	Ksh 2,520,000.00	Ksh 4220	Mangrove zone	Market price	KFS	Values were collectedfrom CFA focus group discussion where indicative figures of ksh 1000-2000 is what is charged for treatment per person while the frequency of visits were estimated at 20-50 people per week.
Tourism/ recreation	No. of visits to mangrove sites No of visits to vendor shops at the mangrove fronts	KSh 500	Ksh 5,232,000	Ksh 8762.41	Mangrove zone	Cost of accessing tourist sites by tourists	CFA/ Community	Visitors access the sites for leisure and other activities. The focus group discussion highlighted frequency of visits were 5-10 people per day charged at ksh 500 per person. There are vendor kiosks in most mangrove fronts, and the estimated businesses are about 100 receiving 30 visitors per day who spend about ksh 500 per visit.
Coastal protection/ flood /storm control	Length of wall that should be built in place of mangroves; 7495.18	Ksh 8500	Ksh 63,709,030	Ksh 106698.14	Coastal protection zone	Replacement cost method	Ministry of planning and development (Valuer based in Mombasa)	Calculated based on engineer's estimate of the cost of building the protective wall. The estimate was done at ksh 8500/ metre.
Sediment trap	Quantification of sediment charge and nutrients in it	0	0	0	Mangrove zone	Replacement cost or damage cost on tourist activities	None	There are no documents with information on sediment loads/charge for the calculation of the value. No data on Nutrient's richness of the site.
Habitat provision (nurseries for fishes and marine species)	Soil organic nutrient productivity in Kg/ha	Ksh 221	Ksh 1,099,551.11	Ksh 1841.50	Mangrove zone	Final consumer price	Remote sensing data by Sanderman et al., 2018	The role that the mangroves play in habitat provision for fishes and mariculture is calculated from soil organic carbon nutrient productivity in Kg/ha. It is also calculated based on price of fish catch.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Carbon sequestration	Quantification of carbon annual sequestration and carbon storage where we have 511,010tC02 and 946.9tC02/ha	Ksh 1000	Ksh 51,013,301.83	Ksh 85,435.68	Mangrove zone	Social cost of carbon	Remote sensing Biomass data for 2019	Annual sequestration rate of 6.3% from Murray et al., 2011 Biomass initial release at 75% from Murray et al., 2011, Biomass half life at 15years based on Murray et al., 2011 Soil carbon (top 1m) half life at 7.5 years Murray et.al 2011. The price of carbon is adopted from price Plan VIVO to GAZI CFA @ 10USd at conversion rate of 1 dollar to KSh 100.
Biodiversity conservation	Specific biodiversity indicators (revealed prices of money spent on conservation)	Ksh 1608	Ksh 32,160	Ksh 53.86	Mangrove zone	Revealed price for conservation	None	Calculated based on the money set aside for conservation of forest in the KFS 2018-2022 draft strategic plan that targeted 500,000ha nationwide. The NMMP estimated the area to be restored as 12 Ha.
Non-use value (existence value)	Socioeconomic indicators registered CFA members	Ksh 500	Ksh 912,000	Ksh 1527.40	Settlement near the mangroves, tourists/ urban inhabitants	Expenditure cost/ contingent valuation	Field data collection	The willingness to pay for conservation is calculated from population estimation captured through dasymetry mapping which allows for apportioning of population. According to the field study all members of CFA were considered to be willing to pay and spend time for conservation. The approximate time as collected from the field is 5hrs once a week per person at a labour cost of ksh 500 per day per person. The CFA has 38 registered membered actively involved in mangrove conservation.
Mangrove education and research	Education visits and grants given for education and research in mangrove	0	0	0	Mangrove zone	Payment for services offered	KMFRI KEFRI KFS	No data was found for this particular service

6. Takaungu Mangrove Forest Formation

The Takaungu mangrove forest formation is situated between geo-coordinates 3°41'S, 39°50' E in the south and 3°40' S, 39°50' E in the north, see maps in Figures 16-3,17-3 and 18-3 below. The total area of the forest formation is 371.39 Ha for the year 2019 and 475.77 for the year 2000 based on a landcover classification done during this study. Mangrove species found in the forest formation include; *R. mucronata*, *C. tagal* and *Bruguiera*. Threats to the ecosystem include; un-controlled felling of trees with or without a license, increasing population, urbanization especially building of hotels, pollution from the surrounding community and frequency of change of wave energy as people set up docks for boats. Biodiversity present in the ecosystem include; coral reefs and sea grass.

Mnarani and Takaungu are the only market centres near the forest formation. The people living in the area are the Giriama and the Bantu Swahili. The socio-economic activities carried out in the area include; tourism/eco-tourism & hospitality, fishing, selling mangrove tree seedlings & wood and bee keeping.

The Table 8-3 below presents the ecosystem service valuation for Takaungu for the year 2019.

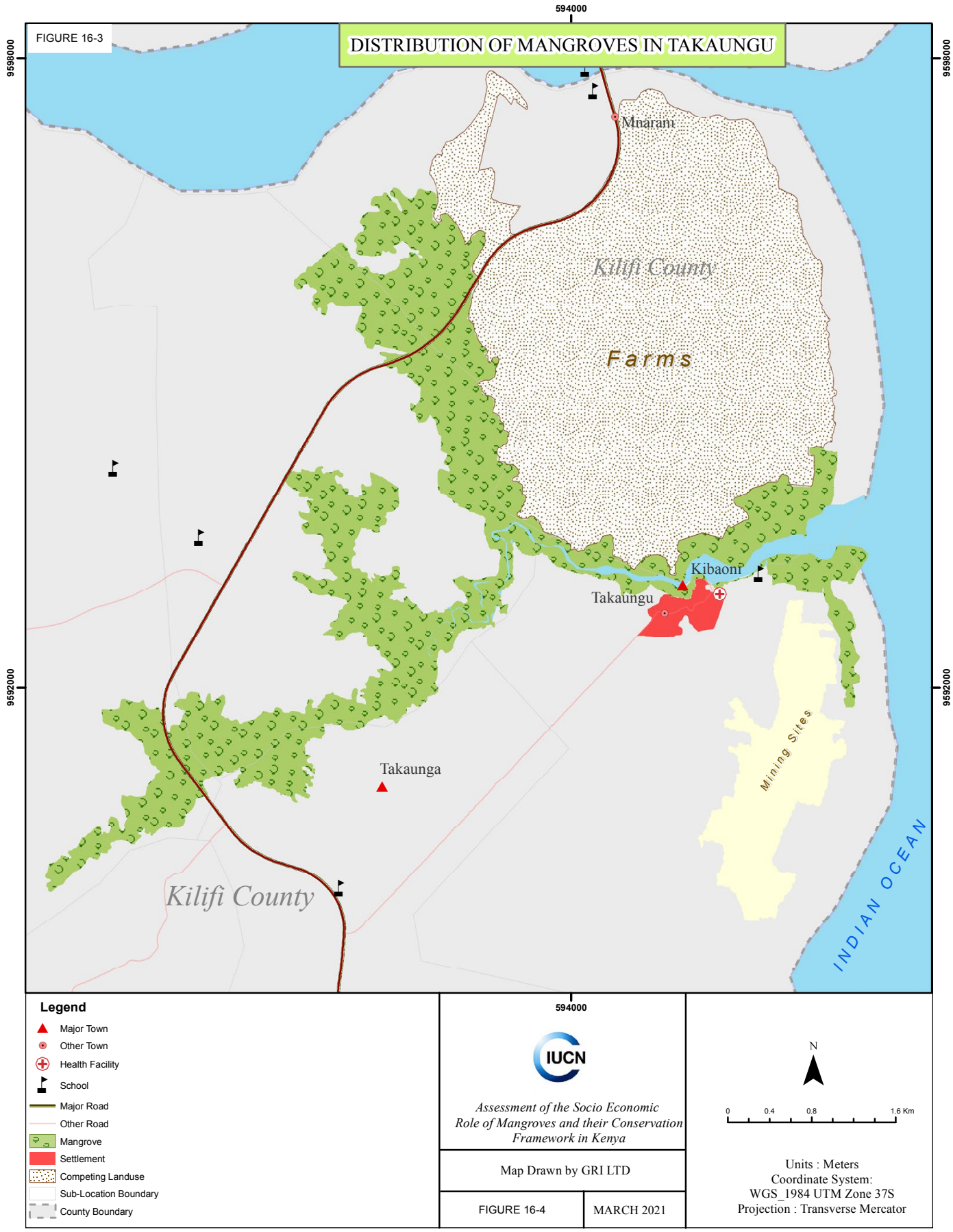


Figure 16-3: Distribution of Mangroves in Takaungu

Figure 17-3: Takaungu Landcover Classification Year 2000

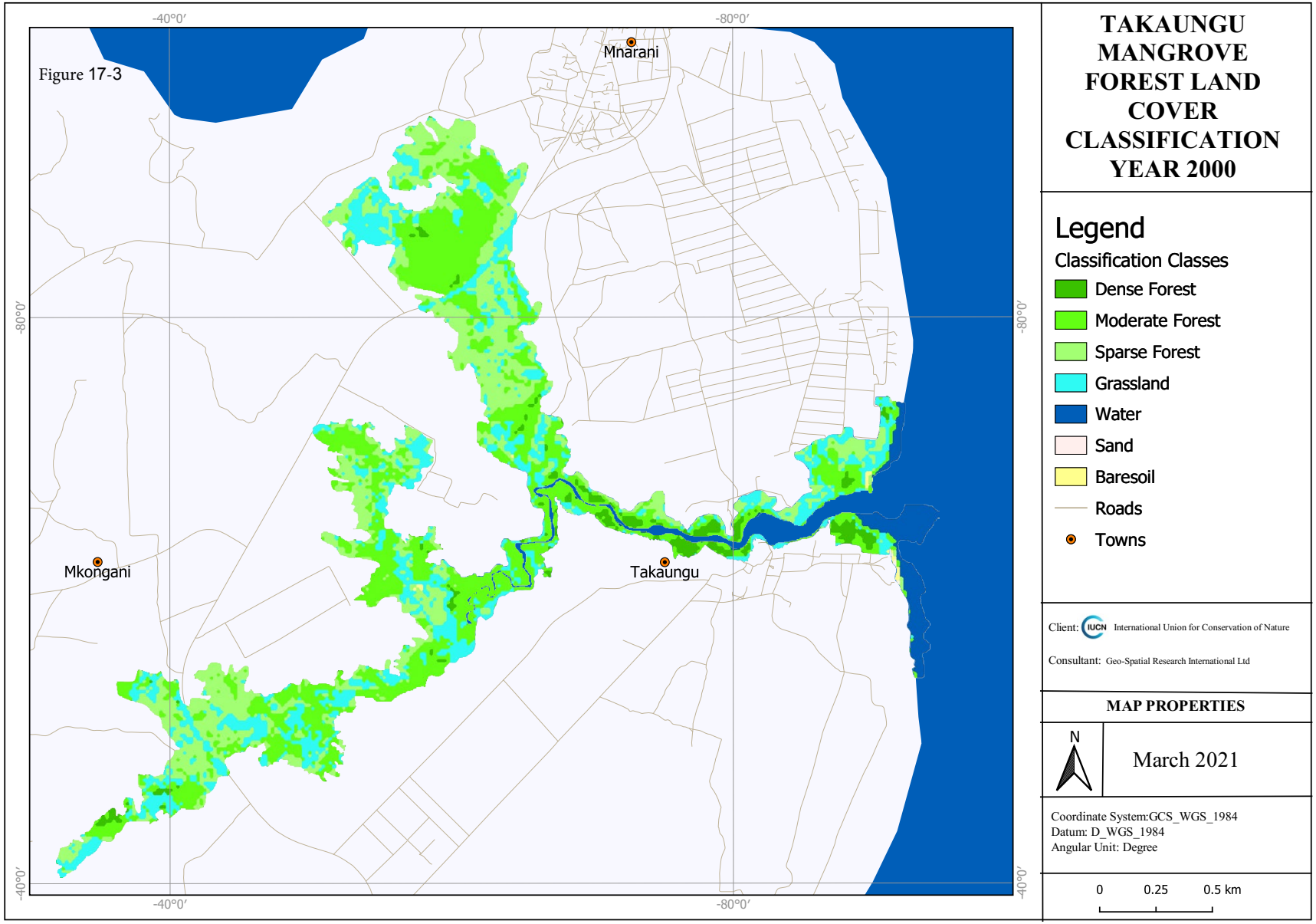


Figure 18-3: Takaungu Landcover Classification Year 2019

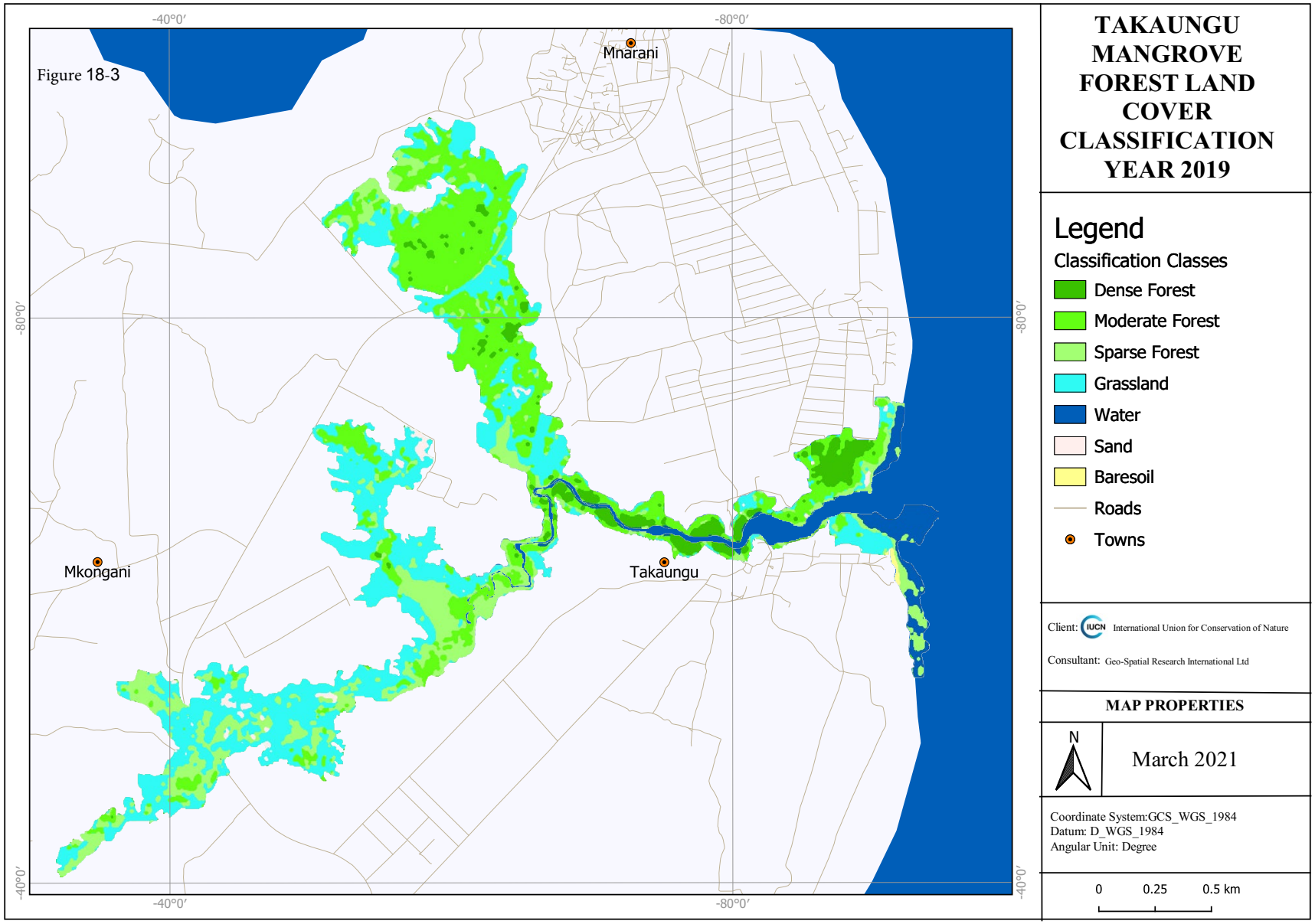


Table 8-3: Takaungu Forest Formation Ecosystem service Valuation for 2019

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Food (Subsistence fisheries)	11,259 Kg/year	Ksh 200	Ksh 2,253,406	Ksh 6067	Mangrove zones and the surroundings based on the government registered landing site, Takaungu	Final consumer prices	County government ministry of fisheries	The value is calculated from the total fish catch where the % role played by mangrove in the fish habitats is applied as cited by UNEP (2011). According to Arbuto Oropreza, 2008, the contribution of mangrove to fisheries is 31.7%. 90% of the marine fishing is done by artisanal fishermen in Kenya, (Ahmed, 2017). Each fish species was calculated based on the specific consumer price and overall average price was obtained. The data was obtained from the department of Fisheries, Mombasa county. There is 1 landing site associated with the Takaungu creek.
Wood extraction	Consumption of firewood and charcoal at Household level	Ksh 30 Firewood Ksh 45 Charcoal	Ksh 100,208,517.12 firewood Ksh 59,938,248.59 charcoal	Ksh 269,820.18 firewood Ksh 161,388.97 charcoal	Mangrove zone	Final consumer prices	Ministry of Energy Report KNBS-KHIB report	Calculated from firewood collected within 10km radius of the mangrove ecosytems. Households within 10km radius were obtained through dasymetric mapping, on 2009 KNBS data projected to 2019. Data on value of charcoal & firewood, consumption per day is based on the 2019 Ministry of energy report titled Kenya Cooking Sector study report. Data on percentage of household using charcoal and Fuelwood in coastal counties is based on the Kenya Integrated Household Budget Survey by KNBS-KIHB 2015/2016 report.
Medicinal use	Volumes of active ingredients extracted per type of use		0	0	Mangrove zone	Market Price	KFS	There is no user group or medicine men involved in traditional medicine as a commercial entity. Most community members collect medicine for personal use.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Tourism/ recreation	No. of visits to mangrove sites		Ksh 840,000	Ksh 2,261.77	Mangrove zone	Price paid by tourists to acess tourist sites	CFA/Community	Local tourism sites are run by the CFA. Less than 5 visitors are received per day each paying ksh 500 to acess the sites.
Coastal protection/ flood /storm control	Length of wall that should be built in place of mangroves; 5338.53M	Ksh 5200	Ksh 27,760,356	Ksh 74,747.18	Coastal protection zone	Replacement cost method	Ministry of planning and development (Valuer based in Mombasa)	Calculated based on engineer's estimate of the cost of building the protective wall. The estimate was done at ksh5200/metre. The meters of protection at Takaungu is estimated at 5338.53 Meters.
Sediment trap	Quantification of sediment charge and nutrients in it	0	0	0	Mangrove zone	Replacement cost or damage cost on tourist activities	None	There was no information on sediment loads/charge for the calculation of the value neither data on nutrients richness of the site.
Habitat provision (nurseries for fishes and marine species)	Soil organic nutrient productivity in Kg/ha	Ksh 200	Ksh 23,145,150.00	Ksh 62,320	Mangrove zone	Final consumer price	Remote sensing data by Sanderman et al., 2018	The role that the mangroves play in habitat provision for fishes and mariculture is calculated from soil organic carbon nutrient productivity in Kg/ha. It is also calculated based on price of fish catch.
Carbon sequestration	Quantification of carbon annual sequestration and carbon storage where we have 44,990tC02 annual release and 945.5tC02/ Ha	Ksh 1000	Ksh 44,985,458.42	Ksh 121,127.27	Mangrove zone	Social cost of carbon	Remote sensing Biomass data for 2019 from sanderman 2018 and Simard 2019	The price of carbon is adopted from price Plan VIVO to GAZI CFA @ 10USd at conversion rate of 1 dollar to KSh 100. Annual sequestration rate of 6.3% from Murray et al., 2011 Biomass initial release at 75% from Murray et al., 2011, Biomass half life at 15years based on Murray et al., 2011 Soil carbon (top 1m) half life at 7.5 years Murray et.al 2011.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Biodiversity conservation	Specific biodiversity indicators (revealed prices of money spent on conservation)	Ksh 1608	Ksh 44,220	Ksh 119.07	Mangrove zone	Revealed price for conservation	None	Calculated based on the money set aside for conservation of forest in the KFS 2018-2022 draft strategic plan that targeted 500,000ha nationwide. The estimated average forest loss is 5.5Ha per year averaged between the years 2000 and 2019. The restorable areas are estimated at 27.5Ha
Non-use value (existence value)	Socioeconomic indicators 16 registered CFA members	Ksh 250	Ksh 382,464	Ksh 1,029.82	Settlement near the mangroves, tourists/ urban inhabitants	Expenditure cost/ contingent valuation	Field data collection	The willingness to pay for conservation is calculated from population estimation captured through dasymetry mapping which allows for apportioning of population. According to the field study all members of CFA were considered to be willing to pay and spend time for conservation. The estimated money the community is willing to spend is 3hrs twice a week per person on conservation. The CFA has 16 registered members actively involved in mangrove conservation.
Mangrove education and research	Education visits and grants given for education and research into mangrove		0	0	Mangrove zone	Payment for services offered	KMFRI KEFRI KFS	No data was found for this particular service

7. Kilifi Creek Mangrove Forest Formation

The Kilifi Creek is located some 55 Km north of Mombasa city, between geo-coordinates 3°39'S, 39°49' E in the south and 3°33' S, 39°48' E in the north, see maps in Figures 19-3,20-3 and 21-3 below. The deepest part of the creek is approximately 38 m at the entrance and a distance of about 4 km (500 m wide) which separates the ocean from an open lagoon known as Bahari ya Wali. The total area of the forest formation was estimated as 371.39 Ha for the year 2019, and 475.78Ha for the year 2000, following a land cover classification of the area. Mangrove species found in the forest formation include; *Avicennia marina*, *Ceriops tagal*, *Sonneratia alba J.*, *Rhizophora mucronata*, *Lumnitzera racemosa* and *Bruguiera gymnorrhiza*. The most dominant species in the forest is *Avicenna Marina* while the less dominant species are *Lumnitzera racemosa* and *Heritiera littoralis*. Threats to the Kilifi Creek mangrove forest include; uneven cutting pressures/over-exploitation of *Rhizophora mucronate* and *Ceriops tagal*, increasing population and pollution from the surrounding community. The biodiversity present include; coral reefs, mudflats with or without seaweeds, estuarine ecosystems, fish, prawn and crabs.

The people living in the area include the Giriama and the Bantu Swahili and the socio-economic activities carried out include; agriculture, fishing and tourism/ eco-tourism.

Table 9-3 below presents the ecosystem service valuation for the Kilifi Creek for the year 2019.

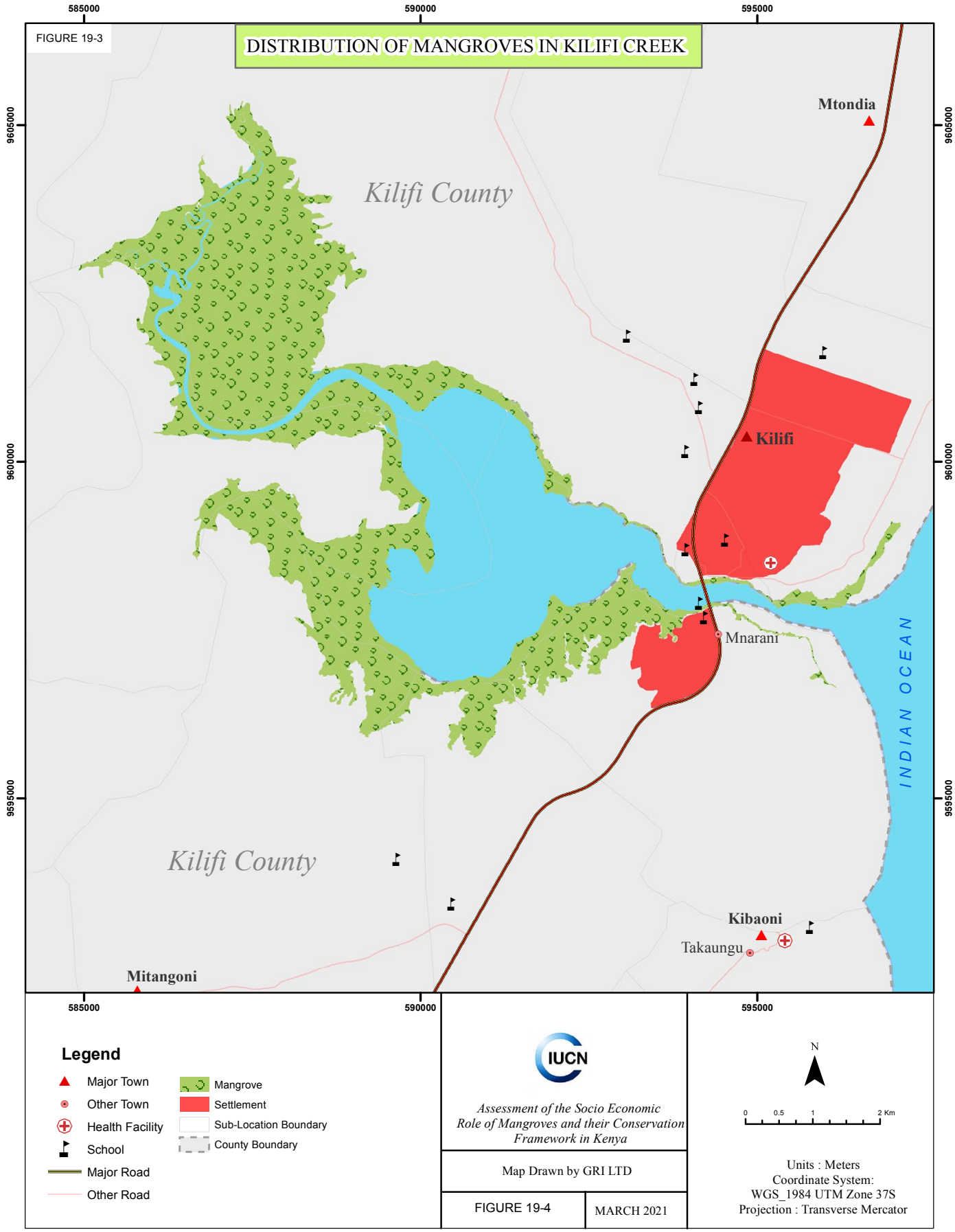


Figure 19-3: Distribution of Mangroves in Kilifi Creek

Figure 20-3: Kilifi Creek Landcover Classification Year 2000

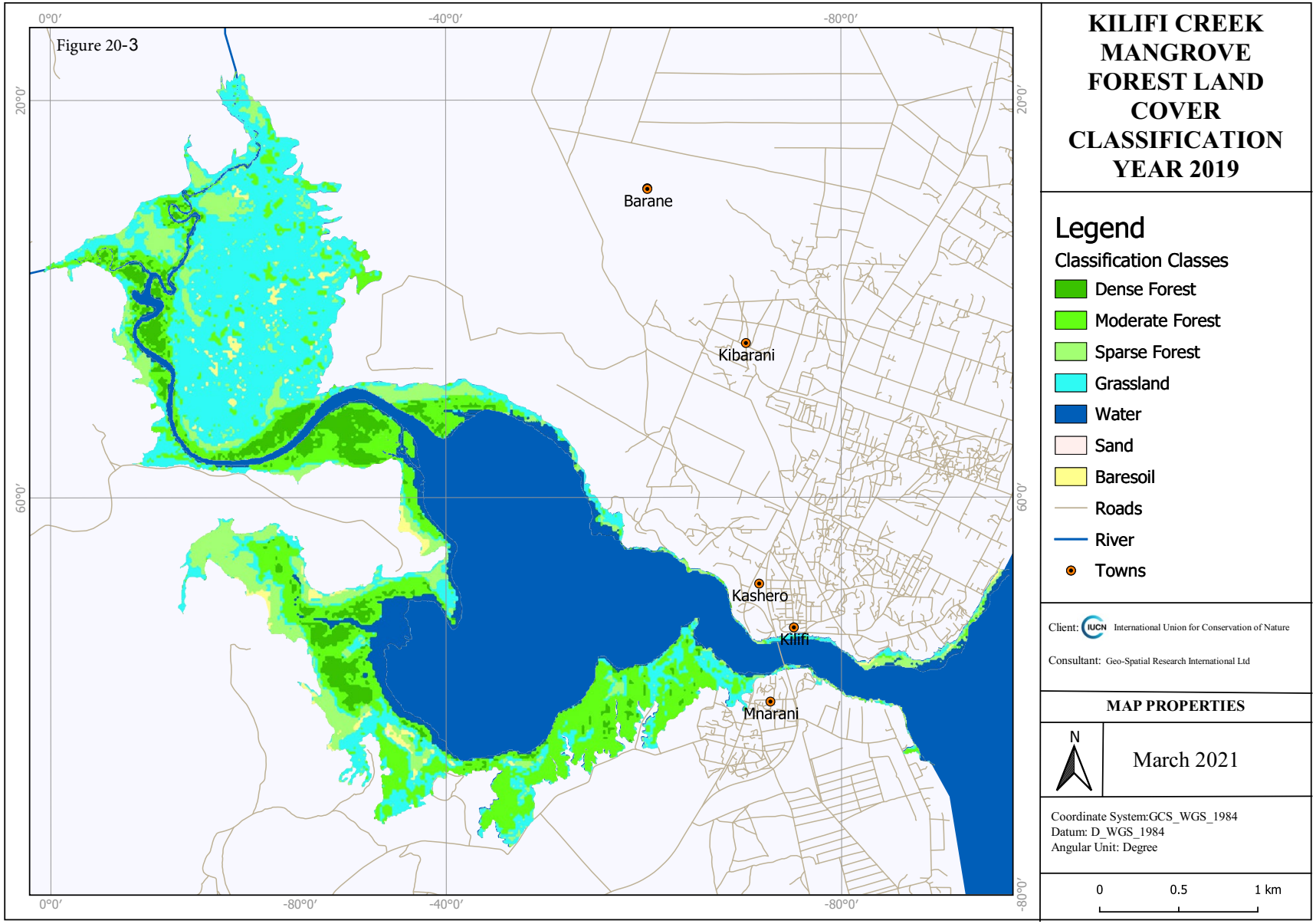


Figure 21-3: Kilifi Creek Landcover Classification Year 2019

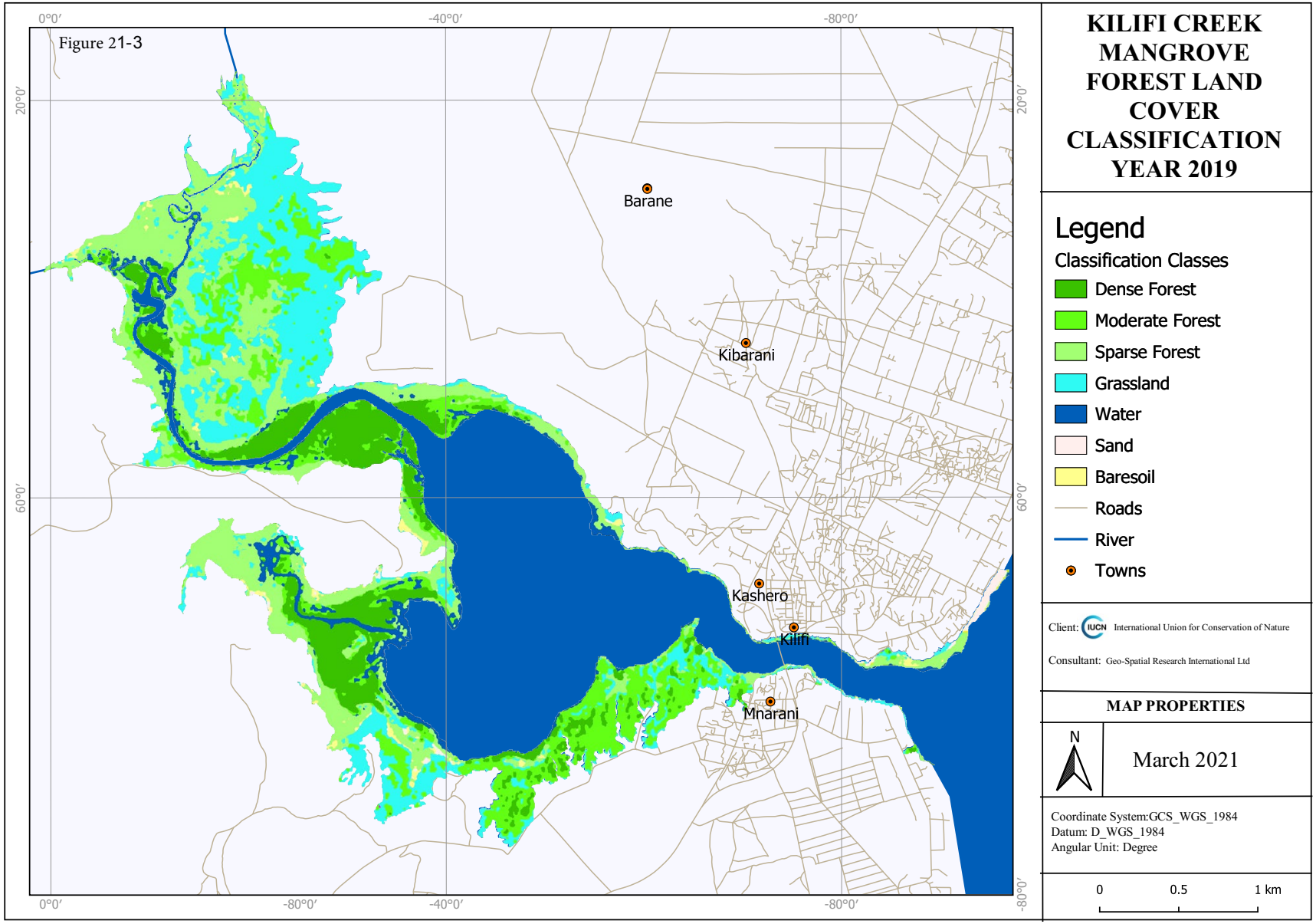


Table 9-3: Kilifi Creek Forest Formation Ecosystem Service Valuation for 2019

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Food (Subsistence fisheries)	101,469 Kg/year	Ksh 176	Ksh 17,870,194	Ksh 17,425.84	Mangrove zones and the surroundings based on the government registered landing sites	Final consumer prices	County Government Ministry of fisheries	The value is calculated from the total fish catch where the % role played by mangrove in the fish habitats is applied as cited by UNEP (2011). According to Arbuto Oropreza, 2008, the contribution of mangrove to fisheries is 31.7%. 90% of the marine fishing is done by artisanal fishermen in Kenya, (Ahmed, 2017). Each fish species was calculated based on the specific consumer price and overall average price was obtained. The data was obtained from the department of Fisheries, Kilifi county. There are 3 landing sites used for this calculation and are associated to Kilifi creek mangroves i.e. Kilifi,Mnarani,Bofa
Wood extraction	Volume of firewood extracted for domestic use	Ksh 30-firewood Ksh 45 - Charcoal	Ksh 213,793,205.76 firewood Ksh 127,877,257.15 Charcoal	Ksh 208,477.04 firewood Ksh 124,697.47 charcoal	Mangrove zone	Final consumer prices	Ministry of Energy Report KNBS	Calculated from firewood collected within 10km radius of the mangrove ecosytems. Households within 10km radius were obtained through dasymetric mapping, on 2009 KNBS data projected to 2019. Data on value of charcoal & firewood, consumption per day is based on the 2019 Ministry of energy report titled Kenya Cooking Sector study report. Data on percentage of household using charcoal and Fuelwood in coastal counties is based on the Kenya Integrated Household Budget Survey by KNBS-KIHB 2015/2016 report.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Medicinal use	Number of patients treated by the medicine men and the frequency of patients per day	Ksh 2000	Ksh 4,800,000.00	Ksh4680.64	Mangrove zone	Market Price	CFA focus group discussions	There are traditional medicine men practicing within the forest. Most commonly used parts of the mangroves are the leaves, bark and roots.
Tourism/ recreation	No. of visits to mangrove sites	KSh 500	Ksh 1,344,000.00	Ksh 1310.58	Mangrove zone	Cost charged for accessing tourist sites	CFA/Community	CFA charges for leisure walks into the mangrove sites. 2 Charges are ksh 500 per person and they receive 5-10 visitors/day.
Coastal protection/ flood /storm control	Length of wall that should be built in place of mangroves i.e., 19,506.52M	Ksh 5200	Ksh 101,433,904	Ksh 98911.66	Coastal protection zone	Replacement cost method	Ministry of planning and development (Valuer based in Mombasa)	Calculated based on engineer's estimate of the cost of building the protective wall. The estimate was done at ksh5200/ metre. The meters of protection at the Kilifi creek are estimated at 19,506.52M.
Sediment trap	Quantification of sediment charge and nutrients in it	0	0	0	Mangrove zone	Replacement cost or damage cost on tourist activities	None	There are no documents with information on sediment loads/charge for the calculation of the value neither data on the nutrient's richness of the site.
Habitat provision (nurseries for fishes and marine species)	Soil organic nutrient productivity in Kg/ha	Ksh 176	Ksh 60,805.01	Ksh 59.29	Mangrove zone	Final consumer price	Remote sensing data by Sanderman et al., 2018	The role that the mangroves play in habitat provision for fishes and mariculture is calculated from soil organic carbon nutrient productivity in Kg/ha. It is also calculated based on price of fish catch.
Carbon sequestration	Quantification of carbon annual sequestration and carbon storage	Ksh 1000	Ksh 74,619,570	Ksh 72,764.09	Mangrove zone	Social Cost of Carbon	Remote sensing Biomass data for 2019 for Simard et al., 2019 and Sanderman et al., 2018	The price of carbon is adopted from price Plan VIVO to GAZI CFA @ 10USd at conversion rate of 1 dollar to KSh 100. Annual sequestration rate of 6.3% from Murray et al., 2011 Biomass initial release at 75% from Murray et al., 2011, Biomass half life at 15years based on Murray et al., 2011 Soil carbon (top 1m) half life at 7.5 years Murray et.al 2011.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Biodiversity conservation	Specific biodiversity indicators (revealed prices of money spend on conservation)	Ksh 0	Ksh 0	Ksh 0	Mangrove zone	Revealed price for conservation	None	Calculated based on the money set aside for conservation of forest in the KFS 2018-2022 draft strategic plan that targeted 500,000ha nationwide. There has been a tremendous improvement in mangrove cover and no data was available on restorable areas.
Non-use value (existence value)	Socioeconomic indicators 36 registered CFA members	Ksh 300	Ksh 129,600	Ksh 126.38	Settlement near the mangroves, tourists/ urban inhabitants	Expenditure cost/ contingent valuation	Field data collection	The willingness to pay for conservation is calculated from population estimation captured through dasymetry mapping which allows for apportioning of population. According to the field study all members of CFA were considered to be willing to pay and spend time for conservation. The estimated amount of money that the members are willing to invest for conservation is ksh 300 per month per CFA member. The CFA has 36 registered membered actively involved in mangrove conservation.
Mangrove education and research	Education visits and grants given for education and research in mangrove		0	0	Mangrove zone	Payment for services offered	KMFRI KEFRI KFS	No data was found for this particular service

8. Ungwana Bay Mangrove Forest Formation

The Ungwana Bay Mangrove Forest Formation is situated in Malindi District covering Gongoni and Fundi issa towns. The forest lies between geo-coordinates 3°03'S, 40°08' E in the South and 2°50' S, 40°08' E in the North, see maps in Figures 22-3, 23-3 and 24-3 below. The total area of the Forest formation is 2062Ha as at 2019 and 1637.84 as at 2000 based on a landcover classification done during the study. The Mangrove species present in the forest formation are *Avicennia marina*, *Ceriops tagal*, *Rhizophora mucronata*, *Bruguiera gymnorrhiza* and *Sonneratia alba*. The biodiversity present in the forest formation include a wide variety of epiphytes, parasites and climbers, large numbers of micro-organisms, crustaceans, molluscs, fishes and birds (Groombridge, 1992). Crabs and molluscs also live permanently in the forest, and prawns and fishes come in on the tide, to feed on the abundant nutrient provided by mangrove detritus from continuous litter fall (Macnae, 1968).

The threats to Ungwana bay forest formation include, discharge of sediment from the Sabaki River and the Tana River, utilization and over exploitation of the mangrove trees, conversion of the forest to other land and water uses, infrastructure development (salt pans) and increasing population growth. The major settlements are in Gongoni, Marereni and Fundi issa market centres. The socio-economic activities in the area include, fishing, agriculture, aquaculture and salt harvesting.

The Table 10-3 below displays the ecosystem service values for the forest for the year 2019.

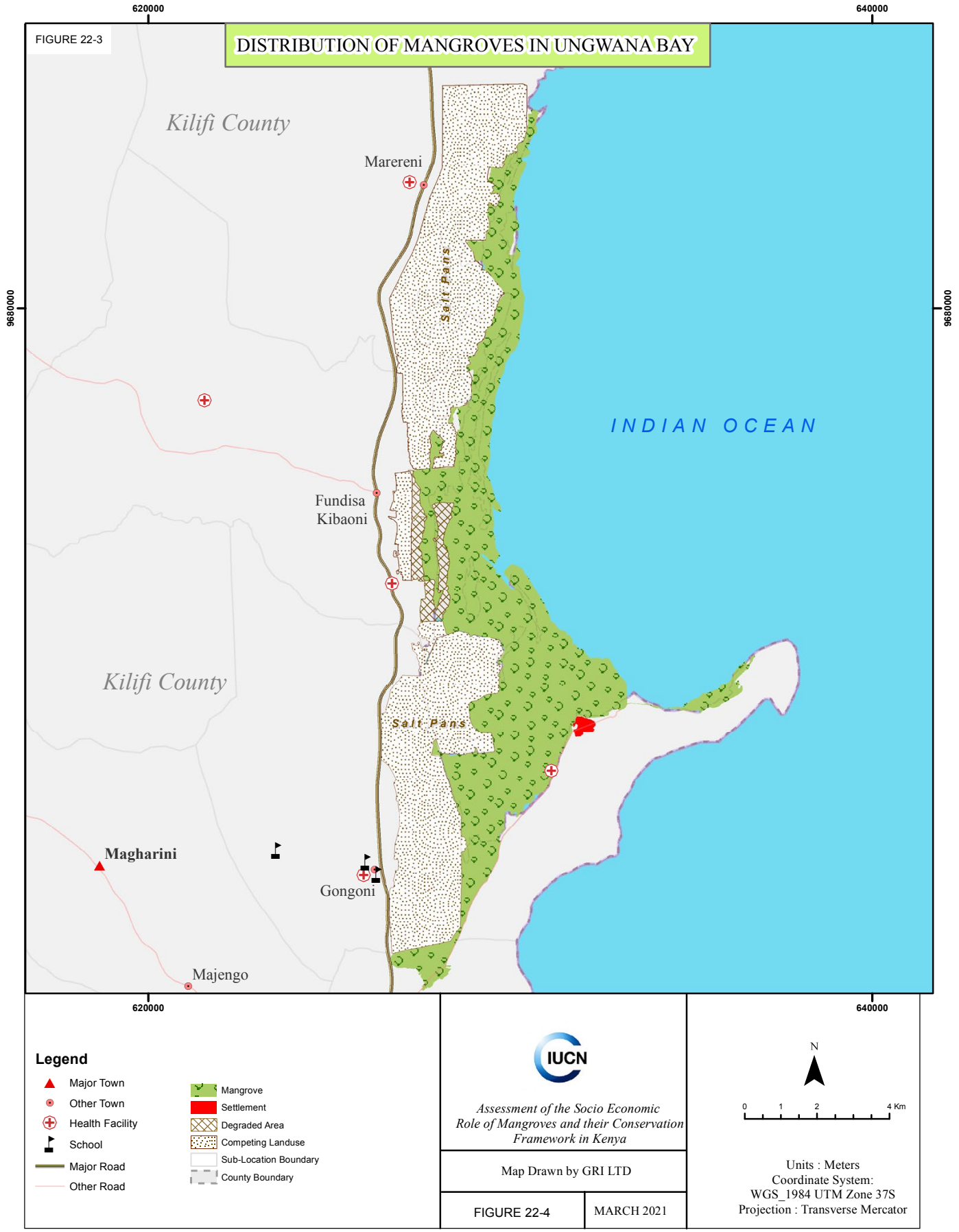


Figure 22-3: Distribution of Mangroves in Ungwana bay

Figure 23-3: Ungwana bay Landcover Classification Year 2000

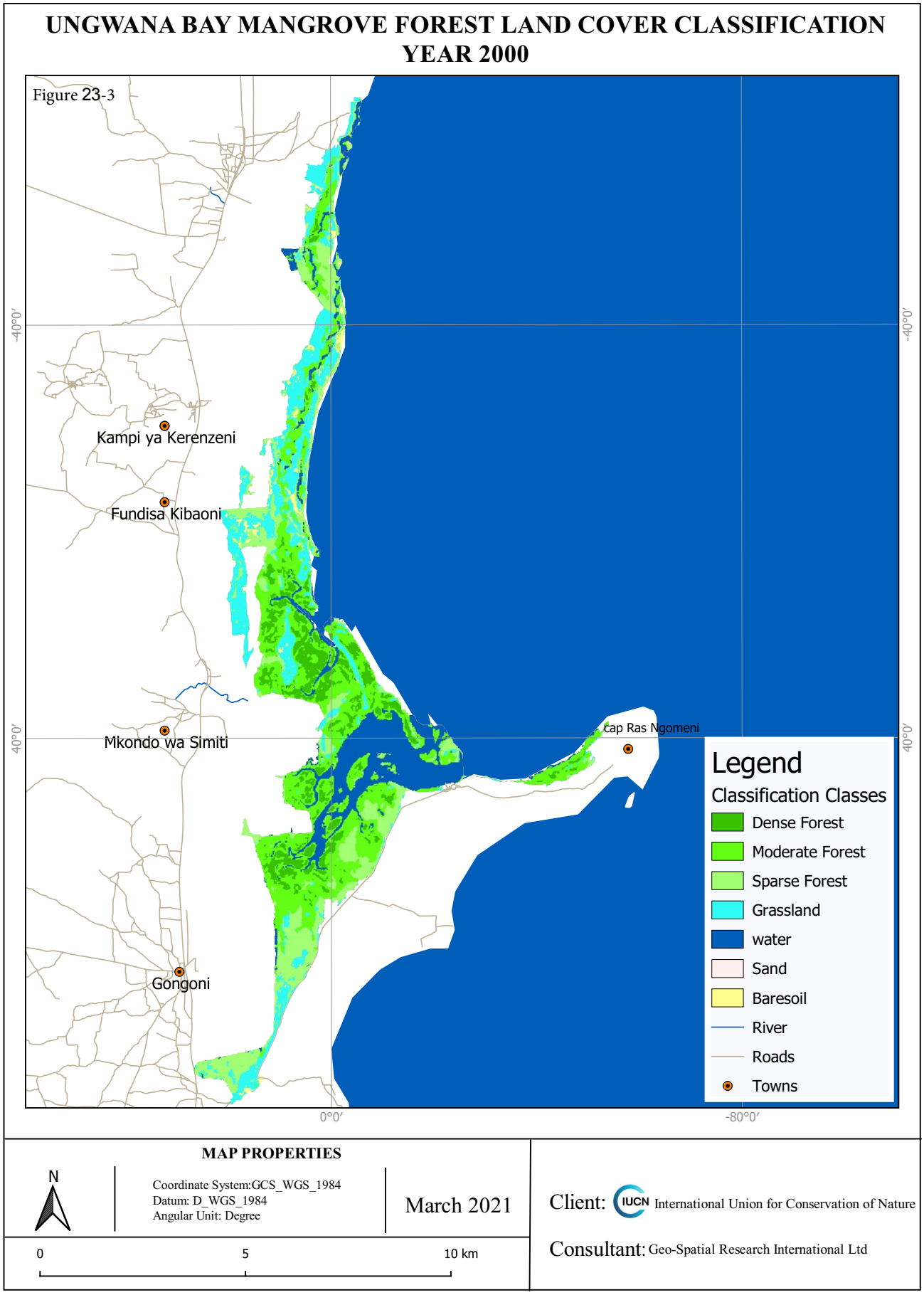


Figure 24-3: Ungwana bay Landcover Classification Year 2019

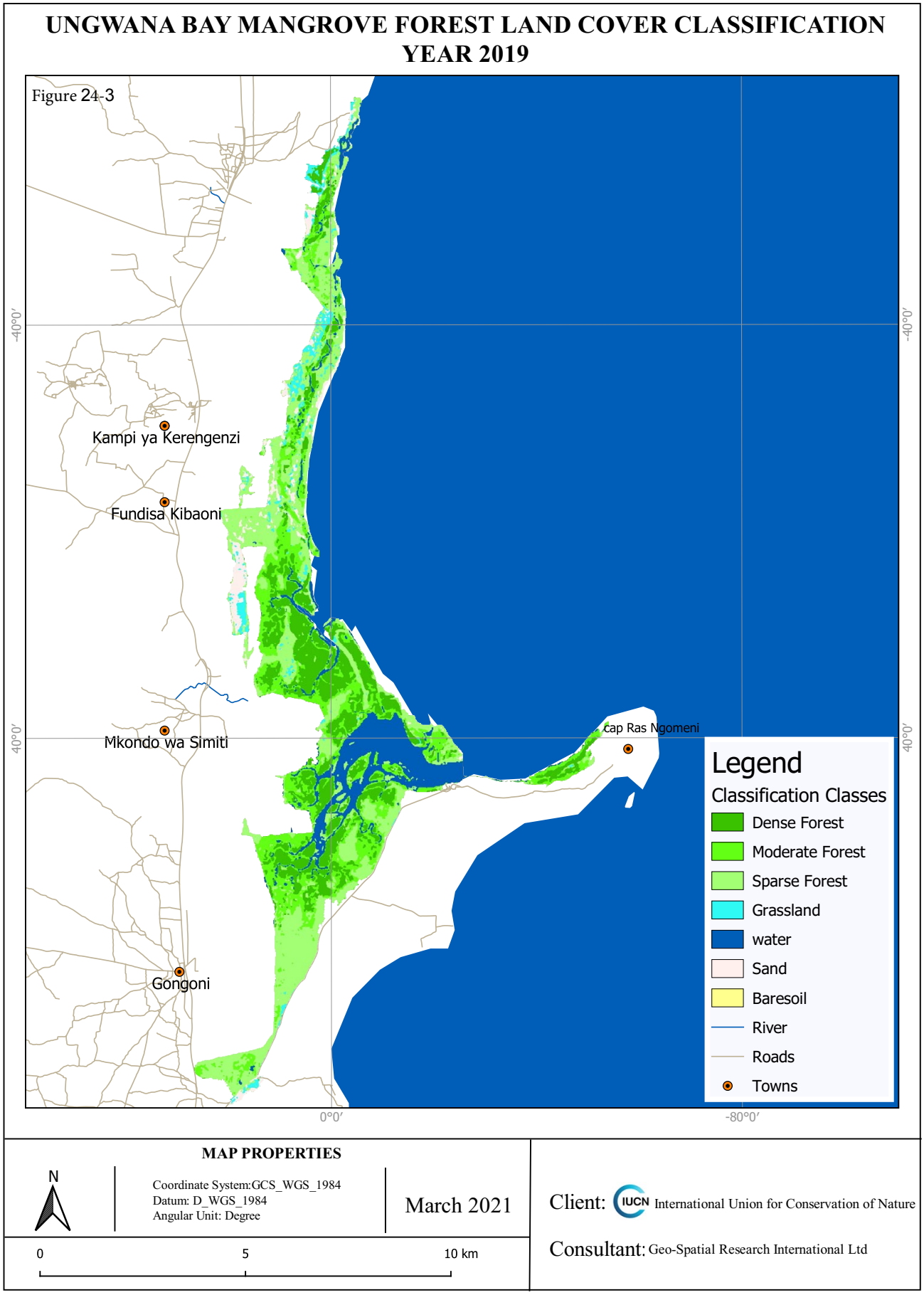


Table 10-3: Ungwana Bay Forest Formation Ecosystem Service Valuation for 2019

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Food (Subsistence fisheries)	140,585.00 Kg/ year	Ksh 287.71	Ksh 40,448,049	Ksh 19,611.00	Mangrove zones and the surroundings based on the government registered landing sites.	Final consumer prices	County government ministry of fisheries	The value is calculated from the total fish catch where the % role played by mangrove in the fish habitats is applied as cited by UNEP (2011). According to Arbuto Oropreza, 2008, the contribution of mangrove to fisheries is 31.7%. 90% of the marine fishing is done by artisanal fishermen in Kenya, (Ahmed, 2017). Each fish species was calculated based on the specific consumer price and overall average price was obtained. The data was obtained from the department of Fisheries, Kilifi county. There are 4 landing sites used for this calculation and are associated with Ungwana bay, i.e. Mayungu, Kichwa cha Kati, Ngomeni and Ngongoni.
Wood extraction	Consumption in Kg of Firewood and Charcoal at Household level	Ksh 30- firwewood Ksh 45 Charcoal	Ksh 93,633,200.64 firewood Ksh 56,005,319.88 Charcoal	Ksh 45,398.58 firewood Ksh 27,154.49 Charcoal	Mangrove zone Within 10 KM radius	Final consumer prices	Ministry of Energy Report KNBS-KIHB	Calculated from firewood collected within 10km radius of the mangrove ecosytems. Households within 10km radius were obtained through dasymetric mapping, on 2009 KNBS data projected to 2019. Data on value of charcoal & firewood, consumption per day is based on the 2019 Ministry of energy report titled Kenya Cooking Sector study report. Data on percentage of household using charcoal and Fuelwood in coastal counties is based on the Kenya Integrated Household Budget Survey by KNBS-KIHB 2015/2016 report.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Medicinal use	Number of patients treated and the cost of treating a patient with mangrove extracts	Ksh 2000	Ksh 13,440,000	Ksh 6516.46	Mangrove zone	Market price	Information generated from CFA through focus group discussion	There are no registered user groups for traditional medicine use however there are known medicine men who use mangrove extracts for treatment. Most commonly used are leaves, bark and roots.
Tourism/ recreation	No. of visits to mangrove sites	Ksh 500	Ksh 1,344,000.00	Ksh 651.65	Mangrove zone	Cost charged for accessing mangrove ecosystem	CFA/ Community	CFA charges for leisure walks into the mangrove site. Charges are ksh 500 per person, and they receive 5-10 visitors/day. Flowering seasons of the mangroves is considered an important peak season.
Coastal protection/ flood /storm control	Length of wall that should be built in place of mangroves is approximately; 22,435.25M	Ksh 5200	Ksh 116,663,300	Ksh 56,550.30	Coastal protection zone	Replacement cost method	Ministry of planning and development (Valuer based in Mombasa)	Calculated based on engineer's estimate of the cost of building the protective wall. The estimate was done at ksh5200/ metre. The meters of protection at Ungwana bay is estimated at 22,435.25 M
Sediment trap	Quantification of sediment charge and nutrients in it	0	0	0	Mangrove zone	Replacement cost or damage cost on tourist activities	None	There are no documents with information on sediment loads/charge for the calculation of the value, neither data on the nutrient's richness of the site.
Habitat provision (nurseries for fishes and marine species)	Nutrient productivity in Kg/Ha calculated from Soil organic Carbon data	Ksh 176	Ksh 929,386.	Ksh 45.07	Mangrove zone	Final consumer price	Remote sensing data by Sanderman et al., 2018	The role that the mangroves play in habitat provision for fishes and mariculture is calculated from soil organic carbon nutrient productivity in Kg/ha. It is also calculated based on price of fish catch.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Carbon sequestration	Quantification of carbon annual sequestration and carbon storage where 74,620tC02 and 945tC02/Ha	Ksh 1000	Ksh 154,785,576.86	Ksh 75,048.64	Mangrove zone	Social cost of carbon	Remote sensing Biomass data for 2019	The price of carbon is adopted from price Plan VIVO to GAZI CFA @ 10USd at conversion rate of 1 dollar to KSh 100. Annual sequestration rate of 6.3% from Murray et al., 2011 Biomass initial release at 75% from Murray et al., 2011, Biomass half life at 15years based on Murray et al., 2011 Soil carbon (top 1m) half life at 7.5 years Murray et.al 2011.
Biodiversity conservation	Specific biodiversity indicators (revealed prices of money spend on conservation)	0	Ksh 0	Ksh 0	Mangrove zone	Revealed price for conservation	None	Calculated based on the money set aside for conservation of forest in the KFS 2018-2022 draft strategic plan that targeted 500,000ha nationwide. There has been a tremendous improvement in mangrove cover and no data was available on restorable areas.
Non-use value (existence value)	Socioeconomic indicators 10 registered CFA members	Ksh 300	Ksh 36,000	Ksh 0.001	Settlement near the mangroves, tourists/ urban inhabitants	Expenditure cost/ contingent valuation	Field data collection	The willingness to pay for conservation is calculated from population estimation captured through dasymetry mapping which allows for apportioning of population. According to the field study all members of CFA were considered to be willing to pay and spend time for conservation. The estimated amount of money that the members are willing to invest for conservation is ksh 300 per month per CFA member. The CFA has 10 registered membered actively involved in mangrove conservation.
Mangrove education and research	Education visits and grants given for education and research in mangrove		0	0	Mangrove zone	Payment for services offered	KMFRI KEFRI KFS	No data was found for this particular service

9. Ngomeni Mangrove Forest Formation

The Ngomeni mangrove forest formation is situated in Malindi district about 150 km north of Mombasa between geo-coordinates 3°04'S, 40°10' E in the South and 2°58' S, 40°14' E in the North stretches and it stretches into Kurawa area in Tana river county, see maps in Figures 25-3,26-3 and 27-3 below. The total area of the forest formation was estimated at 2530.42Ha and 1868Ha in 2019 and 2000 respectively based on a land cover classification done during this study. Mangrove species found in the forest formation include; *Rhizophora mucronate, Avicennia marina*, *Ceriops tagal*, *Bruguiera gymnorrhiza*, Xylocarpus granatum and *Sonneratia alba*. The threats to the Ngomeni mangrove forest formation include; development of large-scale salt production, rapid accretion processes leading to poor water circulation, local development of mariculture & aquaculture and over-exploitation of wood products. The biodiversity present in the forest formation include; seagrasses, algae and fungi (which play an important role together with bacteria in the rapid breakdown of mangrove leaf litter), herbs, Sesuvium portulacastrum, Salicornia species; grasses & sedges, neem, palms and pines.

Marereni, Kurawa and Ngomeni towns are the main market centers surrounding the forest. The dominant ethnic tribes in these areas are the Bantu Swahili, the Giriama, the Chonyi, Jibana, Kambe, Kauma, Rabai and the Ribe. The socio-economic activities carried out in the area include; fishing, agriculture, aquaculture and salt harvesting.

The Table 11-3 below displays the ecosystem service valuation for the Ngomeni mangrove forest formation for the year 2019.

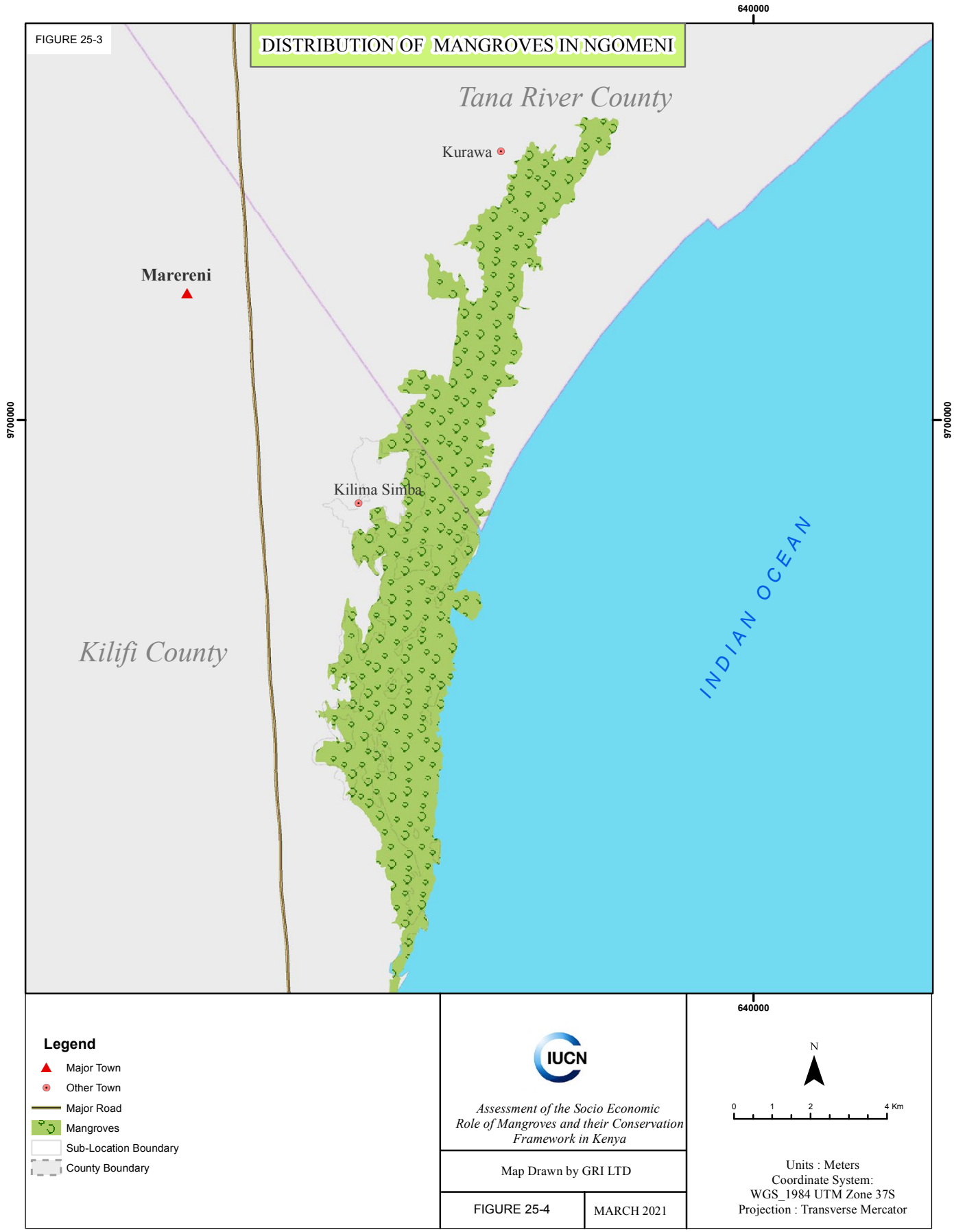


Figure 25-3: Distribution of Mangroves in Ngomeni

Figure 26-3: Ngomeni Landcover Classification Year 2000

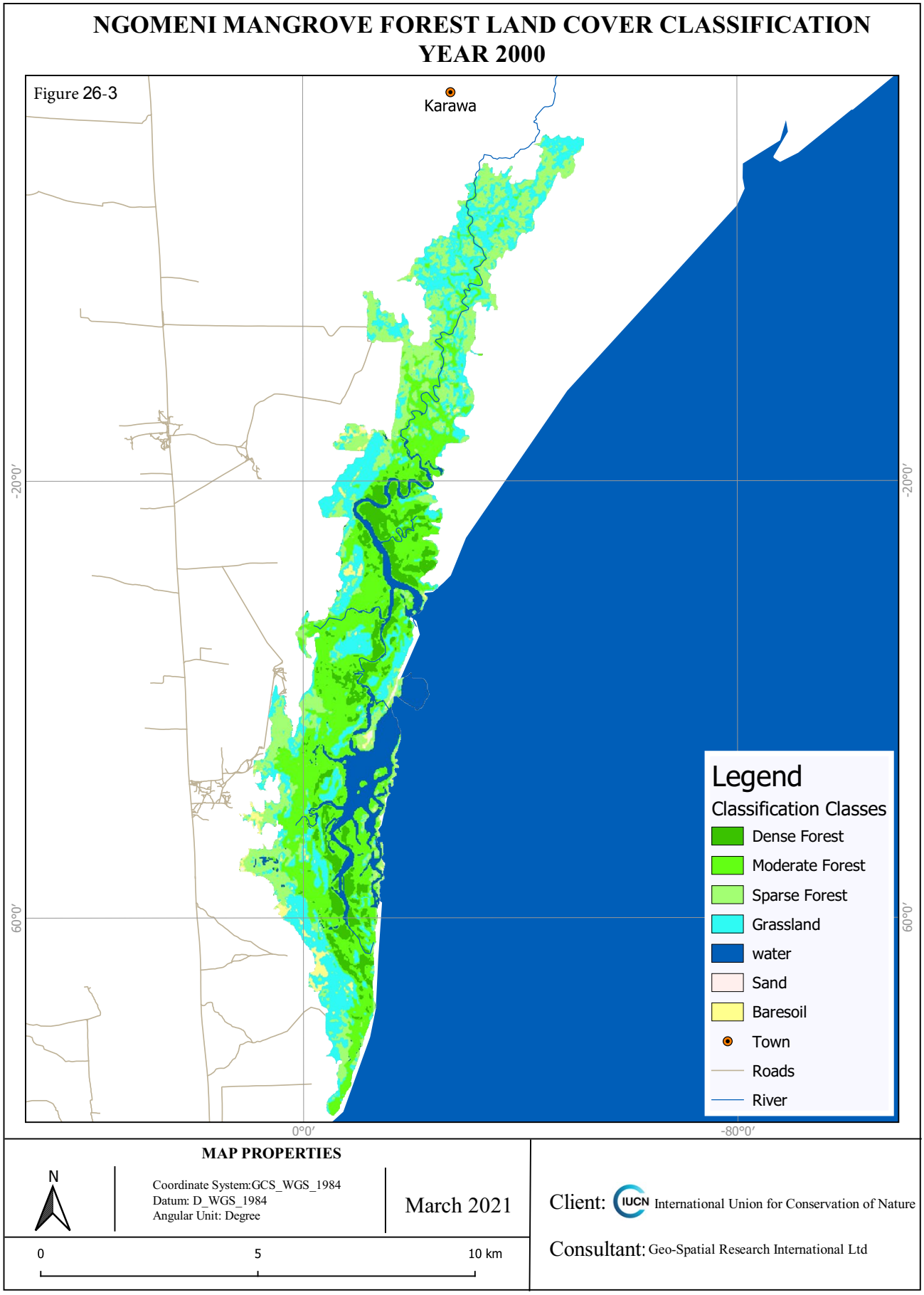


Figure 27-3: Ngomeni Landcover Classification Year 2019

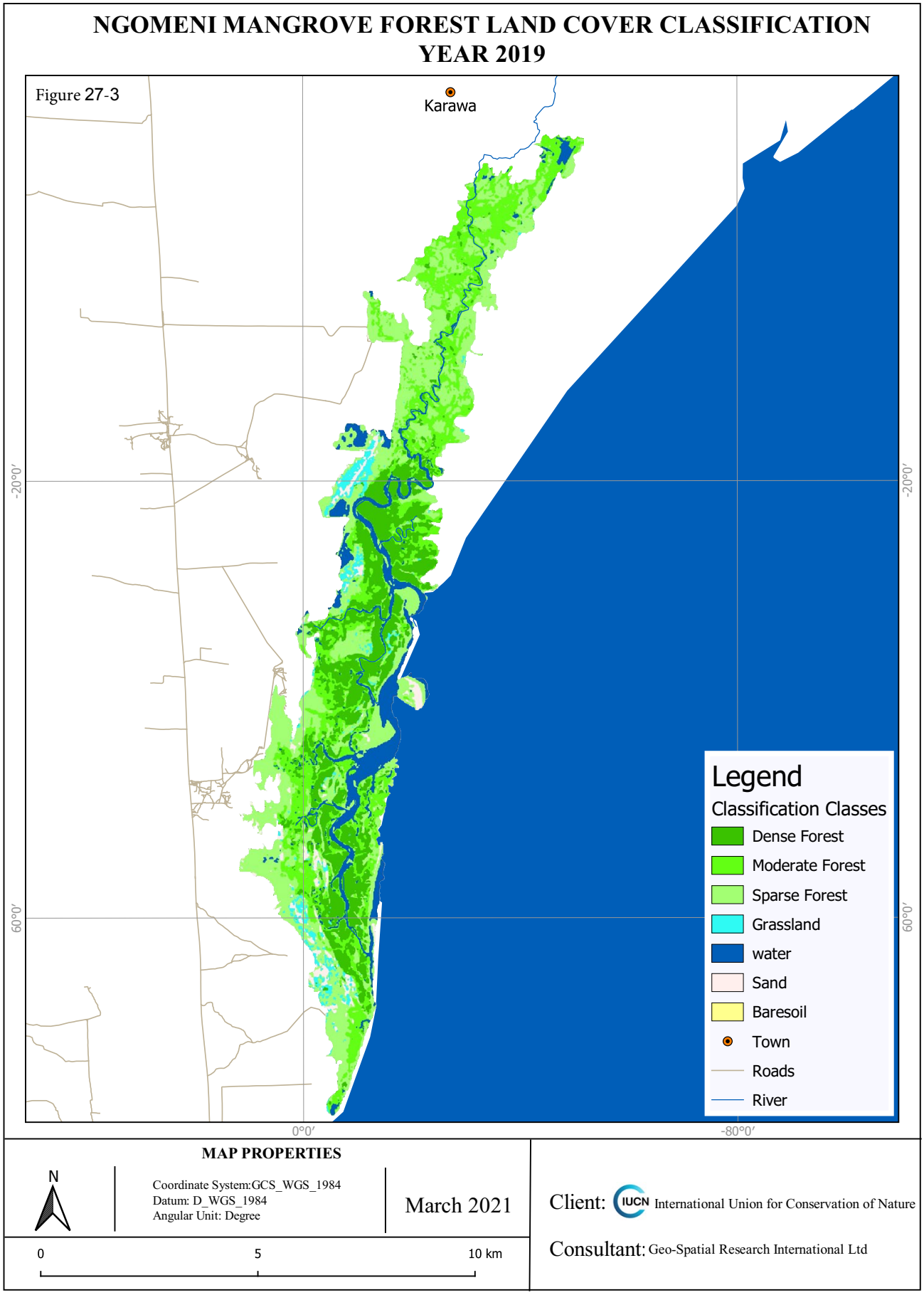


Table 11-3: Ngomeni Forest Formation Ecosystem service Valuation for 2019

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Food (Subsistence fisheries)	20,460.77 Kg/ year	Ksh 203	Ksh 4,163,084.92	Ksh 1645.21	Mangrove zones and the surroundings based on the government registered landing site, marereni	Final consumer prices	County government ministry of fisheries	The value is calculated from the total fish catch where the % role played by mangrove in the fish habitats is applied as cited by UNEP (2011). According to Arbuto Oropreza, 2008, the contribution of mangrove to fisheries is 31.7%. 90% of the marine fishing is done by artisanal fishermen in Kenya, (Ahmed, 2017). Each fish species was calculated based on the specific consumer price and overall average price was obtained. The data was obtained from the department of Fisheries, Kilifi county. There 1 landing sites used for this calculation and are associated to Ngomeni mangroves.
Wood extraction	Quantity of Firewood and Charcoal consumed at household level in Kg	Ksh 30 firewood Ksh 45 for Charcoal	Ksh 262,873,866.24 firewood Ksh 157,234,131.33 Charcoal	Ksh 103,902,.71 firewood Ksh 62,137.56 Charcoal	Mangrove zone	Final consumer prices	Ministry of Energy Report KNBS	Calculated from firewood collected within 10km radius of the mangrove ecosytems. Households within 10km radius were obtained through dasymetric mapping, on 2009 KNBS data projected to 2019. Data on value of charcoal & firewood, consumption per day is based on the 2019 Ministry of energy report titled Kenya Cooking Sector study report. Data on percentage of household using charcoal and Fuelwood in coastal counties is based on the Kenya Integrated Household Budget Survey by KNBS-KIHB 2015/2016 report.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Medicinal use	Volumes of active ingredients extracted per type of use	Ksh 2000	Ksh 13,440,000	Ksh 5311.38	Mangrove zone	Market Price of treatment using traditional medicine	Information generated from CFA through focus group discussion	There is no registered user groups for traditional medicine however there are known medicine men who use mangrove extracts for treatment. Most commonly used mangrove parts are leaves, bark and roots.
Tourism/ recreation	No. of visits to mangrove sites	Ksh 500	Ksh 1,344,000.00	Ksh 531.14	Mangrove zone	Price charged to access mangroves for leisure	CFA/Community	CFA charges for leisure walks into the mangrove sites. Charges are ksh 500 per person and they receive5-10 visitors/day. Flowering seasons of the mangroves is considered an important peak season.
Coastal protection/ flood /storm control	Length of wall that should be built in place of mangroves is approximately; 9072.00M	Ksh 5200	Ksh 47,174,400	Ksh 18,642.18	Coastal protection zone	Replacement cost method	Ministry of planning and development (Valuer based in Mombasa)	Calculated based on engineer's estimate of the cost of building the protective wall. The estimate was done at ksh5200/ metre. The meters of protection at Ngomeni is estimated at 9072 Meters
Sediment trap	Quantification of sediment charge and nutrients in it	0	0	0	Mangrove zone	Replacement cost or damage cost on tourist activities	None	There are no documents with information on sediment loads/ charge for the calculation of the value, neither data on the nutrient's richness of the site.
Habitat provision (nurseries for fishes and marine species)	Nutrient productivity in Kg/Ha calculated from Soil organic Carbon data	Ksh 203	Ksh 20,776,765.53	Ksh 8,210.80	Mangrove zone	Final consumer price	Remote sensing data by Sanderman et al., 2018	The role that the mangroves play in habitat provision for fishes and mariculture is calculated from soil organic carbon nutrient productivity in Kg/ha. It is also calculated based on price of fish catch.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Carbon sequestration	Quantification of carbon annual sequestration and carbon storage where the annual release is 178,300tC02 and 954.4tC02/Ha	Ksh 1000	Ksh 178,272,919.03	Ksh 72,032.67	Mangrove zone	Social cost of carbon	Remote sensing Biomass data for 2019	The price of carbon is adopted from price Plan VIVO to GAZI CFA @ 10USd at conversion rate of 1 dollar to KSh 100. Annual sequestration rate of 6.3% from Murray et al., 2011 Biomass initial release at 75% from Murray et al., 2011, Biomass half life at 15years based on Murray et al., 2011 Soil carbon (top 1m) half life at 7.5 years Murray et.al 2011.
Biodiversity conservation	Specific biodiversity indicators (revealed prices of money spent on conservation)	Ksh 0	Ksh 0	Ksh 0	Mangrove zone	Revealed price for conservation	None	No data for the Hectareage of the rehabilitation areas
Non-use value (existence value)	Socioeconomic indicators 15 registered CFA members	Ksh 300	Ksh 54,000	Ksh 21.34	Settlement near the mangroves, tourists/ urban inhabitants	Expenditure cost/ contingent valuation	Field data collection	The willingness to pay for conservation is calculated from population estimation captured through dasymetry mapping which allows for apportioning of population. According to the field study all members of CFA were considered to be willing to pay and spend time for conservation. The estimated amount of money that the members are willing to invest for conservation is ksh 300 per month per CFA member. The CFA has 15 registered membered actively involved in mangrove conservation.
Mangrove education and research	Education visits and grants given for education and research in mangrove	0	0	0	Mangrove zone	Payment for services offered	KMFRI KEFRI KFS	No data was found for this particular service

10. Lamu Mangrove Forest Formation

The Lamu mangrove forest formation surrounds Lamu town in the northern coast of Kenya between geo-coordinates 2°23'S, 40°46' E in the south and 2°11' S, 40°53' E in the north, see maps in Figures 28-3, 29-3 and 30-3 maps below. The total area of the forest formation was 32790.91Ha as at 2019 while in the year 2000 the area was 35,458.07Ha based on a land cover classification done during this study. The Mangrove species present in the forest formation are *Rhizophora mucronate*, *Ceriops tagal*. The threats to the Lamu forest formation include; uneven cutting pressures of *Rhizophora mucronate* and *Ceriops tagal*, increasing population growth, dredging to deepen ports/navigation channels. The rate of forest depletion between the years 2000 and 2019 as established from this study was calculated at 140 Ha i.e., 1.4% per year. The dense and moderate calssifications of the forest are being converted at a higher rate to sparse forest. This has a direct impact on shoreline protection, habitat provision and carbon sequestration. The biodiversity present in the forest formation include; coral reefs, mangroves and sea grass.

The Ethnic tribes in the area include the Bantu Swahili, Mijikenda and Giriama and the socio-economic activities that they engage in include; agriculture, mariculture, fishing, tourism, harvesting of mangroves (for timber and poles), dhow building and production of tannins.

The Table 12-3 below displays the ecosystem service valuation for the Lamu mangrove forest formation for the year 2019.

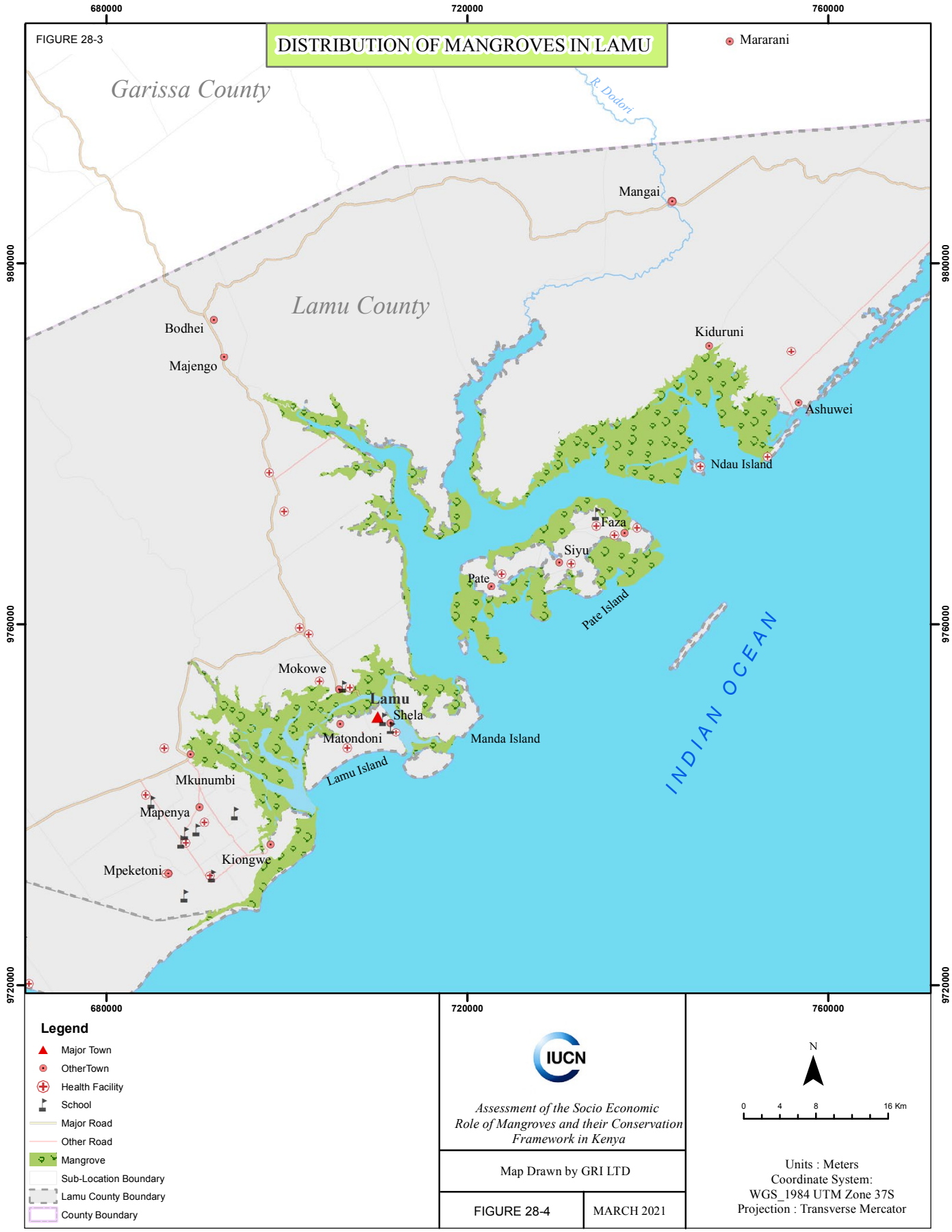


Figure 28-3: Distribution of Mangroves in Lamu

Figure 29-3: Lamu Landcover Classification Year 2000

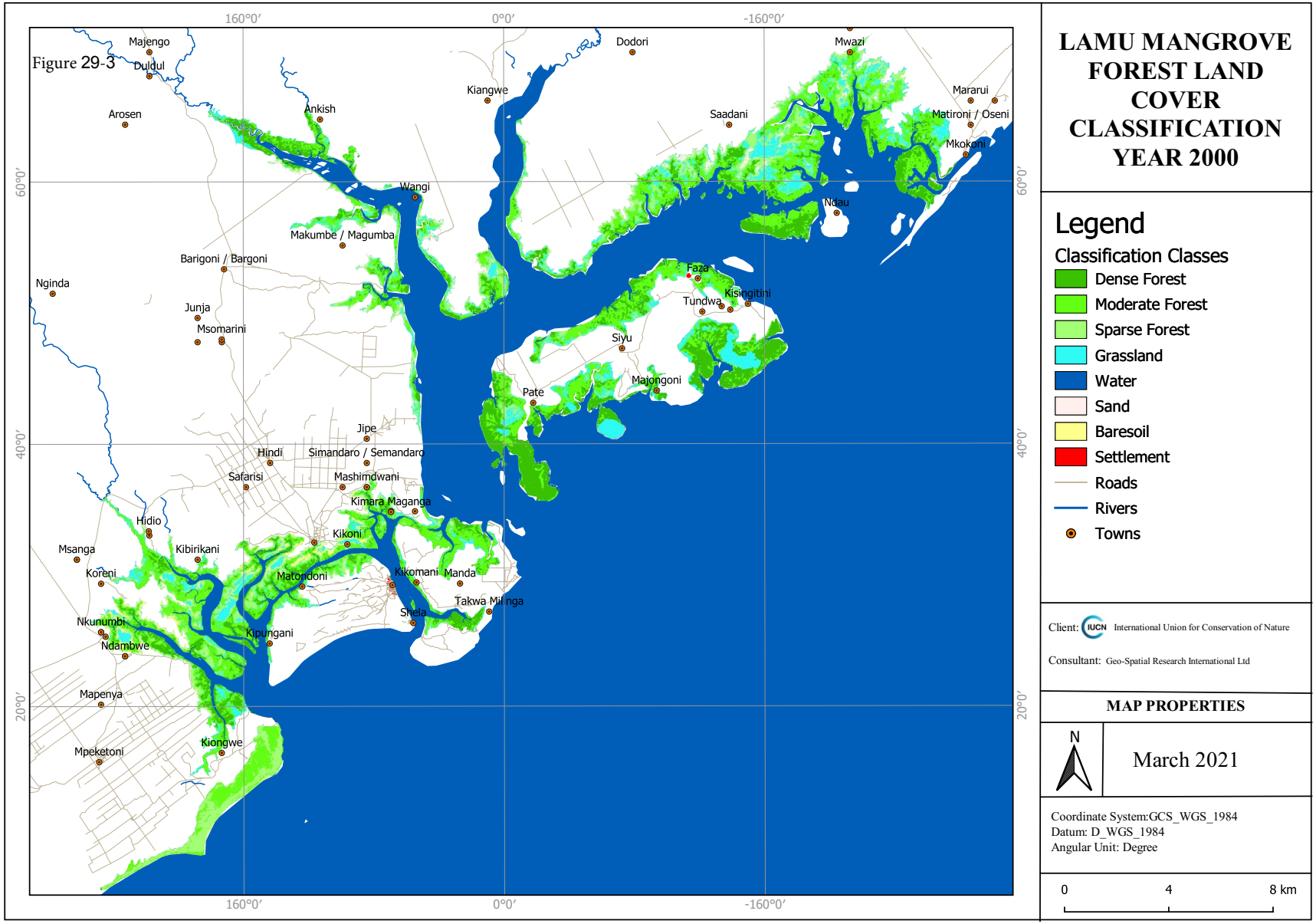


Figure 30-3: Lamu Landcover Classification Year 2019

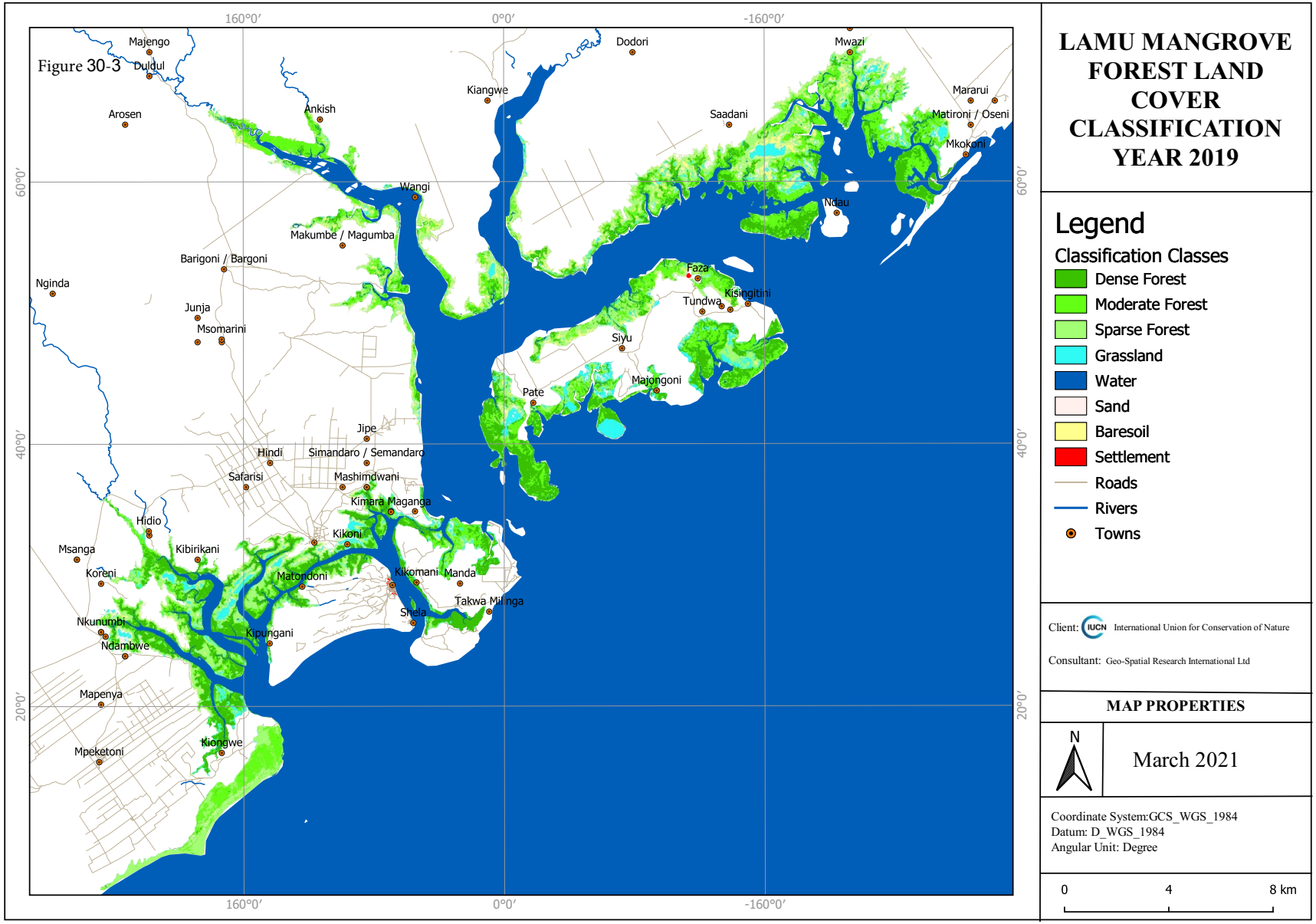


Table 12-3: Lamu Forest Formation Ecosystem service Valuation for 2019

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/ year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Food (Subsistence fisheries)	1,039,760Kg/ year	160.97	Ksh 167,370,167.20	Ksh 5104.16	Mangrove zones and the surroundings based on the government registered landing site,	Final consumer prices	County government ministry of fisheries	The value is calculated from the total fish catch where the % role played by mangrove in the fish habitats is applied as cited by UNEP (2011). According to Arbuto Oropreza, 2008, the contribution of mangrove to fisheries is 31.7%. 90% of the marine fishing is done by artisanal fishermen in Kenya, (Ahmed, 2017). Each fish species was calculated based on the specific consumer price and overall average price was obtained. The data was obtained from the department of Fisheries, Lamu County. There is 1 landing sites used for this calculation and are associated to Lamu mangrove ecosystem
Wood extraction	The amount of firewood and charcoal consumption per household.	Ksh 30- Firewood Ksh 45 - Charcoal	Ksh 172,050,324.48 – Firewood Ksh 94,457,036.73 - Charcoal	Ksh 5246.90 – Firewood Ksh 2880.59 - Charcoal	Households within 10Km radius based on 2009 projected KNBS data	Final consumer prices	Ministry of Energy Report KNBS-KIHB report	Calculated from firewood collected within 10km radius of the mangrove ecosytems. Households within 10km radius were obtained through dasymetric mapping, on 2009 KNBS data projected to 2019. Data on value of charcoal & firewood, consumption per day is based on the 2019 Ministry of energy report titled Kenya Cooking Sector study report. Data on percentage of household using charcoal and Fuelwood in coastal counties is based on the Kenya Integrated Household Budget Survey by KNBS-KIHB 2015/2016 report.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/ year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Medicinal use	Volumes of active ingredients extracted per type of use	Ksh 0	Ksh 0	Ksh0	Mangrove zone	Replacement cost / surrogate market prices/ avoided cost of health	None	No active CFA as at the time of the exercise
Tourism/ recreation	No. of visits to mangrove sites	Ksh 0	Ksh 0	Ksh 0	Mangrove zone	Price charged for accessing tourist sites within mangroves	CFA/ Community	No active CFA as at the time of this exercise
Coastal protection/ flood /storm control	Length of wall that should be built in place of mangroves is approximately; 65,496.93M	Ksh 5200	Ksh 340,584,036	Ksh 10,386.54	Coastal protection zone u	Replacement cost method	Ministry of planning and development (Valuer based in Mombasa)	Calculated based on engineer's estimate of the cost of building and maintaining the protective wall. The estimate was done at ksh5200/ metre. The meters of protection at Ungwana bay is estimated at 65,496.93M
Sediment trap	Quantification of sediment charge and nutrients in it	Ksh 0	0	0	Mangrove zone	Replacement cost or damage cost on tourist activities	None	There are no documents with information on sediment loads/charge for the calculation of the valueneither data on nutrients richness of the site.
Habitat provision (nurseries for fishes and marine species)	Nutrient productivity in Kg/Ha calculated from Soil organic Carbon data	Ksh 200	Ksh 121,176.86	Ksh 3.70	Mangrove zone	Final consumer price of Fish	Remote sensing data by Sanderman et al., 2018	The role that the mangroves play in habitat provision for fishes and mariculture is calculated from soil organic carbon nutrient productivity in Kg/ha. It is alsocalculated based on price of fish catch.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/ year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Carbon sequestration	Quantification of carbon annual sequestration and carbon storage where 3,351,000tC02 and 94.5tC02/Ha	Ksh 1000	Ksh 3,350,802,763.09	Ksh 102,186.94	Mangrove zone	Social cost of carbon	Remote sensing Biomass data for 2019; Sanderman et al., 2018 and Simard 2019	The price of carbon is adopted from price Plan VIVO to GAZI CFA @ 10USd at conversion rate of 1 dollar to KSh 100. Annual sequestration rate of 6.3% from Murray et al., 2011 Biomass initial release at 75% from Murray et al., 2011, Biomass half life at 15years based on Murray et al., 2011 Soil carbon (top 1m) half life at 7.5 years Murray et.al 2011.
Biodiversity conservation	Specific biodiversity indicators (revealed prices of money spend on conservation)	Ksh 9065.57	Ksh 1,269,180	Ksh 38.71	Mangrove zone that has been degraded	Revealed price for conservation	None	Biodiversity conservation by community involves tree plantimg and seedling nurseries in the following villgaes Pate, Faza, Kizingitini, Mtangawanda and Ndau. A total of 34,802 seedling were documented. Calculated based on the conservation/ restoration money set aside by KFS according to their draft 2019 strategic report. Targeted 500,000 ha at Ksh840,000,000 which translates to Ksh 1608/ha. Restorable acreage in Lamu based on expert opnion is estimated at 140 Ha
Non-use value (existence value)	Socioeconomic indicators registered CFA members	Ksh 0	Ksh 0	Ksh 0	Settlement near the mangroves, tourists/ urban inhabitants	Expenditure cost/ contingent valuation	Field data collection	No active CFA as at the time of the exercise, therefore no data collected
Mangrove education and research	Education visits and grants given for education and research in mangrove	Ksh	Ksh 2,000,000	Ksh 60.99	Mangrove zone	Payment for services offered	KEFRI	Estimated budgetary allocation of research and education from KEFRI

11. Gazi (Maftaha) Bay Mangrove Forest Formation

Gazi Bay is located at the far Southern edge of the Kenyan coastline some 55km South of Mombasa, (4° 25'S and 39° 50'E), see maps in Figures 31-3, 32-3 and 33-3 below. Based on a land cover classification for the area, the total area of the forest formation was 544.71 Ha and 528.35 Ha in the years 2019 and 2000 respectively. Mangrove species found in the forest formation include; *R. mucronata*, *C. tagal*, *A. marina*, *S. alba*, *B. gymnorrhiza*, *X. granatum* and *L racemose*. The threats to the forest include, increased emissions of carbon dioxide from human-related activities, sea level rise and temperature surge. According to this study and based on the landcover classification for the Year 2000 and 2019, there have been significant forest gains i.e., 0.86Ha per year which is about 0.0086% increase. The community's efforts of conservation are evident based on the analysis between the years 2000 and 2019. Biodiversity in the area includes; approximately 180 different species of fishes and abundant bird life, coral reef and sea grass.

Gazi bay is surrounded by Gazi and Kinondo market centres, and mainly inhabited by the Digo and a significant number of Kambas. The socio-economic activities carried out in the area include, tourism/ eco-tourism, wood extractions, aquaculture and apiculture.

In 2010, after losing about 20 per cent of their mangrove forests to timber harvesting, residents of Gazi Bay, Kenya partnered with the UK charity Plan Vivo and the Scotland-based Association for Coastal Ecosystem Services (ACES) to launch a mangrove conservation and restoration project, which involved both the prevention of further mangrove deforestation and new reforestation efforts. As a result of the project, mangroves covering 117 ha of land in Gazi Bay are now protected from illegal deforestation by full-time guards. At Gazi Bay, the community co-manages the forest with Kenya Forest Service (KFS) through Gogoni Gazi Community Forest Association (GOGA CFA). This was following the CFA developing a participatory forest management plan for the area and then signing a forest management agreement with KFS. Within GOGA CFA are many user groups, including the Mikoko Pamoja Community Organization (MPCO) that is implementing the Mikoko Pamoja project, a carbon trading project that is protecting 615 hectares of mangroves at Gazi Bay.

The Table 13-3 below displays the ecosystem service valuation for the Gazi mangrove forest formation for the year 2019.

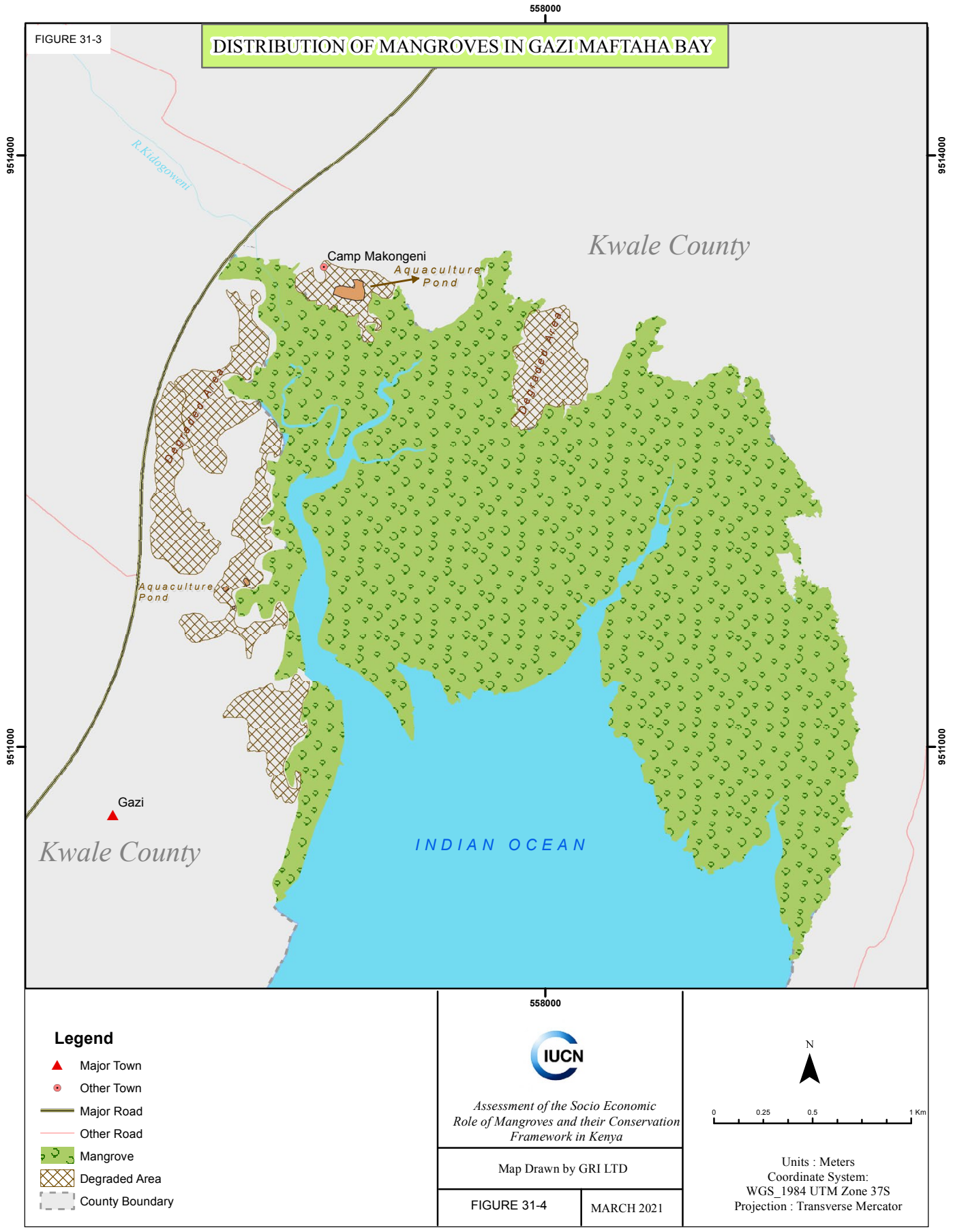


Figure 31-3: Distribution of Mangroves in Gazi(Maftaha)

Figure 32-3: Gazi Landcover Classification Year 2000

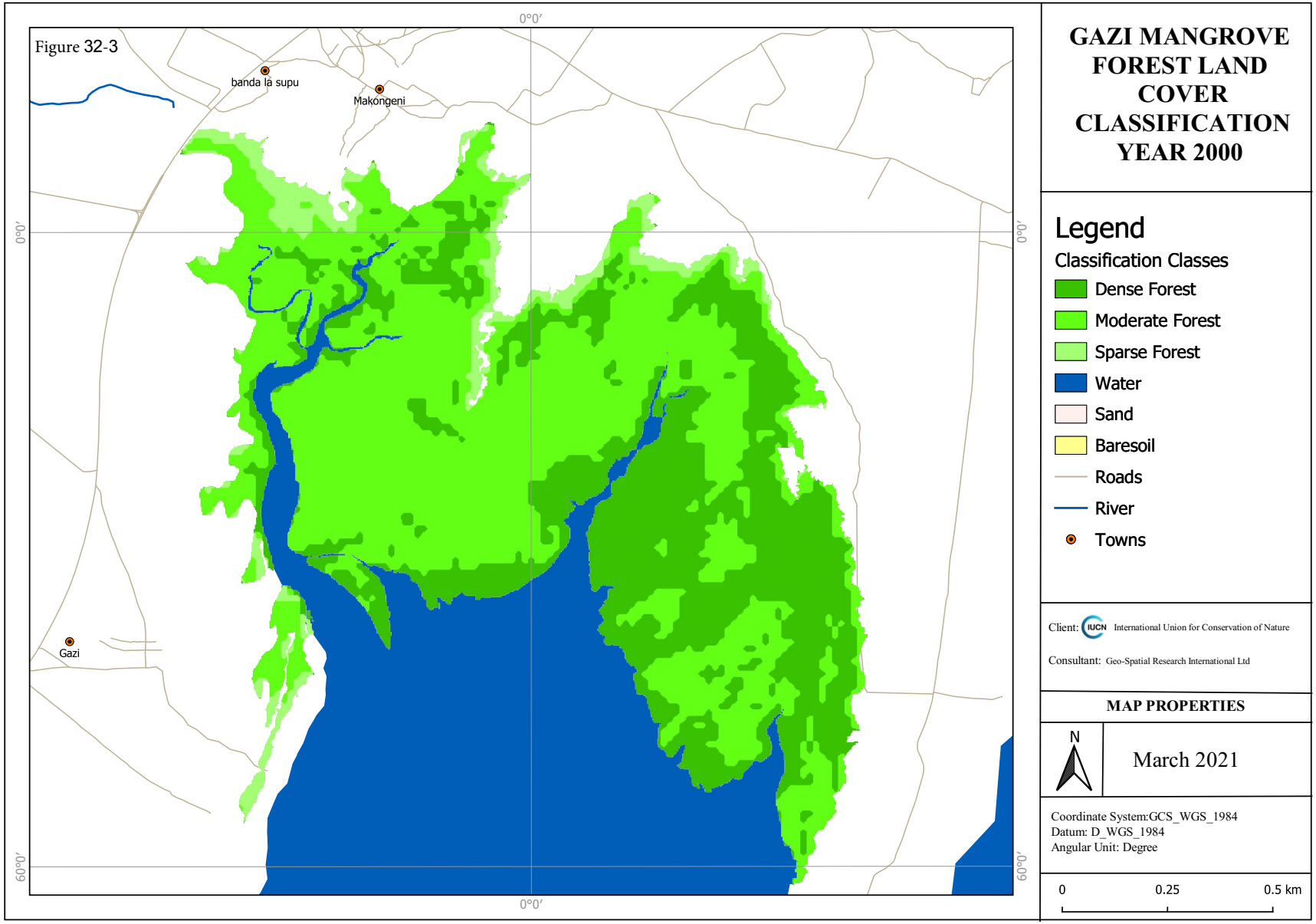


Figure 33-3: Gazi Landcover Classification Year 2019

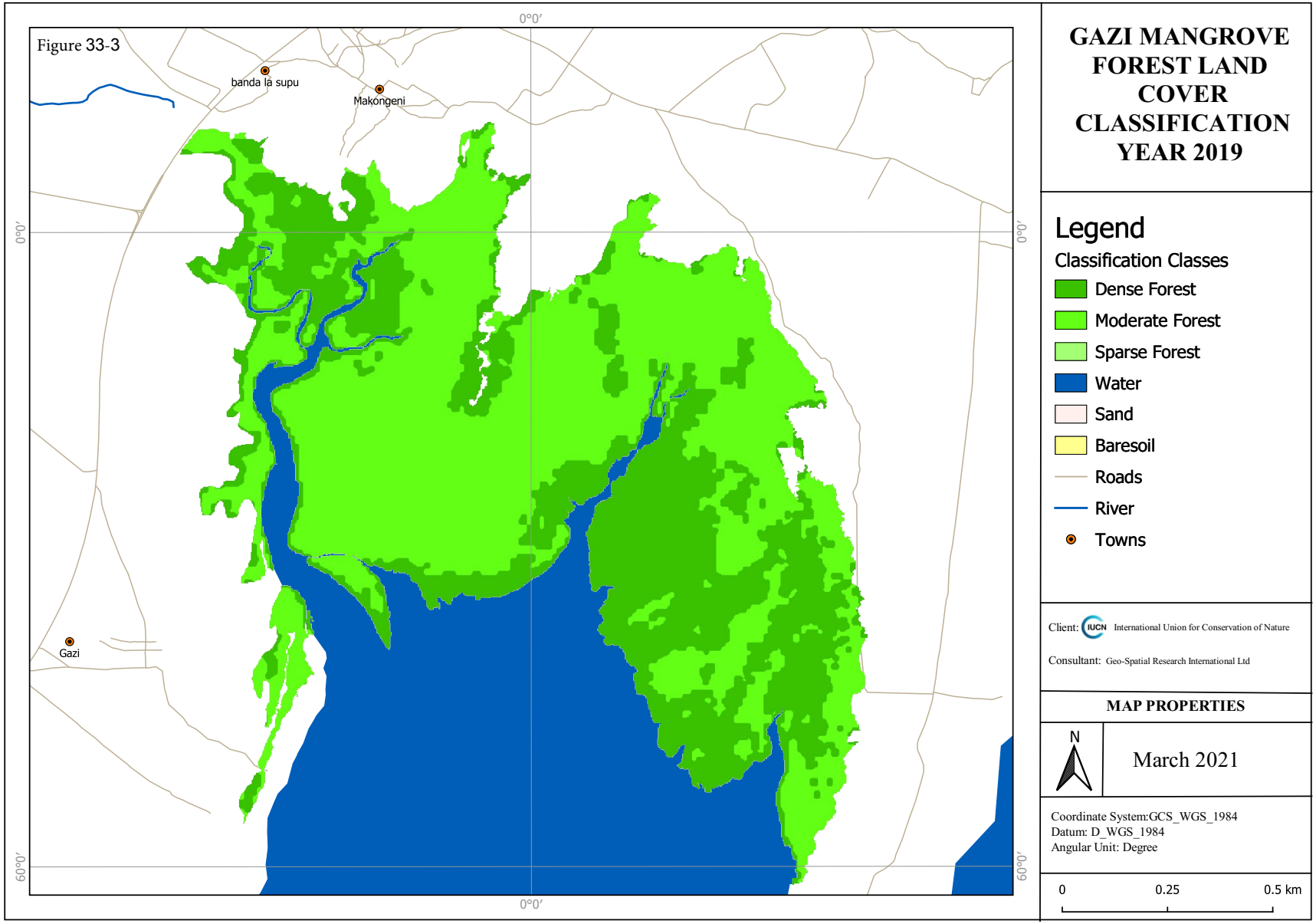


Table 13-3: Gazi Forest Formation Ecosystem service Valuation for 2019

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Food (Subsistence fisheries)	4498 Kg/year	Ksh 104	Ksh 468,887	Ksh 860.80	Mangrove zones and the surroundings based on the government registered landing site, Gazi	Final consumer prices	County government ministry of fisheries	The value is calculated from the total fish catch where the % role played by mangrove in the fish habitats is applied as cited by UNEP (2011). According to Arbuto Oropreza, 2008, the contribution of mangrove to fisheries is 31.7%. 90% of the marine fishing is done by artisanal fishermen in Kenya, (Ahmed, 2017). Each fish species was calculated based on the specific consumer price and overall average price was obtained. The data was obtained from the department of Fisheries, Kwale county. There is one landing site associated with Gazi in this study known as Gazi.
Wood extraction	Volume of firewood extracted for domestic use	Ksh 30- Firewood Ksh 45- Charcoal	Ksh 103,789,019.52 firewood Ksh 17,975,177.95 Charcoal	Ksh 190,539.96 firewood Ksh 32,999,.54	Mangrove zone	Final consumer prices	Ministry of Energy Report KNBS	Calculated from firewood collected within 10km radius of the mangrove ecosytems. Households within 10km radius were obtained through dasymetric mapping, on 2009 KNBS data projected to 2019. Data on value of charcoal & firewood, consumption per day is based on the 2019 Ministry of energy report titled Kenya Cooking Sector study report. Data on percentage of household using charcoal and Fuelwood in coastal counties is based on the Kenya Integrated Household Budget Survey by KNBS-KIHB 2015/2016 report.
Medicinal use	Number of patients attended to per day	Ksh 0	Ksh 0	Ksh 0	Mangrove zone	Market price	Information collected from CFA through focus group discussion	There was no data on medicinal value. The Community forest association highlighted that there were a few mangrove kaya shrines oftenly visited by old men in the community.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Tourism/ recreation	No. of visits to mangrove sites	Ksh 400	Ksh 1,742,200	Ksh 3198	Mangrove zone	Price charged for accessing tourism sites within the mangroves	CFA/ Community	There are several tourism sites and the CFA charges for leisure walks into the mangrove sites. Charges are ksh 400 per person and they receive an average of 11-15 visitors/day/site. Flowering seasons of the mangroves is considered an important peak season.
Coastal protection/ flood /storm control	Length of wall that should be built in place of mangroves is approximately; 10891.93M	Ksh 5200	Ksh 56,638,036	Ksh 103978	Coastal protection zone	Replacement cost method	Ministry of planning and development (Valuer based in Mombasa)	Calculated based on engineer's estimate of the cost of building the protective wall. The estimate was done at ksh5200/metre The meters of protection at Gazi is estimated at 10891.93Meters
Sediment trap	Quantification of sediment charge and nutrients in it	0	0	0	Mangrove zone	Market price	None	There are no documents with information on sediment loads/charge for the calculation of the value, neither data on the nutrient's richness of the site.
Habitat provision (nurseries for fishes and marine species)	Nutrient productivity in Kg/Ha calculated from Soil organic Carbon data	Ksh 104	Ksh 113,361	Ksh 208.11	Mangrove zone	Final consumer price	Remote sensing data by Sanderman et al., 2018	The role that the mangroves play in habitat provision for fishes and mariculture is calculated from soil organic carbon nutrient productivity in Kg/ha. It is also calculated based on price of fish catch.
Carbon sequestration	Quantification of carbon annual sequestration and carbon storage where the total avoided carbon emission are 49,940tC02 and 945tc02/ha	Ksh 1000	Ksh 49,941,486.51	Ksh 91684.54	Mangrove zone	Social cost of carbon	Remote sensing Biomass data for 2019	The price of carbon is adopted from price Plan VIVO to GAZI CFA @ 10USd at conversion rate of 1 dollar to KSh 100. Annual sequestration rate of 6.3% from Murray et al., 2011 Biomass initial release at 75% from Murray et al., 2011, Biomass half life at 15years based on Murray et al., 2011 Soil carbon (top 1m) half life at 7.5 years Murray et.al 2011.

Ecosystem services	Service quantification/ year	Cost/Unit	Service Value in Ksh/year	Service Value in Ksh/year/ ha	Assessment site	Valuation methods	Source of data	Remarks
Biodiversity conservation	Specific biodiversity indicators (revealed prices of money spent on conservation)	Ksh 0	Ksh 0	Ksh 0	Mangrove zone	Revealed price for conservation	None	No data for the Hectareage of the rehabilitation areas in the Gazi forest formation
Non-use value (existence value)	Socioeconomic indicators 50 registered CFA members	KSh 500	Ksh 400,000	Ksh 734.34	Settlement near the mangroves, tourists/ urban inhabitants	Expenditure cost/contingent valuation	Field data collection	The willingness to pay for conservation is calculated from population estimation captured through dasymetry mapping which allows for apportioning of population. According to the field study, all members of CFA were considered to be willing to pay for conservation. The approximated money they are willing to invest for conservation is Ksh 8000 per month per CFA member. The CFA has 50 registered membered actively involved in mangrove conservation.
Mangrove education and research	Education visits and grants given for education and research in mangrove		0	0	Mangrove zone	Payment for services offered	KMFRI KEFRI KFS	No data was found for this particular service

3.1.2.1. Natural capital value as socio-economic benefit to mangrove communitiess in Kenya

The mangrove forest valuation above were combined in order to establish the overall value of mangroves in Kenya, however, only accounting for the 11forest formations that were surveyed during this study. It was evident that the socio-economic benefits of mangrove are present and vary based on the size of the forest and the densities within the formations. The net value was not established due to data challenges for the cost accrued for all the ecosystem services in 2019, nevertheless, the achieved value gives an indication of the socio-economic benefits of mangrove in Kenya.

The highest ecosystem service values were captured for carbon sequestration at Ksh 4,390,754,026.41. This was followed by wood extraction at Ksh 2,740,789,203, coastal protection at Ksh 1,071,373,050, ecotourism (community based) at Ksh 859,694,200, fish catch at Ksh 284,435, 335.86 and finally habitat provision at Ksh 132,280,179.80 in a descending order. The values for rest of the ecosystem services fell below Ksh 100,000,000 as shown in table 14-4 below. These values depict key direct socio-economic beneifts that the communites are highly dependent on, i.e., fish and wood products. The high values reported for wood extraction for instance, are an indication of the high dependency on fuel wood such as firewood and charcoal by the communites. This however, is bound to endanger the mangrove ecosystem in the future if sustainability in not put into consisderation. The Ministry of Energy report on clean cooking for the year 2019, (Ministry of Energy, 2019), indicated high levels of firewood and charcoal use in the Country, and whose current demand cannot be met. This is an indication of the pressures that forests in Kenya are facing, mangroves being one of them since they are known by the local communities to produce the best charcoal. This state of affairs calls for innovation in alternative sources such as those applied in Ngomeni and Ungwana Bay where the adoption of casuarina (whistling pine) wood lots at farm level was documented as one of the alternative options that the communities are using for timber and firewood.

Overall, the study was able to establish that, for the 11-mangrove formations that were investigated, the accrued unit value for the year 2019 was at Ksh 200,473.93/Ha. Further, it was established that there is a high potential for the increase in the value of mangroves in Kenya in the following ecosystem services; fish catch, carbon sequestration, habitat provision, biodiversity conservation, non-use value, ecotourism, medicinal use, coastal protection and education and research. There is however no potential for the increase in value for wood extraction. Investment into schemes that would boost these socio-economic benefits is imperative.

The Table 14-3 below provides a summary of the value of mangroves in Kenya.

Table 14-3: Kenya Mangrove Ecosystem Service Valuation for 2019 (all values in Ksh)

Forest Formation	Mida		Vanga		Tudor		Funzi	
	1814Ha		3879.86Ha		767.39Ha		1305.61Ha	
Ecosystem Service	**Total value**	**Value /ha**	**Total value**	**Value /ha**	**Total value**	**Value /ha**	**Total value**	**Value /ha**
Food (Subsistence fisheries/ Commercial)	16,209,858	8,935.97	8,867,054	2,285.41	22,179,963.78	28,903	315,909	242.08
Wood extraction	238,310,136.98	131,324.23	249,793,811.59	64,382.17	32,858,181.91	42,818.10	185,982,202.06	142,448.73
Medicinal use	0.00	0	0	0	0	0	0	0
Tourism/ recreation	6,000,000	3,307	1,344,000	346.4	840,312,000	1,095,025.00	192,000	147.05
Shoreline protection	76,821,212	42,349	52,395,200	13,504	52,879,176	68,907.83	135,314,400	103,635.19
Habitat provision (fish)	19,073,657	10,514.69	41,888,531.37	10,796.40	6,872,517.70	10,160.58	18,199,278.22	13,938.54
Carbon sequestration	171,172,761.23	94,362	118,417,168.14	95,172.29	4,773,179.14	6,220.02	191,969,842.16	147,026
Biodiversity conservation	10,296,320	6,435.20	73,360	18.91	546,720	712.44	226,084	173.64
Non-use value (existence value)	976,000	538	9,630,000	2,484	3,900,000	5,082	796,800	610.26
Education and Research	0	0	0	0	0	0	0	0
Total Value	**538,859,945**	**297,766.09**	**482,409,125**	**188,989.58**	**1,546,610,757.53**	**1,256,625**	**532,996,515**	**408221.492**

Forest Formation	Mtwapa		Takaungu		Kilifi		Ungwana Bay	
	597.096Ha		371.39Ha		1025.5Ha		2062Ha	
Ecosystem Service	**Total value**	**Value /ha**	**Total value**	**Value /ha**	**Total value**	**Value /ha**	**Total value**	**Value /ha**
Food (Subsistence fisheries/Commercial)	4,288,762.96	7172.32	2,253,406	6,067	17,870,194	17,425.84	40,448,049	19,611.00
Wood extraction	574,009,565.83	961,335.47	160,146,765.71	431,209.15	341,670,462.91	333,174.51	149,638,520.52	72,553.07
Medicinal use	0	0	0	0	4,800,000.00	4,680.64	13,440,000	6,516.46
Tourism/ recreation	5,232,000	8,762.41	840,000	2,261.77	1,344,000.00	1,310.58	1,344,000.00	651.65
Shoreline protection	63,709,030	106,698.14	27,760,356	74,747.18	101,433,904	98,911.66	116,663,300	56,550.30
Habitat provision (fish)	1,099,551.11	1,841.50	23,145,150.00	62,320	60,805.01	59.29	929,386.00	45.07
Carbon sequestration	51,013,301.83	85,435.68	44,985,458.42	121,127.27	74,619,570	72,764.09	154,785,576.86	75,048.64
Biodiversity conservation	32,160	53.86	44,220	119.07	0.00	0.00	0.00	0.00
Non-use value (existence value)	912,000	1,527.40	382,464	1,029.82	129,600	126.38	36,000	0.001
Education and Research	0	0	0	0	0	0	0	0
Total Value	**700,296,371.73**	**1172826.78**	**259,557,820**	**698,881**	**541,928,536**	**528,452.99**	**477,284,832**	**230,976.19**

Forest Formation	Ngomeni		Lamu		Gazi		Total value per Ecosystem service	
	2530.42Ha		32790.9Ha		544.71Ha		47,688.89Ha	
Ecosystem Service	**Total value**	**Value /ha**	**Total value**	**Value /ha**	**Total value**	**Value /ha**	**Value in Ksh per year**	**Value /ha/year in Ksh**
Food (Subsistence fisheries/Commercial)	4,163,084.92	1,645.21	167,370,167.20	5104.16	468,887.00	860.80	**284,435,335.86**	**5964.39**
Wood extraction	420,107,997.57	166,040.27	266,506,361.20	8127.48	121,764,197.47	223,539.50	**2,740,789,203**	**58606.59**
Medicinal use	13,440,000	5,311.38	0	0	0	0	**31,680,000**	**677.42**
Tourism/ recreation	1,344,000.00	531.14	0	0	1,742,200	3198	**859,694,200**	**18382.93**
Shoreline protection	47,174,400	18,642.18	340,584,036	10,386.54	56,638036	103978	**1,071,373,050**	**22909.29**
Habitat provision (fish)	20,776,765.53	8,210.80	121,176.86	3.69	113361	208.11	**132,280,179.80**	**2828.56**
Carbon sequestration	178,272,919.03	72,032.67	3,350,802,763.09	102,186.94	49,941,486.51	91,684.54	**4,390,754,026.41**	**93,887.97**
Biodiversity conservation	0.00	0.00	1,269,180	38.70	0	0	**12,488,044.00**	**267.03**
Non-use value (existence value)	54,000	21.34	0	0	400,000	734.34	**17,216,864.00**	**361.02**
Education and Research	0	0	2,000,000	60.99	0	0	**2,000,000.00**	**42.77**
Total Value	**685,333,167.05**	**272,434.99**	**3,961,284,517.16**	**120,804.35**	**681,396,711.30**	**1,613,343.83**	**9,542,710,903.83**	**200,103.46**

3.1.3: CONCLUSION: NATURAL CAPITAL VALUATION FOR SOCIOECONOMIC BENEFITS

A review of literature revealed that a limited number of studies have carried out ecosystem service valuation of mangroves in details. Notable are; Kairo, (2009) and UNEP, (2011), both of which did studies at the Gazi Bay; FAO & UNEP (2016) carried out studies in the Mida Creek; Awour et al., (2019) also did a study of the Mida Creek; Phillip, (2015) did a study in Kipini and Muiruri et al., (2017) conducted a valuation study in the Tana Delta.

The National Management Plan (NMMP) 2017/2027 (GoK, 2017), provided an indicative figure of the unit value of mangrove ecosystem services in Kenya to be Ksh 269,448.3/Ha. This study established the unit value of mangroves along the Kenyan Coast to be Ksh 203, 473, 93/ Ha for the year 2019. From this study, it can be conclusively said that the natural capital value of mangrove ecosystems has been changing over the years in the various forest formations, partly evidenced by the diffrences in the estimation by GoK, (2017) in comparison to the ouputs from this study. These changes can be attributed to human related activities such overexploiation of avaible resources, increased population pressure, climate change among other factors. Notable changes in value are recognized in supportive services such as fish catch which according to GoK (2017) it was Ksh 9,612.70, while the value from this study is Ksh 5,964.39.

Relatedly, the ecosystem services were perceived to be decreasing due to the limited number of resources that the communities can draw from the mangrove forest formation. This was a narrative that was common across most of the forest formations and this was blamed on the implementation of the moratorium. However, the provision of goods and services is directly correlated to the forest areas and therefore a decrease in area will always lead to a decrease in the provision of such services. Tudor, Mtwapa, Funzi and Lamu recorded the highest decrease in area with an average annual loss of 25ha/year, 58.37Ha/year, 37.3Ha/year, and 140 ha/year respectively between the years 2000 and 2019. This is estimated at 0.3%, 0.17%, 0.54% and 1.4% annual loss respectively. The forest formations with the highest gains in area were Vanga and Kilifi at 13.0 Ha/year and 12.4Ha/year with a percentage gain of 0.13 and 0.2% per year respectively for the data analysed from the year 2000 to 2019.

This study did not undertake to compare value across different forest formations nor across different studies, niether did it look into the differences in the richness of the ecosystems. Different valuation methods were used by the different studies and it is expected that the output figures would be different, however indicative. Generally, what was observed is that the socioeconomic benefits accruing from the mangrove ecosystems are declining over the years in some of the mangrove ecosystems mainly due to the decrease in mangrove area. Others however have experienced minimal decline over the years, mainly due to the sustainable use practiced in the areas, as well as the conservation measures being undertaken.

3.2: OUTPUT 2 – ASSESSMENT OF MANGROVE CONSERVATION FRAMEWORKS IN KENYA

No single legal instrument is sufficient to address the range of threats to mangrove conservation. A comprehensive legal and regulatory framework that adequately provides for laws and policy guidelines is very crucial if proper management and conservation of natural ecosystems is to be achieved. Most countries do not have a special mangrove law, but there are several examples of legal provisions explicitly aimed at protecting mangrove ecosystems. Often these employ protected status or classification for mangrove ecosystems, coupled with a ban on certain activities within or affecting mangroves. Such provisions can appear in frameworks of environmental laws or in sectoral legislation on forests, fisheries or wetlands, among others. Further, different legal tools can be used to address diversion of freshwater sources, pollution, cutting for construction or fuel wood, conversion of mangroves for aquaculture or farming and other threats.

Understanding the range of governance options and contexts for mangrove conservation, therefore, requires the examination of many sectors and areas of law, covering, *inter alia*, forests, marine areas, fisheries, land use, freshwater, biodiversity, protected areas, climate change, industry, and waste management.

3.2.1: METHODOLOGY

A systematic review of Kenya's mangrove management and conservation frameworks from pre-independence was done based on all available Government documents. The assessment was anchored on four fundamental perspectives;

i. Legal and regulatory frameworks governing mangrove ecosystems in Kenya; this looked into the changes and development of the legal and regulatory frameworks governing mangrove forest conservation in Kenya over time.
ii. Mangrove conservation governance structure; this looked into the framework of mangrove goverenace in Kenya, with key emphasies on the delineation of power and management roles in mangrove conservation and management along the Kenyan Coast.
iii. Mangrove conservation actors; this looked into the key actors and institutions in charge of mangrove conservation in Kenya. Among other factors, their objectives, their activities, their challenges and their recommendations for better operations were reviewed. Moreover, the Kenya Forest Management and Conservation Act, 2016 was assessed, and its associated mangrove governance structure was also analyzed
iv. Mangrove resource conservation and management under Community Forest Associations; this looked into evaluating the efficacy of the two perspectives mentioned above. Select Community Forest Associations, and their Paticipatory Forest Management Planss were studied to understand their objectives, mangrove conservation activities, constraints to conservation, and local-level stakeholders' recommendations. Finally, based on field data from across the Kenyan Coast, the constraints to mangrove ecosystem management and conservation, institutional, legal, and governance challenges, and recommendations for improvement were documented.

3.2.2: FINDINGS: MANGROVE CONSERVATION FRAMEWORKS IN KENYA

3.2.2.1. Legal and Regulatory Frameworks for Mangrove Management and Conservation in Kenya

Kenya, alike other Countries like Brazil, Sri Lanka, India, China and Tanzania, pursues protectionist policies. The legal and policy frameworks that govern mangrove management in Kenya, is comprehensive and it varies along a continuum: from strict protection that bans any consumptive use, to mixed protection and use where some regulated use is tolerated, to the promotion of multiple-use regimes that endorse sustainable use and management. In addition, the Constitution sets a firm basis for conservation, with the human right to a healthy environment, constitutional foundations for environmental assessments and audits, and an obligation on the State to eliminate harmful environmental practices.

Historically, mangroves have played a long and important role in the history of human activity in Kenya and on the East African coast as a whole. Records indicate that along with slave and ivory trades, mangrove poles made up a major regional trade commodity by the 9th century (Rawlins, 1957). By the beginning of the 20th century Kenya was exporting an annual average of 24,150 scores of mangrove poles from Lamu forests, equivalent to 483,000 poles per year. Between 1941 and 1956 this export averaged 35,451.3 scores (Rawlins, 1957). Unfortunately, over-exploitation and degradation of mangrove forests led to a Presidential ban on further exportation of mangrove poles from Kenya in 1982. Such a ban was necessary because of the irreversible deterioration of mangrove resources that was taking place, particularly in the Kenyan south Coast.

Currently, the mangroves in Kenya are legally protected as public forests by various legal frameworks, including Proclamation No. 44 (1934), Legal notice No. 174 (1964), and the Forest Conservation and Management (FCM) Act, 2016. For a long time, Kenya had limited specific policies on mangrove conservation, and as a result, the mangrove conservation and management models were only based on wood and timber extraction while ignoring other essential services from the ecosystem such as climate regulation,

shoreline protection, biodiversity conservation, and fisheries. Consequently, a National Mangrove Management Plan was prepared for implementation between the years 2017-2027 to enhance mangrove ecosystem integrity and its contribution to the economy through sustainable management and rational utilization (GoK, 2017).

The FCM Act, 2016, mandates the Kenya Forest Service (KFS) as the lead agency protecting forests and their public land resources. Equally, the Fisheries Act (Cap 378) and the Maritime Act (Cap 250) require the Kenya Fisheries Service (KeFS) to manage and conserve mangroves because they form important fish breeding sites. The other agencies involved in the mangrove conservation framework include; the Kenya Wildlife Service (KWS), which manages marine parks and reserves under the Wildlife Conservation and Management Act 2013; National Museums of Kenya, which are responsible for protected coastal forest areas and monuments, under the National Museums and Heritage Act 2006; Kenya Marine and Fisheries Research Institute (KMFRI), whom are accountable for all aspects of aquatic research including, biological, physical, and chemical oceanography, pollution, fisheries, aquaculture, fishing technology, and law, fish processing; and, the Kenya Maritime Authority (KMA), which is responsible for monitoring, regulating and coordinating the maritime activities (Kenya Maritime Authority Act 2006). Kenya's Environmental Management and Coordination Act of 1999 (EMCA 1999 amended in 2015) created the National Environment Management Authority (NEMA), responsible for the general supervision and coordination of all matters relating to the environment. Therefore, the body monitors the impact of human activities in mangrove forests, neighboring land, and water mass.

A study done by Slobodian & Badoz (2019), that reviewed Kenya's legal framework and constitutional requirements regarding mangrove management and conservation, revealed that, Kenya's mangrove ecosystem conservation legal framework is comprehensive and can effectively battle management ineffectiveness. Additionally, Kenya is a party to various mangrove and biodiversity conservation-related international conventions and treaties such as;

- The Ramsar Convention ratified in 1990, that designated the Tana River Delta as a Ramsar site because it has mangroves and various endemic biodiversity
- Convention on Biological Diversity (CBD), through which the Kenya's National Biodiversity Strategy and Action Plan (NBSAP) was submitted in March 2000
- The Nairobi Convention adopted in 2018 and domesticated through the Wildlife Conservation and Management Act, 2013
- The 2015 Paris Agreement on Climate Change entered by Kenya in 2017 based on the Country's National Determined Contributions (NDC) to the national sustainable development agenda and the United Nation's Framework Convention on Climate Change (UNFCCC)
- Integrated Coastal Zone Management (ICZM) in which the Government had several initiatives spearheaded by the (CDA) in partnerships with various organizations, including IUCN and USAID. It has established Coast Development Authority governance protocols in the Kenyan Coast and built stronger links to implement other international legal instruments.

Furthermore, Kenya's constitutional provisions have provided a strong basis for managing and conserving forest ecosystems, including mangroves. The review by Slobodian & Badoz, 2019, further ascertained that the Country's environmental laws are progressive, however, the current legislative framework has multi-sectoral and cross-institutional mandates, which pose severe coordination and management challenges. As illustrated in Figure 34-3, the management structure and associated constitutional roles and rights at the regional and local levels are influenced by multiple decisions made at diverse governance levels and by stakeholders with varying interests. A summary of the laws and the associated institutions governing mangroves in Kenya are presented in Table 15-3 below.

Table 15-3: Laws governing mangroves in Kenya and the associated Institutions

Legal/ policy instrument	Institution in charge (Drawer)	Objective(s)	Activities and successes	Challenges and gaps	Recommendations
Forest Conservation and Management Act, 2016 ***Forest Policy2014***	Kenya Forest Service (KFS)	To provide for the development and sustainable management, including conservation and rational utilization of all forest resources for the socioeconomic development of the country and for connected purposes.	Facilitated formation of CFAs, development of PFMPs and signing of GMAs with right and responsibilities set out. Taken an 'integrated ecosystem approach' to conserving and managing forest resources as one of the guiding principles.	Mangroves are not explicitly referenced in the legal frameworks. Slow formation of CFAs in some areas and expiry of existing ones.	Feature mangroves appropriately in the forest act. Develop new FMPs replace expiring ones.
Wildlife Conservation and Management Act, 2013 ***National Wildlife Conservation and Management Policy, 2017***	Kenya Wildlife Service (KWS)	To provide for the protection, conservation, sustainable use and management of wildlife in Kenya and for connected purposes.	Managed to regulate and control discharge of any pollutant into a designated wildlife area, including an MPA. Facilitated consultative development of management plans with neighbouring communities and used for the management of every MPA.	Mangroves are not explicitly referenced in the legal frameworks.	Amend the Wildlife Act to clarify its application to mangroves.
Fisheries Management and Development Act, 2016 ***National Oceans and Fisheries Policy 2008***	Kenya Fisheries Service (KeFS)/ State Department of Fisheries (SDF)	To protect, manage, use and develop the aquatic resources in a manner which is consistent with ecologically sustainable development. To uplift the living standards of the fishing communities and to introduce fishing to traditionally non-fishing communities to enhance food security.	Facilitated establishment of Beach Management Units (BMUs) for structured community engagement in fisheries management.	Mangroves are not explicitly referenced in the legal frameworks. Focuses more on the role of fishermen in the management of fisheries through BMUs.	Enhance and clarify the role of BMUs in management of mangroves.
Physical and Land Use Planning Act, 2019 ***National Land Use Policy, 2017***	Ministry of Lands and Physical Planning/ National Land Commission	To provide for the planning, use, regulation and development of land and for connected purposes. To provide legal, administrative, institutional and technological framework for optimal utilization and productivity of land and land related resources in a sustainable and desirable manner at National, County and Sub-county and other local levels.	Delineation of riparian zones along the coast that includes legal status of mangrove ecosystems. Promotion of sustainable coastal environmental management and blue economy, through identification, mapping and gazettement of critical river deltas, mangroves, coral reefs, and other important coastal habitats;	Has not put in place mechanisms or requirements for the physical planning process to coordinate with the management planning of mangrove areas. There is still a continued focus on terrestrial planning with minimal inclusion of spatial planning of the coastal zone.	Bridge the gap between terrestrial physical planning and management planning for mangroves in law and practice. Amend the Act to provide for express commitments to preparation of Specific County spatial plans marine spatial planning for all counties within the coastal zone which would give a detailed framework for governing the land-sea interface within their areas of jurisdiction.

Legal/ policy instrument	Institution in charge (Drawer)	Objective(s)	Activities and successes	Challenges and gaps	Recommendations
Environmental Management and Coordination Act, 1999 (Amended, 2015) ***National Environment Policy, 2013***	National Environment Management Authority (NEMA)	To provide for the establishment of an appropriate legal and institutional framework for the management of the environment and for matters connected therewith and incidental thereto. Promote sustainable use of marine resources and the conservation of vulnerable coastal ecosystems. Ensure the development and implementation of a harmonized Integrated Coastal Zone Management (ICZM) and Integrated Ocean Management Policy, Strategy and Action Plan.	Provided regulatory framework for the protection of wetlands through the requirement for an EIA licence prior to any person undertaking activities specified by law, including excavation, introduction of species, or drainage of a wetland.	EIAs fail at adequately addressing the impacts on mangroves.	Require explicit assessment of direct and indirect impacts on mangroves. Ensure EIAs and Environmental Audits for any activities impacting mangroves integrate climate risks and vulnerability assessments. Establish a public inventory of mangroves compiling information from research, monitoring and EIAs.
County Government Act, 2012	County Governments	To give effect to Chapter Eleven of the Constitution; to provide for county governments' powers, functions and responsibilities to deliver services and for connected purposes.	Facilitated preparation of County Integrated Development Plans (CIDPs), to guide the Counties on a five-yearly basis, includes protection and development of natural resources.	Most CIDPs do not capture explicitly the protection and management of mangroves.	Feature mangroves appropriately in the CIDPs.

3.2.2.2. Mangrove Governance Structure

Evans et al. (2011: 2) describes the governance of Kenya's coastal zone as 'a patchwork of approaches including; customary management, hierarchical governance, integrated coastal zone management; marine protected areas, customary gear restrictions, fisheries regulations, licensing and environmental impact assessments. It also involves developmental initiatives like; infrastructure development, investment in fishing technologies, ecotourism ventures, and others.

According to the FCM Act, 2016, mangrove forests administration is handled by the Kenya Forest Service, and it incorporates perpetual succession and a common seal. It is mandated to manage forest issues, including; suing and being sued, entering into contracts, acquiring, taking, purchasing and disposing of immovable and movable property. The service is managed by a Board of Directors, which include: a Chairperson (President's appointee); a Principal Secretary responsible for forestry or representative; an Inspector General of the National Police Service or designated representative; the Director of Kenya Forest Research Institute or designated representative; and the Chief Conservator who acts as the secretary to the Board. Moreover, the Cabinet Secretary appoints four other persons who come in as representatives of the Kenya's Forestry Society, the Community Forest Associations, the forest industry and the Council of Governors respectively.

The KFS Board is at the top of the forest management hierarchy at the **National level**, followed by the KFS Director and his Assistants. Primarily, National-level management is involved in policy formulation, general management strategies, mangrove resource assessments, and preparing mangrove status reports, among other duties as outlined in Article 8 of the FCM Act, 2016. The **Head of Conservancy** leads the **Regional level** of mangrove conservation structure, and the **Ecosystem Conservator** follows in command as the officer in charge at the **County level**. Each County has to implement National policies, including mangrove management and conservation policies in public lands defined in Kenya's constitution under Article 62(2). The Counties are also mandated to promote afforestation and to advice and assist communities and households in managing forests. Notably, Counties can enter into agreements with individuals or communities to conserve private or public mangrove forests. The County assemblies may enact enabling policies for effective implementation of provisions in Article 21 of the FCM Act, 2016. They can collaborate and partner with KFS to execute its requirements better. Finally, the **forest managers, forest guards, and the CFAs** manage and conserve mangroves and their resources at the **local level**. A Forest Manager heads a forest station that may cut across more than one County or shared by various CFAs. Generally, Forest Managers are responsible for harmonizing KFS's policies and programs at the local level with the assistance of CFAs, NGOs, community members, mangrove product harvesters, and local opinion leaders/politicians. The local levels' interactions are characterized by numerous interest groups, including NGOs, local investors, international organizations, activists, etc. Under the National Government's office, local administration officials, chiefs, their assistants, and ward administrators support law and order in mangrove forest areas. They represent the National Government at the lowest level, hence supporting law enforcement in liaison with KFS staff and facilitating conflict resolution. The local level management and forest guards work with the police service to enforce law and order. For example, the police are engaged when arresting illegal loggers or fisher-men with inappropriate fishing gear. Omondi (2017) reported that Local and Regional governance units/systems get management support from other parastatals such as the Kenya Marine and Fisheries Research Institute (KMFRI), Kenya Wildlife Service (KWS), and the State Department of Fisheries (SDF). The parastatals have complementary roles and interests in protecting mangrove ecosystems because they are habitats and breeding sites for diverse flora and fauna. The fisheries department for instance, creates awareness of various aspects affecting fish breeding sites within mangrove forests, emphasizing on ecosystem conservation vis-a-vis aquatic diversity abundance and richness. Figure 34-3, Illustrates the hierarchy of mangrove governance systems on the Kenyan Coast.

3.2.2.3. Mangrove Conservation Actors

Numerous National Governments continue to be central actors in mangrove conservation. International organizations and NGOs have also increasingly become involved in shaping agendas as well as approaches to mangrove management. The focus remains singularly on mangrove rehabilitation and

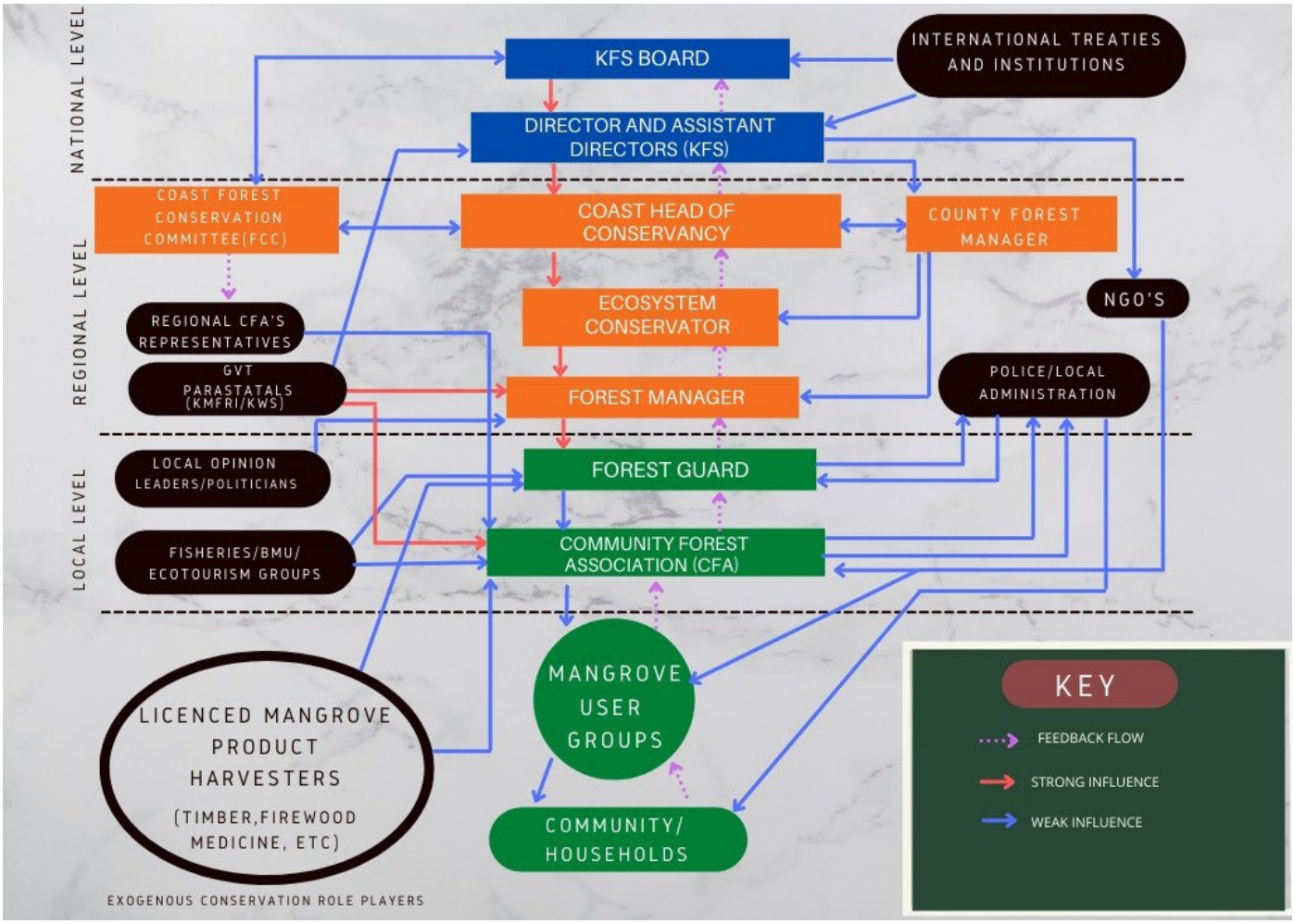


Figure 34 – 3: Hierarchy of mangrove governance in Kenya (figure modified from Omondi (2017))

afforestation but with a shift towards understanding and strengthening community-based management systems to ensure that mangroves will be protected and appropriately managed over the long-term.

In Kenya, the myriad of legislative and policy documents on coastal resources as described in the preceeding chapter, illustrates the diverse range and number of relevant sectors and actors on coastal ecosystem management and conservation. This section expounds on them ranging from the local to the National levels. Table 17-3, below, further presents a synthesis of the conservation frameworks governing the various institutions, the objectives of the conservation frameworks, their successes and the challenges they face in the implementation of the frameworks.

Table 16 - 3: Mangrove conservation frameworks and the Key actors in Kenya

Conservation framework	Institution in charge	Objectives	Implementation/success	Challenges & recommendations
NATIONAL				
National Mangrove Ecosystem Management Plan 2017-2027	KFS KMFRI KWS CDA KEFRI	To enhance mangrove ecosystem integrity and its contribution to the economy of Kenya Sustainable use and management of mangroves Promotion of community participation Strengthening of institutional capacities Promotion of recreational activities as well as research and education	The Plan has set out six programmes including; forest conservation and utilization; fisheries development and management; community; tourism development; research and education; and Human resource and operations. Rehabilitating damaged mangrove forest ecosystems Protecting their species Enhancing mangrove nursery and plantation Developing management plans	Challenges Sectoral governance system which does not recognize the interconnectedness of ecosystems in resource management Expired management plans for some of the CFAs, posing a challenge in staying compliant with the forestry legistaltion Recommendations Enhancing mangrove nursery and plantation establishment in Kenya Renewals of PFMPs
African Mangrove Network (AMN) *Established in May 2003*	FAO WWF EU UNEP NGOs CBOs	To work with mainstream government departments to conserve mangroves Foster regional collaboration and collectively work to bring mangrove agenda to the national and international arenas Strengthening operational capacities (material, technical and financial) of mangrove ecosystem conservation actors; Promoting and strengthening the participation of local populations in the formulation and execution of programmes or projects towards the protection, safeguard and sustainable management of mangrove ecosystems; Undertaking active lobbying and advocacy against local, national or international policies and projects which adversely affects the functional integrity of the mangrove ecosystems; Developing partnership with research institutions, governments and all initiatives geared towards sustainable management of mangrove ecosystems; Participating in the implementation of different national, regional and international programmes related to the protection, safeguard and sustainable management of mangrove areas.	AMN has been playing quite a unique pan-African coordinating role on rehabilitation, conservation and sustainable utilisation of mangrove resources by undertaking programmes. In Kenya, they have been instrumental in enhancing mangrove nursery and plantation establishment	Challenges Mobilising funds to accomplish its activities

Conservation framework	Institution in charge	Objectives	Implementation/success	Challenges & recommendations
Marine Protected Areas (MPAs)	International Union for Conservation of Nature (IUCN)	To achieve the long-term conservation of nature with associated ecosystem services and cultural value Alleviate anthropogenic pressures Conserve outstanding ecosystems, species and/or geodiversity features Protect long-term ecological integrity of natural areas Protect natural biodiversity, underlying ecological structure and support environmental processes, promote education and recreation Protect specific outstanding natural features and associated biodiversity and habitats Maintain, conserve and restore species and habitats Protect and sustain important seascapes, associated nature conservation and other values created by interactions with humans through traditional management practices Protect natural ecosystems and use natural resources sustainably	Collaboration among specialist practitioners dedicated to supporting better implementation in the field, distilling learning and advice drawn from across IUCN. Building institutional and individual capacity to manage protected area systems effectively, equitably and sustainably, and to cope with the myriad challenges faced in practice. Assisting national governments, protected area agencies, nongovernmental organisations, communities and private sector partners to meet their commitments and goals, and especially the Convention on Biological Diversity's Programme of Work on Protected Areas.	Challenges Effective implementation and enforcement particularly in places with limited resources and capacity, and with high pressures for conversion to other land uses
Northern Rangeland Trust-Works with community conservancies in northern and Coastal Kenya.	Northern Rangeland Trust (NRT)	Carry out reforestation in degraded mangrove forests Develop mangrove forest management plan, zonation and harvest strategy in 2020.	30 000 mangroves planted across 10 ha in community conservancies at the Kenyan coast in 2019. 34 people trained in Kiunga, Pate, and Lower Tana conservancies on monitoring and assessing mangrove restoration sites Established 2 CFAs (Pate & Kiunda) in Lower Tana Conservancy Trained 204 people (88 women) from Pate, Kiunga, and Lower Tana Conservancies in the conservation of mangroves in the field	Communities score an average of 53% in management efficiency Sustainability plan aimed at diversifying funding sources Dependence on external funding may lower the program's independence Recommendations Invest in leadership, management skills, and governance Promote voice and inclusion such as involving women and children in decision making Engage County Governments and assemblies in policies and programs

Conservation framework	Institution in charge	Objectives	Implementation/success	Challenges & recommendations
REGIONAL				
Kilifi Country Forest Conservation and Management Act, 2018	Kilifi County (Department of Environment)	Ensure sustainable management of Forest resources in Kilifi Country	Applies to County Forests, Community forests, and Private forests	Lack of awareness among the communites. There is need for massive sensitization
Integrated Coastal Zone Management (ICZM) *Established in the 1970s* *Began in Kenya-1993/4*	Coast Development Authority (CDA) Supported by USAID and IUCN	To manage the coastal zone using an integrated approach factoring the geographical and political boundaries in an attempt to achieve sustainability To apply dynamic, multidisciplinary, and iterative processes promoting sustainable management of coastal zones	The Government analysed the coastal and marine environment – the basis for a Kenyan ICZM plan In 2010, the Government financed the write up of an ICZM action plan for the year 2011-2015 in collaboration with other ministries KenSea Atlas and the Post Doc Project are two completed ICZM projects as per the ICZM action plan for the year 2011-2015	Challenges Implementation of ICZM has been described as 'slow and problematic.' Involvement of separate sectors leads to fragmented decision-making, inadequate communication, and confusion over areas of jurisdiction, implementation, and monitoring Recommendations Capacity-building, through funding support, technical expertise, and regional partnerships established to facilitate MSP implementation To overcome fragmentation and inadequate communication, some form or degree of cooperation and coordination is needed
Vanga Blue Forest Project *Project period 2019-2039*	Vanga, Jimbo & Kiwegu CFAs *South Coast of Kenya, Kwale County*	To restore degraded mangroves through awareness creation, education, and community participation To prevent continued emission from degradation and deforestation of mangroves through models that can be measured, reported, and verified To conserve high-quality mangroves from impacts of encroachment and degradation, ensuring the conservation, carbon enhancement, and scientific purposes To promote long term socio-economic development of local communities through income generation from mangrove conservation, such as through Carbon credits To enhance community capacity on joint mangrove management	Avoided deforestation, reforestation, and establishment of fast-growing trees (Casuarina equisetifolia) woodlots outside the mangroves Carbon benefits; designate 4428 ha of mangroves in Vanga, with 450 ha of avoided deforestation and 0.25 ha of new plantation establishment for 20 years Livelihood benefits; generate direct and indirect benefits to CFAs. The sale of Carbon credit approximately 5019 t CO_2e yr^{-1} will raise USD 35 133, which will support community projects such as water and sanitation, education, and environmental conservation Other livelihood benefits include; shoreline protection, increased fishery, beekeeping, etc. Ecosystem and biodiversity benefits; control sedimentation and protect shoreline erosion plus support mangrove ecotourism	Challenges Mangroves and associated blue Carbon ecosystem have not been incorporated into Kenya's National Determined Contributions (NDCs) of the Paris Agreement-infringing community rights to transact ecosystem services Possible Carbon leakage through mangrove extraction in the form of fuels, wood, timber, etc Recommendation Should be included in the National REDD+ Scheme for Kenya To mitigate Carbon leakage and uncertainty, the project plans to implement 2 ha of fast-growing wood lots

Conservation framework	Institution in charge	Objectives	Implementation/success	Challenges & recommendations
Marine Spatial Planning (MSP-Lamu County)	Lamu County Government	To promote sustainable conservation of mangrove forests and corals as part of the County's natural resource assets	Surveying the acreage of land under mangrove and formal gazettement to protect them Provide a buffer of at least 100 meters around the edge of the mangrove rings Re-afforestation of cleared mangrove trees Prepare Environmental Management Plans for the mangrove forests Carry out public sensitization programs to increase civil conservation awareness	Challenges There is still a continued focus on terrestrial planning, despite the Constitution and the National Land Use Policy recognizing the need for inclusion of spatial planning of the coastal zone. A sectoral approach that limits institutional liability, Numerous sectoral laws with conflicting mandates Inadequate integration to environmental impact assessment, and Lack of integration of MPA planning framework Recommendations High-level policy decision and an institution with a legal mandate and authority to implement MSP is required Gaps in existing national laws on MSP should be identified and bridged through inter-sectoral committees: these committees can serve to steer the process, sharing of information Establish an integrated land-sea planning approach to help mitigate many of the potential problems associated with increased human activity in coastal communities by addressing the human use of land, freshwater, and marine resources while also working to maintain the integrity of terrestrial, aquatic, and marine/estuarine ecosystems (128) Amend the Physical and Land Use Planning Act of 2019 to ensure that there are express provisions committing both the national and respective county governments to apply marine spatial planning as a framework for planning activities within the land-sea interface. All counties within the coastal zone should also prepare specific county spatial plans which would give a detailed framework for governing the land-sea interface within their areas of jurisdiction.

Conservation framework	Institution in charge	Objectives	Implementation/success	Challenges & recommendations
Kwale County Climate Change Act, 2020 October 2020	Dept. of Environment and Natural Resources Management (County Governments of Kwale)	To strengthen the County's capacity to identify, design, and implement Carbon asset projects through mangrove conservation and protection To access international Carbon credit markets To coordinate implementation, monitoring, and evaluation of climate change policies, plans, programs, and projects within the County To manage County Climate Change Fund established by the Act	Established committee a committee referred to as the County Climate Change Planning Committee Committee headed by the Governor and included representatives of the community/ NGOs involved in climate change projects such CFAs Provision of overall policy and guidance and monitoring climate change planning and implementation	Lack of adequate funds to implement activities
Kwale County Development Plan	Kwale County Government	Develop relevant policies and guidelines Sensitization and community awareness, i.e. mobilize communities on their rights and roles to environmental management; develop educational material on rules and regulations with respect to environmental management and Support community groups(CFAs) to participate in PFM activities Develop tree growers' initiative to cater for timber, poles and fuel resource needs as a buffer for indigenous forests like mangroves; like stimulate forming of tree nurseries To gazette forests in the County To promote agroforestry To promote forest conservation activities To develop sustainable community based environmental management strategies such as social forestry To conduct EIAs and EAs on projects	Radio programs developed on environmental issues Developed PFM with BMUs on Diani-Chale Marine Reserve in the process Tree growers' association in process of formation In the process of forming commercial tree nurseries	*Challenges* Major challenges stand out as financial and budgetary limitations, technical understaffing/lack of manpower and logistical issues such as transport specifically inadequate transport facilities. *Challenges specific to fisheries* Institutional; relating to marketing infrastructure and marketing processes which require an elaborate policy framework yet to be formulated. Logistical; related to group dynamics and leadership within community structures such as beach management committees. Water inadequacy due to droughts, vandalism and theft of fish including predation Emergencies; mainly arising from limited advisory services on deep sea risks and poor adoption of the same where and when provided. Lack of using directional gadgets such as the global positioning system (GPS) was a predisposing feature to high emergency incidents *recommendations* Continuing/routine management activities which comprise provision of modern legalized fishing gears and capacity building, up scaling fish quality assurance and marketing, capacity building; and • Building of fish ponds and stocking of the ponds. Other activities proposed include stepping up communication and equipment maintenance

Conservation framework	Institution in charge	Objectives	Implementation/success	Challenges & recommendations
LOCAL				
Community Forest Associations (CFAs) *Established under Forest Conservation and Management Act, 2016 (No. 34 of 2016)*	KFS Registered CFA	To promote Participatory Forest Management (PFM) To encourage communities living adjacent to forests to establish and register CFAs To facilitate co-management of forests between KFS and registered CFAs To enable communities to obtain user rights of mangrove ecosystems depending on the forest characteristics	CFAs are allowed to manage, conserve and protect the Forest CFAs can formulate and implement forest programs CFAs assist KFS in enforcing provisions of the Act CFAs monitor any developments, changes or occurrences within the Forest Communities have direct economic stake in protection and sustainable use of mangroves	Challenges Effectiveness hampered by lack of local capacity to implement PFM Inactive participation by local communities Strained relationship between local communities and KFS Recommendations Community motivation to actively participate in management and decision making Build local capacity to develop suitable PFMs and implement Improved relationship between KFS, NGOs, line ministries, local government local stakeholders and the community
Beach Management Units (BMUs) *Established under Fisheries Management and Development Act 2016*	Department of Fisheries Registered BMUs Local governance get support from KWS, KMFRI and SDF	To ensure co-management arrangement between communities and government agencies in managing marine resources To formally recognize and establish marine areas under co-management with user groups To provide subsidiary regulations for the protection of fish breeding areas including mangroves To legally give community rights over fisheries resources To establish Locally Managed Marine Areas (LMMA) according to the 2007 BMUs' regulations legislative framework	Formally established local executive committee of all stakeholders Developed co-management tool bringing together fish traders, fishermen, boat owners, fish processors and other stakeholders within a landing site Devise and enforce by-laws to govern fisheries Delineate BMU's boundaries and for example, exclude non-registered fisherfolks or boats from the area	Challenges There are more than 60 BMUs in the Kenyan coast, most exist by name but have no formal registration, jurisdiction or by-laws Lack of clear legal framework and guidance that hinder growth of LMMAs Recommendations There is a need for clarity on procedures and implications of establishing LMMAs Facilitate greater collaboration amongst National Government agencies in supporting LMMAs Formal registration of BMUs and establishing their jurisdictions and by-laws
Mikoko Pamoja Community Project *Launched in 2013*	Gazi bay community & KMFRI	To restore and protect mangroves through the sale of carbon credits To develop a model of conservation with an emphasis on PES To enhance the livelihoods of the locals in Gazi and the sorroundings	The world's first community-type project to restore and protect mangroves through the sale of carbon credits Established a model that could be replicated elsewhere in Kenya and internationally Influenced National level policy, for example, the Kenyan National Mangrove Ecosystem Management Plan The model has been replicated in the Vanga Blue Forest (VBF) project, located in the transboundary mangroves of Kenya and Tanzania Capacity creation to the community in terms of nursery establishment, planting, surveillance, and monitoring leading to restoration Rights and skills transfer has bolstered community support, cooperation, participation, and ownership	Challenges and recommendations The relatively small-scale of the Mikoko Pamoja project (117 ha) has prevented it from accessing global compliance carbon markets, such as United Nations Framework Convention on Climate Change mechanisms. This has led to smaller markets for its carbon credits. But its small size has also enabled the project to stay relatively simple, avoiding the extra costs and administrative complexity of complying with complex global mechanisms. The Mikoko Pamoja project does not account for the carbon stored within the protected land's soil, which is likely even larger than what is stored in the mangroves. Not accounting for this soil carbon prevents the project from achieving its full financial potential. There is need to build more capacity and technical expertise on the measurements of soil carbon

3.2.2.4. Participatory Forest Management (PFM) through Community Forest Associations (CFAs)

The FCM Act, 2016 promotes Participatory Forest Management (PFM) through co-management of mangroves by the KFS and CFAs. The Act allows CFAs to protect, conserve and manage Forest through structures and programs embedded in their Forest Management Plans (FMPs). Individual PFMPs must formulate implementable strategies and programs for monitoring development and human activities in the area, enforcing the Act's provisions, identifying changes in forests, and local administration of forest resource utilization. According to Ongugo et al. (2008), PFM has been embraced in Kenya since its inception in 1997 but has not been effective because of limited local capacity negatively affecting various components such as developing suitable FMPs. Therefore, communities do not actively participate in mangrove forest conservation and associated activities.

Concerted awareness creation, incentives, education, and pilot projects focusing on PES and REDD+ schemes have created a positive conservation impetus among the Kenyan Coast communities. Communities' participation in conservation programs and carbon credit schemes requires registration of a CFA and signing a co-management agreement with the KFS. The agreement also mandates the CFA to exercise mangrove forest conservation programs and user rights. Each CFA develops a PFMP according to baseline socio-economic and biophysical characteristics of the area. The PFMP must define the CFA's activities and location to conserve or have other mangrove and fisheries associated activities. Several CFAs have formal agreement registration with KFS having various co-management mandates. On the other hand, some CFAs are operating informally.

Fundamentally, the CFAs having co-management agreements with the KFS contribute to better conservation because they have structures for identifying threats to mangrove ecosystems and conservation constraints. Therefore, they formulate specific direct or indirect sustainable remediation and mitigation measures. Notably, high perceived benefits of PFMP and household head's nature encourage enhanced participation in PFMPs activities (Musyoki et al., 2016). Recent studies have shown that despite the proliferation of CFAs as alternatives to top-down conservation approaches in Kenya's forest ecosystems; there is limited information on factors influencing collective forest conservation efforts (Okumu & Muchapondwa, 2020).

The PFMP framework confers management role to CFAs, whereas the KFS retains forest resource ownership and the right to withdraw the agreement in part or total. The CFA structures and management plans are diverse, but the majority are designed to encourage inclusion, equity, forest conservation, and management (Amanor, 2003). PFMPs development and implementation are multi-stakeholder processes involving Government institutions, NGOs, private developers, local communities, religious groups, international and local funding, etc.

The next section outlines the objectives, threats, and constraints to conservation, proposed activities, and stakeholder's recommendation to mitigate adverse environmental impacts from select CFAs that were surveyed during this study. This section integrates information following a review of select PFPMs, and information collected through focus group discussions with the respective CFAs.

Gede Community Forest Association (GECOFA)

GECOFA CFA under Gede Forest Station is in the larger Arabuko Sokoke Forest Block. The other two forest stations include the Jilore Forest Station in Malindi District and Sokoke Forest Station in the Kilifi district. Arabuko Sokoke Forest (ASF) is the largest block of lowland forest on the East African coast with an area of approximately 41600 ha, of this total forest area 13,100 ha constitute the Gede Forest Station, of which 10500 ha are the terrestrial Forest, and 2600 Ha are the mangrove forest mainly in the Mida Creek along the shores of Indian Ocean. The first PFMP of agreement between GECOFA and KFS was signed to be operational between the years 2012-2016, with the following objectives;

- To train stakeholders on mangrove forest protection and security
- To recruit and train forest scouts
- To develop biodiversity conservation programs such as butterfly netting, placing beehives in forests, ecotourism, and enterprise training
- To manage mangrove ecosystem through an inventory of poles, controlled harvesting,

boardwalk ecotourism, forest protection patrols, and beekeeping

The community's awareness levels regarding the importance of forests are high because previous involvement in various conservation project activities was donor-funded by BirdLife International and CDTF. Therefore, the community has a good working relationship with decision-makers, conservation groups, and ASF member institutions. Some of the identified threats to mangrove conservation include; illegal logging, poaching of wildlife, carving trees, forest fires, charcoal burning, dumping solid waste, and pole poaching, see Figure 35-3 below. Consequently, the PFMP mitigation initiatives include; awareness creation on mangroves' importance and sustained excellent working relationships between the community, donor organizations, and custodial institutions. So far, the co-management agreement has had significant impetus on conservation and mangrove resource management. However, following an interaction with the CFA members, the following constraints negate the success of the conservation efforts;

- High unemployment and poverty encouraging illegal logging for livelihood support
- Unfriendly attitude of KFS staff to local communities
- Fairly strenuous relationship between decision makers and community members involved in mangrove degradation/extractive practices
- The governance structure is partially effective because of numerous loopholes such as unclear roles of the County Government in mangrove conservation/management, the legislation approach is top down, and limited awareness on stakeholder's duties
- Conflicting policies from different stakeholders, and overlapping mandates of Institutions; case in point; KFS and KWS; a situation that requires harmonization of laws, because players are operating independently yet coordinated and inter-dependent coordination would yield better outcome.
- Limited resource and budgetary allocation to support custodial and conservation activities
- Lack of markets for the sustainable use schemes' products; for instance, seedlings meant for sale, get overgrown; further, the sale prices set by the KFS are very low, and the CFA members cannot break even in most cases
- Lack of proper facilities such as boats and infrastructure for surveillance
- Climate change destabilizing natural ecosystem and has led to high tide causing species replacement, affecting mainland farm activities because of high salinity, and some areas cannot grow mangroves anymore
- Conflicts between the licensed harvesters and growers (restoration) since there are no licensed ones locally and those from outside temper with the restored sites, especially from Uyombo and the Kilifi Creek, where permissions are given for licensed harvesters
- Ignorance by the community because they do not understand some of the processes to apply in forest management; further the lack of proper knowledge on the sustainable use of mangrove products is widespread especially with the larger community who are not members of the CFA
- Demotivation of the CFA members owing to the lack of recognition for their efforts in conservation.

Recommendations

The community and other stakeholders can address the identified challenges through a strengthened working relationship between decision-makers and the community, which would create better synergies. Generally, the CFA members expressed that individual user group policies steer conservation better than the bigger management plans. Other recommendations were;

- Mass sensitization of alternative economic activities
- Fair benefit sharing and the introduction of compensatory programmes for conservation efforts was recommended by the CFA if proper management of the mangrove forest is to be acheived
- Job creation and other compensatory measures, especially for women and youth to motivate the community
- Alternative energy sources such as the use of improved jikos instead of firewood and maintain restored areas
- A need for research on applicable alternatives to livelihood support and activities suitable to the local context
- By-laws of user groups should be encouraged because they have a higher efficiency

Figure 35-3: Threats to mangrove ecosystems and replanting Mida Creek forest formation

Mtwapa, Takaungu, Kilifi, Matsangoni and Uyombo Community Forest Association (MTAKIMAU)

The plan is referred to as the "Kilifi Zone Mangrove Forest Area PFM" 2015-2019. It covers a spatial mangrove area of 1715 ha covering Mtwapa Creek, Kilifi Creek, Takaungu, and Uyombo. The Forest falls under the Sokoke Forest Station under the Arabuko Sokoke Forest Ecosystem Complex. Apart from the motivation of fulfilling section 35(1) of the Act 2005, the plan was developed to maintain the integrity of Forest's ecosystem and improve local communities' livelihoods.

Specific objectives

- To conserve and enhance the unique biodiversity of the mangrove forests
- To contribute to subsistence needs of local and neighboring communities and improve their livelihoods
- To contribute and develop sustainable mangrove forest utilization and conservation approaches

The underlying and periphery challenges identified by the plan revolved around the increased demand for mangrove ecosystem resources and ineffective human impacts management. Among the threats identified by the PFMP were; uncontrolled mangrove cutting/poaching, urbanization raising the need for construction materials and mangrove products, charcoal burning, declining biodiversity, loss of cultural sites, decreasing fish stock, no active mangrove rehabilitation projects, and a high incidence of poverty increasing livelihood dependence on mangrove resources, see Figure 36-3 below.

Various challenges constraining conservation measures in specific zones were identified to guide monitoring, evaluation, and implementation of the PFMP. Discussions with the CFA members identified constraints that include;

- Weak institutional capacity at the community level, for instance, there are a limited number of rangers, therefore the patrols are not sufficient, there is aslo a lack of proper surveillance equipments, e.g., boats, watch towers etc.;
- Conflict of laws between KFS, fisheries, and KWS;
- Unsustainable tourism activities and development projects;
- Lack of adequate equipment for fishing; such that fishermen have turned to using mosquito nets for fishing, which in turn, negatively affects fish population because of the harvesting and necessitated disposal of immature fish
- Habitat degradation from pollution, contaminant effluents, and siltation; and conversion of wetlands for settlement, tourism, and aquaculture. Land tenure is also a contributing factor such that people own riparian zones exacerbating degardation
- Theft, vandalism and intentional destructive activities e.g., uprooting of seedlings, burning down of watch towers, vandalism of beehives, board

walks, and even life threats by illegal loggers and rougue community members was also highlighted as a key threat to conservation efforts.

The recommnedations and the activities necessary for the reversal of the identified challenges highlighted include; zonation as a primary management tool; protection, rehabilitation, subsistence, and intervention/buffer zone; biodiversity management programs; rehabilitation of degraded natural forest areas, habitat protection, and controlling illegal logging, encroachment, siltation, pollution; enhanced ecotourism activities and ecotourism products to improve socio-economic benefits to local communities; protection and security to biophysical and cultural mangrove resources; research and monitoring programs to fill knowledge gaps guiding local conservation and sustainable use; empowering communities to impact sustainable forest conservation and gain socioeconomically positively and developing human capacity for quality services and enhanced forest conservation management.

Recommendations

- KFS and government organizations need to have seamless coordination and communication with the communities
- Generally, KFS have not succeeded in their forest conservation and protection role hence the need for dialogue to improve conservation
- Need for rigorous awareness as some community members still feel that mangroves are self-regenerating hence no need for replanting or conservation programs
- Initiation and supporting alternative economic activities and livelihood support systems because community members rely on mangrove resources
- Controlled farming in riparian lands as the current practice encourage sedimentation and loss of mangrove forest areas
- Improved synergy between governing bodies, stakeholders, local administration and the community

Gogoni-Gazi Community Forest Association (GOGACOFA)

The Gogoni-Gazi forest ecosystem is in Msambweni District of Kwale County. Gogoni forest ecosystem is part of the Buda forest ecosystem, including Mrima, Buda, Gonja, Marenje, and Dzombo Forest Reserve. Gazi mangroves fall within the Diani-Chale MPA. The spatial coverage is about 615 ha of mangroves at Gazi. A vital requirement of this PFM was to embrace collaborative and participatory approaches in the conservation of mangrove resources, and it was operational between the years 2013-2017. The plan's envisioned outcome was to provide a mechanism of conserving the mangrove ecosystem as a single ecological and management unit by bringing all stakeholders together.

Figure 36-3: Ilegal Logging and Burnt Watch Tower at a mangrove ecosystem in Mtwapa

Specific objectives

- To promote adequate ecosystem protection and rehabilitation
- To enhance public understanding of Gogoni forest reserve and Gazi mangrove forest
- To contribute to the local community's livelihood improvement
- To promote research, monitoring, and education of ecosystem values and attributes

Notably, several studies and conservation initiatives had been undertaken in the areas. Therefore, a task force team headed the participatory initiatives of preparing the PFM, building on existing knowledge from lessons learned. Discussion workshops with various interest groups and local communities identified the major threats to mangrove conservation and attributed them to the lifting of mangrove resource extraction ban, see Figure 37-3 below. They included illegal cutting, overharvesting by licensed mangrove cutters, and sedimentation leading to mangrove deaths. Moreover, constraints to conservation efforts were; inadequate silviculture knowledge of mangrove species, multiple potential uses of mangrove resources, and limited natural mangrove regeneration techniques and reforestation.

Therefore, the PFMP proposed the following activities that would contribute to sustainable mangrove forest utilization and conservation.

- Biodiversity conservation programs and resource mobilization
- Sustainable use and livelihood initiatives to reduce overdependence on forest resources
- Research and education on effective management options in the local context
- Protection of forest resources and control of illegal activities such as timber harvesting
- Developing supportive infrastructure and supportive technical capacity
- Ecotourism in areas with boardwalks such as Baraka Women Boardwalk and Chale Conservation Group Boardwalk
- Part of the Gazi forest delineated for Carbon trade by Mikoko Pamoja generating revenue from PES

Recommendations

- There is a need for enhancing a cordial relationship between the KFS and the ordinary community because the community members view KFS as a party inhibiting them from harvesting mangroves. In contrast, the KFS views them as offenders degrading mangroves.
- Awareness creation to the adjacent communities because they have limited knowledge of the regulatory and institutional management of mangroves
- Licensed mangrove harvesters have contributed significantly to the forest ecosystem degradation; hence there is a need to control the practice because, despite the adverse impacts, they continue to tamper with degraded sites
- The introduction of policies that promote benefit sharing has escalated conservation activities and controlled mangroves' reckless harvesting.
- Funding IGAs would enhance the adoption of alternative livelihoods and promote employment creation activities
- There is a need to upscale training and capacity building on programs supporting mangrove forest conservation

Figure 37-3: Board Walk and Boat Repair site at Gazi Forest formation

Mombasa Kilindini Community Forest Association (MOKICFA)

Mombasa has a 100 km long coastline running from Port Reitz in the south to the Mtwapa Creek in the north. The mangrove forests cover 3 769.7 ha, mainly dominated by *Rhizophora* and *Ceriops* species. Mangrove forests in Mombasa are distributed along with Port Reitz, Mwache Creeks, and Tudor. Administrative units of mangroves in Mombasa are divided into 4; Majaoni Block in Kisauni Sub County, Port Reitz Creek in Likoni Sub County, Junda and Tudor block the Mombasa Island, and Mkupe block in Changamwe Sub County. For effective management, the plan proposed six mangrove management and conservation objectives;

- To conserve and manage mangrove wood and non-wood products on a sustained yield basis
- To manage and control mangrove areas focusing on erosion, coastal stabilization, fisheries, and biodiversity conservation
- To promote community participation in mangrove resource management and contribute to livelihoods improvement
- To strengthen institutional capacities of institutions responsible for mangrove management
- To promote tourism and recreation in mangroves and mangrove areas
- To promote education and research for efficient management and conservation of mangroves

The problem analysis during the PFM development showed that despite the previous mangrove conservation efforts in the area, the forest resources continued to degrade. Although some conservation success could be reported in some areas, managing sub-urban mangrove sections presented numerous challenges. Most of the stresses arose from the community's organizational structure, especially in forest resource exploitation. Pressures and threats to mangrove forests within MOKICFA mainly orient on encroachment and excision of forests for settlement; farming, and grazing; illegal exploitation for charcoal, wood, poles because of high demand from

Urban development impact on mangroves

Mangrove illegal harvesting

Illegal liquor processing in mangrove forest

Firewood for illegal liquor processing

Figure 38-3: Pressures and threats to mangrove forest in Tudor creek

Photo: BigShip CBO

the increasing population; unsustainable and uncontrolled mangrove resource extraction; commercial, domestic, and subsistence; pollution from oil spillage, solid and effluent wastes; sedimentation due to poor land-use causing mangroves death; climate change affecting and communities, which is acerbated by ill-preparedness; forest management faces institutional constraints and weak governance structures; high poverty leading to mangrove resource degradation because it forms the main livelihood support resource; and conflicts between CFA and KFS on issues such as costs, licensing and benefits sharing. Lawbreakers frustrate conservation efforts. For example, some attack forest scouts in watchtowers or during patrols, whereas others uproot replanted seedlings, especially those from restoration activities of rival user groups. some of challenges can be visualized from figure 38-3 below;

Moreover, mangroves conservation has been hampered by a lack of clear land tenure because most people living in adjacent areas do not have property rights to the land. It has resulted in poor land management and environmental degradation, such as clearing trees that promote sedimentation and soil erosion within mangrove forest ecosystems. Therefore, the plan proposed management structures and activities to mitigate the threats as mentioned earlier and challenges, as follows;

- Promotion of agroforestry through farm tree nursery and establishing commercial wood lots to sustainably supply timber, fuelwood, and other forest resources as an alternative to harvesting mangroves
- Initiating income generating activities through capacity building, user groups IGAs such as bee-keepers, ecotourism, mariculture, etc.
- Strengthening forest protection through increased patrols and rangers, including employing local scouts and encouraging volunteers in the sector
- Capacity building on governance structures, activities, and conflict resolution
- Improved infrastructure for effective transports, equipment such as boats, and service delivery within the mangrove and adjacent areas

Recommendations

- Erosion and sedimentation control awareness creation to people owning riparian land
- Encouraging sustainable user activities such as tree planting and environmentally sound agricultural practices
- Sedimentation challenge should be addressed as it presents a long-term ecological risk
- Ownership of riparian land should be reconsidered with options of reverting to authorities for controlled development

Figure 39-3: Mangrove forest restoration Tudor Creek, Mombasa County

Photo: BigShip CBO

- Licensing of development activities in the area should be devoid of corruption because the vice has been rampant, accounting for a 50% inefficiency leading to development in the protected area
- Improved synergies and clear roles of key stakeholders and decision-makers operating in the area

Some gains in mangrove conservation in tudor creek can be visualized in Figure 39-3 below;

Vanga, Jimbo & Kiwegu (VAJIKI) CFA

The CFA operates in the Vanga mangrove forest ecosystem covering 2049 ha of mangrove at Lunga Lunga Sub County in Kwale County. These mangroves are transboundary between Kenya and Tanzania, and they support the local community's livelihoods. Also, they are rich in biodiversity and have a high potential for ecotourism. It has 7 species of mangroves, 12 species of seagrasses, and several coral reef species. Moreover, the area is rich in fish, invertebrates, dolphins, turtles, and other fauna. Previous studies that formed the basis of the PFMPs objectives and action plans reported that about 98% of the local communities utilize mangrove fuelwood, and fisheries support over 70% of the local economy.

Notably, according to the VAJIKI PFMP, over the past 30 years, Vanga's mangrove forest cover has been reducing at a rate of 1.34% per annum. In this study, mangrove forest was documented to exhbit annual increases of 0.13% about 13 Ha for the period 2000 to 2019. The mangrove ecosystem's major threats are overexploitation of mangroves for wood resources, forest encroachment, poor farming practices, illegal harvesting, and road construction, among other development activities, see figure 40-3 for socioeconomic activities Vanga mangrove forest. The plan's objectives were to embrace a participatory and collaborative approach considering diverse interests surrounding Vanga, Jimbo, and Kiwengu mangrove forests.

Specific mangrove management and conservation objectives

- To promote adequate ecosystem protection, rehabilitation, and development activities
- To contribute to the local community's livelihood improvement through sustainable resource extraction and implementing alternative IGAs
- To enhance participation of all key stakeholders in mangrove conservation
- To enhance public understanding of mangroves forests significance through awareness creation

Constraints to mangrove ecosystem management and conservation

- Community constraints because of limited awareness and negative attitude on the value of mangroves
- Lack of community organization and coordination skills
- Personnel constraints such as inadequate KFS staffing and limited mangrove management technical capacity
- Resource constraints, for example, there are inadequate equipment and poor infrastructure to manage mangrove areas, e.g., boats, attires, and outboard engines
- Overlapping institutional mandates posing coordination challenges, e.g., BMUs Fisheries Act and CFAs under FCM Act

The PFMP identified the following activities to be implemented as a mitigation measure;

- Management actions; mapping out habitats and species diversity, promote the planting of appropriate species, map mangrove areas prone to erosion, and sedimentation
- Awareness creation on leasing and licensing to stakeholders and community members
- Rehabilitation of degraded mangrove areas and adjacent land
- Improved policing and protection of mangrove from human activities through increased personnel and patrol
- Conservation of fisheries habitats to enhance breeding and improve fish population
- Developing and diversification of tourism products
- Controlling illegal activities through better policing and equipping scouts and rangers

Socio-economic activities next to mangrove in Vanga

Pollution within mangrove area

Rice farming adjacent to mangroves

Sewerage within mangrove forest

Figure 40-3: Socioeconomic activities and pollution in Vanga mangrove forest formation

Recommendations

- Sustainable funding for alternative IGA in the community
- Employment of additional personnel in the form of rangers and scouts to patrol, monitor, and generally police the ecosystem from tampering mostly restored sites
- Conflicting mandates between government agencies require harmonization

Increased capacity building and awareness on restoration activities, research, and policy enforcement

CFAs operating without a PFMP: The Case of Magarini Mangrove Community Forest Association

The communities play a fundamental responsibility in conservation by creating conservation awareness, policing forest utilization or status, and active participation in conservation efforts (Mbuvi & Kungu, 2020). Some communities or user groups however, do not have agreements with KFS, and they operate with a limited mandate to organize conservation activities or manage mangrove resources. Lack of full recognition by KFS through the PFMPs lowers conservation efficiency because the community lacks the legal authority to manage mangrove resources or prosecute offenders, even at the local government administrator's offices, neither can their grievances be heard and solved. For example, at the time of this study, the

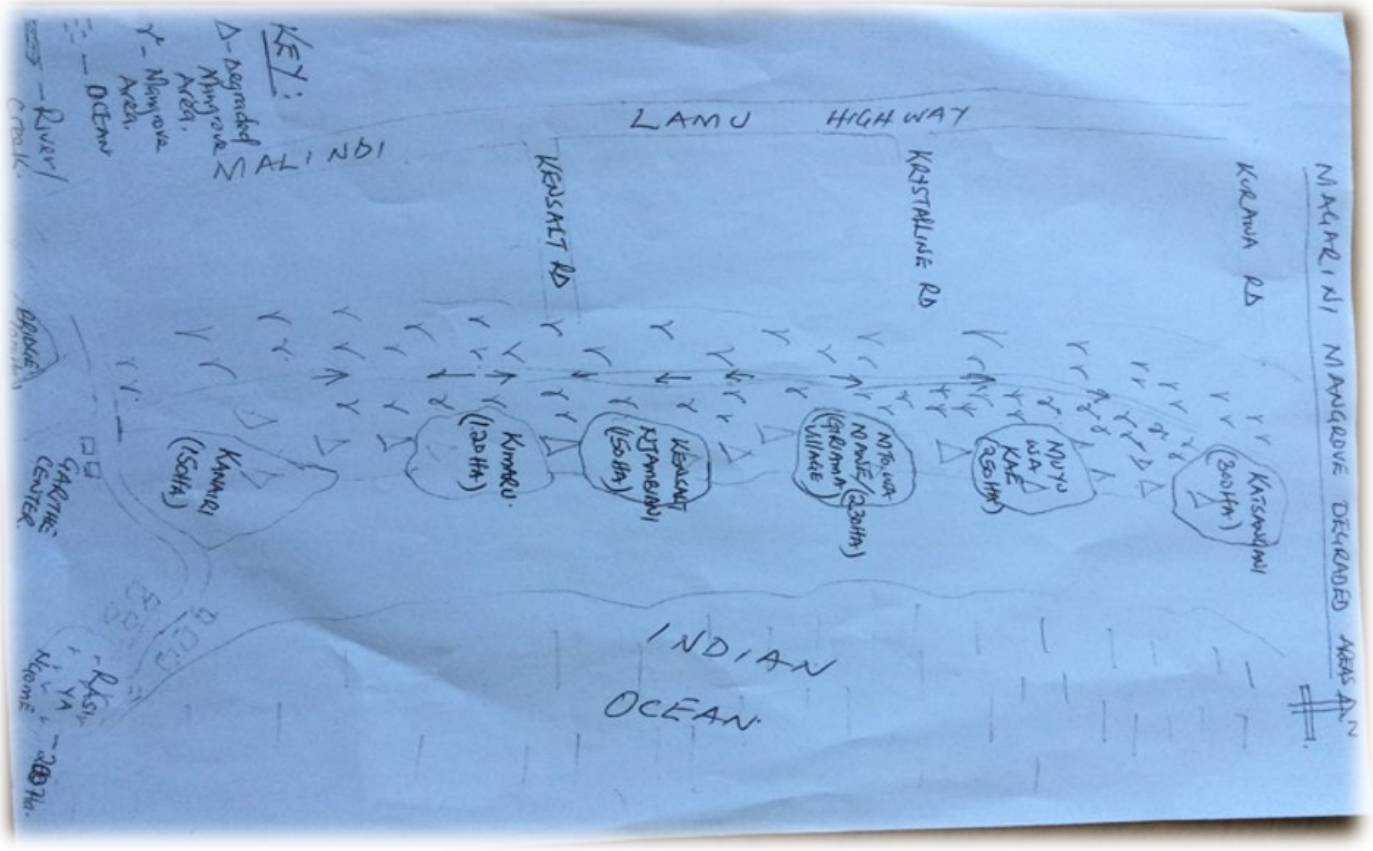


Figure 41-3: Community mapping of mangrove forest degraded areas

Magarini Mangrove CFA reported that despite being active, they have had stagnated PFMP preparation and signing since 2015 because they lacked adequate funds and technical guidance. The outcome has been sustained mangrove ecosystem degradation, loss of biodiversity, and expansion of development activities such as salt farms in mangrove areas. The issues of Magarini CFA have been documented to showcase challenges resulting from active CFAs that are not anchored on legal support and management plans.

The Magarini Community forest association covers all areas from Magaraini to Ngomeni a traboundary between Kilifi and Tanariver counties. The CFA is composed of Village Development Forest Conservation Committees (VDFCCs) namely Kurawa, Kanagoni, Marereni, Kibaoni, and Ngomeni. The community Forest association operates under Jilore Forest station. In the field study, during a group discussion, the community was able to map out degraded areas as shown in Figure 41-3 below.

The CFA has been actively involved in replantation and conservation efforts. However, they have not had sustained funding or support or incentives. The substantial funding was from a turtle conservation conservancy, but the project was terminated in 2019. Most of the conservation efforts are voluntary with no form of compensations. Notably, they have received support in refreshments and branded clothes during events such as world environment day and CSR activities of select cooperates. The CFA does not have a management plan and has been struggling to prepare one unsuccessfully for five years. They do not have a clear goal or budget, or knowledge.

The BMUs are most active and influential in conservation efforts because they depend on mangrove areas as fish breeding sites. A significant number of community members are fishermen, and their livelihoods depend on the status of mangroves. Poverty is a contributing factor to mangrove exploitation; soil degradation by salt companies, clearing of mangrove cover, and pollution of water points see Figure 42-3 below;

The communities have awareness on the conservation's need and justification. However, they note that

there are no programs for protecting illegal extraction and overextraction of the resource. In Ngomeni and Gogoni, sand harvesting is a crucial economic activity. And it has caused massive land degradation. Kurawa Kanangoni, Kibaoni, and Marereni; fishing is the critical economic activity, and the fishermen are at the forefront of conservation. Few community members have work opportunities in salt firms, despite the parties' general hostilities. Communities near the mangroves felt most responsible for conserving them. For example, the Rasi ya Ngome respondents clearly stated that if they fail to plant and conserve the mangroves, they will be displaced by the ocean. In Mambrui, there are no conservation efforts. The mangroves have been cleared for human settlement. There are settlements close to the ocean with limited mangrove coverage.

Constrains to mangrove ecosystem management and conservation

- The salt farms in the area contribute to massive mangrove degradation with numerous cases in court on issues such as clearing natural and replanted mangroves, releasing waste water leading to frequent biodiversity loss, and discharging untreated brine water to farms and into the ocean.
- Wastewater from salt farms has a higher salt concentration (brine), causing fish and turtle deaths, wilting mangroves, and community water points turning salty.
- Major deterioration of mangroves in the past 20 years were attributed to salt firms and their activities. The design of salt firm ponds encourages high tides because of raised gabions protecting the ponds from floods, the scenario has led to loss of nearby land and small islands. Currently, homes and hotels in one island have been swept by tides associated with the impacts of salt firm gabions and case is in court regarding the same.
- The public across the area from Ngomeni to Marareni face various hurdles of accessing the mangroves as most of the roads are privatized by the salt companies. However, there is limited designated land by the government for road construction.
- The land strips designated for road development have not been developed. Therefore, community organizations and individuals use them to produce animal salts using wastewater from salt company's ponds.
- The leading access right to mangroves pertains to accessing fishing grounds in the area and within creeks.
- Generally, the CFA, local administrators, and KFS relationship in the past three years were tumultuous.
- The footprint of KFS in the area is low, particularly in the recent past sicne this is an expansive area managed from Jilore forest station with one KFS officer.
- There are no forest guards, and the local administrators (chiefs and police) do not actively engage in patrols or policing the forest. Therefore, forest resource extraction and degradation are on the rise.
- The relationship between the community and salt companies and related operations is quite unfriendly.
- The relationship between funding organizations such as Nature Kenya and Sabaki area have been progressive leading to better conservation efforts.
- The county government is lacking behind in its proactiveness towards conservation efforts and legislations that support such initiatives
- There are minimal cooperate social responsibility activities despite the negative social, physical and economic impacts of salt firms' activities on the local environment and communities' social fabrics.
- Monetary gains from mangrove and ecotourism activities are in the teething phase with structured programs only in Sabaki river, operating as Community Based Organization. Ecotourism has potential in the Moi-Sabaki region because CFA members are actively involved Sabaki Delta conservation and ecotourism efforts. There are also small islands near Marereni but face access difficulty because there are no roads. For example, visitors to Robbin Island mostly fly in and visitors to Cocoa Beach have to navigate through small paths in salt firms.
- The CFAs and their leaders show a motivation to conserve mangroves but lack the legal support and management plan.

Drying of mangroves due to brine water

Settlements within Mangrove areas

Loss of biodiversity in mangrove ecosystem due to brine water

Commercial Salt pans

Illegal tree harvesting

Soil deposition on soil leading to land degradation

Gates releasing untreated salt pond waste water

Community run salt pans

Figure 42-3: Threats and pressures on Mangrove ecosystem in Ungwana bay and Ngomeni forest formation

Recommendations

- Funding for the development of Particiaptory forest management plan for Magarini CFA which is very active in mangrove conservation
- Reinstall strategic forest guard posts. Withdrawal of forest guards has reduced the authoritative presence of government officials, encouraging overexploitation and illegal harvesting.
- Awareness creation to the community on the need to follow due process when extracting resources
- Review of CFA bi-laws because the current versions are obsolete, unimplementable, and encouraging repeat offenders. For example, once an individual has used illegally extracted mangrove to develop a product such as an item of furniture or used for construction, it becomes almost impossible to arrest them for mangrove degradation related charges directly. It is feasible after a court order linking the product or structure to mangroves.
- There were encouraging alternative livelihood economic cases in Ngomeni, especially Rasi ya Ngome, Moi-Sabaki, and Kanairi. These areas have casuarina plantations and do harvest for export. This can be adopted across the forest formation

Gains in forest conservation in this CFA without viable PFMP can be visualized in Figure 43-3 below; This showcases more gains can be achieved if proper conservation frameworks are put in place.

3.2.3. CONCLUSION: THE STATUS OF MANGROVE FOREST CONSERVATION IN THE KENYAN COAST

Mangrove governance occurs at all levels, from the central government to state or regional governments, to municipal or local councils. Even where there is no formal recognition of customary law, communities and indigenous groups may have traditional knowledge or practices that are relevant for mangrove governance. It is crucial to take the perspectives and needs of local communities and mangrove users into account if mangrove governance is to be effective. Civil society also plays a role in mangrove governance at the international and national levels. Many countries rely on civil society support for operationalization of instruments for mangrove conservation and sustainable use

Casuarina Spp plantation in coconut farms

Tree nursery seedlings in Ngomeni

Fish Trap as socioeconomic activity in Ngomeni

Figure 43-3: Mangorve conservation efforts and socioeconomic activities in Ungwana bay and Ngomeni

Regulation of activities affecting mangrove areas and their connected ecosystems must be supported by integration of mangrove considerations in planning and permitting processes, as well as fair and effective systems for decision-making, dispute resolution and recognition of tenure and rights. Command and control measures can be complemented by market mechanisms and incentives. Prohibitions on use may be appropriate in some cases, while others warrant legal support for sustainable utilization, including benefit sharing systems to enhance community participation.

According to the key stakeholders, the participatory forest management and utilization process has enlightened local communities and made them

appreciate the notion that forests are beneficial to their livelihoods, hence they should manage them as their resource. Sustainable mangrove forest management remains promising with user groups and communities as stewards of the resource. The CFAs, opinion leaders, and institutions, who form the main stakeholders in mangrove conservation, highlighted conservation legislative aspects and decision-making inefficiencies contributing to the governance lapses. This background knowledge identified the underlying constraints to protection and recommendations for improved conservation and management.

Causes of mangrove conservation inefficiencies and governance lapses

The mangrove state in some locations has severely degenerated in the past ten years, and it was attributed to a lack of respect for the law. Although numerous conservation efforts are in place, degradation/overexploitation has been taking place due to high population, pressure on the limited resources, and the public frustration the sustainable management efforts. However, evident restoration and conservation outcomes have been reported. The growing human population in the coastal region has associated demand for land and timber for construction and furniture. Consequently, settlement in previously non-inhabited places and urbanization has resulted in waste generation, sedimentation, infrastructure development, and clearing mangroves for development action.

CFAs with co-management agreements with the KFS, such as Ngomeni do not have the institutional infrastructure and supportive personnel, e.g., forest rangers and scouts. Therefore, the response by the KFS personnel and the Government is slow. In such cases, the forest manager is expected to handle all conservation and mangrove ecosystem conservation issues, yet some jurisdictions are expansive and strenuous to be managed by one individual.
The relationships between KFS and the community in some areas are relatively strenuous. For example, in regions experiencing illegal forest activities or degradation. Notably, there is a generally poor relationship between the decision-makers/key stakeholders and community members, especially those with no membership to user groups. Some community members do not understand or know their applicability or existence. Hence, some community members are poor and hungry; thus, they view mangrove resources as their only livelihood supporting resource, hence utilizing them unsustainably. Therefore, with increasing population, expanding the dependency on mangrove resources, and impacts of climate change, the problem is gaining traction. Inadequate laws governing upstream farming activities have also contributed to high sedimentation downstream.

There are conflicts between the licensed harvesters and growers (restoration) since there are no licensed harvesters in some areas. Therefore, harvesters from external areas tamper with the restored sites, e.g., in Mida Creek's case, the Government has removed the total harvesting ban.

Institutional and governance challenges

- The institutional terrain for the mangrove ecosystems is dominated by multiple actors and institutions, informed by the specific laws and interest of each party. Systemic duplication and overlapping roles of roles and mandates, especially between the KFS and KWS, depict the governance frame for the various institutions in this sector, which has been a major impediment towards efficient management and conservation of the mangrove ecosystems.
- KFS has not embraced dialogue with communities in some areas, resulting in the non-cordial working relationship between and among parties. As a result, community members view KFS as a party inhibiting them from harvesting mangroves, whereas the KFS view the community as offenders degrading mangroves.
- Some community members do not understand regulatory and institutional management of mangroves, impeding the success of implementing laws
- The KWS is perceived to be hostile and inconsiderate because of human-wildlife conflict and unsatisfactory compensation modules. Similarly, the community feels they are being denied harvesting rights in areas or of some marine/mangrove resources
- The National, County, and Sub County Government roles are not clear. There are unclear laws and legislation, which require harmonization and strengthening.

- The governance structure is inefficient. The legal framework and legislation process is mostly a top-down approach
- Few personnel (rangers and scouts) to protect culprits from degrading mangroves especially the restored sites.
- There are problems with structures and governance responsibilities. For example, inter-institutional commitments clash in some cases/sectors.
- Generally, VDFCCs and CFA play a crucial role in the management forests but have limited funding, institutional support, and capacity to execute respective mandates
- The governance structure is applicable and considered acceptable, but the implementation faces numerous challenges. For example, some expansive areas have only one forest ranger negating policing ability.
- The support given to BMUs and other conservation groups is not enough, and associated limited resource allocation for conservation has a minimal constructive outcome
- Rampant corruption and development activities such as urban expansion or tourism activities in protected areas have a long-term impact on sustainability

Recommendations

- Harmonisation of laws between overlapping mandates of institutions is very critical if proper and effective management of the mangrove ecosystems is to be achieved.
- Effective community-level leadership is critical for conservation as stipulated in the Act. Therefore, there is a need for CFA and user-group leaders' capacity-building initiatives plus a regular review of PFMPs.
- The communities are willing to participate in conservation programs; hence crucial decision-makers should in-cooperate their ideas and involve them sustainably
- Community conservation initiatives such as rehabilitation and restoration programs have tremendous success and should be encouraged in most locations
- Alternative IGA has lowered pressure on mangroves ecosystems hence require consideration in in future conservation programs
- KMFRI's Carbon trading project has brought more understanding of the mangrove ecosystem's role in global warming mitigation. Similar projects would improve stakeholders' willingness to participate in conservation
- Increased patrols, surveillance, deployment of rangers, restrictions, and moratoriums were necessary to lower destructive practices
- Encourage increased awareness by external role players, including Cobec, Nature Kenya, Arocha, etc.
- Direct involvement of user groups in activities within the ecosystem indirectly provides protection
- Legal ownership of riparian land encourages development action conserving and protecting the transition zones and mangrove areas
- Facilitate resources, e.g., lack of adequate resources, is a significant setback. KFS sometimes provides boats or motorbikes to ferry the community to replant in far off areas
- Execute mangrove resource remove and replace policy to encourage replanting post-harvesting.
- Encourage individual user groups to have policies and laws because they are crucial tools for steering conservation efforts and more effective than the bigger management plans
- Partnering with government agencies and NGOs towards conservation and management of mangroves
- Harmonization of laws and regulations to encourage cross and inter-institutional cooperation
- Seek market or funding for conservation products such as casuarina and mangrove seedlings to motivate groups.
- There is a need for compensatory measures as a motivation in the form of cash transfers, employment opportunity to community/CFA members
- A lot of sensitization and awareness is needed, especially for CFA non-members who are occasionally hostile.
- The existing regulations governing the relationship between stakeholders, the community, and their access rights are sufficient under the current legal frameworks but require regular review and revision.

3.3: OUTPUT 3 – ASSESSMENT OF THE HUMAN DEVELOPMENT RELATED TO, OR DERIVED FROM, MANGROVES ALONG THE KENYAN COAST

The mangrove ecosystems form some of the unique yet crucial ecosystems that provide support to other marine biological diverse ecosystem. The same ecosystems are vital components for the subsistence livelihoods of the coastal community as they offer various social and economic value to the people. Further, it is projected that billions of people worldwide especially in developing countries depend on coastal and marine resources for their livelihood (Constanza et al., 2014). In the WIO region, it is reported that coastal communities greatly depend on fisheries resources obtained from mangrove ecosystems (United Nation University, 2013). According to Nordlund &Torre-Castro et al., 2013, majority of coastal communities are resource dependent as they rely on marine natural resource for their livelihood. However, being resource dependent is risky due to the reliance on particular resources for income and employment. Depletion of these resources or changes in management policy, oftenly pose serious threats to the resource-dependent communities both socially and economically. Overexploitation of the coastal natural resources especially mangrove is common in coastal communities, however, the linkage between socioeconomic factors and the rate of coastal and marine resources exploitation is mostly not well captured.

3.3.1: METHODOLOGY

To estimate the socioeconomic impact of mangroves, field surveys of the forest formations within the scope of study was done. Further, a field data collection tool was developed, see appendix 1.0, and administered to the communities living adjacent to the forest formations through interviews. Specific attention was given to key informants and focus group discussions composed of members of the various Community Forest Associations. To augment this information, at least 5 households within close proximity (<10Km) to each of the surveyed forest formations were randomly selected and interviewed.

The following thematic approaches were applied;

1. Assessment of the mangrove benefits accrued economically to the communities

The method involved establishing a framework of mangrove ecosystem service evaluation based on earth observation data and information emanating from the focus group discussions. The integration involved the selection of indicators for the evaluation of the socioeconomic role of mangroves to people's livelihoods. A semi-structured questionnaire was developed to capture information related to mangrove ecosystems and how they impact local community livelihoods. All the data captured was analysed using SPSS software[8].

Ultimately, the benefits accrued economically were calculated based on the following equation by Quoc.T et al., (2015);

$$A = \sum (P_i Q_i)$$

Where;
A is the total value of the economic benefit of mangrove to local community per area
$P_{i\,is}$ the product price
Q_i is the quantity
i is the type of product

All the values were obtained from the focus group discussions, and from the household interviews. Additional secondary data from previous studies was examined to bring an understanding of the indicators selected. The prevailing market prices averaged within a period of one year (the year 2019) were used for this assessment. The economic indicators for this evaluation were those that the communities

8 https://www.ibm.com/analytics/spss-statistics-software

mentioned to be the most important in terms of income generation as listed below;

a. Fish harvesting for consumption and commercial use
b. Fuel wood for commercial and own use
c. Ecotourism
d. Honey products

Further analysis was done to determine whether the mean values per area differed among the different percentages of mangrove cover and across different conservation aspects. Mangrove densities were determined using remote sensing data through the use of Normalized difference vegetation index (NDVI) and the categorization of the forest densities i.e., dense, moderate and sparse forests. A comparison was done for the years 2019 and 2000 respectively. This assessment is showcased below in table 22-3.

Assessment of the linkage to mangrove dependence by local communities

Other social and economic benefits were extracted by linking the listed key indicators below as an assessment to mangrove dependence as analysed in table 22-3.

a. Proximity to the mangrove forest (distance)
b. Cultural understanding of the role of mangroves within the communities
c. Social benefits of mangrove as depicted by the communities
d. Mangrove ecosystem use
e. Assessment of the socioeconomic role in both urban and rural settings
f. General importance of mangrove
g. Local knowledge on mangrove conservation
h. Willingness to contribute towards mangrove conservation
i. Time use in the Mangrove ecosystem

Further, the social benefits were also subjected to ethnographic research where an assessment of people's culture in relation to mangroves were captured. Narrations of the social setting and cultural aspects were documented during the field survey. In addition, GIS was employed to deduce linkages between the mangrove ecosystem and the local communities by looking into the following;

a. Mangrove ecosystem areas
b. Community population based on varying distances from the mangrove

Maps of the 10 Km radius, depicted as the area of impact of mangrove use, for the various mangrove forest formations were developed and they form part of appendix 4.0 of the report. Other key indicators were also documented and are presented in table 23-3.

3.3.2: FINDINGS: THE 'HUMAN DEVELOPMENT' RELATED TO, OR DERIVED FROM, MANGROVES

1. General characterization of mangrove dependent communities

The assessment of the human development related to, or derived from mangroves, was done through the characterization of the mangrove dependent communities and the assessment of how the Sustainable Development Goals are addressed through this dependency. This is illustrated in Figure 44-3 and Table 16-3 below.

Characterization based on the SDG.

A number of SDGs are addressed directly or indirectly through the utilization of mangrove ecosystems. The assessment was able to identify SDGs 1, 2, 7,8,11,13,14,15 and 17.

Table 17-3: Utilization of mangroves ecosystem and Sustainable Development Goals (SDG)

Social benefits identified	SDG addressed	Remarks
Improved livelihoods	1,2,3,7,8,14,15	Through increased revenue streams, availability of food, shelter e.t.c
Increased social cohesion	11,14,15,17	Through groups working together towards mangrove conservation. Improved relationship between primary and secondary users.
Improve health	3	Through the use of traditional medicine obtained from the mangroves
Spiritual needs are met	3	Through increased maintenance of the cultural aspects that relate to mangrove ecosystem

2. Mangrove economic benefits accrued to the communities

The accrued mangrove economical benefits were calculated based on Quoc.T et al., (2015) formula discussed above. The assessment looked at forest formations that are geographical within close proximity e.g., in the same County. Other considerations were, the number of forest formations covered by the community forest associations (CFA) and how the communities were integrated. In this case Mtwapa, Takaungu, Kilifi and Mida forest formations which are under one forest station were analyzed together. Secondly, Vanga, Gazi and Funzi which fall in the same

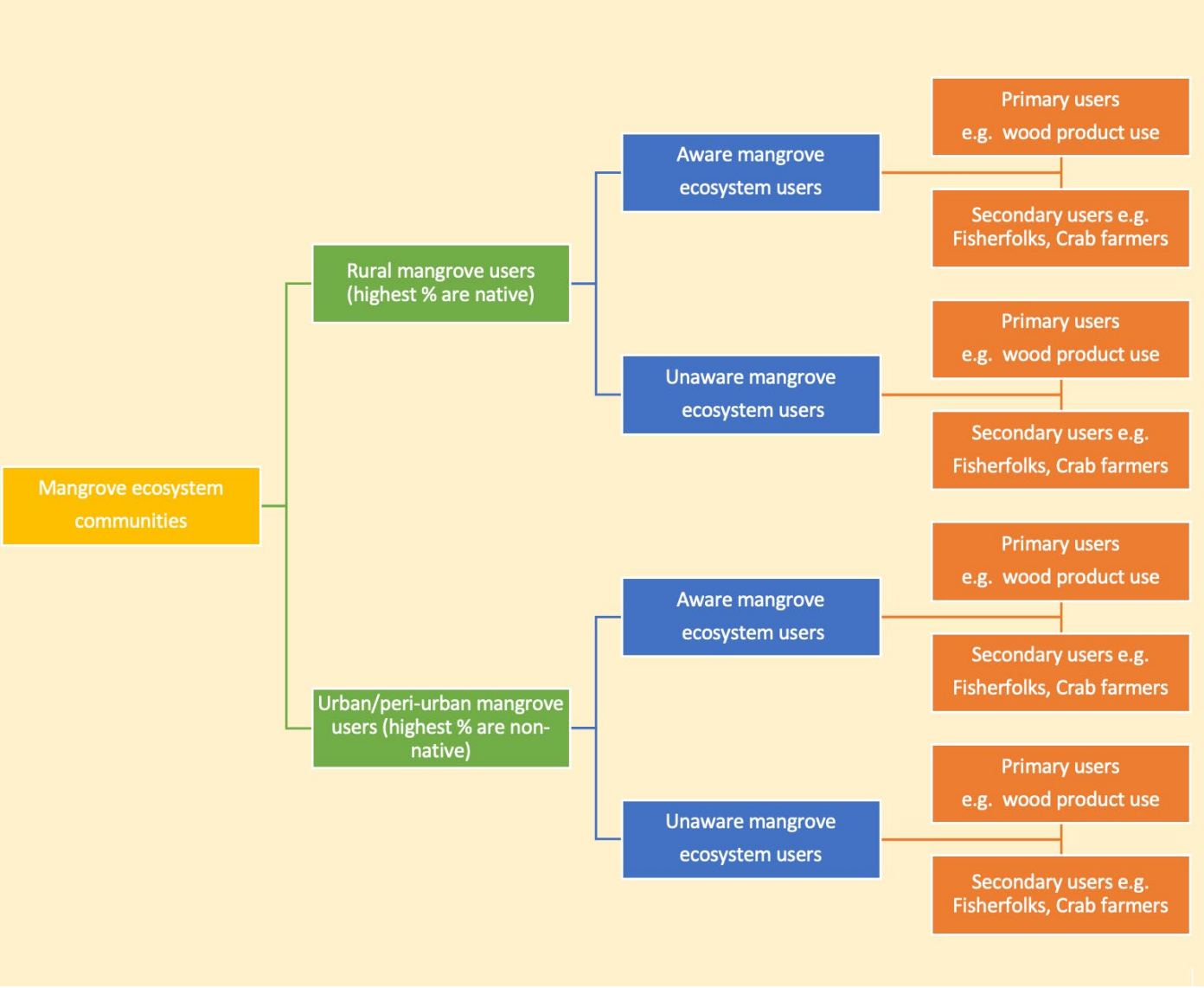


Figure 44 – 3: Characterization of mangrove dependent communities

County were analyzed together. Tudor creek was analyzed alone based on its urban settings. The Ungwana bay and Ngomeni, both under the same Community Forest Association, were analysed together. Lamu was also analyzed alone. The next consideration was the ecosystem services highlighted by the communities to be of direct economic benefits to them. The communities listed fish harvesting for commercial and subsistence use, fuelwood (both charcoal and firewood), ecotourism, and for some communities, beekeeping was highlighted. Tables 17-3 to 21-3 provide the data for the economic benefits to the community in the various clusters analyzed.

Table 18-3: Direct economic benefits to the communities (Mtwapa, Takaungu, Kilifi and Mida)

Activities Forest formation	Mtwapa Value in Ksh	Takaungu Value in Ksh	Mida creek Value in Ksh	Kilifi Value in Ksh	Total
Fish harvesting for consumption and commercial use	4,288,762	2,253,406	16,209,858	17,870,194	40,622,220
Firewood for commercial and own use	359,174,580	100,208,517	203,130,115	213,793,205	876,306,418
Charcoal for commercial own use	214,834,986	59,938,248	35,180,021	127,877,257	437,830,513
Ecotourism	5,232,000.00	840,000	6,000,000	1,344,000	13,416,000
Honey products	-	-	300,000	-	300,000
Total	583,530,329.79	163,240,171.59	260,819,994.98	360,884,656	
Grand total					1,368,475,152

Table 19-3: Direct economic benefits to the communities (Vanga, Gazi and Funzi)

Activities Forest formation	Vanga Value in Ksh	Gazi Value in Ksh	Funzi Value in Ksh	Total
Fish harvesting for consumption and commercial use	8,867,054	468,887	315,909	4,651,850
Firewood for commercial and own use	212,918,025.00	103,789,019	158,526,979.20	475,234,023
Charcoal for commercial own use	36,875,785	17,975,177.95	27,455,222.86	82,306,186
Ecotourism	150,000	1,742,200	192,000	2,084,200
Total	285,810,864	123,975,284	186,490,111	
Grand Total				569,276,259

Table 20-3: Direct economic benefits to the communities (Ungwana bay and Ngomeni)

Activities Forest formation	Ungwana bay Value in Ksh	Ngomeni Value in Ksh	Total
Fish harvesting for consumption and commercial use	17,870,194.00	4,163,084.92	22,033,278.92
Firewood for commercial and own use	93,633,200.64	262,873,866.24	356,507,066.88
Charcoal for commercial own use	56,005,319.88	157,234,131.33	213,239,451.21
Ecotourism	1,344,000.00	1,344,000	2,688,000.00
Total	168,852,714.52	425,615,082.40	
Grand total			594,467,797.01

Table 21-3: Direct economic benefits to the communities (Tudor Creek)

Activities Forest formation	Tudor Value in Ksh	Total
Fish harvesting for consumption and commercial use	22,179,963.78	22,179,963.78
Firewood for commercial and own use	4,775,291.21	4,775,291.21
Charcoal for commercial own use	28,082,890.70	28,082,890.70
Ecotourism	840,312,000	840,312,000
Honey products	60,000	60,0000
Total	895,410,145.69	895,410,145.69

Table 22-3: Direct economic benefits to the communities (Lamu)

Activities Forest formation	Lamu Value in Ksh	Total
Fish harvesting for consumption and commercial use	167,370,167.20	167,370,167.20
Fuel wood for commercial and own use	266,507,361.20	266,507,361.20
Total	433,877,528.40	433,877,528.40

3. Assessment of the 'human development' related to the change in mangrove forest densities and area

An assessment of the changing human development to the mangrove forest densities was also done. The spatial density and the distribution of mangroves is key in land use assessment and is tied to human development. The spatial densities are also tied to rehabilitation measures of mangrove ecosystems by communities within mangrove ecosystems. The spatial densities were established through remote sensing data that has been long recognized as one of the most efficient tools for land use /land cover (LULC). Landsat data was used for the year 2000 LULC classification and Sentinel data was used for the year 2019. Changes in forest densities are correlated to the functionalities of mangrove ecosystems such as coastal protection, carbon sequestration, and biodiversity richness among other important functions of the mangroves. The changing densities can give insight into the conversion rates that are

tied to exploitation of mangrove forest as well as rehabilitation. This process was also undertaken to examine and compare scientifically the engagement of the CFAs and how intensive the rehabilitation exercises have been against human development around the mangrove ecosystem. The Table 22-3 below gives a comparison of the various community level involvement in mangrove forest rehabilitation as well as their exploitation based on the mangrove forest densities. The comparison and the analysis are based on the level of engagement of the CFAs for the period between the years 2000 and 2019. In addition, an assessment of the linkage to mangrove dependence by local communities was done to bring out an understanding of the socio-economic benefits that accrue from mangroves to the communities that are dependent on them. The information was drawn from the focus group discussions, key informants and key experts from the 11-forest formations visited along the Kenyan coast. The assessment looked at aspects such as; the proximity to the mangrove ecosystem (distance), the cultural understanding of the role of mangroves within the communities, the social benefits of mangrove as depicted by the communities, the mangrove ecosystem uses, the socioeconomic role in both urban and rural settings, the general importance of mangrove, the local knowledge on mangrove conservation, the communities' willingness to contribute towards mangrove conservation and their time use in the mangrove conservation. The findings are concluded from the narratives provided for each of the forest formation by the key informants. Various secondary data sources were also used to provide information about the population that live or are adjacent to mangrove communities. A study by Crona et al. (2009) established that the local communities are involved in extraction of forest or marine products in, or in close vicinity, to the adjacent mangroves. The extents and level of exploitations and the associated mangrove products were determined partly by cultural and economic preferences. The household interviews for example, confirmed the level of dependency to be about 69.2% of the people living within the 10Km radius. Those directly dependent on the mangrove ecosystems were identified to be 42.9% of the households interviewed across the 11forest formations.

The local community, through the key informants' interviews and the focus group discussions, confirmed to have considerably good knowledge on the functioning of the mangrove ecosystems. The level of awareness was mostly on the importance of the ecosystems to the existence of fish, crabs and molluscs in the creeks and adjacent lagoons. The contribution of the mangrove ecosystems to; the aesthetic and tourism state, habitat provision for bees, shoreline protection, climate change mitigation and soil erosion control, and the impacts of these benefits to their general well-being was also established during the focuss group discussions as captured in the loop diagrams done during the FGDs, see appendix 5.0. This increased awareness has over time led the communities to become more involved in mangrove conservation initiatives, managed by the communities themselves. For instance, an active community-based mangrove conservation group, the Mida Creek Community Conservation Group, is currently undertaking a project that has integrated mangrove conservation, mud crab fattening and ecotourism. The fishermen from the Mida Creek have also demonstrated a unique understanding of the ecological characteristics of the mangroves. For example, they have supported the efforts of scientists to understand these ecological conditions as was observed and explained during the field study. Similar narratives cut across all the forest formations visited. The details of this are presented in Table 23-3 below. Table 24-3 presents other socioeconomic indicators of interests.

Table 23-3: Assessment of the human development related to the change in mangrove forest densities and area

Forest formation	Area 2000 in Ha	Forest Densities in Ha			Area 2019 in Ha	Forest densities in Ha			Conservation aspects	Remarks
		Dense	Moderate	Sparse		Dense	Moderate	Sparse		
Vanga	3632.89	2335.72	220.72	1076.46	3879.86	2471.54	539.46	868.87	Active CFA (developed a PFMP) Moratorium on wood products harvesting in place	There is significant improvement in forest area. There is significant forest increase calculated to be 12.998ha/year for the period 2000 to 2019. There is significant change in mangrove forest densities. An indication of conservation efforts and the efficiency of the moratorium.
Gazi	528.35	427.52	96.10	4.74	544.71	436.94	100.24	7.53	Active CFA (developed a PFMP) Moratorium on wood products harvesting in place	There is a significant improvement in forest area. There is significant change in mangrove forest densities. An indication of conservation efforts and the efficiency of the moratorium. Forest increase has been calculated to be 0.86ha/year between 2000 and 2019)
Mida	1778.43	1143.97	581.883	52.58	1814	961.97	664.88	187.83	Active CFA (developed a PFMP) Moratorium on wood products harvesting in place	There is a significant improvement in forest area. The forest increase is calculated to be 1.9074ha/year for the period 2000 to 2019. There is significant change in mangrove forest densities. An indication of conservation efforts and the efficiency of the moratorium. There is an indication of degradation ongoing with the changing densities.
Funzi	2009.169	1384.42	432.73	192.01	1305.608	574.86	729.82	0.92	CFA not active and moratorium on wood products in place. A BMU was interviewed instead.	There is significant decrease in mangrove forest area despite the implementation of the moratorium. The forest decrease is calculated to be 37.03ha/year for the period 2000 to 2019. Forest densities are changing significantly indicating the presence of degradation within the mangrove ecosystem. Continued decrease of the dense part of the forest, is an indication that illegal wood extraction activities could be high as was highlighted by the BMU

Forest formation	Area 2000 in Ha	Forest Densities in Ha			Area 2019 in Ha	Forest densities in Ha			Conservation aspects	Remarks
		Dense	Moderate	Sparse		Dense	Moderate	Sparse		
Tudor	1244.24	95.12	971.85	177.26	767.39	62.12	564	140.75	CFA is active (developed a PFMP) and moratorium in place	There is high level of decrease in mangrove forest area. The decrease is calculated to be 25.097ha/year for the period 2000 to 2019. There is less dense mangroves forests which indicate high levels of degradation. Conservation effort may not match the level of degradation This being an urban setting, population pressure from informal settlement adjacent to the mangroves may be playing a significant role in the levels of degradation. Transformative development was highlighted by the CFA as key driver to increased degradation
Mtwapa	538.73	44.05	485.044	19.64	597.096	149.36	273.63	174.106	CFA is active (developed a PFMP) and moratorium in place	There is a significant improvement in forest area. The forest increase is calculated to be 58.37ha/year for the period 2000 to 2019. There is significant change in mangrove forest densities. An indication of conservation efforts and the efficiency of the moratorium.
Takaungu	475.78	16.37	370.17	89.24	371.39	287.52	14.18	69.68	CFA not active and moratorium was in place. A BMU was interviewed instead.	There is significant decrease in mangrove forest area despite the implementation of the moratorium. The forest decrease is calculated to be 5.49ha/year for the period 2000 to 2019. Forest densities are changing significantly indicating the presence of degradation within the mangrove ecosystem. Community members are mostly fisher folk and therefore not dependent on wood products as highlighted during the focus group discussion

Forest formation	Area 2000 in Ha	Forest Densities in Ha			Area 2019 in Ha	Forest densities in Ha			Conservation aspects	Remarks
		Dense	Moderate	Sparse		Dense	Moderate	Sparse		
Kilifi	789.56	242.05	507.67	39.85	1025.50	196.99	542.71	285.80	CFA is active (developed a PFMP) and moratorium in place	There is significant improvement in forest area. The forest increase is calculated to be 12.42ha/year for the period 2000 to 2019) There is significant change in mangrove forest densities. An indication of conservation efforts and the efficiency of the moratorium.
Ungwana Bay	1637.84	404	1173.39	59.79	2062	847.22	779.94	435.31	CFA is significantly active and moratorium in place	There is a significant improvement in forest area. The forest increase is calculated to be 22.35ha/ year for the period 2000 to 2019. There is significant change in mangrove forest densities. An indication of conservation efforts and the efficiency of the moratorium. The community draws products such as tannins and dyes from the mangrove ecosystem. The CFA is involved in serious Casuarina tree planting for timber as alternative. In the focus group discussion, it was highlighted as a very good alternative. The casuarina initiative can be significantly associated with increase in mangrove forest area despite a weak CFA.
Ngomeni	1865	385.66	1425.56	53.78	2530.42	961.07	1139.22	430.12	CFA is significantly active and moratorium is in place	There is a significant improvement in forest area. The forest increase is calculated to be 34.86ha/year for the period 2000 to 2019. There is significant change in mangrove forest densities. An indication of conservation efforts and the efficiency of the moratorium. The forest increase is recorded at 0.35%. The community draws products such as tannins and dyes from the mangrove ecosystem. The CFA is involved in serious Casuarina tree planting for timber as an alternative. In the focus group discussion, it was highlighted as a very good alternative. The casuarina initiative can be significantly associated with increase in mangrove forest area despite a weak CFA.

Forest formation	Area 2000 in Ha	Forest Densities in Ha			Area 2019 in Ha	Forest densities in Ha			Conservation aspects	Remarks
		Dense	Moderate	Sparse		Dense	Moderate	Sparse		
Lamu	35458.07	10461.75	19827.08	5169.243	32790.91	13084.70	12340.79	7365.414	CFA not active and moratorium was lifted	There is an indication of high level of degradation. There is high increase in sparse forest. The rate of forest loss is calculated at 140ha/year between the year 2000 to 2019 Conservation efforts are required and legislative measures to curb the high levels of degradation.

Table 24-3: Assessment of the linkage to mangrove dependence by local communities

Indicator	Household interviews	CFA Focus group discussion	Key informant	Key expert opinion	Remarks
Numbers interviewed	77	7	12	18	
Proximity to the mangrove forests (distance)	Those nearer the mangrove ecosystem, i.e., within 2km radius were found to be highly dependent. Out of the households interviewed 42.9% earned directly from the mangroves. Those further from the mangrove ecosystem are less dependent	Members of the CFA indicated those closer to mangroves especially the fisherfolks were highly depended on mangrove ecosystem	The key informant highlighted the dependency was common among the fisherfolks as they were fishing and making boats from the wood products	The key experts highlighted that communities living in close proximity were more dependent on the mangrove with the dependency not exceeding 5km radius away from the mangroves	Those benefiting directly from the mangrove ecosystem were closer to the mangroves compared to those benefiting indirectly
Cultural understanding of the role of mangroves within the communities	28.6% of the households in Mtwapa, Takaungu, Kilifi and Mida find mangrove ecosystems important to various cultural activities.	Mangroves in Mida creek play a significant role on the preservation of indigenous knowledge revolving around mangroves. Traditional groups and cultural centers are some of the allowable user rights within the ecosystem In Mtwapa, spiritual activities inside the mangrove are very important to the local communities. In addition, the aesthetic value of the mangroves during flowering season is equally important. In Kilifi the spiritual and religious activities within the mangrove ecosystem are key. Traditional activities such as use of mangrove for medicine were also key among the local communities. Overall self-importance, aesthetic /beauty and indigenous knowledge were the most important cultural aspects that brough out the importance of the mangroves to the local communities. In Ungwana bay and Ngomeni, key significant cultural activities were the use of Tannins and dyes from mangrove barks and leaves	The key informants highlighted various religious activities that are conducted in the mangrove ecosystems even though they have reduced over the years. The indigenous knowledge and aesthetic/ beauty were highlighted has key in mangrove ecosystems within the local communities. Ttraditional medicine from mangroves were also highlighted as important	The Key experts highlighted the various traditional activities such marriage ceremonies and the shrines in Kilifi, Mtwapa and Takaungu that form part of the local community culture. The beauty and aesthetic value was also something the community upheld. Communities also used mangroves for their traditional medicines. The traditional housing structures were other significant cultural aspects highlighted indicating the role of mangroves.	The socioeconomic benefit of mangrove accrued to the local communities are linked to cultural activities especially among locals. In urban setting, cultural understanding of the role of mangrove was not evident especially among the non-locals

Indicator	Household interviews	CFA Focus group discussion	Key informant	Key expert opinion	Remarks
Social benefits of mangrove as depicted by the communities	95.2% of households interviewed indicated that the mangrove ecosystem was generally important to the livelihoods of the local people.	The non-economic social uses of mangrove were highlighted as; improved security, increased social cohesion as result of user groups in the mangrove ecosystem, increased empowerment and exposure and improved livelihood resulting to increased sources of income. These were highlighted in forest ecosystems where the CFAs were active such Gazi, Vanga, Mtwapa, Tudor, Kilifi, Ungwana, Ngomeni and Mida.	The key informants highlighted improved livelihoods; security due to increased sustainable use schemes as well as alternative sources of income. Social cohesion, improved health and preservation of cultural activities were among other mentioned social benefits.	Key experts indicated the improvement in livelihoods especially in active CFA areas such as Vanga, Gazi, Tudor, Mtwapa, Kilifi, Ungwana bay, Ngomeni and Mida.	Improved in livelihood was key and evident in this study
mangrove ecosystem use	52.4% of the household interviewed indicated that they do use mangrove ecosystem products such wood, fish building materials and traditional medicine while another 42.9% directly earn from the mangrove ecosystem. The earning was mostly from wood products, fishing, bee keeping and ecotourism. 85.7% were confirmed to use firewood as their primary source of energy while 33.3% relied on charcoal as their secondary source energy.	The following mangrove products and services were highlighted to be of significance; Fish and other invertebrates, Tannins/dye, Fuel wood (charcoal and firewood), building poles, beekeeping, medicine, air purification/ carbon sequestration, aesthetics, soil erosion control, fodder for livestock, educational purposes, job creation, paint, wind breaking, habitat for migratory birds, indicator for weather prediction and ecotourism	The following mangrove products and services were highlighted to be of significance; fish and other invertebrates, tannins/dye, fuel wood (charcoal and firewood), building poles, beekeeping medicine, air purification /carbon, sequestration, aesthetics, soil erosion control, fodder for livestock, educational purposes, ecotourism and job creation	The following mangrove products and services were highlighted to be of significance; fish and other invertebrates, tannins/ dye, beekeeping, medicine, air purification/carbon sequestration, aesthetics/ ecotourism, soil erosion control, educational purposes and job creation	The local community has high level of understanding of the mangrove ecosystem especially in areas where the CFAs are active

Indicator	Household interviews	CFA Focus group discussion	Key informant	Key expert opinion	Remarks
Assessment of the socioeconomic role in both urban and rural settings	The perception of the communites on the importance of mangroves was higher in the rural settings compared to the urban settings. In the urban areas, the inhabitants of the settlements within close proximity to the mangroves were mostly unaware of the importance of the mangrove ecosystems, most of whom are non-native. In the rural areas, the perceived importance was mostly driven by the dependency of the local communities on the mangrove ecosystem and where cultural activities were tied to the mangroves.	It was generally highlighted that urbanization has greatly affected the conservation of mangroves due to population pressure as well as high levels of transformative development being undertaken by the Government and the private sector. The population of the unaware communities in the urban areas was said to be very high	It was generally highlighted that changes have taken place over years such that the dependency on mangrove ecosystems seem to be decreasing in urban settings while in the rural setting the dependency has been maintained or increased.	The Key experts put emphasis on the mangrove ecosystem use and dependency among local communities to be driven by traditions and cultural activities attached to the mangrove ecosystem	Socioeconomic role of mangroves I urban settings is diminishing while in the rural settings it hase been maintained over the years
General importance of mangrove	In the households interviewed, the level of importance of mangroves was placed in the following products across all the forest formation; Fish-85.7% Sea weed farming-28.6% Firewood-42.9% Furniture-28.6% Traditional medicine-19% Ecotourism- 57.1% Cultural activities-28.6% Honey production-52.4% Climate change-95.2%	Mangrove were identified to be very key in supporting the livelihood of the local communities. Fishing, wood products, ecotourism and cultural activities were highlighted to be the ones relying on mangrove ecosystems	The key informants indicated that, the mangroves generally support the livelihood of the local communities.	The key experts highlighted that mangrove were very important to the livelihoods of the local communities	The mangrove ecosystem importance to the local community was evident in this study fromm the field and secondary data collected. The support to the livelihood of local community was very high.
Local knowledge on mangrove conservation	None were highlighted.	None were highlighted.	None were highlighted.	None were highlighted.	

Indicator	Household interviews	CFA Focus group discussion	Key informant	Key expert opinion	Remarks
Willingness to contribute towards mangrove conservation	76.2% of the households interviewed were willing to contribute for the conservation of the mangroves, owing to the importance of the mangrove ecosystems to their livelihood.	The willingness to contribute for mangrove conservation was reported across all the forest formations. The contribution range between Ksh 200 to Ksh 500	The willingness to contribute for mangrove conservation was reported for all the key informants. An average of 1-2hr in a day for mangrove conservation was highlighted. The need to preserve the mangroves for the future generation was highlighted as the main driver, noting the foreseen increased mangrove demands due to increased propulation	The key experts indicated that, the communities' willingness to conserve mangroves is tied to the benefits they draw from the mangroves. The PFMPs have been very key in assisting the communities achieve conservation to date.	In some FGDs, it was highlighted that the continued conservation of mangrove would increase if the benefits that the local communities can draw continues to increase
Time use in the Mangrove ecosystem	The households interviewed indicated the following hours as contributions to mangrove conservation; 1hr-5hrs(Ksh100-500)-38.1% >5hrs(ksh600-1000)-23.8%	The CFAs espressed their willingness to set aside an average of 2-3hrs per day, twice a week to participate in conservation activities. These activities involved tree planting, patrolling and raising tree nurseries.	Most Key informants indicated the importance of conservation while indicating a willingness to contribute 1-2hrs in conservation related activities.	Communities have shown the willingness to set aside time for conservation.	

Table 25-3: Other Socioeconomic indicators analysed

Socioeconomic indicators	Source	Value			Remarks
		Men	Women	Total	
National Parameters					
Population	KNBS 2019 data	1,974,120	2,014,604	3,988,803	Compiled population for five counties.
Population growth	State of population report 2020 by UNEPA	Year and % -	Year and % -	Year 2019 2.2%	Adopted from the KNBS data 2019 for Kenya. These are National parameters
Population Migration	Migration of people in Kenya by UN migration			Rural-40.5% Urban-59.5%	Based on coastal region migration based KNBS 2009 data. These are National parameters
Per Capita Income	Worldbank.org	-	-	$1817	World Banl national accounts data and OECD national account data files
Population living below the National poverty line	Poverty and Equity brief 2020	2015-37%	2015-36%	2015-36.1%	This information is based on the official poverty statistics for 2015/16, produced by the KNBS national poverty lines. The overall rural and urban poverty lines are, respectively, 3,252 and 5,995 Ksh/month/ person (in adult equivalent terms) and include minimum provisions for both food and nonfood expenditures. The food poverty lines without provisions for non-food expenditures correspond to the average expenditure needed in 2015/16 to attain the minimum recommended daily intake of 2,250 kilocalories. These are National parameters
Prevalence of moderate or severe food insecurity in population based on food insecurity experience	Worldbank.org	-	-	2018-25.805%	Information is based on data adopted from FAO. These are National parameters
Mortality rate	Migration of people in Kenya by UN migration	-	-	1,172 death on average per day (48.83 in an hour)	Statistics based on 2018 by UN DESA. These are National parameters
Coverage of essential health services	Measuring progress towards universal health care coverage by KEMRI Wellcome Trust	-	-	2014- 52%	Based on Universal Health Care Coverage Index of 2014

Socioeconomic indicators	Source	Value			Remarks
		Men	Women	Total	
Literacy	Migration of people in Kenya by UN migration	2017-80.08% (11,523,522 persons)	2017- 74.9% (10,638,712 persons)	2017- 77.49 (22,162,234 persons)	Statistics based on 2018 by UN DESA. These are National parameters
Population with access to electricity	Data.worldbank.org	-	-	2018-75%	World Bank national accounts data and OECD national account data files
Number of persons affected by natural disasters	Reliefweb.int	-	-	160,000 persons	The information is based on the floods and landslide information for 2019 provided by Kenya Red Cross Society. The number of persons affected were in 25 counties. Marsabit, Wajir, Tana River, Turkana, Elgeyo Marakwet, Kitui, Meru, Kajiado, Nandi, Kwale, Garissa, Muranga and Busia.
Characterization of population within 10 Km radius of mangroves					
Number of people living near 10km radius of mangroves	KNBS 2009 census data projected to 2019	1,314,831.66	1,332,324.99	2,647,184.1	2009 KNBS data was used due to the lack of geographical reference data for KNBS data 2019. Data related to the 10-forest formation that were surveyed; Vanga, Funzi, Gazi, Tudor, Mtwapa Creek, Takaungu, Kilifi Creek, Mida Creek, Ngomeni, Ungwana Bay and Lamu.
Population growth		-	-	2.7%	Growth rates adopted from the official gazetted data drawn from 1999 census data for the 5 counties.
Prevalence of moderate or severe food insecurity in population based on food insecurity experience		-	-	-	No data available
Mortality rate		-	-	-	No data available
Coverage of essential health care services		-	-	-	No data available
Literacy		-	-	-	No data available
Population with access to electricity		-	-	-	No data available
Number of persons directly affected by natural disasters		-	-	-	No data available
Mangrove area					No data available

Socioeconomic indicators	Source	Value			Remarks
		Men	Women	Total	
Population migration into and out of areas within 10km radius of mangroves		-	-	-	No data available
Per capita income					No data available
Socioeconomic indicators derived from mangroves (Household Survey)					
Total and average household income for communities within 10 km radius	Based on household interviews	-	-	Ksh 1000-10,000 accounting for 34.6% of the household interviewed Ksh 11,000-20000 accounting for 42.3% of the household interviewed Ksh 21000 to 30000 accounting for 19.2% of the household interviewed and Ksh 31000 to 40000 accounting for 3.8% of the household interviewed	The incomes are mostly generated from Farming (42.3%), Business (26.9%), Fishing (26.9%) and Others at (3.8%).
Directly derived from mangroves	Based on household interviews	-	-	42.9% of the household interviewed earn a living directly from Mangroves	These activities include Fishing which takes up 23.2%, Honey/firewood which take up 15.6%.
Indirectly derived from mangroves	Based on household interviews	-	-	69.2% of the household interviewed earn a living indirectly from the mangrove ecosystem.	These indirect earnings are from Fish business (Fish for sale, Crabs and Prawns) which take up 34.2%. Other activities such as acquisition of timber for construction takes up 7.6% of the households interviewed. There are others involved in conservation in exchange for school scholarship programs, this takes up 7.6% of the households interviewed. Tour guiding and Bee keeping each taking up 7.6% and 3.8% respectively.

Socioeconomic indicators	Source	Value			Remarks
		Men	Women	Total	
Total and average household *spending/ consumption* on basic necessities (food, health, etc) in communities near (within 10km of)	Based on household interviews			The amount money spent on food range from Ksh 1000-10,000 which forms 96.2% of the households interviewed. The amount of money spent on health was Ksh 1000-5000 which forms 80.8% of the households interviewed. The amount money spent on clothing and shelter was Ksh 1000-5000 which forms 53.8% of the households interviewed. The amount of money spent on water was Ksh 1000-5000 which forms 65.4% of the households interviewed.	The expenditure is cumulated on monthly basis and based on the household interviews conducted in 2021.
Number of people earning **their living directly from mangroves and their resources**	Based on household interviews			42.9% of people are earning directly from mangroves based on household interviewed.	The households interviewed were not a representative number of the total household within the 10km and therefore may not give indicative figures.
Number of income sources per household (general and specifically highlighting those related to mangroves)	Based on household interviews			Number of household income sources as recorded from the household surveys are; Farming-42.3% Business-26.9% Fishing-26.9% Other-3.8%	The households interviewed confirmed to rely heavily on informal employment. This formed 81.2% of the households interviewed.
Household asset index related to mangroves in households near (within 10km radius)	-	-	-	-	No data available

Socioeconomic indicators	Source	Value			Remarks
		Men	Women	Total	
Perceived value of **mangroves (e.g., improved wellbeing as a result of CBNRM), ideally broken down by ecosystem service (or at least higher-level categories like woody vs. non-woody)**	Based on focus group discussions			The value of mangroves has increased owing to -Improved livelihood and leading to improved health - A sense of security owing to increased IGAs especially for the youth who would otherwise be involved in rogue activities. -Improved aesthetic value due to the beauty of mangroves, especially in the flowering season -Increased social cohesion as result of the community meeting in conservation groups	At household level, importance was placed on mangroves due to the ability to provide the following services. 1.Provision of fish 2.Provision of building material 3.Regulation of climate change 4.Provision of Livelihood e.g., Fish, wood fuel, timber for construction and generally a source of income for the locals
Food and nutrition security **(in general, and specifically related to mangroves)**	Based on household interviews			53.8% of the household interviewed have access to a balanced diet.	Generally, most of the households are food secure.
Mangrove use (household survey)					
Number of people involved with or dependent on mangrove-related cultural activities such as (eco) tourism (specify the type of activity in remarks)				12.4% of the household interviewed are involved in ecotourism activities.	These activities range from Board walks and general tour guiding. Data on exact number couldnot be established in the forest formations visited.
Number of fishers dependent on mangroves as fishing ground or nursery habitat				About 23.2% of the households interviewed are involved in Fishing activities	Data on Beach Management Units (BMU) where most fisherfolks are registered could not be obtained.
Number of species frequenting and/or dependent on mangroves that are of nutritional/ subsistence/ economic value (list species in remarks)				Rabbit fish, Scavengers, Parrot Fish, Rock cod, Cavalla jacks, Baracuda, Milk fish, King fish, Queen fish, Sail fish, Oysters, Beche-de-mer, Octopus, Squids Lobsters, Prawns, Crabs, Mullets, Little Mackerel, Blue Marlin, Black Marlin, Stripped Marlin, Bonito	-Species are captured as per the data provided by the Department of Fisheries at the county level.
Number of people involved with income-generating activities based on mangroves as raw material (timber, fuelwood, ...)	-	-	-	19% of the households interviewed earn from fuel wood.	Based on household intreviews conducted

3.3.3: CONCLUSION: MANGROVE COMMUNITIES IN KENYA

The local communities' utilization of the mangrove ecosystem is highly dependent or driven by culture as was understood in the literature review as well as the field study. From this study, two categories were evident; the "aware" and the "unaware" community users and this highly influenced the resultant type of use of mangrove products. The primary users who were found to be directly dependent on mangrove for products such as wood, were also found to be quite conversant about how valuable the mangroves were, thus they were categorised as the "aware" communities. On the other hand, the secondary users who were mainly composed of fisher folks were the "unaware" users, who drew no significant relationships between the presence of the fish and the health of the ecosystems. This broadly defined the conclusion made on the dependency and the resulting sustainable utilization of the mangrove ecosystem.

It was also established that there were quite a number of sustainable development goals addressed through the utilization of the mangrove ecosystems. This was identified by assessing the SDGs that lead to improved livelihoods, increased social cohesion, improved health and improved access to spiritual needs. In line with this, Sustainable Development Goals number 1, 2, 7,8,11,13,14,15 and 17 were concluded to be directly realisable through the utilization of the mangrove ecosystem.

Further the benefits accrued to the communities economically as summarized in Tables 17-3 - 21-3, evidently show that fishing, fuelwood, ecotourism and honey production have led to significant revenues in the various forest formations that were studied. Even though the investment cost could not be determined at the time of the study due to limited data availability, one can easily visualize the value that the mangrove economic benefits give to the local communities, and the level of dependency attached to it.

The assessment of the human development to the change in area and forest densities led to the identification of the role of communities in sustainable utilization of the mangrove ecosystem. It is apparent that the consolidated efforts of the local communities are key in the conservation of the mangrove ecosystems. Further, their role is strengthened with the increase in the social-economic benefits realised from the mangrove ecosystem. When communities remain unaware and not concerned, then the efforts of sustainable utilization and increased socio-economic benefits to the communities cannot be realised. The presence of a legal system on its own may not achieve any sustainable economic benefits to the communities, but on the contrary, it may be a source of degradation due to the protected or limited availability of benefits by law.

The study also highlighted the dependency of the local communities to the mangrove ecosystems by assessing the proximity of the communities to the mangrove. Communities living closer to the mangrove ecosystems were found to be highly dependent compared to those that were far off. The assessment of the cultural understanding of mangrove ecosystems by the local communities led to the conclusion that, communities whose culture is connected to mangrove use are likely to be highly dependent on the mangrove ecosystem and that communities' activities related to mangroves were mostly connected to their cultural undertakings. In addition, 95.2 % of the households interviewed indicated that the mangrove ecosystems were very important to the livelihood of the local people, because, it was a source of income, provided community cohesion and a sense of security. The local community also placed a level of importance to the certain products and services that are associated to mangrove. The community believed that the mangroves were responsible for fish, sea weed farming, firewood, traditional medicine, ecotourism, cultural activities, honey production, aesthetic value (a place they could visit to relax) and a source of employment for the youth.

The mangrove ecosystem uses also varied between the rural and urban settings. This was attributes to the cultural associations, which were found to be higher in the rural areas compared to the urban areas. It was also established that the urban areas were mainly inhabited by non-natives who have very little understanding on the mangrove ecosystems. Finally, the willingness of the local communities to be involved in the conservation efforts was a sign that they valued the benefits that were accruing from the ecosystems. 76.2% of the households interviewed indicated that, they were willing to participate in mangrove conservation. More details about the dynamics of the communities, populations and households have been provided in Tables 23-3 and 24-3 of this section.

3.4: OUTPUT 4 – BUSINESS CASE DEVELOPMENT FOR MANGROVE CONSERVATION ALONG THE KENYAN COAST

The threats to mangroves in Kenya are many, and most of them are human-induced. In the past, when human populations were relatively low, activities such as cutting mangrove trees for building poles and firewood were on a sustainable basis with no formal system of control, but this is no longer the case. The increase in the population along the Coast, the rapid growth of villages and towns generally, and the influx of people from inland to the Coast because of adverse conditions have increased the threat to mangroves. Wass (1995), estimated that 70% of the wood products demand along the Kenyan Coast are obtained from mangroves, with the demand cutting across the need for firewood and building poles. On the other hand, there are numerous competing lands uses that are currently threatening the mangrove forests' existence through conversion of mangrove areas to other uses. According to (Abuodha & Kairo, 2001), among the most destructive activities affecting mangrove ecosystems are clear-felling of mangroves for; **rice cultivation**, **construction of solar salt pans**, **aquaculture ponds**, **and urban development**. Owing to this, the continued wellbeing of Kenya's Coast and its ever-increasing human population evidently depends on how well the coastal biodiversity and resources are conserved and managed. Therefore, it is vital to effectively manage Kenya's mangrove ecosystems through sustainable mangrove forest management.

To accomplish this, there is a need for environmental reform efforts in Kenya, specifically on the perception of mangrove's importance among the decision-makers. It is also evident that there is an urgent need for awareness and education among coastal communities to preserve the area's coastal resources and implement sustainable resource management. This, can only be achieved by building a strong business case for mangrove conservation along the Kenyan Coast.

3.4.1: METHODOLOGY

The approach adopted for this project took two strategic perspectives;

I. A simple Cost-Benefit Analysis (CBA) was performed with a key focus on substantiating the premise that mangroves have a higher economic value than any other alternative or competing land use. This was achieved by highlighting the economic importance of mangrove ecosystems in Kenya as a comparison to rice farming, a rife competing land use along the Kenyan Coast.
II. An evaluation of viable mangrove investment key entry points was done with a key focus on presenting practical proposals that can be used to mobilize finance for nature-based solutions, with a vision to align both national and global economic development with the value of mangrove ecosystems.

The assessment was anchored on the need to integrate environmental, economic, and social concerns in the development process. Great emphasis has been put on Sustainable Development (SD) which as defined by the United Nations General Assembly, 1987, is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

I. Cost Benefit Analysis (CBA)

i) A simple Cost Benefit Analysis was applied to evaluate and compare the economic unit values of mangrove and the economic unit values of the identified competing land use.

NB. Economic data for the prominent competing land uses along the Kenyan Coast was largely unavailable, and economic data for only rice production in the Vanga area of Kwale County, was considered comprehensive enough to undertake a CBA. This was thus was earmarked for use in this assessment together with the economic data for the associated forest formation i.e. Vanga forest formation

ii) Drawn from Buncle et al. (2013), the following steps were followed in carrying out the CBA;
   (a) Determining the objective of the CBA (by outlining the question that the CBA seeks to answer and the decisions it seeks to inform).

(b) Identifying the costs and the benefits (by determining the impacts that the ventures are expected to generate and the costs and benefits associated with the ventures.
(c) Valuing of the costs and the benefits (by expressing the costs and benefits in monetary terms, and determining the costs and benefits that can be valued, and how this can be done).
(d) Considering the distributional effects (costs and benefits) and how this can be distributed among different groups, over space and time.
(e) Drawing of conclusions and preparing recommendations to determine the feasibility and the viability of the ventures in financial/economic terms and the conditions under which they are intended to occur.

iii) The unit economic values for mangrove in the Vanga forest formation was computed. The calculation process has been expounded in Chapter 3.1.1 of this report. For the purposes of this analysis, the resultant unit economic value of the Vanga forest formation is denoted by 'MV'.

iv) The unit economic values for rice farming in the Vanga irrigation scheme was computed. The calculation, followed the approach as presented by Malik et al., (2015), and the resultant values are denoted by 'RV'.

Total area of Rice (ha) = *Farmland area under Rice (ha)*

Investment cost = *Irrigation channels' cost construction (Ksh/ha) + farming equipment (Ksh/unit) ×total area of aquaculture (ha)*

Production cost = *fixed cost (e.g. equipment depreciation) (Ksh/unit) + variable cost (ploughing, seeds, fertilizer, etc) (Ksh/unit) × total area of rice (ha)*

Benefit of RV = *production (kg/ha/year) × price (Ksh/kg) × total area of rice (ha)*

Undiscounted Net Benefit/year of RV = *benefit of RV (Ksh/year) – (investment cost + production cost) (Ksh/year)*

Undiscounted Net benefit/ha/year (RV) = *net benefit of RV (Ksh/year)/total area of rice (ha)*

v) For the implementation of the CBA, a comparison of the undiscounted annualised net economic benefits per hectare for both mangroves and rice was done

vi) Finally, the CBA analysis outputs were documented, and the conclusions and recommendations on the viability of the associated trade-offs were made.

An assessment of viable mangrove investment key entry points

The measurement of the economic benefits provided by mangroves plays a crucial role in realizing their potential as a natural asset. However, while mangroves support significant value-added, cost reductions, and avoided damages, there are substantial outflows of value, such that little or none of this value is returned as investments to sustain mangroves and preserve the ecosystem values. Further, much of mangroves' sustainable economic potential is not captured, resulting in the non-exploitation of potentially valuable income, employment, business opportunities, and other revenue streams that mostly remain unavailable and untapped.

The intended goal of this assessment was to build a business case for the conservation of mangroves through the identification and recognition of the investment pathways to invest in nature-based resilience in the Kenyan mangrove ecosystems.

To **achieve this**, earth observation-based data, augmented by field data and online literature were used to identify investment priorities or 'benefit areas' where mangroves can provide value to potential investors while at the same time ensuring mangrove conservation and restoration.

The **expected outcomes** are practical proposals that will act as 'calls to action' and that can be used to capture the attention of potential investors and financiers for nature-based solutions that can help

align both national and global economic development with the value of mangrove ecosystems found along the Kenyan Coast. The proposals will seek to promote investments in coastal ecosystem conservation by matching funding and other resources to the locations, actions, communities, and agencies where they are needed most.

3.4.2: FINDINGS: A BUSINESS CASE FOR MANGROVE CONSERVATION ALONG THE KENYAN COAST

3.4.2.1 Cost-Benefit Analysis

A simple CBA was undertaken to build a business case for mangrove conservation. A financial analysis was not conducted as the mangroves benefits generally accrue to the society as opposed to a particular enterprise. The analysis thus considered economic costs benefits analysis. **The aim was to provide a viable comparative baseline platform for determining the benefits and costs associated with mangrove conservation as compared to any other competing land use threatening the existence of mangrove ecosystems along the Kenyan Coast. It was done by showcasing which project's annualized net benefits are greater than its costs, and to whom the benefits accrue. The costs and the benefits of the projects were quantified in monetary terms so as to provide a uniform measure for comparison.** Among the various competing land uses identified along the Kenyan Coast, rice farming in Vanga area in the Southern Coast was earmarked for assessment as a case study.

Rice farming in Vanga – Kwale County

One of the major factors changing mangroves' characteristics within the region is inland topsoil erosion, typically from agricultural-related activities. The flat and rich organic soils of mangrove forests have made them prime locations for conversion. For instance, many thousands of acres of mangrove forest have been destroyed to make way for rice paddies. According to Spalding et al. 2010, when mangrove areas are converted for agricultural purposes, they are first deforested. Water from rain removes salt from the soil, and costly embankments are constructed to protect the area from seawater intrusion. When the soil salt levels are sufficiently low, the area is then ready for cultivation. Deforestation and alteration of natural hydrology often cause mangrove soils to dry out and become irreversibly acidic. Further, farmers often use fertilizers and chemicals, and run-off containing these pollutants makes its way into water supplies. Despite their resilience, mangroves can tolerate only a limited amount of agricultural pollution without dying. Also, waterways are often diverted for irrigation, which alters the natural flow of water. Because mangrove forests are adapted to tidal fluctuations, they end up being destroyed by such habitat changes.

Irrigation projects and other water-based projects in the Vanga area in Kwale County are dependent on the main river drainage systems in the County. The County is well-drained by seven major rivers and numerous minor streams, making it ecologically conducive for irrigation projects, especially rice farming due to the coastal lowland nature. The major rice irrigation schemes in the area are; Waga/Machame Irrigation projects on 190 ha of land and the Vichigini / Matoroni project on 135 ha; (County Government of Kwale, 2013). The Coast Development Authority has also been at the forefront in supporting enhanced food security among the coastal communities, and in 2013 it announced a Ksh 4 billion plan to improve rice production at the Coast through the Vanga Irrigation Scheme, which is mainly used for subsistence (Coast Development Authority, 2021).

Interviews with Agriculture experts within the region, revealed that the use of fertilizer and chemicals for rice farming in the Vanga area is prohibited, a move that negatively impacts on the production levels of the rice farms. This directive from the County Government is known to be beneficial to the general health of the mangrove ecosystems, however, the diversion of water fresh water for irrigation purposes is an impediment due to the resulting increase in salinity levels. This has impacted a lot on the mangrove ecosystems, such that only the salt tolerant varieties have remained. Further, according to the Adaptation Fund, 2013, the people of Vanga have, over the years, been victims of the rise in sea level, posing a threat to the locals as well as their livestock and property. In most cases, the communities are forced to move further inland until the waters subside, which has exacerbated the rate of mangrove degradation. Among other factors, the shoreline instability in the area can

be attributed to the inadequate shoreline protection from the mangrove due to its gradual degradation over time from agricultural activities.

It is therefore evident that there is a need to protect the valuable mangrove ecosystems, while still ensuring that the food security in the region is upheld. The main aim of this component is to showcase that the economic value of mangroves is higher, thus increasing the need for proper management and protection from destructive agricultural activities or any other human-induced activities. This also calls for increased resilience and adaptive capacity of the people of Vanga against the effects of sea-level rise and shoreline changes resulting from climate change and human-induced activities that have impacted the mangrove ecosystems over time.

Cost Benefit Analysis Outputs

The general applied principle was to economically compare the undiscounted annualized net economic benefits per hectare of the Vanga mangrove forest formation, denoted as 'MV' and the annualized net economic benefits of rice cultivation in the Vanga irrigation scheme, denoted as 'RV'. An assumption was made that the mangroves stock per hectare as well as the rice farming per hectare would remain fixed, i.e. there would be no conversion whether natural or otherwise.

For the mangrove ecosystem service values, data was collected from an organized Focus Group Discussion with the VAJIKI CFA. The information from the FGD was augmented by data from a survey of 5 households in the surrounding villages, where data on the costs and benefits of mangrove-related activities was gathered. Earth observation-based data was also used to quantify some of the ecosystem services that were not quantifiable using the field data (see chapter 3.1.1 of this report, for the detailed methods applied in the quantification and valuation of mangrove ecosystem services). The *economic analysis* addressed mangroves' benefits to the local communities for selected ecosystem services covering direct and indirect uses. The included mangrove ecosystem services are; artisanal fishing, fuel-wood harvesting, carbon sequestration, shoreline protection, habitat provision, biodiversity conservation, and tourism. Due to lack of site data, sediment trap, medicinal use, and education and research were not incorporated in the study. The existence values were also eliminated from the analysis. Table 26-3 below presents the undiscounted annualized net economic values for Vanga mangrove forest formation. Details of the totoal economic value can be found in chapter 3.1.2 of this report.

Table 26-3: Annualized Net Economic Values for Vanga Forest Formation (cost or value is in Ksh)

Ecosystem Service (ES)	Quantified ES / Yr	Units	Unit Price of ES	Total Revenue from ES/Yr	Incurred Costs/Yr	Net Revenue/ Yr	Mangrove Area	ES value / ha/Yr	Remarks
Food (Subsistence fisheries)	48,425	Kg.	195	8,867,054	484,250	8,382,804	3,880	2,161	Incurred costs adopted from UNEP, 2011
Fuel wood - Firewood	7,097,268	Kg.	30	212,918,026	-	212,918,026	3,880	54,878	Assumed 0 incurred costs to collect firewood
Fuel wood - Charcoal	819,449	Kg.	45	36,875,186	4,097,242	32,777,943	3,880	8,448	Incurred costs are based on expert opinions for production, transportation, etc. Estimated at Ksh 5 per Kilo
Tourism/ recreation	-	Person	-	1,344,000	-	1,344,000	3880	346.40	Every Site is accessed by 5-10 person as tourist per day from an entrance of Ksh 500. There is 1 ecotourism site in Vanga
Coastal protection	10,076	Meter	5,200	52,395,200	-	52,395,200	3,880	13,504	Construction cost viewed as a replacement cost
Habitat provision	214,813	Kg/ha	195	41,888,531	-	41,888,531	3,880	10,796	No incurred costs assuming a natural habitat: The mangroves' role in habitat provision for fishes and mariculture is calculated from soil organic carbon nutrient productivity in Kg/ha and calculated based on the price of fish catch.
Carbon sequestration	347,975	tones	1,000	118,417,168.14	-	118,417,168.14	3,880	30520.99	
Biodiversity conservation	46	Ha	1,608	73,360	-	73,324	46	1,594	Calculated based on the money set aside for forest conservation in the KFS 2018-2022 draft strategic plan that targeted 500,000ha nationwide, giving a Conservation cost per ha of Ksh 1608. The mangrove loss in Vanga is estimated at 57ha/year from Vajiki PFMP. 46 ha of the restorable area was identified and mapped from satellite imagery
TOTALS						482,409,125.1	3,880	124,336.70	
Undiscounted annualised net economic benefit per hectare (MV)								123,151.45	

Table 27-3: Annualized Net Economic Values for Rice Farming in Vanga

PARTICULAR/ ACTIVITY	UNIT	QUANTITY	UNIT PRICE in Ksh	TOTAL in Ksh
VARIABLE COSTS				
Seeds- (Local)	Kg	74	70.00	5,189.10
Bush clearing	Hectare	1	5,000.00	5,000.00
Ploughing		1	5,000.00	5,000.00
Nursery establishment & management	Unit	1	2,500.00	2,500.00
Flooding of seed bed	Hectare	1	5,000.00	5,000.00
Transplanting	Hectare	1	10,000.00	10,000.00
Scaring of birds	Monthly	2	5,000.00	10,000.00
Harvesting	Hectare	1	7,500.00	7,500.00
Threshing	Lump sum	1	2,500.00	2,500.00
De-hulling	Kg.	1,360	4.00	5,440.00
Packaging materials	50kgs bags	30	30.00	900.00
Total Variable Cost				59,029.10
YIELD	Kg.	1,360	70.00	95,200.00
Undiscounted annualised net economic benefit per hectare (RV)				36,170.90

For rice farming in Vanga, data for the economic benefits were acquired from the County Government of Kwale through the department of Agriculture, Livestock, and Fisheries. Table 27-3 above presents the undiscounted annualized net economic values for rice farming in the Vanga irrigation scheme

The continued degradation of the mangrove ecosystems due to the presence of rice cultivation, or even due to the conversion of mangrove to pave way for the expansion of rice farming in the Vanga area can only be worthwhile if 'RV' is greater than 'MV'. As shown in Tables 26-3 and 27-3 above, the undiscounted annualized net economic benefit for having a mature mangrove is higher than that of rice. Further, 'MV' only represents a minimum value of mangroves since only the 'use value' for selected ecosystem services was accounted for. The eliminated benefits from the eliminated ecosystem services and non-use values are expected to accrue at no additional significant economic costs to the society, and thus increase the superiority of mangrove conservation over rice farming in the study area.

In conclusion, the analysis shows an overall net positive benefit to the society from mangroves and hence the mangroves ecosystems can be argued to be of a higher economic value than rice farming in Vanga. It is however important to note that, for a more conclusive assessment on the viability of either the mangrove ecosystems and/or conversion of the same into rice plantations, a more intricate and in-depth cost benefit analysis would need to be undertaken, perhaps over 15 – 30 years, and factoring in the seasonality variability in the various parameters among others key economic considerations. Further, the practical long term sustainability of the projects has to also be put into consideration. For instance, in Ozi, a similar rice growing area in the neighboring Tanariver County, seawater intrusion forced communities to abandon rice growing. At the time, the rice variety cultivated could not survive in brackish waters and as a result, the communities sought alternative livelihood activities, some of which were not good for the mangrove forest found in the area. Harvesting of mangrove poles was one of the rife alternative livelihood activities people got involved in. Therefore, such associated losses should be taken into consideration when the 'use values' of mangroves and the rice farming or any other competing land use is compared.

3.4.2.2. Mangrove Investment Entry Points

Natural ecosystems form the foundation of life on earth. It is, however, eroding mainly due to human activity, such that in the poorest of countries, the deterioration of the natural environment is making it increasingly difficult for millions of people to meet their subsistence needs. According to Bishop et al., (2008), current conservation approaches are not sufficient, thus bringing about the need to harness the very market forces that are often blamed for biodiversity loss.

The challenge is to re-orient the economic incentives that drive investment, production and consumption, and to make natural ecosystems' conservation a viable business proposition in its own right. This, can only be done by building commercial enterprises that generate profits through activities that conserve natural ecosystems, use biological resources sustainably, and share the benefits arising from this use equitably. Further, the **benefit flows** of natural asset business models, as shown in Figure 36-3 may lower rural poverty while enhancing conservation. Employment and skills development are a normal part of every business; however, natural asset business has the added advantage of stimulating a flow of funds from wealthy urban towns to the countryside, or even from industrialized to developing countries like Kenya.

The growing markets for ecosystem services and biodiversity-friendly energy, food, and recreation, therefore, have a future in providing sufficient opportunities for rural entrepreneurship and employment among the Kenyan coastal communities.

Proposed Mangrove Investment Key Entry Points that can be adopted along the Kenyan Coast

The measurement of the economic benefits provided by mangroves play a key role in realizing their potential as a natural asset. While mangroves support significant value-added, cost reductions and avoided damages, there are significant leakages of value in the sense that little or none of this value is returned as investments to sustain mangroves and perpetuate ecosystem values. Much of the sustainable economic potential of mangroves is not being captured meaning that potentially valuable income, employment, business opportunities and other revenue streams remain unavailable and untapped.

Four 'benefit areas' where mangroves can provide value to potential investors in Kenya while at the same time ensuring that mangrove conservation and restoration is properly implemented, were identified during this study. These 'benefit areas', identified and proposed as investment priorities and business models have been earmarked as '*key entry points*'

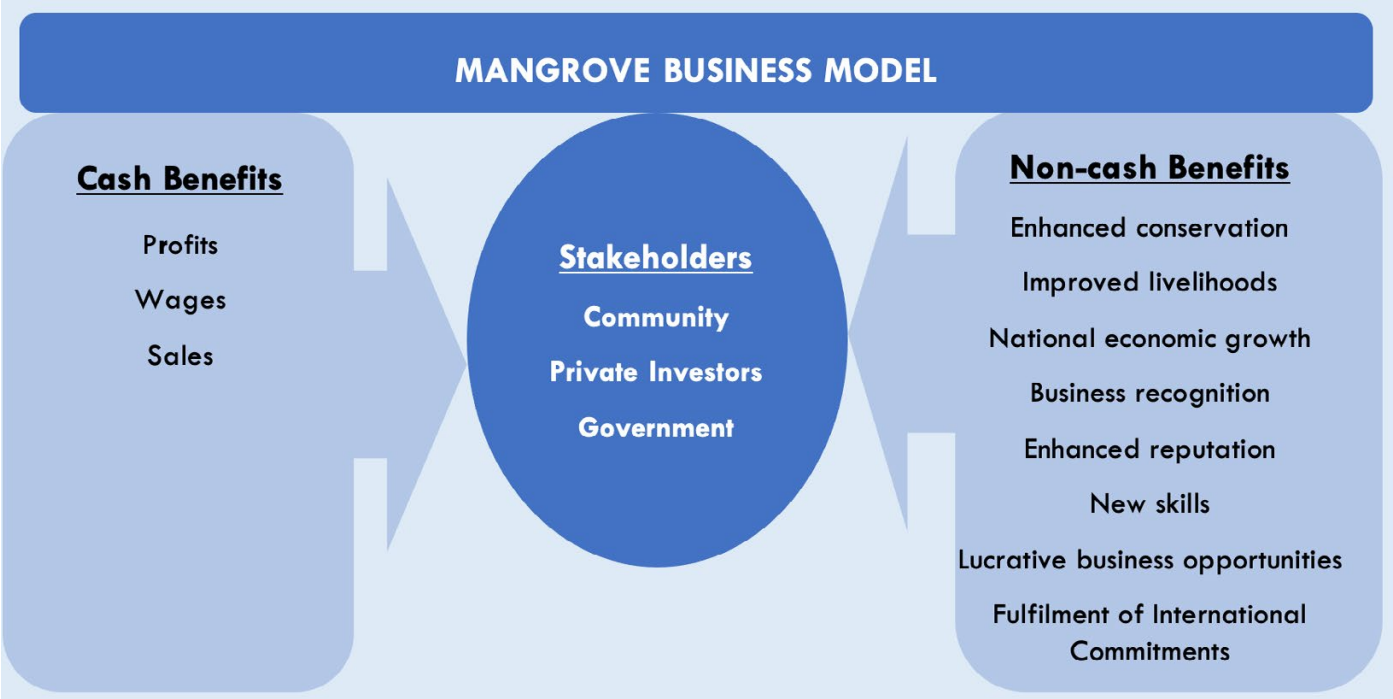


Figure 36 - 3: Mangrove conservation business model benefit flows

for mangrove conservation owing to their evident potential in providing *exceptionally high disaster risk reduction benefits as well as other valuable ecosystem services*. The proposals recognize the critical importance of harnessing the financial capacity and the entrepreneurial spirit of both the Government and the private sector in protecting coastal ecosystems. These 'benefit areas' have been proposed for assimilation in decision-making processes by Government or private investors in any type of coastal development cutting across infrastructure, energy, agriculture or urban development along the Kenyan Coast.

The aim is to make a business case for coastal ecosystem conservation and community resilience by promoting good practices while discouraging those destructive to coastal ecosystems, thus ultimately improving the overall sustainability of business practices in the coastal zone. The main target is to capture the attention of potential investors and financiers on nature-based solutions that can help align both national and global economic development with the value of mangrove ecosystems found along the Kenyan Coast. The proposed four business models are discussed below.

1. Asset Protection business model

Mangroves are a key asset for climate-vulnerable Countries. The mangrove ecosystems are fundamentally very cost-effective structures that can be used for coastal protection. They are known as natural infrastructure for climate adaptation, because they protect against coastal and tidal erosion, storms, and other natural hazards. Indeed, literature shows that mangroves and coral reefs can be fifty times more cost-effective than building a seawall. However, a lack of attention to these benefits means that these systems are being lost at an alarming speed (CDC Group, 2020). According to Earth Security (2020) mangroves are at the frontlines of coastal protection, such that 100 meters of mangrove forests along the coast can reduce the intensity of tidal wave energy by almost 70% and can contain the flooding depth of a tsunami by 30%. In tandem with coral reefs and seagrass, they reduce the power of tidal waves and storm surges, containing coastal erosion.

Tsunami risk is considered low in coastal East African countries, majorly because the impact of the 2004 December teletsunami generated limited damage in the region (Kijiko et al., 2018). The greatest threat however to the Kenyan coastline, according to UNEP (2011) is the Karthala volcano on Comoros. It is said to be active and has had four differing scale eruptions since 2005. Another large-scale outbreak could lead to lava flowing into the ocean and trigger a tsunami that is likely to affect the Eastern African coastline. This raises concerns about the severe consequences it is likely to cause since a tsunami caused by lava flow into the Indian Ocean from the Karthala volcano has a probability of reaching Mombasa within 30 minutes (UN/ISDR, 2005).

The value of mangrove as a shoreline protector has been estimated during this study to be a total of Ksh1, 071,373,050 accounting for 11 forest formations that were surveyed. The average unit cost was estimated at Ksh 22,909.89/ha**,** (see chapter 3.1.2 of this report for a detailed presentation of the ecosystem service values). The replacement cost method was used, which considered the need for the construction of concrete sea walls as a way of protecting coastal communities and assets from extreme weather events.

Literature shows that, as part of its mandate, the National Museum of Kenya (NMK) is on its course to revamp Kenya's gazzeted heritage sites. It is in the final stages of constructing a sea wall to protect the historic Fort Jesus Museum's foundation in Mombasa built by the Portuguese in 1596. Fort Jesus was declared a World Heritage site by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 2011. It was highlighted as one of the outstanding and well-preserved examples of 16th-century Portuguese military fortifications and and thus the intrinsic value attached to it is high and is a key asset to Kenya. Similarly, a sea wall is under construction to protect the historic Vasco Da Gama Pillar in Malindi, which was built by the great Portuguese explorer Vasco da Gama, and which stands as the oldest remaining European monument in tropical Africa. It was enlisted to the World Monuments Watch List, making it a vital asset to Kenya (National Museum of Kenya, 2019). According to Hassan, 2020, the construction of the Vasco Da Gama and the Fort Jesus sea walls, cost the Kenyan Government Ksh. 60 million and Ksh. 497 million, respectively. The need for the substantial investments was occasioned by strong tidal waves caused by a warming planet which have put the iconic architectural treasures at great risk, faced with the prospect of collapse as the coral foundation of the historic landmarks are being

threatened by strong tidal waves due to rising sea levels. It is therefore evident that huge investments are required by the Government to protect communities and other valuable assets from coastal erosion and tidal waves that would have otherwise been provided for if proper management of mangrove ecosystems is taken into consideration. Relatedly, a study done in the Philippines considered a 15-year investment period and reported that the conservation of mangroves and coral reefs is 50 times more cost-effective in comparison to coastal protection investment by constructing a cement seawall. On the other hand, the restoration of 8,961 hectares of mangrove forests alongside a 100km dyke line in the Vietnam's most disaster-prone coastal provinces reduced dyke maintenance by USD 7 million per year, (Earths Security, 2020). These are some of the lessons learnt that can be utilized for the conservation of mangroves along the Kenyan Coast. Earths Security (2020) further portends that by 2030, property damage due to coastal storm surges and sea level rise is set to increase by a factor of 10, making investments in these green infrastructures increasingly important. Mangroves are the cheapest restoration option, costing an average 3.6 times less than other coastal ecosystems.

Some of the realizable value metrics that the Government, private investors, and even the communities can benefit from through the conservation of mangroves include;

- Substantial cost savings from infrastructure construction
- Substantial cost savings from annual infrastructure maintenance
- Reduced insurance costs due to lower exposure to risks

2. Payment for Ecosystem Services (PES) business model

The PES business model is another plausible entry point in which investors are becoming more involved in while investing in nature-based solutions. PES represents a flexible compensation mechanism in which Ecosystem Service providers are compensated by service users (Katoomba Group, 2008). According to ESPA (2018), the local community's stewardship of environmental resources and their contribution to flows of ecosystem services and goods, in their many forms, must be adequately recognized and sufficiently rewarded. Formal markets, some voluntary and others mandated by law, now exist related to carbon, water, and even biodiversity. Besides, focused business deals and PES are also being forged to invest in restoration and maintenance of ecological systems and the services that they provide (Katoomba Group, 2008).

PES markets can be distinguished as (i) compliance markets, where public regulation requires the payment for the use of ecosystem service (e.g. mandatory carbon emission trading for specific industries); (ii) Government-mediated markets, where the Government is the intermediate party collecting payments from users and distributes them to the service providers (e.g. PES markets where local people are providing environmental stewardship at some cost to themselves, and environmental benefits are enjoyed by groups in another locality); and (iii) voluntary markets, where companies voluntarily decide to compensate their negative impacts on biodiversity and ecosystem services by purchasing compensatory credits from conservation projects (e.g. voluntary carbon emission credits and biodiversity offsets) (Lamboy & Levashova, 2011). All the above PES markets are applicable for mangrove ecosystems. However, **Carbon Trading** under the voluntary markets is quickly gaining popularity among the coastal communities living adjacent to the mangrove ecosystems in Kenya. Marine ecosystems capture up to 55 percent of biological Carbon, and mangrove forests can store up to five times as much carbon as land-based forests, better still 40 percent faster. This fact, in its own right, is enough incentive for the communities living adjacent to the mangrove ecosystems in Kenya to highly invest their time and energy in the restoration of mangrove ecosystems with the aim of getting rewards through voluntary markets.

The pioneer project in Kenya, the Mikoko Pamoja, happens to be the **world's first blue carbon project**. It is a community-led mangrove conservation and restoration project in the Gazi mangrove forest formation and it aims to provide long-term incentives for mangrove protection and restoration through community involvement and benefit (PLan Vivo, 2021). Since its inception in 2014, the Mikoko Pamoja Community Based Organization operating as a user group under the Gogoni – Gazi Community Forest Association, has managed the conservation of 117 ha of mangroves in the Gazi bay. Also, the group, through technical support from KMFRI and WWF-Kenya, has established

new mangrove forests covering 10 ha (World Wild Life Fund, 2018). During this study, it was established that the Mikoko Pamoja user group makes an average of Ksh 1,200,000 in annual revenues from Carbon trading (See appendix 2.0). According to the World Wild Life Fund, 2018, the vast proceeds have breathed life into two remote villages of Gazi and Makongeni in Kwale County. It has put them back on a growth trajectory rekindling hopes of a better tomorrow for future generations. This success story has drawn keen attention from the communities living adjacent to neighboring Vanga forest formation. At the time of this study, the VAJIKI CFA, through the Association of Coastal Ecosystem Services (ACES), had submitted a project design document under the Plan Vivo Systems and Standards to engage in the Carbon trading business. The objective of the project is to gain proceeds from carbon trading while restoring and protecting the mangroves of Vanga and promoting long-term sustainable development of the local communities that live within and adjacent to the mangrove areas of Vanga, (Association of Coastal Ecosystem Services, 2018). Relatedly, The Gede Arabuko Community Forest Association had also initiated the same process at the time of this study. Several other CFAs visited during this study also expressed their interest in the Carbon trading business.

Though payments for ecosystem services schemes are designed to incentivize environmental stewardship by providing market-based rewards, they have received scrutiny, especially on the associated **social safeguards**. According to a research done by ESPA Research (2018), PES initiatives provide financial incentives for sustainable use of environmental resources, however, they focus primarily on ecological outcomes. Typically, local people's wellbeing is not central in their design. For example, the research reviewed the evidence on four certification schemes focused on forests, fair trade and carbon. It found that without deliberative efforts to support local access and benefit-sharing, these schemes tend to favor large-scale and high-capacity producers and reinforce existing market inequalities. Unfair distribution of costs and benefits were also found in a case study of biodiversity offsets in Madagascar, governed by the Business and Biodiversity Offsets Programme and associated international standards. Similar challenges were found to be also associated with payments for ecosystem services schemes, mainly when they were found to be reliant on monetization or marketization of ecosystem services. The study further reports that with regards to REDD+ programmes, researchers have highlighted how an excessive focus on 'technical' issues related to carbon measurement and accounting (which lies at the core of performance-based payments for emissions reductions) obscures power imbalances and favors the interests of external actors and investors over local communities.

These findings demonstrate that, although market-based type instruments may deliver on efficiency, they do not necessarily deliver on social protection, equity, and poverty alleviation. One of the key elements that came out during the fieldwork phase of this study is that majority of the community members feel like the benefit-sharing of project outcomes is not equitable. Owing to this, the communities living along the Kenyan Coast expressed the inadequate motivation for their continued support for conservation and restoration of the mangrove ecosystems. It is therefore manifest that while considering the environmental safeguards, the social safeguards should also be well taken care of during the drafting of payment of ecosystem service business models, if at all maximized benefits are to be achieved from the business ventures.

Some of the realizable value metrics that the communities, private investors, and even Government can benefit from through the conservation of mangroves include;

- Increased revenues from carbon offsets generated
- Improved livelihoods for the communities
- Recognition both Nationally and Internationally
- Tons of carbon sequestered
- Avoided CO_2 emissions
- National attainment of International commitments e.g., the Paris Agreement, the Sustainable Development Goals (SDG 14), the Aichi Target 5, and the REDD+ efforts

3. Community Development business model

The Forests Act, (2016), under the laws of Kenya, states that "Every state forest, local authority forest and provisional forest shall be managed in accordance with a management plan drafted by the Kenya Forest Service in collaboration with the communities operating under registered CFAs. The act further stipulates that each management plan should allow

the participation of stakeholders in the conservation and management of the forest resources through collaborative management. The recognition of the communities adjacent to forests as key stakeholders and users of natural resources is therefore considered vital if successful management is to be attained. According to Tsuma (Pers. Comm, January 2021), the Manager of the Sokoke Forest Station; proper forest management and conservation is impossible without the support of the community. Further, wherever indigenous people have a sense of ownership and retain their connections with their lands, their ecosystems tend to remain well preserved. Often, they make significant contributions to the maintenance of many of the earth's most fragile ecosystems, through traditional sustainable resource use practices and culture-based respect for nature, (South Pacific Regional Environmental Program, 2001). In the same sense, the management plans governing the CFAs' operations give the communities legal rights to enter into agreements with the Kenya Forest Service which in turn assigns them conservation roles as well as user rights to sustainably utilize the forests through sustainable use schemes like fishing, beekeeping, ecotourism, carbon trading among others. These avenues thus brands the mangrove ecosystem as an asset that has the potential to improve the livelihoods of local communities through increased incomes from sustainable income-generating activities that can be undertaken within the mangrove ecosystems. According to the South Pacific Regional Environmental Program (2001), a commonly held concept is that if local people get a direct benefit from a business that depends on the biodiversity of a particular area, then they would have an incentive to act to protect it against internal and external threats to its deterioration or destruction.

During this study, it was established that user groups in the Tudor Creek forest formation make an average of Ksh 8,580,000 in annual revenues from sustainable use schemes taking place within the mangrove forests. The activities include, eco-tourism, development of tree nurseries, aquaculture, mariculture, and beekeeping. Similarly, user groups in Gazi forest formation make an average of Ksh 4,042,000 annually, while their counterparts in Mida mangrove forest formation attain an average annual revenue of Ksh 1,595,000 from similar and other sustainable use schemes, to include; carbon trading, butterfly farming and plastic waste management. Appendix 2.0, details the itemized revenues that the various user groups along the Kenyan Coast make from sustainable use schemes.

It is evident that if the sustainable use schemes are properly implemented, the communities' livelihoods would be improved, while at the same time, mangrove conservation efforts will be enhanced. Consequently, this would substantially alleviate the increasing demands and pressure on our valuable mangrove ecosystems, further enhancing the restoration of degraded mangrove areas. However, despite the ready opportunities for sustainable use schemes that the mangrove ecosystems provide, not much has been actualized across the mangrove forest ecosystems in Kenya. Among other challenges, the lack of capital to initiate and run projects was highlighted by the communities as the greatest challenge. In fact, it was noted that majority of the projects that were initially supported by donor money collapsed as soon as it was time for the donors to withdraw their funds. On the other hand, potential investors lack convincing incentives to invest in nature since they are ideally driven by positive returns on investments. However, successful sustainable mangrove uses schemes as showcased by Tudor, Gazi and Mida communities are worthwhile incentives for the investors. These success strories can be used to attract investors to form partnerships with the local communities and take advantage of the many opportunities to make profits from the specific investments allocated as user rights, while at the same time improving on biodiversity and ecosystem services. The ultimate vision is to maximize the benefits that both the communities and the investors can make from the sustainable use of the mangrove ecosystems.

Some of the realizable value metrics that the Government and even the private investors can benefit from by enhancing conservation efforts in the Kenyan Coast include;

- Improved National economy from increased local community income and value of products
- Lucrative business opportunities for the private sector through partnerships and other associated donor agreements
- Business recognition both Nationally and Internationally
- Increased number of local jobs and enterprises
- Reduced costs from local community conflicts
- National attainment of International commitments e.g., the Paris Agreement, the Sustainable

Development Goals (SDG 14), the Aichi Target 5, and the REDD+ efforts

4. Regulatory Obligations business model

The mangrove ecosystem is a cost-effective approach towards nature-based site remediation and restoration for either Government or private investors to meet regulatory standards and other strict environmental requirements for businesses such as infrastructure, extractives, and energy. This is one of the ripe yet under-utilized business opportunities that potential investors can harness to meet their obligatory requirements while at the same time enhancing the restoration and conservation of mangrove ecosystems.

Even though investors have not explored yet, the mangrove ecosystem along the Kenyan coast has great potential for investors to offset their carbon footprints and other site remediation to meet both national and international regulatory standards. Indeed, mangrove ecosystems are a powerful blue carbon ecosystem. They can store up to five times more carbon than upland tropical forests, making them a better and cost-effective option for remediation purposes for investors.

Kenya's ratification to international agreements cuts across agreements like the Paris Agreement, the Aichi target, the Sustainable Development Goals (SDG 14), the REDD++ strategy, the UNCCD's Land Degradation Neutrality Mechanism, among others. Therefore, investors dealing in businesses such as energy, infrastructure, and other extractive ventures, must bear the obligation of offsetting their carbon footprints and other nature-based remediation in line with the State's standards. For instance, the China Road and Bridge Corporation (CRBC), an infrastructure company hired to build Kenya's first double-decker expressway, was tasked by the Government through the National Environmental Management Authority, to seek collaboration with private parties and State agencies to offset the loss of vegetation brought about by the development. This is to be achieved by planting trees at all affected public places, including the Nairobi National Park, the Uhuru Park, Arboretum, public schools, and other lands along the corridor. Further, they have been tasked with cleaning sections of Nairobi and Ngong Rivers crossed by the expressway. According to NEMA, the measures will open green spaces to compensate for the permanent loss of vegetation and the destruction of bird habitats (Mutua, 2020; Centric Africa , 2020). Relatedly, Shell, an international petroleum company and operating in Kenya, has deliberated to invest in nature as part of its ambition to become a net-zero emissions energy business by 2050. Its primary focus is on nature-based solutions which protect or redevelop natural ecosystems such as forests, grasslands, and wetlands (Shell, 2019). In 2019, Shell announced a programme to invest in natural ecosystems as part of its strategy to meet their regulatory obligations while acting on global climate change by addressing carbon dioxide (CO_2) emissions generated by customers when using its products among other interventions. The company plans to invest $300 million by the end of 2021, a programme that will contribute to Shell's three-year target, to reduce its Net Carbon Footprint by 2% – 3% (Shell, 2019). Correspondingly, Suez, a company in Panama City, replanted 23 hectares of mangroves to offset 10 hectares affected by the construction of a wastewater plant, as part of their obligatory requirements. On the other hand, Origin Energy and ConocoPhillips in Australia included over 40 hectares of mangroves in an environmental management plan for a Liquified Natural Gas (LNG) project to meet the state's marine offset requirements, (Earth Security, 2020). These are some of the lessons learnt that can be borrowed and utilized to meet regulatory requirements while restoring and conserving mangroves along the Kenyan Coast.

Drawing from the above examples, it is evident that investors in Kenya have a myriad of opportunities that they can invest in to meet their regulatory obligations. It is therefore time that their attention is drawn to the cost effective and ripe opportunities that the coastal ecosystems in Kenya have in store.

Some of the realizable value metrics that the Government and the private investors can benefit from by enhancing conservation efforts in the Kenyan Coast include;

- Cost savings from reduced regulatory costs from permits, fines, etc.
- Cost savings from reduced remediation costs, i.e. the cost-benefit analysis of mangrove conservation and restoration in comparison with other remediation options, shows that the mangrove option is way more cost-effective

- Investors can improve their operations from increased financial gains that can be attributed to the cost savings
- Boosted access to the international financing facilities owing to the fulfillment of international investment performance standards
- Attainment of the national Land Degradation Neutrality (LDN) targets given that Kenya is a signatory to the United Nation's Convention to Combat Desertification (UNCCD)

3.4.3: CONCLUSION: A PATHWAY TO SUCCESS

The business entry points as discussed in the preceding chapter show various approaches of Government and private sector involvement in mangrove restoration and conservation. However, the successful implementation of the business entry points can only be realized within a conducive environment. Some of the apparent incentives are discussed below;

Enabling environments; the successful growth of any business is majorly dependent on a conducive enabling environment. This generally includes the legislative frameworks, regulations, taxes, subsidies, and even social norms within which potential investors can operate in. Therefore, it is important that significant reforms of the enabling environment are done to enable mangrove businesses to grow, especially where the role of business in conservation is limited by law or where policy incentives such as perverse subsidies are deemed to cause continued harm to ecosystems. To attract investors in mangrove conservation and restoration, it must ultimately become more profitable to conserve mangrove ecosystems than to ignore or destroy them. According to Bishop et al. (2008), laws that incorporate a combination of increased rewards for conservation, increased penalties for biodiversity loss, and expanded information on the biodiversity performance of the business will help to create a biodiversity and ecosystem services friendly economy.

Nature-based financing instruments; ready investment funds are one of the guaranteed entry points for investors to fund revenue-generating conservation enterprises geared towards the conservation and restoration of mangroves. Several facilities have emerged in recent years with a focus on financing nature-based solutions. In Kenya, the linkage between environmental challenges and opportunities for green growth and the effectiveness of its financial system in allocating capital is not widely recognized. For example, it is not addressed in Vision 2030. While the Central Bank considers erratic weather as a potential stress on the economy, it does not consider this in any depth in its Financial Stability Report (International Finance Corporation, 2015). Nevertheless, there are examples of emerging recognition and leadership in the financial sector seeking to integrate a better understanding of sustainability factors into financial decision making. As cited by the International Finace Corporation (2015), examples include;

- The Kenya Bankers Association launched the Sustainable Finance Initiative in 2014 to explore opportunities for industry alignment while building industry-wide capacity in the area of environmental and social risk management;
- CFC Stanbic and Cooperative Bank are providing green credit lines worth KES 3.3 billion for energy and natural resource efficiency projects and green mortgage products, with funding provided by the African Development Bank;
- A few pension funds have begun investing directly in green infrastructure, including the Local Authorities Pension Trust (LapTrust); and
- The Capital Market Authority Draft Code of Corporate Governance Practice released in 2014 includes guidance on including Environmental, Social and Governance (ESG) in responsibilities and reporting. Kenya Commercial Bank and Safaricom have been the first to publish integrated reports as recommended by the code.

According to International Finance Corporation (2015), while these initiatives indicate emergent interest and recognition of the importance of sustainability factors for investment in Kenya, in practice, domestic investment in the green economy has to date, been limited. International financing facilities geared towards conservation have however gained popularity in the recent years. For instance, in November 2020, IUCN, the Global Environment Facility and other partners announced the launch of the Nature+ Accelerator Fund, a first-of-its-kind private sector-focused nature conservation accelerator fund, providing measurable conservation and social benefits while delivering financial returns for investors (Global Environment Facility, 2020). Other international financing facilities that create investor value and social impact by providing growth capital to companies that harness ocean's natural capital include the Sustainable Ocean

Fund, the Blue Natural Capital Financing Facility, the Livelihood Venture's Carbon Funds, among others. According to Earths Security (2020), Investors in these funds need to take a long-term horizon (8–12 years) and be willing to take an outsized risk to attain a commercial, financial return alongside environmental and social impact.

Stakeholder involvement; successful nature-based projects often would involve various stakeholders, such as the Government, NGOs, entrepreneurs, and private investors. For instance, in the 'community development' business model as discussed in the preceeding section of this report, there is a substantial need for local community support. The strategy to set up partnerships makes the business case innovative, and collaboration with local communities and authorities is crucial. One of the key elements that came out from the field study is that most community members feel like the benefit-sharing of project outcomes is not equitably done. Therefore, there is no motivation for the community members to uphold their side of the bargain in project implementation. These factors imply that the investors, whether Government or the private sector, must be willing to form mutually beneficial partnerships with communities. Further, they should be willing to take the time to research the interests of all stakeholders. They must have effective management skills for convening these parties and interests to seamlessly steer the business venture forward.

Bundling and stacking ecosystem services; the focus of many current markets is a single ecosystem service, which often results in an ecosystem-based perspective on management. For some investors, however, an investment object should attain a certain volume and show a good track record. This would constitute a challenge when single ecosystem services are considered (Lamboy & Levashova, 2011). According to Raudsepp-Hearne et al. (2010), by optimizing for one ecological function or attribute, these singular approaches may fail to support the interconnectedness among ecosystem services across a land/sea-scape. They could lead to environmental degradation if the over-emphasis on enhancing or managing one ecosystem service undermines the provision of other services. Hence, only when various projects have been combined do investors recognize it as an investable object. Two primary approaches, "Bundling" and "Stacking" of ecosystem service credits, have emerged as mechanisms for fostering the integration of multiple ecological values into environmental markets or similar transactions, thereby, securing greater ecological benefits than would be possible from a single-program or market approach (Ingram, 2012). Further, in developing countries like Kenya, such approaches may also help community members engaging in ecosystem service markets to increase their revenue, diversify their income streams, and buffer themselves against shocks associated with fluctuations in demand within any single market. Ingram (2012) further indicates that if correctly implemented, bundling, or stacking policies could simultaneously promote economic resilience for sellers and promote ecological resilience by creating financial incentives that promote more holistic approaches for protecting ecosystems rather than emphasizing conservation, restoration or management focused on only one ecological attribute.

The common language between the worlds of business and nature conservation; according to Lamboy & Levashova (2011), the language of nature-based entrepreneurs does not necessarily align with the priorities, time scale and jargon of financial experts and this might form a barrier. Natural scientists often lack the financial acumen and consumer orientation of the private sector while conservationists typically lack business planning and management skills. At the same time, most business people lack understanding of how their companies' operations affect and are affected by biodiversity and ecosystem services, or how to manage biodiversity in their operations. In addition, the long-standing difficulties of integrating conservation and development agendas remain. Nevertheless, new biodiversity business tools are being developed to bring these worlds together and bridge gaps in planning, management, and performance assessment (Bishop et al., 2008).

In conclusion, tangible examples of financially viable nature-based businesses and operational markets for ecosystem services are necessary to persuade all stakeholders to come together to conserve natural ecosystems on a sustainable and commercial basis. The time is therefore ripe to start investing in the mangrove ecosystems of Kenya, and as Bishop et al., (2008) reports; rhetoric is not sufficient; but experience is the best teacher and the coming years will be crucial to demonstrate, document and share the results of successful various market-based approaches to biodiversity conservation in different contexts if nature-based businesses are to be scaled up.

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APPENDICES

APPENDIX 1.0: HOUSEHOLD QUESTIONNAIRE

INTRODUCTION AND INFORMED CONSENT

We are from Geospatial Research International (GRI), which has been consulted by the International Union for Conservation of Nature (IUCN) Eastern and Southern Africa Regional Office. Our objective is to undertake an assessment of the Socio-Economic Role of Mangroves and their Conservation Frameworks in Kenya, as well as the impact of the later. To achieve this, our consultant is required to interview your or members of your household knowledgeable/informed in the area of mangrove products usage, services, or management either locally or regionally. GRI and IUCN remains available to provide any additional clarification as well as share the findings as and when required.

The interview will take about 20-60 minutes and all the information we obtain will remain strictly confidential and your answers and identity will never be shared with anyone or third parties.

MAY I START NOW?

□ YES, permission is given. Record the time and then begin the interview.

□ NO, permission is not given. If permission is not given, leave the household. Discuss this result with your supervisor/lead consultant.

SECTION 1: LOCATION DETAILS

Date		Start-Time	
Enumerator:		End- Time	
County		Division	
District / Sub-County		Location	
Sub-location		Village	

Grid Reference of Household Using the GPS (UTM)

Northing (Lat)	Easting (Long)	Altitude	Time

SECTION 2: CHARACTERISATION OF THE POPULATION

2.1 Household No.	
2.3 Gender of the respondent	[1] Male [2] Female
2.4 Age of respondent	[1] Less than 18 years [2] 18 to 24 [3] 25 to 34 [4] 35 to 44 [5] 45 to 54 [6] 55 to 65 [7] > 66
2.5 Household position of respondent	[1] Husband [2] Wife [3] Child [4] Other.....
2.6 Household Size (i.e., persons who have lived here for the last 2 year including you?)	1. < 5 2. 6-10 3. 11-15 4. 16-20 5. >21
2.7 Education of the respondent	[1] Illiterate [2] Literate but no formal education [3] School up to 5 years (class 1-4) [4] School up to 6-9 years (Class 5-8) [5] Secondary school [6] Artisan training [7] Technical training [8] Undergraduate [9] Post graduate [10] Other.....

2.8 How many years has the respondent lived in the area?	[1] 1- 5 years [2] 6-10 years [3] 11-15 years [4] 16-20years [5] >20 years
2.9 What is the main source of Energy for the household? *Energy sources* 1= Electricity 2 = Firewood 3= Charcoal 4= Others (Specify)	[1] Primary source of energy..... [2] Secondary source of energy.....

SECTION 3.0: SOCIO-ECONOMIC INDICATORS

3.1 FORMAL OCCUPATION of the respondent

Wage laborer
Skilled worker
Service-Government
Service-Private
Retired
Unemployed
Other.....

3.2 How much do you EARN PER MONTH?

[a] 0-10,000
[b] 10,001-20,000
[c] 20,001-30,000
[d] 30,001-40,000
[e] 40,001-50,000
[f] 50,001-60,000
[g] 60,001 and above

3.4 INFORMAL OCCUPATION of the respondent

[a] Livestock and livestock products
[b] Petty trader (shopkeeper, farm produce, firewood, timber)
[c] Casual laborer
[d] Craftsmanship
[e] Fisherman
[f] Tour guide
[g] Conservation/environmental activist
[h] Wood/timber sales
[g] Donation (friends & relatives)
[h] other .....

3.5 How much do you EARN FROM THE INFORMAL work per month?

[a] 0-10,000
[b] 10,001-20,000
[c] 20,001-30,000
[d] 30,001-40,000
[e] 40,001-50,000
[f] 50,001-60,000
[g] 60,001 and above

3.6 Does your household EARN A LIVING DIRECTLY from mangroves and their resources?

[1] Yes
[2] No

3.7 If yes to Question 3.6, please explain HOW.....

.....

3.8 Does your household earn a living INDIRECTLY from mangroves and their resources?

[1] Yes
[2] No

3.9 If Yes to Question 3.8, please explain HOW.....

.....

3.10 HOW MUCH do you earn INDIRECTLY from mangroves?

[a] 0-10,000
[b] 10,001-20,00
[c] 20,001-30,000
[d] 30,001-40,000
[e] 40,001-50,000
[f] 50,001-60,000
[g] 60,001 and above

3.10 What are the major household EXPENDITURE?

Item	KES/monthly
Food	
School fees	
Health	
Shelter and clothing	
Transport	
Water	
Farming/ Livestock inputs	
Energy	
Others	
Total	

3.11. How do you perceive the VALUE of the mangrove based on the following resources?

[1] High [2] Medium [3] Low

Item	Ranking
Food/Fish	
Building materials Timber/Poles	
Furniture/Boat making materials	
Wood fuel (charcoal, firewood)	
Traditional medicine/herbs	
Conservation	
Others	
Total	

SECTION 4.0: FOOD SECUIRTY SITUATION

4.1 Over the past 30 days, did you or any household member reduce the size of meals because of the scarcity of resources?

[1] Yes [2] No

4.2 Over the past 30 days, did the household reduce expenditure on education or food to save money to purchase food?

[1] Yes [2] No

4.3 How many MEALS do you often have in a day over the past 30 days?

[1] Once a day
[2] Once to twice a day
[3] Once to thrice a day
[4] Twice to thrice a day
[5] Thrice a day
[6] More than thrice a day
[7] Occasionally none
[8] Other.....

4.4 Do you think that the DAILY FOOD INTAKE of your household has improved the past 1 year?

	YES	NO
If yes, to what extent? [a] Slightly better [b] Better [c] Much better		
If no, then? [a] Same [b] Worse [c] Much worse		

4.5 Did you or other household members ever not eat for a whole day because of lack of money to buy food?

[a] Once a week
[b] Once a month
[c] Once in 3 months
[d] Once in 6 months
[e] Never happened
[f] Don't know

4.6 In your opinion, what is a balanced meal?

.....

.....

4.7 What is your frequency of not eating a balanced meal?

[a] Once a week
[b] Once a month
[c] Once in 3 months
[d] Once in 6 months
[e] Never happened
[f] Don't know

4.8 How have you dealt with such situation highlighted in Question 4.7 (food shortage) over the last 12 months? (Tick all that apply)

[a] Borrow from friends, neighbors, relatives, etc.
[b] Stick to simple food
[c] Reduce expenditure on health and education
[d] Adults skip meals
[e] Selling assets e.g., ancestral land, bicycle, etc
[f] Others specify .....

4.9 Which food crops have you grown in the past few months for domestic consumption?

[a] Rice
[b] Maize
[c] Cassava
[c] Sugarcane
[d] Vegetables
[e] Nuts e.g., coconut, cashew nuts, etc.
[f] Others .....

SECTION 5.0: MANGROVE USE

5.1 What is your view on the overall condition of the mangrove ecosystem in the past 10 years?

[1] No degradation
[2] Low degradation
[3] Medium degradation
[4] Significant degradation

5.2 How do you view the condition of the mangrove resources for the past 10 years based on the following characteristics?

[1] Decreased [2] No change [3] Increased

Resource	1	2	3
Mangrove forest area size			
Quantity of timber			
Availability of fish/invertebrates			
Quantity of firewood			
Availability of herbs			
Ecosystem services (erosion control)			
Species diversity			

5.3 What INCOME GENERATING ACTIVITIES are you involved in that relates to the mangrove ecosystem?

a) .....
b) .....
c) .....
d) .....
e) .....

5.4. Does your household extract resources/ products from the mangrove ecosystem?

[1] Yes [2] No

5.5 If yes, which products do you harvest from the mangrove ecosystem?

Product	Group Responsible KES/annually
Fish/ invertebrates	
Seaweed	
Fuelwood	
Building materials	
Furniture materials	
Traditional medicine	
Eco-tourism activities	
Cultural/religious activities	
Honey	
Others	

5.6 What is the frequency of harvesting the product(s) listed above? (You can tick multiple and describe corresponding product)

[a] Daily
[b] 2-3 times a week
[c] 4-5 times a week
[d] Fortnightly
[e] Monthly
[f] Bi-annually
[g] Annually
[h] Occasionally

5.7 Quantities harvested per product

Product	Quantity	Value in KES per kg/tonne	Reason for harvesting (consumption or commercial)
Fish/ invertebrates			
Seaweed			
Fuelwood			
Building materials			
Furniture materials			
Traditional medicine			
Eco-tourism activities			
Honey			
Others			

Non-existence valuation of mangrove ecosystem (Non-Monetary valuation)

5.8 How much time is spent in the activities related to mangroves per week?

[1] Less than 5 hr [2] 6-10 hrs [3] 11-15hrs, [4] 16-20hrs, [5] 21-25 hours [6] 25-30 hours [6] >31

Product	Time in hours
Fish/ invertebrates	
Seaweed	
Firewood	
Building materials	
Furniture materials	
Traditional medicine	
Eco-tourism activities	
Cultural/religious activities	
Others	

5.8 Rank the most important resource from mangroves and give reason.

[1] Not at all important [2] Slightly important [3] Important [4] Slightly important [5] Very important

Product	Rank	Reasons
Fish/ invertebrates		
Seaweed		
Firewood		
Building materials		
Furniture materials		
Traditional medicine		
Eco-tourism activities		
Cultural/religious activities		
Honey production		
Others		

5.9 State the importance of mangroves to the following:

Fish population.....
Climate change .....
Livelihood of the people.....
Others.....

5.10 Do you purchase mangrove products, if yes which ones? Give reasons why?

Product	Tick those purchased & indicate the quantity	Price per unit (indicate unit)	Reasons
Fish/ invertebrates			
Seaweed			
Firewood			
Building materials			
Furniture materials			
Traditional medicine			
Eco-tourism activities			
Others			

SECTION 6.0.: MANGROVE MANAGEMENT

6.1 Are you a member of a mangrove conservation group?

[1] Yes [2] No

6.2 Which people oversee the management of mangroves? (Tick all applicable)

[a] Local Leaders
[b] KFS
[c] CFAs
[d] BMU'S
[e] KMFRI
[f] NGO's
[g] Local Conservation groups
[h] Other Government Institutions
[i] Other Local Institutions
[j] All the above
[k] Others .....

6.3 (b) Are there any compensatory measures give to the you participating in Mangrove conservation.

If yes, name them and describe how this is done.

.....

.....

6.4 What are the major threats to mangrove conservation?

[1] Not at all important [2] slightly important [3] Important [4] Slightly important [5] Very important

Threat	Rank	Reasons
Overexploitation		
Pollution		
Illegal harvesting		
Coastal development		
Sedimentation		
Eco-tourism activities		
Settlement		
Others (inadequate policy) or policy enforcement		

6.5 Would you be willing to contribute to mangrove conservation?

[1] Yes, give reason .....
[2] No, give reason .....

If yes how much or how many hours

[1] Money in KES(a) 100-500 (b) 600-1000 (c) 1100-1500 (d) More than 1600
[2] Labor hours (a) Less than 1hr (b) 1-5hrs (c) 6-10 hrs (d) More than 11hrs

6.6 What are your recommendation for improvement of mangrove conservation?

.....

.....

.....

.....

SECTION 7.0: MANGROVES POLICY AND LEGAL FRAMEWORKS

7.1. Are you aware of any rules and regulations governing the management of Mangroves?

[1] Yes [2] No

7.2. If yes, which ones?

.....

.....

.....

.....

.....

7.3. Do you have access rights to the mangrove resources?

[1] Yes [2] No

7.4. If yes, outline the type and strength of rights associated with access to the mangrove resources.

Type of rights	Right present (Yes/ No)	Duration of rights	Strength of rights	
			Weak	Strong
Access - right to enter				
Withdrawal - right to obtain 'products' of a resource, e.g. harvest timber				
Management - right to regulate internal use patterns and transform the resource by making improvements				
Exclusion - right to determine who will have access to the forest and to exclude outsiders				

SECTION 8.0: CULTURAL ACTIVITIES RELATED TO MANGROVES

8.1 What cultural activities form part of mangrove everyday use? List and rank in the order of importance.

[1] Not at all important [2] slightly important [3] Important [4] Slightly important [5] Very important

Cultural activities	Rank the importance	Reasons
Spiritual		
Religious (kaya shrines-worship)		
Aesthetic (value of beauty)		
Self-importance (connect with nature and relax)		
Part of traditional activities (wedding, funerals, circumcision e.tc.		
Indigenous knowledge		
Local tourism		

8.2 Do you access mangrove for medicine? [1] Yes [2] No

If yes, list the uses and rank them in order of importance

[1] Not at all important [2] slightly important [3] Important [4] Slightly important [5] Very important

Medicinal use	Importance	Reasons

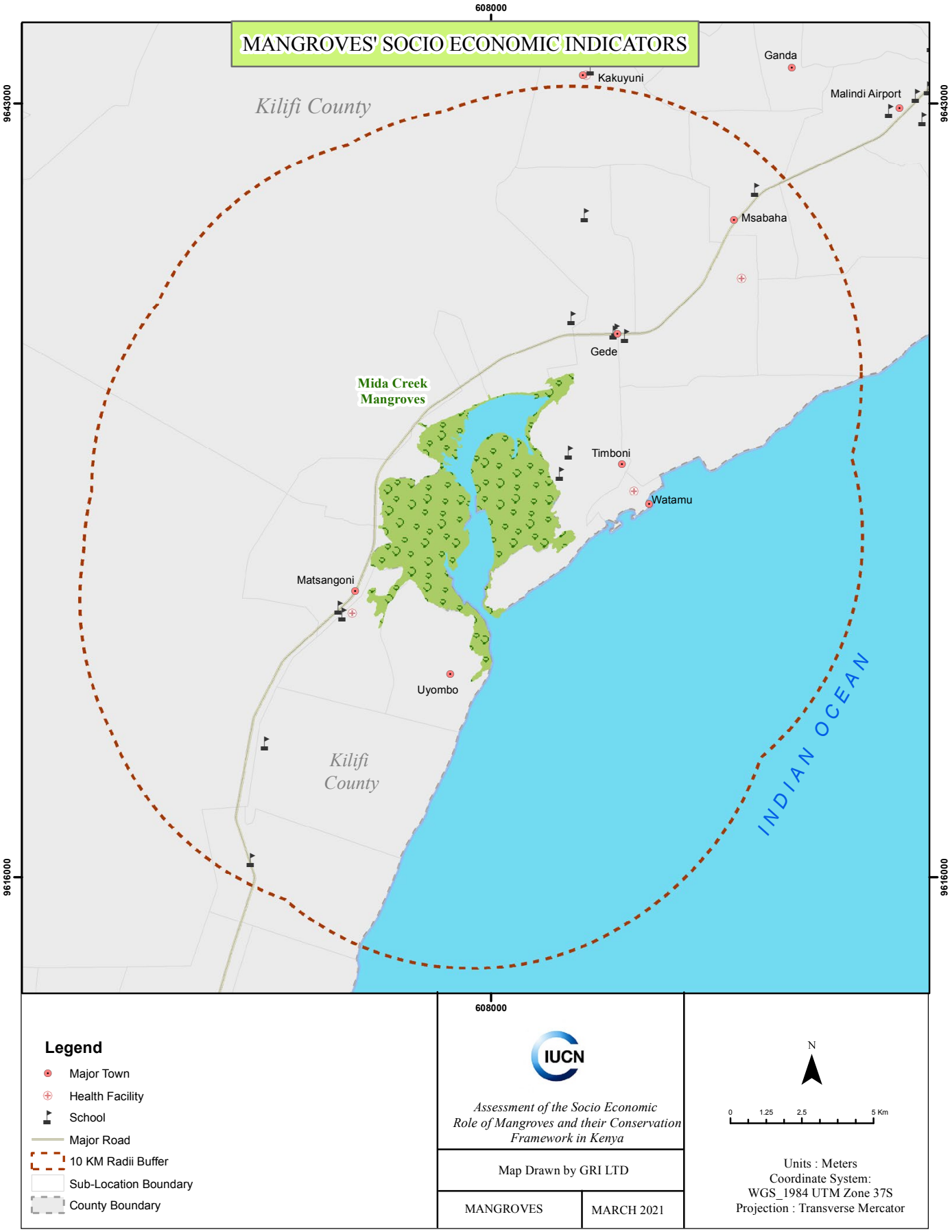
APPENDIX 2.0: REVENUE FROM SUSTAINABLE USE SCHEMES IN THE VARIOUS FOREST FORMATIONS

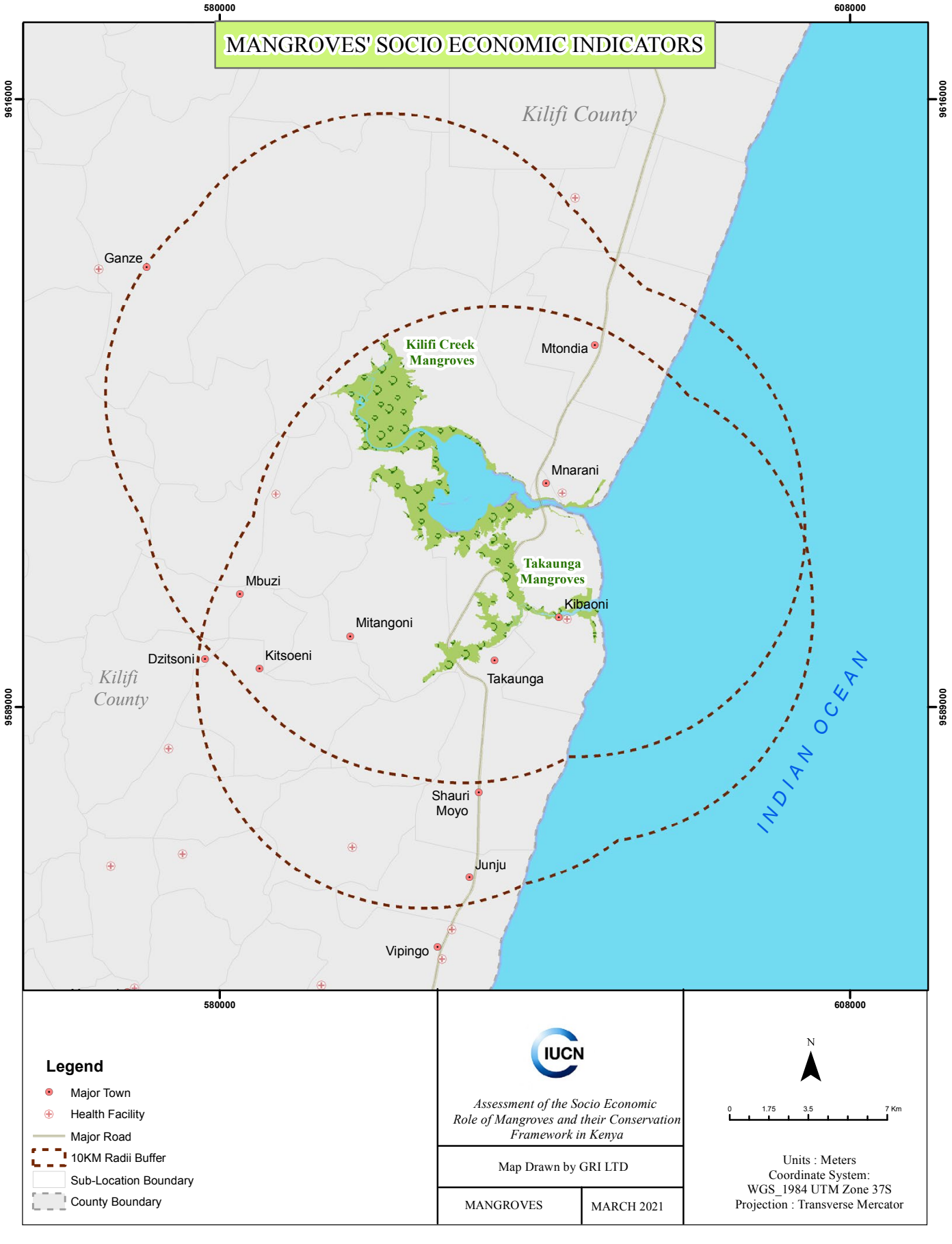
REVENUE FROM SUSTAINABLE USE SCHEMES IN MANGROVE ECOSYSTEMS ALONG THE KENYAN COAST			
	User Group Name	**User Activities/projects**	**Approximated User group Income (Annual)**
TUDOR CREEK FOREST FORMATION			
1	Brain Youth Group	1. Mangrove tree nursery 2. Beekeeping	Kshs 1,200,000/
2	Marimani Fish Pond	1. Beekeeping 2. Mangrove seedlings 3. Fishery (Mariculture	Kshs 600,000/-
3	Gandini Asali S.H.G	1. Beekeeping	Kshs 360,000/-
4	Amani Jipange CBO	1. Beekeeping 2. Mangrove seedlings	Kshs 1,200,000/-
5	Muungano Gairo CBO	1. Mangrove seedlings	Kshs 480,000/-
6	Riziki Women Group	1. Mangrove seedlings 2. Beekeeping	Kshs 300,000/-
7	Madzombani Fish pond	1. Mangrove tree nursery 2. Fishery (Mariculture)	Kshs 120,000/-
8	Bidii Kweli S.H.G	1. Mangrove tree nursery	Kshs 240,000/-
9	Bidii Creek CBO	1. Mangrove seedlings	Kshs 240,000/-
10	Kasa Moyo Women	1. Mangrove seedlings	Kshs 12,000/-
11	Bigship CBO	1. Mangrove seedlings 2. Beekeeping 3. Waste Management	Kshs 1,680,000/-
12	Mrezi Women Group	1. Beekeeping 2. Mangrove tree nursery	Kshs 1,200,000/-
13	Jitahidi S.H.G	1. Fishery (Mariculture) 2. Mangrove tree nursery	Kshs 840,000/-
14	COBWEB CBO	1. Mangrove tree nursery	Kshs 108,000/-
TOTAL			**Ksh 8,580,000**
GAZI FOREST FORMATION			
1	Gogoni conservation group	Tree nurseries Butterfly farming	Kshs 360,000
2	Gogoni green conservation	Tree nurseries Butterfly farming	Kshs 360,000
3	Tumain self-help group	Tree nurseries	Not available
4	Fihoni wildlife conservation	Tree nurseries Re-use of plastic materials	Kshs 120,000
5	Gazi women boardwalk	Eco-tourism Bee keeping	Not available

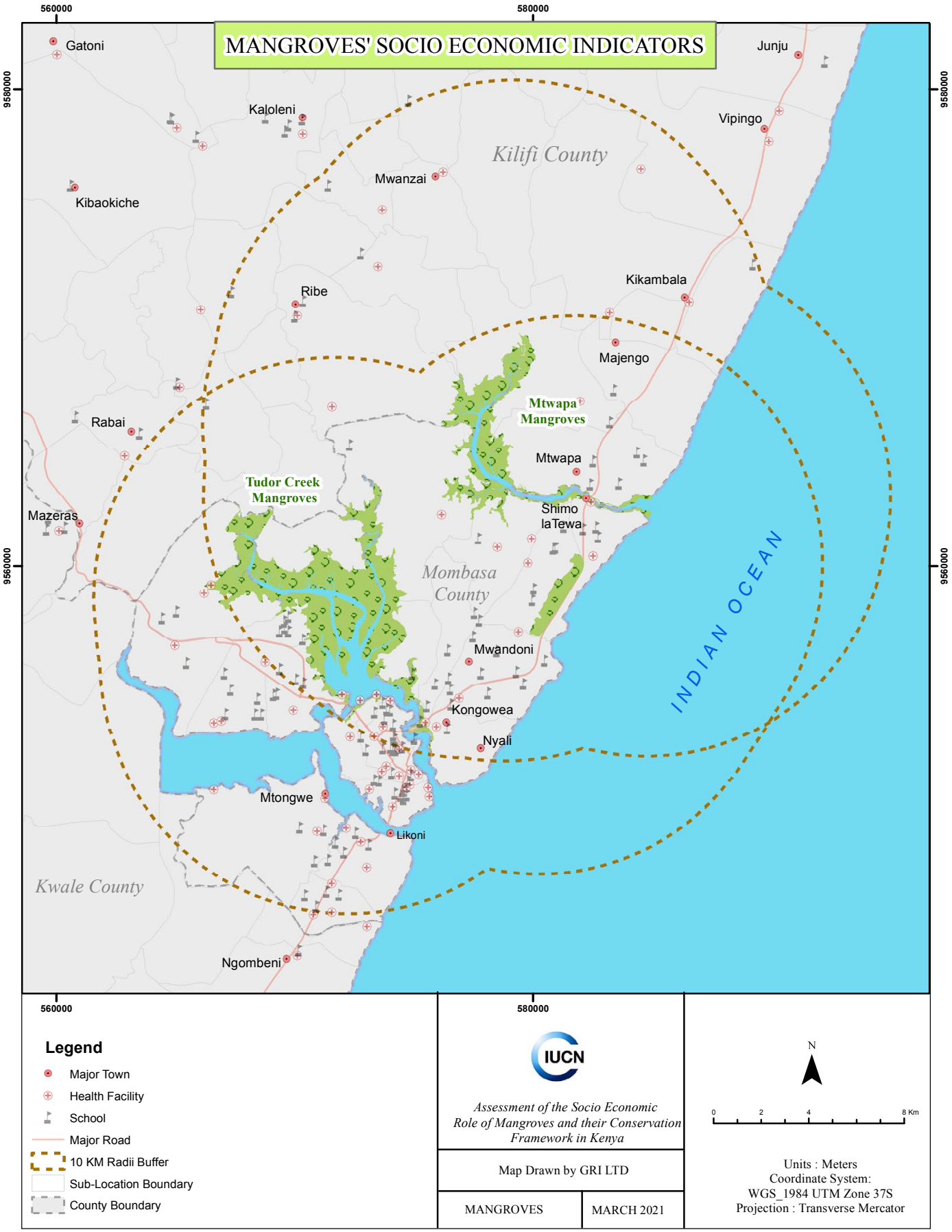
6	Gazi environmental youth	Tree nurseries Tree planting Waste management	Not available
7	Mikoko Pamoja	Carbon centration	Kshs 1,200,000
8	Gazi BMU	Fishing activities	Not available
9	Kinondo Chale marine conservation	Tree nurseries and tree planting (mangrove) Prawn and crab farming(proposed) Bee keeping	Kshs 120,000
10	Makongeni youth Bunge	Environmental waste management Tree nurseries	Not available
11	Camp poa	Tree nurseries Eco-tourism	Not available
12	Chale Jeza BMU	Fishing activities Fish farming Storage and selling of fish	Kshs 1,800,000
13	Baraka conservation	Fish farming Tree nurseries and tree planting (mangrove)	Kshs 300,000
TOTAL			**Ksh 4,042,000**
MIDA CREEK FOREST FORMATION			
1	Bidii na kazi women group	1. Mangrove tree nursery 2. Beekeeping 3. Ecotourism	Kshs 100,000/
2	Mida Creek Community and Awareness Group (MCCAG)	1. Canoe Riding 2. Mangrove tree nursery 3. Tour guiding 4. Restaurant	Kshs 150,000/-
3	Mida Creek Community fishing and awareness group (MCCFAG)	1. Mangrove tree nursery 2. Fishing Activities 3. Ecotourism	Kshs 70,000/-
4	Jitahidi women group	1. Beekeeping 2. Mangrove tree nursery	Kshs 50,000/-
5	Mida youth development group	1. Ecotourism	Kshs 80,000/-
6	Magangani aquaculture	1. Crab and fish rearing 2. Beekeeping 3. Ecotourism	Kshs 50,000/-
7	Green world generation	1. Mangrove tree nursery 2. Beekeeping	Kshs 30,000/-
8	Mkangagani Youth bunge	1. Beekeeping 2. Mangrove tree nursery	Kshs 70,000/-
9	Matsangoni bush garden	1. Beekeeping	Kshs 85,000/-
10	Dabaso Creek Conservation and awareness group	1. Crab Farming 2. Restaurant	Kshs 200,000/-
11	Prawns Lake	1. Crab and Fish Farming 2. Ecotourism	Kshs 100,000/-
12	Kisiwani conservation group	1. Ecotourism 2. Mangrove tree nursery 3. Traditional dance	Kshs 30,000/-
13	Viriko vimoyoni women group	1. Beekeeping 2. Mangrove tree nursery	Kshs 30,000/-

14	Upendo women group	1. Beekeeping 2. Mangrove tree nursery	Kshs 50,000/-
15	Jipe moyo women Self help group	1. Beekeeping 2. Mangrove tree nursery	Kshs 100,000/-
16	Dongo kundu Community conservation group	1. Ecotourism 2. Mangrove tree nursery	Kshs 65,000/-
17	Gede Community Forest scouts	1. Patrols 2. Tree nursery 3. Ecotourism	Kshs 30,000/-
18	Sita fishing group	1. Ecotourism 2. Mangrove tree nursery 3. Fishing	Kshs 60,000/-
19	Uyombo BMU	1. Fishing	Kshs 100,000/-
20	Ziwani Conservation group	1. Ecotourism 2. Mangrove tree nursery	Kshs 95,000/-
21	Mida fishing group	1. Fishing	Kshs 50,000/-
TOTAL			**Kshs 1,595,000**
MTWAPA CREEK FOREST FORMATION			
1	Mtepeni c mangrove forest conservation (VDFCC)	1.Mangrove nurseries 2.Mangrove forest rehabilitation 3.Mari culture	Kshs 120,000
2	Kidutani VDFCC	1.Mangrove nurseries 2. Mangrove forest rehabilitation 3. Bee keeping	Nil (new projects)
3	Kidongo VDFCC	1.Mangrove nurseries 2.Mangrove forest rehabilitation 3. Mariculture 4. Eco-tourism	Kshs 180,000
TOTAL			**Kshs 300,000**
KILIFI CREEK FOREST FORMATION			
1	Ihaleni Kakuluni Conservation	1. Mariculture 2. Mangrove Conservation 3. Beekeeping/Eco-Tourism.	Kshs 108,400
TOTAL			**Kshs 108,400**
TAKAUNGU MANGROVE FOREST FORMATION			
1	Takaungu BMU	Fishing	Kshs 36,000
TOTAL			**Kshs 36,0000**

APPENDIX 3.0: MANGROVE VALUATION STUDIES CARRIED OUT IN KENYA

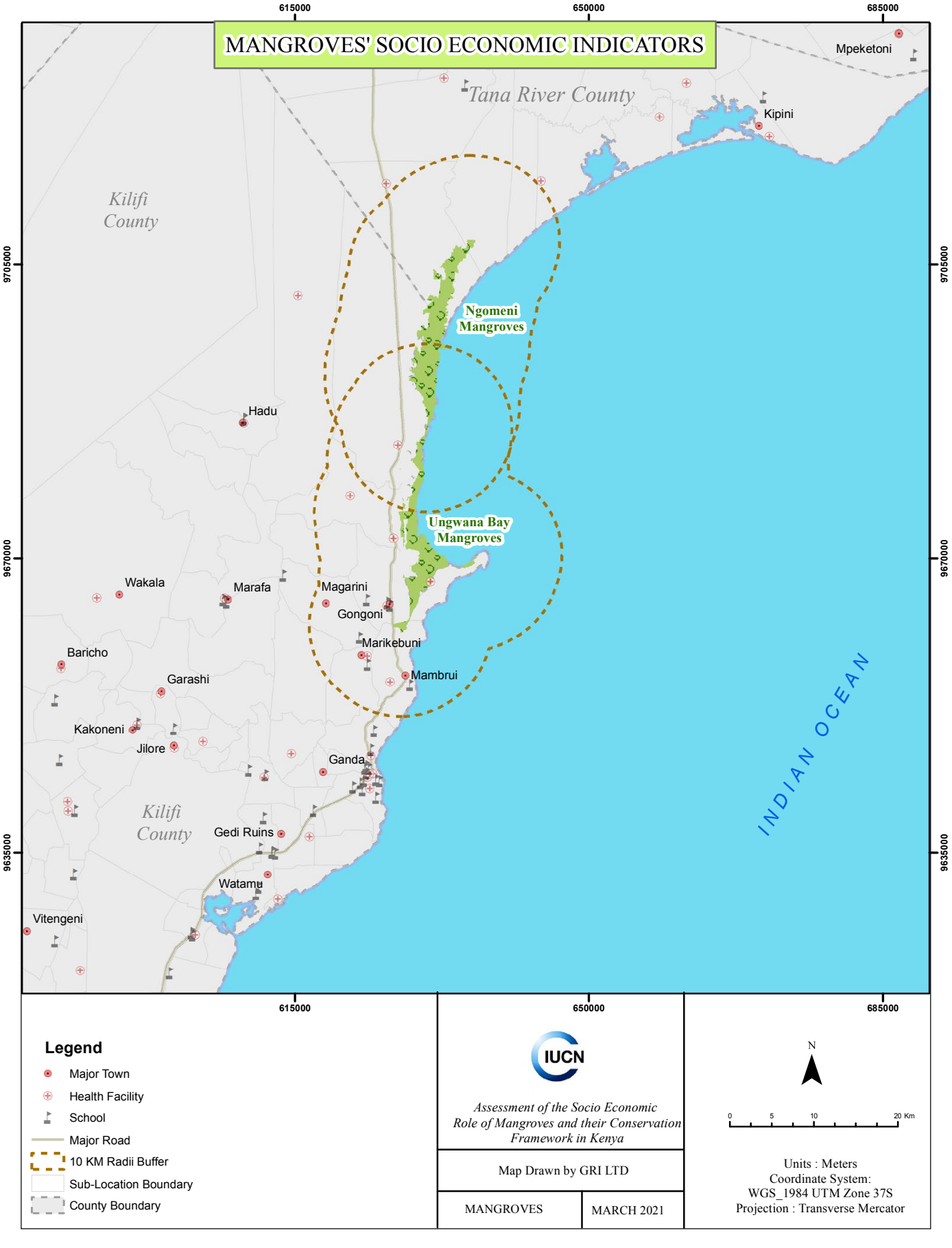


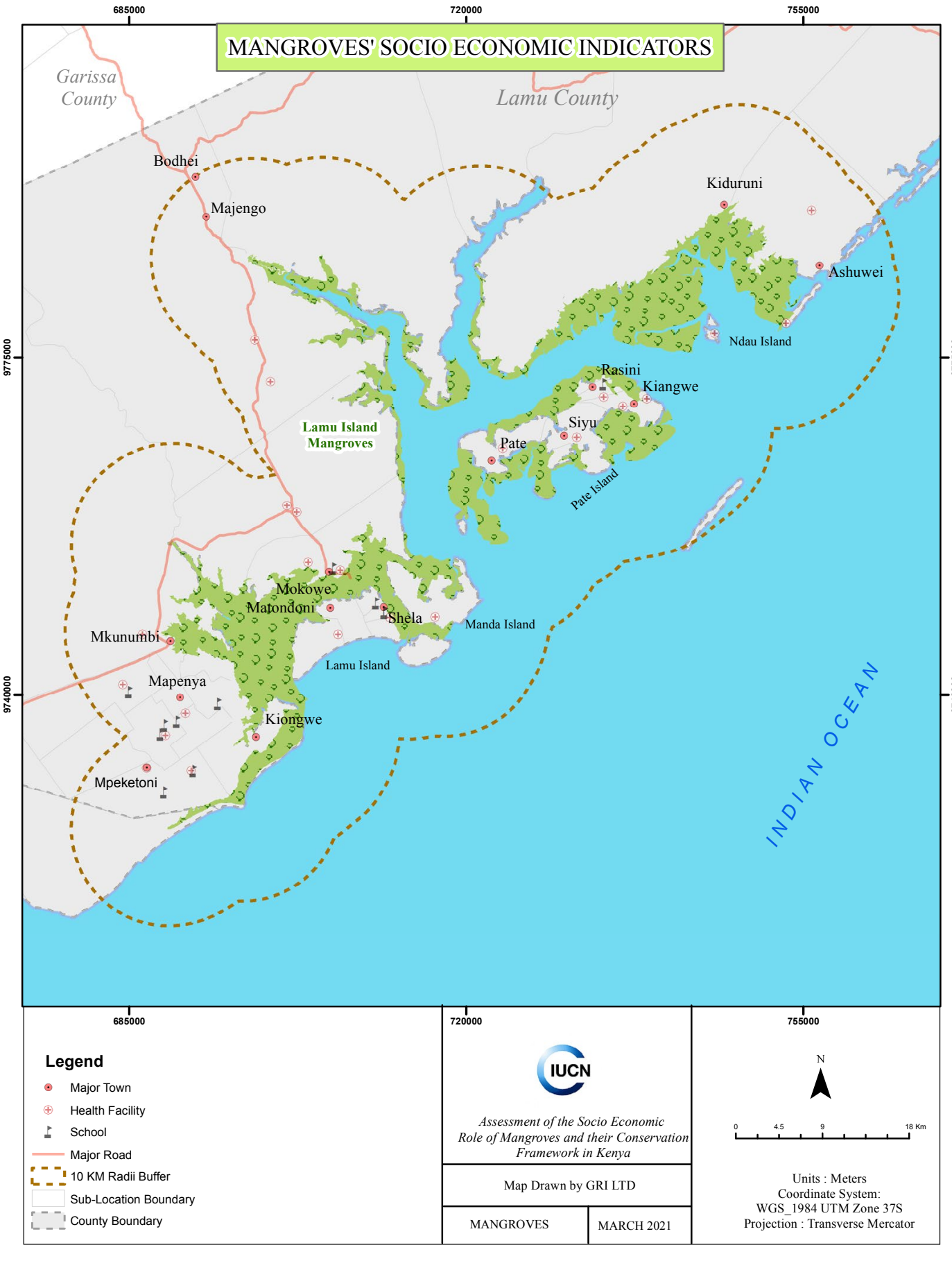

MANGROVES' SOCIO ECONOMIC INDICATORS
580000
608000
9616000
9589000
Kilifi County
Ganze
Kilifi Creek Mangroves
Mtondia
Mnarani
Takaunga Mangroves
Kibaoni
Mbuzi
Mitangoni
Dzitsoni
Kitsoeni
Takaunga
Kilifi County
Shauri Moyo
Junju
Vipingo
INDIAN OCEAN
Legend
Major Town
Health Facility
Major Road
10KM Radii Buffer
Sub-Location Boundary
County Boundary
IUCN
Assessment of the Socio Economic Role of Mangroves and their Conservation Framework in Kenya
Map Drawn by GRI LTD
MANGROVES
MARCH 2021
N
0 1.75 3.5 7 Km
Units : Meters
Coordinate System:
WGS_1984 UTM Zone 37S
Projection : Transverse Mercator


MANGROVES' SOCIO ECONOMIC INDICATORS
560000
580000
9580000
9560000
Gatoni
Junju
Kaloleni
Vipingo
Kilifi County
Mwanzai
Kibaokiche
Kikambala
Ribe
Majengo
Mtwapa Mangroves
Rabai
Mtwapa
Tudor Creek Mangroves
Shimo laTewa
Mazeras
Mombasa County
INDIAN OCEAN
Mwandoni
Kongowea
Nyali
Mtongwe
Likoni
Kwale County
Ngombeni
Legend
Major Town
Health Facility
School
Major Road
10 KM Radii Buffer
Sub-Location Boundary
County Boundary
IUCN
Assessment of the Socio Economic Role of Mangroves and their Conservation Framework in Kenya
Map Drawn by GRI LTD
MANGROVES
MARCH 2021
N
0 2 4 8 Km
Units : Meters
Coordinate System:
WGS_1984 UTM Zone 37S
Projection : Transverse Mercator


MANGROVES' SOCIO ECONOMIC INDICATORS
510000
540000
570000
9520000
9490000
Mihirini
Tserezani
Tiwi
Ndavaya
Ukunda
Kwale County
Mwereni
Mwabungu
R.Ramisi
Gazi
Gazi (Maftaha) Bay Mangroves
Mrima
Msambweni
Mgombezi
Derani
Ramisi
Kambini
Kidimu
Lunga-lunga
Funzi Bay Mangroves
Shimoni
Vanga
Vanga Mangroves
INDIAN OCEAN
TANZANIA
Legend
Major Town
Health Facility
School
Major Road
10 KM Radii Buffer
Sub-Location Boundary
County Boundary
IUCN
Assessment of the Socio Economic Role of Mangroves and their Conservation Framework in Kenya
Map Drawn by GRI LTD
MANGROVES
MARCH 2021
N
0
3.5
7
14 Km
Units : Meters
Coordinate System:
WGS_1984 UTM Zone 37S
Projection : Transverse Mercator

APPENDIX 4.0: SOCIOECONOMIC INDICATOR MAPS WITHIN 10KM OF MANGROVES




MANGROVES' SOCIO ECONOMIC INDICATORS
685000
720000
755000
9775000
9740000
Garissa County
Lamu County
Bodhei
Majengo
Kiduruni
Ashuwei
Ndau Island
Rasini
Kiangwe
Siyu
Pate
Pate Island
Lamu Island Mangroves
Mokowe
Matondoni
Shela
Manda Island
Mkunumbi
Lamu Island
Mapenya
Kiongwe
Mpeketoni
INDIAN OCEAN
Legend
Major Town
Health Facility
School
Major Road
10 KM Radii Buffer
Sub-Location Boundary
County Boundary
IUCN
Assessment of the Socio Economic Role of Mangroves and their Conservation Framework in Kenya
Map Drawn by GRI LTD
MANGROVES
MARCH 2021
N
0
4.5
9
18 Km
Units : Meters
Coordinate System:
WGS_1984 UTM Zone 37S
Projection : Transverse Mercator

APPENDIX 5.0: FGD LOOP DIAGRAMS DEPICTING MANGROVES' SOCIO-ECONOMIC BENEFITS