ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT STUDY REPORT FOR CONSTRUCTION OF THE FIRST THREE BERTHS OF THE PROPOSED LAMU PORT AND ASSOCIATED INFRASTRUCTURE

FINAL REPORT

FEBRUARY, 2013

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PREFACE

This report has been prepared by the consultants to enable the Ministry of Transport pursue an Environmental Impact Assessment license from the National Environmental Management Authority (NEMA) prior to construction of the proposed first three berths of the proposed Lamu Port and associated infrastructure.

Feasibility study carried out by the Japan Port Consultants Ltd in 2010 spelled out that Lamu port development will have extensive irreversible environmental, social, and cultural impacts on on what is a unique and culturally sensitive area. This therefore justified the need for an ESIA study in order to provide for sufficient investigation and participation of a wider section of stakeholders so as to determine mitigation measure aimed at minimizing negative impacts and maximizing on the positive impacts.
EXECUTIVE SUMMARY

The Government of Kenya (GOK) through the Ministry of Transport plans to build a port at Manda Bay in Lamu. The port development is considered a flagship project in the country’s Vision 2030 Strategy of Growth and Development which is expected to accelerate development of trade routes and in the regions traversed by the new transport corridor, in particular the Northern part of Kenya which is still under-developed. The current project aims to undertake the construction of the first three (3) berths and associated infrastructure of the proposed Lamu Port. Project activities would include dredging, reclamation and construction of an access road.

Implementation of the port development project is expected to raise a number of environmental and social concerns that are both negative and positive to the surrounding environment and local communities. The Ministry of Transport commissioned this Environmental and Social Impact Assessment (ESIA) study to determine the likely impacts of the proposed development on the environment and local communities and advise on mitigation measures that need to be undertaken to address adverse negative impacts.

Lamu being largely a “virgin” marine ecosystem presents a diverse floral and faunal make-up. The major impacts likely to occur as a result of the construction of the first three berths are summarized as follows:

(1) Water Quality

The ESIA study has established that at the construction stage there would be significant impact on water quality likely to arise from dredging and dumping of dredged material. These impacts include sedimentation as a result of clearing of land for construction of the berths and the proposed causeway; impacts on aquatic biota as a result of decline in water quality, decline in fish population as a result of turbidity arising from construction activities and potential impact on tourism and leisure activities should turbidity extend to beach areas. During the operations stage there would be a threat to the environment in terms of potential of oil spill from ships.

Mitigation measures proposed include use of less intrusive dredging techniques during the construction phase and development and implementation of an effective oil spill preparedness and response plan at the operations phase.

Lamu being an undeveloped area has a natural state of the environment due to lack of industrial and residential activities that can introduce harmful pollutants into the area. Water samples taken during baseline survey in the area indicated lack of harmful substances within Manda Bay. The long term challenge of port development and operation will be to control the introduction of contaminants from port activities and hinterland effluent, particularly from the industrial zones. In the event that offshore dumping is required and done inappropriately, impacts on the marine ecosystem can be adverse. For the construction of the first three berths, no offshore dumping is anticipated as all the dredged material will be used for reclamation of the area proposed for the causeway and berth structures.

(2) Impacts on Mangroves
In phase one of the project, two hectares of mangroves will be cleared to pave way for the construction of the causeway and access road. Also some mangrove areas may experience altered tidal flushing as a result of the construction of the proposed infrastructure. Mangrove forests will also be at risk from direct human impacts. With the influx of population, the risk of Mangroves being felled for commercial and personal use will increase. Port development should go hand-in-hand with conservation efforts to protect mangrove forests. The risk of pollution will similarly increase with the development of the hinterland.

- To mitigate against direct impacts, there is need to confine areas of direct loss to the proposed infrastructure corridor footprint. Also, there is need to carry out mangrove restoration in sites adjacent to the project site. A minimum area equivalent to that cleared is recommended, however restoration of areas larger than the cleared site on regular/continual basis is highly recommended.

- Management of altered tidal flushing can be done by incorporation of mitigation measures into the engineering designs (e.g. incorporation of as many culverts as possible) to maintain tidal flushing.

- Monitoring program need to be put in place that will assist in the management of potential impacts. This should consist of; mangrove mapping, mangrove health surveys, monitoring of any sediment accumulation and assessments of the potential changes in soil salinity in the vicinity of the project area.

- Contingency measures to be put in place in the unlikely event that the identified direct and indirect impacts of port activities exceed the approved limit, this may involve all clearing activities being temporarily stopped until the outcomes of an investigation into the non-approved clearing have been concluded and options for rehabilitation investigated.

### (3) Impacts on Fisheries

A large number of population in the district are dependent on fishing as means of livelihood. The proposed port development will encroach on fishing grounds thereby displacing the artisanal fishermen from some of their traditional fishing grounds and landing sites. With the development accessibility to fishing grounds will be restricted and some landing sites lost. Even though the area where the port is proposed to be constructed is not a major fish spawning ground, factors that affect water quality cumulatively may reduce fish stock in the area. Sea routes used by fishers, especially Mkanda (main channel) will be affected by dredging. Fishers using small vessels will have difficulty travelling between their fishing grounds and landing sites through the alternate sea route via Manda-Bruno-Museum-Shela-Lamu which is rough and long. The longer travel time will result into post harvest losses.

This report recommends that the proponent empowers the local fishermen to move to deep waters by providing modern fishing gears and vessels that can enable them venture into other more distant deep water fishing grounds in addition to construction of modern fish landing sites (fishing ports) with adequate infrastructure such as power, access roads and cold rooms or ice making plants.

### (4) Impacts on Archaeological, Historical and Cultural Sites
UNESCO inscribed Lamu Old Town on the World Heritage List in 2001. Lamu is the oldest and the best-preserved living settlement among the Swahili towns along the East African coast. Its buildings and applied architecture are the best preserved and carries a long history that represents the development of Swahili technology. With the construction of the proposed port and hinterland, there will be an influx of migrant workers from other districts in search for employment and business opportunities. This can cause a “dilution” of the local culture. Efforts have to be made by the local authority and National Museums of Kenya to preserve and promote the intangible heritage.

There is a chance of encountering archaeological artefacts whilst doing construction works for the port. The proponent should engage NMK to carry out Heritage Impact Assessment (HIA) study prior to construction to avoid damage and destruction of valuable cultural artefacts. The contractor should have procedures and protocols for conserving any artefacts encountered during construction works.

(5) Impacts on Land Ownership

In order to secure the land for the proposed port development project, the proponent will need to acquire land. Land ownership in Lamu district is a highly emotive issue and should be implemented with caution in collaboration with the local authority and the proponent. A detailed Resettlement / Compensation Action Plan has been prepared and would be implemented prior to commencement of the project. The compensation/resettlement will be carried out by Ministry of Transport as per the Resettlement Action Plan and with the assistance of local authorities.

(6) Induced Risks

Construction of marine structures can be dangerous, with the probability of accidents being high. The contractor will have to apply develop strict health and safety rules in conformity with the Factories (Building, Operations and Work of Engineering Construction) Rules 1984, Legal Notice 40.

With the high influx of migrant workers into the area, there will be an increased risk of HIV/AIDS and Sexually Transmitted Infections (STIs) in the area. According to the Government of Kenya, Sentinel Survey of 2006, Coast Province, where Lamu district is found, has a HIV/AIDS prevalence rate of 8.1%. However, NASCOP estimate the prevalence rate in Lamu district at 3.2%. The challenge will be to keep this relatively low prevalence rate with the increase in population.

To mitigate against increase of new HIV/AIDS infections, the County has to project for the increase in population and expand infrastructure to accommodate more hospitals and Voluntary Counselling and Testing (VCT) Centres and initiate Awareness Programs in line with National Guidelines. During construction works, the contractor will be expected to implement an HIV/AIDS Prevention Program that was developed during feasibility studies for this project.

The proposed port development is expected to open up Lamu County and create a new transport corridor that would spur economic growth in Lamu and along the entire corridor including northern and north-eastern parts of Kenya. Due to the magnitude of the project and complexity of activities involved, implementation of the project would result into significant impacts. These
have been identified in this report and detailed mitigation measures proposed in addition to an elaborate environmental management and monitoring plan. A separate Resettlement / Compensation Action Plan (RAP) has been prepared to ensure adequate compensation for socio-economic losses incurred by Project Affected Persons (PAP) in the course of project implementation.

This Environmental and Social Impact Assessment (ESIA) Report therefore proposes that the project be allowed to proceed on condition that the proponent implements the mitigation measures proposed in this report and any further conditions that may be imposed by NEMA following consultation with Lead Agencies and other stakeholders.
Fig 0-1: Location of Project Area

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Fig 0-2: An impression of the first three berths

Fig 0-3: An impression of the administration area and port office tower
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CERTIFICATION

Certification by Firm of Experts:

We hereby certify that this Environmental and Social Impact Assessment Study report has been prepared in accordance with the Environmental (Impact Assessment and Audit) Regulations, 2003 and the methodology and content reporting conform to the requirements of the Environmental Management and Coordination Act, 1999.

Signature_________________________ Date 6th February 2013 __

Name____ HEZEKIAH O. ADALA ______________

Address____ P.O. BOX 42269 – 80100 MOMBASA _________________

For and on behalf of: HEZTECH ENGINEERING SERVICES

Certificate of Registration No____ 5194 _____________________________

Certification by Proponent

We, The MINISTRY OF TRANSPORT hereby confirm that the contents of this report are a true reflection at the site of the proposed port development. We will endeavour to implement mitigation measures proposed in the report to ensure the project complies with applicable environmental regulations.

Name___________________________________________________________

Signature___________________________ Date _______________________

For and on behalf of The MINISTRY OF TRANSPORT.
# SPECIALISTS INVOLVED IN THE STUDY

<table>
<thead>
<tr>
<th>Name</th>
<th>Qualification / Affiliation</th>
<th>Field of expertise</th>
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</table>
| Mr Hezekiah Adala   | B.Sc. (Mechanical Engineering)  
                       | Post Grad Cert (Environmental Management)  
                       | Post Grad Cert (Occupational Safety and Health)  
                       | Registered EIA / EA Lead Expert with NEMA;  
                       | Registered Safety Adviser with DOSHS                                                      | Team Leader  
                       | Environment Engineer / Occupational Safety and Health Expert                               |                                                        |
| Mr Nyagah Wa Kanyange | MSc Ecological Marine Management  
                      | B.Sc Fisheries and Aquatic Sciences  
                      | Registered EIA / EA Lead Expert with NEMA                                                      | Ecologist                                             |
| Mr. Eric Okuku      | M.Sc. Marine Ecology (Option Marine Pollution)  
                       | B.Sc Fisheries and Aquatic Sciences                                                      | Biogeochemist / Pollution Expert                     |
| Dr Charles Magori   | Ph.D. Applied Science  
                       | M.Sc. Physical Oceanography  
                       | B.Sc Mathematics                                                                            | Oceanographer                                         |
| Mr. Innocent Wanyonyi | PhD Environmental Sciences and Fisheries Management;  
                       | MSc Tropical Coast Management;  
                       | BSc Natural Resources Management;  
                       | Registered EIA / EA Lead Expert with NEMA                                                      | Socio-Economist / RAP Consultant                      |
| Jacob Ochiewo       | Master of Arts in Economics  
                       | B.A (Economics)                                                                            | Socio-Economist / RAP Consultant                      |
| Ms. Elizabeth M. Musyoka | M.Sc. (Environmental Science and Technology);  
                       | B.Sc. (Fisheries Management and Aquaculture)                                                 | Fisheries Expert                                      |
| Juliet F. Karisa    | M. Phil. (Fisheries management);  
                       | B.Sc. in Fisheries and Aquatic Science                                                      | Coral Reefs Expert                                    |
| Mr Simon Ndeweni    | Bsc Civil & Environmental Engineering;  
                       | Associate Expert with NEMA                                                                 | Rapotteur / Traffic Management Consultant            |
# ACCRONYMS

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<th>Description</th>
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<td>AIDS</td>
<td>Acquired Immune Deficiency Syndrome</td>
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<tr>
<td>BOD</td>
<td>Biological Oxygen Demand</td>
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<tr>
<td>COD</td>
<td>Chemical Oxygen Demand</td>
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<tr>
<td>DRC</td>
<td>Democratic Republic of Congo</td>
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<td>DWT</td>
<td>Dry Weight Tonnes</td>
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<td>EACC</td>
<td>East African Coastal Currents</td>
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<td>EAM</td>
<td>East African Environmental Management Company Ltd</td>
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<td>ECD</td>
<td>Empty Container Depot</td>
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<td>EIA</td>
<td>Environmental Impact Assessment</td>
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<td>EMCA</td>
<td>Environmental Management and Coordination Act</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GOK</td>
<td>Government of Kenya</td>
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<tr>
<td>IMSR</td>
<td>Inter Monsoon Short Rains</td>
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<td>IMLR</td>
<td>Inter Monsoon Long Rains</td>
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<tr>
<td>JPC</td>
<td>Japan Port Consultants Ltd</td>
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<td>KESCOM</td>
<td>Kenya Sea Turtle Conservation Committee</td>
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<td>Kenya Forestry Research Institute</td>
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<td>KARI</td>
<td>Kenya Agricultural Research Institute</td>
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<td>KMA</td>
<td>Kenya Maritime Authority</td>
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<td>KMFRI</td>
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<td>Kenya Ports Authority</td>
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<tr>
<td>LAPSSSET</td>
<td>Lamu Port South Sudan Ethiopian Transport (Corridor)</td>
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<td>MOT</td>
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<td>NEC</td>
<td>National Environmental Council</td>
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<td>North Eastern Monsoon</td>
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<td>NMK</td>
<td>National Museums of Kenya</td>
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<td>NWCP</td>
<td>National Water Conservation &amp; Pipeline Corporation</td>
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<td>OSMAG</td>
<td>Oil Spill Mutual Aid Group</td>
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<td>OSRAT</td>
<td>Oil Spill Response Action Team</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>PM</td>
<td>Particulate Matter</td>
</tr>
<tr>
<td>ppm</td>
<td>Parts Per Million</td>
</tr>
<tr>
<td>RMG</td>
<td>Rail Mounted Gantry</td>
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<td>RTG</td>
<td>Rubber Tyred Gantry</td>
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<td>SEC</td>
<td>South Equatorial Current</td>
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<td>SLP</td>
<td>Sea Level Pressure</td>
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<td>Stakeholders</td>
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<td>Ship to Shore Gantry</td>
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<td>TSS</td>
<td>Total Suspended Solids</td>
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<td>TOR</td>
<td>Terms of Reference</td>
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<tr>
<td>TEU</td>
<td>Twenty-foot Equivalent Unit</td>
</tr>
<tr>
<td>TGS</td>
<td>Total Ground Slot</td>
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<td>UNEP</td>
<td>United Nations Environment Programme</td>
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<td>United Nations Education Scientific &amp; Cultural Organization.</td>
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<td>WWF</td>
<td>World Wildlife Fund.</td>
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<tr>
<td>MARPOL</td>
<td>International Convention for Prevention of Marine Pollution</td>
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1. INTRODUCTION

1.1 BACKGROUND

The Government of Kenya (GOK) through the Ministry of Transport plans to build a port at Manda Bay in Lamu. This proposed construction is part of a larger project which plans to establish a transport corridor of road, rail and pipeline linking the proposed port of Lamu through Northern Kenya to South Sudan and Ethiopia. The development of the corridor is considered a flagship project in the country’s Vision 2030 Strategy of Growth and Development. It is anticipated that along with Lamu Port, the Corridor will accelerate trade routes and development in the regions traversed by the corridor, in particular the Northern part of Kenya which is still under-developed.

In the late 1970’s Kenya Ports Authority (KPA) developed a purpose-build container terminal with a capacity of 250,000 TEUs. During the last decade, the Port of Mombasa witnessed a rapid increase in cargo traffic. Total port traffic rose from 8.44 million tonnes in 1997 to 14.42 million tonnes in 2006. This was a growth rate of 6.1% per annum; thus the number of Twenty-Foot- Equivalent Units (TEUs) rose from 240,698 to 477,355 between 1997 and 2006 respectively. The remarkable growth in container traffic had profound effect of constraining the container handling capacity.

In the year 2000 an explicit need for expansion of the container handling capacity was made to the Government of Japan to be funded through Official Development Assistance (ODA) Loans. Notwithstanding these developments in Mombasa which serves the Northern Corridor, there remains a need to establish another corridor which has considerable potential for the development of other transport corridors not only in the Eastern and Horn of Africa, but also across the continent from east to west. (Japan Port Consultants: Master Plan for Development of the Proposed Lamu Port at Manda Bay).

The current project aims to undertake the construction of the first three (3) berths of Lamu Port at Manda Bay. Project activities would include dredging, reclamation, access road and rail construction at the coastline.

The berth capacities will be as follows:

- Bulk Cargo (1 Berth) 100,000 DWT ships,
- General Cargo (1 Berth) 30,000 DWT ships and
- Container (1 Berth) for 100,000 DWT ships.

The proposed location is ideal because it is naturally deep hence the requirement for dredging would be reduced and it is sheltered from adverse waves.

Pursuant to such works and as stipulated in the Environmental Management and Coordination Act, 1999 the Proponent is required to carry out an Environmental Social Impact Assessment (ESIA) study to determine the adverse impacts the project would have on the environment and
propose mitigation measures to eliminate or reduce the magnitude of these impacts. The ESIA Study aims to:

- Examine in detail likely adverse environmental and social impacts directly and / or indirectly attributable to this project
- Appropriate mitigation measures for the identified impacts.
- Equip stakeholders with tools for making informed decisions about key impacts expected to emanate from the project
- Establish environmental and associated baselines for future monitoring purposes.

The ESIA Study includes a full on-site field assessment to characterize the ecological resources present with particular reference to identification of environmentally sensitive areas or species. The possibility of adverse impacts resulting from the implementation of the proposed development was assessed with respect to faunal and floral and other ecological resources associated with the site. In addition project impacts on public health and safety was assessed. This ESIA study report proposes necessary mitigation measures that will greatly reduce or prevent environmental damage that would be caused by the project’s activities and outlines an Environment Management Plan (EMP) to ensure compliance with the proposed measures.

1.2 PRESENT ENVIRONMENTAL CONDITIONS IN THE PROJECT AREA

1.2.1 Natural Conditions

Coastal environment is made up of very fragile environments in the region, such as wetland, threatened natural forests, tidal-flats and biodiversity habitat sites.

(1) Mangrove Forests

Lamu County has the largest area of mangrove in Kenya. Although on a straight line basis, the district extends only 138 km southwest from the Somali border, its irregularity and numerous islands gives it a total coastline length of 650 km. The three biggest islands are Lamu, Pate and Manda. Except for the south coast of the Islands of Lamu and the southeast coast of Manda directly exposed to the Indian Ocean, most of the coastal areas are covered with mangrove forests of varying widths (FAO fisheries and aquaculture department, 1986).

Mangrove forests are the cradles of various marine lives and the local communities make use of the mangrove forests for fishing ground but cutting of mangrove trees is still licensed to the local communities. These facts imply that the local communities have a right to use the mangrove forest as their property based on the law/regulations and will request compensatory measures as a part of compensation issues if mangrove habitats are destroyed. The mangrove trees are of economic value and traded around the area as timber for use in various construction activities. The common species found in the Lamu Archipelago are Sonneratia Alba, Rhizophora mucronata, Avicennia Marina and Ceriops Tagar.

(2) National Reserves (Dodori/Boni and Kiunga) and UNESCO Biosphere Reserve (Kiunga)
**Kiunga Marine National Reserve**, a designated UNESCO Biosphere Reserve\(^1\), consists of about 50 offshore islands and coral reefs in the Lamu Archipelago. The larger and more sheltered inner islands are covered with tangled thorny vegetation including grass, aloes and creepers. The small outer islands provide nesting sites for migratory seabirds. The reserve conserves valuable coral reefs, sea grass and extensive mangrove forests and is also a refuge for sea turtles and dugong that are on the IUCN Red List e.g. Hawksbill (CR: Critically Endangered).

Major wildlife includes Reptiles, Sea turtles, Reef Fish, Lobsters, Sea Urchins and Sea Star. It is also an important site for marine sports such as wind surfing, diving and snorkeling, water skiing and sunbathing. The World Wildlife Fund (WWF) and the Kenya Wildlife Service (KWS) have been collaborating to enhance the management of the Kiunga Marine Reserve since 1996 with full participation of local communities.

**Dodori National Reserve** located adjacent to Kiunga Marine National Reserve was established to preserve a breeding ground for the East Lamu Topi, Pelicans and other local wildlife. It covers 877sq. km with views of Dodori River and creek outlet with the most dense and most varied species of mangrove forest in Kenya. Lion, Lesser Kudu, Giraffe and Hippo which are on the IUCN Red List, are also common to this Reserve. Birds already noted are Palmut Vulture, Southern Branded Harrier Eagle, Honey Buzzard, Brown Hooded Kingfisher, European and Carmine Bee-Eaters, Brown Breasted Barbet and Violet Breasted Sunbird. According to the IUCN and Biodiversity Hotspots web sites, Ader’s Duiker is a well-known critically endangered animal living only in the coastal forests of Eastern Africa.

(3) **Coral Reef**

Coral reefs are among the most productive of all marine ecosystems providing a habitat for numerous species, including turtles, dugongs, whale, sharks and others. Their essential ecosystem services, such as protecting the coastline from ocean waves, and high biodiversity and productivity make them the target of many uses, but also numerous threats (State of the Coast report, NEMA 2009).

Coral reefs in Kenya are managed as Marine Protected Areas (MPAs) under the Wildlife Act. Coral reef fisheries outside protected areas are under the jurisdictions of the Fisheries Department, while only the traditional fishing methods are allowed in Marine Reserves.

(4) **Sea Grass**

Sea grass beds are important foraging grounds for endangered species such as dugongs and marine turtles and important habitats for various fish species.

(5) **Sea Turtle**

The Lamu Archipelago is one of the most important feeding and nesting grounds for Sea Turtles in Kenya. Five out of the seven species of sea turtles feed/nest in Kenya waters. All five species are categorized as endangered or critically endangered listed on the IUCN Red list. Female Sea

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\(^1\) A biosphere reserve is a representative ecological area with 3 mutually reinforcing functions: conservation, sustainable development and logistic support for scientific research and education
turtles always return to the beach where they were born and lay eggs on the beaches. Most common three turtles found in the Lamu Archipelago are: Green Turtle \((Chelonia mydas)\)

- Hawksbill Turtle \((Eretmochelys imbricata)\)
- Olive Ridley \((Lepidochelys olivacea)\)

The other two kinds are:

- Loggerhead \((Caretta caretta)\)
- Leatherback \((Dermochelys coriacea)\)

The main areas of concentration are said to be Kiunga, Manda Island and Shela.

**(6) Dugong (Dugong dugon)**

The dugong is a large marine mammal categorized vulnerable on the IUCN Red list and designated in the Wildlife (Conservation and Management) Act, Cap 376 as a protected species. They are referred to as "sea cows" because their diet consists mainly of sea-grass. They are particular about their diets, with certain "fields" of sea-grass being regularly cropped. Dugongs are exclusively benthic, or bottom feeders. Their primary feeding mechanism is uprooting sea-grass by digging furrows in the seafloor with their snouts. Though the dugongs are one of the species found in Kiunga National Reserve, there is no information about this species around the project site so far.

In Kenya large dugong herds were commonly reported before the 1960s and a herd of 500 was seen in 1967 off the South Coast. The exact number of dugong in Kenya is currently not known (WWF, 2004). The most important dugong habitats in Kenya are considered to be the Kiunga Marine National Reserve (KMNR) (Nature’s Benefits in Kenya, World Resource Institute).

**(7) Wildlife**

For animals around the area, located near the ecologically significant area, Manda Bay area is rich in biodiversity habitats consisted of shrubs, swamps, tidal-flat and so on. The area is considered Biodiversity Important Area and by KWS.

**(8) Vegetation**

Lamu district is located in a semi-arid area with sandy soils. Coastal forests and bushland vegetation is seen around the Kenya Navy Naval base. There are also some ponds where wetland plants such as Lotus species are naturally growing. Those ponds are used as water source for animals that inhabit the area. There exist two wetlands on the mainland of Lamu that are the source of drinkable water, supplied by pipelines to the local settlements. Beside the Mangrove forests, on the terrestrial side the vegetation consists of indigenous and planted tree species. Key indigenous plants include Doum Palm \((Hyphaena spp)\) and Mkingiri \((Dichrostachys spp)\).

**(9) Tana River Delta**

The Tana River Delta is the only estuary that comes under a consistent management umbrella, as it falls under KWS. It has high conservation and biodiversity value. The legal status of estuaries
and deltas remain controversial, as they cut across several jurisdictions (riparian, forest, marine and coastal zone). The Ramsar Convention could be a primary instrument for the conservation of the ecosystem at the national level. An application for appropriate Ramsar designation of the Tana River Delta is under preparation.

1.2.2 Social Conditions

(1) Land Tenure

By the end of the 18th century there were three main population groups at the Kenya coast, namely Arabs, Swahili and Mijikenda. The first two were mainly concentrated in towns and areas near the coast. The Mijikenda majority were living more inland or working as labourers on the Arab-Swahili plantations.

At independence in 1963, there was no action by the government to resettle the local people who had settled on these lands but were regarded as squatters, even though some had lived there for more than a generation. However, the policy of the government has changed to resettle the landless through settlement schemes to cope with the problem of squatters and this process is still on-going.

(2) Land Use and Settlements

Part of the land along the shoreline of the proposed port area is used as Naval Base and private ranch. Along the road D568, a settlement scheme of Hindi-Magogoni area is on-going and the land has been plotted and allocated by the government. The scheme started as the German Assisted Settlement Programmes (GASP) in 1974. GASP provided the necessary infrastructure such as road, water and so on. According to “Lamu District Regional Physical Development Plan”, the progress of the scheme is as shown below as of 2007.

- Size of the scheme: 7,700ha
- Total number of plots: 795
- Occupied plots: 676
- Population: 5,800

(3) Fishery

Fishing is one of the main sources of income around the project site. Centers playing the functions as fishing villages are Faza, Kizingitini, Kiunga etc. Those villages also serve the tourist industry. The fishermen in Lamu Island are said to fish individually and sell their catches to the local market or traders who transport them to Mombasa and Malindi.

In Lamu district, the main fish species of catch are rabbit fish, scavenger, snapper, cat fish, cavalla jacks, mackerel, blackskins, barracuda, mullets, queen fish, sail fish, tuna, prawns, lobsters, crabs, and sharks/rays in dried form, sardines, oysters and octopus. Prawns are caught in areas like Dodori creek, exploited by fishermen from Kipungani and Matondoni. Lobster and crab, which represent some of the best in the world, are caught in places like Kizingitini, Faza and Kiwayuu. Kiwayuu also produces sharks and rays for the dry fish market while places like Kiunga
produce shells, lobster, crab and fin fish (Sarah Heddon, 2006). The shallow water within the numerous creeks is notable for a very high incidence of Black Tiger Shrimp (*Penaeus Monodon*). Whereas in all other areas of Kenya as well as the Indo-Pacific region, Black Tiger Shrimp would rarely constitute more than five percent of catch, in Lamu the proportion of Black Tiger Shrimp can be as high as 80 percent according to information supplied by project KEN/80/018 staff (FAO Fisheries and aquaculture department, 1986).

(4) **Timber Production and Trade**

Mangrove forests in Kenya provide many direct products – both timber and non-timber. Timber products include firewood, building poles and charcoal used in urban and rural areas. Poles used in construction are normally graded into different utilization classes depending on their uses. Other uses of mangrove poles include boat masts and fish traps/stakes. Larger logs of mangroves, especially of *A. Marina*, are used in traditional boat construction. Aerial roots of *S. Alba* are also used as floaters for fishing nets.

![Figure 1-1: Mangrove Stock-Pile in Mokowe](image)

Mangrove wood is also utilized by the local communities for furniture. Among the non-timber products derived from mangrove forests include honey harvesting, medicinal values, crabs and fish caught inside the forest (Joseph K. S. et al.).

Historical records show that as early as 200BC mangrove poles were an important item of commerce between East Africa and the desert countries of Arabia. By the 1970's, Kenya was exporting some 34,000 scores of mangrove poles to Somalia, Iran, Iraq, Kuwait and Saudi Arabia, until this export was stopped in 1982 by a presidential ban aimed at stemming overexploitation. As a result, mangrove pole production fell significantly from 1990 (State of the Coast report, NEMA 2009).

Local communities are still allowed to cut mangrove trees thus there is a timber industry that supports the livelihood of the local people. There are some shops that sell mangrove poles in Lamu Island and others are transported to the main land through Mokowe.
Limestone

Extensive limestone deposits occur along the coastal area from the Tanzania border in the South to Malindi in the north. A 70-m-thick and 4-8 km-wide band of limestone runs parallel to the coast. Older limestone units occur further inland in the north of Malindi but only a few isolated exposures of limestone are found between Malindi and Lamu. The Coral Rock deposits in the north of Lamu have not been mapped. Exploitation of limestone is already widespread and depends on local variation in the limestone’s texture, composition and market demand.

Coral rocks that are excavated and shaped into coral blocks for building are available in large quantities in Manda Island of Lamu district. The production of coral blocks meets local demand in Lamu district, providing a livelihood to many people employed as excavators of building blocks and stone masons in the construction industry.

Figure 1-2: Limestone Extraction (Source: JPC)

Sand and limestone are currently being mined without supporting legislation. Both are non-renewable resources, and if their mining continues unabated, environmental degradation of a wide area is likely to occur. Already, sand exploitation has had detrimental effects, including endangering indigenous forests and depredating ecosystem (State of the Coast report, NEMA 2009).

Transportation

1. Road

The carriage units on the roads are buses, matatu (minivan) and lorries. A number of buses operate each way between Mokowe and Mombasa. Earlier on, these buses only operated during the day but at present, there are buses that operate during both day and night.

2. Railway

Currently there is no rail network in the district.

3. Air

In a county like Lamu where road transport is very poor and sea transport is slow and unreliable, air transport emerges as key. There are several airstrips in the district located on Manda Island, at Mokowe, Witu, Mkunumbi, Pate, Siyu, Kizingitini, Kiwayuu, Mkokoni, Kiunga and Mararani.

4. Sea

Sea transport in the district dates back a very long time and is very important because it links Lamu with other ports in and outside Kenya. There are no roads within the archipelago where
majority of the people live. A movement between islands, therefore, is by sea. Sea transport is also used extensively during the wet season when most roads in the mainland are impassable. Both passengers and goods are carried by small ships, motor-boats and dhows.

Public sea transport is only established within the district. Areas with regular public sea transport are around the islands of Lamu, Manda, Pate, Siyu and Faza. In the rest of the areas such as Ndau, Kiwayuu, Mkokoni and Kiunga, public sea transport is irregular and at times people have come together to hire transport.

Public sea transport outside the region to such areas like Mombasa Malindi and outside the country to destinations such as Dares Salaam and Zanzibar and other parts of the world is not established. There are very few private boats that engage in sea transport to places like Zanzibar and Seychelles. These are mainly for tourists (Lamu District Regional Physical Development Plan).

(7) Public Facilities (Hindi Division)

There are seven (7) primary schools in Hindi division, of which six (6) are located near Hindi or in the south of Hindi. The number of health facilities are: one (1) health center, two (2) dispensaries in the whole division (Lamu District Regional Physical Development Plan).

(8) Water (Hindi Division)

In the division, the main water undertaker is Hindi-Mokowe Water Association (HIM-WA). The association runs three boreholes. Currently at least 30 households had been connected. The rest of the population is served through 20 water kiosks distributed along the pipeline. The installed capacity was 400,000 litres per day whereas the daily demand was 70,000 litres per day. There is need to extend the pipeline further field to serve more people and exploit the excess capacity (Lamu District Regional Physical Development Plan).

(9) Energy

There are two major sources for power in Lamu, namely electricity from the diesel power stations and solar. Solar energy use in Lamu is very minimal and is confined to very few individuals in the rural areas who can afford and also some companies e.g. KPA in the navigational lights in the sea.

The main electric power use in Lamu is mainly household appliances, general lighting, street lighting, small scale workshop i.e. welding etc. There are two diesel power generating station in Lamu District, namely the KenGen Power Station in Lamu Island and Mpeketoni Electricity Company in Mpeketoni (Lamu District Regional Physical Development Plan).

(10) World (Cultural) Heritage

Lamu is the oldest and the best-preserved living settlement among the Swahili towns along the East African coast. Its buildings and applied architecture are the best preserved and carries a long history that represents the development of Swahili technology. The old town is thus a unique and
rare historical living heritage with more than 700 years of continuous settlement. It was once the most important trade center in East Africa before other towns such as Zanzibar took over.

Since the 19th century, Lamu has been regarded as an important religious center in East and Central Africa due to the ‘Tarika’ (The Way of the Prophet). It is said that there are many descendants of the Prophet in Lamu. Their presence has kept up the tradition, which continues to the present day Lamu in form of annual festival known as ‘Maulidi’. These festivals are endemic to Lamu and draw the Muslim community from all over East and Central Africa as well as the Gulf. Lamu is an Islamic and Swahili education center in East Africa. Researchers and scholars of Islamic religion and Swahili language come to Lamu to study this cultural heritage, which is relatively unchanged. The island town has adopted very little modern technology due to its isolation (UNESCO Nomination Dossier, 2000).

(11) **Other main Gazetted Historical Sites**

There are some gazette historical monuments within and around the project site. Most of them have not been checked well and need archaeological assessment before construction. The relevant monuments to port development are Mkokoni, Mashundwani, Ungu, Kililana, Manda, Takwa, Pate, Shanga and Siyu. Of those, Takwa and Siyu fort are well-known historical sites as well as a tourism spot where the magnificent scenery of mangrove forests and Indian Ocean can be seen at the same time.

1.3 **TERMS OF REFERENCE FOR THE ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT**

The following Terms of Reference for the Environmental Impact Assessment (EIA) of the proposed project were adapted in accordance with the World Bank and NEMA environmental impact assessment guidelines.

1. **Introduction** – The consultants would identify the development project to be assessed and explain the executing arrangements for the environmental assessment. This chapter would detail the rationale for the development and its objectives.

2. **Background Information** – The experts would highlight the major components of the proposed project, the implementing agents, a brief history of the project and its current status including a justification why the project is necessary.

3. **Study Area** – Specification would be made of the boundaries of the study area as well as any adjacent or remote areas considered to be affected by the project such as dredged material disposal sites, area projected for relocation of displaced persons, reclaimed land etc.

4. **Description of the Proposed Project** - a full description of the relevant parts of the project, using maps at appropriate scales where necessary.

5. **Description of the Environment** - Assemble, evaluate and present baseline data on the relevant environmental characteristics of the study area (and disposal sites), including the following:
a) Physical environment: geomorphology, meteorology (rainfall, wind, waves and tides), sea currents and bathymetry, surface hydrology, estuarine/marine receiving water quality, and ambient noise.

b) Biological environment: terrestrial and marine vegetation and fauna, rare or endangered species, wetlands, coral reefs, and other sensitive habitats, species of commercial importance and endangered species.

c) Socio-cultural environment: shipping and fishing activities and use of the port, population, land use, planned development activities, employment, recreation and public health, community perception of the development, vulnerable occupants. Field survey would also be conducted on the number of households to be displaced and areas of resettlement and land acquired for the project.

d) Hazard vulnerability; vulnerability of area to flooding, hurricanes, storm surge, and earthquakes. Also to be included here is an assessment of impacts of oil spill from ships and from land based industrial activities.

The consultants would characterize the extent and quality of the available data, indicating significant information deficiencies and any uncertainties associated with the prediction of impacts.

6. **Legislative and Regulatory Considerations** – A description of the applicable legislation, regulations would be outlined as well as environmental policies that are relevant and applicable to the proposed project. Appropriate authority jurisdictions that will specifically apply to the project will be identified.

7. **Identification of the Potential Impacts of the Proposed Project** – Identification of impacts related to port construction, dredging, spoil disposal and possible land filling. Also to be identified are impacts related to construction of the access road, land reclamation and construction of office buildings and associated facilities. A distinction will be made between significant impacts that are positive and negative, short and long term. Special attention would be paid to:

- Effects of the project (dredging and spoil disposal) on water quality and existing coastal ecosystems and resources,
- Effects of dredging on the coastal stability of adjacent shorelines,
- Effects of dredging works on fishermen, and on the rights/operations of any other stakeholders,
- Effects of the project on future port development and the tourism sector,
- Effects of the project on maritime, boating and road traffic,
- Effects of the project on ambient noise levels, and
- Effects of the project on any historical resources.

8. **Analysis of Alternatives to the Proposed Project** – A Description of the alternatives examined for the proposed project that would achieve the same objective including the “no action” alternative. This includes dredging vessel types and disposal sites, alternative traffic routes and alternative resettlement plans. The most environmentally friendly alternatives would be identified and proposed for implementation.

9. **Mitigation and Management of Negative Impacts** – The consultants will identify possible measures to prevent or reduce significant negative impacts to acceptable levels with
particular attention paid to compensation of Project Affected Persons (PAPs), dredge material disposal and sedimentation control, as well as measures to minimise disruption to existing operations.

10. **Development of a Monitoring Plan** – Identify the critical issues requiring monitoring to ensure compliance with mitigation measures and present impact management and monitoring plan for such issues.

11. **Public Participation and Consultation** - The consultants would identify appropriate mechanisms for providing information on project activities and progress of project to stakeholders, assist in co-coordinating the environmental assessment with the relevant government agencies and in obtaining the views of local stakeholders and affected groups.

12. **Report Preparation** - The environmental and social impact assessment report, to be presented in electronic and hard copies, will contain the findings, conclusions and recommended actions supported by summaries of the data collected and citations for any references used in interpreting those data. The report will be prepared in the format prescribed by NEMA.

### 1.4 METHODOLOGY FOR THE ESIA

The consultants adopted the following methodology in order to fulfil the requirements of the Terms of Reference for the ESIA:

#### 1.4.1 Characterization of the Physical Environment:

An assessment and description was made of physical environmental conditions such as the geomorphic setting, altitudinal range, spatial setting, basin morphology, soil types, bottom sediments / substrata, surface water regime and ground water regime. In particular, the following subcomponents were assessed:

- Geomorphology and sedimentology,
- Meteorology (rainfall, wind, surface hydrology) patterns,
- Oceanography (bathymetry, circulation systems, sea currents {tidal, stream-flow, wind-driven}, winds, pressure, waves and tides),
- The port near shore environment (lagoons, creeks, bays, sub-tidal, intertidal and supratidal environments, estuarine/marine receiving water quality).
- Hazard vulnerability; vulnerability of port near shore environments to flooding, storm surge, and drowning.

#### 1.4.2 Characterization of the Chemical Environment:

This includes a description of the physico-chemical properties of both the surface and subsurface water (including, temperature, salinity, pH, transparency, and nutrients at the sampling point. Attention was paid to physico-chemical characterization sediments beneath the water sampling points as well). The samples were taken to a NEMA approved laboratory (SGS Kenya Limited) for analysis where the following subcomponents will be assessed:

**Water Quality**

- sedimentation, suspended and dissolved solids
- Salinity/conductivity;
• Dissolved oxygen
• pH, BOD, COD
• Phenol
• Oil and grease content
• Total coliforms
• E. coli

_**Sediments Quality Survey/Sampling:**_

Sediment Quality Survey (seabed sediment material sampling) was done at the same sampling as the water quality sampling and the following recorded:

• Sample condition such as appearance, odour, and colour;
• Physico-chemical characterization – ambient air temperature, water temperature, pH, redox, BOD, COD, Ammonia nitrogen, Total N, Total P
• Density
• Water content
• Heavy metal content – Mercury, Arsenic, Lead, Chromium, Cadmium, Nickel, Iron, Lead, Zinc, Copper

_Air Quality Survey_

Sampling for air quality was done at selected sampling points close to project area and the following parameters shall be recorded:

• Sampling conditions, such as time, weather (wind direction, wind speed, cloud cover, tidal height, sea state)
• location of the sampling point; sampling depth; latitudes and longitudes
• Air Quality Parameters such as CO, SO₂, NO₂, H₂S, Volatile Organic Compounds (VOC), Suspended particle material (SPM)

1.4.3 **Characterization of the Biological Environment:**

For each sampling sites and sampling points, this included a description of _vegetation_ (including dominant assemblages, dominant species, environmental weeds, species and assemblages of conservation significance, and vegetation cover), _fauna_ (including dominant assemblages, dominant species, species of conservation significance, populations, and alien invasive and vermin/pest species), and _habitats_ (including major types and biological significance of each). In particular, the following subcomponents were assessed:

a) **Marine Habitats and Species:** sensitive/critical habitats potentially impactable:

• Mangrove and other wetlands community sites
• Coral reef and sponge community sites
• Seagrass community sites
• Rocky platforms with attached/sessile life-forms (encrusting algae, mussels, oysters, barnacles, etc)
• Soft bottom communities with macro-benthos
• Sand, shingle or pebble shores (including sand bars, spits and sandy islets, sand dunes, etc)
• Estuarine waters (permanent water of estuaries and estuarine systems of deltas)
b) Terrestrial Habitats / Species:

Flora:
- Wild plants – floristic composition, physiognomy and growth form, ethnobotany, economic species, endangered and rare species,
- Crop and plantation plants

Fauna:
- Invertebrates, small fauna and burrowers
- Visiting populations: birds, reptiles
- Wildlife populations – conventional big animals, bats,
- Livestock populations – domesticated animals

1.4.4 Socio-economic Survey

This included an assessment of present social conditions of local residents such as livelihood, security, health and education and providing the relevant information on the social characteristic of the area including:
- Demographics
- Socio-economic profile
- Socio-cultural profile
- Land use activities
- Social infrastructure (households, schools, health facilities, water, electricity, roads, sanitation etc).

The information was obtained by literature review and site visits to obtain information at the micro-scale, validate the same and fill gaps where necessary.

Resettlement Survey

Through demographic studies and socio-economic activities, the built up environment was studied to identify all the facilities that will be uprooted by the proposed development and the owners of these facilities. The consultants then prepared a Resettlement Action Plan (RAP) report detailing the number of people affected, loses incurred and the compensation mechanism.

1.4.5 Fishery Survey

The fishery survey was undertaken through the identification of the fishing grounds, the fishing villages, the fish landing sites, the amount of fish landed, the marketing arrangements, the income generated from fishing and the impact the sector will suffer from the proposed development, i.e. loss of the fishing villages, fishing grounds, landing sites, loss of incomes, loss of employment, poverty situation as a result of the loss, and the available alternatives.
For all thematic areas the following were undertaken:

- A report was prepared documenting findings from the survey;
- Identification was made of the potential impacts that may arise from implementation of the project;
- Mitigation measures have been prescribed to address adverse negative impacts;
- A monitoring plan has been prepared to ensure that the prescribed mitigation measures are undertaken and the desired results achieved;
- Conclusions have been drawn on environmental sustainability of the project and the acceptability of the proposed project to local residents.
2. PROJECT DESCRIPTION

2.1 INTRODUCTION

The proposed site for Lamu port is located in Manda Bay, Lamu County to the North end of the Kenyan Coast, bordering Somalia. The development area falls within 40°52'00” to 41°00'00” in Easting and -2°13'00” to -2°16'00” in Southing. Lamu County is located in the coast province and boarders Somali to the North, Indian Ocean to the East and south east, and Tana River Districts to the West. The district occupies an area of approximately 6,500 km2.

The proposed project site is shown in the figure below:

![Project Area](image)

Figure 2-1: Project Area (Source, WRI)

The location is ideal because the proposed port area is naturally deep hence there would be reduced requirement for dredging and it is sheltered from adverse waves. The port will allow Kenya to remain competitive against other regional ports such as Dar-es-Salaam and Durban and is expected in the long run to function as one of the major hub ports on the East Coast of Africa, given the potential for its transport corridor to extend to Rwanda, the Democratic Republic of Congo (DRC) and even Cameroon.
The development of the Port has been divided into the following development phases:

**Table 2a: Development Phases of Lamu Port Master Plan**

<table>
<thead>
<tr>
<th>No.</th>
<th>Term</th>
<th>Development Description</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Short</td>
<td>First Three (3) Berths, Access Rd, Offices, yards, warehouses and workshops</td>
<td>2011 to 2015</td>
</tr>
<tr>
<td>2</td>
<td>Medium</td>
<td>Further Twenty (10) Berths, railway, Hinterland development, shunting yards, railway cargo stations</td>
<td>2015 to 2020</td>
</tr>
<tr>
<td>3</td>
<td>Long</td>
<td>Further Eleven (11) Berths,</td>
<td>2020 to 2030</td>
</tr>
</tbody>
</table>

(Source JPC)

The current EIA Study Report covers the components Short Term where the proponent desires to undertake the construction of three (3) berths and associated activities of which include dredging, reclamation and road construction.
Figure 2-4: Berth Locations (Zoomed)
2.2 PROJECT COMPONENTS

The project consists of the construction of the following components.

2.2.1 Channel and Basin Dredging.

The required channel dimensions were designed utilizing ship simulation results and applying international standards to ascertain the appropriate dimensions for safe passage of vessels. In that respect the channel dimensions proposed as follows:

<table>
<thead>
<tr>
<th>Channel</th>
<th>Design Ship (DWT)</th>
<th>Width</th>
<th>Depth</th>
<th>Radius</th>
<th>Type of Cargoes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Channel</td>
<td>100,000</td>
<td>500</td>
<td>18.0</td>
<td>-</td>
<td>Bulk, Container</td>
</tr>
<tr>
<td>Sub Channel</td>
<td>30,000</td>
<td>310</td>
<td>12.5</td>
<td>-</td>
<td>General, Cargo</td>
</tr>
<tr>
<td>Approach Channel</td>
<td>100,000</td>
<td>500</td>
<td>17.5</td>
<td>2,290</td>
<td>Bulk, Container</td>
</tr>
<tr>
<td>South Channel</td>
<td>100,000 100,000 30,000</td>
<td>500 400 400</td>
<td>17.5 16.0 12.0</td>
<td>-</td>
<td>Bulk, Container, General Cargo</td>
</tr>
<tr>
<td>Manda Pass</td>
<td>100,000</td>
<td>500</td>
<td>17.5</td>
<td>2,290</td>
<td>Bulk, Container</td>
</tr>
</tbody>
</table>

(Source: JPC)

To achieve these dimensions, dredging will be carried out in areas shown in figure below and the estimated dredge volume is 11.8 million m$^3$ in both the basin and the channel. Cutter suction dredgers will be used.

Maintenance dredging volume of 60,000m$^3$ is expected and should be carried out every 10 years.
Figure 2-5: Dredge Areas (Source JPC)

Figure 2-6: Graphic of Cutter Suction Dredger (Source: www.fremantleports.com.au)
2.2.1 Berthing Structures

Three (3) Pile Platform type Berths will be constructed with the following dimensions:

<table>
<thead>
<tr>
<th>No</th>
<th>Type</th>
<th>Depth</th>
<th>Width</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>General Cargo Berth</td>
<td>-16m</td>
<td>400</td>
<td>800</td>
</tr>
<tr>
<td>2.</td>
<td>Bulk Cargo Berth (B1)</td>
<td>-17.5m</td>
<td>330</td>
<td>800</td>
</tr>
<tr>
<td>3.</td>
<td>Container Berth</td>
<td>-17.5m</td>
<td>400</td>
<td>800</td>
</tr>
</tbody>
</table>

(Source JPC)

Typical construction sequence for these type berths is:

1. Excavate existing ground and backfill with sand (Reclamation) and dredge material;
2. Drive piles into ground and lay cover stones.
3. Make foundation mound and install concrete blocks on it.

2.2.2 Access Road

An access road will be constructed from the Port Gate to connect with C112. The road will have Right of Way (RoW) of 43m, a road reserve of 100m and will extend for a total length of 8.8km.

The road will be designed and constructed to Bitumen standards.

2.2.3 Port Craft Repair Facility

As shown in figure for berth locations, an area for port craft repair will be developed to the south of the port management zone.

2.2.4 Port Management Zone

Within this area, the facility will have administration buildings as follows:

- Joint Government Tower
- Custom Warehouse
- Custom Warehouse
- Operation Building
- Welfare Building
- Sub-Station
- Check Gate
- Fuel Station
- Gate Office
- Car Park
- Toilets
- Security Hut
- Fire Station
- Marine House
The architectural design of the buildings will adopt a Swahili concept to fit in with the culture of the surrounding community and in harmony with Lamu World Cultural Heritage Site.

2.2.5 Container Handling Equipment

Two (2) Ship to Shore Gantry Cranes (SSG) and four (4) Rubber Tyred Gantry Cranes (RTG) will be procured and installed at the project site for operations. Typical SSG and RTG are shown below.

<table>
<thead>
<tr>
<th>Typical SSG Equipment</th>
<th>Typical RTG Equipment</th>
</tr>
</thead>
</table>

**Figure 2-8: Equipment** (Source: JPC)
Other equipment that will be used during operation includes Trailer, Chassis, Reach Stackers, Side Lifters and Forklift Trucks. Conventional vehicles serving the proposed container terminal will also be operated by both management and port users.

2.2.6 Water and Electricity Supply

The Ministry of Water Resources has sunk boreholes in Hindi area and laid pipelines to the proposed port area in preparation for boosting water supply to the proposed port.

For Electricity supply, Kenya Electricity Generation Company plans to enhance the thermal power station at Kipevu which will accommodate demand for the proposed port. The Ministry of Energy has also embarked on future power distribution system modernization project.

2.2.7 Siyu Channel

A channel will be developed for small boats to navigate through during low tide.

2.3 PRELIMINARY SITE SURVEYS

In order for the detailed designs of the project be carried out, site surveys were carried out to establish important factors that determine dimensions and location of the project. The following surveys were conducted.

2.3.1 Hydraulic & Geophysical Surveys

Geophysical & Hydraulic surveys were carried out by M/s EGS (Vietnam) Ltd.

Hydraulic surveys were carried out to determine Tide, Current and Wave activity at the project site. The surveys included the analysis of characteristics of the wave, tidal current and tide levels; vector harmonic analysis to establish the tidal component of the currents and assessment of the non-tidal residuals. Samples of the seabed sediments were also attained and analysed to determine seabed condition at the study site. Purposes of geophysical and hydraulic surveys were as follows:

<table>
<thead>
<tr>
<th>No</th>
<th>Survey Item</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tide Current and Suspended Solid (SS) Measurement</td>
<td>To set up hydraulic conditions in simulation works</td>
</tr>
<tr>
<td></td>
<td></td>
<td>To decide dredging dimensions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>To assess construction efficiency</td>
</tr>
<tr>
<td>2.</td>
<td>Bathymetric Survey</td>
<td>To set up seabed elevation in simulation works.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>To design dredging dimensions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>To calculate dredging volumes</td>
</tr>
<tr>
<td>3.</td>
<td>Seismic Survey</td>
<td>To verify existence of hard material</td>
</tr>
</tbody>
</table>
Two (2) tide stations were set out on site; one near Manda Island and another near the Naval base. For the current measurements, three (3 No) Acoustic Doppler Current Profiler (ADCP) were deployed; one was placed in the offshore of the project area, another in the access channel and the third in the South Channel.

The locations of survey are shown in Figure below:

![Figure 2-9: Survey Locations For Hydraulic Surveys (Source JPC)](image)

Geophysical surveys were carried out to map sea bed levels and to identify seabed features. The survey areas are shown in figure below:
**Table 2e: Key Results of the Hydraulic and Geophysical Surveys**

<table>
<thead>
<tr>
<th>No.</th>
<th>Survey Item</th>
<th>Key Results</th>
</tr>
</thead>
</table>
| 1.  | Tide, Current and Suspended Solid (SS Measurement) | Tide levels are semidiurnal  
The current location offshore of the project area has a strong net current drift to the east north east, mostly due to the effects of the dominant wind direction at this time of the year.  
Currents are strongest at the location in the access channel, up to 2.0m/s on spring tides. Current speeds are slightly faster in the ebb tides than on the floods.  
Inside the bay area, currents were generally weaker, up to max of 0.9 m/s  
Wave conditions are rough in the exposed offshore areas. Wave conditions attenuate significantly in the channel and inside the bay. |
| 2.  | Bathymetric Survey                               | Seabed level in the entire area was obtained.  
Approach channels are shallow in some areas and may need to be dredged. Deepest areas of ~60m in some areas |
| 3.  | Seismic Survey                                   | Hard material found in both the entrance and navigation channel.                                                                                           |
2.3.2 Geotechnical Surveys

Geotechnical Investigations were carried out by M/s Maru Piling Ltd with the objective of assessing the soil conditions beneath the seabed and on land. The other objective was to verify seismic survey results.

Figure below shows the locations of the 37 boreholes drilled in Manda Bay and Manda Pass during the preliminary investigations stage.

![Figure 2-11: Location of Geotechnical Boreholes (Source JPC)](image)

Based on the boring data, the substrata are classified into the following layers:

i) Alluvial deposit

ii) Dilluvial deposits

iii) Weathered Coral

i) Alluvial Deposits

Alluvial deposits are found in almost all boreholes on the seabed. They are considered to have been deposited within the past 10,000 years. They are basically sand mixed with some proportion of silt and shell fragments. Clay/silt is also encountered along the Eastern side of the Manda channel.

The thicknesses of alluvial deposits are in the range of 2-6m and 10m in the maximum. The densities of most of them are less than 10 blows in N-value, implying that they are loose.

ii) Dilluvial Deposits

Underneath the alluvial deposits are dilluvial deposits, formed within the past 1-2 million years. They consist of sand and clayey sand. Their distribution is confirmed by the results obtained
from boreholes numbers BH8, BH10 BH11, BH26, BH31 and BH32. These boreholes surround a coral reef named Shaka La Paya.

The thicknesses of the dilluvial deposit are almost 2m except for BH11 and BH 26 where it is found to at least be 7m of thicknesses. The densities are classified as medium to very dense.

iii) Coral

These are dead coral layers which define the base formation. The Coral was encountered almost in all boreholes except BH11 and BH26. They are subdivided based on the N-values, obtained as follows:

- Decomposed coral (N<50)
- Heavily weathered coral (N>50)

Decomposed coral is a condition of completely weathered coral rock into clay, sand, gravel or mixture of both. The thicknesses are less than 5m in most case, covering the less weathered coral underlying below. The SPT N-values confirmed are mostly greater than 40 blows, indicating as good bearing layer.

Heavily weathered coral is defined as a coral layer with SPT N-values being greater or equal to 50 blow. Coring was carried out for this layer and a core recovery was about 50% while rock Quality designation (RQD) was in the range of 0-15% only. This indicated that the quality is very poor.

The compression strengths of this coral range between 5000 to 2000kPa. Thus, this coral layer can be ripped by conventional suction cutter dredger.

3 Aerial Photo Surveys

Aerial Photo Mapping Surveys was carried out of the area by M/s Geomaps (Kenya). The objective of this survey was to produce high accuracy maps that will produce Digital Terrain Models (DTM) to be used in the design

As a result, digital orthophoto maps were produced of the project area, with a Ground Sample Distance (GSD) of 30cm.

2.4 JUSTIFICATION FOR THE PROJECT

The Government of Kenya is keen to implement the proposed project for numerous reasons.

2.4.1 Competition from Other Ports

The only port in Kenya, The Port of Mombasa has served as regional port and a principal gateway for many landlocked countries and a major source of revenue for the Government. Competition from other regional ports such as Djibouti Port (Djibouti), Port Salala (Oman), Jeddah Port (Saudi Arabia), Dar es Salaam (Tanzania) and Port of Ngcucqa (S. Africa) has put the Port of Mombasa under pressure to expand to deal with increased traffic and if not addressed could relegate the Port of Mombasa to become a feeder port. Currently the Port of Mombasa is undergoing an expansion program in an attempt to remain competitive in the region. Studies have indicated that Mombasa port is nearing its saturation point and construction of another port is justifiable for the country.
2.4.2 Economic Boost

The proposed port will boost the economy of Kenya significantly as it will open up new channels of business and trade in the region and country as a whole. Along with the proposed northern corridor to South Sudan, the potential of Lamu Port is very significant to the country’s GDP. The development will also boost local industry in the form tourism and fisheries. The proponent will develop two (2) fishing ports alongside this proposed project that will boost the fishing industry in the area.

2.4.3 The site is naturally suitable

When the government of Kenya was identifying suitable locations for a second port in the country, Lamu was considered for the fact that the area naturally suitable, having deep waters therefore reduce the cost of construction significantly as there would be less need for dredging. The location proposed for development has also taken into account future expansion and has the sea front capability to be developed into a “Super-Port” with over 30 Berths by the year 2030.

2.4.4 Promotion of Regional Development

In line with the Government of Kenya’s Vision 2030 policy, the construction of the port will promote regional development, not only in Lamu but also in areas to be traversed by the proposed northern corridor. If implemented, the corridor (port included) will open up areas such as Isiolo, Garissa & Marsabit that are considered marginalized areas of the country devoid of development. The port will act as a gateway for transport, trade and development routes that will pass through these areas, all part of the “Northern Corridor”.

2.5 CONSIDERATION OF ALTERNATIVES

The design consultants considered the following options from engineering and environmental points of view.

2.5.1 Option 1: Lamu Island (North Shore)

This location as shown in the figure below was considered as a possible location of the proposed project.

Reasons for abandoning this location were:

- The site is close to the sand dunes that are protected. These sand dunes are a source of fresh water for inhabitant of Lamu Island.
- Construction would be prohibited since there exists a buffer zone to protect the designated World Heritage Site on Lamu Island
- The area is very shallow and large quantities of dredging would be required, making the project non-feasible
- From maintenance perspective, the channel that would be created would experience high levels of siltation therefore requiring regular maintenance
- The area would require dredging with large economic and environmental costs.
Extensive transport network would also be required on the island.

2.5.2 Option 2: Manda Island (East Shore)

This location on Manda Island was also considered. Reasons for not settling on this location were:

- There was a possibility that the construction would be prohibited since it lies within the World Heritage Site buffer zone designated to protect the Lamu Island.
- Close to sea turtle nesting ground which will affect the nests and the migration routes of sea turtles.
- There is significant presence of coral reef in the area and dredging there would adversely reduce fishing potential.
- Turbidity plumes will adversely affect the coral reef habitats.
- Limited space for hinterland development, will affect Takwa Ruins.
- No freshwater source.
- The area is very shallow and large quantities of dredging which would make the project non-feasible.
- From a maintenance perspective, a channel that would be created would experience high levels of siltation therefore requiring regular maintenance dredging with large economic and environmental costs.
- A bridge would be required to link with mainland which may be a source of bottlenecks and cost escalation.
2.5.3 Option 3: No Action Alternative

The selection of ‘No Action” alternative will mean the discontinuation of the project and maintaining the Port of Mombasa as the sole port in Kenya. This will result in continued congestion of the port of Mombasa in the short term, in as capacity to expand is limited. The future trends of shipping could render the port of Mombasa as a “feeder” port, which will reduce the revenue from this vital source of income and jobs in Kenya.

Without realization of the Port of Lamu, the country will face challenges in meeting the goals set out in the country’s Vision 2030. This port is supposed to be a gateway to open-up the north of Kenya and the coast of Lamu. Without this port, development of these areas will remain a challenge.

Physically, the site is unlikely to undergo any significant changes from its present condition. Biologically, the vegetation at the area is also unlikely to severely change. Natural colonization and existence of species is likely to determine the floral cover in the area.

Socially, the intangible heritage of the surrounding communities will remain. The dominant Swahili culture will be preserved with minimal threat of influx of migration workers and economic migrants.

2.6 PROJECT COST AND EIA REVIEW FEES

The project cost is yet to be confirmed as detailed design for the construction works is still going on. However it is clear from the scope of the project that the EIA review fees would be Ksh. 1,000,000.00 (One Million Kenya Shillings) to be paid as follows:

- Ksh 500,000.00 to be paid on submission of this report to NEMA;
- Ksh. 500,000.00 would be due prior to collection of the EIA license.
3. ANALYSIS OF LEGAL AND REGULATORY FRAMEWORK

3.1. ESIA PROCESS IN KENYA

The role of the Environmental and Social Impact Assessment (ESIA) in Kenya is to identify, predict, evaluate and mitigate the environmental and social effects of a development proposal prior to major decisions being taken or explored. The process of EIA can be broken down into discrete stages:

**Stage 1:**
To determine whether or not the project falls within the scope of ESIA.

**Stage 2:**
To provide mandatory project report/ statement detailing the different facets of the project. This is done to identify scope of the project and key environmental aspects e.g. ecological aspects, land, water etc.

**Stage 3:**
To provide an ESIA report that will cover all environmental issues prior to, during and after project implementation. Any required mitigating measures will also be suggested.

Once a proponent announces the project, a project report is initially prepared to meet the criteria in Part II of the Environmental Impact Assessment & Audit Regulations, 2003. The project report includes details of proposal and most importantly activities and materials that will be involved during the project construction, operation and decommission phases. The project report for the proposed port development was submitted to NEMA on March 2, 2012.

The project report goes through an assessment process involving NEMA and lead agencies to make a decision on whether a license can be issued. If NEMA is satisfied that the project will not have significant impact, a license can be issued. However if NEMA finds that the activities of the project will have significant environmental impacts or insufficient mitigating measures have been proposed, the proponent will be required to undertake a full ESIA study. Once the proponent receives notification that full ESIA is required, a study is required to be conducted in accordance with terms of reference (TOR) developed during the scoping exercise. The Terms of Reference for the ESIA were submitted to NEMA on July 20, 2012 and approved on July 25, 2012.

Upon completion of the ESIA study, ten copies of the report shall be submitted to NEMA with a non-technical summary, an electronic copy and the prescribed fee. NEMA would thereafter distribute the report to lead agencies who will in turn review the report and respond with written comments within 30 days. NEMA then proceeds to invite the public to make oral and written comments and if necessary hold a public hearing involving the proponent, the public and NEMA.

3.2. LEGAL FRAMEWORK

The following pieces of legislations and regulations are applicable to the proposed project:
Table 3a: Legal and Regulatory Provisions

<table>
<thead>
<tr>
<th>Laws and Regulations</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Laws/Regulation</td>
<td>Environmental Management and Coordination Act, 1999</td>
</tr>
<tr>
<td>Environmental Impact Assessment</td>
<td>The Environmental (Impact Assessment and Audit) Regulations, 2009 Legal Notice No.101</td>
</tr>
<tr>
<td>Air quality</td>
<td>Draft Air Quality Regulations</td>
</tr>
<tr>
<td>Water quality</td>
<td>Environmental Management &amp; Coordination (Water Quality) Regulations, 2006 (Legal Notice No.120)</td>
</tr>
<tr>
<td>Noise and Vibration</td>
<td>The Environmental Management and Coordination (Noise And Excessive Vibration Pollution) (Control) Regulation, 2009 Legal Notice No.61</td>
</tr>
<tr>
<td>Waste Management</td>
<td>The Environmental Management and Coordination Waste Management Regulations, 2006 Legal Notice No.121</td>
</tr>
<tr>
<td>Coastal Zone</td>
<td>The Environmental (Preservation of Pollution in Coastal Zone and Other Segments of The Environment) Regulation, 2003</td>
</tr>
<tr>
<td>Wetland</td>
<td>(Wetland, River Banks, Lake Shores And Sea Shore Management) Regulations, 2009 Legal Notice No.19</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>The Environmental Management and Coordination (Conservation of Biological Diversity and Resources, Access to Genetic Resources and Benefit Sharing) Regulations, 2006 Legal Notice No.160</td>
</tr>
<tr>
<td>Wildlife</td>
<td>Wildlife Conservation and Management Act 1989</td>
</tr>
<tr>
<td>Forest</td>
<td>The Forest Act, 2005</td>
</tr>
<tr>
<td>Water</td>
<td>The Water Act, Cap 372</td>
</tr>
<tr>
<td>Resettlement / Compensation</td>
<td>Land Act , 2012</td>
</tr>
<tr>
<td></td>
<td>The Registered Land Act, 2012</td>
</tr>
<tr>
<td></td>
<td>The Fisheries Act (Cap378)</td>
</tr>
<tr>
<td></td>
<td>Kenya National HIV/AIDS Strategic Plan</td>
</tr>
<tr>
<td></td>
<td>MOT Policy on HIV/AIDS (Draft)</td>
</tr>
<tr>
<td>Cultural and Historical sites</td>
<td>National Museum and Heritage Act of 2006</td>
</tr>
</tbody>
</table>

3.2.1 The Environmental Management and Co-ordination Act, 1999

This Act that came into force in 1999 aims at improving the legal and administrative co-ordination of the diverse initiatives in the field of environment with the ultimate objective of
integrating environmental considerations into the country’s overall economic and social development.

According to section 58 of the Act projects specified in the second schedule that are likely to have significant impact on the environment have to be subjected to an ESIA study. This project is considered to fall under the said schedule.

Part V section 42, subsection 1 directs that no person shall among others deposit any substance in a water body if the substance will have adverse environmental effect on the water. Part VIII, section 72 of the Act prohibits discharging or applying poisonous, toxic, noxious or obstructing matter, or any other pollutant into aquatic environment.

Being a development on the seafront this project is affected by the foregoing provisions.

### 3.2.3 Land Act 2012

This is an Act of Parliament to give effect to Article 68 of the Constitution, to revise, consolidate and rationalize land laws; to provide for the sustainable administration and management of land and land based resources. It has repealed the Way leaves Act, Cap 292 and the Land Acquisition Act, Cap 295 and therefore provides for land acquisition for various purposes. Section 5 (1) of this Act provides the following forms of land tenure:

- (a) freehold;
- (b) leasehold;
- (c) such forms of partial interest as may be defined under this Act and other law, including but not limited to easements; and
- (d) customary land rights, where consistent with the Constitution.

The Act specifies that there shall be equal recognition and enforcement of land rights arising under all tenure systems and nondiscrimination in ownership of, and access to land under all tenure systems.

### 3.2.4 The Occupational Safety and Health Act, 2007

This Act came into force in 2007 replacing The Factories and Other Places of Work Act, Cap 514. It makes provisions for the health, safety and welfare to be observed by employers and persons employed in places of work. Part IV of the act covers health issues such as the state of cleanliness, refuse management, employee space requirement, ventilation and sanitary conveniences. Part V covers fire safety, operation and maintenance of machinery, fencing requirements, storage of dangerous substances, training and supervision of workers. Part VI deals with welfare issues; drinking water supply, washing facilities, sitting areas and first aid provision.

### 3.2.5 The Water Act 2002 (No. 8 of 2002); Laws of Kenya

The Water Resource Management Authority was established under this Act to regulate and protect resources from adverse impacts. The Water Act provides for the conservation and controlled use of water resources in Kenya. Under the Ministry of Water the Act prohibits pollution of water resources and controls the discharge of industrial and municipal effluents into the ocean and other water bodies. The proposed project would impact on sea water due to
dredging and disposal of dredged material and hence is subject to the provisions of the Water Act.

3.2.6 National Museum and Heritage Act No. 6 of 2006

This act of Parliament was passed to ensure protection of Kenya’s rich and diverse natural and cultural heritage. It is also aimed at establishing new legal framework for heritage management that will domesticate some of the international conventions and protocols on heritage which Kenya has ratified.

National Museums of Kenya (NMK) is a multi-disciplinary institution whose role is to collect, preserve, study, document and present Kenya’s past and present cultural and natural heritage. This is for the purposes of enhancing knowledge, appreciation, respect and sustainable utilization of these resources for the benefit of Kenya and the world, for now and prosperity. (www.museums.or.ke)

3.2.7 Wildlife Conservation and Management Act 1989

This law relates to the protection, conservation and management of wildlife in Kenya. The law mandates KWS to act as a consolidated service of the Government that will manage and conserve wildlife in Kenya. The prime objective of the service is to ensure that wildlife is managed and conserved so as to yield to the nation in general and to individual areas in particular, optimum returns in terms of cultural, aesthetic and scientific gains as well as such economic gains as are incidental to proper wildlife management and conservation and which may be secured without prejudice to such proper management and conservation.

3.2.8 Fisheries Act

The Fisheries Act Cap 378 of the Laws of Kenya provides a legal framework for the management, exploitation, utilization and conservation of fisheries and other connected purposes. It regulates the landing of fish and provides for the management of fish landing areas. Article 4 of the Act empowers the Director of Fisheries in cooperation with other appropriate agencies and other departments of Government to promote the development of traditional and industrial fisheries, fish culture and related industries. This Act recognizes the contribution of fishing to local livelihoods and gives fishermen rights to fish in the Kenyan fishery waters. Consequently, any development that interferes with fish landing beaches or displaces fishermen from their traditional fishing grounds can be challenged if it is not supporting the development of sustainable fishing in the coastal waters.

3.2.9 Kenya Maritime Authority Act

Kenya Maritime Authority (KMA) is charged with the responsibility of regulating, coordinating and overseeing maritime affairs in the country. In fulfilling this mandate KMA is expected to advise the government on the development of international maritime conventions, treaties and agreements as well as their codification into the laws of Kenya. In addition KMA is expected to:

- Conduct and liaise with other stakeholders in doing research, investigations and surveys relating to maritime affairs;
- Develop and maintain the national oil spill response plan in coastal and inland waterways in liaison with players in the oil industry;
- Serve as coordinators of search and rescue operations in liaison with KPA, Kenya Navy and other relevant bodies; and
- Ensure sustainable exploitation of marine resources and rapid response to marine calamities.

3.3 APPLICABLE REGULATIONS

3.3.1 The Environmental (Impact Assessment and Auditing) Regulations, 2003.

These Regulations guide on the procedure for conducting ESIA studies by detailing the parameters to be evaluated during the study. It also provides guidelines on the payment of the EIA license fees, procedures for environmental audits and development of environmental monitoring plans.

Legal Notice No 30 published by the Minister for Environment in the Kenya Gazette Issue Number 14 under these regulations reviewed EIA license application fee from 0.1% to 0.05% and fixed the maximum payable fee at Ksh. 1 million.

3.3.2 Environmental Management and Coordination (Water Quality) Regulations, 2006

These regulations provide for protection to ground water or surface water from pollution due to anthropogenic activities. It also provides the limits and parameters of pollutants in treated waste water which can be discharged into the environment.

3.3.3 Environmental Management and Coordination (Waste Management) Regulations, 2006

These regulations outline the responsibility of the waste generator and prescribe proper mechanism of handling all waste through segregation, recycling and reuse. At the construction stage large volumes of construction debris would be generated. The proponent should ensure that the waste is managed in line with the provisions of these regulations.

3.3.4 Noise and Excessive Vibration (Pollution Control) Regulations, 2008

The regulations apply to operation of equipment or machinery and engagement in commercial or industrial activity that is likely to emit noise or excessive vibrations. The regulations specify the limits or levels within which these shall be undertaken. The Regulations also stipulate in the second schedule that construction activities undertaken during the night should not emit excessive noise beyond the permissible levels.
3.3.5 Building Operations and Works of Engineering Construction Rules, 1984

The provisions of the Factories Act relevant to building operations and engineering construction works are contained in the Abstract of the Act for Building Operations and Works of Engineering Construction Rules. These rules specify the minimum safety and health measures to be taken during construction works which include that the proponent should:

- Give notice of particular operations or works;
- Such notice should be sent in writing to the Occupational Health and Safety Officer, not later than seven days after commencement of construction;
- Post printed copies or prescribed abstracts of the Occupational Safety and Health Act at the site of operations or works (Section 61 of the Act);
- Provide sufficient and suitable sanitary conveniences for persons employed. These must be kept clean and well lit.

The contractor appointed by the proponent would be expected to adhere to these provisions.

3.4 INTERNATIONAL TREATIES & CONVENTIONS

3.4.1 Marine Pollution (MARPOL) 1973 & 1978

This is the most important instrument for preventing pollution arising from marine transportation. It was adopted in 1973 and modified by the Protocol of 1978 relating thereto, hence MARPOL 73/78.

Its stated object is to preserve the marine environment through the complete elimination of pollution by oil and other harmful substances and the minimization of accidental discharge of such substances. All ships flagged under countries that are signatories to MARPOL are subject to its requirements, regardless of where they sail and member nations are responsible for vessels registered under their respective nationalities.

It consists of five Annexes as follows:

**Annex I**: Oil - Ships are prohibited from discharging oil or oily water, such as dirty ballast water and oily bilge water containing more than 15 ppm of oil, within 12 miles of land. Other conditions apply to discharges outside 12 mile limits.

**Annex II**: Noxious Liquid Substances in Bulk - Chemicals are evaluated for the environmental hazard they may cause if discharged into the sea (Categories A, B, C and D). Discharge into the sea of the most harmful chemicals (Category A) is prohibited and tank washings and other residues of less harmful substances (Categories B, C and D) may only be discharged under certain conditions.
conditions, e.g., total quantity, distance from the shore, depth of water, prescribed depending on the hazards. There are substances, e.g., water, wine, acetone, ethyl alcohol, for which no restrictions apply.

Annex III: Harmful substances in packaged form - this is principally oriented towards prevention of pollution by regulating packaging, marking and labeling and stowage.

Annex IV: Sewage - It is prohibited to discharge ship-generated sewage unless it is treated with an approved sewage treatment plant or at a certain distance from land.

Annex V: Garbage - Garbage produced on board a ship, food waste, packaging, etc. must be kept on board and discharged either ashore or into the sea under certain conditions, such as the distance from land. Discharge of all plastics is prohibited.

3.4.2 UNESCO Convention 1972

This is an international treaty approved by United Nations Education, Science and Culture Organization (UNESCO). This convention states that the duty of states is to ensure the identification, protection and transmission to future generations the cultural and natural heritage referred to in Articles 1 and 2 situated on its territory. The aim is to identify, protect and preserve both cultural and natural heritage.

Kenya, being a member state since 1964 has national sites that are listed as World Heritage sites, including Lamu old Town which was inscribed on 16th December 2001.

3.4.3 London Convention, 1972

This is the convention on the prevention of marine pollution by dumping of waste and other matter at sea to which Kenya is party.

3.4.4 World Bank Policy on Involuntary Resettlement (OD 4.30)

This document provides guidelines for “compensation, disruption or displacement” of a population by a project. The proposed project would result into both terrestrial losses (farmlands, crops) and marine losses (fishing grounds and landing sites). Terrestrial losses are fairly easy to estimate and would be calculated from the valuation of land and crops. However given the variation in fishing techniques and their employment across the strategic areas identified for dredging, no single formula or regional approach is likely to be suitable for all sites. Hence the focus on a general framework based on best practice principles (World Bank guidelines). Within this framework, the following definitions have been adopted.

<table>
<thead>
<tr>
<th>Table 3b: Term Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Compensation</strong></td>
</tr>
<tr>
<td><strong>Disruption</strong></td>
</tr>
<tr>
<td><strong>Displacement</strong></td>
</tr>
</tbody>
</table>
### 3.5 Summary of Applicable International Treaties and Conventions

<table>
<thead>
<tr>
<th>Item</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESIA</td>
<td>World Bank Operational Policy 4.01 (Environmental Impact Assessment)</td>
</tr>
<tr>
<td>Resettlement</td>
<td>World Bank Operational Policy 4.12 (Involuntary Resettlement)</td>
</tr>
</tbody>
</table>
  International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978 (MARPOL 73/78)  
  World Bank Technical Paper Number 126 (Environmental Considerations for Port and Harbor Development) |
| Cultural and Historical sites| Convention Concerning the protection of the World Cultural and Natural Heritage, Paris 1972 |
| Wetland                     | Convention on Wetland of International Importance (Ramsar, 1971)           |
| Biodiversity                 | Convention on Biological Diversity (1992)                                 |
| Wildlife                    | Bonn Convention on the Conservation of Migratory Species of Wild Animals  
  Washington Convention on International Trade In Endangered Species (CITES, 1973) |
| Oil Spill                   | International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC 1990) |

(Source: JPC)
4. BASELINE INFORMATION

4.1. GEOLOGY AND GEOMORPHOLOGY

The coastal environment of Kenya is set in a passive continental margin, whose evolution was initiated by the breakup of mega continent Gondwanaland in the Lower Mesozoic era. The initial opening of the Indian Ocean was preceded by extensive faulting and down-warping, similar to that observed in the Modern Great Rift Valley of East Africa. These tectonic movements formed a North–South trending depositional basin. During the Mesozoic era, this marine basin was exposed to numerous marine incursions and by the Jurassic period, purely marine conditions are thought to have existed (UNEP, 1998).

Throughout the Tertiary era, the coastal areas experienced further faulting and extensive continental erosion. In many areas the older Cretaceous deposits were totally removed. The present coastal configuration, however, evolved during the Pleistocene to Recent times, a period marked by numerous fluctuations in sea level. Because of its evolutionary history, the principal rocks observed along the coastal area are sedimentary in origin, and range in age from Triassic to Recent (UNEP, 1998). The upper Mesozoic is represented by marine limestone and shales, with occasional horizons of sandstones and early limestone. Recent rocks comprise mostly limestone, and are represented by the sandstone, clay, conglomerates and gravels such as those found in the Marafa beds. This well-developed reef complex, consisting of coral reefs, coral rubble and sandstone, is extensively exploited by the building industry.

4.2. DEMOGRAPHIC CHARACTERISTICS LAMU COUNTY

The available and most detailed demographic information on Lamu County which houses the project area is from the national population and housing census of 2009. This census is consistently conducted after every ten years and the results just came out in 2010. Based on this census a summary of selected demographic information is presented in Table 1 below. According to the 2009 census results, the number of households in the larger Lamu County has risen from 15,006 households in 1999 to 22,184 households in 2009 and population has increased from 72,686 people in 1999 to 101,539 people in 2009. The population density has also increased from 12 persons per square kilometer in 1999 to 16 persons per square kilometer in 2009. While it may appear that this population density is way below the national population density of 66 persons per sq. km, some divisions such as Amu have relatively higher population densities of 224 persons per sq. km (Table 4 - 1). It is worth noting that population density is higher in areas that depend mainly on fisheries and other marine resources for livelihoods and income. This
implies that population pressure in the Lamu County impacts more heavily on fisheries and other marine resources than on terrestrial resources. It is worth noting that the population size and density has changed significantly between 1999 and 2009.

Table 4c: Population by Sex, Number of Households and density in Lamu County

<table>
<thead>
<tr>
<th>Division</th>
<th>Location</th>
<th>Sub-location</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
<th>Household</th>
<th>Density</th>
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<td>Mkomani</td>
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<td>Langoni</td>
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<td>831</td>
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<td>Sub-Total</td>
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<td>Mokowe</td>
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<td>Ndambwe</td>
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<td>Tewe</td>
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<td>1,214</td>
<td>2,649</td>
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<td>1754</td>
<td>3568</td>
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<td>1016</td>
<td>2245</td>
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<td>1149</td>
<td>2253</td>
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<td>659</td>
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<td>Tchundwa</td>
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<td>Kizingiti</td>
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<td>3154</td>
<td>529</td>
<td>5096</td>
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<tr>
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<td>Ndau</td>
<td>Ndau</td>
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<td>450</td>
<td>854</td>
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<td>Kiwayu</td>
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<td>545</td>
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<td>Mbwajumwali</td>
<td>Myabogi</td>
<td>977</td>
<td>1047</td>
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<td>Sub-Total</td>
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<td>Kiunga</td>
<td>Kiunga</td>
<td>Rubu/Mwambo re</td>
<td>1259</td>
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<td>2203</td>
<td>447</td>
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<tr>
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<td>361</td>
<td>302</td>
<td>663</td>
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<td>Milimani</td>
<td>323</td>
<td>279</td>
<td>602</td>
<td>108</td>
<td>1</td>
</tr>
</tbody>
</table>
4.3. **SOCIO-ECONOMIC PROFILE**

**i) Demographic and Population Profile**

Lamu had a population of 101,539 people in 2009 with a population density of 16 persons per square kilometer (Republic of Kenya, 2010). The project area is sparsely populated with the highest concentration of the population found in Amu have relatively higher population densities of 224 persons per sq. km. Population density is higher in areas that depend mainly on fisheries and other marine resources for livelihoods and income. Most of the people in Lamu County live in Lamu island, Faza, Pata and Kiwayu. Due to the cultural and historical nature of the district, tourism has been very dominant over recent years.

**ii) Health**

The most prevalent diseases in Lamu County are malaria, respiratory tract infections and skin diseases. The county has 42 health facilities which are spread in different levels as follows: one (1) district hospital, two (2) sub-district hospitals, twenty (20) dispensaries, five (5) health centres, thirteen (13) medical clinics, and one (1) nursing home. Besides, there is a very low doctor to population ratio (1:36, 343) but very high infant mortality rates (72/1000) and an even higher under five mortality rate of 123/1000. These high figures could be attributed to few deliveries in health centers (29.6%), and even fewer qualified medical assistants during births (27.2%). However, most children within the county have undergone all vaccinations (80.5%).

**iii) Education**

The project area is generally characterized by low levels of education and a significant disparity in levels of education exists between men and women. The socio-economic assessments revealed that women dominated the section of population who never attended school as well as those who only acquired basic literacy and madrassa while the section of population that had attained secondary, tertiary, university and youth polytechnic levels of education were dominated by men. Lamu County has a total of 70 primary schools with 22,633 pupils, 11 secondary schools with 972 students, less than 5 tertiary learning institutions which include a youth polytechnic and some commercial colleges and adult literacy classes with no credible enrollment statistics available. The teacher to pupil ratio is: 1:40 and 1:39, in public primary and secondary schools respectively. Overall, 66.4% of the county residents possess primary education whereas 9.7% of the population have earned secondary education; placing the county at the 30th and 35th positions in the same order for the national counties’ educational ranking. However, a high rate (73.2%) of the entire population is literate in spite of little formal education, a fact that is attributed to the vast influence of the prominent Islamic religion (over 70%) which imposes mandatory religious classes during childhood – usually referred to as madrassa.
iv) Livelihoods and economy

Fishing and farming are the main economic activities in the Lamu County and the project area in particular. At the Mokowe-Hindi-Kililana-Baragoni stretch, agriculture is the most dominant occupation. The same applies to Pate village. On the other hand, at Amu, Matondoni, Faza, Kizingitini, Kiwayu, Shanga and Kiunga artisanal fishing is the main occupation. Other important occupations are small scale business, mangrove cutting, tourism, pastoralism and casual labour. Mangrove cutting is mainly practiced by the inhabitants of Pate and Ndau.

It is estimated that Lamu County has five main livelihood zones namely; mixed farming (cash crops/food crops/horticulture), mixed farming (food crops/cash crops), livestock farming, fishing and formal employment (casual waged labor/Business), the predominant being mixed farming: food crops / cash crop (Long Rains Food Security Report, WFP). High levels of poverty among the population which is manifested in a large population size living below the poverty line in Lamu and the increasing drug problem have made the population highly vulnerable to HIV/AIDS infection. However, it is worth noting that the HIV/AIDS prevalence in 2009 was relatively low (3.4%) compared to the national rate of 7.3%. According to World Health Organization the top 5 diseases in the general population were malaria, upper respiratory tract infections (URTI), diarrhea, skin disease and urinary tract infections (UTI) (Long Rains Food Security Report, WFP).

v) Gender and Equality

Gender disparity in Lamu County is characterized by relatively low levels of education among women compared to men. The gender roles are clearly demarcated and this has left a large number of women bearing a disproportionately large share of domestic work.

4.4. PHYSICAL INFRASTRUCTURE

4.4.1 Transport

The project area is served by road, air and sea transport. There is an all-weather road that links Lamu with other major towns along the coast of Kenya. The section of this road which stretches from Lamu to Garsen is murram while the remaining section between Garsen and Mombasa is tarmac. Consequently, public road transport between Lamu and the other major towns is reliable. However, there is no reliable road transport between Mokowe and Magogoni and Bargoni in the project area as no public transport is available. The local community are therefore forced to trek over long distances. An airstrip is also available at Manda Island about two kilometres from Lamu. This airstrip receives scheduled flights from Malindi and Nairobi. Sea transport is very important at Lamu since the town is located in an Island. Entry into the island is through a mainland jetty at Mokowe. Many ordinary boats are available for use by the public.

4.4.2 Energy Supply

Lamu relies on thermal electricity from a generator which is managed by the Kenya Electricity Generating Company. Petroleum products are also available in small petrol stations especially at Mokowe. These products are transported to the island by boat. There are boats that specifically
transport petrol. Wood and charcoal also constitute important sources of energy in the project area.

4.4.3 Water Supply

Some areas in the larger Lamu County are water insecure while other areas have adequate water supplies. Lamu Town has adequate fresh water supplies from the sand dunes which are located on the southern side of the town. In addition, there are boreholes in the mainland that also provide fresh water to the residents.

4.4.4 Public facilities

Lamu town has public facilities that serve the residents of the larger Lamu County. For example, there is a district hospitals (King Fad Hospital) that offers both inpatient and out-patient services. Dispensaries have also been built in different locations. For example, at Bargoni, there is a new dispensary that had just been constructed at the time we visited the area. This dispensary has however not started operating. Lamu Secondary School which is a public school is also located in the Island. Public primary schools also exist. Hotels of different categories are also available.

Fig. 4-1: Consultation with PAPs at the project site
5. PHYSICO-CHEMICAL ENVIRONMENT AROUND THE PROPOSED PROJECT AREA

5.1 INTRODUCTION

Port establishment may create a wide range of impacts on the environment through dredging, construction work, landfills, discharges from ships and waterfront industries, cargo operations and other port related activities. The potential adverse effects of port development encompass water pollution, contamination of bottom sediments, loss of bottom habitat, damage to marine ecology and fisheries, beach erosion, current pattern changes, waste disposal, oil leakage and spillage, hazardous material emissions, air pollution, noise, vibration, visual pollution, and other socio-cultural impacts.

Major sources of adverse effects to air, water and sediments quality in the proposed Lamu port area can result from: (a) location of port; (b) construction; and (c) port operation, including ship traffic and discharges, cargo handling and storage, and land transport. Location of port connotes the existence of structures or landfills, and the position of the development station. Construction implies construction activities in the sea and on land, dredging, disposal of dredged materials, and transport of construction materials. Port operation includes ship-related factors such as vessel traffic, ship discharges and emissions, spills and leakage from ships; and cargo-related factors such as cargo handling and storage, handling equipment, hazardous materials, waterfront industry discharges, and land transport to and from the port.

This section of the EIA report therefore aims at identifying the potential impact of the proposed port development on the environment in relation to sediment, water and air quality. It also indicates how these impacts can be mitigated.

5.2 STUDY METHODOLOGY

5.2.1 Baseline Characterization

Environmental baseline survey of the proposed port area was an important phase of the ESIA in provision of baseline data that is vital in assessment of the existing environmental quality and in providing the data that will act as reference for EMP. Environmental baseline data acquisition was undertaken through literature survey of different studies conducted in the proximity of the project area. Gaps in environmental baseline information were identified and fieldwork activities designed to acquire additional data to fill these gaps conducted in August 2012.

5.2.2 Air, Water and Sediment Quality Survey

A survey of the various indicator of air, water and sediments quality was undertaken as the first part of Lamu port EIA. Secondly, the existing condition was analyzed in comparison with permissible levels of pollutants where available. Thirdly, impacts on the environment are predicted by considering future situations and activities.
Air, water and sediments samples were collected from permanent stations established for the purposes of water, sediments and air quality monitoring. Air, water and sediment quality samples were collected from Wange fish port, Berth 1 Port area, Mokowe fish port and entrance of proposed port. Additional stations (Port 1, Port 2, channels 1 and channels 2) were sampled for water while additional stations (Port 1 and Port 2) were sampled for sediments. Standard sampling protocols were strictly adhered to. In brief, duplicate water samples were collected from the sub-surface layer (about 0.5 m depth). Top 5 cm sediment samples were obtained using 30 cm plastic hand-held corers (for heavy metals, organic carbon, particle size analysis) and shovel (for PAH). Biota samples (oyster) were also collected alongside water and sediments samples for analysis of heavy metals. Samples were transported to laboratory frozen for further analysis.

Water quality included three elements: (a) general features such as temperature, salinity, pH (b) turbidity measured by suspended solids; and (c) eutrophication-related factors measured by dissolved oxygen (DO), nitrogen (N), phosphorus (P) and Chla. Sediments quality encompassed:-

- a) general feature such as grain size, organic carbon
- b) quality related issues i.e. contamination of bottom sediments by toxic or harmful substances including heavy metals such as mercury, cadmium, lead, PAH, oils, grease and other hazardous materials.

Air quality consisted of two main elements: (a) soot and dust, measured by particulate matter (PM), and (b) concentration of sulfur dioxide (SO₂) nitrogen dioxide (NO₂), carbon monoxide (CO) and carbon dioxide (CO₂). NO₂ and SO₂ were sampled through passive sampling. This involved adsorption of pollutant gases in a capture tube (adsorption cartridge) placed about 1.5 m above the ground. Samples were analysed for volatile compounds and results used to calculate gases concentration. CO and CO₂ were analysed using NDIR analyser. Ambient dust or particulate matter (PM) was sampled using minivol air samplers.

5.3 RESULTS

The results of water quality parameter are presented in Table 1. Temperature in most stations analyzed ranged between 24.4-27.6°C. Dissolved oxygen ranged between 4.56-7.66 mg/L. Total suspended solids concentration ranged between 0.07 and 0.12 mg/L. pH and salinity ranges were 6.63-7.45 and 31.07-31.82 respectively. Chl concentration ranged between 0.83 and 3.04 mg/L. Concentration of nitrates range between 0.001 - 0.004 mg/L whereas phosphates and ammonium ranged between 0.001-0.01 and 0.005-0.02 mg/L respectively. These values fall within the permissible levels of water quality guidelines provided by EPA.

Sediments in Lamu comprised mainly of sand which contributed 81.8-96.0% of the total sediments grain size particles. Total organic carbon was uniformly distributed in the stations with a range of 0.02-0.04 mg/Kg (Table 2). Minimal oil contamination was observed in the sampling stations with oil and grease in sediments ranging between 11.4-22.2 mg/Kg. PAHs in all the stations were below detection limits (Table 6). Results of sediments’ heavy metals are shown in Table 3. Mercury, lead and cadmium were not detected in most of the sediment samples. The ranges of concentrations detected in sediments were: 659.5-1674.9, 0.35-3.54, 2.55-7.58, 0.51-2.98, 1067.9-3014.0 and 16.1-58.5 mg/Kg for Al, As, Cr, Cu, Fe and Mn respectively. Cd was only detected at Port 2 station at a concentration of 0.13 mg/Kg. Heavy metal concentrations
were low in all the samples and as such there was no indication of metals accumulation in the sediments as a result of past/present activities.

The observed levels of metals were comparable to the levels observed in Gazi and Chale, stations that are considered to be least impacted by anthropogenic activities (Table 4). However, the level of heavy metals in Lamu sediment were generally lower than the average levels reported for Kenyan coastal waters (Evaarts and Nieuwenhuize, 1995) and those observed in Thailand and Russia. These results are similar to the results of previous studies by Biney et al., (1994) and Okuku et al., (2010) that showed that the impacts of pollution was mostly evident around urban areas with remote places showing relatively low background levels in most parts of Africa.

Table 5a: Level of water quality indicators in the proposed Lamu Port area

<table>
<thead>
<tr>
<th>Station</th>
<th>Temp (°C)</th>
<th>DO (mg/L)</th>
<th>pH</th>
<th>Salinity</th>
<th>Ammonium (mg/L)</th>
<th>Nitrates (mg/L)</th>
<th>Phosphates (mg/L)</th>
<th>TSS (mg/L)</th>
<th>Chl a (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wange Fish Port</td>
<td>27.0</td>
<td>4.56</td>
<td>7.08</td>
<td>31.68</td>
<td>0.005</td>
<td>0.001</td>
<td>0.002</td>
<td>0.09</td>
<td>0.84</td>
</tr>
<tr>
<td>Port 1</td>
<td>27.6</td>
<td>7.65</td>
<td>6.83</td>
<td>31.45</td>
<td>0.009</td>
<td>0.002</td>
<td>0.004</td>
<td>0.12</td>
<td>2.66</td>
</tr>
<tr>
<td>Port Berth 1</td>
<td>27.5</td>
<td>6.62</td>
<td>6.63</td>
<td>31.31</td>
<td>0.010</td>
<td>0.002</td>
<td>0.010</td>
<td>0.12</td>
<td>2.90</td>
</tr>
<tr>
<td>Port 2</td>
<td>27.3</td>
<td>7.66</td>
<td>6.67</td>
<td>31.25</td>
<td>0.028</td>
<td>0.003</td>
<td>0.005</td>
<td>0.12</td>
<td>3.04</td>
</tr>
<tr>
<td>Port Channel entrance</td>
<td>26.2</td>
<td>7.53</td>
<td>7.01</td>
<td>31.17</td>
<td>0.010</td>
<td>0.002</td>
<td>0.001</td>
<td>0.10</td>
<td>2.08</td>
</tr>
<tr>
<td>Channel 1</td>
<td>26.6</td>
<td>5.65</td>
<td>7.27</td>
<td>31.07</td>
<td>0.005</td>
<td>0.003</td>
<td>0.011</td>
<td>0.10</td>
<td>0.83</td>
</tr>
<tr>
<td>Channel 2</td>
<td>26.2</td>
<td>7.25</td>
<td>7.31</td>
<td>31.09</td>
<td>0.008</td>
<td>0.003</td>
<td>0.002</td>
<td>0.07</td>
<td>1.51</td>
</tr>
<tr>
<td>Mokowe Fish Port</td>
<td>24.4</td>
<td>5.49</td>
<td>7.45</td>
<td>31.82</td>
<td>0.008</td>
<td>0.004</td>
<td>0.001</td>
<td>0.11</td>
<td>2.67</td>
</tr>
</tbody>
</table>

Table 5b: Characterisation of sediment in proposed Lamu Port area

<table>
<thead>
<tr>
<th>STATION</th>
<th>Clay-silt (%)</th>
<th>Sand (%)</th>
<th>TOC (mg/Kg)</th>
<th>Oil/ grease in sediments (mg/Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wange F. P</td>
<td>3.96</td>
<td>96.04</td>
<td>0.03</td>
<td>19.4</td>
</tr>
<tr>
<td>Port 1</td>
<td>15.64</td>
<td>84.36</td>
<td>0.02</td>
<td>13.2</td>
</tr>
<tr>
<td>Port Berth 1</td>
<td>16.20</td>
<td>83.8</td>
<td>0.02</td>
<td>11.4</td>
</tr>
<tr>
<td>Port 2</td>
<td>18.21</td>
<td>81.79</td>
<td>0.02</td>
<td>17.2</td>
</tr>
<tr>
<td>Port Chanel entrance</td>
<td>16.74</td>
<td>83.26</td>
<td>0.03</td>
<td>22.2</td>
</tr>
<tr>
<td>Channel 1</td>
<td>16.90</td>
<td>83.10</td>
<td>0.04</td>
<td>21.2</td>
</tr>
<tr>
<td>Channel 2</td>
<td>17.21</td>
<td>82.79</td>
<td>0.04</td>
<td>20.2</td>
</tr>
<tr>
<td>Mokowe Fish Port</td>
<td>9.60</td>
<td>90.40</td>
<td>0.02</td>
<td>20.0</td>
</tr>
</tbody>
</table>
### Table 5c: Sediment heavy metals concentration (mg/kg) in the proposed Lamu Port area

<table>
<thead>
<tr>
<th>Station</th>
<th>Al</th>
<th>As</th>
<th>Cd</th>
<th>Cr</th>
<th>Cu</th>
<th>Fe</th>
<th>Mn</th>
<th>Pb</th>
<th>Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wange Fish Port</td>
<td>856.8</td>
<td>1.03</td>
<td>ND</td>
<td>2.88</td>
<td>1.81</td>
<td>1351.9</td>
<td>16.8</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Port 1</td>
<td>713.0</td>
<td>0.35</td>
<td>ND</td>
<td>3.25</td>
<td>1.95</td>
<td>1496.6</td>
<td>21.7</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Port Berth 1</td>
<td>660.1</td>
<td>ND</td>
<td>ND</td>
<td>2.55</td>
<td>1.88</td>
<td>1067.9</td>
<td>17.4</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Port 2</td>
<td>1674.9</td>
<td>3.54</td>
<td>0.13</td>
<td>7.58</td>
<td>2.98</td>
<td>3014.0</td>
<td>34.7</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Port Channel entrance</td>
<td>659.5</td>
<td>1.09</td>
<td>ND</td>
<td>4.73</td>
<td>0.51</td>
<td>1551.1</td>
<td>58.5</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Mokowe fish Port</td>
<td>991.6</td>
<td>1.22</td>
<td>ND</td>
<td>2.64</td>
<td>1.93</td>
<td>1716.3</td>
<td>16.1</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

Note: ND- Not detected.

### Table 5d: Comparison of metals contamination (mg/kg) in selected locations in the world

<table>
<thead>
<tr>
<th>Site</th>
<th>Pb</th>
<th>Cu</th>
<th>Hg</th>
<th>Cr</th>
<th>As</th>
<th>Cd</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gazi Bay/</td>
<td>BDL</td>
<td>1.576</td>
<td></td>
<td></td>
<td>0.027</td>
<td></td>
<td>Okuku et al., 2010</td>
</tr>
<tr>
<td>Chale</td>
<td>2.188</td>
<td>9.576</td>
<td></td>
<td></td>
<td></td>
<td>BDL</td>
<td>Okuku et al., 2010</td>
</tr>
<tr>
<td>Laptev, Russia</td>
<td>16-22</td>
<td>12-20</td>
<td></td>
<td></td>
<td>0.03-1.06</td>
<td></td>
<td>Nolting in press</td>
</tr>
<tr>
<td>Pattani Bay, Thailand</td>
<td>79-97</td>
<td>22-27</td>
<td></td>
<td></td>
<td>0.01-0.04</td>
<td></td>
<td>Evaarts et al., 1994</td>
</tr>
<tr>
<td>Coastal Zone, Kenya</td>
<td>0.13-0.56</td>
<td>45-90</td>
<td></td>
<td>1.1-8.5</td>
<td></td>
<td></td>
<td>Evaarts and Nieuwenhuize, (1995)</td>
</tr>
<tr>
<td>This study</td>
<td>BDL</td>
<td>0.51-2.98</td>
<td>BDL-7.58</td>
<td>0.35-3.54</td>
<td>BDL-0.13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 5e: Sediment Quality Guidelines(SQG) modified from Persuad et al. (1992)

<table>
<thead>
<tr>
<th>Metal</th>
<th>LEL (μg/g)</th>
<th>SEL (μg/g)</th>
<th>This Study (μg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>6.0</td>
<td>33.0</td>
<td>0.35-3.59</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.6</td>
<td>9.0</td>
<td>0-0.13</td>
</tr>
<tr>
<td>Chromium</td>
<td>26.0</td>
<td>110.0</td>
<td>2.55-7.58</td>
</tr>
<tr>
<td>Copper</td>
<td>16.0</td>
<td>110.0</td>
<td>0.51-2.98</td>
</tr>
<tr>
<td>Lead</td>
<td>31.0</td>
<td>110.0</td>
<td>ND</td>
</tr>
<tr>
<td>Manganese</td>
<td>460.0</td>
<td>1100.0</td>
<td>16.1-58.5</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.15</td>
<td>1.3</td>
<td>ND</td>
</tr>
</tbody>
</table>
### Table 5f: Comparison of PAH concentration in Lamu port area and SQG

<table>
<thead>
<tr>
<th>PAH</th>
<th>ERL (mg/Kg)</th>
<th>ERM (mg/Kg)</th>
<th>This study (mg/Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naphthalene</td>
<td>340</td>
<td>2100</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Acenaphthylene</td>
<td>150</td>
<td>650</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Fluorene</td>
<td>35</td>
<td>640</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Phenanthrene</td>
<td>225</td>
<td>1380</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Anthracene</td>
<td>85</td>
<td>960</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Fluoranthenene</td>
<td>600</td>
<td>3600</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Benzo(a)anthracene</td>
<td>230</td>
<td>1600</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Chrysene</td>
<td>400</td>
<td>2800</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Benzo(a)pyrene</td>
<td>400</td>
<td>2500</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Benzo(b)fluoranthenene</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>TOTAL PAH</td>
<td>4000</td>
<td>35000</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

### Table 5g: Levels of Air quality indicators in Proposed Lamu Port area

<table>
<thead>
<tr>
<th>Station</th>
<th>Temp (°C)</th>
<th>Humidity (%)</th>
<th>PM (mg/M³)</th>
<th>CO (ppm)</th>
<th>CO₂ (ppm)</th>
<th>NO₂ (ppm)</th>
<th>SO₂ (ppm)</th>
<th>Noise (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wange Fish Port</td>
<td>26.9</td>
<td>69</td>
<td>1.5</td>
<td>0.6</td>
<td>216</td>
<td>0.002</td>
<td>0.01</td>
<td>20.6</td>
</tr>
<tr>
<td>Berth 1 Area</td>
<td>27.5</td>
<td>68</td>
<td>0.4</td>
<td>0.1</td>
<td>232</td>
<td>0.002</td>
<td>0.01</td>
<td>51.7</td>
</tr>
<tr>
<td>Port Enterance</td>
<td>27.9</td>
<td>59</td>
<td>0.7</td>
<td>0.2</td>
<td>190</td>
<td>0.001</td>
<td>0.01</td>
<td>20.3</td>
</tr>
<tr>
<td>Mokowe Fish Port</td>
<td>29.0</td>
<td>62</td>
<td>1.1</td>
<td>0.0</td>
<td>184</td>
<td>0.002</td>
<td>0.02</td>
<td>46.6</td>
</tr>
</tbody>
</table>

### Table 5h: Comparison of Heavy metals in oysters to international food standards (Codex standards 193-1995)

<table>
<thead>
<tr>
<th>Station</th>
<th>Al</th>
<th>As</th>
<th>Cd</th>
<th>Cr</th>
<th>Cu</th>
<th>Fe</th>
<th>Mn</th>
<th>Pb</th>
<th>Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wange</td>
<td>524.8</td>
<td>1.13</td>
<td>0.07</td>
<td>0.27</td>
<td>1.22</td>
<td>283.1</td>
<td>8.70</td>
<td>0.49</td>
<td>ND</td>
</tr>
<tr>
<td>Port 2</td>
<td>315.4</td>
<td>0.75</td>
<td>0.07</td>
<td>10.99</td>
<td>1.90</td>
<td>242.1</td>
<td>14.16</td>
<td>1.14</td>
<td>ND</td>
</tr>
<tr>
<td>Berth 1</td>
<td>194.5</td>
<td>0.29</td>
<td>0.05</td>
<td>0.14</td>
<td>1.98</td>
<td>112.7</td>
<td>17.80</td>
<td>0.90</td>
<td>ND</td>
</tr>
<tr>
<td>Mokowe</td>
<td>183.1</td>
<td>1.68</td>
<td>ND</td>
<td>0.17</td>
<td>1.32</td>
<td>98.3</td>
<td>9.90</td>
<td>1.57</td>
<td>ND</td>
</tr>
<tr>
<td>Codex Standards</td>
<td>25.0</td>
<td>26.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>27.0</td>
<td>30.0</td>
</tr>
</tbody>
</table>

### Table 5i: Permissible levels of air quality indicator (SOx and NOx-ppm) and PM (mg/M³).

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>NEMA STANDARDS</th>
<th>WHO Guidelines (1 hr average)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Industrial area (24 hrs)</td>
<td>Residential areas (24 hrs)</td>
</tr>
<tr>
<td>SOx</td>
<td>120</td>
<td>80</td>
</tr>
<tr>
<td>NOx</td>
<td>120</td>
<td>80</td>
</tr>
<tr>
<td>PM</td>
<td>120</td>
<td>60</td>
</tr>
</tbody>
</table>
5.4 POLLUTION RISK ASSESSMENT

Currently, no sediment guidelines exist for heavy metals and PAH in Kenya. However, several sediment quality criteria have been developed in the world that was applied in this study. A comparison of the results of this study was made against two levels of risk that have been established for metals and PAH contamination in sediments, Effects Range Low (ERL)/ Lowest Effect Level (LEL) and the Effects Range Low (ERL)/ Severe Effect Level (SEL) [Table 5 and Table 6]. These guidelines have been applied as useful tools for predicting chemical toxicity in screening or assessments of sediment quality. These approaches generally set two threshold levels, one below which effects rarely occur [e.g. ERL/LEL], and one above which effects are likely to occur [e.g. ERL/SEL]. Sediment is considered contaminated if either criterion is exceeded. If both criteria are exceeded, the sediment is considered to be severely impacted. If only the Lowest Effect Level criterion is exceeded, the impact is considered moderate. The following results were confirmed:

- Sediments in the proposed port area had PAH and metals concentrations below the threshold levels where effects rarely occur (LEL). The concentration of the heavy metals and PAH in the analyzed samples occurred in trace levels or very minute quantities far below recommended sediment quality guidelines that is able to cause any effects thus no PAH and heavy metals contamination is anticipated in the proposed project area.
- Heavy metals in biota (oysters) ranged between 183.1-524.8, 0.29-1.68, 0.05-0.07, 0.14-10.99, 1.22-1.98, 98.3-283.1, 8.70-17.80, 0.14-10.99, 1.22-1.98, 98.3-283.1, 8.70-17.80, 0.49-1.57 and ND-30 mg/Kg for Al, As, Cd, Cr, Cu, Fe, Mn, Pb and Hg (Table 8). The observed levels were much below the Codex international standard (193-1995) thresholds thus posing no current heavy metals contamination from seafood.
- The ranges of air quality indicators were: temperature 26.9-29°C, humidity 59-69%, PM 0.4-1.5 (mg/M³), CO 0-0.6 ppm, CO₂,184-232 ppm, NO₂0.001-0.002 ppm, SO₂>0.01-0.002 ppm. (Table 7). Air quality indicators levels are below the threshold levels recommended by NEMA (Table 9).
- Noise levels observed were between 20.3-51.7 dBA. These are below World Bank standards for industrial areas zones (70 dBA). This is baseline value that is set to increase during construction and operational phase of the project but would be used for monitoring (EMP).
6. OCEANOGRAPHY & TURBIDITY SIMULATION

6.1 INTRODUCTION

Estuaries have received considerable attention over the past decades, principally because of their recognized importance to coastal communities. They are an important spawning and nursery grounds for many coastal fish and invertebrates and support commercial and recreational fishing. Estuaries also contain important harbors, ports and navigational channels. The various uses of estuaries place conflicting demands and burdens on water quality. Important questions concerning beneficial uses of, and potential changes to estuaries are left unanswered without a clear understanding of estuarine water circulation processes occurring on tidal and inter-tidal time scales. With that in mind, research on water circulation in estuarine systems including exchange with offshore waters is crucial for the short- and long-term sustainability of these systems.

Knowledge on water circulation is necessary for a better understanding of the biological, chemical and physical processes taking place. Research on hydrodynamics of estuarine systems including exchange with the open sea is crucial for the short- and long-term sustainability of those systems.

One such system is at Manda Bay located in Lamu along the northern part of Kenyan coast. In this study, we focus on water movements in Manda bay and their response to tidal forcing and explore the possibility of predicting the hydrodynamics of the bay by means of mathematical modeling. The study also assessed how the bay responds to different scenarios associated with alteration of bathymetry due to berth construction and dredging of the main channel at the proposed Lamu port.

6.2 FIELD MEASUREMENTS

6.2.1 Measurements of Water & Currents

Two current meters were deployed in Manda bay at ‘Oceanic’ station and ‘Berth’ station.

An Aquadopp Recording Current Meter (RCM) was moored at about 2m below the water surface during low water spring tide (LWS) close to the mouth of Manda bay within the proposed location of the main navigation channel (Oceanic station). This equipment was utilised to monitor variations of water levels as well as current velocities at intervals of 10 minutes. The pressure sensor has a water level range of 0 to 15m and an accuracy of ±1.5cm. The duration of deployment was 45 days.

During the same period, an Aanderaa recording current meter was moored at the proposed location of berth ‘A’ about 2m below the water surface during LWS (Berth station). This RCM was programmed to measure and record current speed and directions at 10 minutes interval. The
current velocity sensor has a velocity range of 0 to 3 ms\(^{-1}\) and a precision of ±2 cms\(^{-1}\). The magnetic compass Hall Effect type of the current direction sensor has a precision of ±1.5°. The scheduled sampling period was 45 days (22 October – 7 December 2010). The RCM is also equipped with an additional sensor for measuring and recording water temperature. The temperature sensor has a precision of ±0.1° C.

6.2.2. Monitoring of water elevations by Lamu tide gauge

In this assessment study one year time series of sea level observations from a tide gauge installed at fisheries jetty in Lamu Island was utilized, fairly close to the proposed location of Lamu port. The Lamu tide gauge, managed by Kenya Marine & Fisheries Research Institute (KMFRI) is a principal station on the Global Sea Level Observing System (GLOSS) network. It measures sea level at 15 minutes interval and transmits a signal every hour to University of Hawaii Sea Level Centre for inclusion in the global sea level database. Data from this station is for monitoring climate change induced sea level rise and also for detecting extreme oceanic events such as storm surges, tropical cyclones and tsunamis.

The station is equipped with 3 sensors

i) Float

ii) Radar

iii) Pressure sensor

The additional sensors are for redundancy checks in the system. Figure (6) - 1 below is a photo of the Lamu tide gauge station.

![KMFRI GLOSS Tide Gauge at Fisheries Jetty in Lamu Island.](image)
Table 6a: Main Tidal Constituents from Harmonic Analysis Results from T_TIDE software. (Station Name: Lamu tide gauge)

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Constituent name</th>
<th>Amplitude (cm)</th>
<th>Phase (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₂</td>
<td>Principal Lunar semi diurnal</td>
<td>97.90</td>
<td>31.34</td>
</tr>
<tr>
<td>S₂</td>
<td>Principal Solar semi diurnal</td>
<td>48.60</td>
<td>72.92</td>
</tr>
<tr>
<td>O₁</td>
<td>Lunar declinational diurnal</td>
<td>12.51</td>
<td>4.31</td>
</tr>
<tr>
<td>K₁</td>
<td>Luni-solar declinational diurnal</td>
<td>20.79</td>
<td>358.53</td>
</tr>
<tr>
<td>K₂</td>
<td>Luni-solar declinational semi diurnal</td>
<td>14.09</td>
<td>69.38</td>
</tr>
<tr>
<td>N₂</td>
<td>Larger Lunar elliptic semi diurnal</td>
<td>18.01</td>
<td>11.38</td>
</tr>
</tbody>
</table>

Table 6b: Tidal statistics, amplitudes and phases based on harmonic analysis for Lamu tide gauge.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Formula</th>
<th>Lamu Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form number</td>
<td>((K₁+O₁)/(M₂+S₂))</td>
<td>0.23</td>
</tr>
<tr>
<td>Spring Range</td>
<td>(2.0(M₂+S₂))</td>
<td>2.93 m</td>
</tr>
<tr>
<td>Neap Range</td>
<td>(2.0(M₂-S₂))</td>
<td>0.99 m</td>
</tr>
<tr>
<td>Mean Range</td>
<td>(2.2(M₂))</td>
<td>1.96</td>
</tr>
</tbody>
</table>

6.3 OCEANOGRAPHIC CONDITIONS AT MANDA BAY

6.3.1 Tides at Lamu Tide Gauge

From observed data, water level variations at Lamu tide station are sinusoidal with two unequal peaks daily during both spring and neap tides (Figure 6 - 2).

Results of harmonic analysis performed by T_TIDE software are presented in Tables 1 and 2 and Figure 3. The semi-diurnal constituents account for over 90% of the water level variations of which \(M₂\) alone accounts for 47%.

A form number, \(F\), has been defined as the ratio of the sum of amplitudes of diurnal tidal species over semi-diurnal species. According to Defant (1958), a simplified definition for \(F\), \(F = (k₁+O₁)/(M₂+S₂)\), can be used to characterize tidal types. If \(F\) is less than 0.25, the tide is referred to as semi-diurnal, and if \(F\) is greater than 3.0, the tide is diurnal. Value of \(F\) between 0.25 and 3.0 are considered as mixed tides. From results of harmonic analysis, the form number for Lamu tide gauge station is 0.23, indicating that the tides are typically semi-diurnal. The spring tidal range for Lamu is 2.93 m while the neap range is 0.99 m.
Figure (6) - 2: Water level variations at Lamu tide gauge station during (a) Neap tides and (b) spring tides duration.
Figure (6) - 3: Time series of (a) observed, (b) computed and (c) residual water levels at KMFRI Lamu Tide gauge station for year 2009 from harmonic analysis
Table 6c: Results of Harmonic Analysis of Water Levels at Oceanic Station.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Period (h)</th>
<th>Oceanic Amplitude (m)</th>
<th>Phase (°)</th>
<th>Lamu Tide Gauge Amplitude (m)</th>
<th>Phase (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2</td>
<td>12.42</td>
<td>1.204</td>
<td>32</td>
<td>1.042</td>
<td>31</td>
</tr>
<tr>
<td>K1</td>
<td>23.93</td>
<td>0.251</td>
<td>358</td>
<td>0.204</td>
<td>358</td>
</tr>
<tr>
<td>S2</td>
<td>12.00</td>
<td>0.542</td>
<td>75</td>
<td>0.520</td>
<td>73</td>
</tr>
<tr>
<td>O1</td>
<td>25.82</td>
<td>0.086</td>
<td>8</td>
<td>0.086</td>
<td>5</td>
</tr>
<tr>
<td>P1</td>
<td>24.07</td>
<td>0.054</td>
<td>2</td>
<td>0.056</td>
<td>0</td>
</tr>
<tr>
<td>N2</td>
<td>12.66</td>
<td>0.204</td>
<td>12</td>
<td>0.191</td>
<td>11</td>
</tr>
<tr>
<td>K2</td>
<td>11.97</td>
<td>0.139</td>
<td>65</td>
<td>0.078</td>
<td>69</td>
</tr>
</tbody>
</table>

The residuals are small (~20 cm) for Lamu tide gauge station as can be seen in Figure 3(c). They could be attributed to local forcing by wind stress and air pressure fluctuations. This indicates that meteorological forcing plays a minor role in the water level variations at the station. It also further indicates that water level variations are exclusively driven by tidal forcing.

T_TIDE tidal analysis software was able to resolve tidal constituents with higher periods. A total of 68 harmonics were generated with corresponding amplitudes and phase lags (Annex I). This is attributed to the one-year continuous hourly data set (with few gaps) that was used as input data in harmonic analysis.

6.3.2 Tides at Oceanic station in Manda Bay

The water level variations at Oceanic station are sinusoidal with two unequal peaks daily. The results from harmonic analysis are presented in Table (6) - 3 and Figure (6) - 4. The semi-diurnal and diurnal constituents account for over 90% of the water level variations of which M₂ alone accounts for 48%.

The form number for Oceanic is 0.19, indicating that the tides are typically semi-diurnal. The spring tidal range for Oceanic station is 3.10 m while the corresponding neap range is 0.92. (Table (6) - 5). The amplitudes of the harmonic constituents compare fairly well with those obtained by analyzing one year of data collected by Lamu tide gauge (Table (6) - 3).

The computed phase age indicates that spring tides lag local passage of full or new moon by 41 hours, whereas the inequality phase relationship, 32° indicates that water level inequalities occur in both high and low water (see Table (6) - 5). Figure (6) - 4 shows observed sea levels at Oceanic station also indicating the semi-diurnal inequality with successive high water and successive low waters having different heights.
Figure (6) - 4: Time series of (a) observed (b) computed) and (c) residual water levels at Oceanic station in Manda Bay from harmonic analysis results.

The residuals are small (~20 cm) for Oceanic station as can be seen in Figure (6) - 4 (c). They could be due to local forcing by wind stress and air pressure fluctuations. This indicates that during the period of observations, meteorological forcing plays a minor role in the Manda Bay channel-ocean exchange processes. In this case, it also indicates that water movements in Manda Bay channel are exclusively caused by tidal forcing.

Spectral analysis results for sea level are shown in Figure (6) - 5. At the Oceanic station, the semi-diurnal and diurnal energy peaks are dominating the spectrum. At periods above 50 hours, the spectrum becomes somewhat ragged, and the computed energy peaks are probably not statistically significant. This further indicates that water level variations are exclusively driven by tidal forcing.
Current measurements at Oceanic station (Figures 6 - 6 and 6 - 7) showed that velocities in spring tides were generally higher than in neap tides. Current meter data was analyzed in a manner similar to that described above for tides. Harmonic analysis procedure was applied to the east-west \( (v) \) and north-south \( (u) \) components of velocity. The results are presented in Table (6) - 4 and Figure (6) - 10. The average flood and ebb flow directions at Oceanic station are separated by about 180° (310° during flood and 130° during ebb (Figures (6) - 8). Maximum spring velocities of 0.80 ms\(^{-1}\) and 0.50 ms\(^{-1}\) were observed during flood and ebb respectively. A scatter plot of \( u \) (along-channel) and \( v \) (cross-channel) components of velocities at Oceanic station indicates that the flow is confined along the axis of the main Manda Bay channel during both spring and neap tides (Figures (6) - 9).

The currents at Oceanic station in Manda Bay channel indicate a relatively strong asymmetry with ebb currents being stronger than flood currents. The ebb period is roughly 5.8 hours compared to a flood period of about 7 hours. This can be readily seen in Figure (6) - 12 where a comparison is made between along channel components and sea level at the Oceanic site. The asymmetry is not pronounced during neap, however. Higher velocities during ebb (0.8 ms\(^{-1}\)) as compared to flood (0.5 ms\(^{-1}\)) are because of the different flow dynamics during filling of the mangrove area (on the upstream part of the Oceanic station) compared to during emptying (Wolanski, 1990).
The asymmetric velocity is a key parameter that reflects the topography of the estuary (Shetye and Gouveia (1992)).

Although there is very little asymmetry in the tide, current measurements in Manda Bay channel reveal an asymmetry of ebb-dominance, i.e. high ebb velocities and shorter ebb periods. This asymmetry of ebb-dominance fits well with the conclusions concerning topography by Shetye and Gouveia (1992). This features are similar to those in Hinchinbrook channel (Wolanski et al., 1980) and in the North inlet, which is a channel surrounded by salt marshes (Kjerfve et al., 1991). Ebb-dominance has also been observed in deep sub-tidal channels with mudflats e.g. the Wachapreague inlet (Boon and Byrne, 1981). Non-linear friction effects in the mangrove swamps could result in an asymmetry between the filling and emptying of the mangrove swamps (Wolanski et al., 1980).

Comparison of water levels and current velocities indicate that water levels lead the currents by an average of 3.45 hours (104°) suggesting that water movements represent barotropic standing waves. Slack waters coincide with the times of high and low water. The two variables are almost out of phase. Zero velocities in the channel lag the occurrence of high water and low water by 0.6 hours and 0.2 hours respectively (Figures (6) - 12).

![Figures (6) - 6: Time series of along-channel (u) velocity component at Oceanic station.](image-url)
Figures (6) - 7: Time Series of Across-Channel ($v$) Velocity Component at Oceanic Station.

Figures (6) - 8: Direction Verses Current Speed at Oceanic Station.
Figures (6) - 9: Scatter Plot of along - Verses Cross-Channel Velocity Components at Oceanic Station.

Table 6d: Results of Harmonic Analysis of Current Velocities in Oceanic Station

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Period (h)</th>
<th>(u)-component</th>
<th>(v)-component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Amplitude (cm)</td>
<td>Phase (°)</td>
</tr>
<tr>
<td>M(_2)</td>
<td>12.42</td>
<td>29.16</td>
<td>341</td>
</tr>
<tr>
<td>K(_1)</td>
<td>23.93</td>
<td>5.33</td>
<td>39</td>
</tr>
<tr>
<td>S(_2)</td>
<td>12.00</td>
<td>18.15</td>
<td>47</td>
</tr>
<tr>
<td>O(_1)</td>
<td>25.82</td>
<td>5.72</td>
<td>51</td>
</tr>
<tr>
<td>P(_1)</td>
<td>24.07</td>
<td>2.52</td>
<td>24</td>
</tr>
<tr>
<td>N(_2)</td>
<td>12.66</td>
<td>3.84</td>
<td>156</td>
</tr>
<tr>
<td>K(_2)</td>
<td>11.97</td>
<td>1.20</td>
<td>172</td>
</tr>
</tbody>
</table>
Table 6e: Tidal Statistics, Amplitudes and Phases Based on Harmonic Analysis.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Formula</th>
<th>Water Levels Oceanic station</th>
<th>Current Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form number</td>
<td>( \frac{(K_1+O_1)}{(M_2+S_2)} )</td>
<td>0.19</td>
<td>0.23</td>
</tr>
<tr>
<td>Inequality Phase</td>
<td>( M_2-\frac{(K_1+O_1)}{2} )</td>
<td>-116°</td>
<td>264°</td>
</tr>
<tr>
<td>Relationship</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase age</td>
<td>0.98( S_2-M_2 )</td>
<td>48</td>
<td>26</td>
</tr>
<tr>
<td>Mean Range</td>
<td>2.2( M_2 )</td>
<td>2.28</td>
<td>0.64</td>
</tr>
<tr>
<td>Spring Range</td>
<td>2.0( M_2+S_2 )</td>
<td>3.20</td>
<td>0.92</td>
</tr>
<tr>
<td>Neap Range</td>
<td>2.0( M_2-S_2 )</td>
<td>1.02</td>
<td>0.26</td>
</tr>
<tr>
<td>Tropic Range</td>
<td>2.0( K_1+O_1 )</td>
<td>0.54</td>
<td>0.20</td>
</tr>
<tr>
<td>Equatorial Range</td>
<td>2.0( K_1-O_1 )</td>
<td>0.24</td>
<td>0.02</td>
</tr>
<tr>
<td>Diurnal Age</td>
<td>0.91( K_1-O_1 )</td>
<td>112°</td>
<td>-34°</td>
</tr>
</tbody>
</table>

Harmonic analysis results of along channel (u) and cross channel (v) velocities using 7 principal tidal constituents are presented in Table (6) - 4. The results reveal that tidal currents dominate the flow. Like the water levels, the semi-diurnal and diurnal constituents account for more than 90% of the total variability. \( M_2 \) tidal constituent alone accounts for over 40%.

As in the case of tides, a form number can be defined to characterize tidal current types where \( F \) is the ratio of the sum of the semi-major axes of tidal current ellipses for diurnal over semi-diurnal constituents. The computed \( F \) value is 0.23 thus indicating that the currents in Oceanic station can be characterized as semi-diurnal (Table (6) - 5). The maximum current speed at spring tide is estimated by \( (M_2+S_2) + (k_1+O_1) \), where the four major harmonics are assumed to be in phase. The maximum current speed at neap tides is estimated to be not less than \( (M_2-S_2) + (O_1-K_1) \) where \( M_2 \) and \( S_2 \), \( O_1 \) and \( K_1 \) are assumed to be out of phase at the same time.

Comparison of the relative phase differences between the tides and tidal currents reinforces the conclusion that the tides in Oceanic are primarily standing waves. The phase of \( M_2 \) and \( K_1 \) tidal currents at the entrance are compared with the phases of tidal levels at Oceanic station. The phase differences are 86° and 82° for \( M_2 \) and \( K_1 \) respectively with the tides leading the tidal current. For a pure standing wave, the phase of the tidal-height leads the phase of tidal current by exactly 90°.

Spectral analysis results for currents are shown in Figure (6) - 13. At the Oceanic station, the semi-diurnal and diurnal energy peaks are dominating the energy spectrum indicating that tidal forcing is driving water movements at the site.
Figure (6) - 12: Time series of (a) observed, (b) computed and (c) residual $u$-velocity component at Oceanic station from harmonic analysis.

Figures (6) - 13: Time series of (a) observed, (b) computed and (c) residual $v$-velocity component at Oceanic station from harmonic analysis.
Figures (6) - 14: Comparison of Water Levels (solid line) and Current Velocities (dotted line) at Oceanic Station.

Figure (6) - 15: Relative energy density spectrum of (a) $u$-velocity and (b) $v$-velocity components at Oceanic station from spectral analysis.
6.5 WATER TEMPERATURES

Water temperatures at Oceanic station varied from 26.7°C to 28.9°C with a mean of 27.2°C. A comparison between water levels and temperatures at Oceanic station is shown in Figure (6) - 14. When the temperatures are related to the time of the day, the maximum are observed between 12-13 h, corresponding to mid-day time when there is maximum solar radiation. Another peak appears at about 18 h, corresponding to the high water time when warmer surface water from the ocean moves into the channel. There is no corresponding peak during the morning HW time, and this is probably because at this time the ocean surface water has not been heated by solar radiation.

At Oceanic station, the temperature decreases during flood (Figure (6) - 15). Semi-diurnal variability is apparent at this site, where the flood is bringing more cool water into the channel from the deep Indian Ocean. Temperature variations at Oceanic could be attributed to rapid tidal flushing and the effect of wind. Similar patterns in water temperatures have also been observed in Tudor Creek (Odido, 1994) and Mtwapa Creek (Magori, 2004) in Mombasa.

In general, the temperature variations at Oceanic station are dominated by the diurnal solar heating and night cooling due to a combination of evaporation and long wave back radiation. Temperature rise and fall patterns were asymmetric with rapid rises during the day and gradual decreases in the evening and night.

Figure (6) - 16: Time Series of Water Temperatures Recorded at Oceanic Station
Figures (6)-17: Comparison of (a) water temperature and (b) water levels at Oceanic station.

6.6 TURBIDITY LOAD FOR DISPERSE SIMULATION

6.6.1 Available Data

Among the borehole log data in Manda Bay, the relevant data to the urgent development phase, inter alias, dredging and reclamation are the data at the location No.11, B, 8, 10, C and BB. The data at No.11 is isolated and different from others because the log does not show any silty stratum but sand. The rest all contains the silty and sandy layers. Due to the certain financial reasons of the Kenya Government, the results of sieve test analysis are available only for No.11 and No. B.

The data, except for ones at No.11, are studied to estimate the turbidity load during dredging/reclamation operations in the urgent development phase. It is noticed the all the data show both sandy/gravel strata and silty/clayey strata. For simplicity of the estimate, the only the strata above -18.5 m below CD are considered because the deepest dredging depth is -17.5m plus one meter dredging allowance for the cutter suction dredger of the 10,000HP. Based on the borehole logs data, all strata are divided in to two i.e., sand and gravel and silt and clay strata for calculating the turbidity.
By studying the sieve test analysis at Bore Hole No.B, even the sandy strata have silty/clayey soil element and the silty/clayey strata have sand/gravel element. The sand/gravel elements sink rapidly and do not float from the bottom once discharged from the pipeline and sink to reach the marine bottom, while the silty/clayey elements disperse and suspend in the water.

<table>
<thead>
<tr>
<th>Bore Hole Log Data</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. B</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>No. 8</td>
<td>5</td>
<td>1.5</td>
</tr>
<tr>
<td>No. 10</td>
<td>7.5</td>
<td>4</td>
</tr>
<tr>
<td>No. C</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>No.BB</td>
<td>8.5</td>
<td>2.5</td>
</tr>
<tr>
<td>total strata depth (m)</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>constituent ratio</td>
<td>0.333333</td>
<td>0.666667</td>
</tr>
</tbody>
</table>

Table 6f: Borehole Data

Table 6g: Borehole Sieve Test Analysis

<table>
<thead>
<tr>
<th>Bore Hole Sieve Test Analysis</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CD level Depth m</td>
<td>clay</td>
<td>silt</td>
<td>sand</td>
<td>gravel</td>
</tr>
<tr>
<td>0.0–2.0</td>
<td>9</td>
<td>4</td>
<td>77</td>
<td>10</td>
</tr>
<tr>
<td>2.0–4.0</td>
<td>30</td>
<td>11</td>
<td>55</td>
<td>4</td>
</tr>
<tr>
<td>sand stratum composition</td>
<td>20</td>
<td>7</td>
<td>66</td>
<td>7</td>
</tr>
<tr>
<td>4.0–6.0</td>
<td>25</td>
<td>30</td>
<td>44</td>
<td>1</td>
</tr>
<tr>
<td>6.0–8.0</td>
<td>28</td>
<td>19</td>
<td>51</td>
<td>2</td>
</tr>
<tr>
<td>clay stratum composition</td>
<td>27</td>
<td>24</td>
<td>47</td>
<td>2</td>
</tr>
</tbody>
</table>

(Source: JPC)

6.2.2 Method of Estimate of Turbidity Load:

1) From the Table (6) – 6 the Borehole log data, it is assumed that one third of the total dredging material are sandy material and the rest clayey/silty material.

2) From the Table (6) – 7 the sieve test analysis, sandy/clayey strata have the shown constitutive ratio of the various grain size ranges respectively.

3) The clayey strata material is to be chipped into fragments by the cutter head and partially melt into the water while being transported through the discharge pipeline for one to several kilometers. The melting ratio is assumed as 15% ~ 25%.
4) One way to estimate the average turbidity discharge is to calculate the constitutive ratio of the grain size category based on the weighted average of the ratio as the mixture of the sandy and clayey strata. (refer to 1) and 2) above)

5) The other way might be show two cases of only sandy and only clayey strata dredging separately. The total dredging operations periods is about 36 months and 12 month might be sand dredging and the rest clayey dredging in total.

6) It is conceivable to carry out the stochastic simulation selecting the clayey and sandy strata with the probability of 2/3 and 1/3 as the turbidity load, but it may only complicate the analyses without much improvement of our understanding on the phenomenon. Because it may take long calculation time to reach the equilibrium.

7) **Case 1-1 Mixture Dredging** Turbidity load is shown in the bottom line, i.e. clay load is 369 tons and silty load 273 tons per day respectively.

8) **Case 1-2 Sandy Layer Dredging** Assuming the case of dredging only sandy layer, the turbidity load is shown in the seventh line in the table.

9) **Case 1-3 Clayey Layer Dredging** For the case of dredging only clayey and silty layer, the load in the eleventh line.

![Table 6h: Turbidity Load Estimation](image)

Source: JPC

10) **Sensitivity Analysis for the melting ratio;** The clay melting ratio is assumed completely without any experiments but only intuitively. Because the experimental method itself is not established yet nor the financial restriction allows the study team to carry out the additional experiments, since we cannot afford to get the sieve test results which have already been completed and waiting for delivery upon the receipt of payments. The sensitivity is checked by altering the melting ratio to 25%.

**Case 2-1, Case 2-2 and Case 2-3** is corresponds to **case 1-1, 1-2 and 1-3** respectively.
The turbidity load for each case is shown in the 15th, seventh and 11th lines.

Table 6i: Turbidity Load Estimation (Alternative Melting Ratio)

<table>
<thead>
<tr>
<th>Clay</th>
<th>Silt</th>
<th>Sand</th>
<th>Gravel</th>
<th>Cobble</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>1.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.34</td>
<td>0.068</td>
<td>0.0238</td>
<td>0.2244</td>
<td>0.0238</td>
<td>0.34</td>
</tr>
<tr>
<td>1500</td>
<td>300</td>
<td>105</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clay melt in discharge pipes*²</th>
<th>0.25</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay load t/d *¹</td>
<td>1,000</td>
<td>1,500</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Silt &amp; Clay</th>
<th>0.66</th>
<th>0.1782</th>
<th>0.1584</th>
<th>0.3102</th>
<th>0.0132</th>
<th>0.66</th>
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<tbody>
<tr>
<td>1500</td>
<td>405</td>
<td>360</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1,350</td>
<td>5,143</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

| Mixture | 0.2462 | 0.1822 | 0.5346 | 0.037 | 0.1 | 1 |
|---------|--------|--------|--------|-------|-----|
| 100 |        |        |        |        |     |

<table>
<thead>
<tr>
<th>Dredging capacity m³/h</th>
<th>1500</th>
<th>369.3</th>
<th>273.3</th>
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</thead>
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<tr>
<td>Dredge t/d</td>
<td>1,231</td>
<td>3,904</td>
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</tr>
</tbody>
</table>

\*²: Clay melts in discharge pipes
\*¹: 20 hour per day operations

(Source: JPC)

6.7 RESULTS

Figure (6) – 16: Envelops of SS Density Dist. (Case1-1, no enclosure revetments built; Dry season) unit: mg/l
Figure (6) – 17: Envelops of SS Density Dist. (Case1-1, no enclosure revet. built; Rainy season)  unit: mg/l

Figure (6) – 18: Envelops of SS Density Dist. (Case1-1, partially reclaimed; Dry season)  unit: mg/l
Figure (6) – 19: Envelops of SS Density Dist.  
(Case1-1, partially reclaimed; Rainy season)  unit: mg/l

Figure (6) – 20: Envelops of SS Density Dist  
(Case1-2, no enclosure revet.; Dry season)  unit: mg/l
Figure (6) – 21: Envelops of SS Density Dist. (Case 1-2, no enclosure revet.; Rain season) unit: mg/l

Figure (6) – 22: Envelops of SS Density Dist. (Case 1-2, Partially Reclaimed; Dry season) unit: mg/l
Figure (6) – 23: Envelops of SS Density Dist.
(Case1-2, Partially Reclaimed; Rainy season)  unit: mg/l

Figure (6) – 24: Envelops of SS Density Dist.
(Case1-3, No enclosure rev.; Dry season)  unit: mg/l
Figure (6) – 25: Envelops of SS Density Dist. 
(Case 1-3, No enclosure rev.; Rainy season)  unit: mg/l

Figure (6) – 26: Envelops of SS Density Dist. 
(Case 1-3, Partially Reclaimed; Dry season)  unit: mg/l
ESIA for the First 3 Berths of Lamu Port & Associated Infrastructure

Ministry of Transport

Figure (6) – 27: Envelops of SS Density Dist. (Case1-3, Partially Reclaimed; Rainy season)  unit: mg/l

Figure (6) – 28: Envelops of SS Density Dist. (Case2-1, No enclosure rev.; Dry season)  unit: mg/l
Figure (6) – 29: Envelops of SS Density Dist.  
(Case 2-1, No enclosure rev.; Rainy season)  unit: mg/l

Figure (6) – 30: Envelops of SS Density Dist.  
(Case 2-1, Partially Reclaimed; Dry season)  unit: mg/l
Figure (6) – 31: Envelops of SS Density Dist.
(Case2-1, Partially Reclaimed; Rainy season)  unit: mg/l

Figure (6) – 32: Envelops of SS Density Dist.
(Case2-2, No enclosure rev.; Dry season)  unit: mg/l
Figure (6) – 33: Envelops of SS Density Dist. (Case2-2, No enclosure rev.; Rainy season) unit: mg/l

Figure (6) – 34: Envelops of SS Density Dist. (Case2-2, Partially Reclaimed; Dry season) unit: mg/l
Figure (6) – 35: Envelops of SS Density Dist. (Case2-2, Partially Reclaimed; Rainy season)  unit: mg/l

Figure (6) – 36: Envelops of SS Density Dist. (Case2-3, No enclosure rev.; Dry season)  unit: mg/l
Figure (6) – 37: Envelops of SS Density Dist. (Case2-3, No enclosure rev.; Rainy season) unit: mg/l

Figure (6) – 38: Envelops of SS Density Dist. (Case2-3, Partially Reclaimed; Dry season) unit: mg/l
Figure (6) – 39: Envelops of SS Density Dist. (Case 2-2, Partially Reclaimed; Rainy season) unit: mg/l
7. BIOLOGICAL ENVIRONMENT – MARINE & TERRESTRIAL LIFE

7.1 MARINE LIFE

Marine life in the project area comprises of:

*Seagrass*

Seagrass are submerged flowering plants found in shallow marine waters, such as bays and lagoons and along the continental shelves. They are a vital part of the marine ecosystem due to their productivity level, provision of food, habitat, and nursery areas for numerous vertebrate and invertebrate species. The vast biodiversity and sensitivity to changes in water quality inherent in seagrass communities makes seagrass an important species to help determine the overall health of coastal ecosystems. Seagrass stabilizes sediments and prevents erosion. Seagrass provide food, shelter, and essential nursery areas to commercial and recreational fishery species and to countless invertebrates living in seagrass communities.

*Seaweeds*

Seaweeds provide home and food for many different sea animals, lend beauty to the underwater landscape, and are directly valuable to man as a food and industrial raw material. Together with phytoplankton, seaweeds form the basis of the food chain in the sea. Seaweeds are also vital as a habitat for all sorts of other marine organisms. Modern science uses extracts from certain seaweeds as stabilizers, gelling agents or emulsifiers, in thousands of everyday products from pet food to dental moulds. In the East there are vast farms where seaweeds are grown for food. They are highly nutritious and particularly rich in some vitamins and trace elements.

*Macrofauna (Soft Bottom Sediment)*

Macrofauna, including fish eggs play important roles in ecosystem functioning. They form part of food web, providing food to secondary consumers mainly invertebrates and juvenile vertebrates. Macrofauna activity impacts global carbon, nitrogen and sulphur cycling, transport, burial and metabolism of pollutants, biodeposition and transport of sediments. In addition, due to their sedentary behaviour and a wide range of physiological tolerances, they are used as indicators of environmental quality. Macrofauna also form part of invasive and fouling organisms. Invasive species have the ability to prey on other species if introduced to a new environment where they never existed, as such they can find their way into ballast water and cause problems elsewhere. Fouling organisms cause corrosion of marine structures and vessels which has economic implications when losses occur.

*Zooplankton*

Zooplankton communities play a major role in the ecosystem and economy of Kenya. They provide a source of food to the consumers in higher trophic levels and provide a conduit for packaging the organic material in the biological pump. Most importantly, they are a critical source
of first food for post larvae fish thus their knowledge plays a significant part in fisheries management.
Fig (7)-1 Key Environmental Issues in Project Area
Fig (7)-2 Environmental Sensitivity Map of the Project Area
**Phytoplankton**

Phytoplankton are microscopic algae that swim or float in water. They include single-cells, colonies of cells, and filaments (linear strings of cells) that are usually capable of photosynthesis. Floating or swimming cyanobacteria, which are prokaryotes (lacking a true nucleus), are often regarded as phytoplankton, because they are photosynthetic. Phytoplankton, together with other algae and plants, are the source of most of the oxygen in Earth's atmosphere.

### 7.1.1 Methodology for Marine Ecological Assessment

A review of the technical information on the proposed project was made from project documents and a scooping exercise undertaken to identify and focus marine biological and environmental issues and concerns into an investigation framework that informed this EIA study. The biological field study was designed with a careful selection of study site locations focusing on flora and fauna in several locations likely to suffer direct impacts and indirect impacts. An ecological survey team was assembled comprising scientific divers, marine ecologists, fish specialists and GIS experts.

**Sampling Locations**

Sampling was done at four stations (A,B,C,D) with the following points:

- 2.19993S 40.93101E
- 2.19449S 40.9272E
- 2.19433S 40.92319E
- 2.19124S 40.92325E

The stations were situated within and near the proposed site. The proposed site for the first three berths extends 1 km towards the intertidal area. The stations were used for seaweed, macrofauna and plankton sampling, with little variations. Identification was done to species level where possible. Abundance, composition and Shannon-Weiner diversity index were calculated and plotted accordingly.

**Seagrass Sampling**

Sampling of seagrass was done using three 50 m transects at each station. The transects were laid perpendicular to the shoreline and stretching about 100 m apart. Quadrants (50*50 cm) divided into 100 sectors (each sector representing 1%) were laid at 5 m intervals along the 50 m transect for visual percentage cover estimation. Canopy height was also measured for dominant species. Seagrass methodology was guided by Seagrass net protocol as described by Short et al (2006).

**Seaweed Sampling**

Seaweed sampling was done at the same time as the seagrass sampling, using the same transects and quadrants and using similar methodology (Seagrass net protocol as described by Short et al (2006).
Macrofauna Sampling

Macrofauna samples were collected from four stations characterised by soft sediment, mainly sand and mud, using core sampler (6.4 cm diameter) and according to Eleftheriou and Eleftheriou (2005). Collected samples were fixed in 5% formalin and taken to the lab for identification and classified using Branch and Griffiths (2002) and Richmond (2002).

Zooplankton Sampling

Sampling of zooplankton was done using a bongo net (300µm) attached to a flow meter and towed from the back of a boat cruising at a speed of about one knot for five minutes. This method was adapted from Osore et al. (2003). Collected samples were fixed in 5% formalin and taken to the lab for identification and classification using Bradford-Grieve et al. (1999) and Conway et al. 2003.

Phytoplankton Study

The phytoplankton study involved collection of triplicate samples from the shallow sampling points onboard vessel using a 20 L bucket and sieved through 20 µm mesh size plankton net. They were then transferred to 100 ml sample bottles and preserved in Lugo’s solution for identification (Grethe, et al.,1997) and enumeration in the laboratory.

7.1.2 Detailed Field Methodologies for Biological Studies

Fieldwork focused on flora and fauna existing at different levels: water column, soft sediment, hard substrata, beach and tidal flats, and seagrass beds. A total of 16 study locations were selected (Figure 7-4) and a multiple set of techniques used for biological assessments studies (see table yy below).
Fig 7-4: Study locations in the EIA survey for the Biological Studies at the proposed first 3 berths of Lamu

- Red dot represents underwater diver census surveys for benthic habitats and fish (13 sites), while
- Green dot represents fishermen haul areas (3 sites)
7.1.3 Sampling methods used in the baseline survey

The following habitat and taxa-specific techniques were used (Table 5-1):

Table 5a: taxa-specific techniques used in the biological assessments

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Sampling methods</th>
<th>Photo presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live fish and other mobile fauna</td>
<td>• Underwater visual census along four sets of 25m belt transects, each 5m wide.</td>
<td><img src="image1" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td>• Observation guides provided</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Unfamiliar taxa photographed and analysed at KMFRI Labs in Mombasa</td>
<td><img src="image2" alt="Image" /></td>
</tr>
<tr>
<td>Benthic habitats: Seagrass, seaweeds and sponges</td>
<td>• Underwater visual census along 50 m transects used with shoot density taken every 10m at 5 m areas</td>
<td><img src="image3" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td>• Quadrat size for percentage cover used was 50 cm * 50 cm</td>
<td><img src="image4" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td>• Quadrat size for canopy height and density at 25 cm * 25 cm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Unfamiliar species hauled on deck for taxonomic analysis</td>
<td></td>
</tr>
<tr>
<td>Fishermen fish hauls</td>
<td>• A team of fishermen were contracted to do a special haul for this investigation.</td>
<td><img src="image5" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td>• Their catch was analysed using standards statistical and taxonomic methods</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 fishers (2 women &amp; 3 men) encountered collecting holothuridea were interviewed for their catch information and data</td>
<td><img src="image6" alt="Image" /></td>
</tr>
</tbody>
</table>
7.1.4 Results

a) Seagrass Abundance and Composition

The proposed port site was found to be surrounded by seagrass beds and results revealed 44% abundance, 39% sand and 14% seaweed (Figure 7-5). Eight out of 12 species of seagrass occurring in the Western Indian Ocean region were found, representing 67% occurrence. The species were Cymodocea serrulata, Syringodium isoetifolium, Halophila stipulacea, Thalassia hemprichii, Halodule wrightii, Thalassodendron ciliatum, Enhalus acoroides, Halophila ovalis. Syringodium isoetifolium comprised of the highest percent cover and Halophila stipulacea the lowest (Figure 7-6). The species Syringodium isoetifolium and Enhalus acoroides were dominant in stations B and C respectively (Figure 7-7). Canopy height varied depending on the species (Figure 7-8). Halophila ovalis represented highest percentage of maximum height (recorded maximum height the species can attain) and Enhalus acoroides, the lowest, a sign for relatively high disturbance for this species as indicated by observed grazing. The species was probably grazed by turtles and other herbivores.

![Figure 7-5: Seagrass and seaweed abundance within and around the proposed site](image)

![Figure 7-6: Overall mean (±SE) percentage seagrass cover.](image)
Figure 7-7: Seagrass mean (±SE) percentage cover grouped by station.

Figure 7-8: Seagrass canopy mean (±SE) height and percentage maximum species height (max. height species can grow)
b) Seaweed Abundance and Composition

Seaweed abundance was 14% (Figure 7.9) comprising of 16 species, namely, Gracilaria sp., Halimeda sp., Padina sp., Amphiroa sp., Rosevinglea intricate, Hypnea nidifica, Dictyota sp., Caulerpa sp., Ulva sp., Stoechospermum sp., Jania adhaerens, Ceratodictyon sp., Chaetomorpha crassa, sargassum sp., Udotea indica and Codium geppii. The site was generally dominated by Halimeda sp. while Sargassum sp. was least dominant. (Figure 7.10). Per station, Station A represented the highest abundance and Station C lowest (Figure 7.11).
c) Macrofauna Abundance, Composition, distribution and Diversity

A total of 21 taxa comprising of 116 species (annexed) were identified, namely, Amphipoda, Bivalvia, Ciliophora, Cnidaria, Copepoda, Cumacea, Gastropoda, Insecta, Isopoda, Loricifera, Mollusca, Nematoda, Oligochaeta, Opisthobranchia, Ostracoda, Polychaeta, Priapulida, Spicula, Tanaidacea and Thecata, Turbellaria. Benthic fish eggs (mean density, $103.6 \pm 25.91$) were also found suggesting that the site could be a breeding ground for fishes. The taxon Gastropoda, comprising of 13 species was most abundant while the least abundant were Loricifera and Thecata comprising of one species each (Figure 7). Polychaetes comprised of the highest species number (26). Overall mean species richness was $17.7 \pm 1.63$ and mean Shannon-Wiener diversity index $1.1 \pm 0.04$. Non metric Multi Dimensional Scaling (MDS) plot showed distinct species composition and distribution of macrofauna between the stations (figure 7-11).
**Figure 7-12:** Overall mean (±SE) macrofauna density and species distribution in each taxon.

**Figure 7-13:** Non-metric MDS plot showing the composition and distribution of macrofauna in three different stations, based on species abundance of Log(X + 1) transformed data.

d) **Zooplankton abundance, composition and diversity**

Zooplankton communities comprised of 18 main taxa and 48 sub-taxa (annexed), namely, Tintinnida, Brachyura, Larvacea, Copepoda, Caridea, Chaetognatha, Stomatopoda, Cavoliniidae, Cephalopoda, Mollusca, Ctenophora, Geryonidae, Amphipoda, Annelida, Caligidae, Scyphozoan,
Nematoda and Pycnogonida. Planktonic fish eggs and larvae were also found with a mean density of $427.5 \pm 220.04$ m$^{-3}$. The taxa Tintinnida and Brachyura were most abundant while Geryonidae was least abundant (Figure 7-12). The taxon Brachyura comprises of marine crabs, probably representing planktonic stages of mangrove crabs, some of which (mangrove crab, *Scylla serrata*) form important component of highly expensive and scarce seafood delicacies. Copepoda, that was relatively abundant, was represented by the highest number of species. Copepods are a major source of food for post fish larvae. The taxa Amphipoda, Annelida, Caligidae, Nematoda, Pycnogonida and Scyphozoan were least represented with a total of one species each. Overall mean species richness was $24.3 \pm 1.75$ and overall Shannon-wiener diversity index $0.9 \pm 0.08$.

![Figure 7-14: Overall mean (±SE) zooplankton abundance and species distribution by taxon.](image)

**Phytoplankton**

e) **Phytoplankton abundance, distribution and diversity**

A total of 41 species of phytoplankton were identified namely, *Coelosphaerium* sp., *Scenedesmus* sp., *Micractis* sp., *Chlamydomonas* sp., *Enteromorpha* sp., *Chaetomorpha* sp., *Vovox* sp., *Ankistrodesmus* sp., *Protoderma* sp., *Characium* sp., *Laminaria* sp., *Aplatodora* sp., *Chlorosarcinopsis* sp., *Axlosphaera* sp., *Aphanopchaete* sp., *Dinophysis* sp., *Microspora* sp., *Pleodorina* sp., *Sphaeroplea* sp., *Scribelowena* sp., *Striella* sp., *Odontella* sp., *Acetabularia* sp., *Bulbochaete* sp., *Ceratium* sp., *Cladophoropsis* sp., *Codium* sp., *Coelastrum* sp., *Cylindrospermum* sp., *Dictyocha* sp., *Eucoceros* sp., *Erythrocladia* sp., *Fragilariopsis* sp., *Gloeacapsa* sp., *Pinularia* sp., *Prasiola* sp., *Punctaria* sp., *Rhizosolenia* sp., *Stichococcus* sp., *Thalassionema* sp. and *Ulothrix* sp. The highest mean density was represented by *Coelosphaerium* sp. (454,166.6 ± 227,083.33 Cells/L). Overall mean species richness was $8.25 \pm 0.91$ and overall Shannon-Wiener diversity index was $0.7 \pm 0.05$.Per station, the highest phytoplankton density was in Station B (closest to the mangroves and comprising 12 species) and lowest Stations D and A (Figure 7-14)
7.2 TERRESTRIAL LIFE

7.2.1 Introduction

Project activities including dredging, land reclamation, road construction, and soil compacting will impact on marine and coastal environment in the project area in a number of ways. Of ecological significance in the pilot area are the mangrove forests. These forests form belts of fringing vegetation between high and low water marks of spring tide. Mangrove forests, a combination of woody trees and shrubs found along sheltered tropical and subtropical coastlines cover an area of about 152,000 km² globally (Spalding et al. 2010).

Although mangroves are able to grow on sand, peat, rock and coral, the most extensive and luxuriant forests are often associated with muddy soils usually found along deltaic coasts, in lagoons and along estuarine environments (Saenger, 2002). Mangrove forests are among the most productive ecosystems and offer a variety of goods and services, including:
Figure 7–16: Percentage of respondents (n = 100) depending on mangroves for various uses at Mida Creek, Kenya
(Source: Dahdouh-Guebas et al. 2000).

1) Provisioning Services:
Mangroves provide a diversity of forest products including wood for timber, fuel wood, poles and boat construction among other uses (Aksornkoe 1987; Dahdouh-Guebas et al. 2000; Field 2000). Mangrove timber is valuable for construction to coastal communities especially because of its resistant to rotting and insect attacks. Mangrove wood has the highest calorific energy value of any word products; no wonder they are used as fuelwood in industries. In Kenya Rhizophora mucronata and Ceriops tagal are the most preferred species for domestic and commercial uses (Dahdouh-Guebas et al. 2000, Kairo et al., 2002) because of their excellent wood quality. Additionally, mangrove forests provide rich fisheries, both fin and shellfish (Ngoile and Shunula 1992, Sasekumar et al. 1992, Ronnback et al. 2002). A variety of traditional products extracted from mangroves include medicines, and tannins used for coating and preserving wood, nets and other fishing gear as well as dying of clothes; and honey especially from Avicennia spp (Field 2000, pers obs).

2) Regulating Service:
Mangroves stabilise shorelines by their intricate root networks (Teas 1977, Field 1995, UNEP_WCMC 2006), and thus help in controlling soil erosion. The root network and the trees themselves form a barrier against storm surges which protects farmlands and human habitations in the backyard of mangroves. During the Dec 2004 tsunami, shorelines with healthy mangrove forests experienced less damage than degraded ones (Dahdouh-Guebas et al. 2005). Mangroves also trap land based sediments, heavy metals, nitrogen from domestic wastes and other pollutants, (Ewel et al. 1998; Machado et al. 2002; Silva et al. 2003) thus moderating water quality and protects the integrity of adjacent ecosystems (sea grass beds and coral reefs). Mangroves fix and store significant amounts of carbon (Alongi 2002) and play an important role in carbon
sequestration by absorbing an estimated $218 \times 10^6$ ton C a year (Bouillon et al. 2008), hence moderating global climate change.

Figure 7 – 17: Map of Kenya showing major mangrove locations  
(Source: Kairo 2001 modified)

3) Supporting Services:

Mangrove organic productivity (Odum and Heald 1972, Boto and Bunt 1981) has been suggested to support nearshore fisheries production (Lee 1999). The organic material produced by the system serves as the base for a complex chain of food-web which supports a wide variety of marine life. The mangrove environment supports a rich nursery and breeding ground of many fish species, which may be harvested within the mangroves or they may leave the system at a certain stage of their life cycle to nearshore waters thus representing some form of biotic export. Other wildlife that utilize mangroves as feeding and breeding grounds includes seabirds, alligators, and thousands of insects and other invertebrates’ species (Hamilton and Snedaker 1984, Slim et al. 1997, Alongi 1994, Ashton et al. 2003)

4) Cultural services:

Many local communities use designated locations in mangrove forests as sacred shrines where tree extraction is forbidden (UNEP-WCMC 2006, pers obs). While mangroves are not traditionally viewed as tourist attractions, there is a growing interest in the ecosystem for eco-
tourism due to its unique structure and diversity (UNEP-WCMC 2006). Through the construction of mangrove boardwalks, visits to mangroves have become an emerging alternative livelihood to mangrove dependent communities. In Kenya mangroves cover about 64,400 ha (Dadouh-Guebas et al. 2000); representing 3% of the forested area of Kenya; or only 1% of state land (Wass 1992). A bulk of these mangroves is found in Lamu and the surrounding islands.

Table (7) –18: The orders and genera of mangrove species recorded along the east African coast

<table>
<thead>
<tr>
<th>Family</th>
<th>Genus</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>1). Rhizophoraceae</td>
<td>1. Rhizophora</td>
<td>1. R. mucronata</td>
</tr>
<tr>
<td></td>
<td>2. Ceriops</td>
<td>2. C. tagal</td>
</tr>
<tr>
<td></td>
<td>3. Bruguiera</td>
<td>3. B. gymnorrhiza</td>
</tr>
<tr>
<td>3). Sonneratiaceae</td>
<td>5. Sonneratia</td>
<td>5. S. alba</td>
</tr>
<tr>
<td>5). Meliaceae</td>
<td>7. Xylocarpus</td>
<td>7. X. granatum</td>
</tr>
</tbody>
</table>

(Source: Banyikwa, 1986; Nomenclature according to Tomlinson, 1986)

Other important mangrove locations include: Tana, Mida Creek, Kilifi, Mombasa and Kwale (Fig 2). All the 9 mangrove species described in the Western Indian Ocean occur in Kenya (Table 1). The dominant species are Rhizophora mucronata (Mkoko), Ceriops tagal (Mkandaa), Avicennia Marina (Mchu), and Sonneratia alba (Milina).

The development of mangroves follows the deposition of sediment along tidal estuaries, creeks and protected bays. On the newly formed mud, ‘pioneer species’, Milina (Sonneratia alba) and Mchu (Avicennia marina) develop. These grow and establish themselves rapidly by the formation of horizontal (cable) roots with numerous upright-breathing roots (pneumatophores). The pneumatophores are able to accrete more sediment and trap seeds of other species brought in by tides. The substrate gradually becomes established as more and more trees establish themselves. The forest is pushed back and forth depending on sea level. Mainly climate, tidal oscillation, salinity and the nature of the substratum control distribution of mangroves.

7.2.2 Lamu Mangroves

The total mangrove area in Lamu County where this project will be implemented is 46,000ha, representing about 70% of the total mangroves in Kenya. Apart from providing coastal protection and supporting rich fishery in the area, the mangroves of Lamu are exploited for wood products utilized in urban centres along the coast. Historically, mangroves of Lamu were a major export commodity to treeless Arab countries until 1982. In the 1950’s the sale of mangrove wood products from Lamu was ranked 3rd in revenue generation among forest products (Rawlins, 1957).
Figure (7) – 19: The Mangroves of Lamu Showing the Five Management Units.

The current study was carried out at the Pate Island Swamps, Southern Swamps and the Mongoni and Dodori Creek Swamps (Kairo, 2001 after Roberts & Raura, 1996). In the context of the climate change, mangroves are known to sequester about five times more carbon than any other productive terrestrial forest. Considering their large area and high productivity, mangroves of Lamu can be said to sequester and store the most carbon stocks of all mangrove blocks in the country, thus suggesting that degradation of these mangroves can lead to significant national carbon emissions.

For management purposes the Kenya Forest Services have divided the mangroves of Lamu into five block as follows; southern swamps; Mongoni and Dondori Creek Swamps; Pate Island Swamps, northern swamps, and north central swamps. Based on this classification, the new port in Lamu will be constructed within the Southern Swamps forests, Mongoni and Dondori creek swamps, and Pate Island Swamps Figure (7) – 3. The Southern swamps includes those mangroves south of latitude 20 11’ 15”S; but excludes the southern tip of Chongoni. The best quality mangroves are concentrated in scattered locations throughout these swamps bordering the mainland; particularly south of Mukowe jetty.
The stands off Manda Island bordering the project area are stunted and virtually useless in terms of harvestable wood. The mainland mangroves particularly where the three births will be constructed are backed by large areas of wind-blown sand. These stands are however sitting on deep peat layer (Figure (7) – 20). The Southern Swamps is the most accessible region to the highest population concentrations in Lamu archipelago. Most sites sampled during this survey indicated serious signs of over-exploitation and forest degradation.

**Mongoni and Dondori creek swamps** include the mangroves found in the banks of the two creeks; and opening to Manda bay. The proposed fishing port will be located in these swamps. The swamps contain quality stands of Ceriops tagal; giving way to pure stand of Avicennia marina on the landward side of the creek. The merchantable Rhizophora stands in these swamps are limited in quality and extend; and have been heavily removed. Regeneration is poor in most sites of these swamps.

**The Pate Island Swamps** includes the mangroves surrounding Pate Island to Ndau. A good percentage of the poles in these swamps are of merchantable quality. Good stands of Rhizophora and Ceriops mangroves in these swamps occur in Chongoni and Raiwa Creek. The swamps bordering the project area to Kisingitini contains stunted stand of over-wash Sonneratia with
huge crown cover. Most of the poles sold to Mombasa and Malindi are extracted from these swamps, and serious signs of over-cutting were evident during our survey. The objective of the present survey was to assess whether the new port in Lamu has any conceivable consequences on the mangrove environment. Results of this survey will in combination with other EIA studies are used to develop and implement an integrated environmental management plan for the proposed Port.

7.2.3 Methodology for Mangrove Survey

Forest inventory was carried out in the Southern Swamps, and Pate Island swamps using stratified sampling design. A few sampling points were made in Mongoni and Dondori Creek Swamps. The sampling unit was a 10 x 10 m square quadrant laid along a belt transect. We made use of a toposheet of the area and high resolution Google maps to select sampling points. Transects were selected and made to run from the sea-ward side or creek inland. Sampling plots were located using compass, beginning from the starting point of the transects and following the bearings. The distance between plots along a transect was estimated by use of land marks or change in vegetation as seen on the aerial photographs. In the mangroves, slope is negligible making the estimate of horizontal distance possible. All sampling plots were georeferenced.

In each plot all individuals >5cm diameter were identified and recorded. Natural regeneration was also determined by enumerating seedlings/saplings of various classes in the 10m x 10m quadrants. Based on the 1992 FAO map, further re-classification of the mangrove classes in the project sites was done to capture dominant mangroves species in the different units as key determinants of the new classes. Land use history e.g. areas dredged to allow seaways, method and recovery after disturbance was also assessed. To calculate the area of primary impact on mangroves as a result of the development, the 1992 FAO mangrove map was used as base and the project map superimposed after harmonizing the scale. The objective was to determine the area of mangroves to be directly cleared to pave way for the road from the port to the hinterland. It was assumed that the road will be 30m wide (standard width) including reserve. The area of mangroves to be cleared directly was then obtained. Any mangroves not foreseen for clearing but likely to suffer from primary impact will be assessed during project implementation.

7.2.4 Data Analysis

Stand table data were summarised for each plot by calculating species composition, stand density, and basal area. These expressions of abundance (cover, basal area, and density) were used to characterise stand structure of different forests within the project area. This information was then used to populate the GIS maps of the area.

7.2.5 Results and Discussion

1) Floristic composition

The principal mangrove species in the project area are *Rhizophora mucronata* (87% at Njia ya Ndovu), *Ceriops tagal* (92% at Nthununi) and *Sonneratia alba* (56% at Manda). Others are *Avicennia*
moss, Bruguiera gymnorrhiza, Xylocarpus granatum, X. mollucensis and Lumnitzera racemosa (Table 2) although the latter three weren’t recorded in the present study.

**Table (7) - 7. Mangrove Results in Project Area**

<table>
<thead>
<tr>
<th>Location</th>
<th>Species</th>
<th>DBH (cm)</th>
<th>Height (m)</th>
<th>Stand density (stems/ha)</th>
<th>BA (m²/ha)</th>
<th>Relative derivatives (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Freq</td>
</tr>
<tr>
<td>Manda Island</td>
<td>Rm</td>
<td>14.5±2.3</td>
<td>9.2±0.9</td>
<td>767±259</td>
<td>15.6±2.8</td>
<td>50.0</td>
</tr>
<tr>
<td></td>
<td>Sa</td>
<td>11.3±2.0</td>
<td>8.2±0.5</td>
<td>1,580±470</td>
<td>20.0±5.4</td>
<td>50.0</td>
</tr>
<tr>
<td>Overall/mean</td>
<td></td>
<td>12.4±2.2</td>
<td>8.6±0.8</td>
<td>2,347±407</td>
<td>35.5±5.0</td>
<td></td>
</tr>
<tr>
<td>Njia Ya Ndovu</td>
<td>Rm</td>
<td>14.4±2.2</td>
<td>8.8±1.1</td>
<td>978±138</td>
<td>10.3±4.3</td>
<td>88.9</td>
</tr>
<tr>
<td></td>
<td>Sa</td>
<td>19.4±0</td>
<td>14.0±0</td>
<td>100±0</td>
<td>3.0±0</td>
<td>11.1</td>
</tr>
<tr>
<td>Overall/mean</td>
<td></td>
<td>8.0±2.2</td>
<td>7.0±1.1</td>
<td>1,128±244</td>
<td>13.3±4.1</td>
<td></td>
</tr>
<tr>
<td>Nthununi</td>
<td>Am</td>
<td>9.3±1.2</td>
<td>4.6±0.5</td>
<td>1,100±314</td>
<td>8.9±2.0</td>
<td>16.7</td>
</tr>
<tr>
<td></td>
<td>Bg</td>
<td>12.0±0</td>
<td>2.0±0</td>
<td>100±0</td>
<td>1.1±0.0</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>Ct</td>
<td>9.8±1.5</td>
<td>6.5±0.5</td>
<td>140±0</td>
<td>13.2±0.0</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>Rm</td>
<td>14.5±2.5</td>
<td>9.5±1.7</td>
<td>914±95</td>
<td>17.1±4.2</td>
<td>38.9</td>
</tr>
<tr>
<td></td>
<td>Sa</td>
<td>16.5±2.1</td>
<td>7.3±0.6</td>
<td>1,000±209</td>
<td>25.7±6.2</td>
<td>33.3</td>
</tr>
<tr>
<td>Overall/mean</td>
<td></td>
<td>11.5±2.3</td>
<td>6.3±1.3</td>
<td>4,514±4773</td>
<td>66.6±5.1</td>
<td></td>
</tr>
</tbody>
</table>

Key:
- **Rm** = Rhizophora mucronata
- **Sa** = Sonneratia alba
- **Am** = Avicennia marina
- **Bg** = Bruguiera gymnorrhiza
- **Ct** = Ceriops tagal.

Table 2 above attributes mangrove vegetation at the proposed port area. Manda Island is under the Pate Island Swamps, while Njia Ndovu is under the Southern Swamps and Nthunununi both the Southern Swamps and Mongoni and Dondori creek Swamps.

The non-forested area is mainly mudflats, but also include rangelands and agricultural fields within and adjacent the reserve, sand beaches and water-spread areas.

2) **Stocking rate and volume**

The average stand density was highest at Nthununi at 4,514 stems/hectare, followed by Manda at 2,367 and lastly Njia ya Ndovu at 1,128 corresponding to an average stand biomass of 518.0, 320.8 and 107.9 t/ha respectively. Most of the poles were of the fito size class (5 – 7cm) in all sites, while the bigger size classes were under-represented at Manda and Njia ya ndovu due to high extractive pressure. Size class distribution in these two sites thus obeyed the reversed J distribution typical of un-even stands. However, at Nthununi the pattern was different with small size classes leading in density but the bigger size classes were also well represented suggesting lower and non-selective exploitation regimes at this site.
Except for the Njia ya Ndovu site, the stocking densities recorded here were much higher than those reported from other mangrove blocks in the country e.g. Mida Creek with 1,197 stems/ha (Kairo et al., 2002); Gazi mangroves with 892 stems/ha (Dahduoh-Guebas et al., 2002) and the Shimoni – Vanga area 1,839 stems/ha. The stocking rates are, however low, comparable to the mangroves of the Northern Swamps; located within Kiunga Marine National Reserve (Kairo et al., 2002). These densities are higher than 1,343 and 812 trees/ha respectively reported in the managed mangroves of Matang in Malaysia, and Ranong in Indonesia respectively; (Hanon, 1981; Aksornkoae, 1993), suggesting potential of sustainable exploitation of mangrove wood products in the pilot area.

The pattern of natural regeneration of mangroves in the pilot areas is provided in table 2. Unlike the adults, only 4 species were represented in the juvenile stage. R. mucronata was the dominant species and represented in all the sampling units. Nthununi had the highest density of juveniles (30,787/ha) comprising of three species, while Manda Island had the lowest.

(a)

(b)
The density of juveniles recorded here are higher than those recorded in other forest blocks in Lamu e.g. Kiunga but far much lower than the densities observed at Mida Creek (Kairo 2001). However, the regeneration potential observed at the project site is sufficient to support future re-stocking of the forest (FAO 1994).

### Table (7) - 8: Natural Regeneration at Different Locations at the Project Site

<table>
<thead>
<tr>
<th>Species</th>
<th>RC I</th>
<th>RC II</th>
<th>RC III</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manda</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R. mucronata</td>
<td>356</td>
<td>978</td>
<td>1,633</td>
<td>2,967</td>
</tr>
<tr>
<td>S. alba</td>
<td>0</td>
<td>0</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>356</td>
<td>978</td>
<td>1,833</td>
<td>3,167</td>
</tr>
<tr>
<td><strong>Njia Ndovu</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R. mucronata</td>
<td>0</td>
<td>22,000</td>
<td>0</td>
<td>22,000</td>
</tr>
<tr>
<td><strong>Nthununi</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. gymnorrhiza</td>
<td>45</td>
<td>0</td>
<td>0</td>
<td>45</td>
</tr>
<tr>
<td>C. tagal</td>
<td>6,875</td>
<td>450</td>
<td>1,250</td>
<td>8,575</td>
</tr>
<tr>
<td>R. mucronata</td>
<td>18,117</td>
<td>2,392</td>
<td>1,658</td>
<td>22,167</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>25,037</td>
<td>2,842</td>
<td>2,908</td>
<td>30,787</td>
</tr>
</tbody>
</table>

### 7.3 BIRD LIFE

Lamu district is very rich in a diverse number of bird species. During a field survey, the following birds were spotted. Figures (7) – 6 to (7) – 37 showed the birds within the project site. It shows that the area is very rich in bird species. Monitoring of ecological richness will use these baseline species to determine effect of development of the area.
Figure (7) – 22: Bateleur

Figure (7) – 23: African Jacana

Figure (7) – 24: Spur-winged Lapwing

Figure (7) – 25: Common Tern

Figure (7) – 26: Little Swift

Figure (7) – 27: Common Tern 2
Figure (7) – 28: Black-chested Snake-Eagle

Figure (7) – 29: Little Egret

Figure (7) – 30: Little Egret – Dark Morph

Figure (7) – 31: Wolly Necked Stork

Figure (7) – 32: Saddle billed Stork

Figure (7) – 33: Marabou Stork
<table>
<thead>
<tr>
<th>Figure (7) – 34: Sacred Ibis</th>
<th>Figure (7) – 35: African Fish Eagle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure (7) – 36: Hadada Ibis</td>
<td>Figure (7) – 37: Speckled Mouse Bird</td>
</tr>
<tr>
<td>Figure (7) – 38: Mangrove Kingfisher</td>
<td>Figure (7) – 39: Grey Headed Kingfisher</td>
</tr>
</tbody>
</table>
Figure (7) – 40: Northern Carmine Bee-eater
Figure (7) – 41: African Pied Wagtail

Figure (7) – 42: Lesser Striped Swallow
Figure (7) – 43: Yellow Throated Langclaw

Figure (7) – 44: Amethyst Sunbird
Figure (7) – 45: Grassland Pitpit
Figure (7) – 46: Common Bulbul

Figure (7) – 47: Fork Tailed Drongo
8. CORAL REEF AND ROCKY PLATFORM ASSESSMENT

8.1. INTRODUCTION

A detailed field study was done to gather information on coral reef habitats and key species found on/close to the project footprint area. It is intended that the coral reef surveys will provide information on the location, size and condition of the coral reef habitats in the area. During the surveys, information on key species was also collected and this can be used to inform the design and engineering teams on the suitability of the site for the proposed project. Basic information collected during the survey can also provide the basis for more detailed survey in the future should this be required. More importantly, these surveys will provide a permanent record of the existing situation in this part of the coastline.

8.2. OBJECTIVES

These coral reef surveys were conducted for a rapid ecological assessment and reporting with the aim of categorising the importance and quality of the existing coral reef habitats (flora and fauna) within the footprint of the proposed project.

![Figure (8) – 1: A Map Showing Coral Coverage in Lamu](image)

8.3. METHODOLOGY

1) Study area
The study covered the areas shown in the sketch map below, extending along the shores of the Manda and Pate Islands channel and bending out to reach the exposed reef edges of both Islands. The map shows the stretch in which coral reefs were surveyed.

2) Diving survey locations
This was done to cover the coral reef area and to a depth of approximately 20 m, to identify the location and approximate size of coral reefs (boulders, patches, etc.). For each dive area the
Location was recorded using GPS after doing the dive survey. These points were used to generate a map of the surveyed points as shown in the figure below:

### Table (8) – 1: GPS Locations of diving survey areas

<table>
<thead>
<tr>
<th>Site</th>
<th>E</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iweni 1</td>
<td>41° 00.760'</td>
<td>2° 12.955'</td>
</tr>
<tr>
<td>Iweni 2</td>
<td>41° 00.488'</td>
<td>2° 12.898'</td>
</tr>
<tr>
<td>Iweni 3</td>
<td>41° 01.172'</td>
<td>2° 12.812'</td>
</tr>
<tr>
<td>Iweni inner</td>
<td>41° 00.454'</td>
<td>2° 13.248'</td>
</tr>
<tr>
<td>Mpupu 1</td>
<td>40° 59.389'</td>
<td>2° 12.398'</td>
</tr>
<tr>
<td>Mpupu 2</td>
<td>40° 59.388'</td>
<td>2° 12.398'</td>
</tr>
<tr>
<td>Mpupu 3</td>
<td>40° 57.967'</td>
<td>2° 11.088'</td>
</tr>
<tr>
<td>Pezali</td>
<td>41° 01.990'</td>
<td>2° 13.229'</td>
</tr>
<tr>
<td>Manda toto 1</td>
<td>40° 58.836'</td>
<td>2° 13.030'</td>
</tr>
<tr>
<td>Manda toto 2</td>
<td>40° 58.509'</td>
<td>2° 13.137'</td>
</tr>
</tbody>
</table>

![Figure 8-2: Coral study areas](image)

3) Benthic Cover

Benthic cover information provides the main overall indicators of reef state, and particularly the balance between corals and algae. During the surveys, digital still photographs of the reef substrate were taken from a height of approximately 0.6-0.75 meters above the substrate. Natural light was used in waters < 5 m deep with fill-in flash at deeper depths. Photographs were taken...
haphazardly, counting 3-4 kicks between frames and ensuring successive images did not overlap. Fifty photographs were collected per site and they were all used for analysis.

Photographs were downloaded onto a computer and analysed for benthic composition and coral cover using 25 fixed points on the screen. The benthic substrate beneath each point was identified according to the classes in the table below:

<table>
<thead>
<tr>
<th>Invertebrates</th>
<th>Algae</th>
<th>Substrate</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard coral</td>
<td>Macroalgae</td>
<td>Sand</td>
<td>Seagrass</td>
</tr>
<tr>
<td>Soft coral</td>
<td>Halimeda</td>
<td>Bare substrate</td>
<td>Microbial</td>
</tr>
<tr>
<td>Sponge</td>
<td>Coralline algae</td>
<td>Rubble</td>
<td></td>
</tr>
<tr>
<td>Other invertebrates</td>
<td>Turf algae</td>
<td></td>
<td>Unidentified</td>
</tr>
</tbody>
</table>

4) **Coral Population Structure**

Coral size class distribution gives the most accurate information on the demography and sizes of coral colonies, and can show indications of past impacts by the presence or not of large colonies. Coral population structure was quantified using fixed size classes of corals, from the smallest recruits to the largest adults at a site. A belt transect of 25 m long and 1 m wide was used to record the number of colonies. Coral colony sizes were put in the following size class categories: 0-10 cm, 11-20 cm, 21-40 cm, 41-80 cm, 81-160 cm, 160-320 cm and >320 cm. A 1m stick was used to help guide estimation of transect width and was also marked at relevant points to help guide size estimation of coral heads. Replication of transects depended on logistics at a site and the complexity of the coral community, varying between 1 and 2.

5) **Reef Fish Community Structure**

Fish community rapid assessment was done at four transects at each site. Locations were separated by at least 10 m. At each location, sampling was done using 1 belt transect of 50 m by 5 m. This involved two observers with one laying the transect and the other counting and recording fish and this was done at family level and within four size class categories: 0-10 cm, 11-20 cm, 21-30 cm, 31-40 cm and >40 cm. Large and ‘snorkeler shy’ fish were counted along the first pass and small fishes clustering around large coral bommies mainly small Pomacentrids counted on the way back along the same transect. To maintain consistency in counting errors, the same observers were used to do the counts throughout the survey. Biases associated with visual estimates however, restricted the census to diurnal and non-cryptic fish species.

6) **Invertebrates**

Invertebrates were sampled along the same fish transect using six 1 m² quadrants at 10 m interval. The counts of each type of invertebrate were done (e.g., lobster, octopus, sea urchin, sea cucumber).
7) Other Important Species

General searches were done for rare resources, such as sharks or lobsters, where it is unlikely that any would be covered by randomly place belt transects. The amount of time and locations covered was standardized as far as possible, and specified each time, to allow future replication.

8.4 FINDINGS

8.4.1 Benthic Cover

a) Overall benthic cover

Turf algae and hard coral were the most abundant benthic types at the study sites. Highest cover was turf algae with a 53% followed by hard coral which had 29% cover. Macroalgae and rubble showed a considerable cover which was at less than 6%. There were a few sandy patches and some occurrence of seagrasses within the coral reef area. Coralline algae and Halimeda was also recorded but had a very low cover of 1% each. This survey did not show any record of soft corals.

b) Benthic cover at the channel

The dominating benthic cover at the channel area was mainly turf algae (55%) which was followed by hard corals (26%). Rubble and macroalgae had a very low cover of 6% and 5%, respectively. Other benthic substrates that were recorded in the survey were sand patches, seagrasses and coralline algae and these had a below 2% cover.
b) Benthic cover at the berths area

The dominating benthic cover at the channel area was mainly turf algae (51%) which was followed by hard corals (35%). There was also a considerable cover of sandy patches. *Halimeda* also occurred here but with a low cover of 3%. Rubble and macroalgae had a very low cover.

![Fig 8-5: Benthic Cover at Berth Area](image)

![Fig 8-6: Pictures showing the benthic substrates/condition at the channel area](image)

- Large Echinopora at the edge of the channel coral reefs
- Small Echinopora with a lot of fleshy algae around
- Massive *Porites* with *Halimeda* growing and sediment settling on top
- *Pocillopora* recruits on a highly sedimented bottom
Fig 8.7: Pictures showing the bottom sediment/condition at areas adjacent to the three berths.

Benthic cover overgrown by *Halimeda*

Some areas with healthy corals

Heavily sedimented corals

Sediments covering a coral head

**8.4.2 Coral Population Structure**

a) Overall, coral genera

A total of 22 coral genera were recorded for the size class analysis. The coral community was dominated by relatively sediment-tolerant species characteristic of turbid channel habitats. These were as follows in their order of area they occupied: *Porites, Echinopora, Goniopora, Galaxea, Pocillopora, Montipora, Fungia, Platygrya, Favites, Favia, Pavona, Coscinarea, Goniastrea, Echinophyllia, Turbinaria, Psammocora, Acropora, Astreopora, Lobophyllia, Cyphastrea, Hydnophora, Alopeora.*

Massive *Porites* covered the largest area (2.8m$^2$). Other genera that covered wide area include *Echinopora, Goniopora*, branching *Porites, Galaxea and Pocillopora.*

The highest number of coral colonies was massive *Porites* followed by *Pocillopora, Echinopora* and *Fungia* (2375, 1406, 930 and 798, respectively). The rest of coral genera had coral colonies that were less than 600.
b) Genera, sites

At the channel area, a total of 20 coral genera were recorded. The highest number of colonies was in massive *Porites* followed by *Pocillopora, Echinopora, Fungia* and branching *Porites*. The rest were at below 400 in number of colonies.

At the berth area, a total of 18 coral genera were recorded, with Massive *Porites* dominating the coral population at this site.

<table>
<thead>
<tr>
<th>Genus</th>
<th>Berth area</th>
<th>Channel area</th>
<th>Genus</th>
<th>Berth area</th>
<th>Channel area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acanthastrea</td>
<td>x</td>
<td>x</td>
<td>Lobophyllia</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Acropora</td>
<td>x</td>
<td>x</td>
<td>Millepora</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Alveopora</td>
<td>x</td>
<td>x</td>
<td>Montipora</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Astreopora</td>
<td>x</td>
<td>x</td>
<td>Mycedium</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Coscinarea</td>
<td>x</td>
<td>x</td>
<td>Pachyseris</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Cyphastrea</td>
<td>x</td>
<td>x</td>
<td>Pavona</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Echinoophyllia</td>
<td>x</td>
<td>x</td>
<td>Platygyra</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Echinopora</td>
<td>x</td>
<td>x</td>
<td>Plesiastrea</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Favia</td>
<td>x</td>
<td>x</td>
<td>Pocillopora</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Favites</td>
<td>x</td>
<td>x</td>
<td>Porites (bran)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Fungia</td>
<td>x</td>
<td>x</td>
<td>Porites (mas)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Galaxea</td>
<td>x</td>
<td>x</td>
<td>Psammocora</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Gardineroseris</td>
<td>x</td>
<td>x</td>
<td>Seriatopora</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Goniastrea</td>
<td>x</td>
<td>x</td>
<td>Siderastrea</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Goniopora</td>
<td>x</td>
<td>x</td>
<td>Stylophora</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Herpolitha</td>
<td>x</td>
<td>x</td>
<td>Tubastrea</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Horastrea</td>
<td>x</td>
<td>x</td>
<td>Tubipora</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Hydnophora</td>
<td>x</td>
<td>x</td>
<td>Turbinaria</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Leptastrea</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
c) Overall, coral size class

The distribution of size classes is shown by number of colonies, and by area of colonies for all size classes. On average, there were 8625 colonies at the studied areas, corresponding to 8.1 m$^2$ of coral colony surface. The highest contribution of the area covered by coral colonies was from the large colonies > 3.2 m. Other dominant size classes by area were 81-160 cm and 41-80 cm. There is a drop in the size class 161-320 cm.

The small coral of size class 0-5cm and 6-10cm had high number of colonies which was followed by a sharp drop for the subsequent size classes. A sharp drop in area as well as number of colonies in the size class 11-20cm indicates some disturbance that this cohort could have experienced leading to failure of recruitment or mortalities.
d) Size class distribution at berth area

Small coral of the size class 0-5 were absent at the berth area. This could be because this area is largely covered by a thick layer of sediments and may have covered most of the young recruits. The large corals were also not recorded here and this may be as a result of sediments smothering corals causing mortalities.

![Berth area graph](image1)

e) Size class distribution at the channel

Size class distribution at the channel area followed the normal population trend of high number of recruits and low numbers of adult/large corals which is corresponded by a large area covered by large corals and a small area covered by small corals.

![Channel area graph](image2)

f) Recruitment of genera

Recruitment analysis was done only for the channel area. *Massive Porites* had the highest number of small coral colonies of 0-5cm, (825 colonies) followed by *Pocillopora* (623 colonies). Most of the other coral genera showed recruitment of below 200 colonies.
colonies per site.

8.5  CORAL REEF FISH COMMUNITY

8.5.1  Overall, Family

A total of 18 fish families were recorded. These were: Scarids (parrotfishes), Acanthurids (surgeonfishes), Siganids (rabbitfishes), Haemulids (sweetlips), Pomacentrids (damselshfish), Lethrinids (emperors), Lutjanids (snappers), Pomacanthids (angelfishes), Mullids (goatfishes), Serranids (groupers), Chaetodontids (butterflyfishes), Labrids (Wrasses) and Balistids (triggerfishes).

Parrotfishes had the highest biomass (22 kg/100 m$^2$) followed by surgeonfishes which had 19 kg/100 m$^2$. The other fish families had relatively low biomass of less than 10 kg/100 m$^2$.

Damselshishes had the highest density in this area (163 fish/100 m$^2$). The other families had very low densities with surgeon fishes having a density of 32 fish/100 m$^2$ parrot fishes having a density of 28 fish/100 m$^2$. 

![Overall biomass and density chart](image_url)
8.5.2 Overall, sites

The berth area had very few fish with a density of 4 fish/100 m². The fish biomass at the berth area was almost negligible due to the presence of only small fishes like the Caesionids (Fusiliers).

Much of the fish density and biomass was recorded in the channel area. A density of 23 fish/100 m² at the channel with damselfishes being the majority representing almost 90% of the number of fish recorded. The fish biomass at the channel area was 5 kg/100 m² represented mainly by surgeon fishes and parrot fishes.

8.5.3 Overall, size class

Overall, 61% of the fish population density comprised small fishes of size class 0-10 cm (15 fish/100 m²). The other size classes had very low densities of less than 4 fish/100 m².

Fish biomass was such that the small fish had very low kg/100 m² and the large fish contributed more to the biomass. For example, biomass for size class 0-10 was 0.1 kg/100 m² while that for size class >40 cm was 1.2 kg/100 m².

8.5.4 Invertebrates

Sea urchins (Diadema spp.) were the most dominant type of invertebrates encountered in the quadrants at an average of 2 individuals/m². Most of the areas that had a high density of urchins also exhibited a lot of degradation of corals possibly as a result of fishing and mainly at the channel area. A few sea cucumbers were also encountered but these were outside the quadrants.

8.5.5 Other Important Species

During the surveys, the following important species were observed:
- Four turtles
- One black tip reef sharks
- Three marbled grouper (Epinephelus fuscoguttatus); 1 was >60cm in size and 2 were less than 50 cm
- One juvenile endangered Napoleon wrasse (Cheilinus undulatus) and was <50cm in size.
- A flock of birds (Roseate Tern - Sterna dougallii) perched on an exposed patch of dead coral near the beach.
9. FISHERIES ASSESSMENT

9.1 METHODOLOGY

The main source of information on catch and effort data was from fisheries statistics obtained from the fisheries department. Field surveys were also conducted at various landing sites to quantify the fish catches and species of fish caught. Field visits to the fishing grounds and key breeding sites were done and key areas identified. This information gave the spatial scale of catch and effort in the proposed project area. The fishers were also consulted to understand their views in relation to the port development and the perceived impacts from construction of the three berths and the general port development.

![Figure 9-1: Area considered in fisheries environmental assessment](image)

Map showing the north coast Kenya and the Lamu-Kiungu marine waters (encircled dotted line). The location of the proposed project is within the Manda Bay (red line) lying between Manda, Siyu and Pate Islands in the Lamu archipelago.

9.2 FISHERIES STRUCTURE

Fishing remains an important source of revenue for Lamu district and an undisputed age-old source of livelihood for the coastal fisher communities. Important species of these marine waters and the Lamu archipelago include marine Crustacean such shallow water, lobsters and crabs. Fishing is largely undertaken in the near shore waters and according to statistics Lamu
The archipelago is an important fishing ground for both resident and migrant artisanal fishers of the Kenya coast.

Over 50 marketable finfish and shellfish species inhabit the waters of Lamu and are target for both the commercial and artisanal fisheries. Dominant families included Carangidae, Serranidae, Scombridae, Lutjanidae, Siganidae, Haemulidae, Mullidae, and Mugilidae. Decapods of the family Panuliridae dominate the crustacean catch.

9.2.1 Fishing effort and Facilities

The fishing grounds within 5 nm offshore are mainly utilized by the artisanal fishers while industrial fishers purse seine and long line boats fish beyond 5nm. Most of the fishing boats are non mechanized using mainly sails. A few motorized vessels are also recorded, belonging mainly to traders who also supply gears and other supplies to the artisanal fishers.

There are a total of 1026 boats within Lamu fishery waters with 246 fishers recorded as foot fisher. In the proposed project area there are 640 fishing crafts. Fishers in this area use Mashua and Hori type of crafts propelled mainly by sails. There are 19 fish landing beaches as shown in Figure 9-2. Two landing sites will be lost completely as they occur in the mainland. Landing sites in Pate island will be affected if fishing activities will be disrupted. There are approximately 4,111 fishers in the Lamu District (Fisheries Department, frame survey 2012). Those fishers who will be directly affected by the proposed construction are 3,170.

In Faza division there is a fish cold storage facility which is meant to serve fishers from the county by provision of ice and cold storage.

<table>
<thead>
<tr>
<th>Craft type</th>
<th>Numbers of crafts</th>
<th>Crew numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mashua</td>
<td>248</td>
<td>2354</td>
</tr>
<tr>
<td>Ngalawa</td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td>Mtori</td>
<td>53</td>
<td>521</td>
</tr>
<tr>
<td>Dau</td>
<td>5</td>
<td>36</td>
</tr>
<tr>
<td>Hori</td>
<td>187</td>
<td>843</td>
</tr>
<tr>
<td>Dugout</td>
<td>41</td>
<td>87</td>
</tr>
<tr>
<td>Foot fisher</td>
<td>-</td>
<td>264</td>
</tr>
</tbody>
</table>
Fishing areas and breeding grounds

Fishers from Faza (Rasini) and Ndua are known to fish in fishing grounds within the Manda and Kizingitini channels. Kizingitini, Mbwajumwali and Shanga fishers fish in the open sea with Pezali rocks most preferred by lobster divers. They also fish in the Manda bay during the south east monsoon winds. A lobster fishery survey conducted in 2011 in Kizingitini estimated the Catch Per Unit effort (CPUE) at 0.72kg lobsters/fisher/day for fishers at Pezali fishing grounds. Fishers from Shanga (Shanga Rubu and Shanga Ishakani) fish at the Manda channel. Matondoni and Kipungani fishers access their fishing grounds in Ndununi and Dodo creeks in the proposed port berth areas. A key shrimp fishing area is within the proposed fishing port at Ndununi area.

The mangrove ecosystem is important as nursery and breeding ground for most fish species. The shrimp fishery has its juveniles using the mangrove habitats as feeding grounds before they migrate into the open waters and recruitment into the fishery. The area proposed for construction of the three berths is a key breeding and nursery ground.

Fish catch data

Fishing activities are more intense during the Northeast monsoon when the sea is calm and the fishers are able to access their fishing grounds. It is during this season when migrant fishers from
other locations visit the productive fishing grounds of Lamu County. There are several peaks in a year and this is depended on the fishery targeted in two monsoons seasons. Landings peaks in May and September in Kizingitini figure xxx while no varying trends in fish landings from Amu and Faza areas.

![Graph showing fish landings by month](image)

**Figure 9-3: Target Species Landed Fish/Crustacean in the Area- Fisheries Department Data**

Fisheries catches show no generalized trends (Figure 9-3). In the landing sites of the Amu, Kizingitini and Faza divisions of Lamu County, high fish production is noted for demersal fish species and crustacea especially rabbit fish, scavengers, lobster, crabs and shrimps. Lobster, crab and sea cucumber are commercially important fisheries exploited for either domestic tourism market or for export market. Crabs fishing is largely in the mangrove areas, while lobsters are fished in the reef areas and some important fishing grounds area at the Manda channel include the Pezali rocks. Five species of spiny lobsters inhabit the marine waters of Kenya but only three; Panulirus ornatus, P. longipes, P. homarus are commercially important, supporting the main fishery within the Kizingitini lobster fishing areas. Lobsters generally occur in the rock crevices and therefore distributed at varying depths and habitat types.

Shrimp fishing is within the creeks of Ndununi and Dondori. Fishers from Matondoni and Kipungani fish mainly for shrimps. The most common shrimp species in the creeks are Giant tiger shrimps (Penaeus monodon) and Indian Banana shrimps (P. indicus).

Fishing is the primary occupation to 89% of the investigated households in the seascape Based on data collected by WWF-Kiunga. Almost 50% of the marine catch in the district is consumed locally, while the rest is transported to markets outside the district including Malindi and Mombasa. Species of high economic value include the spiny lobsters, mangrove mud crabs, and sea cucumber.
The spiny lobster fishery in the Lamu archipelago presents one of the most valuable. The lobster fishery is mainly artisanal based and involves a large number of fishers who are skin divers. Figure 9-5 shows catch and value of key commercial species in Lamu archipelago and specific to the area under proposed project.
The highest catches are from the Faza division which covers Kizingitini, Pate, Tchundwa, Mbwajumali and Rasini. Catches range from 800 – over 1000MT annually valued between Ksh. 40 – 50 million except for 2009 as shown in Table 9b.

Table 9b: Variations in Yearly total catch and yearly value of total catch of the artisanal fishery in Amu, Faza and Kiunga during 2008-2010

<table>
<thead>
<tr>
<th>DIVISION</th>
<th>WT (t)</th>
<th>VALUE (Kshs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>568</td>
<td>48,255,571</td>
</tr>
<tr>
<td>2008</td>
<td>866</td>
<td>46,997,450</td>
</tr>
<tr>
<td>2009</td>
<td>12</td>
<td>40,784,608</td>
</tr>
<tr>
<td>2010</td>
<td>465</td>
<td>55,034,458</td>
</tr>
<tr>
<td>FAZA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>943</td>
<td>61,475,100</td>
</tr>
<tr>
<td>2008</td>
<td>1038</td>
<td>69,559,631</td>
</tr>
<tr>
<td>2009</td>
<td>28</td>
<td>72,157,383</td>
</tr>
<tr>
<td>2010</td>
<td>1185</td>
<td>85,212,173</td>
</tr>
<tr>
<td>KIUNGA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>254</td>
<td>13,411,866</td>
</tr>
<tr>
<td>2008</td>
<td>279</td>
<td>14,268,107</td>
</tr>
<tr>
<td>2009</td>
<td>61</td>
<td>17,255,026</td>
</tr>
<tr>
<td>2010</td>
<td>339</td>
<td>16,765,485</td>
</tr>
</tbody>
</table>

Shrimp catches are high during the rainy season between March and June and are valued as high as 6500 US$. They are most expensive during November -December which coincides with the peak tourism season.

Fig 9-6: Consultation with fishermen in Faza
Lobsters are either sold in the tourist hotels or exported alive or frozen. 426,626kg of lobsters was exported between 2002 and 2005 with 304,698kg (71.3%) whole lobsters, 54,880 (12.6%) lobster tails and 64,690kg (16.1%) deep-water lobsters. High catches of lobster are during the North East monsoons. Lobsters are highly valued commodity over 70 000 US$.

![Graph](image.png)

**Figure 9-7:** Temporal variations in mean catch and value of Spiny lobster species landed in the Lamu-Kiunga artisanal fishery during 2008-2010. The species comprised mainly Panulirus spp

### 9.2.4 Fish Markets and marketing

Most of the fish is sold to fish traders who are organized through the BMUs at the various landing sites. There are 47 traders who buy fish, crabs and lobsters and either sell in Lamu or transport to other markets. **Table 9c** shows the administrative divisions of Lamu County with respective landing beaches, Beach management Units and cooperatives in the marine fisheries within the larger area of the proposed port area. There are 29 BMUs in Lamu County and 13 of these BMUs are within the proposed project area.
**Table 9c: Distribution of BMUs and Cooperatives within proposed area Lamu County**

<table>
<thead>
<tr>
<th>Division</th>
<th>Landing site</th>
<th>BMU members</th>
<th>Cooperative members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faza</td>
<td>Kizingitini</td>
<td>372</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Rasini</td>
<td>358</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Mbwajumwali</td>
<td>54</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Shanga Rubu</td>
<td>89</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Shanga Ishakani</td>
<td>66</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Mtangawanda</td>
<td>68</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Patte</td>
<td>86</td>
<td>0</td>
</tr>
<tr>
<td>Amu</td>
<td>Amu</td>
<td>78</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Matondoni</td>
<td>77</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Shella</td>
<td>54</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Kipungani</td>
<td>46</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Ndununi</td>
<td>67</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Kiangwe</td>
<td>113</td>
<td>0</td>
</tr>
</tbody>
</table>

Most fishers from these BMUs share fishing grounds between Manda and Kizingitini channels. Others fish for shrimps within the Ndununi creek.

Fishers from Faza (Rasini) and Kizingitini are also members of fishermen cooperatives society (FCS). For example in Faza fish is sold through the cooperative society and for every kilogram of fish sold, the fisher saves 1 Ksh with BMU as shares and pays 2 Kshs to the cooperative as commission. Table 9d shows monthly landings and how the same is shared amongst the fisher, the BMU and cooperative.

**Fig 9-8: A billboard at a BMU office in Faza**
Table 9d: Monthly quantities (Kgs) and value of fish, BMU share and cooperative commission in Faza 2011 and 2012

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Quantity(Kg)</th>
<th>Sales(Ksh)</th>
<th>BMU Shares (Ksh)</th>
<th>Corporative Commission (Ksh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>August</td>
<td>33548</td>
<td>1841987</td>
<td>33548</td>
<td>67096</td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>34079</td>
<td>1862851</td>
<td>34079</td>
<td>68158</td>
</tr>
<tr>
<td></td>
<td>October</td>
<td>24031</td>
<td>1574485</td>
<td>24031</td>
<td>48062</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>23089</td>
<td>1622864</td>
<td>23089</td>
<td>46178</td>
</tr>
<tr>
<td></td>
<td>December</td>
<td>50809</td>
<td>4246379</td>
<td>50809</td>
<td>101618</td>
</tr>
<tr>
<td>2012</td>
<td>January</td>
<td>35321</td>
<td>2146490</td>
<td>35321</td>
<td>70642</td>
</tr>
<tr>
<td></td>
<td>February</td>
<td>25301</td>
<td>1657900</td>
<td>25301</td>
<td>50602</td>
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<td>March</td>
<td>29442</td>
<td>2081310</td>
<td>29442</td>
<td>58884</td>
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<td></td>
<td>April</td>
<td>45920</td>
<td>3246160</td>
<td>45920</td>
<td>91840</td>
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<td>May</td>
<td>31541</td>
<td>2221725</td>
<td>31541</td>
<td>63082</td>
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<td>31558</td>
<td>2401005</td>
<td>31558</td>
<td>63116</td>
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<tr>
<td></td>
<td>July</td>
<td>20606</td>
<td>1422434</td>
<td>20606</td>
<td>41212</td>
</tr>
</tbody>
</table>

9.3 POTENTIAL AND EXISTING AQUACULTURE/ MARICULTURE

The archipelago has potential for aquaculture with the swamplands at Lamu, with 28,400 ha total area, important aquaculture areas. Therefore there is a high aquaculture potential along Dodori and Dununi creeks especially for shrimps and crabs culture and any development may have an impact of the potential sites within the mangroves. It is proposed that the loss be quantified as aquaculture is taken as an alternative to capture fisheries and contribution to food security in this area.

9.4 MARINE PROTECTED AREAS

Kiweni Community Conservation Area

Kiweni community conservation area is located at the opening of the Manda channel and extends to Pezali rocks. The community conservation project is a non-political community based organization, formed and registered under the Ministry of Gender and Social Service in Lamu. The project has a development agenda which is to support local community to utilize the marine resources in a sustainable manner. The conservation area was started with the aim of promoting sustainable fisheries and is managed by Amu, Shela, Pate, Shanga rubu, and Shanga ishakani all from Pate, Manda and Amu Islands. These BMUs carry out joint patrols within the area of protection. Apart from providing direct environmental and livelihood benefits locally community conservation area offers tangible ‘Models’ to inspire policy-making and give voice to the local disadvantaged players. The project employs 10 staff who participates in various capacities in the day to day running of the community project. The overall objective of the community project is to develop a holistic ecosystem based approach to conservation and management of the marine resources in Lamu. Figure xxx shows communities carrying out patrols in the conservation area.
Figure 9-9: Boat anchored to a buoy patrols in the Kiweni Community Marine Conservation Area, Pate Island, Kenya (Source Kiweni report March 2010)

9.5 SPECIES OF SPECIAL CONCERN

Marine waters of Kenya are home to various marine mammals (order Cetacea, Brisson 1762) although data on the cetacean by-catch in both artisanal and commercial fisheries is still very scanty. The cetacean species observed in Kenya include Sperm whale Physeter macrocephalus, Killer whale Orcinus orca, Humpback whale Megaptera novaeangliae, Bryde’s whale Balaenoptera edeni, Minke whale B. acutorostrata, Melon-head whale Peponocephala electra, Tursiops sp., Delphinus sp., Indo-Pacific Humpback Dolphin Sousa chinensis, Spinner dolphin Stenella longirostris, Pantropical Spotted dolphin Stenella attenuata, Fraser’s dolphin Lagenodelphis hosei, Risso’s dolphin Grampus griseus and Striped dolphin Stenella coeruleoalba (Kasuya and Wada, 1991; Leatherwood and Donovan, 1991; De Boer et. al. 2003; Amir et. al. 2002; Muir et. al. 2004). Some incidental catches of dugongs have been recorded during interview surveys conducted in 2003 in 14 villages (Kiszka et al. 2008). Gears attributed to the cetacean by-catch include gillnets and bottom trawls (Kasuya and Wada, 1991; Leatherwood and Donovan, 1991; WWF EAME, 2004). Although detailed statistics on cetacean by-catch are lacking, incidental catches of cetaceans is suspected in many fishing villages where gillnets are used including Bofa, Tenewi Ziwayuu and Manda (KMFRI, unpub. data). The main species in the by-catch include Indo-pacific humpback and bottlenose dolphins. In overall, it is estimated that the marine fisheries in Kenya was responsible for over 3,500 tons of by-catch in 2005 ((FAO 2006). There are no reports of direct take for cetaceans in Kenya’s marine waters.

Additionally, the marine waters of Kenya are home to five of the seven species of the sea turtles in the world. The species include the green turtle Chelonia mydas, hawksbill Eretmochelys imbricata, loggerhead Caretta caretta, olive ridley Lepidochelys olivacea, and leatherback Dermochelys coriacea (Humphrey & Salm 1996, Okemwa et. al. 2004). The Lamu Archipelago is one of the most important marine turtle nesting grounds in Kenya. Five of the seven sea turtle species that range in the Western Indian Ocean are found within the Lamu Seascape. Three among these species - Chelonia mydas, Eretmochelys imbricata and Lepidochelys olivacea nest, and the other two - Caretta caretta and Dermochelys coriacea, have been reported to feed within the Lamu Archipelago. The main areas of concentration are Kiunga, Manda Island and Shela (Humphrey & Salm 1996, Okemwa et. al. 2004). All of these sea turtles are at risk for being taken as by catch in trawl nets and gill nets. Wamukoya and Salm (1998) in a 1997 survey reported that 100 to 500 sea turtles were
caught annually as by catch in trawl nets. Therefore, human activities appear to pose the main threat to the marine turtle species which are listed endangered species (IUCN Red list, 2010). The over-exploitation of fish stocks in Kenya has caused a severe decline in the catch per fisher and thus income, and as a result, fishers may target the marine turtles for their economic value (Okemwa et. al. 2004). Even though dugongs are protected under national and international legislation, they are still harvested in Kenya for their meat and for medicinal purposes (Muir et. al. 2004).
10. SOCIO-ECONOMIC ASPECTS OF THE PROJECT

10.1 INTRODUCTION

The socioeconomic study was undertaken in order to establish baseline data and information that will be used towards monitoring the impacts of the project on the local communities and other stakeholders. This study therefore provided an avenue for the local communities and other stakeholders to air their views and perceptions about the project. It also provided an opportunity for the project EIA team to engage the local communities and other stakeholders in a participatory manner in the identification of people who are affected by the project so as to prescribe mitigation measures that should be put in place in order to eliminate or minimize the negative effects of the project. The monitoring plan and mitigation measures that resulted from this study will help to reduce damage caused by the project’s activities to the social, cultural and economic wellbeing of the local communities and other stakeholders.

10.2 METHODOLOGY

10.2.1 The study site

The study was carried out at the areas that are likely to be affected by phase I of the project such as Kililana, Pate, Faza, Amu, Shella, Matondoni, Mokowe and Bargoni. Kililana is the site where the port offices and staff houses will be constructed. It is linked to the main Lamu-Mombasa road by an access road that was recently constructed. The construction of the access road and the port headquarters has already affected the local communities whose land and other property have been taken over. Bargoni and Mokowe areas are going to be affected by the land based activities while, Shella, Amu, Matondoni, Pate and Faza will be affected by the sea-based activities such as construction of a causeway, 3 berths, actual shipping and other related activities. Other more distant fishing villages that depend on the fishing grounds along the port site are also likely to be affected by the first 3 berths in one way or another.

10.2.2 Methods of data collection

The socioeconomic assessments involved collection of both secondary and primary data and information. Literature review was carried out to obtain relevant secondary data and information from publications, official Government documents and records, technical reports held by different agencies and other grey literature (unpublished materials). Primary data and information was collected from the different categories of stakeholders in the project area. These stakeholders included the Lamu Port Steering Committee, local community, Government agencies, NGOs and CBOs in the project area. Data was collected from 150 respondents. A combination of four primary data collection techniques were used namely questionnaires, key-informant interviews, focus group discussions and direct observation as follows:

1. Questionnaires: Two sets of questionnaires were prepared and administered to different stakeholders. One set was administered to the local community while the other set was administered to all other stakeholders. The two sets of questionnaires have both closed and open-ended questions. The open-ended questions that are normally used in semi-structured interviews were included in the questionnaires to make it possible to probe for answers and
create room for two-way interactions and exchange of information between the interviewer and the respondent. At the end of each day, the research team sat together to review the results.

2. **Key-informant interviews**: Key-informant interview technique was used to gather information from the opinion leaders in the project area. The snowball method (in which information is gathered by asking an initial informant to suggest other informants) was used to identify key informants in the project area. The key informants included members of the Lamu Port Steering Committee, religious leaders, women group leaders, political leaders (Councillors), leaders of youth groups such as Promise Ahadi Youth Group, leaders of some strategic NGOs and CBO such as Secure Kenya, Kenya Marine Forum, teachers and other people who hold respected positions in Lamu and could therefore provide insights on many issues that needed further clarifications.

![Fig 10-1: The consultants engage PAP at a consultative meeting in Lamu Fort](image)

3. **Focus group discussions**: Focus group discussions were conducted with particular focus on BMU officials and members from various sites to represent the interests of the artisanal fishers, women groups, youth groups, and other social groups. Each focal group consists of 5–12 participants. A discussion guide (a set of open-ended discussion points) was used to prompt participants into free discussions focusing on the issues under the study.

4. **Direct observation**: Direct observation was used to watch events as they unfold in the area and explore key features of human activity. The information gained from the observation formed the basis for detailed interviews with the stakeholders. It was also useful in confirming some issues that came up during the semi-structured interviews and focus group discussions. During observation, questions were asked about the cultural property, land tenure, economic activities and challenges that the local people faced in the area. The questions concentrated heavily on issues that could not be observed.
Data collection procedures and formalities

The research team conducted themselves well in the study area to ensure that they respected the cultures of the communities under study and observed the acceptable norms. This was important because the success of socio-economic studies depend to a large extent on the approach and conduct of the research team.

Data analysis

Qualitative data was coded for ease of analysis. A code sheet was developed and refined and open-ended questions recorded. Open-ended questions were summarized and coded in a meaningful manner. Data entry and analysis was done in MS-Excel and Statistical Package for Social Sciences (SPSS). Data from each respondent was entered in separate columns and the data cleaned using frequencies and cross tabulation outputs. Statistical analyses were conducted on the quantitative data while content analysis method was used to analyze the output from the focus group discussions.

RESULTS

Demographic Characteristics Lamu County

The available and most detailed demographic information on Lamu County which houses the project area is from the national population and housing census of 2009. This census is consistently conducted after every ten years and the results just came out in 2010. Based on this census a summary of selected demographic information is presented in Table 1 below. According to the 2009 census results, the number of households in the larger Lamu County has risen from 15,006 households in 1999 to 22,184 households in 2009 and population has increased from 72,686 people in 1999 to 101,539 people in 2009. The population density has also increased from 12 persons per square kilometer in 1999 to 16 persons per square kilometer in 2009. While it may appear that this population density is way below the national population density of 66 persons per sq. km, some divisions such as Amu have relatively higher population densities of 224 persons per sq. km (Table 1). It is worth noting that population density is higher in areas that depend mainly on fisheries and other marine resources for livelihoods and income (Figure 2). This implies that population pressure in the Lamu County impacts more heavily on fisheries and other marine resources than on terrestrial resources. It is worth noting that the population size and density has changed significantly between 1999 and 2009.

<table>
<thead>
<tr>
<th>Division</th>
<th>Location</th>
<th>Sub-location</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
<th>Households</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amu</td>
<td>Mkomani</td>
<td>Mkomani</td>
<td>3,565</td>
<td>3,475</td>
<td>7,040</td>
<td>1,620</td>
<td>1,424</td>
</tr>
<tr>
<td></td>
<td>Langoni</td>
<td>Langoni</td>
<td>4,901</td>
<td>4,892</td>
<td>9,793</td>
<td>2,281</td>
<td>3,304</td>
</tr>
<tr>
<td>Shella/Manda</td>
<td>Shella</td>
<td>1,201</td>
<td>981</td>
<td>2,182</td>
<td>514</td>
<td>371</td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>Manda</td>
<td></td>
<td>681</td>
<td>411</td>
<td>1,092</td>
<td>371</td>
<td>29</td>
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<tr>
<td>Matondoni</td>
<td>Matondoni</td>
<td>844</td>
<td>831</td>
<td>1,675</td>
<td>377</td>
<td>110</td>
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<tr>
<td>Sub-Total</td>
<td>Kipungani</td>
<td>350</td>
<td>234</td>
<td>584</td>
<td>109</td>
<td>27</td>
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<tr>
<td>Sub-Total</td>
<td>Hindi</td>
<td>H/Magogoni</td>
<td>3,124</td>
<td>2,322</td>
<td>5,446</td>
<td>1,187</td>
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<tr>
<td>Sub-Total</td>
<td>Bargoni</td>
<td>1,192</td>
<td>864</td>
<td>2,056</td>
<td>366</td>
<td>3</td>
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<tr>
<td>Sub-Total</td>
<td>Mokowe</td>
<td>1,342</td>
<td>1,222</td>
<td>2,564</td>
<td>596</td>
<td>52</td>
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<tr>
<td>Sub-Total</td>
<td>Kilimani</td>
<td>363</td>
<td>271</td>
<td>634</td>
<td>137</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>Hindi</td>
<td>6,021</td>
<td>4,679</td>
<td>10,700</td>
<td>2,286</td>
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<tr>
<td>Sub-Total</td>
<td>Mpektoni</td>
<td>1,288</td>
<td>1,171</td>
<td>2,459</td>
<td>527</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>H/Magogoni</td>
<td>3,568</td>
<td>3,448</td>
<td>7,016</td>
<td>1,838</td>
<td>250</td>
<td></td>
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<tr>
<td>Sub-Total</td>
<td>Maharani</td>
<td>3,580</td>
<td>2,984</td>
<td>6,564</td>
<td>1,638</td>
<td>5</td>
<td></td>
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<tr>
<td>Sub-Total</td>
<td>Ndambwe</td>
<td>463</td>
<td>490</td>
<td>953</td>
<td>194</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>Bahari</td>
<td>1,857</td>
<td>1,725</td>
<td>3,582</td>
<td>783</td>
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<tr>
<td>Sub-Total</td>
<td>Tewe</td>
<td>1,435</td>
<td>1,214</td>
<td>2,649</td>
<td>589</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>Hindi</td>
<td>19,128</td>
<td>17,399</td>
<td>36,527</td>
<td>8,524</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>Mpektoni</td>
<td>1,045</td>
<td>984</td>
<td>2,029</td>
<td>417</td>
<td>101</td>
<td></td>
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<tr>
<td>Sub-Total</td>
<td>Hindi</td>
<td>6,740</td>
<td>6,365</td>
<td>13,105</td>
<td>2,540</td>
<td>13</td>
<td></td>
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<tr>
<td>Sub-Total</td>
<td>Faza</td>
<td>597</td>
<td>578</td>
<td>1,175</td>
<td>240</td>
<td>472</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>Kwanjani</td>
<td>652</td>
<td>659</td>
<td>1,311</td>
<td>275</td>
<td>167</td>
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</tr>
<tr>
<td>Sub-Total</td>
<td>Kizingitini</td>
<td>1,104</td>
<td>1149</td>
<td>2,253</td>
<td>458</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>Obi</td>
<td>610</td>
<td>560</td>
<td>1,170</td>
<td>250</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>Siya</td>
<td>339</td>
<td>320</td>
<td>659</td>
<td>113</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>Tchundwa</td>
<td>910</td>
<td>868</td>
<td>1,778</td>
<td>305</td>
<td>263</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>Kizingitini</td>
<td>1573</td>
<td>1581</td>
<td>3154</td>
<td>529</td>
<td>5096</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>Ndau</td>
<td>404</td>
<td>450</td>
<td>854</td>
<td>168</td>
<td>623</td>
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<td>Sub-Total</td>
<td>Mbwajumwali</td>
<td>977</td>
<td>1047</td>
<td>2024</td>
<td>347</td>
<td>184</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>Kiunga</td>
<td>1259</td>
<td>944</td>
<td>2203</td>
<td>447</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>Rubu/Mwambore</td>
<td>361</td>
<td>302</td>
<td>663</td>
<td>118</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>Basuba</td>
<td>323</td>
<td>279</td>
<td>602</td>
<td>108</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>Mararani</td>
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<td>95</td>
<td>198</td>
<td>42</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Sub-Total</td>
<td>2162</td>
<td>1756</td>
<td>3918</td>
<td>762</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The larger Lamu County consists of five administrative divisions namely Kiunga, Kizingitini, Faza, Amu and Mpeketoni divisions.

10.3.2 Gender, age characteristics

Survey results show that about 80% of the respondents were men while 20% were women. Respondents were in the age of 20 to 80 years with the average age of 44 years. Most of the respondents (86%) were married and had families to take care of.

10.3.3 Education characteristics

The respondents were characterized by low levels of education with most of them (about 84%) having attained different levels of primary education, madrassa (Islamic education) or no education at all (see Figure (10) - 1). Only 6% of the respondents had attained complete secondary education while 4% had attained incomplete secondary education. Furthermore, less than 6% had attained tertiary or university education.

![Figure 10 – 2: Distribution of levels of education among the residents](image)

A significant disparity in levels of education was found between men and women in the project area (see Figure (10) – 2). Women dominated the section of population who never attended school as well as those who only acquired basic literacy and madrassa while the section of population that had attained secondary, tertiary, university and youth polytechnic levels of education were dominated by men.

Overall, Lamu County has a total of 70 primary schools with 22,633 pupils, 11 secondary schools with 972 students, less than 5 tertiary learning institutions which include a youth polytechnic and some commercial colleges and adult literacy classes with no credible enrollment statistics available. The teacher to pupil ratio is: 1:40 and 1:39, in public primary and secondary schools respectively. Overall, 66.4% of the county residents possess primary education whereas 9.7% of the population have earned secondary education; placing the county at the 30th and 35th positions.
in the same order for the national counties’ educational ranking. However, a high rate (73.2%) of the entire population is literate in spite of little formal education, a fact that is attributed to the vast influence of the prominent Islamic religion (over 70%) that promotes religious classes during childhood – usually referred to as *madressa*.

![Figure (10) – 3: Distribution of levels of education between men and women](image)

**Household roles**

Most of the respondents (over 84%) were household heads that were responsible for providing food, shelter, clothing and other needs to their households. They are also responsible for taking decisions on behalf of their households. 13% were housewives while 3% were dependants. There is gender distribution of roles in economic activities within the project area. For example fishing and mangrove cutting are mainly male occupations. Some boats that facilitate these activities are however owned by women but women are generally not involved in actual fishing or mangrove cutting. Women participate mainly as fishmongers.

**Dwelling characteristics**

The study has revealed that 83% of the respondents are permanent residents of Lamu and live in their own houses. Only 17% live in rented houses.

**Health**

Lamu County has a total of 42 health facilities which are spread in different levels as follows: one (1) district hospital, two (2) sub-district hospitals, twenty (20) dispensaries, five (5) health centres, thirteen (13) medical clinics, and one (1) nursing home. The most notable Hospitals within the county are: Lamu District Hospital, Faza Sub-District Hospital and Mpeketoni Sub-District Hospital. Besides, there is a very low doctor to population ratio (1:36, 343) but very high infant mortality rates (72/1000) and an even higher under five mortality rate of 123/1000. These high
figures could be attributed to few deliveries in health centers (29.6%), and even fewer qualified medical assistants during births (27.2%). However, most children within the county have undergone all vaccinations (80.5%). The most prevalent diseases in the county are malaria, respiratory tract infections and skin diseases.

![Fig 10-4: One of the temporary dwelling structures affected by the project](image)

10.4 SOCIO-CULTURAL PROFILE

The inhabitants of Lamu (the project area) are mainly the Bajuni and Boni people. In terms of population size in the entire Lamu County, the Bajuni people are the most dominant community. They live along the coast and their traditional livelihoods include fishing which is their main occupation, mangrove harvesting especially at Ndau, subsistence farming and animal husbandry. The Boni people live inland in the forested areas and their traditional livelihood is hunting and gathering, but this is gradually changing and they have started practicing small-scale agriculture and harvesting forest resources such as honey. The population of the Boni is very small compared to Bajuni and they are considered a threatened tribe categorized by the World Bank as Indigenous People. The Kenyan Constitution also categorizes the Boni community under the Vulnerable and Marginalized Groups that need special considerations in developmental projects.

Islam is the primary religion in the project area with about 96% of the people being Muslim. This implies that any interventions that target the livelihoods of the local communities must take cognizance of the values that are enshrined in the Islamic faith.

The area that borders the project site in the north especially Kiunga was affected by the political instability in Somalia and the “Shifta” problem that caused people to migrate from their homes to settle in areas that were perceived to be relatively safer. This interfered with peoples’ way of life. Up to now, some villages such as Rubu and Mwambore are still largely unoccupied since those who lived here migrated to Pate Island to settle at Shanga. Apart from the migrations due to political instability, the migrant fishermen from other areas have also influenced the social
dynamics of the villages where they temporarily settle. In many cases the migrant fishermen camp and fish for weeks or months, before they travel back to their homes.

10.5 LIVELIHOODS AND ECONOMY

The study has revealed that economic activities vary from place to place. Overall, fishing and farming are the main economic activities in the Lamu County and the project area in particular. At the Mokowe-Hindi-Kililana-Baragoni stretch, agriculture is the most dominant occupation. The same applies to Pate village.

![Fig 10-5: Enumeration of crops and trees in Kililana area](image)

On the other hand, at Amu, Matondoni, Faza, Kizingitini, Kiwayu, Shanga and Kiunga artisanal fishing is the main occupation. Other occupations that were reported by a section of the population as their main occupations are small scale business, pastoralism and casual labour. Other important occupations that did not come out explicitly during the interviews are mangrove cutting which is mainly practiced by the inhabitants of Pate and Ndau. Table (10) - 1 shows the relative importance of these occupations at the project area based on our survey results (the survey was conducted at Amu, Shela, Matondoni, Pate, Faza, Kililana, Mokowe, Bargoni). Basically the results in this table show that farming and fishing are the most dominant sources of livelihood and income. Small-scale business ranks third. It is however surprising that tourism was identified by only 2% of respondents.

**Table 10b: Distribution of Occupations in the Project Area**

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Proportion of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>47%</td>
</tr>
</tbody>
</table>

Chapter 10
10.5.1 Fisheries

The waters adjacent to the whole of Lamu County are known to be the most productive area in Kenya, with the most valuable species being shrimps and lobsters. The local communities are well-known for their fishing skills as well as skills in boat building, sailing and other marine activities. 4,111 fishers operate in the Lamu County (Fisheries Department, 2012). On average, Lamu County landed between 1,500 and 2,000 metric tons of fish per year between 2000 and 2008, of which about 40% is sold to other areas outside Lamu County. Fishing is more intense during the Northeast monsoon (September to February) when the sea is calm and fishermen are able to access their fishing grounds without fear of capsizing. In addition, migrant fishers from outside the Lamu County also arrive mostly during the Northeast monsoon season.

The main species of fish landed from the artisanal fishery of Lamu include lobsters, rabbit fish, scavenger, snapper, catfish, cavalla jacks, mackerel, barracuda, mullets, queenfish, sailfish, tuna, prawns, crabs, sharks and rays, sardines, oysters and octopus. While most of these fish are commonly landed from the fishing grounds within the Lamu Archipelago, lobsters and crabs are mainly fished in Kizingitini, Faza, Kiwayu and Kiunga.

The distribution of fish landing beaches that are recognized by the Fisheries Department is shown in Table 2. Most of the landing sites are within Faza, Amu and Kizingitini Divisions reflecting the dispersion of fishing activities within the area. Fishers from most of these landing sites often share the same fishing grounds some of which are within the project site.

Table 10c: The main fish landing sites in Lamu County excluding sites at Mpeketoni and Witu (Fisheries Department Frame Survey, 2006)

<table>
<thead>
<tr>
<th>Division</th>
<th>Landing site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faza</td>
<td>Dodori, Shanga Ishakani, Shanga Rubu, Tchundwa,</td>
</tr>
<tr>
<td></td>
<td>Rasini, Pate</td>
</tr>
<tr>
<td>Kiunga</td>
<td>Kiunga, Mkokoni</td>
</tr>
<tr>
<td>Kizingitini</td>
<td>Kiwayu, Ndlau, Mbwajumwali, Kizingitini</td>
</tr>
<tr>
<td>Amu</td>
<td>Langoni (Amu), Shella, Mkomani (Amu), Matondoni,</td>
</tr>
<tr>
<td></td>
<td>Kipungani</td>
</tr>
<tr>
<td>Hindi</td>
<td>Ndununi, Mokowe</td>
</tr>
</tbody>
</table>

The importance of these fish landing sites was also echoed by the respondents during our study.
a) **Trends in fishing effort**

Table 3 shows the trends in fishing effort between 2004 and 2008. The trends in fishing effort has been captured in terms of the number of fishers, fishing crafts and fishing gears in Lamu County based on the frame surveys that were conducted by the Fisheries Department in 2004, 2006 and 2008. The 2008 survey indicated that there are 22 fish landing sites and 21 BMUs. The frame surveys have shown that the number of fishers in the county increased by 73% between 2004 and 2008 while the number of fishing crafts increased marginally by less than 1%. In addition, the artisanal fishers use non-motorized sail boats to conduct their fishing operations. In fact the non-motorized sailboats constituted 77% of the total enumerated crafts during 2008 frame survey. This shows that artisanal fishing is still carried out using traditional fishing crafts which cannot venture into open sea especially during rough conditions. Motorized vessels using outboard and inboard engines constituted only 9% of the total crafts, similar to those using paddles.

The fishing gears that are commonly used include gill nets, hand lines, beach seines, long lines, fence traps (*uzio*) and basket traps (*malema*). In addition diving masks are used to fish for lobsters. Gill nets constituted 37% of all the gears followed by long lines that constituted 22%, handlines (12%), monofilament nets (10%) and traps (8%). Other gears encountered were prawn seines (2.5%), beach seines (4.9%), troll lines (1.4%), cast nets (0.2%), spear guns (0.6%) and reef seines (0.1%).

<table>
<thead>
<tr>
<th>Gear Type</th>
<th>2004</th>
<th>2006</th>
<th>2008</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of fishers</td>
<td>1104</td>
<td>1344</td>
<td>1912</td>
<td>4,111</td>
</tr>
<tr>
<td>Fishing crafts</td>
<td>395</td>
<td>347</td>
<td>429</td>
<td>756</td>
</tr>
<tr>
<td>Gillnets</td>
<td>2308</td>
<td>876</td>
<td>830</td>
<td>954</td>
</tr>
<tr>
<td>Long lines</td>
<td>1140</td>
<td>798</td>
<td>461</td>
<td>4,548*</td>
</tr>
<tr>
<td>Hand lines</td>
<td>648</td>
<td>440</td>
<td>249</td>
<td>360</td>
</tr>
<tr>
<td>Monofilament</td>
<td>352</td>
<td>196</td>
<td>568</td>
<td>881</td>
</tr>
<tr>
<td>Traps</td>
<td>352</td>
<td>286</td>
<td>248</td>
<td>291</td>
</tr>
<tr>
<td>Beach seines</td>
<td>102</td>
<td>370</td>
<td>54</td>
<td>97</td>
</tr>
<tr>
<td>Prawn seines</td>
<td>55</td>
<td>86</td>
<td>137</td>
<td>71</td>
</tr>
<tr>
<td>Trolling lines</td>
<td>27</td>
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<td>98</td>
<td>14</td>
</tr>
<tr>
<td>Cast nets</td>
<td>14</td>
<td>0</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Spear guns/harpoons</td>
<td>0</td>
<td>0</td>
<td>63</td>
<td>549</td>
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<tr>
<td>Reef seines</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Scoop nets</td>
<td>276</td>
<td>440</td>
<td>394</td>
<td>371</td>
</tr>
<tr>
<td>Number of landing sites</td>
<td>22</td>
<td>22</td>
<td>21</td>
<td>19</td>
</tr>
<tr>
<td>Landing sites with BMUs</td>
<td>9</td>
<td>7</td>
<td>21</td>
<td>19</td>
</tr>
</tbody>
</table>

*number of long line hooks

The frame survey data showed a consistent decline in the number of fishing gears between 2004 and 2008 but the trend changed in 2012 when the number of fishing gears generally increased.
For example, it is evident that the number of gill nets decreased by approximately 64% between 2004 and 2008, handlines declined by 62 between 2004 and 2008, longline declined by 60% between 2004 and 2008 and traps declined by 30% between 2004 and 2008. The reasons for the massive decline are not yet clear but probably some fishers did not show their gears for enumeration during the 2008 frame survey. It is also interesting that the trend has changed in the 2012. It is only a few gears that showed some increase for example, the number of monofilament nets that showed a threefold increase between 2006 and 2008, prawn seines more than doubled between 2006 and 2008 and trolling lines also increase almost three fold between 2004 and 2008. However, the trend for these last two fishing gears has also changed in 2012 when their numbers have radically decreased.

In terms of spatial distribution of the fishing gears, gill nets are dominant at Kiunga, Kizingitini and Amu locations while beach seines are prevalent in Faza, Kizingitini and Amu. Hand lines were found to be dominant at Hindi location. Trolling lines, scoop nets and long lines were found to be used at Amu and Faza.

**b) Fishing grounds**

A number of fishing grounds were identified by the fishers who operate in the project area. These fishing grounds include:

- Dodori creek
- Ndununi creek
- Kiweni
- Bahari
- Shella
- Mkanda
- Manda

From their characteristics, most of these fishing grounds are within the port area and are mainly sheltered areas where fishers operate comfortably with their traditional fishing crafts and gears. It was noted that even Dodori creek which may appear to be slightly outside the site where the first 3 berths will be constructed is an important fishing ground for fishers from Matondoni who still have to pass through the port area in order to reach Dodori creek where they fish for prawns. Only a few boats are able to venture into the open waters but even where this is possible, the fishers are constrained by lack of gears that are appropriate for deep water fishing.

**c) Fishing routes**

The fishers often travel to fish in their preferred fishing grounds. It was interesting to notice that the fishers from Matondoni depend on the Channel (Mkanda) as their main route as they head towards Dodori and Ndununi creeks where they fish for prawns. The fishers from Amu and Shela also confirmed Mkanda as their main route to reach their fishing grounds. It was also interesting that the same sentiments were echoed by fishers from Faza and Pate who on the other hand rely on Mkanda to reach Lamu Town where they have a big market for fish and fishing equipment. The fishers who operate from Bandari ya Bwana Mkuu as well as those from
Mokowe and Ngiini also use the channel. The fishers from other fishing villages such as Faza, Kizingitini, Kiwayuu and Kiunga will also be affected by the project since they share the same fishing grounds. The primary source of livelihood in these villages is artisanal fishery that depends on the market in Lamu. All fish landed is sold to traders who operate from Lamu town using boats equipped with ice-boxes to preserve fresh fish.

d) Fisheries Management and conservation in the project area

Fishery is managed by the technical arm of the Ministry of Fisheries Development, the Fisheries Department. To promote co-management in the fisheries sector, the Fisheries Department established Beach Management Units (BMU) in all the main fish landing beaches. Besides the Fisheries Department, the Kenya Wildlife Services (KWS) is responsible for managing the Kiunga Marine National Reserve (a marine protected area). WWF, an international conservation agency, has also contributed immensely towards building capacity in co-management and environment conservation in the Lamu Archipelago.

The Beach Management Units (BMUs) at Amu, Shela, Pate, Shanga Rubu and Shanga Ishakani have established the Iweni Community Conservation area which they manage jointly. These BMUs benefit from the conservation area by collecting revenue from tourists who visit the site. The revenue is shared between these participating BMUs with much support towards education, schools and health issues. The BMUs perform their duties in accordance to the Fisheries (BMU) Regulations, 2007. Their core mandate is co-management and environmental protection for sustainable fisheries. They generate their income from fisheries and related activities. The revenue that is generated from this community conservation area will be lost since the site falls within the project site around Manda Bay.

10.5.2 Agriculture

Subsistence and cash crop farming is carried out by the communities who live in the rich agricultural areas in Hindi, Pate, Mpeketoni and Witu Divisions of Lamu county. Many households that engage in fishing and small scale business as their main occupations also practice agriculture as a supplementary source of livelihood and income. The food crops that are grown in the county include maize, beans, cowpeas, sorghum, squash, bananas, pawpaw and millet. Cash crops on the other hand include cashew nut, mango, sesame seed, coconut, citrus fruit, bixa and tobacco. About 9,214 acres of land is under cash crop production.

Agriculture which is the most dominant occupation providing livelihood to 51% of the respondents is based on the availability of rich agricultural land in the project area. Mixed farming which involves both food crops and cash crop grown together is a common practice. Focus group discussions revealed that cashew nut was introduced by the colonial government in the area, to date the cashew nut trees are spread in the entire project area. As a result, the area has cashew nut trees that are at different stages with most of the cashew nut trees being over 10 years old. The cashew nuts are sold to agents who buy them from the farms/homes and transport to where processing is done. The farmers therefore have a reliable market for their cashew nut. Some of the farmers have built their homesteads in their farms so that they are able to manage their crops themselves while other farmers have employed farm workers who have settled in the
farms with their families to take care of the crops. It was evident from the visits made to these farms that there are genuine farmers from the local communities who have either lived in the area or developed their farms with tree crops over many years. Their rights to ownership of land cannot therefore be questioned. The Hindi settlement scheme has also introduced a new phase of commercial farming in the area.

Livestock rearing is also an important occupation in the project area. The farmers in the project area keep some livestock such as goats and poultry. Outside the project area of Kililana, there are households at Bargoni, which depend on pastoralism as their main source of livelihood. These households keep large herds of cattle, goats and sheep. Some households also keep bees on smallholder basis.

10.5.3 Small-scale business

Small scale business is practiced by 11% of the households as their main occupation. It includes small businesses such as shop-keeping, fish trade, groceries, food kiosks, coconut trading, and thatch (makuti) making and selling.

10.5.4 Tourism

Tourism is another occupation that employs a section of the population especially in Lamu town. Lamu town is historically known for cultural tourism. The tourists are mainly attracted by the rich culture and the existence of unique heritage sites, hospitality of the local people, rich biodiversity and the beautiful scenery in the archipelago. Other tourist attractions which are marine-based include activities such as diving, snorkeling, surfing, fishing, donkey races and dhow trips. Consequently, different categories of hotels have been built at the seafront in the main town and at SheIIa beach. These hotels thrive on tourism that reaches its peak in November-January and during the ‘Maulidi’ and Lamu Cultural Festivals. Different categories of restaurants have also been built to meet the demand in the tourism industry. In addition, there are two tourist hotels (resorts) at Mkokoni and Kiwayu Island.

The hotels and restaurants provide direct employment and market for local products thus directly supporting the economy of Lamu. Indirectly, the hotels and restaurants provide an opportunity for many people who obtain their livelihood by offering supportive services especially at the jetty when tourists arrive. Their services include tour-guide services, directing visitors to the available hotels and assisting with transportation of luggage to the hotels at a fee.

A number of boat operators are also supported by the tourism industry. Both speed boats and the traditional wooded-sail boats are available to provide transport to tourists to attraction sites. 118 youths have registered as boat operators in Lamu. Each transport boat supports 10 people but only 2-4 crew members accompany the tourists at a time. Members of the boat operators association are trained on safety measures, swimming and rescue. If the tourism projects are managed properly, such projects may provide a market for local products as well as employment.
The few tourism establishments in Lamu have experienced a major recession in the last 3-4 years. This is attributable to rising insecurity in the horn of Africa region due to the instability in Somalia.

10.5.5 Mangrove harvesting

Lamu area is historically associated with flourishing mangrove trade and transportation to Arabia following the monsoons. The international trade continued until the government banned export of mangroves in the 1980s. It was observed that trade in mangrove poles is still an important economic activity. The mangrove forest resources of the broader Lamu County contribute significantly to the local livelihoods and income. This area has approximately 20,000 hectares, which is about 40% of the country’s mangrove forest cover. While mangrove harvesting is not a main occupation in most of the villages, about 90% of the households in Ndau sub-location and a number of the households at Pate depend entirely on mangrove cutting as their main occupation. The mangroves are mainly cut from Manda, Ndununi, Bwari, Kidansini, and Ndau. The mangrove cutters travel to these mangrove areas by sailboats (jahazi), which are traditional vessels with each having a capacity crew of six. Mangroves poles that are harvested are of different sizes and uses. These include boriti (Lamu roof), pau (roofing), vigingi (for fencing and construction of wall) and fito.

The mangrove poles are cut and sold to dealers who transport them to Lamu town by boat. The local people also cut mangroves for their own use. The demand for mangrove poles from the Lamu archipelago is high because the poles are tall, straight and resistant to termite attack. It is however worth noting that the key informants felt that the mangroves are being over-exploited and there is need for a mangrove management plan to be developed and implemented. Besides the mangrove poles and other wood products that support the economy of Ndau and Pate villages, the local communities also harvest other non-wood products such as honey, fish, crab, animal fodder and medicine from the mangrove forests.

10.5.6 Exploitation of terrestrial forests

Lamu district has 9,533 ha of non-gazzeted forest out of which 4,673 ha are terrestrial forests. Large areas of forest land fall within non-gazetted areas. This presents a serious challenge to the Kenya Forest Services’ effort to conserve forests. Charcoal burning and firewood collection are major economic activities from the non-gazzetted forest areas. It was established during the study that the Kenya Forest Service did not undertake an independent study before the port development project or after the clearance of the 2 ha of mangrove forest in Kililana. However a private consultancy (ESF) conducted a risk assessment with focus on the likely effect of oil spills on Lamu mangroves. A report from the Kenya Forest Services has shown that the agency was not directly involved in the decision to clear the first 2 ha of mangrove forest in Kililana.

Lack of formal land ownership and prevalence of self-allocation of land by individuals has accelerated forest degradation in the project area. Since most forest land is government land, individuals have cleared forests and bushes for charcoal burning, agriculture and for settlement including in the Hindi - Magogoni area. Charcoal burning is serious issue since it is being commercialized to serve the increasing island populations.
It may not be possible to replant an entirely cleared mangrove field. To increase forest cover in the district three strategies and measures have been taken namely: preparation of more tree nurseries and encouragement of farm forestry; initiating annual enrichment planting of mangroves in affected areas e.g. areas affected by disease, dredging or cutting. The third approach is use of CFAs as a means of promoting sustainable forestry e.g. through encouraging ecotourism ventures.

10.6 LAND TENURE

Like other parts of the coast where land along the coastal strip is owned by absentee landlords, land tenure in Lamu has remained unresolved for long with the local communities, the Boni and Bajuni communities, living as squatters without land titles for years.

Consequently, land has remained public (in the hands of the Government) except in places such as Mpeketoni and parts of Hindi that have been converted into settlement schemes and land parcels formally allocated to people and ownership documents issued. Notably, lack of land titles (or any form of ownership documents) by the local communities has created significant discontentment.

In order to address some of the land issues that arose at the project site at Kililana, studies were conducted by different Government departments in Lamu County to evaluate lost property within the boundary wall affected by the project at the time of groundbreaking in March 2012. The lands report was meant to identify the land ownership and acreage for the affected people. A second report that was prepared by the District Agricultural Officer enumerated crop losses by each farmer. A third report was done by the Lamu Port Steering Committee. These three reports were submitted to the County Commissioner and were found to differ on the exact numbers affected. This may be due to the differences in area and scope of coverage by each and the
hurried preparation before the ground breaking. As a result these reports may have missed some landowners.

![Consultation with PAP in Hindi area](image)

Fig 10-7: Consultation with PAP in Hindi area

The affected land owners in the area can be categorized into 3:

(i) Land owners within the 1.3 sq. km project area who lack ownership documents but have ancestral claim.

(ii) Land owners outside the 1.3 sq. km project area who lack ownership documents but have ancestral claim.

(iii) Land owners outside the 1.3 sq. km area who have ownership documents. This category of land owners are mainly found in the Hindi scheme.

Some of the salient issues that were raised by the respondents regarding land

- Most of the households that are affected by the project only have ancestral land ownership without any supporting documentation from the government i.e. title deeds or allotment letters.

- The households and farms already affected by the access road also lack supporting documentation from the government i.e. title deeds or allotment letters yet they have ancestral ownership of their land.

- The only people who have ownership documents are those within the settlement schemes most of whom are not indigenous people. There is apparent skewed allocation of title deeds where schemes such as Mpeketoni-1977, Hindi-Magogoni-1983 and Witu-1988 mainly benefited non indigenous groups and were swiftly allocated land with ownership documents.

- Residents and land owners were evicted without due process by KeNHA for the highway construction.
• There is urgent need for compensation for the project affected persons some of who are already displaced while others cannot productively use their land and property due to anxiety.
• There was concern as to whether the compensation process would take into account the projected increase in land value as a result of the port development and the attendant speculative activities.

10.7 CULTURAL AND HERITAGE SITES

10.7.1 Lamu Old Town

Lamu is the oldest and the best-preserved living settlement among the Swahili towns along the East African coast. Its buildings and applied architecture are the best preserved and carries a long history that represents the development of Swahili technology. The old town is thus a unique and rare historical living heritage with more than 700 years of continuous settlement. It was once the most important trade center in East Africa before other towns such as Zanzibar took over.

Since the 19th century, Lamu has been regarded as an important religious center in East and Central Africa due to the ‘Tarika’ (The Way of the Prophet) activities introduced by Habib Swaleh, a Sharif descendant of Prophet Mohamed (P.B.A.H). It is said that there are many descendants of the Prophet in Lamu. Their presence has kept up the tradition, which continues to the present day Lamu in form of annual festival known as ‘Maulidi’. These festivals are endemic to Lamu and draw the Muslim community from all over East and Central Africa as well as the Gulf. Lamu is an Islamic and Swahili education center in East Africa. Researchers and scholars of Islamic religion and Swahili language come to Lamu to study this cultural heritage, which is relatively unchanged. The island town has adopted very little modern technology due to
its isolation (UNESCO Nomination Dossier, 2000). UNESCO inscribed Lamu Old Town on the World Heritage List in 2001. The justification for the inscription is as a result of the following:

- Lamu is the oldest and the best-preserved Swahili town in East Africa dating back to the 12th century.
- Lamu ‘exhibits an interchange of human values over a span of time on developments in architecture,’ with its unique fusion of Arabic, Indian, European and Swahili building styles.
- The town has continuously been inhabited since its foundation.
- Lamu is a reservoir of the Swahili culture and plays an important role as a religious Islamic centre as well as Swahili education centre for whole of East Africa.

Due to the above, Lamu meets criteria (ii) and (vi) of the test of authenticity in accordance with the Operational Guidelines as follows:

Criterion (ii): The architecture and urban structure of Lamu graphically demonstrate the cultural influences that have come together there over several hundred years from Europe, Arabia, and India, utilizing traditional Swahili techniques to produce a distinct culture.

Criterion (iv): The growth and decline of the seaports on the East African coast and interaction between the Bantu, Arabs, Persians, Indians, and Europeans represents a significant cultural and economic phase in the history of the region which finds its most outstanding expression in Lamu Old Town.

Criterion (vi): Its paramount trading role and its attraction for scholars and teachers gave Lamu an important religious function in the region. It continues to be a significant centre for education in Islamic and Swahili culture.

10.7.2 Current Information and Request from UNESCO

According to the document (WHC-09/33.COM/7B) on the UNESCO Web site, as a result of consultations between the Ministry of Transport and National Museum of Kenya (NMK), it has been agreed that both the Ministry of National Heritage and NMK will be consulted at all levels and a Cultural and Archeological Impact Assessment will be carried out before the port development commences. In November 2008, the NMK convened a UNESCO donors’ conference and the conference agreed that the development of the new port should respect all the historical sites in the area. All the above-mentioned facts will be taken into consideration for the entire study.

According to the document (WHC-10/34.COM/7B.Add.2), with regard to the Lamu Port Project, UNESCO recommended that a comprehensive EIA be well integrated with the cultural assessment and archaeological report of the NMK. Aspects to be addressed in the cultural assessment are to be focused on protecting the Outstanding Universal Value (OUV) 2 and authenticity and integrity of the World Heritage property, and include impacts on tangible and
intangible heritage of the property, impacts on artisanal fishing industry, impacts on population increase in the district, increase in informal settlement, impacts of demographic change, impacts of labor migration, visual impacts, impacts on sea current and coast edge vegetation, loss of archaeological deposits and sites.

10.7.3 Maulidi (Festival)

Since the 19th century Lamu has been regarded as an important religious center in East Africa. Every year, thousands of pilgrims from the region flock to Lamu town for the famous Maulidi, or Milad-un-Nabi, celebrations that are held during the third month of the Muslim calendar to mark the birth of the Prophet Mohammed. The East African Maulidi is believed to have been started by HabibSwalehJamalely, a Comorian Arab who emigrated to Lamu and established himself as a scholar and doctor of traditional Arabic medicine. He was a pious man whose deeds are still emulated today, as exemplified by Maulidi. The Maulidi celebrations are known to bring people from as far as the Comoros, Sudan and Democratic Republic of Congo (NMK).

10.7.4 Other main Gazetted Historical Sites

There are some gazette historical monuments within and around the project site as shown in Most of them have not been checked well and need archaeological assessment before construction. The relevant monuments to port development are Mkokoni, Mashundwani, Ungu, Kiliana, Manda, Takwa, Pate, Shanga, Siyu. Of those, Takwa, Siyu fort and Pate are well-known historical sites as well as a tourism spot where the magnificent scenery of mangrove forests and Indian Ocean can be seen at the same time.

i. Takwa Mulinga Ruins

A mosque, houses, a well and other structures and also a pillar tomb are located on this site at the point where Manda Island is almost bisected by a tidal channel. Site is a national monument. Archaeological potential above average because of the number of surviving structures (NMK Document on Lamu Sites, 2010).

ii. Siyu

Still inhabited, this settlement lies on the landward side of Pate island at end of shallow winding creek. Many ruins including 19 stone houses, 3 mosques some still in use. Remains date to 18th Century onwards. It also has town walls, 4 gates and residential houses. Siyu fort is also located within Siyu village (NMK Document on Lamu Sites, 2010). NMK and the Government of China have embarked on an archaeological survey to establish whether a Chinese trade ship sunk north of Pate Island approximately 600 years ago. This will look to give a better understanding of the history of Lamu.

iii. Pate

An assessment at Pate revealed that the entire Pate old town (the current Pate village) is a heritage site consisting of historical prison, town wall, custom house, royal family grave yards, 9 gates surrounding the historical town and residential houses. In addition, there is Mbui at Mtangawanda. It was also noted that the Pate community has preserved its heritage. We however noted that some parts of the monument are threatened by human activity with some areas
being converted into smallholder farms. The historical town covers 68 acres and had a population of 48,000 people living inside the town wall. The population has since then decreased to approx. 4,000 people who occupy only 30% of the 68 acres. There is fear that people would buy part of the land and construct new buildings hence destroying the heritage. All these monuments are under the management of the National Museums of Kenya.

10.8 PERCEPTIONS ABOUT THE PORT CONSTRUCTION PROJECT

Majority of the community and other stakeholder who were interviewed have expressed their support for the project. 89% of the respondents stated that the port will benefit the local community by opening up the area through the construction of a tarmac road (see Table (10-5). A good road will open the area for development, improve transport and investment including attracting more public transport vehicles.

![Fig 10-9: One of the PAPs expresses her views during consultation in Hindi](image)

Those who live at Bargoni have had perpetual transport difficulties and they believe that the project will stimulate transport flow in the area thereby making it easy to commute and transport farm produce and fish to the market. However, there is a strong feeling that the community needs should be considered in the project including adequate compensation and resettlement where necessary. Where compensation is involved, it should include compensation for lost land, issuance of title deeds and provision of passage to the fishing grounds. In addition, the fishers should be empowered with better fishing gears and boats so that they can access the alternative fishing grounds. Employment opportunities should also be provided to the local communities.

<table>
<thead>
<tr>
<th>Perception</th>
<th>Proportion of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>The project is good since it will benefit will improve transport and open up the area for development</td>
<td>89%</td>
</tr>
<tr>
<td>Accepted only when adequate compensation is provided</td>
<td>10%</td>
</tr>
<tr>
<td>Against the project</td>
<td>1%</td>
</tr>
</tbody>
</table>
A section of the community (1% of the respondents) however fears that the project will result in to an abrupt relocation that might lead to loss of un-harvested farm produce, loss of land and source of livelihood. Some people stated that the project will displace fishers from their traditional fishing grounds and landing beaches thus disrupting their livelihood. They are therefore only ready to accept the project if adequate compensation and resettlement is provided.

Those against the project cited lack of consultations with the project affected persons, inadequate disclosure of project information, poor approach to land acquisition that caused tension and hostility among the local communities, and the general suspicion that the local communities may be marginalized by the project.

In general the proposed Lamu Port project is acceptable to the Lamu community due to the following expected benefits:

- The new port project will open up Lamu County for business and development that will benefit the people of Lamu by
- Facilitate marketing of fishery products
- Opportunity to reduce piracy due to increased security in the Lamu county

However the residents are categorical that their concerns, in particular compensation for loss of land and livelihood has to be addressed to their satisfaction in the process of implementing the project.
Figure 10 – 10: Location of Lamu Old Town Cultural Heritage and Buffer Zone (Source: NMK)
Figure 10 - 11: Lamu Sand Dunes Dealination (Source: NMK)

Legend
- 723_Beacon
- Plots
- Catchment Area
- Wells
- Settled Areas
- 723_HA

N.B.
1. 723_HA = 723 Hectares proposed
2. Catchment area = area delineated by WRMA officers during the exercise
3. Plots = Areas within Catchment noticed by the team to have been sub-divided and some activities going on
Figure 10 - 12: Lamu Gazetted Sites and Monuments in Lamu District (Source: NMK)
Figure 10 – 13: Location of Marine Archeological Survey Areas (Source: NMK)
11. POTENTIAL IMPACTS AND MITIGATION MEASURES

11.1. SOCIO-ECONOMIC IMPACTS

11.1.1 Positive Socio-economic impacts

On the positive, it is anticipated that the proposed project will have the following impacts:

(1) Increased economic activity

Many businesses will come up to support the large number of resident and migrant workers at the project site. The anticipated increase in the flow of money will create a suitable environment for micro and small-scale enterprises.

(2) Improved infrastructure

The proposed project would open up Lamu area. It is expected that with the construction of the port there would be increase in the demand for commercial and residential property within Lamu.

(3) Employment creation

The project will create employment at inception, construction and operational phases as follows:

- During inception consultants will be commissioned to undertake services such as engineering and architectural design, land and quantity survey, environmental impact assessment and development of procurement specifications. At the construction stage many contractors would be hired who will employ site engineers, technicians and equipment operation personnel alongside hundreds of unskilled workers. At this stage professional services would also be required for contractor supervision.

- On commissioning the project would be expected to hire staff to manage the new port. This would create jobs in engineering, operations and administration as well as requirement for support personnel in security and accounts. This will address the unemployment problem in the short-term and will trigger more economic activity since demand for goods and services will increase. Once the construction phase is completed and the volume of business increases, employment will be created through the linkage effects especially in the area of road transport since trucks may have to come in to clear the containers from the new container terminal.

11.1.2 Negative Socio-economic Impacts and Mitigation Measures

Lack of consultation with the community in the entire Lamu Port development process at the initial stages raised serious concerns among the local leadership, the community as whole and other stakeholders. It was also noted that a Lamu Port Steering Committee was constituted to create the link with the local community and the port project. However, the committee felt that it had not been engaged in the decision making process so as to provide the highly needed local support for the project.

This assessment has noted that the development of the New Lamu port project will negatively affect the Lamu community as follows:
### Table 11a: Summary of Socio-economic Impacts

<table>
<thead>
<tr>
<th>Sector/activity affected</th>
<th>Impacts/Issues identified</th>
<th>Mitigation measures suggested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport shipping &amp; harbor</td>
<td>Marginalization of the local people with respect to employment at the proposed port due to lack of required skills</td>
<td>MoT should initiate a middle level class training program for courses that relate to Port operations and management in Lamu. In the interim, MoT can enter into partnership with the Lamu Youth Polytechnic to utilize the facility to initiate the training programme. This would enable the graduates of the polytechnic qualify for employment once the port is operational.</td>
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<tr>
<td></td>
<td>Loss of fishing grounds and landing sites</td>
<td>Gear and vessel exchange to use other fishing grounds and methods Investment in fish storage facilities Construction of an alternative landing site in liaison with KPA and Fisheries Department Allocation of specific sea routes for small vessels</td>
</tr>
<tr>
<td>Fishing</td>
<td>The proposed port will encroach on fishing grounds thereby displacing the artisanal fishermen from some of their traditional fishing grounds and landing sites.</td>
<td>Empower the local fishermen to move to deep waters by offering training on deep-sea fishing methods and provision of fishing gears and vessels that can enable them venture into other more distant deep water fishing grounds. Provide modern fish landing sites with adequate infrastructure such as power, access roads and cold rooms or ice making plants.</td>
</tr>
<tr>
<td></td>
<td>Sea routes used by fishers, especially Mkanda (main channel) will be affected by dredging. Mkanda is used by fishers from Faza, Kizingitini, Matondoni, Kiunga, Mkokoni, Kiwayu, Chandani and Dodori to access their fishing grounds. Fishers using small vessels will have difficulty travelling between their fishing grounds and landing sites.</td>
<td>Provision of improved fishing gears, vessels and cold storage facilities such as ice plants.</td>
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<tr>
<td></td>
<td></td>
<td>• Put in place measures to revive existing facilities at Faza and Kiunga.</td>
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<td></td>
<td>• Fast track the building of the 2 fishing ports.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Provide proper transport to enable fishery products to reach market on time.</td>
</tr>
<tr>
<td>Sector/activity affected</td>
<td>Impacts/Issues identified</td>
<td>Mitigation measures suggested</td>
</tr>
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<td></td>
<td>through the alternate sea route via Manda-Bruno-Museum-Shela-Lamu which is rough and long. The longer travel time will result into post harvest losses</td>
<td>Demarcate passageways for small fishing vessels away from those used by ships</td>
</tr>
</tbody>
</table>
|                          | Possibility of marine accidents                                                                                                                                                                                             | Carry out ecological surveys and physico-oceanographic studies before mangrove clearing to ensure maintenance of the ecological balance  
Re-plant mangroves in other areas to replace the areas that are cut to pave way for the project.  
Provide training and skills to enable local community currently dependent on mangrove harvesting join other sectors.  
Provision of loans to invest in other sectors of the economy                                                                                                                                                                                                                                           |
| Mangrove harvesting      | Clearing mangroves will affect the livelihood of the Ndau & Pate community who are mainly dependent on mangrove harvesting and have limited skills to join other sectors.                                                          | Unacknowledgment of local community right of access and allocation of hours of free pass during construction period                                                                                                                                                                                                                                                                                                     |
|                          | Restriction and/or loss of sea routes and access to mangrove resources on Shella, Magogoni and Ndununi areas during port construction                                                                                          | Identification and acknowledgement of local community right of access and allocation of hours of free pass during construction period                                                                                                                                                                                                                                      |
|                          | Port area in Kililana is agricultural land and these land owners are being displaced.                                                                                                                                      | Compensate land owners based on size of land affected.  
Compensation to land owners to be based on customary ownership and not based on title deeds.  
Compensation process to be steered by DC, Chiefs and community leaders                                                                                                                                                                                                                              |
| Farming                  | Reduction in value of mangroves and coral reefs would affect tourism including diving and snorkeling                                                                                                                      | Use clean technology and put measures to minimize damage to mangroves and corals  
Provide training, skills and capacity to local tour guides and operators                                                                                                                                                                                                                                                                                      |
|                          | The new resort cities of Lamu, Kilifi and Kwale will kill the traditional tourism in Lamu                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                             |
| Socio-cultural and Political | Ownership issues – fear of local residents being locked out of port related benefits                                                                                                                                  | Incorporate a clear benefit sharing system with the community  
i) Include the local leaders especially the all-inclusive Lamu Port Steering Committee in the decision-making process so that the project obtains local ownership and support to eliminate conflicts.  
i) Develop a policy on community consultation and involvement. If necessary, reconstitute the steering committee, provide it legality and incorporate it fully in the port development process  
i) Address natural resource related conflicts |
<table>
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<tr>
<th>Sector/activity affected</th>
<th>Impacts/Issues identified</th>
<th>Mitigation measures suggested</th>
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<td><strong>before initiating project</strong></td>
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<td>w) Establish a fair mechanism for addressing community grievances including holding consultations on their roles to have their trust</td>
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<td>v) The port planning should integrate community development projects as part of corporate social responsibility to benefit the affected local communities</td>
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<tr>
<td>Loss of the world heritage site</td>
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<td>Protection on the world heritage site by ensuring proper mitigation measures are put in place. Deliberate strategies to conserve the traditional cultures of the Lamu people should be put in place.</td>
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<tr>
<td>Possibility of displacement, domination and loss of the cultural identity of the indigenous Lamu people (The Swahili/Bajuni, Boni, Pokomo and Orma) following influx of outsiders</td>
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<td>Through Corporate Social responsibility, MoT should consider providing annual support to the two major festivals in Lamu – ‘Maulidi’ and Lamu Festivals. Set up a centre to document and share cultural information in the area.</td>
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<tr>
<td>Majority of the businesses in Lamu are small retail and will probably be dominated in an expanded space</td>
<td></td>
<td>GoK to provide facilitation, capacity, loans and resources to enable small businesses to expand e.g. into go downs, supermarkets etc.</td>
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<tr>
<td>Lifestyle of the Boni community who are mostly hunter-gatherers has already been disrupted by the presence of settlement schemes in Hindi–Magogoni. The community is now getting involved in slash and burn agriculture and more recently settling. Port development in the area will further affect this community.</td>
<td></td>
<td>• Study on the effects of the port development on hunter/gatherer populations and assessment of viable alternative livelihoods e.g. beekeeping, agriculture, fishing. This could be done alongside the proposed Heritage Impact Assessment. • Capacity building for the hunter gathers groups through community groups and community projects such as demonstration projects, fish farming should be promoted.</td>
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<tr>
<td>Overpopulation and expected influx of outsiders to Lamu county will have major impacts on the local culture and will change the political landscape</td>
<td></td>
<td>i) Mechanisms to safeguard/secure the local culture and interests to create sense of ownership among the local people. This could be achieved through the establishment of a cultural centre. ii) Establishing integrated learning institutions where the values enshrined in Swahili culture are learned e.g. marriage counseling, dressing, handicraft (carpentry and joinery, dressmaking, men’s Islamic hat weaving), traditional dances (vugo, lele mama, shangani for</td>
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<tr>
<td>Sector/activity affected</td>
<td>Impacts/Issues identified</td>
<td>Mitigation measures suggested</td>
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<td>Possibility of proliferation of drug trafficking through multiple transport avenues - sea, rail, air</td>
<td>Institute proper control measures to address drug related issues such as initiating anti-drug awareness initiatives.</td>
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<td>The majority Islam population has coexisted with Christian Population. The anticipated population increase may introduce many different and unacceptable cultures including atheism, homosexuality, prostitution and drug abuse.</td>
<td>Deliberate strategies to conserve the indigenous culture of the Lamu people.</td>
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<td>Conflicts between government and local population due to inadequate consultation or poor communication</td>
<td>Institute proper measures to address local community concerns ahead of implementation. Institute a proper communication strategy to share information about the project with local community</td>
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</table>
| Land                     | Conflicts arising from lack of or inadequate disclosure on the project and tension among the local communities due to lack of land title deeds despite the existence of ancestral ownership | • Recognize traditional/ancestral land ownership and ensure the Ministry of Lands accelerates land adjudication as well as the provision of title deeds to local land owners in the project area and its surrounding who still do not have official land titles.  
• Provide due compensation to people whose pieces of land are taken over by the project. |
|                          | Displacement of people from their homes and land | • Develop a Resettlement Action Plan and a Compensation Action Plan for the project affected persons.  
• Affected persons to be issued with title deeds for their new locations |
|                          | Unresolved land issues and skewed allocations of title deeds for previous schemes at Mpeketoni-1977, Hindi-Magogoni-1983 and Witu-1988 leaving out local communities has created mistrust with government intentions | • Fairness and Equality in allocation of land ownership documents to include the local communities of Lamu  
• Government should address local community’s concerns through positive interventions to create positive attitude |
|                          | Increased speculation and acquisitions by outsiders resulting in increased price of land (from Ksh 500,000 to approx Ksh 1.5 million | Fast-track land adjudication in the project area to forestall speculative tendencies |
### Sector/activity affected

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<tr>
<th>Impacts/Issues identified</th>
<th>Mitigation measures suggested</th>
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<td>per acre)</td>
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The Lamu port project has attracted attention from numerous community groups, activists and pressure groups and international activities including groups with vested interests. Some of these groups have submitted their petitions.

The EIA team has accessed these petitions forwarded to NEMA, Lamu County Commissioner, and the Ministry of Transport and incorporated the concerns into the EIA report. Interest groups were invited to the stakeholder consultative meetings and their concerns incorporated into this report.

Livestock and Wildlife

Clearing of trees and forest for road and rail

Planting of an equivalent area of trees in locations not affected by the port development

Benefit sharing

The lack of information and consultation implies the likelihood of no benefit from the port project for local community

Allocation of a percentage of port proceeds for Lamu County for direct investment into development projects including:

- a) Adult education and empowerment especially for women
- b) Higher education and scholarships for local community to enable them join formal job market
- c) Exchange activities and exposure of Lamu community to similar port cities e.g. in Japan, China, Singapore, Korea, Malaysia to facilitate skills development and business linkages
- d) Industrial development to exploit available resources such processing of mango, orange, pineapple, coconut, cashew-nut, fish, cotton, milk etc.
- e) Promotion of cottage industries/jua kali sector such as iron smelting, jewelry, dressmaking, carpentry by local community, particularly the elderly to reduce divorce rates
- f) Tourism development: provide foreign language training (English, French, German) for youth to enable them conduct tourism activities
- g) Establishment of a community social centre including cultural library and museum where youth and elderly interact to exchange information
- h) Establishment of a community bank to encourage saving culture and access to loan facility tailored to local conditions

### 11.1.3 Implementation of the Resettlement Action Plan (RAP)

It is clear from the foregoing that the project would involve Involuntary Resettlement. This can have a dramatic impact on the lives of the people affected by the project. It can cause a sudden
break in the social continuity of their lives, resulting in the impoverishment of the relocated people. It may disrupt settlement patterns and means of livelihood, and generally diminish people’s sense of control over their lives. The foregoing sections and the above table have characterized the socio-economic impacts of involuntary resettlement on local farmers and fishermen.

Given the magnitude of the predicted resettlement impacts, the proponent has prepared a detailed Resettlement Action Plan (RAP) so that the programme is implemented in an orderly manner and is mutually acceptable to both the proponent and the Project Affected People. The Resettlement Action Plan has been guided by the following best practices:

- Involuntary settlement should be avoided, or minimized where unavoidable;
- Where resettlement is unavoidable resettlement plans and activities should be seen and executed as development programmes;
- Resettled persons should be provided with sufficient investment resources in order to restore their livelihoods;
- Project Affected People should be meaningfully consulted and participate in planning and implementation of resettlement programmes;
- Displaced persons should be compensated for their losses at full replacement cost prior to their relocation;
- Resettled persons should be assisted with the relocation and be provided with support during the transition period;
- Resettled persons should be assisted in their efforts to improve or at least restore their former living standards or income earning capacity.

An understanding should be developed between the government and the local community to safeguard the following:

- Protection of the world heritage site;
- Guarantee the mitigations required;
- Secure the interests of the indigenous people of Lamu (The Swahili/Bajuni, Boni, Pokomo) following the expected influx by upcountry communities. This includes provision of direct support and motivations thorough provision of schools, scholarships, and technical educational facilities such as polytechnic to prepare them for economic opportunities expected to be generated by the port development.

11.2 IMPACTS ON FISHERIES

11.2.1 Negative Impacts

The perceptions of impacts due to the proposed construction were grouped into:

- Relocation
- Pollution
- Loss of fishing grounds
• Loss of breeding grounds
• Improved facilities, safety and security
• Employment

There would be disruption to normal fishing activities as a result of restricted access due to dredging and construction activities. Since these fishermen currently use dug-out canoes which can hardly take them to the distant fishing grounds, there is need to empower them with motorized boats that can enable them fish far without difficulties.

(1) Loss of beach access/ fish landing sites.

Two landing sites will be lost due to the construction of the port. Fishers may be consolidated in some landing sites hence introducing conflict among fishers. Markets may be lost for those who buy fish at these landing sites

(2) Water pollution

Construction activities such as dredging and dumping would result into deterioration of water quality and there is a likelihood of oil spills at the operational phase. This may adversely affect the nursery and breeding sites of fish hence reduced fish catches.

(3) Loss of key fish habitats- breeding and nursery grounds

The proposed port area is considered a nursery and breeding grounds for exploited penaeid shrimps, some crabs and fish species. While most shrimps larvae are planktonic, the abundance of adult shrimp stocks is dependent the quantity of juveniles inhabiting the nearshore areas. The availability of suitable areas is an important factor that may the abundance of shrimps and crabs. This will lead to reduced catches and eventually loss of employment.

(4) Loss or significant modification of fishing grounds

This is likely to occur as the construction of the three berths will remove fisher’s access to fishing grounds. Dredging activities at the channels will also temporarily or permanent displace the fishers. Vessels anchoring and associated vessel exclusion zones could deny access to fishers. Any at sea disposal sites could lead to disruption of fishing activities. Since these fishermen currently use non–motorized boats propelled by use of sails access to the fishing grounds may be hampered. There is need to empower them with motorized boats that can enable them fish far without difficulties. Key lobster fishing grounds at the dredge channels will also be lost.

11.2.2 Mitigation for fisheries impacts

♦ The affected local artisanal fishermen are willing to move to other fishing grounds offshore. In the case of displaced fishing effort fishers may require to travel to far off grounds, the gears may not be suitable for the new fishing. A structural package should be considered to enable them adapt to the new fishing arrangements. Motorized boats and appropriate gears should be provided to the affected fishermen so that they are able to venture into the more distant fishing grounds.

♦ The displaced fishers may not have adequate knowledge of the new fishing methods. It is therefore necessary to train the fishers to equip them with skills to use the proposed motorized boats.
♦ Conflicts may arise due to increased pressure in the new fishing grounds. There is need to involve the rest of the fishers and create awareness on the port development and the empowerment to fishers to venture offshore.

♦ Loss or modification of fisheries habitats. It is important to restore other degraded areas and ensure protection of the same. It is also important to study further to understand the levels of disturbance to the key fisheries like crabs and shrimps.

11.3 IMPACTS OF DREDGING AND DREDGED MATERIAL DISPOSAL

11.3.1 Significant Negative Impacts

1) Impacts on the community marine conservation area- Iweni

At the entrance of the Manda channel is a community managed conservation area already demarcated by buoys. This area is under protection by the community and earning five BMUs a livelihood but will be lost due to dredging. The area is a tourist attraction and currently used as a diving site by tourists. Sea turtles are also sighted in the area.

2) Loss of key fishing grounds areas

Pezali rocks are important lobster fishing grounds accessed by fishers from various BMUs diving for lobsters. The channel is a key fishing ground for most fishers and during dredging fishers will lose a source of livelihood.

3) Loss of fish landing sites and boat anchor and repair sites

With about 10 designated fish landings sites within the Lamu archipelago, loss of fish landing and boat repair and anchor sites during construction phase is likely to trigger growth of more fisher-established sites. This calls for restructuring of the fisheries data and statistics collection within the immediate project area with a view to designing effective mitigation measures such as fishing ports.

4) Disturbance of dolphin areas

Dredging of the berth area may interfere with movement patterns of Dolphins that are known to occur between the Manda and Kizingitini channels.

5) Water Column Turbidity and Sedimentation

Deteriorating water quality will occur to a large extent since the disturbance is likely to be of high intensity in the construction and dredging phase. However, synergistic actions cannot be accounted for now, and will need more data and precautionary principle approach in the initial implementation plan. Changes in community structure may result proliferations of some toxic algae which may already exist locally here.

Impacts will be temporary, localized, & may not be well understood currently. Monitoring is therefore prescribed.
11.3.2 Mitigation for Dredging and Disposal Impacts

The following measures are proposed:

- Selection of dredging period in relation to tidal currents, time of the year and dredging period should be short. To minimize turbidity MoT shall undertake dredging and offshore dumping operations during dry periods when no buoyant water would enhance surface transport of the turbid discharge.

- Chemical analysis has shown that the dredged material is free of contamination. It would therefore be dumped at the proposed port area where it would be used for reclamation of the site in preparation for construction of the container yards.

- Negotiate with fishers to allow fishing once the dredging work is completed and compensate for lost fishing opportunity during dredging.

- Hydraulic and engineering studies to be conducted prior to dredging and during dredging to identify the direction of sediment transport and depositional nodes.

- Pay careful attention to the proximity and condition of nearby shore zones and other structures to ensure that dredging operations pose no threat to their structural integrity.

11.4 ECOLOGICAL IMPACTS

11.4.1 Key Issues

Reviews of likely impacts were assessed from the understanding of background effects (the existing impacts, etc.) and the scientific knowledge of species and population dynamics in space and time. The presumed impacts were thus assessed through:

1) predicting the assumed changes that will occur from the activity on the composition and abundance of species lists generated in the baseline survey;

2) determining the known and assumed habitat associations of the species present;

3) predicting the likely effects the proposed impacts will have on habitats within the project areas, and in turn on the survival and biology of habitat specialists; and

4) Assessing the likely consequences these impacts will have on the known and presumed species of conservation concern.

11.4.2 Marine Environment

1) The total area of mangrove to be lost through direct clearance to pave way for the construction of port gate and access road is 2 hectares. Loss of mangroves habitats may impact upon the marine flora and avifauna that inhabit mangrove areas. The relative environmental and ecological values of the different mangrove vegetation associations in terms of the contributions to ecosystem functions have been discussed in another section of this report and demonstrate that there is considerable variation in the likely
contributions per unit of area between mangrove vegetation associations which vary widely based on metrics such as above ground biomass (AGB).

2) Primary impacts: Since the construction will be mainly in the water, the direct loss of mangroves will be as a result of the access road construction. Assuming the road to be a major standard road with a width of 30m (including road reserve), the area of mangroves to be directly lost is 2.4 ha. Mangroves fringing the area of construction are also likely to be affected and this will need to be quantified through monitoring during pre-construction/preparatory destructive activities and during actual construction.

3) Secondary impacts: Sedimentation as a result of dredging and dumping is likely to have secondary impacts on mangroves and this will need ascertained during actual construction and periodic monitoring during port operation. Changed hydrodynamics due to increased activity in the channel is likely to have secondary impacts on adjacent mangroves and this will needs to be accounted for through monitoring during port operation.

4) Oil spill impacts from construction works and in the future from operations may have an immediate kill-off residual effect with deleterious consequences. Creek areas in Lamu have extensive mangrove which support a big fisheries base, bird population, and has a lot of other potential opportunity costs. Potential of oil pollution during operations is real and can be devastating.

Impacts may be permanent, widespread, & highly significant (mangroves supported biodiversity).
Significance: High due to potential loss to economy and environment in the event of spill

5) Loss of benthic habitats and benthic fauna: Impacts will be temporary, localized, & not significant. However, resilience, recovery and synergistic actions cannot be accounted for now, and will need more data or precautionary principle approach at all times.

The project area is characterized by Low benthic taxa diversity. Species involved have high reproductive & recruitment potential in adjacent areas & in newly created zones.

6) New species invasions by ships – ballast water invasions by ships during operations may introduce alien species. Invasive species have potential consequences to human health, food security and environmental degradation

Impacts may be permanent, localized, & significant.

7) New Habitats Formed by Structures (Especially Pilings): Erection of piers and possibly breakwaters would provide an abundant supply of new attachment surfaces, i.e., habitats for marine/estuarine organisms. Breakwaters or other structures possessing quarried rock also supply shelter for mobile aquatic animals. Organisms occupying these habitats (both attached and sheltered) may be desirable or undesirable.

8) Disturbances from Pile Driving and other Construction Activities: Pile driving and other waterfront construction activities would cause considerable noise and vibration easily transmitted to the adjacent waters. This disturbance may temporarily cause
displacement of fisheries and other mobile marine animals. However these animals will usually return to the area once the disturbance ceases.

Construction activities in the channel may also result into re-suspension of sediments and turbid water with possible effects of remobilization of heavy metals, nutrients and petroleum and Polyaromatic Hydrocarbons (PAH) into the water column and reduce sunlight penetration (resulting into lowered primary production).

11.4.3 Mitigation for Ecological Impacts

1) Loss of Habitats:
   - Support one ecosystem rehabilitation program by at least 2 times the area to be altered or damaged by project.
   - Support one BMU project as part of CSR

2) Oil spill pollution:
   - Upscale use of OSMAG and related oil spill contingency plans currently in Mombasa to cover Lamu Port.
   - Provide a contingency fund as per NEMA’s polluter pay principle.
   - Monitoring of fish catches & fish mortality cases.
   - Monitor biodiversity loss and recovery patterns.

3) Introductions of alien species
   - Support ballast water surveys and management
   - Enforcement of shipping regulations related to control of ballast water.

4) Loss of biodiversity:
   Monitor fish catches, rare species & birds

11.5 IMPACTS ON PHYSICO-CHEMICAL ENVIRONMENT

Scoping was carried out to identify potential environmental impacts which may be caused by the project and to isolate key issues for decision-making. The aim was to determine what impacts will occur as a result of the execution and operation of the project, the extent, magnitude, and duration of the impacts, which of these impacts will be important within local and national contexts and what could be done to mitigate, reduce or avoid the adverse impact or to enhance/maximize positive impacts.

11.5.1 Impacts on ambient noise levels

The proposed Port area is an isolated station away from major human activities, however, operations of the port is likely to cause noise pollution resulting from vessel and road traffic movements, operational equipment, marine vessels, and cargo movement around the dock. The potential sources of noise and vibration during the construction and operation of the proposed development include:
1. Construction noise from activities on site from additional traffic generated during the construction phase;
2. Construction vibration, including those relating to piling activities;
3. Operational noise from the proposed port including from use of mobile plant or from static machinery and from vessels berthed at the marine facility;
4. Operational noise impacts due to changes in traffic flows on surrounding roads resulting from staff/clients accessing or leaving the proposed port area;
5. Noise from vessels.

11.5.2 Potential impacts on water quality

1. During construction, potential impacts include contamination from suspended solids in site runoff and accidental discharge of pollutants and foul waste held on site.
2. Due to dredging, a temporary increase in the volume of fine sediment is predicted in the channel during construction.
3. Long-term changes to drainage and flow during the operational phase. These could affect receiving water bodies in terms of their use and attributes (such as their ability to support aquatic life, dilute and remove pollutants and associated impacts such as erosion and flood risk).

![Fig 11-1: Water quality sampling](image)

4. Fuelling operations that will take place for vessels berthed at port and vehicles used within the proposed port area are a potential source of spillages entering watercourses.
5. Breakwaters and landfills may change current patterns and cause stagnation of water behind the port structures. If waste water flows into port, stagnant port water quality may deteriorate through a dramatic increase of phytoplankton and decrease of dissolved oxygen resulting from eutrophication.
6. Drill cuttings and the muddy component may be released during the construction phase especially in the processes of drainage and back filling causing turbidity and a temporary plume in the water column that may have localized impacts on plankton and pelagic fish species (e.g. irritation of gills).

7. Runoff from raw material storage, spills from bulk cargo handling, and wind-blown dust are possible sources of contamination of water. Toxic or harmful substances may be included in runoff from sulfur, bauxite, phosphates, nitrogenous manure, coal, metal ores and other raw materials. Organic materials in runoff may be decomposed to the inorganic form, depleting dissolved oxygen and increasing the nutrient level in water.

8. Accidental spills of toxic, harmful materials, oils or oily compounds, lubricants, fuels and other raw materials are possible sources of contamination of water. Accidental spills usually result from marine accidents, equipment failures and improper operating procedures during cargo transfer or bunkering.

9. Effluent from waterfront industries may contain toxic or harmful materials, unsanitary wastes, oily wastes and other hazardous materials.

10. Possible discharges from ships that could be sources of water pollution are bilge water, ballast water, fuels, oily wastes, sewage, garbage and other residues in a ship.

11. Repair docks may be a possible source of toxic or harmful materials such as antifouling agents, paints, or heavy metals.

12. Treated and untreated wastes may be discharged into the sea during the construction and operation of the port. A number of waste types such as metal scraps, gaskets, lubricant filters, domestic waste, plastics, metal, tins etc. will be generated during the construction and operational phases of the proposed port. Uncontrolled and improper disposal of waste into the water may lead to loss of aesthetics, risk of accidents by sharp objects/scrap piles, and contamination of water. It may also result into an increase of organic matter concentration in vicinal water and can be a main source of eutrophication in the adjacent waters.

11.5.3 Potential impacts on sediment quality

1. The location of the port may accelerate sediment deposition in stagnant water behind structures and cause contamination of the sea bottom.

2. Altered sedimentation pattern may favour deposition in the port area resulting into smothering of bottom biota and physical habitat.

3. Eutrophication may induce high primary production rates, plankton die backs, sedimentation of dead plankton and changes in chemical characteristics of bottom sediments, resulting in an increase of organic matter, hydrogen sulphide, and mobilization of harmful substances.

4. Construction work and dredging may disturb bottom sediments and induce re-suspension, dispersal and settlement of such sediments, thus altering the structure bottom habitats.

5. Dumping of dredged material in the sea directly alters bottom configuration and biota and may disperse toxic or harmful chemicals around the disposal site.

6. Dredging removes bottom habitat and may lead to a loss of fishery resources
11.5.4 Potential impact on air quality

1. Presence of potentially dusty construction materials.
2. Construction activities can generate fugitive emissions of airborne dust, which may have the potential to deposit beyond the works boundary.
3. Construction and operational phases due to changes in traffic movements on local roads. The level of impact will depend upon the additional traffic movements on the local highway network as a result of the proposed development operational traffic.

4. Changes in vessel movements during the construction and operational phases. The level of impact will depend upon the additional vessel movements at the proposed development. Ships are a possible source of airborne emissions such as gasses, smoke, and soot and fumes that may cause air pollution in the hinterland.
5. Emissions of dust from bulk cargo handling and gasses from cargo handling equipment may be a source of air pollution.
6. Liquid cargo handling may result in the release of vapour during the cleaning of storage tanks and by the breather system for ambient temperature changes.
7. Accidental leakage of gasses may cause problems such as toxic material emission, explosions, fumes, odours and hazardous airborne emissions. Waterfront industries may release various kinds of gasses and can be major sources of air pollution.

11.5.5 Mitigation Measures for Chemical Impacts

Mitigation measures are defined for the identified significant associated and potential impacts based on the following three criteria: Prevention (design and management measures for ensuring that significant potential impacts and risks do not occur); Reduction (operational and management measures for ensuring that the effects or consequences of those significant...
associated and potential impacts that cannot be prevented are reduced to a level as low as reasonably practical) and Control (operational and management measures for ensuring that residual associated impacts are reduced to a level as low as reasonably practical).

The mitigation measures identified include:

11.5.6 Mitigation measures for noise impacts

The proposed port area is in isolated less populated area. Overall, it is expected that the proposed port is likely to result in minor and temporary noise effects. However, the following mitigation measures should be put in place:-

1. Procurement of machinery / construction equipment should be done in accordance with specifications conforming to source noise levels.
2. Well-maintained construction equipment, which meets the regulatory standards for source noise levels, should be used and where applicable, noise shield should be used.
3. Any equipment emitting high noise, wherever possible, will be oriented so that the noise is directed away from sensitive ecosystems and human habitation.
4. Noise attenuation should be practiced for noisy equipment by employing suitable techniques such as acoustic controls, insulation and vibration dampers.
5. Personnel exposed to noise levels beyond threshold limits should be provided with protective gear like earplugs, muffs, etc.
6. Ambient noise levels should be maintained below threshold levels and monitored at regular intervals for conformity to NEMA noise regulations.
7. Construction and traffic movements should be minimized at night (between 11pm and dawn) by carefully programming works.
8. All immediate neighbours to the proposed port station should be consulted and made aware of the likely noise issues/ activities, including the possibility of night works. High noise generating activities such as piling and drilling will be scheduled for daytime to minimize noise impacts.

11.5.7 Mitigation measures for impacts on water quality

1. Dredging should be carried out using less intrusive dredging techniques and dredge material shall be disposed only at designated disposal area informed by appropriate research. Chemical analysis has shown that the dredge material is free of contamination and can be used for land filling the proposed berth areas.
2. Environmental monitoring of marine water quality, marine sediment quality & marine ecology should be initiated one week prior to commencement of dredging & will be carried out during dredging period.
3. Discharge of waste into sea should be prohibited & oil spill control measures adopted as per the port oil spill contingency plan. Prompt reporting systems are keys to prevention of oil dispersal.
4. Marine environmental monitoring as per environmental monitoring programme will be carried out at the recommended periods with baseline levels as reference during entire monitoring programme.
5. Appropriate regulations on ship discharges and provision of reception facilities are indispensable for proper control of emissions and effluent from ships. Ships will be
required to comply with the MARPOL convention and are prohibited from discharging wastewater, bilge, oil wastes, etc. into the harbour waters.

6. Ships/ carrier will be required to exchange ballast water in a deep sea prior to arrival in the harbour, in addition waste reception facility for bilge water and waste oil should be provided for handling cargo and oil spills. Slop tanks should be provided to barges/ workboats for collection of liquid/ solid waste. Enforcement of a waste management plan that ensures sorting, treatment and responsible disposal of wastes should be put in place.

7. In case of any cargo spillage during transfer from/to ships, attempts will immediately be made to recover the spills. Oil spill control equipment such as booms/ barriers should be provided for containment and skimmers will be provided for recovery. Response time for shutting down fuelling, containment and recovery should be prompt.

8. Dumping of the maintenance dredge spoil should be uniform and in such cases, turtle deflectors on dredge head should be provided.

9. Sewage treatment plant should be provided for treatment of wastewater from the port facilities.

10. Careful port design should be carried out, focusing on the possibility of reducing water stagnation thus reducing water quality issues related to localized eutrophication.

11. NEMA regulations on effluents standards discharged from waterfront industries and provision of sanitary treatment facilities would be complied with for reducing pollutants from hinterlands and in ensuring port environment protection.

12. The adverse effects of construction work could be minimized by appropriate selection of equipment in pile driving or dredging, proper use of silt curtains, careful planning of settling ponds and overflow weirs for landfills, and suitable transport of construction materials and dredged material.

13. Counter measures against runoff are: (a) covering or enclosing raw material storage areas; (b) sprinkling water on raw material except anti-humid materials like grains or cement; (c) providing special equipment for cargo handling and transport (e.g., covered conveyor or pneumatic unloader); and (d) reversed slope apron is an effective means to avert rainfall from washing the apron and pouring into the sea directly. The drains from the apron should be directed to a settling pond and released into the sea after settlement of suspended materials. Runoff from stock piles should also be collected directing into settling ponds where it should be neutralized using lime to ensure settlement of heavy metals, if any.

14. Detection of spills is important for regulating ship discharges. Since accidental spills are unavoidable, recovery vessels, oil fences (booms) and treatment chemicals (dispersants) should be prepared with a view to minimizing dispersal.

15. Periodical clean-up of floating wastes is also necessary for preservation of port water quality.

16. Qualified and experienced staff for maintenance and operation exercise is a precautionary approach of dealing with accidents and spills.

11.5.8 Mitigation measures for impacts on sediment quality
1. Removal of contaminated sediments, capping, as well as other measures could be effective against adverse effects on water quality.
2. A survey of contamination of bottom sediments should be undertaken before dredging and be used as baseline for monitoring during dredging.
3. Selection of disposal station, disposal methods and requirements for capping are key issues in undertaking disposal dredge material at sea. In shallow water, silt curtains, as well as careful selection of the dredging method, should be ensured to minimize dispersal of re-suspended sediments.

Mitigation measures for impacts on air quality

1. Use of specialized ship loaders/ off-loaders, wagon tippler, covered conveyors and rapid loading system through silos could greatly reduce air pollution.
2. Prohibition of the use of heavy diesel oil as fuel and promotion of the use of ultra-low sulphur diesel fuel to reduce pollutants emissions.
3. Dust suppression measures (such as use of covers, screens, enclosures, sprinkling water and other similar methods) should be put in place at loading/unloading points, wagon tippler complex, transfer points, stockyard, rapid loading system and in internal roads.
4. Stacking of cargo piles should be regulated and offloading done through underground wagon tipplers.
5. Regularization of truck movement using only designated routes. Such vehicles should use tarpaulin covers and their speed regulated.
6. Periodic cleaning of cargo spills, equipment and transport vehicles to remove accumulated dirt.
7. Adequately sized construction yard should be provided for storage of construction materials, equipment tools, earthmoving equipment, etc.
8. Effective spill control measures should be adopted during construction and operation of the port.
9. Movement of construction materials should mostly be carried out during non-peak hours to reduce re-suspension of dust.
10. Environmental awareness training should be carried out to all personnel involved in developmental works and port operations.
11. Regulation and proper detection of emissions from ships as means to reduce emission of pollutants.
12. Monitoring of air quality to ensure acceptable levels of emissions.
13. Regulations on emissions from waterfront industries should be introduced in accordance with environment management plan.

11.6 CORAL REEF IMPACTS AND MITIGATION MEASURES

Dredging operations are expected to mobilise sediment into the water column that will migrate with the prevailing currents resulting in a dredge plume. The migration of the dredge plume will cause increased turbidity, light attenuation (reduced light penetration) and sediment deposition. Low current velocities that prevail around the channel and berths area are expected to expose corals to such impacts.
Summary of Potential Impacts on Corals

Potential impacts which may occur to coral during the project include:

- Death or injury due to smothering, increase in nutrients and physical damage;
- Decreased growth rates;
- Bleaching; and
- Reduction in species diversity and abundance.

A summary of these impacts and the mitigation measures are as follows:

**Table 11b: Coral Reef Impacts and Mitigation Measures**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Potential Impacts</th>
<th>Impact mitigation measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate removal during dredging</td>
<td>- Loss of corals &lt;br&gt;- Reduction in species diversity and abundance.</td>
<td>- Minimise coral reef habitat loss by applying careful control on boundaries during the dredging process &lt;br&gt;- Translocate corals from areas that will be dredged to appropriate safe habitats</td>
</tr>
<tr>
<td>Sediment disturbance during dredging</td>
<td>Settlement of suspended solids on corals leading to death or reduced growth of corals</td>
<td>- Minimise sediment dispersion &lt;br&gt;- Deploy turbidity barriers to prevent sedimentation on corals &lt;br&gt;- Arrange for construction of artificial reefs to provide habitat to replace corals that are affected by the dredging as indicated during monitoring</td>
</tr>
<tr>
<td>Leakage of sediments during transportation of dredge material to disposal site</td>
<td>Increased turbidity over sensitive coral habitats</td>
<td>- Monitor vessel logs and records for each disposal trip</td>
</tr>
</tbody>
</table>

11.7 TERRESTRIAL AND MARINE TRAFFIC IMPACTS

Construction of the proposed port and the access road will result into increase in volumes of marine and terrestrial traffic in an area currently characterized by low volumes of such traffic especially road based traffic.

During the ESIA study an assessment was made of the current traffic volumes to form a baseline survey for traffic impact monitoring. The results indicated that the traffic comprises mainly of motorcycles and passenger cars. This can be attributed to the poor infrastructure (the Mokowe – Garsen road is a murram road) and the relatively low density of population on the area. Both these factors are projected to change as the project would induce an influx of immigrants into the County resulting into increased traffic.

The results are captured in the table below:
### Table 11c: Average Percentage Flow for each type of Vehicle

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Omnibuses (Matatus)and Pick-ups</th>
<th>Passenger Cars</th>
<th>Motorcycles</th>
<th>Heavy Commercial Trucks (&gt;2 axels)</th>
<th>Light Commercial Trucks (1-2 axels)</th>
<th>Buses and Minibuses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/11/2012</td>
<td>7:00 am – 8:00 am</td>
<td>0</td>
<td>18</td>
<td>50</td>
<td>18</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>1/11/2012</td>
<td>8:00 am – 9:00 am</td>
<td>22</td>
<td>29</td>
<td>32</td>
<td>5</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>1/11/2012</td>
<td>9:00 am – 10:00 am</td>
<td>15</td>
<td>17</td>
<td>33</td>
<td>13</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>1/11/2012</td>
<td>10:00 am – 11:00 am</td>
<td>11</td>
<td>32</td>
<td>36</td>
<td>7</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>1/11/2012</td>
<td>11:00 am – 12:00 pm</td>
<td>5</td>
<td>16</td>
<td>60</td>
<td>7</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>1/11/2012</td>
<td>12:00 pm – 1:00 pm</td>
<td>11</td>
<td>24</td>
<td>35</td>
<td>11</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>1/11/2012</td>
<td>1:00 pm – 2:00 pm</td>
<td>24</td>
<td>15</td>
<td>42</td>
<td>9</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>1/11/2012</td>
<td>2:00 pm – 3:00 pm</td>
<td>18</td>
<td>18</td>
<td>48</td>
<td>6</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>1/11/2012</td>
<td>3:00 pm – 4:00 pm</td>
<td>16</td>
<td>19</td>
<td>56</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1/11/2012</td>
<td>4:00 pm – 5:00 pm</td>
<td>9</td>
<td>14</td>
<td>56</td>
<td>0</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>1/11/2012</td>
<td>5:00 pm – 6:00 pm</td>
<td>17</td>
<td>9</td>
<td>70</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>1/11/2012</td>
<td>6:00 pm – 7:00 pm</td>
<td>19</td>
<td>6</td>
<td>56</td>
<td>0</td>
<td>13</td>
<td>6</td>
</tr>
</tbody>
</table>

#### Fig 11-3: Pie Chart Showing the percentage composition of each type of vehicle
It is projected that the project would introduce the following traffic related impacts:

1) **Possibility of Marine Accidents**

Boat traffic is likely to increase and errors in navigation may cause accidents endangering lives of local people.

2) **Noise and Dust During Construction**

People’s health will be affected by noise and dust especially from the construction of the access road. This will raise the cost of health care as residents may have to seek treatment more often.

3) **Interference with Movement of Goods and People**

During the construction phase there would be interference with traffic flow around Mokowe jetty as construction equipment would obstruct roads rendering them either impassable or blocking part of the road. Sections of this road would also be closed for repair and expansion. This would cause delay in movement of people and goods.

4) **Loss of Usable Farmlands to New Access Road.**

The access road from Hindi through Kililana to the proposed port site has resulted into loss of farmlands and grazing fields in addition to wetlands being filled for construction of berths and the causeway. The extent and magnitude of these impacts depends on the unique value of each
area type and the extent to which alternative locations would supply suitable replacement by involuntary resettlement of inhabitants and their activities.

11.8 IMPACTS FROM PORT OPERATIONS AND WATERFRONT INDUSTRY

The foregoing sections highlighted likely impacts from project activities on receptors such as corals, sediments, water, air and mangroves. However impacts directly related to the operations phase are as follows:

1) Sanitary Wastes

Treated and untreated sanitary wastes may be discharged to sea water from waterfront industries and the proposed administration offices. Project planning should include provisions for treating and handling of these wastes. As part of project planning, proposed waste water treatment facilities should be evaluated regarding capacity and efficiency. Treatment/extraction procedures that are planned should also be described. The impact of handling waste water from vessels should also be addressed.

2) Noise from Port Traffic and Terminal Operations

Port activities such as clamping and loading/offloading of containers and movement of cargo handling equipment may generate noise above levels of comfort to the operators. Noise would also be generated by trucks hauling containers to and from the terminal.

3) Effects of Dust and Other Airborne Emissions

Dust sources would include various industrial operations such as construction activities, outdoor storage of raw materials and particulates (ranging from coal and limestone to grain and wheat storage, for example).

Smoke is expected from increased traffic along the proposed access road during the operation stage and also from construction equipment during the construction phase. If vehicles and equipment are not well maintained exhaust fumes can be a safety hazard as the fumes obstruct vision and increasing the potential for accidents.

4) Traffic Burden Projections

The proposed access road is a highway with most of the traffic expected to be heavy commercial vehicles. This will interfere with the traffic patterns along Mpeketoni – Mokowe road that currently comprises of mainly public service vehicles and passenger cars.

Additional problems include parking for trucks, damage by trucks to roadways, and spillages from trucks. Further there would be secondary traffic impacts - traffic increases not directly attributable to the project but expansion of residential, market and commercial areas due to the enlarged industrial employment base.

5) Discharge of Garbage and Litter

Discharge of garbage into the waters, if not controlled will result in unsightly conditions on the shoreline owing to accumulation of non-biodegradable materials such as plastics, glass and metal
containers. Plastic bags and sheets can block cooling water intakes or foul propellers of vessels and small craft using the port.

6) Accidental Spills

Accidental spills may occur owing to marine casualties (collisions, groundings, fires, etc.), failure of equipment (pipelines, hoses, flanges, etc.) or improper operating procedures during cargo transfer or bunkering. Such spills can involve crude oils, refined products or residual fuels, noxious liquid substances and harmful substances in packaged form.

Chemical spills can result in the introduction of water-soluble toxic substances into the marine environment, which can have a damaging effect upon marine organisms.

8) Dry Cargo Releases

Most such releases are likely to be wind-blown particulates from vessels loading or offloading or from waterfront deliveries. Engineering/planning should be done prior to project implementation to determine the feasibility of requiring enclosed storage or loading/offloading facilities.

11.9 MITIGATION FOR IMPACTS ARISING FROM PORT OPERATIONS

Incidents arising from port operations are usually large in magnitude and impacts may spill over from the project site and assume a regional dimension. As such the proponent shall liaise with stakeholders such as Kenya Maritime Authority (KMA), Kenya Marine & Fisheries Research Institute (KMFRI), KWS, Kenya Navy, local residents and other private sector stakeholders to ensure these impacts are properly managed. The proponent shall organize periodical meetings (say every 3 months) where any accidents and incidents would be reviewed. Also to be discussed at these meetings would be the effectiveness of control measures implemented and any further proposals for improvement.

MoT in liaison with KPA shall extend activities of the Oil Spill Mutual Aid Group (OSMAG) to cover the proposed port. OSMAG was established in conformity with the International Maritime Organization (IMO) Conventions and comprises of membership from KPA, stakeholders from the oil industry and the Kenya Navy and its core function is to make the port compliant with internationally accepted norms in maritime safety and oil pollution preparedness. OSMAG members undergo training and drills on oil pollution prevention and maritime safety every three months.

Table 11d: Summary of Mitigation Measures

<table>
<thead>
<tr>
<th>No.</th>
<th>Possible Impact</th>
<th>Mitigation Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Dispersal of re-suspended dredged material.</td>
<td>o Use of silt-curtains where possible during dredging and dumping of dredged material;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Disposal of reduced amounts of material to reduce agitation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Use of appropriate dredgers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Reduction of dumping frequency</td>
</tr>
<tr>
<td>2.</td>
<td>Ecological/</td>
<td>o Relocation of species.</td>
</tr>
</tbody>
</table>
| Biological Loss                                                                 | ○ Re-plantating of equal or greater areas to felled mangrove trees (compensatory restoration)  
|                                                                              | ○ Education and conservation efforts with local communities.  
| 3. Dust and Other Airborne/ Fugitive Emissions                               | ○ Dust Screens  
|                                                                              | ○ Covering of stockpiles  
|                                                                              | ○ Spill control of bulk cargo  
|                                                                              | ○ Implementation of the National Oil Spill Response Contingency Plan.  
|                                                                              | ○ Water sprinkling during construction  
|                                                                              | ○ Provision of Personal Protective Equipment (PPE)  
| 4. Ship Discharge Waste (Oil, Bilge)                                         | ○ Shore based facility to receive waste  
|                                                                              | ○ Use of licensed waste contractor companies to collect and dispose waste.  
| 5. Spills                                                                    | ○ Enforcement of response and clean up protocols  
|                                                                              | ○ Training of response crew and provision of equipment.  
|                                                                              | ○ Bunding of bulk liquid storage areas.  
|                                                                              | ○ Creation of a participatory oil spill response group with stakeholders such as Oil Spill Mutual Aid Group (OSMAG)  
| 6. Effluent Discharge                                                        | ○ Oil Interceptors.  
|                                                                              | ○ Treatment Plants (Biodigesters).  
| 7. Noise                                                                     | ○ Control of times of noisy activities.  
|                                                                              | ○ Noise Barriers.  
|                                                                              | ○ Personal Protective Equipment (PPE)  
| 8. Vibration                                                                 | ○ Control of times of Vibration generating activities.  
|                                                                              | ○ Personal Protective Equipment (PPE).  
|                                                                              | ○ Livelihood Restoration.  
|                                                                              | ○ Compensation.  
| 10. Constraints on Fisheries on Fisheries                                    | ○ Construction of Fishing Port(s)  
|                                                                              | ○ Provision of modern fishing equipment.  
|                                                                              | ○ Provision of Cold Storage Facilities.  
|                                                                              | ○ Training on fishing techniques, aquaculture.  
| 11. Socio-Cultural Impacts                                                   | ○ Corporate Social Responsibility (CSR) Programs.  
|                                                                              | ○ HIV-AIDS Programs for construction – VCT, Peer Counseling.  
|                                                                              | ○ HIV/AIDS outreach programs during operation.  
|                                                                              | ○ Establishment of a Maritime Museum.  
|                                                                              | ○ Archeological Impact Assessments prior to development  

12. ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

Prior to commencement of the project Ministry of Transport will prepare a detailed Environmental Management and Monitoring Plan (EMMP) to ensure the implementation of the project is conducted in conformance with the ESIA report. The report would contain management programmes to be put in place during project construction and operation outlining key project impacts, magnitude of occurrence, mitigation measures, monitoring locations and parameters and frequency of monitoring. An outline of the EMMP is given in this chapter but the detailed EMMP would be developed during project inception.

12.1 Objectives

The main objectives and purpose of the Environmental Monitoring Plan are to:

- Monitor compliance with prevailing regulations;
- Monitor whether the environmental aspects predicted at the EIA stage are significantly affected and to measure changes that occur;
- Assess the adequacy of environmental management plan such as selected monitoring locations, schedule, monitoring methods, as well as required supervision, and to suggest improvements, if appropriate in the light of the results;
- Monitor the effectiveness of adopted environmental management programs to ensure compliance with the Kenyan policy in relation to ecologically sustainable development and utilization of natural resources;
- Ensure that environmental management is being performed effectively in accordance with technical requirements and relevant laws and regulations;
- Prescribe mitigation measures to eliminate or minimise adverse impacts.

The proponent may, after consultation with relevant authorities decrease or increase the frequency and/or parameters of specific monitoring if circumstances demonstrate requirement for such change.

12.2 Application of Environmental Management Plan

The Environmental Management Plan may be used to:

- Describe the basic methods and procedures to detect environmental changes at an early stage of the project development, including any changes that may not have been predicted in the environmental impact analysis;
- Provide a feedback mechanism to government policy makers on project execution, particularly in regards to similar projects in the future, by providing data and information on environmental impacts resulting from related infrastructure activities;
- Demonstrate to the community the Project Proponent’s commitment to monitor potential impacts;
• Provide quantitative data relating to environmental and social impacts to demonstrate MoT’s compliance with agreed management actions;
• Accumulate data obtained from environmental monitoring that may be used to support or defend the MoT against unjustified allegations of environmental damage.

The following regulatory and administrative documents form reference material for development of the EMMP:

• Environmental (Impact Assessment, Audit & Strategic Environmental Assessment) Regulations, 2009;
• The Environmental (Prevention of Pollution in Coastal Zones and Other Segments of The Environment) Regulations, 2003;
• The Factories (Building Operations and Works of Engineering) Rules, 1984 (Legal Notice No. 40);
• Environmental Management & Coordination (Water Quality) Regulations, 2006 (Legal Notice No.120);
• Environmental Management & Coordination (Waste Management) Regulations, 2006 (Legal Notice No.121);
• The Environmental Management and Coordination (Noise And Excessive Vibration Pollution) (Control) Regulation, 2009 Legal Notice No.61;
• Wildlife Conservation and Management Act 1989;
• The Occupational Safety and Health Act, 2007.

12.3 Water Quality Monitoring

12.3.1 Sources of Impacts

Key sources of water pollution would be

❖ Excavation;
❖ Offshore dumping;
❖ Oil spill or leakage from operations;
❖ Waste water from Labour Camp – domestic activities may be a source of waste water in the event that a labour camp is erected;
❖ Leakage of oils, lubricants and chemicals from storage yards may impact negatively on water quality;
❖ Surface water run-off from access roads during the construction stage may cause siltation and degradation of water quality

12.3.2 Significant Impacts

❖ Sedimentation as a result of clearing of land for construction of the berths and the proposed causeway;
❖ Sedimentation from drainage channels blocked by cleared vegetation;
❖ Potential impacts on aquatic biota (i.e. plankton and benthos) as a consequence of decline in water quality;
Decline in fish population as a result of turbidity arising from construction activities
Potential impact on tourism and leisure activities should turbidity extend to beach areas.

12.3.3 Indication of Impacts

- Increased sediment load in the receiving waters;
- Increased turbidity in the receiving water;
- Decline in fish populations;
- Concerns from fishermen and conservation bodies
- Traces of oil and increased biological load in water samples.

12.3.4 Monitoring Objectives

- To assess the variation in water turbidity and chemical properties due to project activities which could alter the physical or chemical characteristics of the project area;
- To assess the effectiveness of environmental management programs designed to minimize surface water contamination.

12.3.5 Monitoring Methods

Water quality monitoring shall be done at prescribed monitoring points at port areas and at the dumping site using an approved water quality meter. Monitoring would start prior to project commencement so that the prevailing baseline conditions can be documented.

12.4 Air Quality Monitoring

12.4.1 Sources of Impact

Sources of impact on air quality are mobilization of equipment, material haulage, site clearance and earthworks at the site of the proposed administration buildings and staff houses as well as along the proposed access roads.

12.4.2 Significant Impacts on Environment

The most significant potential impact would be fugitive dust and this would be expected to be localised within 100 to 200 m of the site preparation areas. Emissions from these sources would not be expected to result in significant deterioration in local air quality. In addition there would be emission from exhaust of haulage trucks and other construction equipment during the construction phase. At the operations phase significant quantities of fugitive dust would be generated by trucks hauling goods to and from the proposed port.

12.4.3 Indicators of Impact

Reported cases of respiratory and visual irritation complaints raised by local residents.

12.4.4 Monitoring Objectives
To measure concentrations of dust and gaseous emissions at selected locations surrounding the project area so that the results can be assessed in relation to Environmental Management and Coordination (Draft Air Quality Regulations), 2008 concerning Air Pollution Control and World Bank Standards.

To ensure that adopted air pollution controls and management procedures are effective.

12.4.5 Monitoring Methods

Air monitoring parameters will include 24-hour readings of the following parameters: H₂S, NO₂, CO, SO₂ and SPM (Suspended Particulate Matter). Other parameters may be monitored subject to specific complaints received from residents.

12.5 Noise Level Measurement

It is noted that some sections of the access road will be constructed in the neighbourhood of residential areas. The Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulations, 2009 (Legal Notice No.61) provides that for residential, institution and educational areas and health facilities noise levels should not exceed 65 dBA during the day and 35 dBa during the night.

12.5.1 Indications of Impacts

Reported cases of noise and vibration complaints raised by local residents.

12.5.2 Monitoring Objectives

To ensure the noise limits prescribed in Noise and Excessive Vibration Control Regulations are not exceeded.

12.5.3 Methodology and Reporting

The noise measurements would be carried as follows:

- Inspection of the measurement area and the implicated activities.
- Identification of perimeter points.
- Recording of the meteorological conditions during the measurement such as temperature, wind speed and relative humidity;

The measurements results would be expressed as follows:

- **Lmax**, Maximum sound pressure level obtained during the measurement period
- **Lmin**, Minimum sound pressure level obtained during the period of measurements
- **Leq**, Value of A - weighted sound pressure level of a continuous steady sound that, within a specified interval, has the same mean square sound pressure as a sound under consideration whose level varies with time;
- **Noise levels** at the following distances from source – L₅, L₅₀, L₉₅;
- **Vibration velocity** – maximum value during 10 minutes hourly;
- Record of noise and vibration source.
12.6 Monitoring of Terrestrial and Marine Ecosystem

Monitoring of the biological environment will be required, particularly in instances where the project activities have the potential to negatively impact sensitive areas such as wetland habitats.

12.6.1 Sources of Impact

- Clearance of vegetation;
- Dredging and disposal of dredged material;
- Disturbance of fauna as a result of noise from construction activities;
- Gathering/hunting of flora and fauna by workers;
- Land clearing;
- Oil spill from port and terminal operations.

12.6.2 Significant Impacts on Environment

Potential significant impacts on flora as a result of dredging and construction activities include:

- Loss of mangrove habitats cleared to create room for construction of the proposed berths;
- Net vegetation loss, resulting in secondary impacts on fauna due to habitat loss;
- Loss of benthic habitats due to dredging;
- Increased predation (i.e. from gathering of flora).

Potential significant impacts on fauna as a result of construction activities include:

- Injury and mortality due to increased road traffic, particularly protected fauna species.
- Direct loss or damage to habitat leading to reduced foraging/food resources, disturbance and displacement.
- Obstruction/interruption of movement/migration patterns due to new access road.
- Increased exposure to hunting and trapping.

12.6.3 Indicators of Impact

- Total area of vegetation cleared as a result of construction activities;
- Changes in fauna population in project area, as indicated by evidence of fauna eliminated either by motor accidents or starvation resulting from loss of grassland/habitat.
- Fish deaths
- Visible changes in turbidity.
- Reported complaints from fishers, community and conservation groups.

12.6.4 Monitoring Objectives

- To monitor the impact of land clearance and impacts due to other project activities;
- To monitor impact on flora and fauna in order to limit damage resulting from project activities.
12.6.5 Monitoring Methods

- Site surveys and photographic records of land clearance and subsequent rehabilitation;
- Rehabilitation progress will be recorded by measuring projected foliage cover;
- Photographic records of flora / fauna exposed to adverse project impacts such as dust cover.

12.6.7 Monitoring Frequency

Ecosystem will be monitored biannually for presence, absence or abundance of flora and fauna to ensure it is maintained or improved. In addition photographic documentation would be maintained of flora / fauna exposure to adverse project impacts as observed during routine inspections.

12.7 Coral Reef Monitoring

12.7.1 Objective

The aim of coral reef monitoring would be to ensure that impacts to coral communities are minimised and kept within the limits of acceptable loss.

12.7.2 Key Performance Indicators

Key performance indicators are as follows:

- Percentage cover of corals
- Coral health and mortality
- Coral recruitment

12.7.3 Monitoring Methods

Coral reef monitoring will be undertaken at the same locations where baseline surveys covered as well as adjacent coral reefs. Monitoring will be done on quarterly basis, but a rapid response coral health assessment will be required once water quality trigger values are exceeded. This form of monitoring will quickly determine if the coral colonies being monitored are being stressed by dredging and spoil disposal activities and trigger a more detailed assessment whilst management is initiated.

12.8 Monitoring of Traffic / Transport Impacts

12.8.1 Sources of Impact

- Haulage of material and equipment.
- Increased volumes of motor vehicles as a result of demand for port access.

12.8.2 Significant Environmental Impacts

During the construction phase accessibility on local supporting roads may be reduced due to congestion associated with raw material supply and road diversions around construction areas. In addition there would be secondary negative impact on local air quality and noise levels.
The construction of access roads will increase accessibility as there would then be a motorable road with low density of traffic. This would however create risk of accidents resulting from speeding and lack of awareness from local residents who are currently not used to high density of traffic.

12.8.3 Indicators of Impact
- Increased traffic congestion along access roads;
- Complaints from villagers.
- Increased road traffic accidents.
- Increased noise and air pollution.

12.8.4 Monitoring Objectives
- To document disturbances to local villagers due to transportation;
- To avoid traffic accidents.
- To mitigate nuisance of increased noise and dust levels due to increased traffic.

12.8.5 Monitoring Methods
- Monthly traffic count at strategic points especially at junctions of key roads;
- Formal and informal feedback from residents close to the construction areas;
- Compilation and analysis of statistics on numbers of accidents.

12.8.6 Monitoring Period and Frequency
Traffic volume survey shall be done monthly commencing with the start of the construction stage at the designated monitoring points. The traffic shall be categorized into the following classes:
- Motorcycles / Tricycles;
- Passenger Cars;
- Minibuses / Vans;
- Buses
- Light Trucks / Pick-up trucks;
- Medium Size Trucks (7-15 tonnes with 1-2 rear axles);
- Heavy commercial vehicles

In addition the proponent will conduct periodical spot inspections along access roads to monitor compliance with traffic management system (safety signs in place, dusty areas are watered, control of children crossing areas, manholes covered, barricade tapes in place and visible etc.) during the construction phase. Accident numbers and community feedback will be captured on an ongoing basis and reported monthly to the regulatory authorities.

12.9 CONTINGENCY AND DISASTER MANAGEMENT PLANS

12.9.1 Contingency Plans for Construction Activities
Ministry of Transport will liaise with KPA to ensure that activities at the proposed facility are incorporated into the overall emergency response plan, clearly indicating authority and
responsibility for dealing with such incidents. MoT will appoint a Health, Safety and Environment (HSE) Officer who will be charged with the responsibility of coordinating HSE matters. The HSE Officer will be responsible for the implementation of this EMMP and his/her roles include the following, among others:

- Advising MoT on applicable HSE regulations such as the Occupation Safety and Health Act (OSHA) 2007, The Factories and Other Places of Work Act (H & S Committee Rules), 2003, EMCA (Water Quality Regulations), 2006, EMCA (Waste Management Regulations) 2006 etc.;
- Ensuring that all accidents and incidents occurring at the site are promptly reported and investigated;
- Administration of safety awareness and motivation scheme;
- Keeping statistics of accidents, incidents and dangerous occurrences and ensuring that reportable cases are filed with the Directorate of Occupational Health and Safety Services;
- Ensuring all construction machinery and equipment are properly maintained and lifting equipment inspected by approved government inspectors.

In addition to ensuring that all staff at site are trained in performing their duties to prevent accidental injuries MoT will provide employees with personal protective equipment (PPE) such as safety shoes, hand gloves, ear plugs, helmets etc to reduce exposure.

12.9.2 Contingency Plan for Spills

Reporting and altering mechanism will be established to ensure that any spillage is promptly reported in line with KPA emergency response plan. In addition, specialized oil spill response equipment will be made available in the proximity of the proposed container terminal to deal with small to medium spillages. Such equipment may include containment booms, recovery pumps, temporary storage tanks and approved dispersants. Equipment operators will be trained in deployment of the equipment, and the contingency plan regularly exercised to test reporting and altering procedures.

MoT through KPA will liaise with the Oil Spill Mutual Aid Group (OSMAG) to make the proposed port compliant with internationally accepted norms in safety preparedness and containment of marine oil spill. MoT will ensure that employees of the proposed facility undergo training and thorough drills on oil pollution prevention and on marine safety aspects to develop their capacity to respond to marine accidents.

12.10 Monitoring Locations and Parameters

12.10.1 Monitoring Locations

Monitoring Locations to be indicated on a map shall include, but not be limited to:

- Construction Site for the first three berths;
- Coral reefs area;
- Outer access channel dredging area;
- Within 200m of the access road
- Nearby Mangrove vicinity
- Area in front of sea turtles nesting grounds
- Other areas to be determined as a result of results of subsequent monitoring.

12.10.2 Monitoring Components and Responsibility

Common components for monitoring and responsibilities for each component shall be as follows:

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Key:
D: Detailed Design
C: Construction Phase
O: Operation Phase
13. CONCLUSIONS AND RECOMMENDATIONS

The ESIA study has established that at the construction stage there would be significant impact on water quality likely to arise from dredging and dumping of dredged material. During the operations stage there would be a threat to the environment in terms of potential of oil spill from ships. Mitigation measures proposed include use of less intrusive dredging techniques during the construction phase and development and implementation of an effective oil spill preparedness and response plan at the operations phase.

In phase one of the project, two hectares of mangroves will be cleared to pave way for the construction of the causeway and access road. Mangrove forests will also be at risk from direct human impacts. With the influx of population, the risk of Mangroves being felled for commercial and personal use will increase.

This report proposes the need to carry out mangrove restoration in sites adjacent to the project site. A minimum area equivalent to that cleared is recommended, however restoration of areas larger than the cleared site on regular/ continual basis is highly recommended.

A large number of populations in the district are dependent on fishing as means of livelihood. The proposed port development will encroach on fishing grounds thereby displacing the artisanal fishermen from some of their traditional fishing grounds and landing sites. This report recommends that the proponent empowers the local fishermen to move to deep waters by providing modern fishing gears and vessels that can enable them venture into other more distant deep water fishing grounds in addition to construction of modern fish landing sites (fishing ports) with adequate infrastructure such as power, access roads and cold rooms or ice making plants.

UNESCO inscribed Lamu Old Town on the World Heritage List in 2001. With the construction of the proposed port and hinterland, there will be an influx of migrant workers from other districts in search for employment and business opportunities. This can cause a “dilution” of the local culture. Efforts have to be made by the local authorities and National Museums of Kenya to preserve and promote the intangible heritage.

In order to secure the land for the proposed port development project, the proponent will need to acquire land. A detailed Resettlement / Compensation Action Plan has been prepared and would be implemented prior to commencement of the project. The compensation/ resettlement will be carried out by Ministry of Transport as per the Resettlement Action Plan and with the assistance of local authorities.

The proposed port development is expected to open up Lamu County and create a new transport corridor that would spur economic growth in Lamu and along the entire corridor including northern and north-eastern parts of Kenya. In addition the project would create new trade routes for the neighbouring countries such as South Sudan, Ethiopia and the Democratic Republic of Congo. Due to its magnitude and complexity of activities involved significant impacts have been identified in this report and detailed mitigation measures proposed in addition to an elaborate environmental management and monitoring plan. A separate Resettlement / Compensation Action Plan (RAP) has been prepared to ensure adequate compensation for socio-economic losses incurred by Project Affected Persons (PAP) in the course of project implementation.
This Environmental and Social Impact Assessment (ESIA) Report therefore proposes that the project be allowed to proceed on condition that the proponent implements the mitigation measures proposed in this report.
14. REFERENCES


References


## 15. ANNEXES

### ANNEX 1: OCEANOGRAPHIC DATA

**Harmonic Analysis Results** *(by T_TIDE Software)*

### Lamu Station

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