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Environmental Sensitivity

Atlas of Lamu County

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WWF

FOREWORD

Ecosystems in Lamu County are under enormous pressure from increasing human population. The population is extracting and using resources at an accelerated rate from a resource base that is vulnerable and finite. The pressure on the natural resources is manifested in vegetation removal; land and water resources degradation and pollution; overfishing and degradation of fish habitats; competition for use of aquatic space; and changes in atmospheric processes, such as climate change and its consequences.

Environmental resources are important to Kenya's socio-economic development. They support wealth creation, ensure food security and maintain a safe and clean environment. To secure sustainability and environmental resources management, there is need for stakeholders that include national and county governments, lead agencies, academia, industry, policy-makers, local communities and NGOs, to act in ways that maximize synergy and maintain a safe and productive environment. The benefits arising from the use of environmental resources should be shared equitably and should at the same time be available for posterity.

The Kenya Government commitment to sound environmental management is spelt out in the Constitution of Kenya (2010) which entitles every citizen the right to a clean and healthy environment and provides for protection of the environment for the benefit of present and future generations In addition, the national policy blueprint, Kenya Vision 2030, highlights the importance of sustainable utilization of natural resources in its social pillar. Vision 2030 seeks to build a just and cohesive society with social equity in a clean and secure environment. The Environment Management and Co-ordination Act (1999) and the Environment Management and Co-ordination (Amendment) Act (2015) provide for the application of the precautionary principle through strategic environmental assessment, environmental impact assessment and environmental audit.

This Environmental Sensitivity Atlas of Lamu County documents ecological areas that may suffer if appropriate measures are not taken into account in the process of development. Lamu County has been a target of oil exploration and the on-going construction of the Lamu Port-Southern Sudan-Ethiopia Transport (LAPSSET) Project, and the new Lamu Port development among a host of other proposed development initiatives such as an oil refinery, a coal powered plant and modern city area, by the government will have far reaching consequences if proper strategic environmental assessments are not done. The Atlas presents information in map and pictorial form to draw the attention of decision-makers to existing environmental hotspots and anticipated human impacts that may lead to environmental degradation and therefore loss of environmental resources. The Atlas also documents the location and extent of current environmental resources such as the coral reefs, sand dunes, mangroves, coastal forest and cultural heritages whose conservation value has attracted both local and international sentimental concern.

Lamu County's environmental resources including rare marine biodiversity such as corals, dugongs and sea turtles which is what lead to the establishment of Kiunga Marine National Reserve. The sheltered bays have deep waters leading to the proposal to develop the Lamu Port part of the LAPSSET Project. The discovery of oil and gas both at Lamu and in Turkana among other minerals in in the country has positioned the County as Kenya's future industrial hub. These call for informed Environmental Management, the reason for this Sensitivity Atlas.

It is hoped that the Environmental Sensitivity Atlas of Lamu will serve as a useful tool in our collective effort to ensure a balance between the needs of development and a safe and secure environment. There is need also to create opportunities to achieve sustainable development through sound economic investments and diversification, social development and environmental protection through wide public participation and access to environmental information as is envisaged in this Atlas.

Prof. Judi Wakhungu

Cabinet Secretary, Ministry of Environment, Natural Resources and Regional Development Authorities.

STATEMENT FROM THE PRINCIPAL SECRETARY

The Environmental Sensitivity Atlas of Lamu County will be used to create and increase awareness on the sensitive ecosystems in Lamu's Coastal area and the coast of Kenya in general. The Atlas provides evidence on environmental hotspots in the area and the changes likely to take place due to Government development projects, and pressure from increasing population and climate change. The Atlas documents the urgency of putting in place appropriate measures if the environmental resources are to be conserved and sustained.

The Atlas identifies the areas of environmental concern and illustrates the required strategy by both the National and County Governments to achieve a balance in the mutually interdependent economic, social and environment needs. Both governments will continue to review the environmental legal framework to ensure that development and natural resources exploitation is consistent with the principles of sustainable development and that the general public and the private sector participates fully in ensuring that environmental resources are sustainably utilized. The Government is committed to the promotion of private-public partnerships and other efforts that will contribute to improved management of our environment resources in the macro and micro development environment.

Charles T. Sunkuli
Principal Secretary, Ministry of Environment and Natural Resources

PREFACE

The Constitution of Kenya (2010) ushered in a paradigm shift in the management of natural resources and socio-economic development in Kenya. It introduced two tiers of government: the National Government and 47 County Governments, with the authority of county governance bringing management of public affairs closer to the grassroots. The Constitution provides a mechanism for identifying priority areas for development investments. Each County prepares a County Integrated Development Plan (CIDP) which provides comprehensive baseline information on environment, infrastructure and social-economic development priorities.

Some of the laws enacted since the Constitution came into force and which support implementation and operationalization of devolution include: The Urban Areas and Cities Act, 2011; The County Governments Act, 2012; The Transition to Devolved Government Act, 2012; The Intergovernmental Relations Act, 2012; The Public Finance Management Act, 2012; the National Government Coordinating Act, 2012, and the County Governments Public Finance Management Transition Act, 2013. The County Executive Committee supervises administration and delivery of services to county communities as well as conceptualizes and implements county policies and legislations. Kenya's Vision 2030, development blueprint aim to transform the country into an industrialized, middle-income country. The Vision's three pillars: Economic, Social and Political, point to a number of flagship projects among which Lamu Port-Southern Sudan-Ethiopia Transport (LAPSSET) Project will benefit Lamu County. With this project and the discovery of oil and gas in the Lamu Basin the county will face a fast paced development process that will require appropriate environmental safeguards for a sustainable development.

Lamu County Government aspires to implement the LAPSSET project and her own CIDP (2013-2017) using a process that takes into account the people's welfare, especially the protection of the sensitive coastal ecosystems that supports the fishing industry along with the cultural heritage that is an important source of foreign exchange through tourism. Environmentally safeguards will be achieved through comprehensive environmental information database upon which informed decision will be made. The Environmental Sensitivity Atlas of Lamu provides one such repository. The Atlas summarizes the key environmental issues of policy concern in Lamu through use of maps, photographs, graphs, charts and descriptive text.

The Lamu County Government will endeavour to sustainably use her environmental resources to benefit her people and to grow and transform the local economy. Although LAPSSET project is envisaged to bring into Kenya the much needed foreign exchange and create employment, the infrastructure development process and the discovery of oil and gas within the county, poses great environmental challenges that will affect environmental resources. Among the challenges are land degradation, deforestation, water and air pollution, effluent and solid waste discharge and urban growth and development. This Environmental Sensitivity Atlas provides a general guide on which areas to safeguard and monitor for any adverse impact.

Hon. Issa Timamy
Governor, Lamu County

STATEMENT FROM WWF

The world has for a long time depended on oil and gas to power its industries and homes and support vehicular transport. The impacts from the use of the fossil fuels on a healthy environment are well known, impacting all ecosystems from soil to water and air. Some of the major climatic changes documented today are a direct result of long term discharge of waste from burning fossil fuel. This has resulted in a range of environmental and social costs which need to be balanced against the benefits the oil and gas can bring. Key to maximising benefits and minimizing conflicts is good oil and gas industry governance that safeguards the environment.

Exploration for oil and gas in Kenya was carried out for the first time in the 1950s with the first exploration well being drilled in 1960. Following successful oil exploration in Mozambique, Uganda, Tanzania, and Sudan many oil and gas companies invested heavily in the oil exploration sector with heightened activities seeing successful discoveries in the Turkana basin in Kenya. Kenya has 4 other prospective sedimentary basins: at Anza, Lamu, Mandera and the Tertiary Rift Valley. The Lamu basin has exploration oil blocks that extends offshore into the Indian Ocean.

Besides exploration for oil and gas, a region extending from Lamu though Garissa, Isiolo to Lodwar and Nakodok at the border with South Sudan, with a branch of the project area to Moyale at the Ethiopian border is under a major infrastructure development, the Lamu Port-Southern Sudan-Ethiopia Transport (LAPSSET) project. The Environmental Sensitivity Atlas of Lamu County has been prepared to provide information on environmentally sensitive areas from the LAPSSET and the oil exploitation and the likely impact scenarios to the county government, the coastal resource managers, the communities, the general public and other specialized agencies in the area. The Atlas will provide tools to identify environmental risks, establish protection areas, prioritise and identify responses required and to put in place clean up strategies especially in the event of an oil spill. The Atlas will enable the County Government monitor her environmental resources and the activities of the oil companies and other development partners to incorporate environment considerations into their development activities.

The Atlas also provides information on biological resources, the rich cultural heritage of Lamu as a historical site, community sacred sites and water resources. It will enhance knowledge on the need to safeguard these resources using instruments such as the Constitution of Kenya 2010 which entrenches protection of environment; the Petroleum Exploration and Production Act Chapter 308; the Income Act Chapter 470 and the Environmental Management and Coordination Act (EMCA) 1999. The use of this Atlas will be a milestone towards sustainable management of natural resources and improvement of livelihood in Lamu County.

Mohamed Awer

EXECUTIVE SUMMARY

This Atlas has been developed through stakeholders' consultation forums that were facilitated by the National Environment Management Authority (NEMA) with support from NORAD and WWF Kenya. The development of the Atlas was guided by the principle of protection of the environment and natural resources spelt out in the Constitution of Kenya 2010. The constitution provides fundamental rights to a safe and secure environment and establishment of durable and sustainable systems of development. In addition to the constitution, the Environment Management and Coordination Act (EMCA) 1999 is the primary law on environment which is also supported by various policy and legislative instruments that ensures protection of specific environmental components that include: wildlife, forest, wetlands and water among others.

Environmentally Sensitive Areas and their importance

Environmentally Sensitive Areas (ESA) are ecosystems that have special environmental attributes worthy of note and retention through special human attention and care. These areas are critical to the maintenance of productive and healthy ecosystem that supports biodiversity and sometimes rare and endangered plant and animal species and diverse plant and wildlife populations apart from providing for livelihoods of communities through environmental resource use.

ESA are easily disturbed by human development activities and encroachments that occur during development projects implementation and actualization. Use of an area for settlement and agricultural production is especially detrimental to such areas which are often home to rare plant and animal species. The areas are valuable to both terrestrial and marine food web support and can range in size from small patches to extensive landscape features.

ESA enhance the quality of the environment where communities live, work and play. Development initiatives that demonstrate good environmental stewardship and involve the protection of sensitive areas that eventually support livelihoods, draw the support of communities that benefit from them. Best developments management practices are ecosystems centered and aim at protecting ecosystems from adverse impacts associated with the conversion of natural landscape to other forms of land uses such as mining, urban development, agriculture or even livestock keeping.

Management of environmentally sensitive areas aim at maintaining and restoring ecological diversity, fauna and flora including fish and their habitats. The process protects the environment and provides for human health and safety by ensuring a clean and safe habitat. To achieve the best for ESA, management options incorporate wide consultations amongst stakeholders, use available legal instruments and infuse re-known best environmental practices. A detailed site inventory with stakeholders is usually made to identify the presence or absence of ESAs in the proposed development site. All data that is accessed and collected should be scientifically acceptable (NEMA, 2009). This is followed by a site planning and design that pays due attention to environmentally sensitive areas with a view to instituting measures that supports the viability of an area as ESA. Three steps are followed in the "Before", "During" and "After" project implementation scenarios.

Before Development Project Implementation (Preventive measures)

Detailed development site planning that involves mapping and documenting with the communities and stakeholders is made. The important environmental resources in an area and their sensitivity to change are documented noting the requirement for adequate buffer zones to environmentally sensitive areas. The buffer zone is left wide enough to protect the ecological integrity of the environmentally sensitive area and also to prevent future impacts from encroachment. Buffers are left as public land and may be considered as protected areas for their resource in order to provide the best long term protection.

Buffers connect environmentally sensitive areas to nearby green spaces using features such as wildlife corridors. A development project is usually designed to retain pre-existing wildlife corridors to avoid and/or reduce human-wildlife conflicts. Environmentally sensitive areas are in most cases designated as park land, nature trails and any other recreational facilities that may be constructed with minimum disturbance. The designs should be established to allow acceptable tolerance to interacting human and environmental forces.

During Development Project Implementation (Protective Measures)

Deliberate initiatives are taken to avoid disturbing the environmentally sensitive areas during development. Construction and waste discharge should in as far as possible avoid ESA. Protection of existing stable ecosystems is much cheaper than enhancement and restoration of disturbed ecosystems. Technically it is almost impossible to restore ecosystems to their original functioning state once disrupted or destroyed.

After Development Project Implementation (Monitoring and Evaluation Measures)

After development, controls should be put in place to limit access to ESA through use of physical barriers such as fencing or through employing environmentally-friendly landscaping design using native plants that are better adapted to local conditions. Efforts should be made to avoid use of alien species that may invade into the environmentally sensitive areas. Provide signage that informs people that they are in an environmentally sensitive area and institute monitoring measures to assess compliance.

Some ecosystems are dependent on natural processes such as frequent or infrequent flooding or fires. These natural processes should be retained. Develop and implement a restoration plan of the disturbed environmentally sensitive areas including use of qualified professionals.

Lamu County's Environmentally Sensitive Areas

Lamu County consists of a coastal zone of islands, creeks, bays, sand bars and mangrove swamps that are rich with marine resources. The areas are significant breeding grounds of turtles, and various types of fisheries including prawns. The islands consists of the Lamu-Kiunga Archipelago that incorporates a chain of about 50 small calcareous offshore islands and coral reefs extending 60 km parallel and close to the coastline, Among these string of islands is Lamu Island that hosts Lamu Town, the county headquarters and which has been designated by UNESCO as a Cultural World Heritage Site, for its historical and cultural significance of the Swahili and Islamic cultures of the region. The islands shelter an extensive system of creeks, channels and mangrove forests and are significant biodiversity areas. Most of the islands are fully enclosed within the Kiunga Marine National Reserve (KMNR) (243.4 Km^2) and Ras Tenewi Marine Park that occupying the coastal area between Faza and Ras Tenawi.

The mainland area consists of forested areas and grasslands that are habitat to diverse wildlife including birds and primates. Dodori National Reserve (732.7 Km^2) is located on the mainland in Kiunga area and is wholly in Lamu. Boni National Reserves (133,900 Km^2) is located along the northern border with Garissa with only a small strip stretching along the border. To the southern end of Lamu Country area is Witu Forest Reserve (23.1 Km^2). The forests host a significant forest biodiversity.

Lamu Island ecosystem is greatly influenced by reversals between the Somali and East Africa Coastal currents during the two monsoon seasons, characterized by the influence of upwelling cool, nutrient rich waters that results in a highly productive marine ecosystem with a high degree of endemism. It has a wide range of ecosystems interlaced with terrestrial and marine habitats; including coastal sand dunes, rocky and sandy shores, mangrove forests, sea grass beds, coral reefs and open ocean (Baker et al 2010, Church and Obura 2004).

This Environmentally Sensitive Atlas for Lamu County will help outline, inventory and enable comparison of differing sensitivities (environmental, biological, geographical, and socio-economic) to development activities and envisaged oil drilling and refinery; extraction of minerals, sand and limestone for development construction; and urban development management with attendant population growth and pressure on environmental resources.

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ACRONYMS

CBD	Convention of Biological Diversity
CS	Cabinet Secretary
CIDP	County Integrated Development Plan
EIA	Environment Impact Assessment
ESA	Environment Sensitive Area
KENGEN	Kenya Electricity Generating Company
KWS	Kenya Wildlife Service
IBA	Important Birds Area
LPG	Liquefied Petroleum Gas
KMNR	Kiunga Marine National Reserve
LAPSSET	Lamu Port Southern Sudan Ethiopia Transport Corridor
MWENR	Ministry of Environment, Water and Natural Resources
NCPB	National Cereals and Produce Board
NEMA	National Environment Management Authority
NORAD	Norwegian Agency for Development Cooperation
PS	Principal Secretary
TFAP	Tropical Forest Action Plan
UNCED	United Nations Conference on Environment and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
WWF	World Wide Fund for Nature

CHAPTER 1: INTRODUCTION

1.0 BACKGROUND INFORMATION

The coastline of Kenya extends for nearly 600 Km and is a unique and globally significant natural resource base that provides the essential goods and services that support biodiversity as well as economic development and the livelihoods of the people. Kenya's coastal and marine ecosystems areas are a significant component of the country's natural and cultural heritage and the economy. The coastal ecosystems include the coastal sand dunes, mangrove swamps, coral reefs, coastal tropical forests and rangelands. These ecosystems are of great interest in view of their protective role against coastal siltation and erosion.

Kenya's coastal mangrove environments are part of the global priority conservation areas and considered a World Heritage Site exhibiting outstanding marine and coastal biodiversity. The coastline area has six distinct mangrove sites differentiated in terms of the coastal geology, hydrology, oceanography and the characteristics of the continental shelf. These are from south to north: Gazi-Vanga at the border with Tanzania; Mombasa; Kilifi; Watamu; Tana River Delta; and Lamu-Kiunga. The coastal coral reefs support significant fisheries and other biodiversity leading to the establishment of the Kiwayu, Kiunga, Watamu, Mombasa, Diani-Chale and Kisite-Mpunguti Marine National Reserves that are major tourist attractions. The area is also an important tourist destination for its sand beaches, scuba diving and land based tourism.

There are significant mineral deposits in Kenya's coastal area such as titanium (Kwale), iron (Kilifi, Taita Taveta), glass sand (Kwale), manganese (Kilifi), hydrocarbon (Lamu) and coral limestone (throughout the coast). Most of the minerals are found in the Karoo Sediments of the coastal geology. There are also minerals of gemstone value in Taita Taveta and Tana River Counties in the areas within the Precambrian Metamorphic terrain. The coast is also known for its cultural heritage inscribed into the world heritage list by UNESCO and listed as National Monuments. Among the cultural heritages are Fort Jesus (Mombasa), Lamu Old Town (Lamu), Kaya Forests (Kilifi), Shimoni Caves (Kwale) and Takwa Ruins (Lamu).

The Lamu Archipelago is a significant world ecological and cultural heritage with 75 % of Kenya's mangrove forests located here. The area has outstanding and endemic marine biodiversity of diverse coral reefs, sea-grass beds, sand bars, lagoons and creeks that support a lucrative fishing industry. The marine water hosts finfish and invertebrate fishery with siting's of Dugong and Dolphins within the Kiunga Marine National Reserve. The mangrove ecosystems provide a protective buffer zone between marine and terrestrial ecosystem dynamics. Lamu County marine resources are also habitats and breeding grounds of turtles. The creeks, bays, sand bars and mangrove swamps also form unique ecosystem structure that is a habitat and breeding ground for various types of fisheries and prawns. The ecosystem is also a habitat to wildlife resources such as birds and faunal resources.

In the recent past, the coastal and marine resources in the Lamu Archipelago and indeed in Lamu County's hinterlands are increasingly under threat. Key among these are over-harvesting of corals, pelagic fish, marine turtles, and invertebrates; use of destructive and unsustainable methods of resources exploitation such as beach seining, drift nets, coral mining, marine pollution; and encroachment on the sand dunes. In addition, recent and on-going development of Kenya's second port at Manda, under the Lamu Port South Sudan Ethiopia Transport (LAPSSET) Project, increasing population and settlements as Lamu becomes a preferred investment locale, are projected to accelerate further destruction of the sensitive ecological resources of the archipelago. Efforts are needed to ameliorate further destruction.

The Indian Ocean waters are an important transport corridor for East and Central African countries including Southern Sudan and over the years Mombasa Port has been serving as the main port for container goods and other ocean transport services. The country's Development agenda based on Vision 2030 has proposed new flagship projects with interest to develop a larger port in Lamu under the LAPSSET project. The project will include road network, railway network, airports and an oil pipeline that will open up the hinterland through Garissa, Isiolo, Lodwar and the neighbouring countries of South Sudan through Nakodok and Ethiopia through Moyale. There is also oil and gas exploration in the Lamu Basin. Six blocks have been identified with a number of test wells already developed. The planned irrigation for crop production at the Tana Delta and the Galana area just to the South of Lamu County is another development programme in the area. Coal based power generation using coal from Kitui County and further to be supported by imported coal is poised to place pressure on the natural resources especially from the waste discharge. Following the discovery of oil and gas in Turkana, Kenya has enhanced her activities in oil exploration with some activities extending to offshore areas of Lamu. Subsequent oil production and refinery proposed at Lamu Port will necessitate development of extensive physical infrastructure both for settlement, storage of oil and shipping, and on-land transportation. The spurred growth and development activities will have significant implications on all the sensitive habitats in Lamu County

The government of Kenya acknowledges that the development of a successful petroleum sector is never about petroleum alone, but also about managing its impacts for sustainable development. Striking a balance between high economic and development returns from exploitation of oil and gas projects against high financial and environmental risks is a challenge Kenya has to face. The need for all stakeholders responsible for oil and gas development and those in environmental management to partner cannot be underscored. This is to ensure that oil exploration and its development is carried out sustainably especially in biodiversity sensitive areas along the coast. It is against this background that the National Environment Management Authority (NEMA) and World Wide Fund for Nature (WWF) through the Oil for Development project have developed the Environmental Sensitivity Atlas for Lamu County to guide development.

This atlas provides information on the areas in Lamu County that are sensitive and that can get impacted from any unsustainable development actions from the proposed projects in the area.

1.1 LAMU COUNTY ADMINISTRATIVE STRUCTURE AND POPULATION

Lamu County is located in the northern coast of Kenya and is one of the six counties in the coastal region of Kenya. The County has two sub-counties, Lamu East and Lamu West. It lies between latitude 1° 40´ and 2° 30´ South, Longitude 40° 15´ and 40° 35´ East and is bordered by Tana River County to the southwest, Garissa County to the north, and touches the Republic of Somalia at the north east corner and the Indian Ocean to the south and east (Figure 1). The county has a land surface area of 6,273 Km² with a 130 Km long coastline. The area includes the mainland and over 65 islands that form the Lamu Archipelago. The Indian Ocean water mass cover an area of 308 Km². Some of the bigger islands are: Lamu, Manda, Pate, and Kiwaiyu. There are 51 islands in the area covered by Kiunga Marine Reserve.

Lamu County Administrative Map

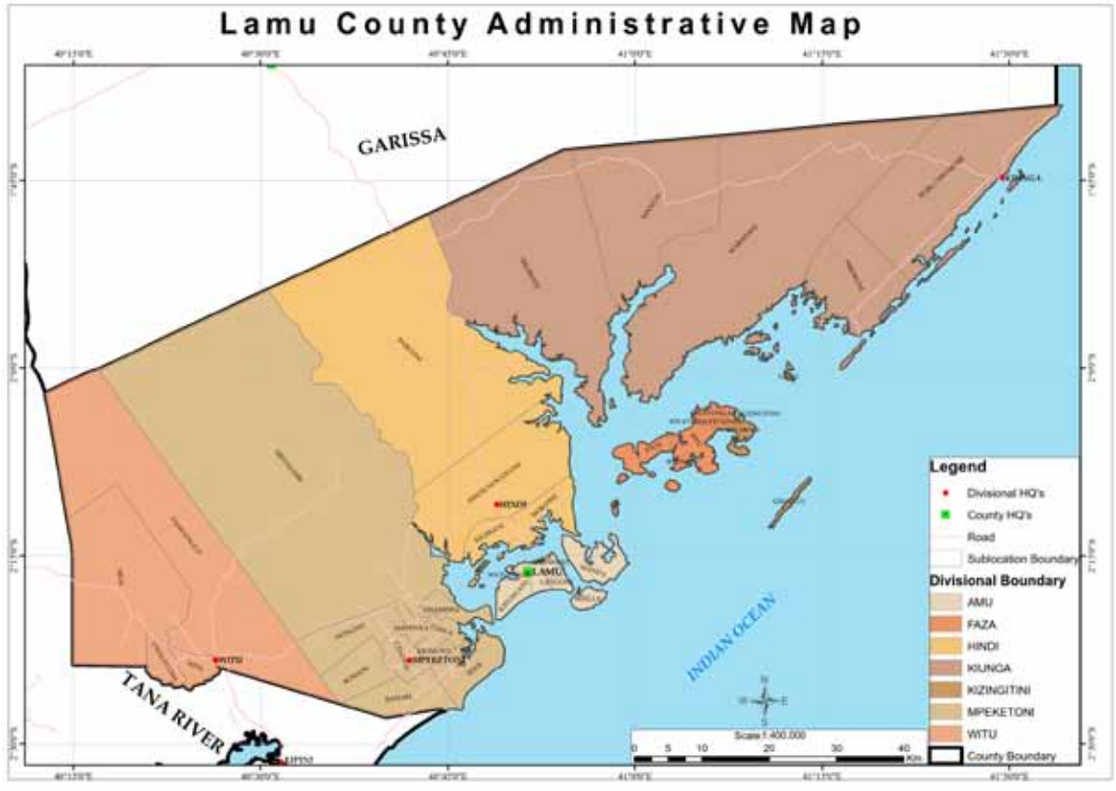

Figure 1: Location Map of Lamu County showing Divisional Boundaries

The National government has aligned its activities to the County governments in terms of administration structure through ward based administration units (Figure 2). The County is now implmenting its projects based on the ward political boundaries which now dictate how the national budget is allocated. Administratively, Lamu has 23 locations and 7 divisions as shown in Table 1. Lamu is divided into two sub counties, 7 administrative divisions, 10 wards and 23 locations. The total population of Lamu was estimated to be 101539 in the 2009 Population and Housing census with an annual growth rate of 2.47%. In 2014, the population was estimated to be 124,092. Table 1 shows the distribution of populations and households within the ten counties.

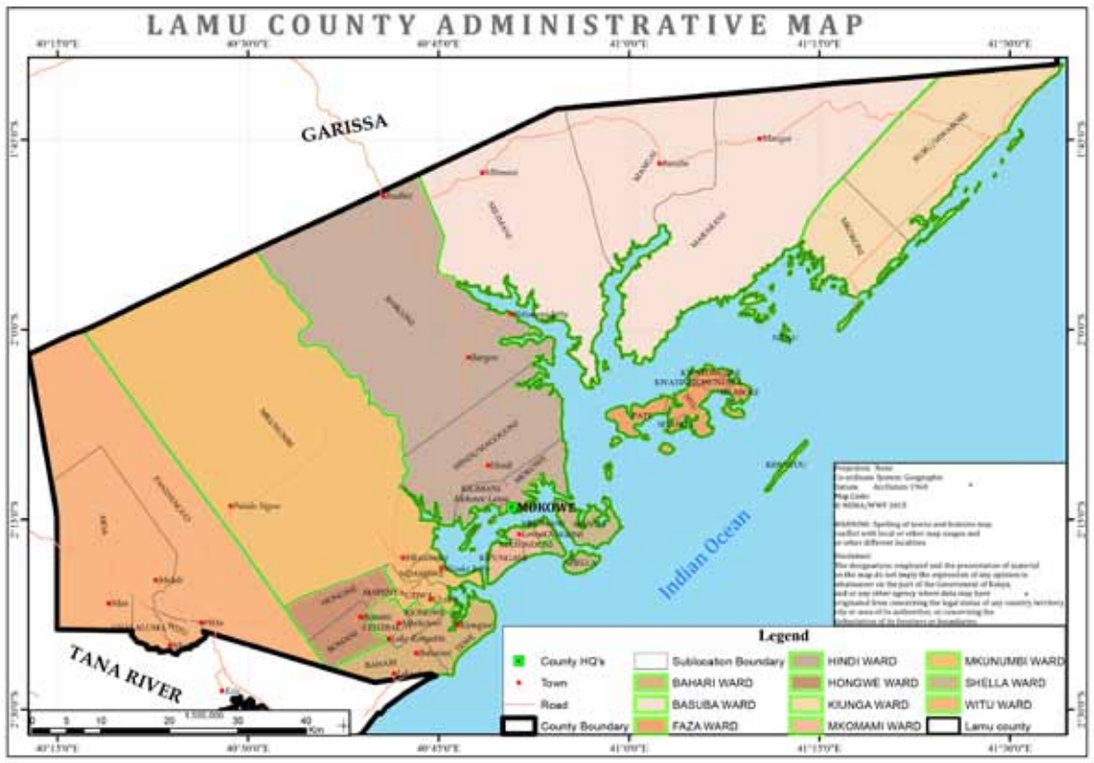

Figure 2: Administrative Map of Lamu County showing the County Wards

Table 1: Lamu County ward administrative units and population (Source: KNBS, 2010 and Lamu CIDP June 2014

Sub-County	Ward	Male	Female	Total	Households	Area(Km²)	Density
	Lamu County	53045	48494	101539	22184	6272.4	16.2
Lamu East	Faza	6762	6762	13524	2517	90.8	149.0
Lamu East	Kiunga	2310	1955	4265	848	519.6	8.2
Lamu East	Basuba	542	510	1052	197	1708.0	0.6
Lamu West	Shela	1882	1392	3274	885	54.7	59.8
Lamu West	Mkomami	9660	9432	19092	4387	44.9	425.2
Lamu West	Hindi	6021	4679	10700	2286	1150.8	9.3
Lamu West	Mkunumbi	6232	5492	11724	2687	1428.7	8.2
Lamu West	Hongwe	4748	4349	9097	2100	128.5	70.8
Lamu West	Witu	6740	6365	13105	2540	975.7	13.4
Lamu West	Bahari	8148	7558	15706	3737	170.7	92.0

Lamu's population density distribution by the Wards is shown in Figure 3. The population includes both indigenous and migrant people whose culture has been influenced by the Portuguese and Arab settlers. These are Swahili, Arabs, Wardea, Orma, Wasanye, Pokomo, Giriama, Somalis, Awer (Bonis) and Bajuni, There is also a significant population of Kikuyu settlers and other inland tribes. As can be seen from Figure 3, the highest population density is found in the islands of Lamu (Mkunumbi Ward) and Pate (Faza Ward) and the mainland area of Mpeketoni (Bahari and Hongwe Wards).

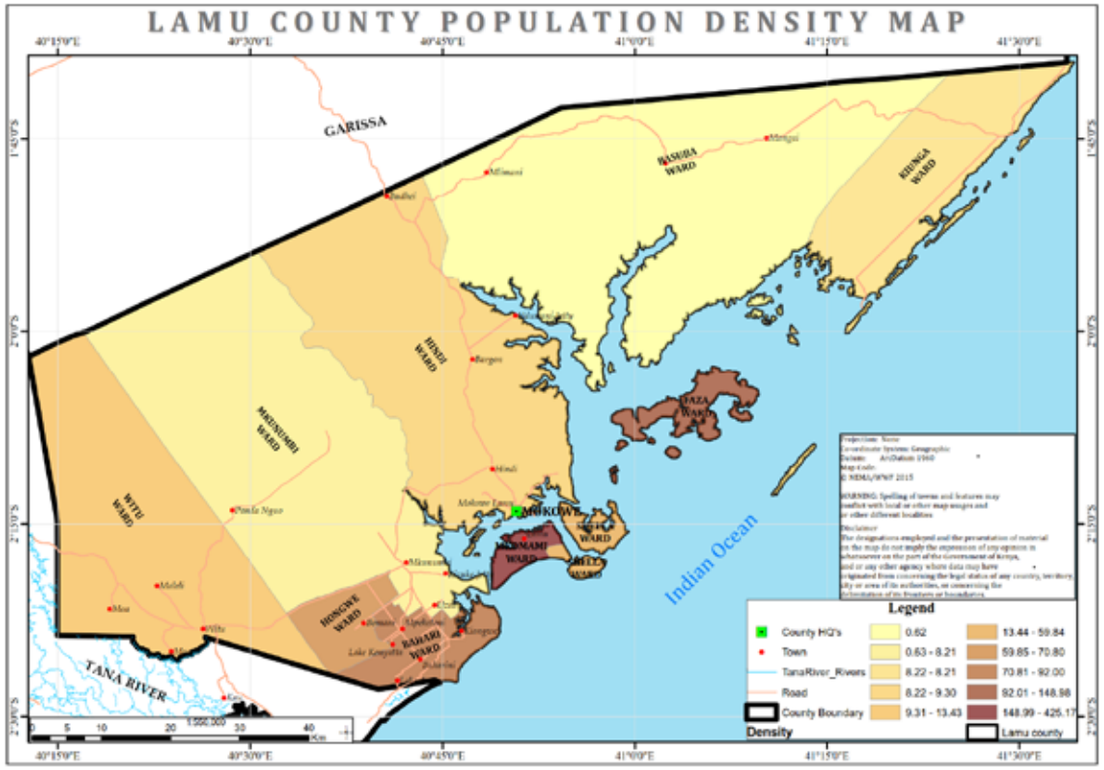

Figure 3: Lamu County population density and distribution by Wards

Lamu Town or Amu as is locally referred, is the largest urban area and is located on Lamu Island. The town is only accessible by boats and dhows and is a UNESCO World Cultural Heritage Site for her archaeological artefacts dating back to the 14th century. Lamu Town is Kenya's oldest continually inhabited town, and was one of the original Swahili settlements along coastal East Africa. Lamu County itself is classified as an important global biodiversity hotspot because of its unique marine and terrestrial habitats, resident and migratory bird species and extensive mangrove forests (WWF, 2001). The Kiunga-Kiwaiyu Marine National Reserve (60,000 ha) was designated as a protected area in 1979 and a biosphere reserve the following year. Economically, fisheries and mangroves in this area have traditionally been very important in supporting the livelihoods of especially the coastal communities as well as the local and national economies through tourism activities.

1.2 PHYSIOGRAPHY AND CLIMATE

The topography of Lamu County is generally flat and prone to flooding during rain-storms. Some areas within the mainland Lamu such as Mokowe are below sea levels as a result of the areas being a limestone karst terrain. The highest areas are around Boni-Lungi. The area is poorly drained and because of the karst terrain and the sand deposits, most of the runoff water completely percolates into the ground. Because of this, there is poor surface and spring water supply especially during the dry season. The highest average annual rainfall in Lamu County is 1,200 mm along the coast and reduces to 600 mm inland at Bargoni, Pandanguo, Milimani and Basuba areas (Figure 4). Lamu lies along the Equatorial Climate Systems where the weather is characterized by two monsoon winds and warm climate. The mean annual potential evaporation is high at 2,327 mm per year and the temperatures range between 24°C and 30°C. Generally and over the last 30 years, there has been an increase in both the annual average rainfall and mean temperature in Lamu (Figure 5). The hottest months are December to April while the coldest are May to July. The physiography influences settlement, road infrastructure and farming.

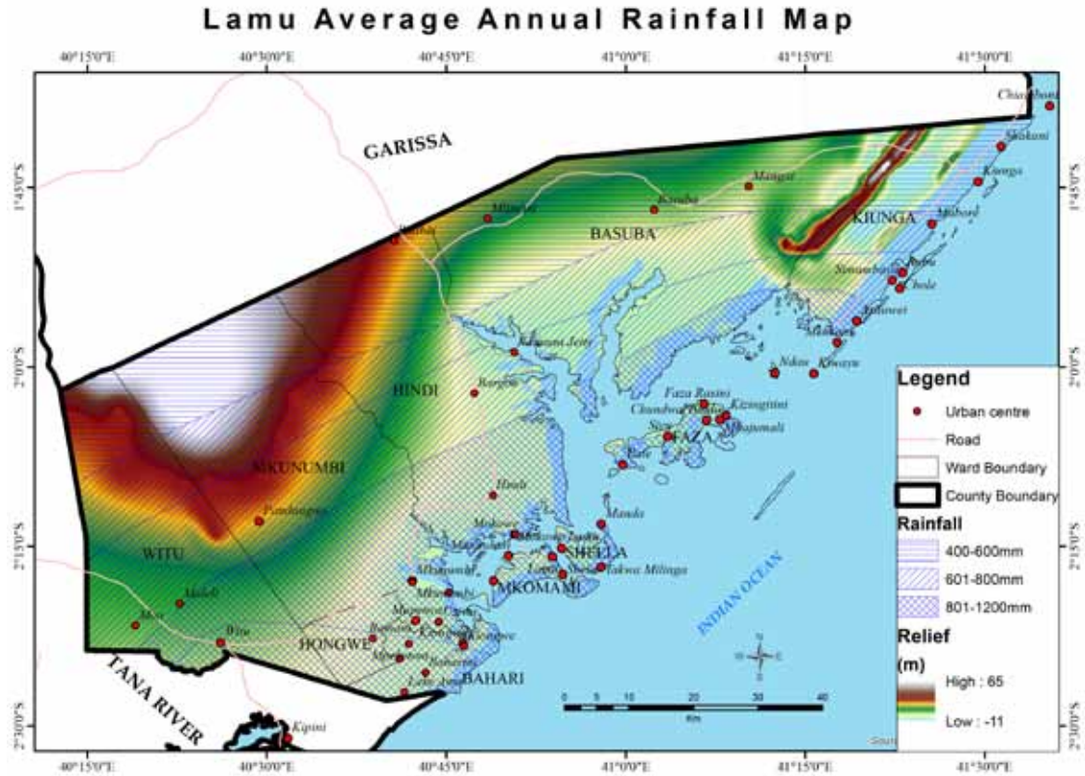

Figure 4: Lamu County Average Annual Rainfall

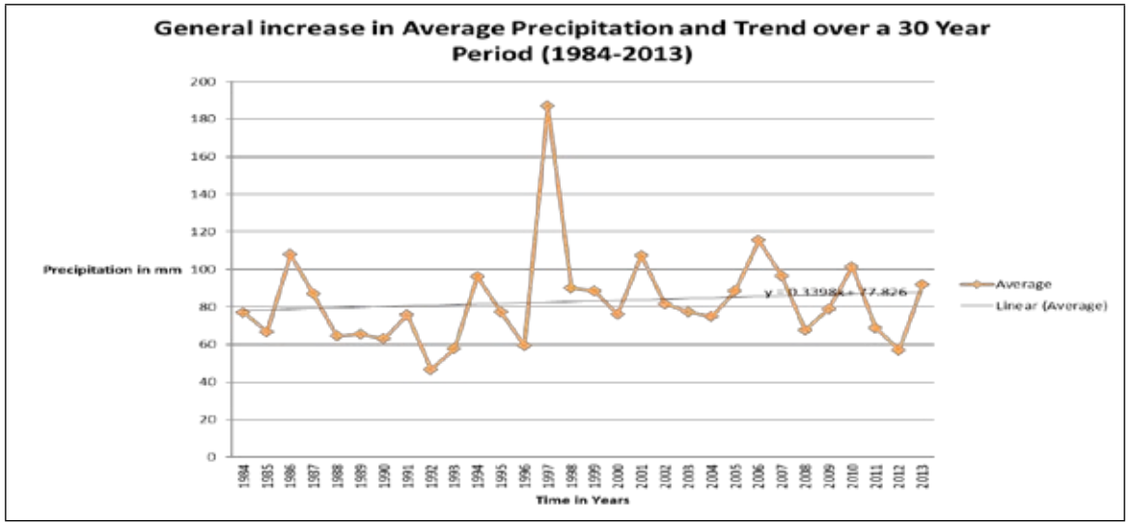

Figure 5: General increase in Average Precipitation and Trend in temperature in Lamu over the last 30 years

There are four oceanic currents affecting the Kenya coast and that influence the sediment distribution. These are the South Equatorial Current; East Africa Coastal Current; The Equatorial Counter Current; and Somali Current. The East Africa Coastal Current flows northwards all the year round at least as far as Malindi during the Northeast Monsoon (November to March). During the South East Monsoon (May to August) it continues beyond Malindi and joins the Somali Current and flow towards the Horn of Africa. The Somali Current is the only one that reverses its direction of flow under the influence of the monsoon. It flows in a south-westerly direction with the Northeast Monsoon, while during the South East Monsoon, the current reverses its flow and appears as the northwards extension of the East African Coastal Current which arises from the onshore South Equatorial Current (Johnson et al., 1982)[1].

1.3 HYDROLOGY AND GEOLOGY

Lamu County is characterized by Quaternary to Recent sediments mainly of, limestone and coral reef stones. It has distinct sandstone facies which formed from the Permo-Carboniferous through the Tertiary in four Mega-sequences that show variation in grain sizes, porosity, permeability, compaction, shaliness and cementation. This geology influence groundwater availability. Lamu sits in a basin with eastward thickening succession of sediments on which sea level fluctuation and a sequence of unconformities have developed leading to hydrocarbon potential (Nyagah, 1995)[2]

The hydrology of the area is highly influenced by the topography and geology of the area with rivers flowing south easterly in a direction perpendicular to the Indian Ocean coastline. Many of the streams are ephemeral draining into the limestone karsts found in the area and therefore contributing to groundwater in the area.

Lamu Island and a significant area of Lamu's coast is covered under sand dunes that are a catchment area for groundwater that serves the settlements including Lamu Town with fresh water. These are recharged directly from rainfall and seasonal runoff. The Lamu County water wells are also influenced by recharge from the Tana River flowing south easterly inside Tana River country and a few kilometres away from the border. Tana River is the largest river in Kenya and enters the Indian Ocean at Kipini in the neighbouring Tana River County. The hydrology of the Tana Delta influences the groundwater resources in the southern part of Lamu County.

1 Johnson, D. R., Mutua Nguli, M., IClmani, E. J (1982). Response to annually reversing monsoon winds at the southern boundary of the Somali Current. Deep Sea Res. 29: 1217-1227

2 Nyagah, (1995). Sedimentary Geology Vol 96 pgs 43-71 issues 1-2 Elsevier– Stratigraphy, depositional history and environments of deposition of Cretaceous through Tertiary Strata in the Lamu basin, South East Kenya and Implications for reservoirs for Hydrocarbon Exploration

CHAPTER 2: LAMU TERRESTRIAL AND MARINE ECOSYSTEMS AND THEIR SENSITIVITY TO DEVELOPMENT

2.0 INTRODUCTION

Ecosystems are basic functional units of nature that provide habitats for earth's living and non-living elements. They comprise assemblages of organisms operating as a system in which energy flows and nutrients are processed and recycled. The earth's ecosystems consist of terrestrial (land), marine (ocean), coastal (coast), and aquatic (freshwater) environments all within which are many smaller ecosystems or subsystems. When functional an ecosystem generates a unique ecology and therefore biodiversity niches that support life and are used for socio-economic development.

Manmade, unnatural ecosystems evolve in landscapes as a result of man modifying the natural ecosystems as he exploits various resources for food and for development. Urban settlements, agricultural areas, constructed dams, mining areas and irrigation areas are examples of such ecosystems. They present themselves as evidence of changes in natural states and in many cases lead to environmental change, habitat modification and/or loss all together.

Functional ecosystems cycle oxygen, carbon, nitrogen, water, and phosphorous that enables nature to sustain her, and maintain equilibrium across ecosystem without much need for human intervention. The flow systems are also a medium for transporting environmental pollutants like waste water, acid rain and greenhouse gases. They also regulate temperature rise occasioned by climate change from global warming. The ecosystem's ability can be exceeded (or challenged) by the above changes. Lamu County boasts of the entire assemblage of ecosystems: Terrestrial ecosystems; Marine ecosystems; Aquatic ecosystems; and Unnatural ecosystems.

2.1 LAMU TERRESTRIAL AND MARINE ECOSYSTEMS

Lamu's terrestrial and marine ecosystems (Figure 6) are home to a wide variety of faunal and floral species ranging from micro-organisms (phytoplankton and zooplankton) to macro-organisms (elephants, giraffes and buffaloes). Species of conservation concern in Lamu are sea turtles, dugongs, dolphins and corals. These, along with the need for mangrove conservation lead to the establishment of Kiunga-Kiwaiyu Marine National Reserve. The ecosystems are also globally recognised as an Important Bird Areas (IBAs) (Bennun and Njoroge, 1999).

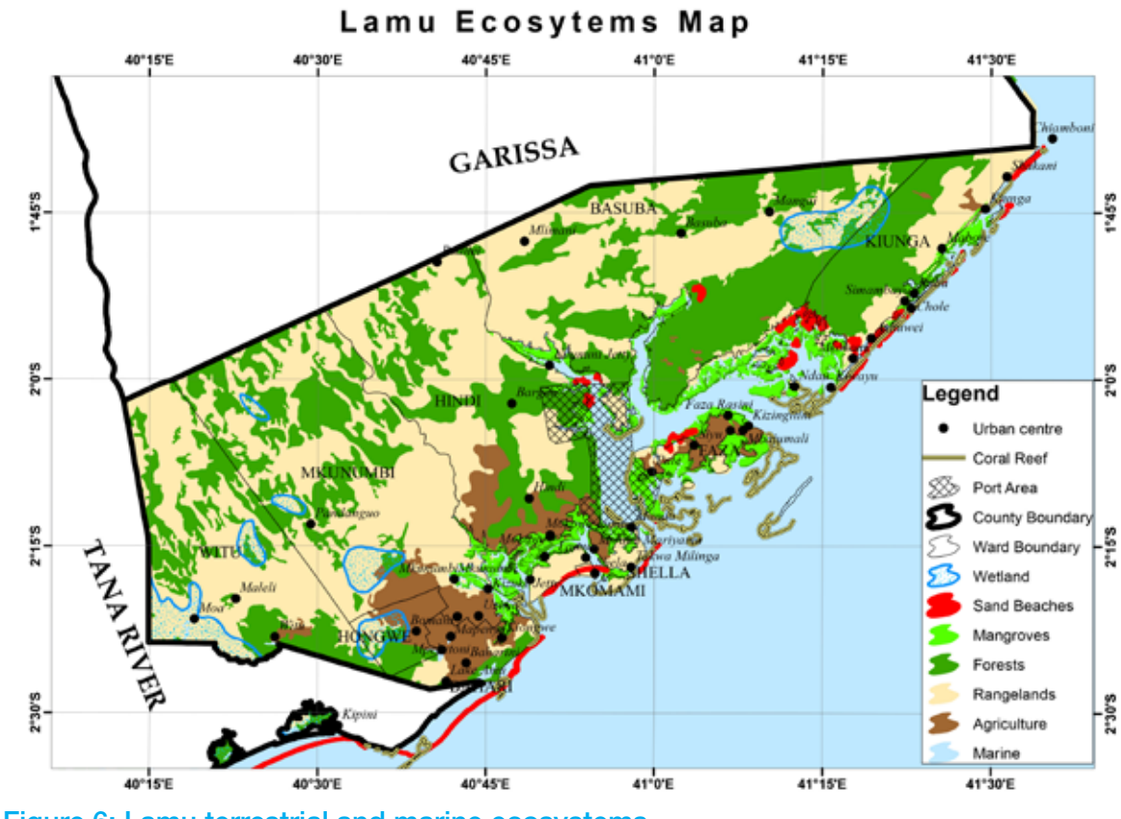

Figure 6: Lamu terrestrial and marine ecosystems

Lamu's terrestrial, inter-tidal and sub-tidal ecosystems form an interdependent continuum, divided into habitats dominated by keystone species of mangrove forests, sea grass and corals. Other natural resources in Lamu County include coastal forests with Dodori and Witu Forest Reserves (Figure 7) being the most significant and that are habitats to various forms of wildlife. There are also creeks and estuaries sheltering marine fishes and the open sea resources. Indeed Lamu is considered a biodiversity hotspot. There are various ecosystem services that the communities derive from the Lamu's ecosystems and natural resources. These resources are however under threat from a variety of causes.

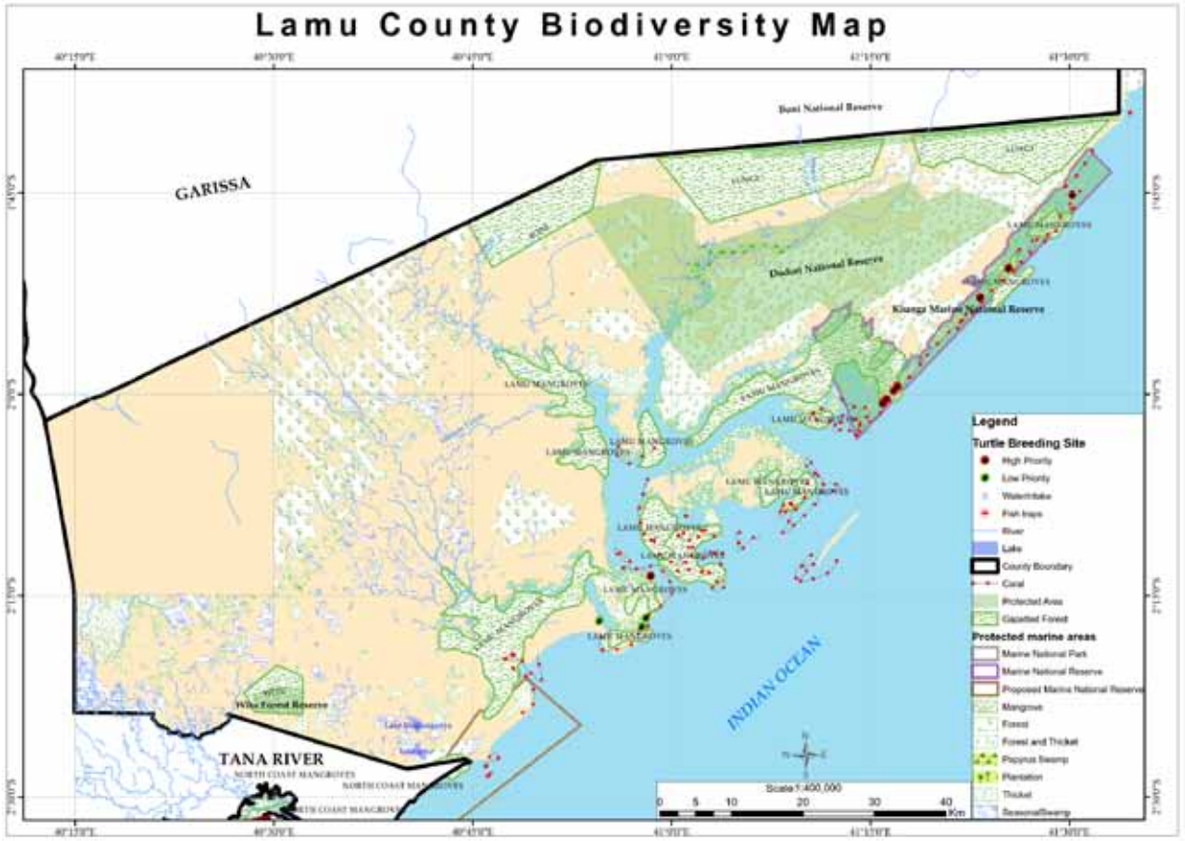

Figure 7: Lamu County biodiversity and protected areas map

2.2 TERRESTRIAL ECOSYSTEMS

2.2.1 Lamu Forest Ecosystems

Forest ecosystems are landscapes dominated by trees and also characterised by woody and herbaceous flora with complex interactions between soils, water and other physical factors (Barnes et. al 1982)[3]. Lamu's forest vegetation area covers 33.9% of the total county land surface area. The largest forest area in Lamu is the area referred to as the Boni-Dodori which has two forest blocks; Boni Forest (Boni National Reserve) mainly located in Garissa County but stretching into Lamu County; and the Dodori Forest (Dodori National Reserve) wholly located in Lamu County. The two forests are at the northern limit of the East African Coastal Forest, classified by Conservation International as a 'biodiversity hotspot.' The area is a mosaic of closed-canopy forest, savannah woodland (Plate 1), thicket and farmland which supports significant populations of mammals such as buffalo, coastal topi, African wild dog, Aider's duiker, baboons, wild pigs, hippos, the rare rumped back elephant shrew (a rare and endangered mammal), a host of other faunal species such as snakes, birds, and butterflies. Other than the main forest area there are smaller pockets of protected forest areas such as Witu, Lungi, Pandanguo, Kipini and Lake Kenyatta buffer zone. Most of these smaller forest areas are threatened by human pressure

Plate 1: Aerial view of a section of Dodori forest a mosaic of closed forest and savannah woodland (*Photo: USAID Kenya SECURE Project (2012*)

The Boni and Dodori National Reserves have experienced significant depletion of wildlife, mostly due to poaching over the past decades. In the early 1970s, the area had some of the highest concentrations of elephants and other game in Kenya. Today, the elephant population is estimated to be between 100 and 300, down from an estimated 30,000 (USAID Kenya SECURE Project (2012)[4].

3 Barns B. V., Bregitzer K.S. Spies. T. A. and Spooner V, H. 1982. Ecological forest site classification, Journal of Forestry Vol 80, pgs 493-498, Society of American Foresters.

4 USAID Kenya SECURE Project (2012), Boni-Lungi-Dodori Participatory Resource Map facilitated by TetraTech ARD, in partnership with the KiBoDo Trust, Ministry of Lands, Kenya Wildlife Service, and Kenya Forest Service, with technical assistance from ERMIS Africa.

The forest ecosystems are also important catchment areas and host various forms of wetlands including swamps (Plate 2). The forests also have significant and endemic biodiversity which are habitat to primates such as velvet monkeys (Plate 3).

Plate 2: A protected wetland in Dodori Forest in Lamu surrounded by rich biodiversity (*Photo: WWF-Kenya*)

Plate 3: Velvet Monkey one of the rich primate biodiversity in Dodori Forest, Lamu (*Photo:: WWF-Kenya*)

Dodori/Boni forest area (Figure 8) spread into Garissa County in the north. Kipini forests spread into Tana River at the Tana Delta area are rich in many colourful bird biodiversity (Plate 3). The forest areas were declared important bird areas in March 2014 by the National Museums of Kenya. The listing of birds in the forests was based on occurrence of globally threatened species such as the Southern Banded Snake Eagle, Bateleur, Crowned Eagle, Martial Eagle, Fischer's Turaco, plain-backed Sunbird, Malindi Pipit, Eurasian and Rollers. Vulnerable and endangered species in the forest include Lappet-faced and White-headed Vultures and Migrants Basra Reed Warblers. Kipini wildlife and botanical conservancy just outside Lamu in Tana River delta, was gazetted as an environmentally significant area using the Environmental Management and Coordination Act (EMCA) 1999 and the Forest Act of 2005 through, legal gazette notices No 208 of 2013 and No 214 of 2010 respectively. The important bird areas in Lamu are shown in Figure 8.

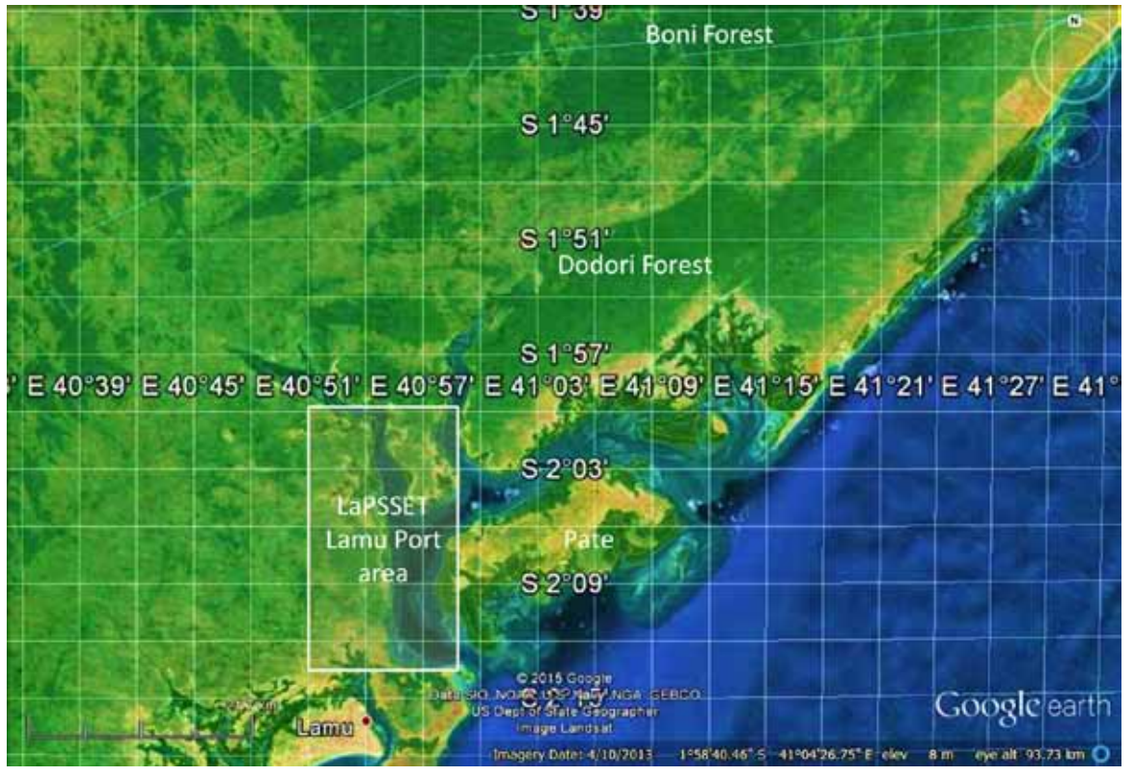

Figure 8: Dodori-Boni Forest area of Lamu and the site of LAPSSET Lamu Port

Plate 4: One of the colourful bird biodiversity found in Dodori Forest, Lamu
(Photo: WWF-Kenya)

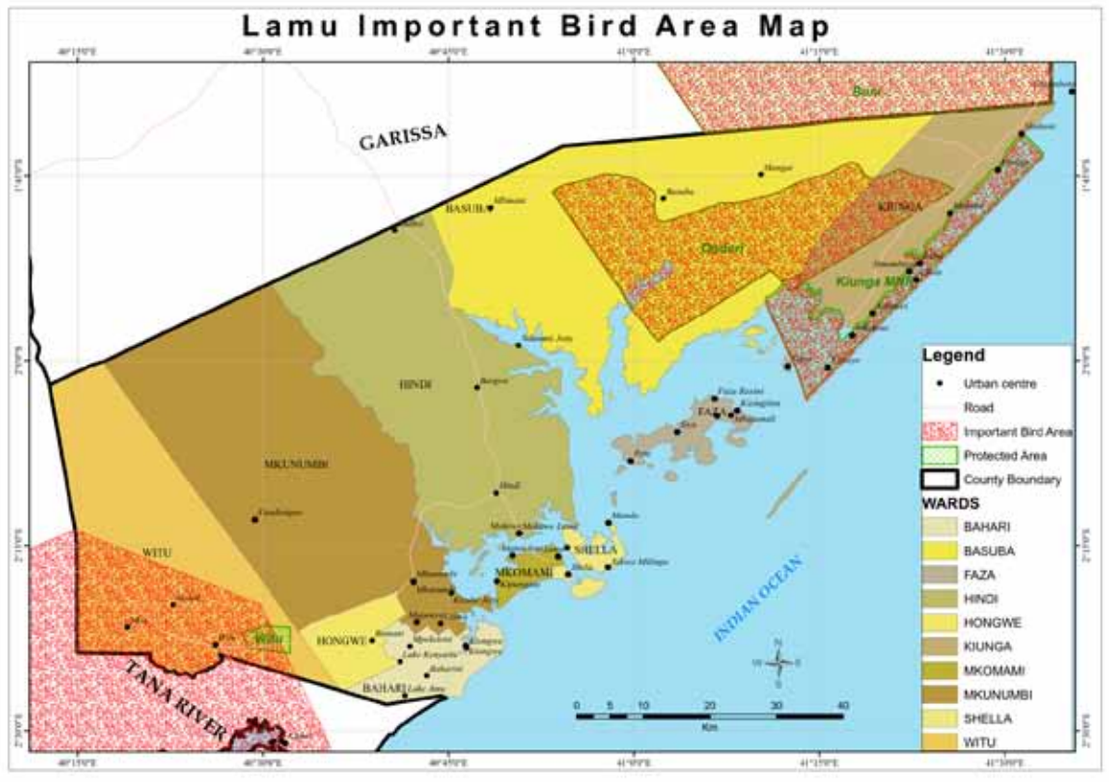

Figure 9: Lamu County Important Bird Areas

Boni (or Aweer), Bajun and Basuba communities inhabit the Boni-Lungi-Dodori forests area in small villages (Plate 5 and 6). The communities have conserved the forest area as shown by the participatory mapping by USAID Kenya SECURE Project (2012) that was used to identify the current extent of the forest, cultural heritage sites, migration patterns and utilization of the forest resources (honey harvesting, gathering fruits, firewood etc). There is need to continue improving the process the communities are suing to protect and manage these biologically sensitive areas while securing the community land and resource rights of the local people.

Plate 5: Aerial view of Basuba Village within Dodori Forest a settlement in harmony with the forest use (*Photo: USAID Kenya SECURE Project (2012*)

Plate 6: Aerial view of Kiangwe village within Dodori forest and within reach of a watering wetland (*Photo: USAID Kenya SECURE Project (2012*)

The Lamu community use the forest in various ways and derive their livelihoods from the forest products such as fruits; wild vegetables; herbal medicine from leaves, roots, and stems of the trees bee keeping and honey harvesting; pastures for livestock; construction materials; boat making in form of dug-out canoes, and fuel-wood. Due to increasing population in the area, attracted by availability of land, good climate for rain-fed agriculture and the opening up of the area in anticipation of the planned LAPSSET project and other developments, the terrestrial resources are facing new pressure. This has occasioned forest and vegetation removal for agricultural land and settlement. This is likely to affect the marine environment from siltation due to erosion from agricultural land and waste discharge from settlements

2.2.1.1 Forest Ecosystems' Sensitivity to Development Process

The sensitivity of terrestrial forest ecosystems is broadly based on its importance and difficulty of replacement once destroyed by development activities. Key direct impacts of development on forest ecosystems are the removal of vegetation and canopy cover. Forest degradation is often associated with logging, clearing for agriculture and settlement (Plate 7) and for infrastructure development for oil exploration activities. Development interventions such as clearing using fire (Plate 8) lead to severe degradation. These are the major cause of the degradation leading to direct loss of biodiversity. Pollution from domestic or industrial effluent and other forms of waste including air pollution reduces forest habitat quality. Other drivers include global warming that may result in emergence of invasive species and pathogens.

Plate 7: Forest degradation in Witu from clearing for development using fire (*Photo: Onywere, Feb. 2011*)

Plate 8: Forest replacement with settlement and agriculture (*Photo: Onywere, Feb. 2011*)

Indirectly, long term increased access to remote areas, livestock grazing and products harvesting such as for medicine and fruits can also degrade a forest. Most of the farming systems end up fragmenting the forest leading to habitat fragmentation and loss. Larger intact forest ecosystems may withstand major developments but smaller forest fragments are likely to be sensitive to all forms of clearing.

Some of the impacts resulting from forest loss are not detectable in the short term. For instance, changes in upstream and downstream hydrological cycles may take years to be noticed. The effects of deforestation are in most times not felt instantly and *insitu*, but over time, the absence of vegetation cover in a previously forested area affects both the living and non-living components of that environment. In addition, it affects both the upstream and downstream hydrological cycle of the areas.

2.2.2 Rangeland ecosystem

Rangelands are considered as marginal ecosystems with a highly varied vegetation structure, often forming a mosaic with other ecosystems such as forests and wetlands (Hamerlynck, et al., 2010)[5] and grading into bush land. Apart from being rich in biodiversity, rangelands have also traditionally constituted a multi-user and

5 Hamerlynck O., J. Nyunja, Q. Luke, D. Nyingi, D. Lebrun, and S. Duvai, 2010. The communal forest, wetland, rangeland and agricultural landscape mosaics of the Lower Tana: a socio-ecological entity in peril. In: Bélair C., Ichikawa K., Wong B.Y. L., and Mulongoy K.J. (Editors). Sustainable use of biological diversity in socio-ecological production landscapes. Background to the 'Satoyama Initiative for the benefit of biodiversity and human well-being.' Secretariat of the Convention on Biological Diversity, Montreal. Technical Series no. 52, 184 pages.

multifunctional unit of great economic value to surrounding communities. They are the major resource for livestock based livelihood systems (Plate 9 and 10) and a great variety of wildlife. Kenya's rangelands are the ecosystems that support many of the national parks and the tourism economy. In Lamu's Rangelands for example it is not uncommon to encounter the ostrich (Plate 11).

Plate 9: Large herds of livestock in the rangelands between Hindi and Bargoni (*Photo: Onywere, Oct. 2015*)

Plate 10: Small livestock in the rangelands between Hindi and Bargoni (*Photo: Onywere, Oct. 2015*)

Plate 11: Maasai ostrich in an open grass patch within Boni Forest area (*Photo: Brianmarv, web*)

A number of community conservancies are juxtaposed within the rangelands adjacent to the protected areas. On-going developments and land use practices coupled with societal trends have influenced rangeland management priorities particularly when considering the multiple, competing, complementary and exclusive uses. Some of the rangeland areas in Witu, Mpeketoni and Mokowe are under threat due to conversion of the areas to farming through burning of the rangeland grasses and vegetation (Plate 12).

Plate 12: Clearing of rangeland areas through slashing and burning for agriculture (*Photo: Onywere, Oct. 2015*)

2.2.2.1 Rangeland Sensitivity to Development Interventions

Land use changes due to agricultural expansion and settlements are direct drivers of change that interfere with ecosystem functioning in rangeland areas. The removal of vegetation and overgrazing reduces ecosystem productivity thus affecting important ecological function of rangelands as wildlife feeding, dispersal and migration corridors. Changes in human demography with immigration into the area by people of other cultures from other parts of Kenya in search for land and new economic ventures will create pressure associated with anthropogenic activities. Development of oil exploration wells, access roads, pipelines and the LAPSSET

corridor associated infrastructure will fragment the rangelands and interfere with the wildlife migration corridor between the Dodori/Boni Forest and the Tsavo West National Park and the riparian areas of Tana River. There is need to mitigate the impacts on ecosystem functionality in sustaining the wildlife species and biodiversity. Developments threaten effective rangeland ecosystem management. This calls for measures that minimise such disturbances and overcome undesirable cumulative effects including loss of plant community through habitat fragmentation as well as encroachment by invasive species.

2.2.3 Farmlands Ecosystems

There are specific areas where agriculture is practiced in Lamu County. These areas are mainly Hindi, Magogoni, Mpeketoni, Bomani, Bargoni, and at Shela and Amu areas of Lamu Island, the islands of Lamu, and at Faza and Pate areas of Pate Island. These locations exhibit higher population densities with a fast paced population growth. The main crops in these areas include fruit and nut trees such as coconut, mangoes and cashew nuts; and cereals such as simsim, maize, and bixa. Cotton, water melons and pulses, are also grown in the area. All of the agricultural activities are practiced within the herbaceous rain-fed agriculture ecosystem. Increasingly more farmers and institutions are participating in diversification of the crops, further changing the biodiversity of the area.

The growth in the population has been accompanied by expansion of agricultural areas and increased infrastructure associated with human settlement. Mpeketoni area in particular has seen a marked growth in human settlement since 2007 as seen from the Google Earth images of 2007 and 2014 (Figure 10). There is also attendant encroachment into Kipini Forest area and the fragile coastline area as also seen from Google Earth images of 2007 and 2014 (Figure 11).

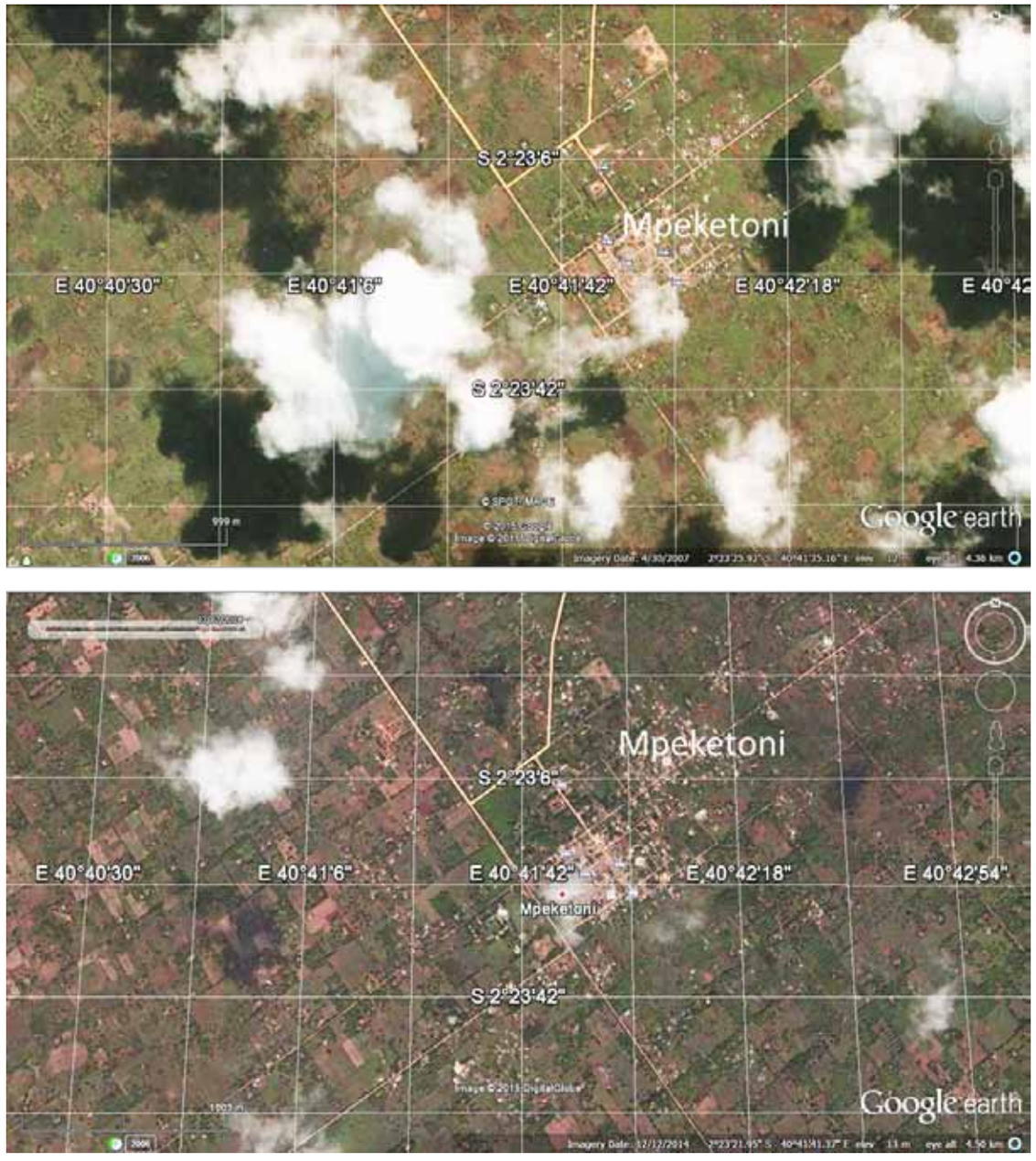

Figure 10: Land fragmentation and intensification of agriculture in Mpeketoni area between 2007 and 2014

Figure 11: Replacement of Kipini Forest in Lamu with agriculture activities as seen from the Google Earth images of 2007 and 2014

2.2.4 Inland Wetland Ecosystems

Wetlands are highly varied and dynamic ecosystems and include freshwater, brackish or saline, inland or coastal, seasonal or permanent, natural or man-made water bodies (www.wetlands.org). Examples include swamps, marshes, rivers, lakes, floodplains and dams. Wetlands are one of the world's critical environmental assets due to their unique biodiversity. Lamu County's wetlands comprise of rivers draining the Ijara plains in Garissa County and flowing southwards into the creeks along the coastline (Figure 12). They modify the salinity of the ocean waters at the creek areas and bring in nutrients that support the fisheries food web. There are 4 main sheltered creeks: Mkunumbi, Hindi, Wange and Dodori all receiving water from rivers named after the creeks. The creeks, Channels and Bays support the mangrove ecosystems that line the coastal areas of the creeks and the islands (Plate 13). The seasonal and permanent inflows recharging the creeks ensure the survival of prawns, an important fishery for the coastal communities.

Figure 12: Lamu's Coastal wetlands of Creeks, channels and Bays

Plate 13: Mangrove Swamp lining the coastline area of the Lamu bays, channels and islands (*Photo: Onywere, Oct. 2015*)

There are two small lakes in the county namely; Lake Amu and Lake Kenyatta (or Mukunguya as is locally known). They are a vital source of domestic and livestock water supply offering the coastal community with many opportunities for survival and development. Lake Kenyatta (Figure 13) also supports fresh water fisheries although it is faced with siltation challenges from the farming activities which have now encroached onto the riparian areas.

Figure 13: Lake Kenyatta (Mukunguya) and the surrounding farmlands as seen from Google Earth Images. A small forest is located on the western side of the lake

2.2.4.1 Inland Wetland Ecosystems' Sensitivity to Development Interventions

Wetlands are highly sensitive and fragile ecosystems. Their functionality is destroyed through physical alteration and by pollution. Physical alteration occurs through drainage and siltation from farming activities which also bring in farm agrochemicals and other inputs. Urban settlements are a major source of pollution of wetlands through solid waste disposal and urban effluents. Infrastructure construction and road overburden is often deposited in wetlands in the notion of reclaiming them. In the event of the presence of only refinery and export of crude oil and industrial activities heavy metals, oil spills and industrial effluents will be a potential source of damage to wetlands and their functionality. The flow regime of wetlands is also altered by mining, and riparian agriculture thus contributing to the destruction of wetlands. Due to high nutrient associated with flood plain sediments, wetlands are often targeted for drainage for farm use. The demand for direct surface water abstraction for domestic and agricultural use is also exerting pressure on wetland ecosystems.

2.3 MARINE ECOSYSTEMS

Lamu's marine ecosystems are complex habitats characterized by a wide range of physical, chemical, and geological variations of Kenya's Indian Ocean Coast. The habitats range from highly productive near-shore regions within the Lamu Archipelago of islands, channels and creeks, to off-shore coral reefs, to the deep sea habitats. The Kiunga-Lamu seascape features rich marine habitats such as mangroves, sea grass and coral reefs and sustains a population of keystone species such as turtles, dugongs, sharks and dolphins. The marine habitats also support fisheries which provide livelihoods to the local communities living along the coastline. The shallow waters harbour a patched framework of coral reefs that provide diverse habitats for finfish and invertebrates such as lobster and sea cucumber.

The coral reef ecosystems support a rich biodiversity, which includes five (5) sea turtles species, 150 reed fish species, six dolphin species and 183 species of hard corals. There are 40 fishing grounds with an annual catch of about 1,500 metric tonnes. The five sea turtle species include the Leatherback turtle (Dermochelys coriacea), the Loggerhead turtles (Caretta caretta), the Green Turtle (Chelonia mydas), Hawksbill turtle (Eretmochelys imbricata) and Olive Ridley turtle (Lepidochelys olivacea). Most of the turtle nesting sites are located on Manda Island and in Shela on Lamu Island. The fish catch is however very low considering

the huge potential within the coral reef areas. The low catch is attributed to the limited capacity of the local fisher folk to conduct deep sea fishing owing to lack of appropriate deep sea fishing equipment. Sport fishing is also carried out around the tourist resorts in Kisangundi, Manda and Shela (Lamu CIDP, 2014).

Plate 14: One of the Turtle species found in Lamu's coast (*Photo: Olendo-WWF*)

Plate 15: Green turtle (*Chelonia mydas*), found in Lamu (*Photo: Murage, 2012*)

2.3.1 Mangroves Ecosystems

The extent of coverage of mangroves in the coastal Kenya is about 50000 ha with Lamu having 33,500ha (70%) (Kairu et al 2002)[6] .The mangrove forests within Lamu County form the largest single block of mangroves in Kenya and currently covering an area of 304.75km^2. Ecologically, mangroves are defined as an assemblage of tropical trees and shrubs that inhabit the coastal intertidal zone and bridge terrestrial and marine environments. The forests consist of diverse, salt-tolerant tree and other plant species, ranging from small shrubs to tall trees tens of metres high. Mangrove forests are periodically flooded, with the frequency and magnitude of flooding determined by local topography combined with tidal action, river flow, rainfall, surface runoff, groundwater, and evapotranspiration. Within the mangrove forests, there are also extensive non-forested areas that include mudflats, agricultural fields and sandy beaches.

The shores of Lamu, Manda and Pate Island (Figure 14) and the area along Kiunga are extensively covered with mangroves except in a few areas that are directly exposed to the Indian Ocean. The common mangrove species found in Lamu Archipelago are Sonneratia alba and Rhizophora mucronata (Rh) found at the outermost seaward side; Avicennia marina (Avec, Av) and Ceriops tagal (Ceriops, Cer) found in the intermediate zone; and Brugeira (Brug) and Xylocarpus (Xylo) found at the landward side in the areas that receive low intertidal floods (Murage, 2012)[7]). The cover and zonation of the mangroves is influenced by coastal geomorphology.

6 Kairu et al 2002. Application of remote sensing and GIS in the management of Mangrove forest within and adjacent to Kiunga Marine protected area, Lamu, Kenya, Environment, development and sustainability Vol 4 pgs 153-166 Springer.

7 Murage, D. L. (2012). GIS Baseline Report for the Lamu Archipelago Conservation and Community Livelihood Initiatives Project. LAMCOT, Kikozi Program Group, CDTF- CEF and DANIDA

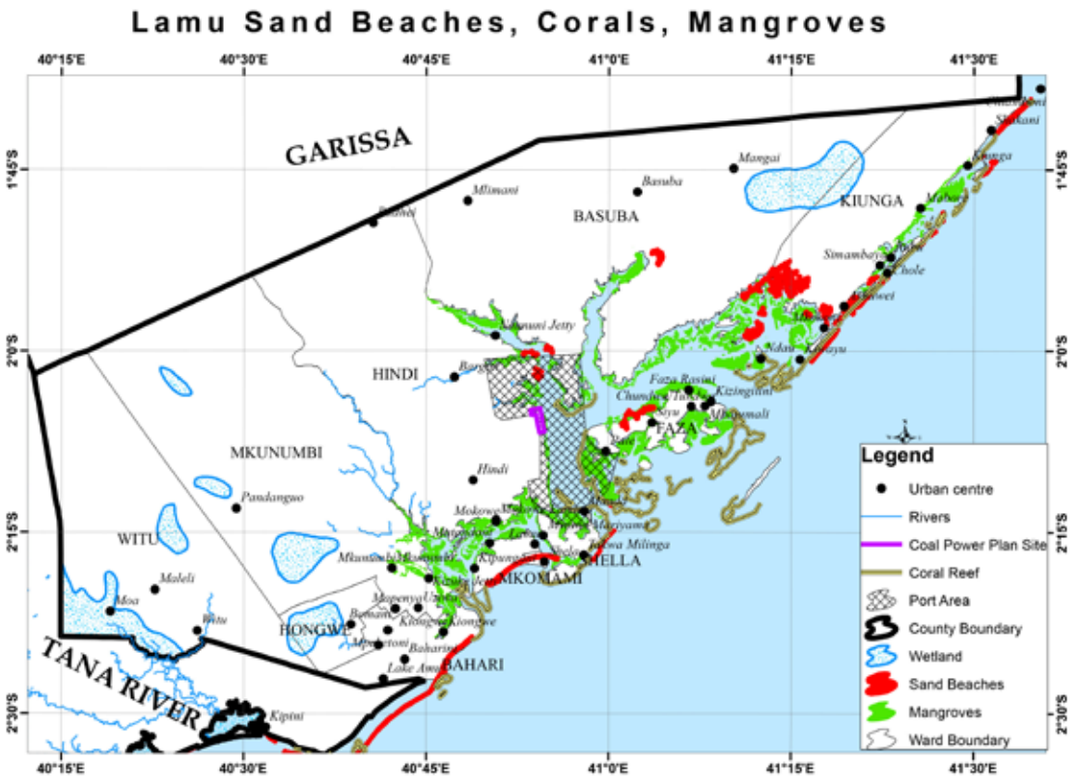

Figure 14: Lamu Mangrove areas, Sand Beaches and Coral areas.

Plate 16: Lamu Mangrove on the seaward zone of the ocean (*Photo: Onywere Oct. 2015*)

Plate 17: Lamu Mangrove at the intertidal zone (*Photo: Onywere, Oct. 2015*)

Plate 18: Lamu Mangrove at the landward zone (*Photo: Onywere, Oct. 2015*)

Mangrove ecosystems are extremely productive and provide food and refugia for marine organisms. They forests transfer a lot of organic matter and energy from the land to the sea, forming the base of many marine food webs. They are also home to a wide variety of marine and terrestrial life, and serve as nurseries for many coral reef and commercially important fish species. In addition, mangrove forests play a vital role in trapping sediments, thereby stabilizing coastlines and protecting coral reefs and sea grass meadows. The dense root systems form a home for fish, crabs, shrimp, and molluscs. They also serve as nurseries for juvenile fish such as reef fish. The young fish stay in the forest, where there is plenty of food and shelter from predators, until they are old enough to move to the reef area. 90%, of the faunal species found in the mangrove forests are known to spend their entire life, or at-least a major part of their life cycle in these areas. These species include a

number of prawns (Penaeus indicus, P. monodon, P. semisulcatus, Matapenaeus monoceros); crabs (Scylla serrata, Uca spp., Sesarma spp.and Birgus latro); mollusc (oysters such as Brachydontes spp. and Crassostrea cucullata; and cockles, Donax spp.). Mangroves also act as purification, spawning areas, nutrient transfer, habitat for birds (Plate 19) and other water species requiring shelter, and support for snails which are important food chain for faunal species in the area (Plate 20).

Plate 19: White pelican water birds part of biodiversity in the mangrove ecosystems of Lamu (*Photo: Onywere, Feb. 2011*)

Plate 20: Snails anchored in a mangrove trunk part of the rich biodiversity in the mangrove ecosystems at Mkunumbi area (*Photo: Onywere, Feb. 2011*)

The mangroves are harvested for their wood which is a main source of construction materials in the area. Most of the fuel-wood for domestic use and firing of lime for cement is sourced from the mangrove. The thicker wood is used for dug-out canoes. Bee keeping is also practiced within the ecosystems and its leaves are used for herbal medicine. The communities in Lamu have traditionally exploited the mangrove forest for timber and building poles, firewood and charcoal, medicine and non-timber products such honey harvesting. In addition, Lamu exports mangrove poles to the Middle East countries of Iran, Iraq, Kuwait and Saudi Arabia and also to the neighbouring Somalia. Some of the poles are also sold outside the coast especially for building tourist resorts. Mangrove forest areas are also important fishing grounds for the local communities. The extent of harvesting of the mangroves is degrading the resources thus affecting their functions in the ecosystem.

Mangrove forests are also nesting and migratory sites for hundreds of bird species, as well as home to a wide variety of reptile, amphibian, and mammal species. For example mangroves are home to Bengal tigers, spotted deer, saltwater crocodiles, fishing cats, and various dolphin species. KBDCA has designated some mangrove forest under protected areas meant to protect and conserve biologically significant habitats. It is a ‘no-take’ area where extraction of natural resources is not allowed and activities that may harm plants or animals are prohibited Such areas include the fish breeding areas, the turtle nesting areas (Mkokoni, Kiwaiyu Safari Village, Kongowale, Ashuwei, and Mvundeni), the dugong foraging areas (Dodori creek) and bird breeding, feeding and nesting sites (Kitanga Kikuu, Kiunga Mwini, Chole, Mwongo Sharif, and Mtumumwe). Intertidal zone of about 600 meters width from the high tide mark.

2.3.1.1 Sensitivity of Mangrove Ecosystems to Development Interventions

Mangroves support about 70% of the people living along the coastline by providing timber for construction and fuel wood as well as supporting fisheries and preventing sea erosion. The linkages in the mangrove ecosystem and the development regime is illustrated in Figure 15. Field evidence indicates that existing approaches to the exploitation of the mangroves in Lamu is unsustainable. Mangroves forests in Lamu face severe threats that include clear cutting of mangroves with no replantation. This is despite the presence of Kenya Forest Service Mangrove Forest Management Unit. In some areas only dead stumps of mangrove trees are seen (Plate 21). In addition, the establishment of the LAPSSET project has already started affecting the mangrove cover in Wange Creek (Plate 22) and will likely affect the mangrove

areas in Manda Bay and Pate Bay. This will lead to increased shoreline erosion, affect ocean current flow and tidal movements and consequently kill the habitats. The impact on the shoreline is already evident in Manda Island where large areas of mangroves have been removed to give way to limestone mining. Cases of encroachment on mangroves areas for settlements or other development have been reported. Clear felled areas with little or no regeneration are readily observed all along the coastline.

Plate 21: Mangrove forest degradation in Witu area that has left dead stumps of mangrove trees (*Photo: Onywere, Feb. 2011*)

Plate 22: An extensive are of mangrove forest being cleared to give way to the LaPSSET Project infrastructure development (*Photo: Onywere, Oct. 2015*)

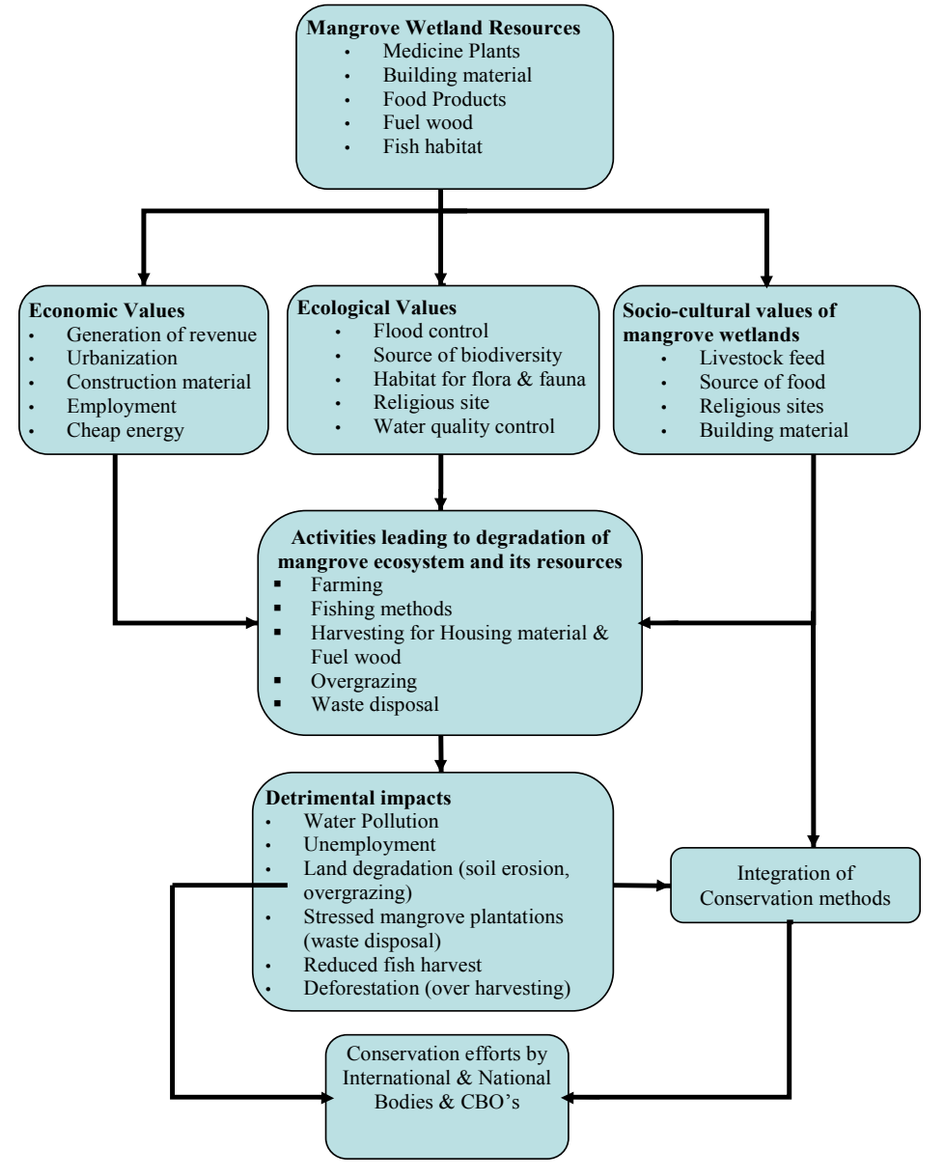

Figure 15: Mangrove ecosystems and their interaction in the development process
(Source: Adapted from Vanucci, 1989 [8]and Wood, et al, 1999[9])

8 Vanucci, M., 1989. The mangroves and us: a synthesis of insights. Indian Association for the advancement of Science, New Delhi, India.

9 Wood, A. Stedman Edwards and Mang J, (1999). Ten Case Studies: The Root causes of Biodiversity Loss. Earthscan, UK.

The sustainable use of mangroves will involve conservation measures and sustainable harvesting and or other uses at rates that enables the system to maintain itself in as natural a state as possible. The heavy pressure being exerted on Mangrove for wood products, particularly for fuel wood and building materials, by the high and fast growing populations in coastal area can permanently damage the habitat if no control measures are taken. Unless sustainable methods for increasing the availability of mangrove products are found, substantial losses of mangrove swamps and acute shortages in these products in the coming years will lead to increased hardships for the Urban and rural poor. More projects on mangrove conservation and management that empower community participation should be enhanced. Mangrove conservation is very important if their many values are to be maintained.

Mangroves are extremely sensitive to ecological disturbances. With new development initiative in the area incorporating Oil exploration and the LAPSSET Project more diverse impacts are anticipated. A coating of oil on the mangrove prop roots for example can be fatal to the tree. Replacement of mangrove trees can take decades owing to the long maturity period for the species. According to Proffitt (1996), the effects of the physical stranding of oil in intertidal mangrove habitats largely depends on the oil type, the elapsed time between a spill and its stranding, wind and current conditions, and tidal stage. Mangrove mortality and the expression of stress symptoms may be delayed for one to several years following an oil spill for reasons that may be related to the toxicity of petrogenic compounds and the weakened state of the trees.

Oil, especially the refined products that have high concentrations of water soluble aromatic carbons can be acutely toxic to mangrove ecosystems. Heavier oils may smother aerial roots, hindering ventilation and leading to suffocation and stress and eventual death of mangroves. Moreover, oily debris and sediments may leach for months thus raising the costs of clean-up operations. Furthermore, mangroves have been shown to be more susceptible to damage by the physical disturbance during clean-up exercises than by the oil itself. As a mitigation measure, leaving residual oil to weather and degrade naturally is usually recommended for such sensitive shoreline ecosystems including salt marshes. It is evident from the mangrove location map (Figure 15) and in relation to the location of the New Lamu Port and the likely dynamics of an oil industry, which if an oil spill accident occurs, extensive areas of the mangrove within the Lamu Archipelago will be affected.

2.3.2 Coral Reefs Ecosystems

Corals are diverse underwater ecosystems held together by calcium carbonate structures secreted by corals. Coral reefs are built by colonies of tiny animals found in marine water that contain few nutrients. Most coral reefs are built from stony corals which in turn consist of polyps that cluster in groups. They grow around Pate Islands in shallow waters towards the sea and adjacent to sand beaches. Most of the coral reefs in Lamu are found within the Kiunga Marine National Reserve (KMNR) as well as at the rest of the coastline, mainly occurring in patch reefs, with fringing reef in the northern part.

Lamu coastline is endowed with the patchy fringing hard and soft coral reefs (refer to Figure 14 for location) ringing the islands and lining the area along the Kiweni-Kiunga Marine National Reserve in a direction parallel to the coastline. The abundance of the corals is shown in Figure 15. The variety and types of corals number over twenty with the common families being *Portidaea* and *Faviidae*. They form a pattern of mosaicking beautiful sea-bed structures that are habitat to marine fauna associated with them. Plates 23-25 are examples of some of these corals; an impressive diversity of structure usually visible through the clear waters and that are a source of the thriving marine tourism in Lamu. They provide a recreational attraction.

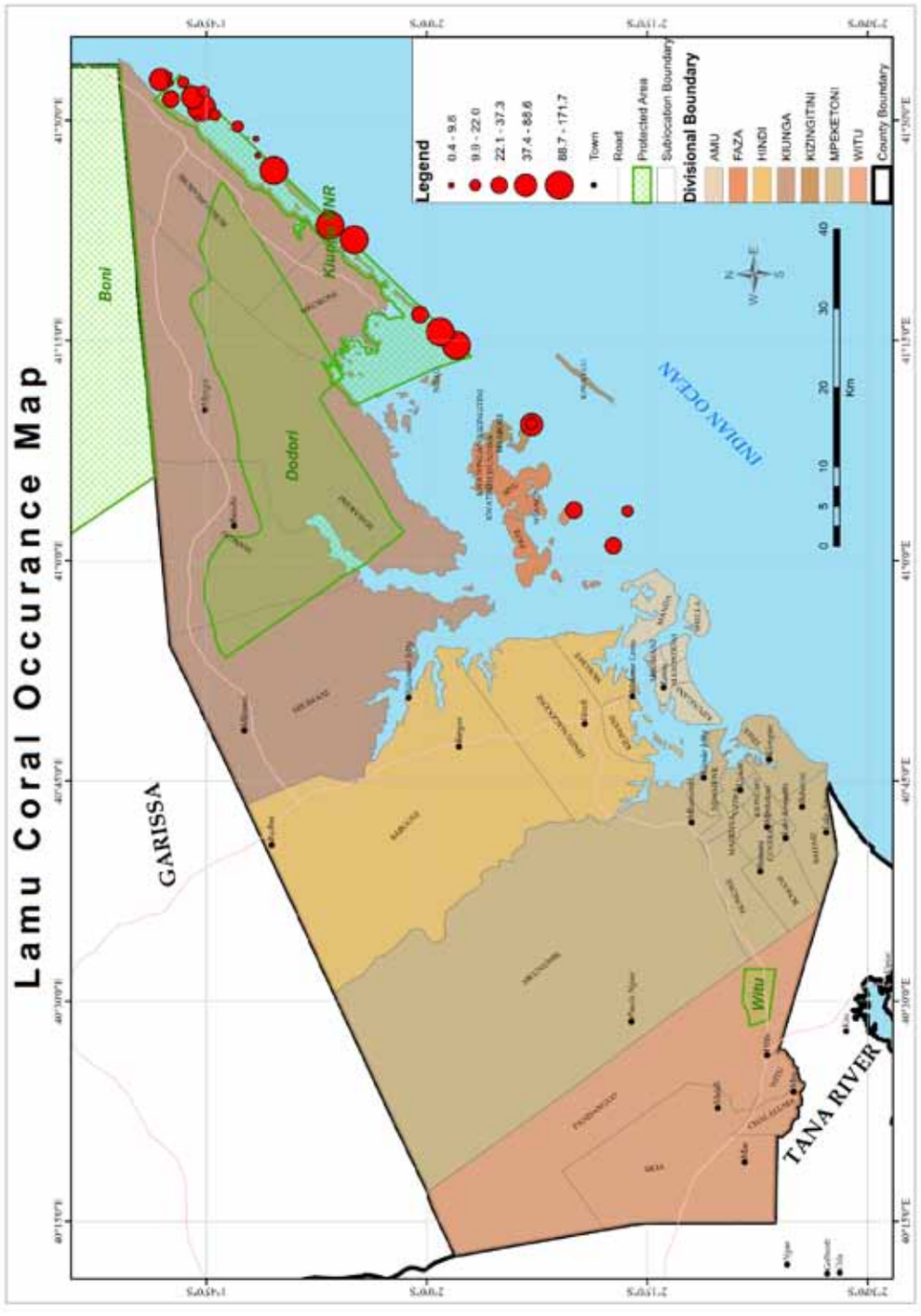

Figure 16: The distribution and abundance of coral occurrence in Lamu

Plate 23: Colonies of hard corals (*Echinopora spp*) at Kiweni community marine park (*Photo: Lionel Murage. 2012*)

Plate 24: A rocky pile of hard corals (*Goniopora spp*) in Kiweni community protection area (*Photo: Lionel Murage. 2012*)

Plate 25: A beautiful colony of corals species *Acropora spp* at Kiweni community protection area_(*Photo: Lionel Murage, 2012*)

Coral reef ecosystem support giant sea anemone, lobsters, turtles, parrot fish, crown of thorns star fish, moray eels, damselfishes (*acanthurida)* cardinal fish, scorpion fish etc. The coral reefs harbour the most biodiversity of any marine ecosystem in Kenya's Coast. They are important links in maintaining healthy fisheries as they area nurseries for shrimp, fish, and other animals. These reefs are home to over 50 genera (4 of which are globally-rare), 150 identified coral species, as well as over three hundred species of fish (Murage, 2012). Coral reefs within and adjacent to the reserve are integral to the lifestyle of village communities along the shoreline, with fishing being an important source of income and also daily sustenance. The coral reef environments are particularly important to the lobster, hand line and seine net fishers.

2.3.2.1 Sensitivity of corals to Development Interventions

Coral reef resources within the Lamu Archipelago and Kiunga Marine National Reserve in particular are critical to the survival of the community Destructive practices will led to increasing poverty levels within the marine resources dependent communities of Lamu, Shela, Pate and Shanga and those settled within the creek areas. The coral reef areas are currently threatened by over fishing, shell collection, impacts from sedimentation, and effects of pollution from the settlements. Further threats are envisaged from the New Lamu Port and the cargo shipping movement that is likely to increase sea water turbidity from the disturbance generated by the ship movement.

Reef systems are highly sensitive to human disturbance and sediment input. Obura et al (2002)[10] reports coral bleaching and mortality during the El Niño event of 1998 as the most severe in the north coastal area of Kenya. During and after the El Niño the corals greatly diminished and were severely damaged with levels of coral mortality of 50-90%. Obura et al (2002)'s observation supports the assertion made by Glynn (1993)[11] that coral reef bleaching, the whitening of diverse coral invertebrate taxa as a result of the loss of photosynthetic pigmentation within the tissues of host animals. The consequences of bleaching of large numbers of reef-building scleractinian corals and hydrocorals follows major climatic episodes sich as the El Niño.

The coral cover on lagoon patch reefs and fore-reef slopes receive the greatest impact from climate episodes. Several potential stressors that are implicated are change in salinity, light, temperature, sedimentation, aerial exposure, xenobiotics and epizootics. Inland surface runoff and sedimentation from mainland upstream inflow due to poor land-uses is a major contributor to clouding the ocean waters, changing its salinity and temperature. Pollution especially from urban settlements is also among the greatest threats to coral reefs. The accelerating climate changes (IPCC 2007) and with the severest El Niño expected in November – January 2015 further coral interactions synergistically with occasioned stressors will compromise their integrity and survival. Other key threats to the coral reef include destructive fishing practices and overfishing both of which can cause damage to coral reefs by changing the community structure. Poorly managed and planned tourism are also a major stressor damaging coral reefs.

Mining directly impacts coral reefs through increased sedimentation, especially in cases where wastes are dumped directly into rivers and oceans, as well as through increased pollution of heavy metals. Coral reefs and the marine organisms that live within and around the reefs are at risk from exposure to the toxic substances. The Government of Kenya through the Ministry of Transport and Infrastructure is building a port at Manda Bay in Lamu. One of the expected impacts of this project is coral damage as a result of dredging.

Long term declines in fisheries stocks and reef health is expected as the development dynamics take a toll of the coral reefs. The community socio-economic dependence on the fisheries require assessments and monitoring as part of the regular activities and this atlas provide a reference document on the areas to be on the watch list.

10 Obura D., L. Celliers, H. Machano, S. Mangubhai, M. S. Mohammed, H. Motta, C. Muhando, N. Muthiga, M. Pereira and M. Schleyer (2002). Status of Coral Reefs in Eastern Africa: Kenya, Tanzania, Mozambique and South Africa. Status of Coral Reefs of the World: 2002.

11 Glynn, P.W. (1993), Coral reef bleaching: ecological perspectives. Coral Reefs (1993) 12:1-17, Springer-Verlag

2.3.3 Lamu Sand Beaches Ecosystems

Sandy beaches are characterized by open shorelines within the inter-tidal zone. They comprise functional ecosystems with unique biodiversity determined by the physical properties of the sand. The sandy beaches and adjacent surf zones provide important habitat for a variety of birds, wildlife and fish that feed on intertidal and sub-tidal invertebrates (Plate 26 and 27). Besides, beach ecosystems are important in processing large quantities of organic material and recycling nutrients back to coastal waters. The combined effects of population growth, demographic shifts, economic development and global climate change are currently posing unprecedented threats to the sandy beach ecosystems worldwide. The sandy beaches of Lamu are not spared from these increasing pressures.

Plate 26: Spotted sand beach, a sign of intertidal and sub-tidal invertebrates barrowing through the sand (*Photo: Onywere, Feb 2011*)

Plate 27: Snails barrowing through the sand at a beach at Kipini at the intertidal and sub-tidal sand beaches (*Photo: Onywere, Feb 2011*)

2.3.3.1 Sensitivity of sandy beaches to Development Interventions

The extraction of shoreline resources especially mangrove degradation and mining activities are changing the erosion patterns and sediment disposal. The dredging of the Manda Bay for Lamu Port Development under the LAPSSET project will in particular change the sediment inflow and distribution pattern. These will most likely lead to increased sand beach erosion that is already being witnessed (Plate 28). The other effects are from increased compaction due to trampling by machinery in the areas where material extraction is taking place and in the areas where ore shipment take place (Schlacher, et. al, 2008)[12]

12 Schlacher T. A., Schoeman, D. S., Dugan, J., Lastra, M., Jones, A., Scapini, F. and McLachlan A., (2008). Sandy beach ecosystems: key features, sampling issues, management challenges and climate change impacts. Marine Ecology 29: 70 – 90.

Plate 28: Sand beach erosion affecting the coastal village settlements. (*Photo: Olendo, WWF*)

Mudflats within the beaches can be sensitive to oil spill in case they occur. Oil contamination in these areas may seep into the muddy bottoms of these flats, creating potentially harmful effects on the ecology of the area. Although exposed sandy, gravel or cobbled beaches can usually be cleaned by manual techniques its presence can affect many invertebrates. Few organisms can withstand oil that soak into sand and gravel as these changes the health of their full-time habitats. Sheltered beaches have very little wave action to encourage and facilitate natural dispersal and dilution of any oil and thus the fauna and flora there can easily be suffocated if timely clean-up efforts are not immediately instituted. Oil and other pollutants may remain stagnant on the sheltered beaches for many years. Mangrove sheltered beaches in particular are difficult to clean mechanically without down-mixing the oil into the sandy sediments and damaging the prop roots of mangroves. Such mixing make the sandy beach sediment unsuitable as habitat for biota such as invertebrates due to oil remains. Gundlach and Hayes (1978)[13] provide an environmental classification of vulnerability of the various coastal ecosystems (Table 2).

Table 2: Summary of Environmental Classification level of Vulnerability to Oil Spill Damage (*after Gundlach and Hayes (1978)*

Vulnerability Index	Shoreline Type	Comments
1	Exposed rocky head lands	Wave reflection keeps most of the oil off-shore. No clean-up is necessary
2	Eroding wave-cut platforms	Wave swept. Most oil is removed by natural processes within weeks.
3	Fine-grained sand beaches	Oil doesn't penetrate into the sediment, facilitating mechanical removal where necessary. Otherwise, oil may persist several months.
4	Coarse-grained sand beaches	Oil may sink and/or be buried rapidly making clean-up difficult. Under moderate to high energy conditions, oil will be removed of the beach face naturally within months from most beaches
5	Exposed, compacted tidal flats	Most oil will not adhere to, nor penetrate into, the compacted tidal flat. Clean-up is usually unnecessary.
6	Mixed sand and gravel beaches	Oil may undergo rapid penetration and burial. Under moderate to low energy conditions, oil may persist for years.
7	Gravel beaches	Same as 6 above. Clean-up should concentrate on the high tide swash area. A solid asphalt pavement may form under heavy oil accumulations.
8	Sheltered rocky coasts	Areas of reduced wave action. Oil may persist for many years. Clean-up is not recommended unless oil concentration is very heavy.
9	Sheltered tidal flats	Areas of great biologic activity and low wave energy. Oil may persist for years. Clean-up is not recommended unless oil accumulation is very heavy. These areas should receive priority protection by using booms or oil sorbent materials

13 Gundlach E. R. and M. O. Hayes (1978), Vulnerability of Coastal Environments to Oil Spill Impacts. Marine Technology Society Journal, 1978

10	Salt marshes and mangroves	These are the most productive of the aquatic environments. Oil may persist for years. Cleaning of salt marshes by burning or cutting should be undertaken only if heavily oiled. Mangroves should not be altered. Protection of these environments by booms or sorbent material should receive first priority.

Early Oil Spill detection is important and different satellite sensors provide a platform for oil spill detectability under varying conditions. In particular manual and automatic approaches are available to discriminate between oil slicks and look-alikes based on pattern recognition (Brekke and Solberg, 2005)[14]. Microwaves are commonly used for ocean pollution monitoring by remote sensing and the steps for doing this is presented in Figure 17. This technique can be adopted in monitoring the Lamu Coastal environment for any oil spills as the development of a refinery and export of oil is envisaged in the area.

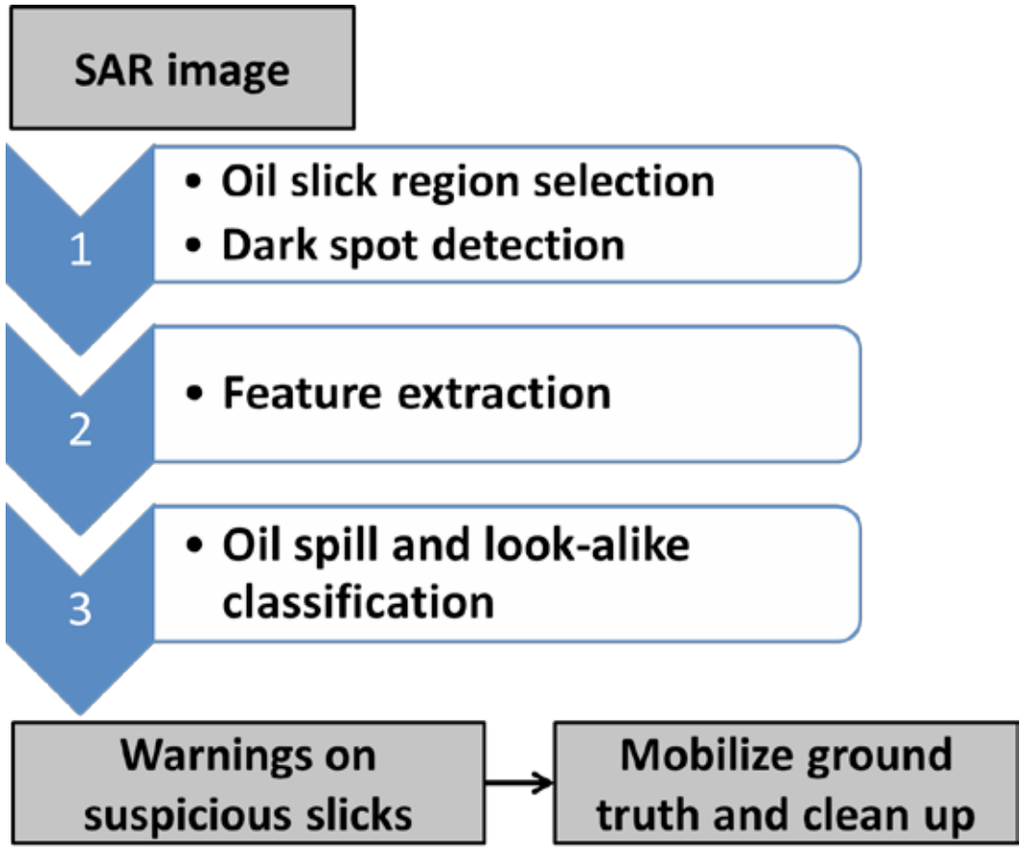

Figure 17: A framework for oil spill detection using SAR Remote sensing satellite imagery (Brekke and Solberg, 2005)

In a remote sensing study by Leifer and Lehr et al (2012)[15] of the BP Deepwater Horizon oil spill the oil slick processes on day to week timescales show a typical response in its spread pattern that include wind and wave advection, compression from waves and currents (into wind rows or narrow slicks), spreading and surface diffusion, sedimentation and dissolution into the water column, emulsification, evaporation, and photochemical and biological degradation. Weathering describes non-advective processes that alter the oil's chemical and physical characteristics.

14 Brekke C. and A.H.S. Solberg (2005) Oil spill detection by satellite remote sensing/ Remote Sensing of Environment 95 (2005) 1–13

15 Leifer, Ira; Lehr, William J.; Simecek-Beatty, Debra; Bradley, Eliza; Clark, Roger; Dennison, Philip; Hu, Yongxiang; Matheson, Scott; Jones, Cathleen E.; Holt, Benjamin; Reif, Molly; Roberts, Dar A.; Svejkovsky, Jan; Swayze, Gregg; and Wozencraft, Jennifer, "State of the art satellite and airborne marine oil spill remote sensing: Application to the BP Deepwater Horizon oil spill" (2012). NASA Publications. Paper 117. http://digitalcommons.unl.edu/nasapub/117

2.3.4 Island ecosystems

Lamu County covers a strip of the mainland in the north eastern coast and the Lamu Archipelago. The archipelago area has extensive mangrove forests. The northernmost islands are Kiunga located only 15 kilometres to the border with Somalia and are part of a major marine conservation area, the Kiunga Marine National Reserve. The reserve is an important habitat for mangrove, turtles, and many species of birds. The largest of the archipelago (islands) are Pate Island, Manda Island and Lamu Island which are all close to one another (Figure 17). Smaller islands include Kiwayu, which lies in the Kiunga Marine National Reserve, Manda Toto Faza, Kiwaiyu, Kizingitini, Mtangawanda among others many other islands only tens of meters wide (Plate 29).

Plate 29: Some of the Small Islands at Kiunga Marine National Reserve (*Photo:* Waruguru-WWF)

Figure 18: The Lamu Archipelago showing the islands of Lamu, Manda, Pate and Kiwayu

The islands are made of coral limestone that is extensively mined in Manda Island for building stone and cement. The Islands are also covered in sand dunes that are important catchment areas and act as groundwater reservoir that has served the Island communities for centuries. In particular Lamu Island sand dunes (Plate 30 and 31) cover the larger part of the island and only a small part at Lamu Town and Shela has been used for settlement.

Plate 30: Lamu Island sand dunes (*Photo: Murage, 2012*)

Plate 31: Settlement encroachment onto the Lamu Island sand dunes (*Photo: Onywere, Oct. 2015*)

2.3.4.1 Sensitivity of Islands

Islands are ecologically and culturally unique. 45% of IUCN red list endangered species occur on islands[16] and 80% of known species extinctions have occurred on islands mainly due to sudden ecological changes. With most of the infrastructure developments happening in Lamu County, islands may be directly or indirectly affected. More people would prefer to live in islands and this may lead to loss of ecosystem and the saline/fresh water balance will be affected.

2.3.5 Estuarine ecosystems

Estuaries are termed as open ecosystems because they are the link between two contrasting environments, the terrestrial and marine, leading to fluctuating salinity levels. They are rich in nutrients transported from land by rivers and from the marine by tidal movements (Elliotta and McLusky, 2002)[17]. Estuaries are thus considered as the world's most productive habitats. They support unique plants, seaweeds and photosynthetic microorganisms all of which absorb nutrients faster, grow rapidly and produce abundant biomass at the base of the food web. The prevailing salinity fluctuation is a major constraint leading to low species diversity but high abundance rates.

The nutrients into the Lamu estuaries that form a network of creeks is supported by inflows from the rangelands and the forested gentle slope that characterize the Lamu ecosystems. These support phytoplanktons, zooplanktons and the filter feeders like the prawns, clams, worms, shellfish and fish spawns that give livelihood opportunities to surrounding communities. Threats to the estuaries are catchment development activities such as riparian agriculture, and aquaculture. Jetties and berths for boating especially for tourists are also usually located in estuaries. Some of the threats associated with these developments include habitat conversion through dredging and species loss due to overfishing. Three estuarine ecosystems areas in Lamu where prawns breed are shown in Figure 19.

16 https://www.iucn.org/about/union/commissions/cem/cem_work/tg_islands/ as accessed on 4th June 2015

17 M. Elliotta, D.S. McLusky, 2002. The Need for Definitions in Understanding Estuaries, Estuarine, Coastal and Shelf Science, Volume 55, Issue 6, December 2002, Pages 815–827.

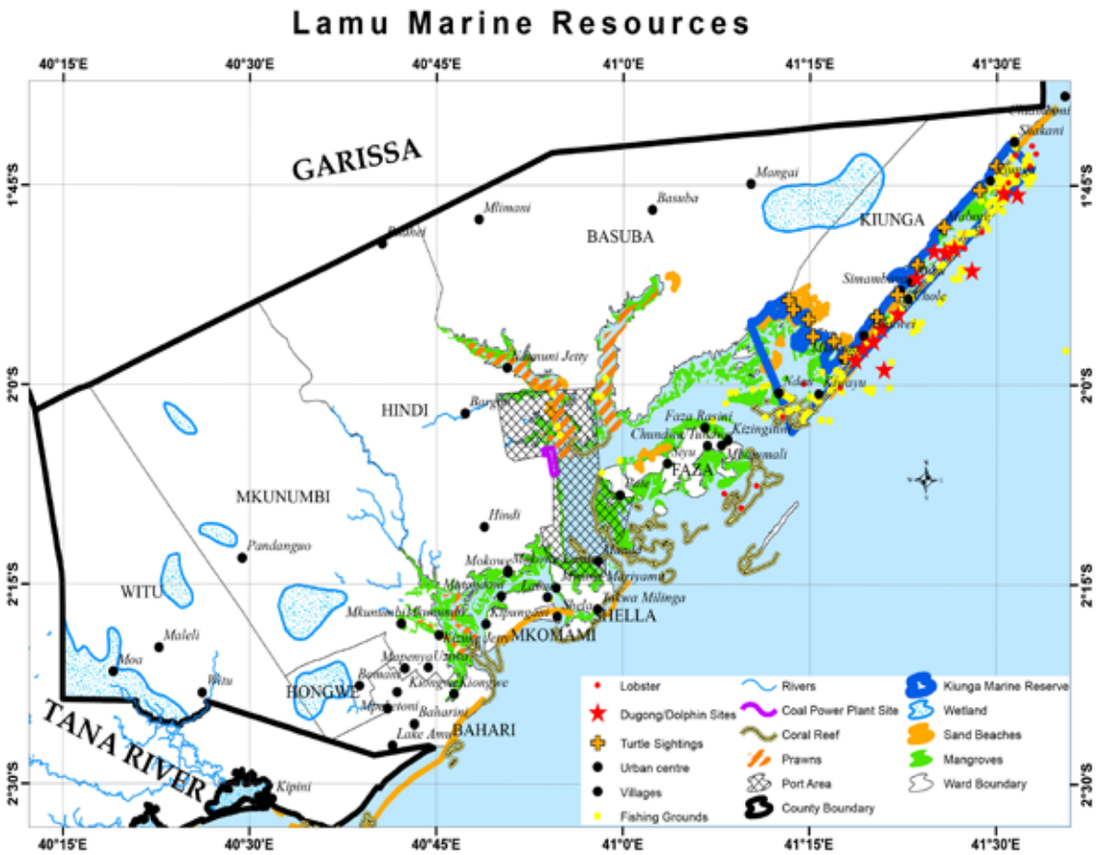

Figure 19: The Lamu Archipelago and estuarine resources

2.3.5.1 Sensitivity of Estuarine ecosystems

Estuaries are highly sensitive to pollution inputs, habitat alteration and other anthropogenic stressors (Kennish, 2002)[18]. Water quality within estuaries is often compromised especially in urbanized systems due to overloading of nutrients and organic matter (Plates 32 and 33). This is often accompanied by influx of pathogens and a build-up of chemical contaminants. Habitat alteration in itself is associated with degradation of biotic communities. Human population increase, which is evident in Lamu since the initiation of the LAPSSET project, is the major force behind some of these stressors. Influx of raw sewage into the fragile creeks can result in greater eutrophication, hypoxia as well as anoxia. Fresh water diversions with a view to meeting the growing water demand for domestic, agricultural and industrial needs in Lamu County in general are also anticipated. This will alter the natural balance of the estuarine ecosystems by changing the nutrient loads, biotic community structure and food webs in this ecosystem. Ecological consequences with long-term impacts could also be experienced in form of introduced species, sea level rise and debris/litter accumulation.

18 Kennish, M. J. 2002. Environmental threats and environmental future of estuaries. Environmental Conservation. Pp. 78–107. doi: 10.1017/S0376982902000061.

Plate 32: Waste discharge into the mangrove ecosystems within the estuaries of Lamu at Mokowe (*Photo: Onywere, Oct. 2015*)

Plate 33: Direct discharge of waste into the ocean at Old Lamu Port (*Photo: Onywere, Oct. 2015*

CHAPTER 3: WATER RESOURCES

INTRODUCTION

With only 450 m³ per capita freshwater availability, Kenya is classified as a water scarce country by the United Nations. Following the declaration of 1991 – 2000 as the International Drinking Water and Sanitation Decade by the United Nations, the Kenya Water Master Plan was launched with a target to ensure access to at least 20 litres of water per person per day. However, this goal has not been realized to date. Considering its geographical location and groundwater aquifers that are threatened by saline water intrusion from global sea level rise, Lamu County is one of the water deficient landscapes in Kenya. The value of portable water for socio-economic development in Lamu cannot therefore be understated.

Lamu County is characterised by a poor surface hydrologic regime with a poorly drained topography most of which is flooded during the rainy season. Ephemeral rivers flow in a south easterly in a direction perpendicular to the shoreline (Figure 20). There is enhanced presence of flood waters in the south at the border with Tana River County attributed to the floods waters of the Tana Delta at Kipini area (Figure 21). Generally, Lamu County because of its sandy and limestone terrain has groundwater accessed from hand-dug shallow wells. Surface water comes from direct rainfall runoff that feed small lakes scattered in the terrain.

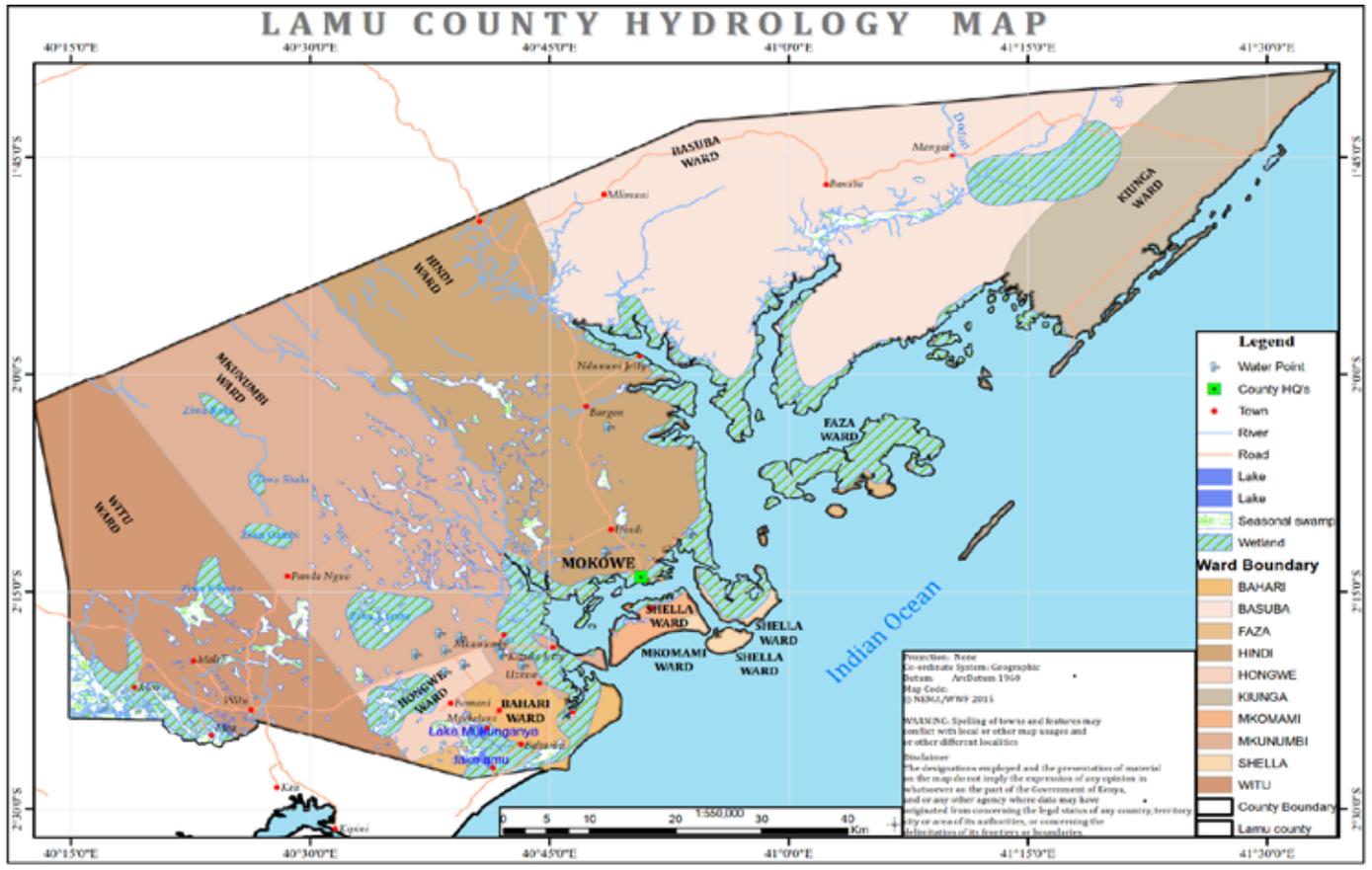

Figure 20: Lamu County Hydrology Map

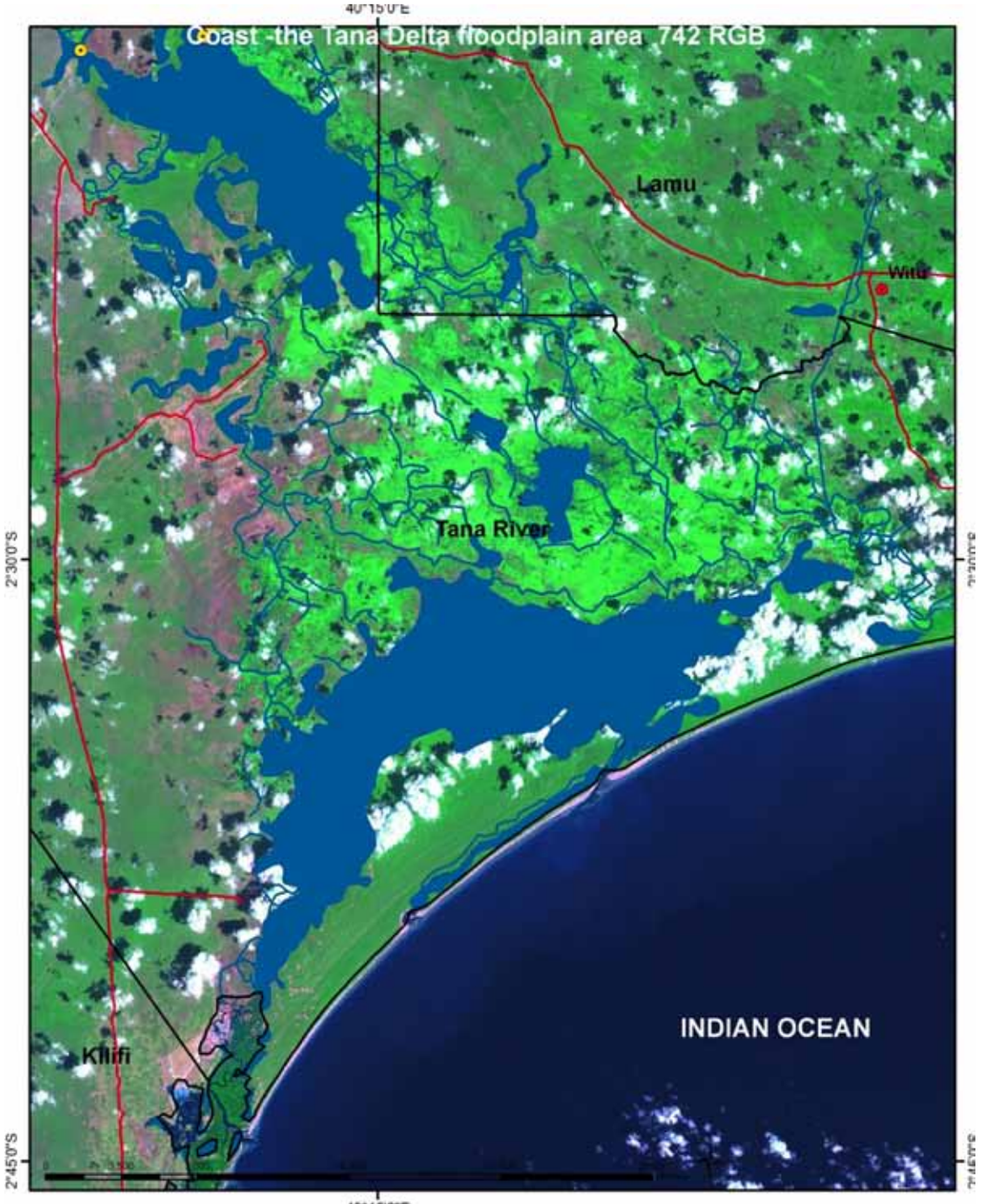

Figure 21: Lamu's Coastal lowland at Tana Delta Flood Plain

3.1 SURFACE WATER

Lamu's surface water comprises of rainfall runoff most of which accumulates on the limestone karst terrain. Rainfall distribution in the county is fairly uniform though it shows a slight decrease from the coastline towards the inland area. Lake Kenyatta (or Lake Mkunguya) and Lake Amu are the two main fresh water lakes in Lamu County. Lake Kenyatta covers about 5 Km^2 and is an ecological site with variety of fish, a large population of hippos and birds. The population of Mpeketoni Town depend on the lake to a large extent for fisheries livelihood and water supply. Lake Amu covers just about a couple of square kilometres. Lamu also has a number of swamps from which the majority of the rivers/streams that flow through the county drain into or from. These include the fresh water marshes of Ziwa Roka, Ziwa Gambi, Ziwa Kiboko, and Ziwa Kambe.

The main rivers in the County are Wange, Duldul, Arosen and Dodori. They are largely dependent on rainfall for their input, and quickly drain into the creeks and the ocean. The limestone karst terrain and the sand dunes support percolation of runoff into the groundwater aquifers. There is high evapotranspiration in the area leading to most moisture being lost. During the wet season these rivers provide the locals with the much needed fresh water for domestic use. The recharge of ground and surface water is important for ecological balance.

3.2 OCEAN WATER

The part of the Indian Ocean in Lamu County has in the past played a major role in the early development of navigation, trade and settlement. Presently the ocean is still a major source of water transport for transit goods and also for humans within the archipelagos and to other coastal towns. Dhow transportation and as fishing boats, is significant in the area (Plate 34). The Ocean water is also an important means of transport between the islands and with the mainland. The ocean water is desalinated at Magogoni by the Kenya Navy and at Kiunga, Siyu, Kizingitini and Ndau for domestic use. Underscoring the challenge of fresh water availability in the area.

Plate 34: Fishing dhows heading to the open ocean in the early morning hours. (*Photo: Onywere, Oct. 2015*)

3.3 GROUNDWATER AND SAND DUNE AQUIFERS

Sea water intrusion because of hydrological changes have given rise to salinization of coastal groundwater systems. Where there is sand harvesting, groundwater systems is lowered leading to intrusion of saline water. Other causes is over-abstraction which has led to severe deterioration both in amount and quality of fresh groundwater resources. In Lamu, the results of the analytical modelling by Okello, ***et. al.*** (2015)[19] have shown that the average water table elevation in the coastal area of Kenya is 2m above sea level and the average depth of the freshwater/ saltwater interface is -80m a.s.l. The volume of the aquifer is approximately 124 to 106 m^3 when discharge from the Shela water well field is factored in.

A number of studies have focused on the perennial shortage of fresh water supply along the coast of Kenya (Ochiewo, 2001)[20]. The settlement patterns within the county are largely influenced by the availability of freshwater, with high population densities currently concentrated in Lamu Island and Mpeketoni areas. A recent study in Mpeketoni settlement scheme found that household water demand increased from 7m^3 per day in 1994 to 269 m^3 per day in 2009 (Mwangi, 2009)[21]. According to an undocumented study, the number of traditional wells in Lamu Town are estimated to be close to 300. In Shela the number of wells is close to 30. The well are mainly located in private homesteads, mosques and schools with a few wells in public spaces. In Lamu the water demand has partially been met by sinking boreholes, but when they are sunk too deep or too close to the shoreline, they normally face the problem of salt water intrusion.

The sand dune in Lamu form low undulating hills while the areas along the coastline and adjacent beach sands and the areas immediately behind the mangroves on the landward side are flatter. The Lamu-Shela sand dunes are found in Lamu Island, running through the island. They stretch about 12 km and cover 958 hectares. The dunes rise to about 60 metres above sea level forming a continuous ridge along the Lamu Bay. The dunes protect Lamu against strong winds from the open sea. For instance, it is believed they shielded the island from the winds associated with the 2006 Tsunami. Apart from being a shield, the sand dunes have since 1950s been a source of groundwater, leading to their gazetting as a water catchment area in March 2002. They are a source of groundwater in Lamu Island but are currently facing a challenge from human developments and especially population growth and urbanization of the island.

The other source of Lamu Island freshwater is piped water from Lamu Water Service Company which sources its water from Tana River and operates under the Coast Water Services Board. With increased urbanization and urban poverty, some residents are increasingly relying on groundwater which is also under pollution threat due to lack of proper sewer management in the town. There is also the impact from saline water intrusion as the wells are drawn down.

19 Okello, C., M. Antonellini, N. Greggio, N. Wambiji, 2015. Freshwater resource characterization and vulnerability to climate change of the Shela aquifer in Lamu, Kenya. Environmental Earth Sciences, 73: 3801–3017

20 Jacob Ochiewo, 2001, Socio-economic aspects of water management along the coast of Kenya Hydrobiologia, August 2001, Volume 458, Issue 1-3, pp 267-273

21 Mwangi, P. K., 2009. Environmental impacts of government land settlement schemes in drylands: the case of Lake Kenyatta settlement scheme, Lamu County, Kenya University of Nairobi eRepository. Available at: http://erepository. uonbi.ac.ke: 8080/xmlui/ handle/ 123456789/ 6930. Accessed on 20th May 2015

3.4 SENSITIVITY OF WATER RESOURCES TO DEVELOPMENT INTERVENTIONS

There is a range of ecological and sociological impacts associated with threats to seasonal rivers. Pollution arising from activities like the proposed coal power plant and the LAPSSET project will have immediate impact on the river biodiversity and water quality. The pollutants may also get transferred through active transport to ecosystems within the sub-basin like the estuaries, lakes, swamps and creeks. Localized impacts comprise loss of species, introduction of invasive species, shifts in estuarine and marine water quality.

The development initiatives under LAPPSET is earmarked to host a major port with drenching activities to clear the sea-bed sand in the Manda Channel into the Wange Creek for passage of ships. Within the LAPPSET Plan, crude and refined oil pipelines will be constructed with terminus offshore Manda Island at the Takwa Town area for oil loading. The dynamics will change the sediment distribution pattern with possible sea-floor erosion from ocean currents affecting ocean biodiversity and habitats. The ocean is also sensitive to oil spills and the pipeline construction and functionality is an area to access and monitor. There are also challenges from runoff from the mainland from roads and railway line, the 3 path new Lamu port, special economic zone, resort city and the Port related industries. Pollution from ships, effluent release from factories, and farm chemicals runoff especially will therefore be an issue of concern.

Borehole and water wells are sensitivity to development interventions. Untreated domestic sewage effluent due to expanding human population seeping into boreholes poses a major threat to public health. In a geologically fragile environment like Lamu, any development undertaking must mitigate against aquifer pollution to avoid disease outbreaks (Nkhuwa, 2003)[22]. Due to the very low elevations in Lamu in relation to the sea level, sea water intrusion is a practical problem to water sources such as boreholes.

There exist both natural and artificial stressors to sand dunes e.g. floods and sand harvesting. Safeguarding sand dunes that will provide an on-going yield of freshwater for domestic purposes is a key objective of sustainable water resource management. The most severe risk is from flooding from sea storms and possibly tsunami surge sourced from the Mid-Pacific volcanic Arc activities. To guard against this and other risks, coastal and shoreline management is usually placed as a priority by relevant authorities (Pethick and Crooks, 2000)[23]. Sand harvesting to meet the demands of the building industry is common in Lamu-Shela sand dunes, leading to habitat modification and degradation. It interferes with biotic integrity as well as the species habitat and ecological functions of the dunes as water reservoirs. On the other hand, natural phenomena like flooding events may compromise the water quality by introducing toxic influxes.

Plate 35: Sand dunes in Amu Island

22 Nkhuwa, D.C.W, 2003. Human activities and threats of chronic epidemics in a fragile geologic environment, Physics and Chemistry of the Earth, Parts A/B/C Volume 28, Issues 20–27, 2003, Pages 1139–1145.

23 John S. Pethick and Stephen Crooks, Development of a coastal vulnerability index: a geomorphological perspective, Environmental Conservation / Volume 27/ Issue 04 / December 2000, pp 359-367.

CHAPTER 4 MINERAL AND ENERGY RESOURCES

4.0 OIL, GAS AND SUPPORT INFRASTRUCTURE

The coastal area in Lamu is rich in a number of exploitable mineral resources that are located along a 50 km strip. Some minerals of economic value include, coral rocks, limestone, rutile, ilmenite, building sand, barites, silica sands, iron ore and clay. In addition, apatite, galena, and manganese oxide are present in economically exploitable quantities. Lamu County presently exploits limestone, coral stones, and sand for the building industry. The main sand and ballast quarrying sites in Lamu are in Manda, Matondoni, Lake Kenyatta, Kizingitini and Faza.

Extensive exploration for oil and gas has been done with drilling of test wells accomplished. Although not explored or documented in the region, the impact of oil mining on the environment and biodiversity cannot be under estimated. The impact can be direct as in the case of land clearance for road access, during oil exploration and exploitation or from stripping of overburden for drill cuts handling and disposal or direct discharge of drill mud to water bodies.

Indirect impacts of mining include social and environment changes that are not easy to identify immediately such as from mining induced settlement patterns. Cumulative impacts are felt after an extended period of time and may result from other development infrastructure to support the growing population.

As can be seen in Figure 22, the Lamu Oil and Gas exploration activity is being conducted in the entire Lamu Basin covering the whole county and offshore, thus any impacts will affect Table 3 documents some of the environmental sensitivities that can result from oil exploration and subsequent discharge or spill of oil into the environment.

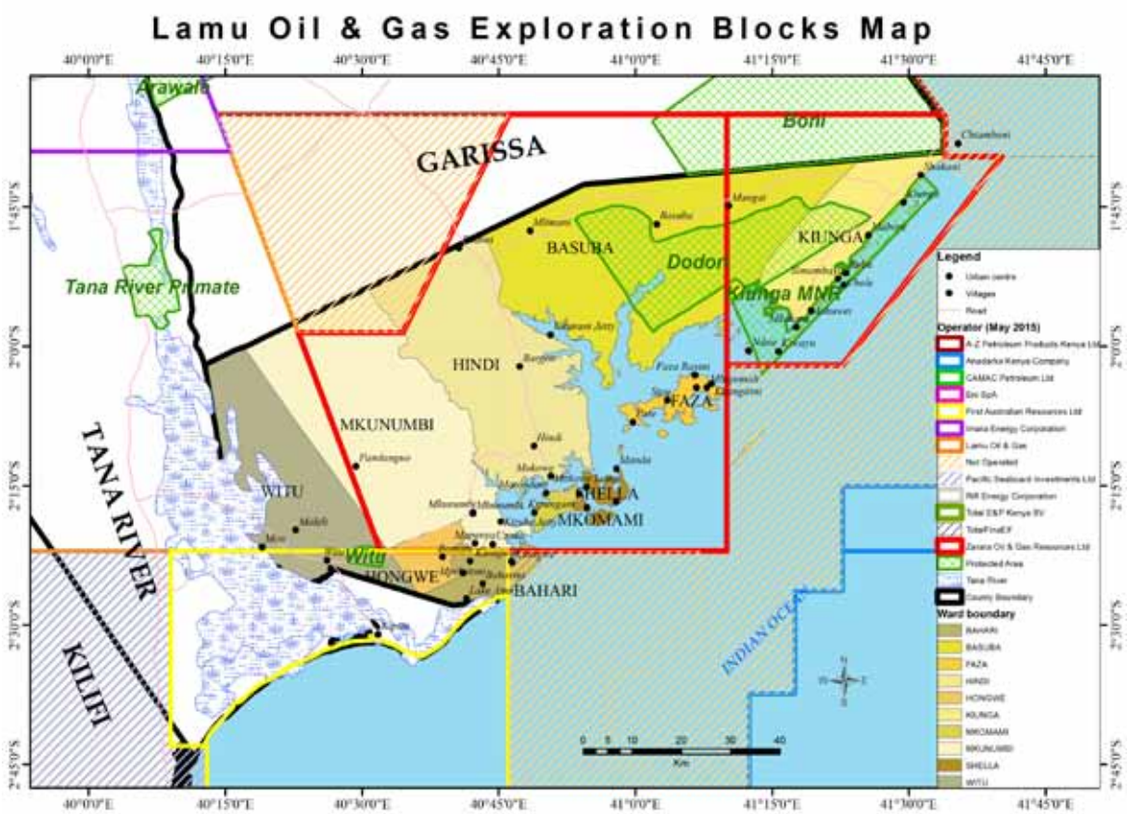

Figure 22: Lamu oil and gas exploration sites as at May 2015

4.1 SENSITIVITY OF THE ENVIRONMENT TO OIL AND GAS

The ecosystem response to oil and gas spill shows that current practices for assessing ecological risks of oil in the oceans and by extension, other toxic sources should be changed. It has been assumed that impacts to populations derive almost exclusively from acute mortality but studies by Peterson et al (2003)[24] in the Alaskan coastal ecosystem show that persistence of toxic subsurface oil and chronic exposures can continue to affect wildlife. Delayed population reductions and cascades of indirect effects postpone recovery. Peterson et al (2003) proposes a new paradigm of ecosystem-based toxicology that can be used to understand and ultimately predict chronic, delayed, and indirect long-term risks and impacts this is shown in Table 3 and which can be adopted in the understanding and management of the Lamu environment.

24 Peterson, C. H.; S. D. Rice, J. W. Short, D. Esler, J. L. Bodkin, B. E. Ballachey, D. B. Irons (2003). Long-Term Ecosystem Response to the Exxon Valdez Oil Spill. Science 19 Vol 302 Dec. 2003 pg 2082-2086, www.sciencemag.org.

Table.3: Changing paradigms in oil ecotoxicology, moving from acute toxicity based on single species toward an ecosystem-based synthesis of short-term direct plus longer-term chronic, delayed, and indirect impacts (after Peterson et al, 2003)

Old paradigm	**Emerging appreciation**
Physical shoreline habitat	
Oil that grounds on shorelines other than marshes dominated by fine sediments will be rapidly dispersed and degraded microbially and photolytically.	Oil degrades at varying rates depending on environment, with subsurface sediments physically protected from disturbance, oxygenation, and photolysis retaining contamination by only partially weathered oil for years.
Oil toxicity to fish	
Oil effects occur solely through short-term (_4 day) exposure to water-soluble fraction (1- to 2-ringed aromatics dominate) through acute narcosis mortality at parts per million concentrations.	Long-term exposure of fish embryos to weathered oil (3- to 5-ringed PAHs) at ppb concentrations has population consequences through indirect effects on growth, deformities, and behaviour with long-term consequences on mortality and reproduction.
Oil toxicity to seabirds and marine mammals	
Oil effects occur solely through short-term acute exposure of feathers or fur and resulting death from hypothermia, smothering, drowning, or ingestion of toxics during preening.	Oil effects also are substantial (independent of means of insulation) over the long term through interactions between natural environmental stressors and compromised health of exposed animals, through chronic toxic exposure from ingesting contaminated prey or during foraging around persistent sedimentary pools of oil, and through disruption of vital social functions (care giving or reproduction) in socially organized species.
Oil impacts on coastal communities	
Acute mortality through short-term toxic exposure to oil deposited on shore and the shallow seafloor or through smothering accounts for the only important losses of shoreline plants and invertebrates.	Clean-up attempts can be more damaging than the oil itself, with impacts recurring as long as clean-up (including both chemical and physical methods) continues. Because of the pervasiveness of strong biological interactions in rocky intertidal and kelp forest communities, cascades of delayed, indirect impacts (especially of trophic cascades and biogenic habitat loss) expand the scope of injury well beyond the initial direct losses and thereby also delay recoveries.

CHAPTER 5: TOURISM AND CULTURAL RESOURCES

5.0 LAMU COUNTY CULTURE AND HERITAGE SITES

Cultural resources, the collective evidence of past activities and accomplishments of the people are evident in Lamu County. The evidence includes pre-historic and historic archaeological sites, historic standing structures and buildings, bridges, cemeteries, and monuments of scientific and cultural value[25]. Identification and mapping of cultural resources in Lamu County provides a quick reference on their spatial location against emerging developments. This will promote their preservation by ensuring that developers identify and mitigate impacts to cultural resources in project areas before construction activities. This is because cultural resources are finite and non-renewable which once destroyed cannot be returned to their original state. Impacts to resources that are eligible for the National Register of Historic Places must be mitigated through protection, avoidance of encroachment and preservation.

The Lamu Community have a set of believes, unique art, religion and rituals including calligraphy that has been practised over centuries. Lamu culture has been attracting visitors all through history. The County has hosted numerous religious, Swahili and Arab cultural festivals since the 19th century, and has served as a centre for the study of Islamic and Swahili cultures. The region therefore has both numerous nature and cultural based tourist sites.

5.1 TOURISM

Kenya's tourism contributes 12.5% of the GDP to the country, of which coastal tourism accounts for 60%. Lamu has 130 km of a sandy beach coastline and diverse tourist attractions sites and a well-developed tourism hotels and hospitality infrastructure (Figure 23). The region enjoys unique advantage as tourist destination with a number of attractions including three (3) national reserves, two national parks and three private ranches which are home to several species of wildlie. The resources have placed tourism is a major economic activity in Lamu County. The estimated total number of visitors annually in Kiunga-Lamu alone is 200,000.

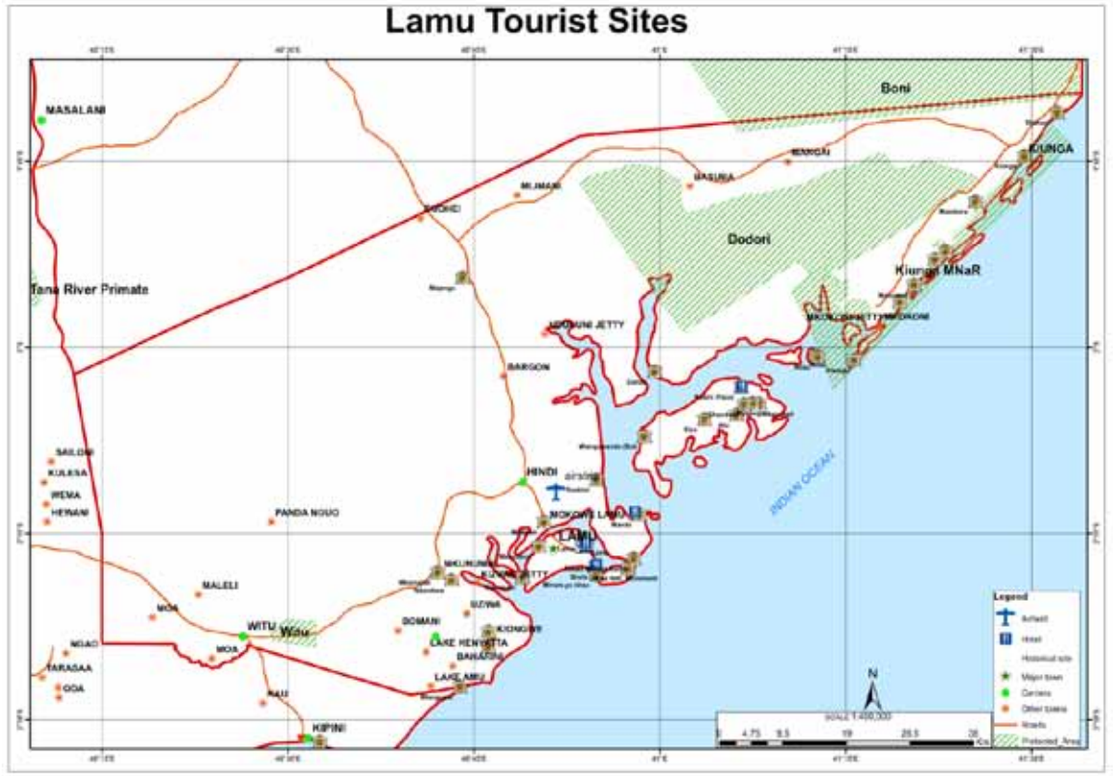

Figure 23: Key tourists sites in Lamu

The annual Lamu Cultural Festival which exhibits the past and the present beliefs and traditions that are the heart and soul of the Lamu Community is a key visitor attraction. Several competitions and races are staged during this week long festival. These events are designed to each encourage local skills or practices that are central to Lamu life. These include traditional *Swahili* poetry, *Henna* paintings and *Lamu yoga* festival and *Bao* games competition, the oldest known game in human history. Archaeological evidence suggests that the *Bao* game has been played throughout Africa and the Middle East for thousands of years. In order to preserve and encourage the art of dhow sailing, now threatened by increasing availability of engines and prefabricated boats, a dhow race is also held.

In recognition of Lamu Town's status as the oldest and best-preserved Swahili Settlement in East Africa, UNESCO scripted it as a World Cultural and Heritage Site in 2001. Built in coral stone and mangrove timber, the town is characterized by the simplicity of structural forms enriched by such features as inner courtyards, verandas, and elaborately carved wooden doors. The Old Town has a gazetted buffer zone that includes the Manda and Ras Kitau mangrove skyline and the

25 https://www.nysm.nysed.gov/research/anthropology/crsp/crm_faq.html

Shela Sand Dunes[26]. The Old Town is managed by the Lamu World Heritage Site and Conservation Office, established by the National Museums of Kenya. Other important sites include Takwa and Manda towns and the Kiunga region.

Plate 36: Lamu Old Town and Port (*Photo: Onywere, Oct. 2015*)

Plate 37: Morning skyline of Lamu heritage of Swahili architecture at Shela Town (*Photo: Onywere, Oct. 2015*)

5.2 KIUNGA MARINE NATIONAL RESERVE

The main natural resources protection area is the Kiunga Marine National Reserve (KMNR) that was designated as a reserve on June 11, 1979. The reserve is legally registered on the Boundary Plan 216/39. In 1980, Kiunga Marine National Reserve together with Dodori National Reserve were designated as important Man and Biosphere Reserve with a total area of 60,000 ha. The limits of this zone are indicated by latitude and longitude bearings only[27].

The Kiunga region encompasses the Bajun Archipelago, and lies at the Northern most extremity of the Kenya coast, at the border with Somalia. It is characterized by a linear system of barrier islands with extensive mangrove stands in the protected lagoons, and large areas of sea grass in the estuarine channels and shallow reef areas. As indicated in Table 4 marine national parks are highly sensitive to development activities.

Table 4: Sensitivity matrix of Kiunga Marine National Reserve

RESOURCE	ACTIVITY	ISSUE	IMPACT
Marine aquatic resources	Hotel and Hospitality Services	Increased tourist movement using motorized boats. • Water pollution • Resources exploitation	• Noise and Vibration • Loss of Biodiversity • solid and effluent waste • Loss of Marine Biodiversity • Promotion of traditional cuisine • Promotion of material culture

26 http://lamutourism.org/island-culture/lamu-history/http://www.lamuconservationtrust.org/culture/historical-sites

27 http://cca.kws.go.ke/Kiunga.html

	Mass tourism/ Beach Sports (snookering, scuba diving, sport fishing, camel riding, netball, donkey riding etc)	• Noise pollution • Disturbance of beach sand stability • Water pollution • Land based sedimentation	• Disturbance of breeding ground for turtles, prawns, dugongs and other marine biodiversity • Erosion of cultural values and material Culture • Degradation of Cultural Monuments and Sites
	Tourists Transportation	• Noise pollution • land degradation • beach degradation	• Noise and vibration • Increased erosion from off-road tracks • Loss of biodiversity
Terrestrial	Urban Sprawl	• Urbanization	• Loss of Cultural Values and material culture • Destruction of historical sites in favor of urban designs • Loss of water catchment areas e.g. Sand dunes • Loss of Biodiversity • Loss of productive agricultural land
	Implementation of LAPPSET Project	• Massive Infrastructure Development	• Loss of Marine Biodiversity and irreplaceable prawn habitats by the port • Loss of Historical Sites

5.3 HISTORICAL AND ARCHAEOLOGICAL SITES

Lamu Island hosts the headquarters of Lamu County and is a UNESCO World Heritage site for its architecture and culture dating back to the 14th century. Lamu Town is Kenya's oldest continually inhabited town, and was one of the original Swahili settlements along coastal East Africa, founded in 1370 (Romero, 1997)[28]. The town is reached from the mainland through Mokowe Jetty from where Lamu channel is crossed by boat to reach Lamu Island. Adjacent to Lamu Island is Manda Island that hosts the County's airport (Figure 24) and boast of historical civilizations, the Takwa Ruins. Lamu and Manda Islands are part of the Lamu Archipelago that also contains several other archaeological/historical sites whose excavations is shedding light on Swahili history and culture. The archaeological, historical and cultural sites within the East African coast are believed to belong to a single cultural tradition dating back to the 9th Century (Wilson, 1982)[29].

The archaeological sites vary in size from town ruins measuring 30ha to isolated mosques along the coastline. The kind of settlements represented by these ruins also varied in population characteristics. Whereas some belonged to small rural communities living in houses of thatched roofs with mud set on wooden frames, others were densely populated and concentrated towns where most inhabitants lived in homes built of coral rag set in mortar and sand. A study by Wilson (1982) sampled 116 such settlements stretching from Mogadishu southwards to Vumba Kuu on the Kenya-Tanzania border. In Lamu County, there are a number of such sites documented and gazetted under The National Museums and Heritage Act, 2006.

28 Romero, Patricia W. (1997): Lamu: history, society, and family in an East African port city. Princeton, N.J.: Markus Wiener, c1997. ISBN 1-55876-106-3, ISBN 1-55876-107-1.

29 Wilson, T. H. (1982). Spatial Analysis and Settlement Patterns on the East African Coast. In: "Paideuma: Mitteilungen zur Kulturkunde Bd. 28, From Zinj to Zanzibar: Studies in History, Trade and Society on the Eastern Coast of Africa", pp. 201-219. Published by: Frobenius Institute.

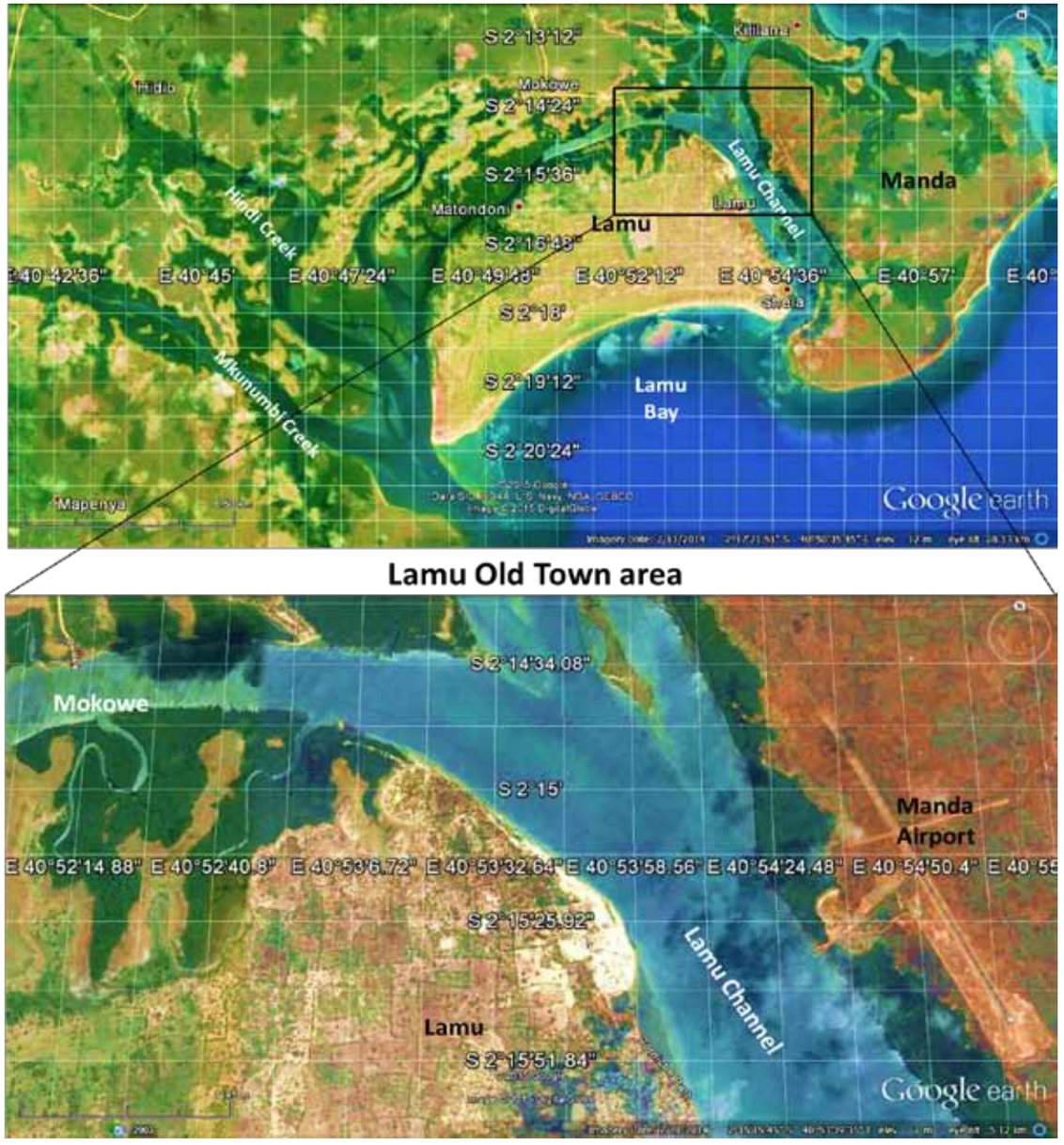

Figure 24: Lamu and Manda Islands showing the location of Old Town and Manda Airport

The historical Town of Lamu contains the Lamu Fort (Plate 37) on the seafront. The Fort was constructed during the rule of Fumo Madi ibn Abi Bakr, the sultan of Pate, and was completed after his death in the early 1820s (Romero, 1997). Lamu was an important trade centre with the Middle East and faced invasion by the Portuguese in the 16th Century. It is currently home to 23 mosques, including the Riyadha Mosque, built in 1900. Today, the majority of Lamu's population is Muslim. The town has a donkey sanctuary. Donkeys are used as the main and the only mode of transportation on the Island as there are no roads on the island, just alleyways and footpaths (Plate 38 and 39), and therefore, there are very few motorized vehicles mainly for the county government officials and the health services. Residents move about on foot or by boat, and donkeys are used to transport goods and materials. This is part of the heritage of Lamu Island.

Plate 38: Lamu Fort, a historical heritage in Old Lamu Town (*Photo: Onywere, Oct. 2015*)

Plate 39: A narrow pathway in Old Lamu Town (*Photo: Onywere, Oct. 2015*)

Plate 40: Narrow footpath in Shela town of Lamu Island (*Photo: Onywere, Oct 2015*)

Lamu's early economy was based on slave trade until its abolition in the year 1907 (Eliot, 1966)[30]. The area also engaged in traditional exports that included ivory, mangrove, turtle shells and rhinoceros horn, which were shipped to the Middle East and India. These trades are now prohibited as the protection of elephants and rhinoceros protection is a key mandate of KWS. Initially this hampered trade and therefore the growth and development of Lamu until tourism has gradually started to flourish. Lamu is a popular destination for backpackers, scooper divers, historical artifacts seekers and cultural heritage enthusiasts. The local people are involved in providing dhow based trips to the tourists along with running hospitality business where coconut, mango, grapefruit and seafood such as crab and lobster are common food ingredients.

There are several museums, among them the Lamu Museum which is the largest. Notable buildings in Lamu Town include: Lamu Fort, Riyadha Mosque, Swahili House Museum, Donkey Sanctuary and German Post Office all recognized as national monuments. Lamu is home to the Maulidi Festival, held in January or February and which celebrates Mohammed's birth. It features among other things donkey racing, dhow-sailing competition and swimming. The other cultural event is the Lamu Cultural Festival which is usually held in the last week of August and features traditional dancing (such as chakacha, wedding dance and sword dance), crafts and embroidery, dhow races and donkey. Many of these activities led to Lamu Old Town being designated as a UNESCO World Heritage site.

The most conspicuous of the Archeological sites in Lamu is 8th century Shanga Ruins in Pate Island (named after the Washanga ("the people of Shanga"), a clan who still live in the nearby Swahili town of Siyu) is situated on the South East Coast of Pate Island. It was excavated during an eight-year period, starting in 1980. The earliest settlement was dated to the 8th century, and the conclusion drawn from archaeological evidence (locally minted coins, burial sites) indicate that a small number of local inhabitants were Muslim, probably from the late 8th century onwards, and at least from the early ninth century. The excavations also reveal major break in the development of Shanga in the mid or late 11th century, with the destruction and the rebuilding of the Friday Mosque. Takwa ruins (Plate 40) are dated 15th – 16th century and are located in Manda Island was an old village that was abandoned due to lack of fresh water. Due to over abstraction of ground water sea water seeped in and hence the village was no longer habitable.

Plate 41: Some of the remnants of Takwa Ruins in Manda Island. (*Photo: Walter Deshler - , Web.*)

30 Eliot, Charles (1966). The East African Protectorate. Routledge. ISBN 0-7146-1661-3.

CHAPTER 6: SOCIO-ECONOMIC DEVELOPMENT

6.0 SOCIO-ECONOMIC DEVELOPMENT OF LAMU COUNTY

Lamu County is endowed with substantial natural resources for economic development. These include over 550 Km² of arable land, large tracks of natural forest, rich diversity of fauna and flora, marine resources and minerals, including oil and gas deposits. Trade and economy in Lamu County date back to the 14th century when Arabs travelers settled in Lamu Town. The town is a joint product of trade and Islam (web.mit.edu, 2015)[31] that provided the wealth and incentive for settlement respectively. The traders sailed between the Middle East and East African Coast aided by monsoon winds, called the trade winds.

Lamu economy is also heavily dependent on cultural heritage tourism (web.mit.edu, 2015). Examples of the many tourist sites in the region include Pate Ruins, Manda Island, Matondoni dhow making and the Lamu Cultural Festival and the Maulidi Festival (The County Platform, 2015[32]). Foreigners have bought traditional stone houses as summer cottages mainly used during three months of their holiday.

Despite it being one of the richest counties in Kenya in terms of natural resources, Lamu is listed among the poorest regions and considered marginalized in terms of development. Any development achieved in the area is concentrated in the urban centres. The challenge is to bring about equitable development across the County that will secure the interest of all the communities in the area based on the available natural resources. There is therefore need to map and understand the spatial distribution of environmental resources and their sensitivity to change. Environmental sustainability tools must be employed to strike a balance between development and environment in the County.

Community based organizations and non-state actors and natural resource management contributors[33] are some of the groups that are players/contributors to the county's socio economic development. There are 33 registered cooperatives with only 13 being active, 19 active NGO's and 1345 self-help groups. There is need to develop this sector to play a more significant role in contributing to the socio-economic development of the county.

The County has 5 Km of Tarmac road which demonstrates years of development negligence by the government. The rest of the road infrastructure is 688.6 km of all-weather hard surfaced roads with the two main ones being Mokowe-Garsen and Mokowe-Kiunga roads (Lamu CIDP, 2013-2017). Most transport however is between the islands on ferries, dhow and boats. The county has eight main jetties: Kiunga, Amu, Mokowe, Manda, Matondoni, Hospital Jetty, Lamu and Faza. The Lamu-Faza seaway is plied by semi-motorized dhows and speed boats. There are 13 airstrips (11 public and 2 private) in Lamu County (Lamu CIDP, 2013-2017).

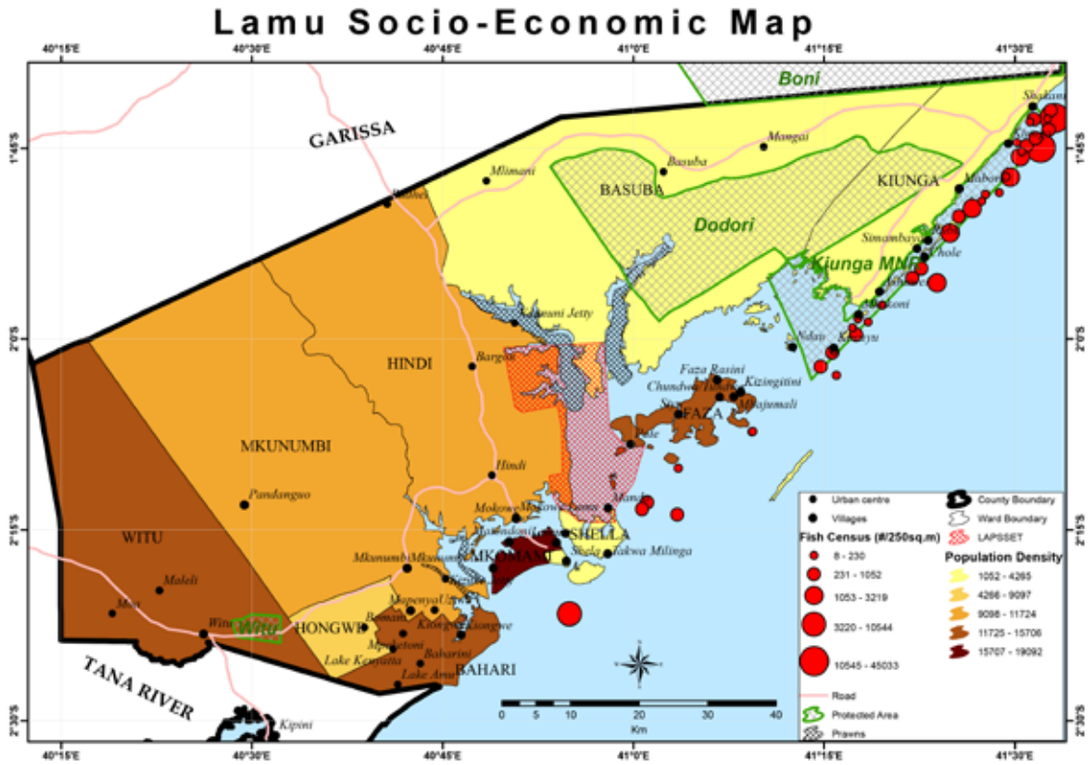

Figure 25: Lamu socio-economic and development map

Lamu County is also endowed with several resources ranging from; beaches, forests and historical heritages among others. Despite of all these, Lamu suffers high youth unemployment rates, high poverty rates, poor access to basic services such as water and good and shelter.
(Source: http://ejatlas.org)

31 web.mit.edu/akpia/www/AKPSite/4.239/lamu.html accessed on 20/5/15
32 www.thecountyplatform.or.ke/lamu-county/ accessed on 21/5/2015
33 CIDP page 29

6.1 THE LAMU PORT SOUTHERN SUDAN-ETHIOPIA TRANSPORT (LAPSSET) PROJECT

Key among the social economic drivers for Lamu County is the proposed LAPSSET project. LAPSSET is a transport and infrastructure project that forms the second transport corridor in the country, the first one being the Mombasa-Nairobi-Malaba corridor that since its establishment has spurred development in the areas it passes through. The corridor comprises a number of components, including the Lamu Port, a refinery, a modern railway, a road to South Sudan and Ethiopia, airports at Lamu, Isiolo and Lokichogio, and resort cities at Lamu, Isiolo and Turkana counties. The project is expected to contribute approximately 3% to the nation's GDP. The project will:

- Improve regional trade and investment in the three countries of Kenya, Ethiopia, and South Sudan, with an estimated population of 130 Million people
- Enhance the economic activities in Northern Kenya and spur socio-economic development and improve communication and transport in the region.
- Offer an alternative economic and transport corridor to the existing Mombasa-Nairobi-Malaba.
- As an international and regional transport system, LAPSSET will directly connect Kenya, Ethiopia and South Sudan and open up the arid and semi-arid region of Northern Kenya and indirectly benefit Cameroon, Central Africa, Uganda and Rwanda.

The LAPSSET components in Lamu County include:

- **LAMU PORT**, a key element of the Lamu corridor is proposed to have a 32-berth modern port that will be about three times the size of Mombasa Port and will located at Manda Bay. The Bay enjoys a natural depth for large ships to dock, facilitating importation of goods and other materials.
- **LAMU RESORT CITY** will help attract investors and tourists and generate revenue and will be integrated with modern hotels, shopping malls, and golf courses.
- **OIL REFINERY** is one of the LAPSSET projects that will be domiciled in Lamu. The proximity to Lamu Port is expected to ease logistics of transportation and export of oil products.
- **LAMU AIRPORT** will be built in the strategic locations of Lamu and will offer transportation solutions, encourage tourists to visit areas within easy proximity to the airports. In addition to transport, the airports will complement the proposed resort cities by availing infrastructural support.
- **ROADS** infrastructure will be the nerve centre connecting Lamu County with the rest of the country and beyond. The LAPSSET design provides for a highway that will be the vehicular transport route from Lamu to South Sudan through Garissa, Isiolo, Kisima and Nginyang to connect with the existing Kenya–Sudan road at Lokichar.
- **OIL PIPELINE** will be constructed along the road and the railway line linking Lamu-Isiolo, Isiolo-South Sudan, and Isolo-Ethiopia. The pipeline will carry both crude oil and oil products, with 1260 Km expected to transport crude and 980 Km will transport fished oil products.
- **THE RAILWAY LINE** comprises a 1500 Km standard gauge line from Lamu to Ethiopia and South Sudan. The rationale for a modern railway is to facilitate the transportation of freight along the corridor, but also to allow intermodal transportation between the roads and the railway.

The LAPSSET corridor is expected to revolutionize development in Lamu County, attracting many investors and settlers that will have a multiplier effect in terms of human population and settlements. Ultimately this will have a number of impacts on the sensitive culture and natural environment that will need project interventions for mitigating adverse impacts from the developments. Lamu is intended to be a resort city under the LAPSSET project with an international airport, a sea port and an oil refinery (www.kenyanemabassysouthsudan.org,2015). LAPSSET will offer benefits such as employment, local contracts and creation of huge business opportunities. The project is of historical significance with wide ranging and far reaching socio-economic impact across the three nations involved and beyond.

The development of a new port and associated infrastructure at Magogoni in Manda Bay near Lamu are already underway with indications of significant impact on the ecosystems through clearance. The fledgling project to build a huge new port, oil refinery and transport hub although promising to deliver thousands of jobs and is a pillar of the government's long-term development agenda, critics fear the project will displace tens of thousands of people in Lamu, exacerbate decades of marginalization, degrade marine environments essential to local livelihoods and increase the risk of conflict.

Plate 42: Massive construction site at Magogoni nere the site for the Lamu Port. (*Photo: Onywere, Oct 2015*)

Plate 43: A pile of harvested Mangroves at Mokowe awaiting export to inland towns (*Photo: Onywere, Oct 2015*))

Plate 44: Mangrove clearing at Magogoni for the development of the Lamu Port (*Photo: Onywere, Oct 2015*)

The conflict over the occupation and development along the Wange Creek already began in the form of preventive resistance and was mobilized by the fishermen, indigenous groups / traditional communities, International NGOs, Local NGOs, landless peasants, pastoralists and discriminated ethnic groups mainly the Bajuni, and and Orma. The forms of mobilization included the development of a network/ collective action, lawsuits, court cases, judicial activism, objections to the EIA Officials, complaint letters and petitions, public campaigns and street protest/ matches. This has led to displacement, loss of livelihood, loss of traditional knowledge/practices/cultures, social problems (alcoholism, prostitution) violations of human rights, loss of landscape/sense of place on the socio-economic and biodiversity loss (wildlife, agro-diversity), deforestation and loss of vegetation cover on the environment. The Lamu port therefore poses another great reason for the need of a well-coordinated and a binding land use plan that will call for sober use of land and mobilization of the available resources in order to realize their full potential of the development agenda.

6.2 AGRICULTURE

The county has land surface area of 6273.1 Km² (6474) composed of 5517 Km² of arable land 649.7 Km² of non-arable land, 130 Km² of coastline and 308 Km² under water mass. Lamu West sits on land surface area of 3971.3 Km² hence taking 63.3% of total land, leaving Lamu East with 36.7%. Kiunga Division in Lamu East occupies 96.6% of Lamu East land surface area. The bulk of arable land is in Lamu West and is influenced by the soil characteristics of the area (Figure 26) while Lamu East takes the bulk of water mass.

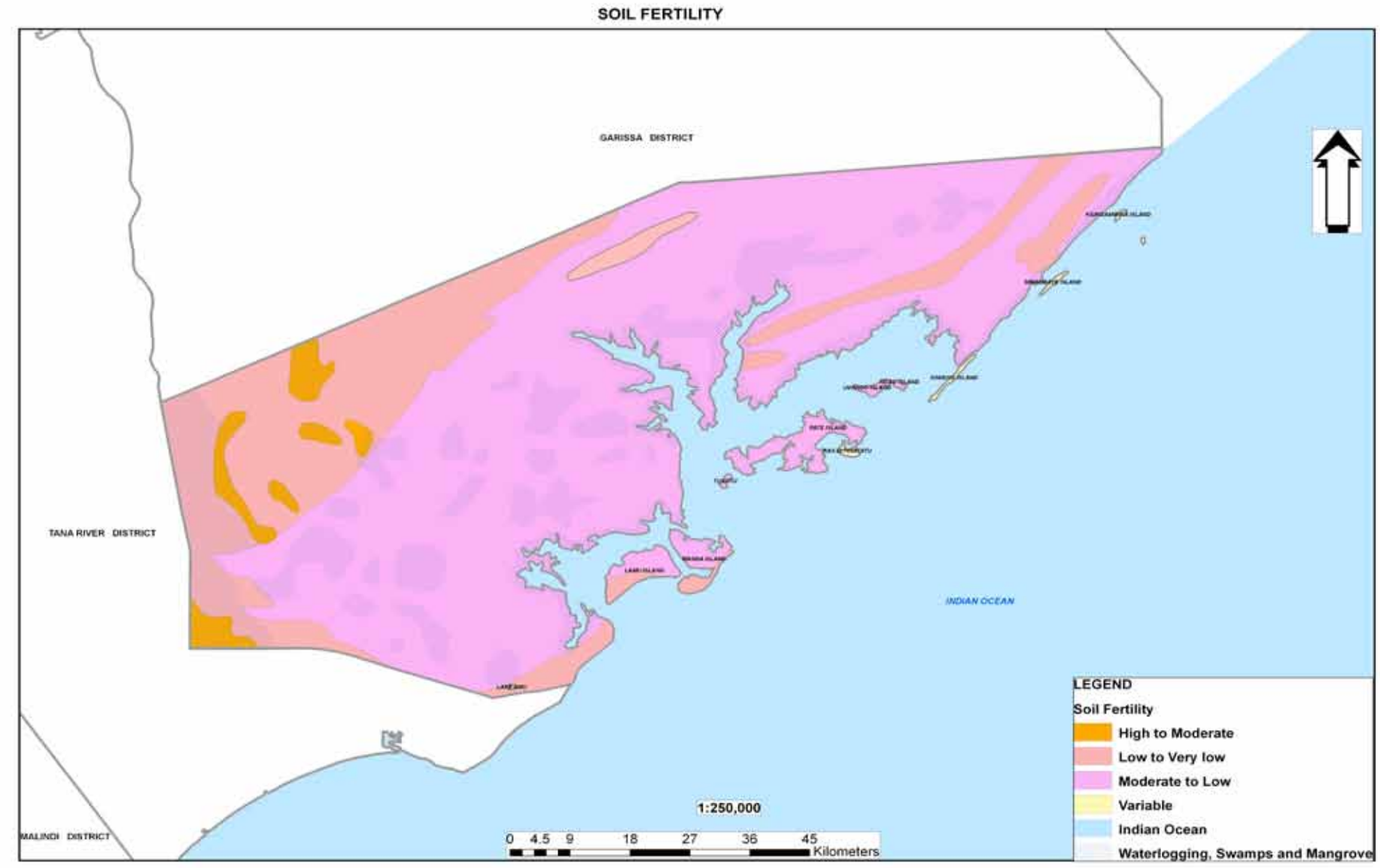

Figure 26: Soil fertility Map of Lamu

Based on the physiographic and climatic conditions, the county is classified into 5 Agro-Ecological zones (Figure 27).

- Coastal lowlands
- CL3 - Coconut/ Cassava zone
- CL 4 - Cashew nut-Cassava zone
- CL 5 - Livestock millet zone
- CL 6 Lowland ranching zone.

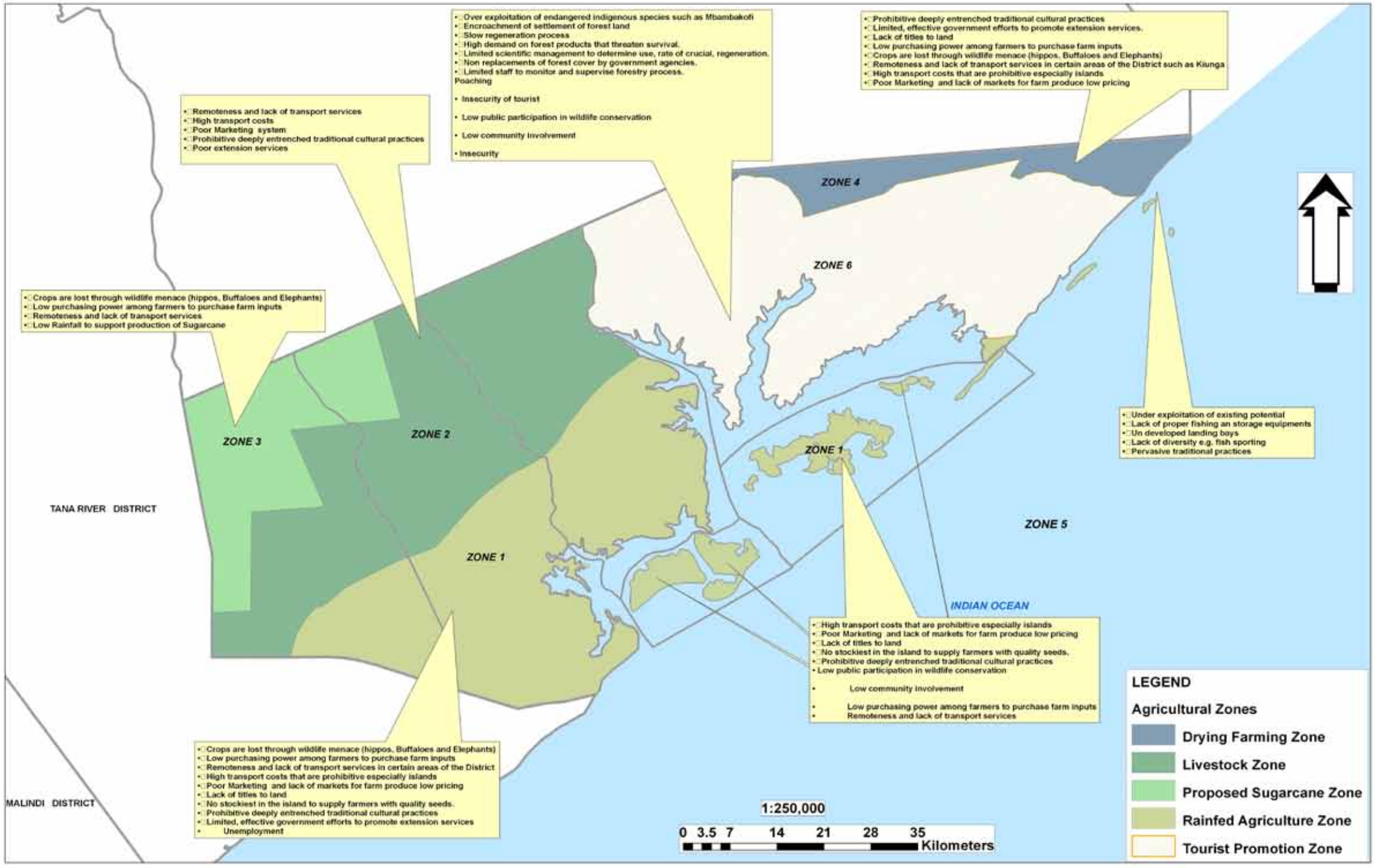

Figure 27: Ecological zones and Agriculture Potential areas

Agriculture is an important economic activity in Lamu (web.mit.edu, 2015) mainland where maize, cassava, purlse, surgum, cassava, peas and green grams are grown for food. Cash crops include cotton, cassava, coconut, mangoes, bananas and bixa oil crop and simsim. 42% of households' income is from cotton production[34] while the other crops contribute to household income as follows: 14% bananas, 8% maize, 7% cassava, 6% bixa, 5% mangrove and 18% from the rest of the crops in the area. Horticultural farming has currently been introduced. Horticultural crops include vegetables, tomatoes, bananas and water melons. NCPB depots provide storage facilities for the cereal crops.

The main livestock species include cattle, goats, sheep, camels, donkey and poultry (Lamu CIDP 2013-2017[35], KETRACO, 2014[36]). Small scale dairy farming is also practiced in Mpeketoni and Hindi. There is a designated livestock market at Nagele and Witu.

6.3 FORESTRY AND AGRO FORESTRY

Forests cover 33.9% of total county land surface area. 428 Km² (64%) of these forests cover is gazette, hence protected against commercial exploitation. These include 382 Km² of mangrove forest and 46 Km² of Witu forest. The non-commercial activities cover 280 Km² comprising of Lingi forest, Boni forest and Lake Kenyatta buffer zone. More and more farmers and institutions are now participating in agro-forestry. The main forest products include the Mangrove poles used for construction, fire wood, charcoal and casuarinas poles. Forest products such as mangroves are harvested for building also have been sold for years to the Middle East.

6.4 FISHERIES

Fishing is the main economic activity for the residents of the Islands. The fishing ground in Kenya cover 3,100 Km² of territorial water surface extending from Dar-es-Salaam to Kiunga to Ras Tenewi. Fresh water fishing is also carried out in the mainland under fish pond programmes and remnant ox-bow lakes in part of the Tana Delta, (Lamu CIDP 2013-2017).

There are rich fish species in the county, among them 5 turtle species, 150 reed fish species, 6 dolphin species and 183 species of hard coral fish. There are 40 fishing grounds that produce 1500 metric tons annually. Dugongs and octopus are other forms of fishes found in the area (plate 44 and 45) Lobster catch found manly along the northern part of Lamu's coastline and within Kiunga Marine National Park (Figure 28) and prawns found in creeks in the area (Figure 29) are very popular. Generally the production of fisheries is low considering the huge potential in the area. This is caused by poor fishing equipment and possible migration of fish due to various impacts. Fishing is undertaken using traditional vessels and traditional gears that include basket traps, hand lines and hand spears, as well as more modern gear types such as spear guns, gill nets and seine-net. The fish catch per year based on the fishing gear is shown in Figure 30a while Figure 30b shows the growth in the number of fishers between 2004 and 2012. Due to declining trends of reef fish, fishers are opportunistically using modern fishing gears that have higher efficiency of capturing more fish than traditional ones. There has been an increase in the number of fishermen in the region over the years but a decline in the fish catch between 2004 and 2012.

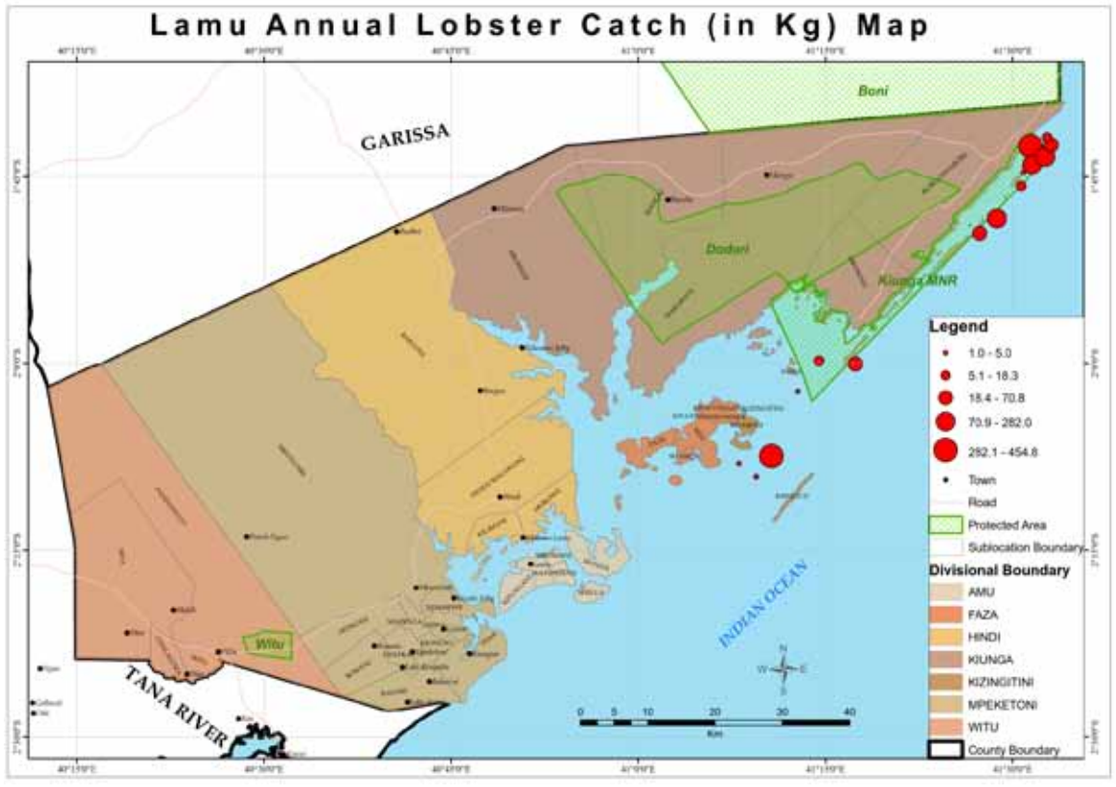

Figure 28: Annual lobster catch areas and size of catch

34 CDIP- June Page 27

35 www.lamu.go.ke/images/Downloads/LAMU_CIDP_2013-2017.pdf accessed on 20/5/15

36 KETRACO, 2014.The environmental and social impact assessment (ESIA) study for Lamu-Nairobi East 400 KV transmission line.

Plate 45: Fishermen displaying a dugong catch off Pate Islands (*Photo: Olendo/WWF*)

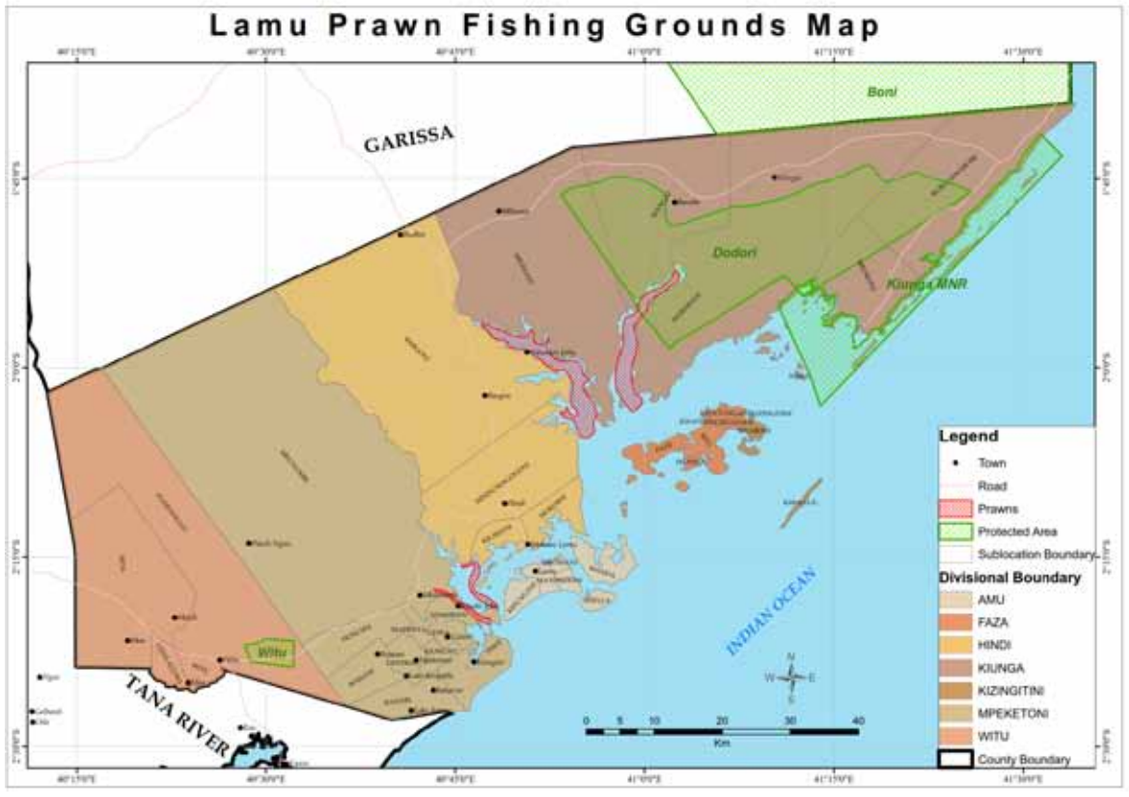

Figure 29: Prawn fishing grounds located along the creeks

Plate 46: An octopus catch, one of the many fish species in the area (*Photo: Hassan Mohamed/WWF*)

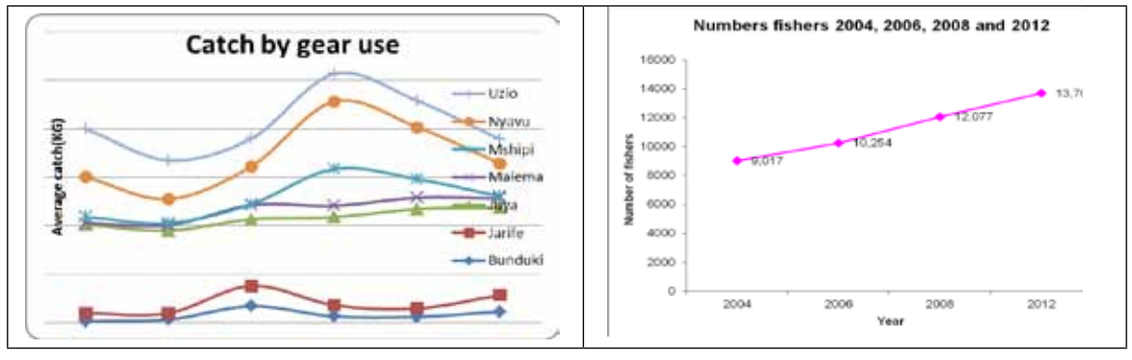

Figure 30: Fish catch in Lamu County by gear and the growth in number of fishermen between 2004 and 2012

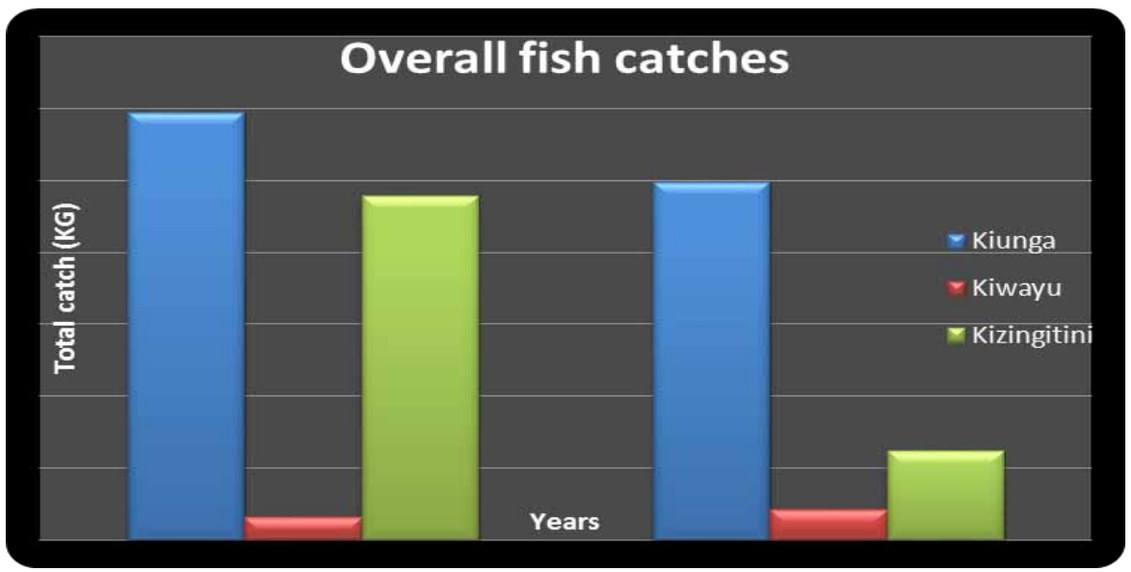

Figure 31: Fish catch in 2004 and 2012 compared (Source- KEMFRI)


Plate 47: Lamu Old Town fish landing area (*Photo: Onywere, Oct 2015*)


Plate 48: Fishermen out in the shallow ocean area at low tide with net fishing gear (*Photo: Onywere, Oct 2015*)

Spawning areas include Sea grass and mangroves areas in Kimbanini, Tenewi, Sanani, Dodori, Simwe, Ivondo, Chakani, Kuni Kavu, Magogoni, Kiweni, Dondo, Kitau, Biongwe, Mandatoto, Pate, Lamu and Jumba la Simba. Commercial fishing using trawlers is exploiting the local waters in the region. This in the process is causing destruction to the coral reefs, the breeding sites for the fish.

6.5 HEALTH CARE

The health services in Lamu County include 42 health facilities 3 of which are Level Five Health facilities, 5 health centres, 1 nursing home and 33 dispensaries. The county's main sources of water include groundwater, surface water from dams, pans, jabias, lakes and seasonal rivers. The average distance to the nearest health centre is approximately 5 Km. With the county's poor road infrastructure and limited availability of transport services, access to health care is a major challenge. Malaria accounts for 63.3% of illness in the county. Despite the high prevalence rates, only 30% of children less than 5 years of age sleep under treated nets. There is increased access to immunization programmes and incidence of malnutrition is becoming fewer[37].

37 Ref CIDP-June- Page 34

6.6 ENERGY

Information available in the Lamu County Integrated Development Plan, 2013- 2017 indicate that electricity in the area is generated from diesel generators managed by KENGEN and connected to the main grid. This mainly covers Lamu West Sub County, although generators have been installed through CDF funding in Lamu East market centres. Private investors have also shown interest in developing renewable sources of energy such as solar and wind energy. Firewood and charcoal are the main sources of cooking fuel, with use of LPG limited to the affluent in the urban centers.

6.7 EDUCATION

There are adequate physical facilities for pre-school, primary and secondary levels and 4 polytechnics and 1 satellite university campus. For pre-school, primary and secondary school levels, there are adequate physical facilities and enrolment. The challenge is on poor performance. The county's literacy level is estimated at 70% but this proportion represents the highly exposed residents of Lamu west Sub County. Literacy levels for Lamu East are estimated to be 30%.

6.8 EMERGING ISSUES

6.8.1 Environment and Climate change

Uncontrolled environmental degradation and effects of climate change negatively impact on the socio economic development of the county. Human activity is the major contributor to environmental degradation in the county. These activities include deforestation through illegal logging, charcoal burning, forest clearing for agricultural activities, overstocking and subsequent overgrazing, illegal quarrying and water pollution through waste disposal. The depletion of mangrove forest reduces reproduction of marine life; deforestation and overgrazing leads to desertification and reduce rainfall and water sources; water pollution leads to water borne diseases; while climate change has increased the frequency of high tide flooding. These environmental risks are being mitigated through gazetted forest protection, regular anti-logging patrols, re-afforestation; better sanitation services and better disaster monitoring and management programmes.

6.8.2 Land Tenure Security

Land Tenure security is a problem in the county with squatter occupation as the biggest concern for the communities in the area i.e. the Swahili, Arabs, Korei, Boni and Orma and is the perennial source of conflict between more recently settled communities and livestock herders some who moved into the area from the neighbouring counties of Garisa and as far as Mandera during dry spells. Only 13,000 (42%) households most of whom reside in Lamu West have title deeds to their land. Most of the household in Lamu east where most of the recent settlements have taken place have no title deed to the land. For sustainable future development, this disparities in land ownership needs to be corrected through robust land policies and deliberate settlement schemes targeting the landless ahead of immigrant influx attracted by envisaged opportunities from LAPSSET project.

Although 130,00 households have land title deeds the majority of the county residents especially Lamu East have no title deeds and live on ancestral land as squatters. Most of the landowners are also keeping their parcels idle, without much economic benefits. The county suffers from poor land use with unplanned villages with very low population mushrooming up, overstretching existing social services. Among the challenges facing Lamu is population growth owing to migration into Lamu from other parts of the country, fuelled partly by the anticipated opportunities accruing from the Lamu Port South Sudan-Ethiopia Transport (LAPSSET) Corridor. Other challenges include landlessness and poor land management, insufficient social services such as healthcare and education, inadequate supply of piped and fresh water, under-developed infrastructure, and food insecurity. A well thought out spatial plan is inevitable and this environmental sensitivity atlas bring to the fore the issues that need to be addressed I spatial planning.

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APPENDIX: WWF AND PARTNERS STAKEHOLDER LAMU ATLAS VALIDATION WORKSHOP

WWF Coastal Kenya Programme
Lamu Environmental Sensitivity atlas
LCSP GOV & OFA
6 - 7th Oct 2015

S/N	Name	Organization	Email
1.	Awadu Awadh	WWF	aawadh@wwfkenya.org
2.	Nathan Mutunga	WWF	nkiiti@wwfkenya.org nkiiti@wwf.panda.org
3.	Prof Simon Onywere	Kenyatta University	onyweres@gmail.com onywere.simon@ku.ac.ke
4.	M.A. Mwakuphunza	Agriculture	cdalamu@gmail.com
5.	Madoya Micah	NDMA	madoyamic@yahoo.com
6.	Ishaq Abubakar	Save Lamu	ishakbakar2030@yahoo.com
7.	Abdulhakim Abdul	LYA	hacks8692@yahoo.com
8.	Samuel Lodiro	KFS	snachotoi@gmail.com
9.	Zachary K. Maritim	WWF	zmaritim@wwfafrica.org
10.	Isava Izava	WWF	molendo@wwfkenya.org izavamike@me.com
11.	Christopher N. Aura	KEMFRI	auramulanda@yahoo.com
12.	Dr K. I. Ondimu	NEMA	kenmariaria@gmail.com
13.	Nickson Orwa	WWF	norwa@wwfkenya.org
14.	John Bett	WWF	jbett@wwfkenya.org
15.	Hillary M. Vidonyi	WWF	hmjumba@gmail.com

S/N	Name	Organization	Email
16.	John Kareko	Naturecom	jkareko@naturecomgroup.com
17.	Ann Komen	WWF	akomen@wwfkenya.org
18.	Abubakar Mohamed Ali	Kikozi	amaelamuday@yahoo.com
19.	Mohamed Baishe Athman	Director LC Natural Resources	mohabaish@yahoo.com mohabaishe2@gmail.com
20.	Ali S Bwana	KWS	ali.shebwana@gmail.com
21.	Cliff Baricatch	NEMA	cliffbaricatch@gmail.com
22.	Hadija Guraba	AWER	
23.	Kiunga Kareko	WWF	KKareko@wwfkenya.org kkareko@wwfesarpo.org
24.	Nadhir Hashim	PMCC	nadhirhashim20@gmail.com
25.	Faith Waruguru	WWF	fwaruguru@wwfkenya.org
26.	Simon Kunu	Fisheries	simonkunu2000@gmail.com
27.	M. Mwanje	Museums	mamwenje@museums.or.ke mamwenje@yahoo.com
28.	Elias Kimaru		EKimaru@wwfkenya.org

Notes: