Environmental Impact Assessment (EIA) Report for the Liquefied Natural Gas Project in Cabo Delgado

FINAL EIA REPORT- VOLUME I

Project ref: 0133576

February 2014

Anadarko Moçambique Área 1, Lda

eni

IMPACTO PROJECTOS E ESTUDOS AMBIENTAIS

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Sections / Chapters	Version	Change Description
Abbreviations/ Units	Portuguese	The unit "mg/l^{-1}" was replaced by "mg/l or mg.l^{-1}" to represent milligrams per litre.
Acronyms Chapter 9 Chapter 13	Portuguese	The Acronym "ASA" used to denote Environmental Health Area (Área de Saúde Ambiental) has been changed to EHA.
Acronyms Chapter 9 Chapter 13	Portuguese	The acronym "TS" used to denote "sex workers" (Trabalhadoras de Sexo) has been removed.
Acronyms	Portuguese	A Portuguese translation for the following acronyms has been included: • EGPAF • FH • GDACE • HYCOM
Acronyms	Portuguese	Where an English acronym is used, the English definition has been provided in addition to the Portuguese definition.
Acronyms	Portuguese and English	The definition for the acronym "DWAF" now states: "South African Department of Water Affairs and Forestry".
Acronyms Chapter 2	Portuguese and English	The acronym "MdP" to denote "Ministry of Fisheries" has been replaced with "MPescas".
Acronyms	Portuguese	The word "manganésio" used to explain the chemical symbol "Mn" has been replaced with "manganês".
Acronyms	Portuguese	The term "non-aqueous based mud" used to explain WMB, has been replaced by "water based mud".
Acronyms	Portuguese	The acronyms LBA and LBS were deleted as the EIA Report uses WBM and SBM (for water based muds and synthetic based muds respectively) and not LBA and LBS.
Chapter 3	Portuguese	In *Table 3.4*, the date the EIA Report was submitted to MICOA has been corrected to state 2014, not 2013.

Environmental Impact Assessment (EIA) Report for the Liquefied Natural Gas Project in Cabo Delgado

FINAL EIA REPORT

February 2014

Project Ref: 0133576

Prepared by: ERM and Impacto

For and on behalf of ERM and Impacto

Approved by: Andrew Bradbury

Signed:

Position: Partner

Date: 24 February 2014

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Anadarko Moçambique Área 1, Lda

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Non-Technical Summary

Mozambique Gas Development Project

Non-Technical Summary (NTS)

Project Ref: 0133576

February 2014

Anadarko Moçambique Área 1, Lda

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IMPACTO PROJECTOS E ESTUDOS AMBIENTAIS

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Mozambique Gas Development Project

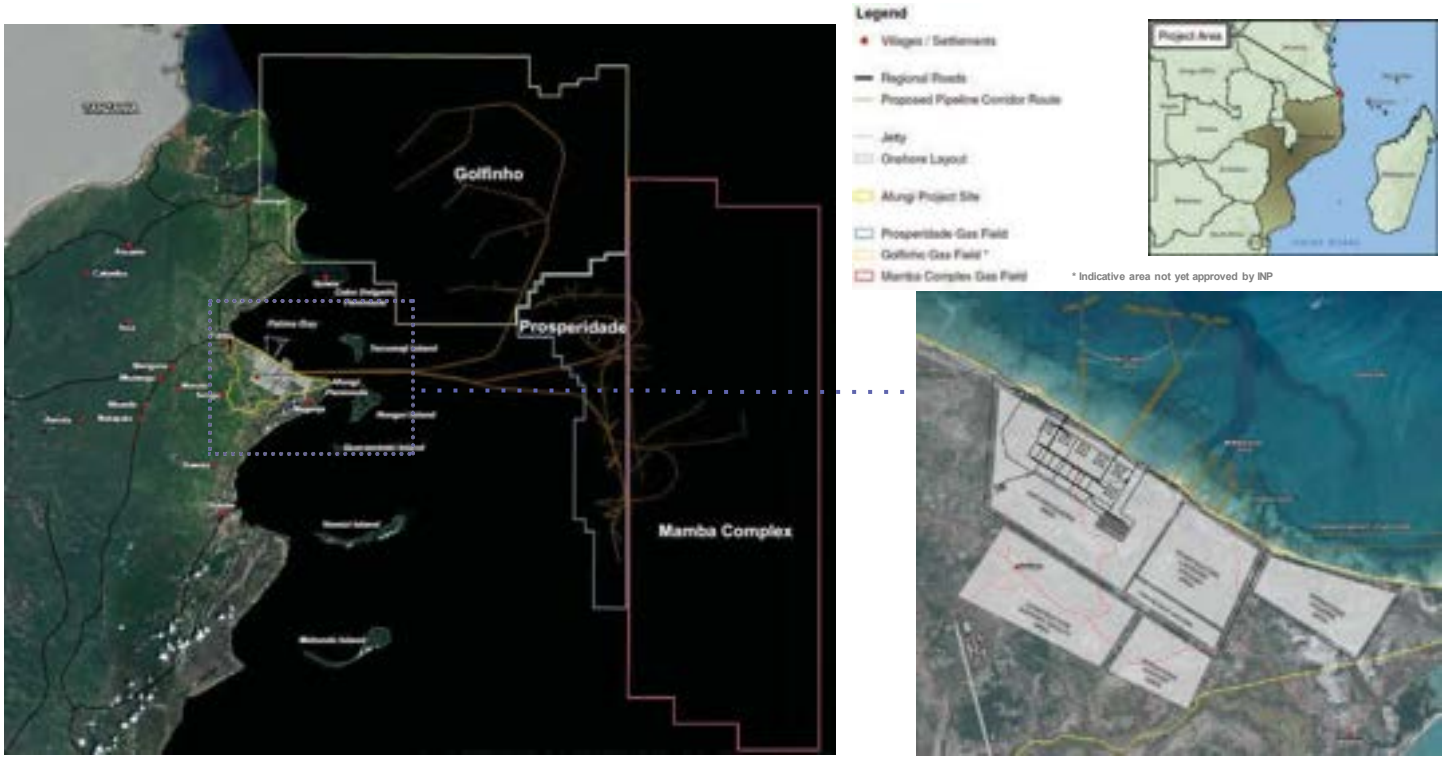
Introduction and Background

Natural gas discoveries made in the Rovuma Basin off the coast of northern Mozambique are among the world's most significant discoveries in the last 20 years. Anadarko Moçambique Área 1, Lda (AMA1) holds rights to explore, develop and produce natural gas reserves in Area 1 in the Rovuma Basin and Eni East Africa S.p.A (eni) holds similar rights to explore, develop and produce in Area 4. These areas are adjacent to one another and a number of gas reservoirs or gas fields have been discovered within each area. AMA1 and eni are joint proponents for the Project, working to develop a Liquefied Natural Gas (LNG) Facility and associated infrastructure to convert the natural gas to a liquid state and export it to international markets.

The proposed LNG Project (hereinafter "the Project") would see Mozambique become one of the world's leading natural gas exporting countries. Figure 1 below illustrates the location of the Project.

The Project is required to obtain permission (in the form of an environmental licence(s) from the Government of Mozambique) before AMA1 and eni can construct and operate the facilities. An Environmental Impact Assessment (EIA) Report has therefore been developed to inform the Government's decision making process. The EIA Report documents the process undertaken for identifying, assessing, mitigating and managing the biological, physical and socio -economic impacts of the Project.

Figure 1: Location Area



The Project Developers

AMA1

AMA1 is a wholly-owned subsidiary of Anadarko Petroleum Corporation (APC) and is a commercial entity duly registered under the Republic of Mozambique Laws. AMA1 has offices in Maputo and Pemba. APC is headquartered in The Woodlands, Texas, United States of America and is among the largest independent oil and natural gas exploration and production companies in the world. Information on AMA1 can be accessed on the internet at:

http://www.anadarko.com/Operations/Pages/LNGmozambique.aspx

ENI

eni S.p.A is an Italian company with activities in close to 85 countries. Eni East Africa S.pA (eni) is an affiliate of eni S.p.A. and has a branch in Mozambique with offices in Maputo and Pemba. eni S.p.A. is one of the leading global operators in the deep-water sector worldwide and is currently involved, as operator or partner, in exploration activities in deep water in the Gulf of Mexico and along the coast of Brazil. More information on eni can be accessed on the internet at:

http://www.eni.com/en_IT/media/casebook/casebook-mozambique.html

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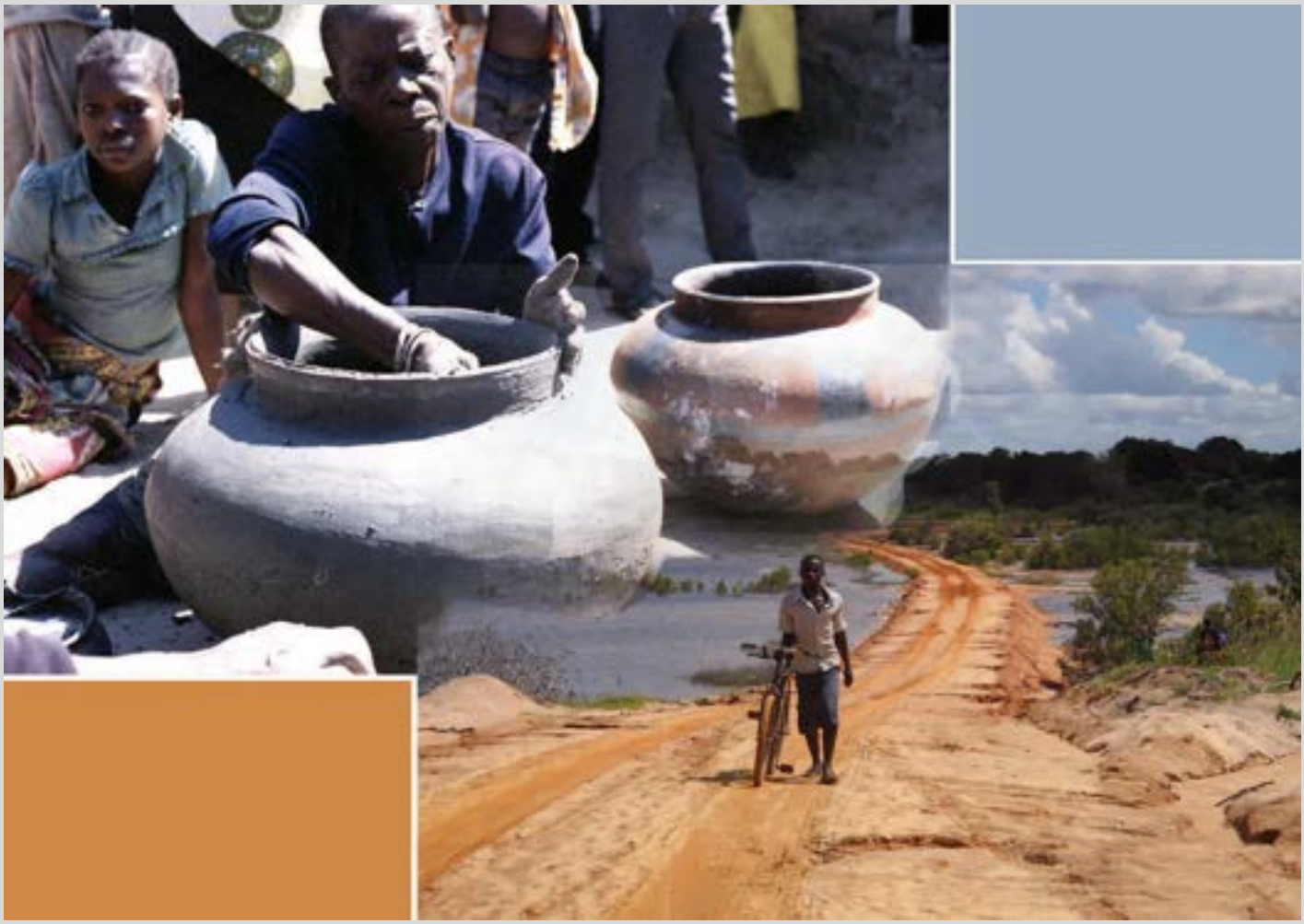
Economic Benefits of the Project



The initial LNG development (two LNG trains estimated 10mtpa) represents an overall investment of up to US$25—30 billion, making the project the largest single investment project in Mozambique to date. Assuming export of the LNG to premium markets, such as Japan and the Far East, the Government of Mozambique should see a significant increase in Gross Domestic Product (GDP) and increased revenue through its royalty, tax and equity gas rights.

Mozambique will benefit from a substantial increase in Government revenue for several decades. This economic benefit could be used to improve the health, education and quality of life of the people of Mozambique.

As the number of trains and volume of LNG export, increases, the economic benefits could be compounded several times. The Government of Mozambique has stated it wishes to encourage industrial development using natural gas in the area of the Project. This could further increase the social and economic benefits derived from the Project.

The purpose of the Project is to gather, process, and export natural gas in liquid form known as LNG. This LNG will be used as a fuel source in other countries.

The process begins offshore in Area 1 and Area 4 of the Rovuma Basin, where natural gas will be extracted via subsea wells from gas reservoirs (storage areas) up to 1,500m below the seafloor. The collected gas will be transported to the onshore LNG facility by pipelines on the seafloor. Once onshore, the gas will be processed in the LNG facility to remove impurities, converted to liquid (by cooling the gas) and stored in specially designed storage tanks.

The LNG will then be transported through pipelines to an export jetty where it will be loaded into specialized LNG carriers to be transported to international markets. These specially designed ships maintain the LNG in a refrigerated liquid state for sea voyages of several thousand kilometres. The Project has an initial 30 year lifespan but this may be extended depending on future gas reserve development.

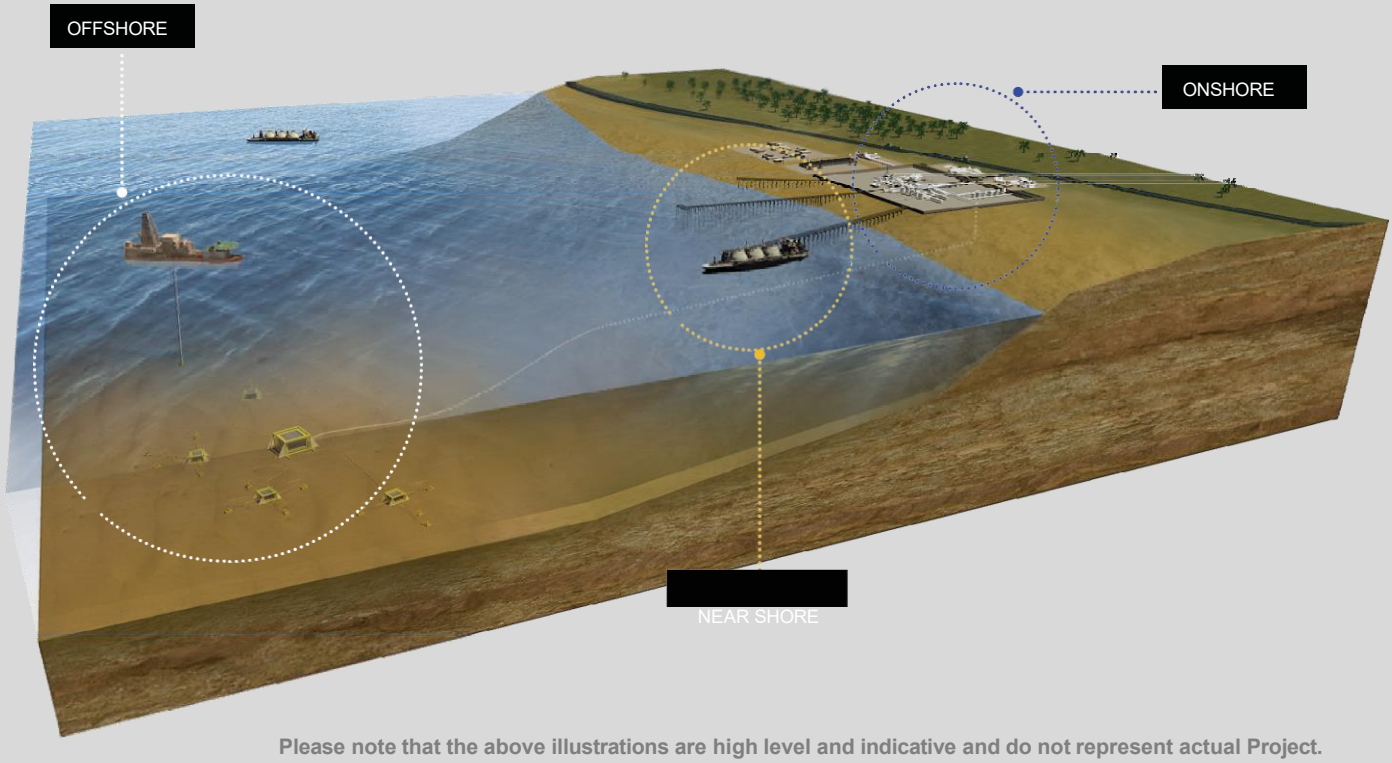
The three main elements of the Project are as follows and illustrated in Figure 2:

- **Offshore** - drilling of wells and installation of pipelines on the seafloor to connect the wells and then bring the natural gas to the shore.
- **Near Shore** - construction of a Multi-Purpose Dock and jetties. The dock will house support vessels and allow for equipment and material (for onshore construction) to be brought ashore. LNG carriers will berth at the jetties while they are filled with the LNG.
- **Onshore** - construction and operation of the LNG Facility and all associated infrastructure eg housing, construction camp, airport etc.

The above three main elements are described in detail overleaf.

The project description will be refined through the Front End Engineering and Design (FEED) process currently being undertaken). Should there be any significant departure from the project description in the EIA, such that impacts are different or there needs to be new mitigation measures, the Project will undertake the necessary environmental processes (eg addendum to the EIA).

Figure 2: Illustrative Scheme of Project



Please note that the above illustrations are high level and indicative and do not represent actual Project.

The term 'Offshore' refers to the deep water environment. Offshore Project components comprise the wells, infrastructure connecting the wells with systems known as manifolds, to the gas pipelines leading up to Palma Bay (areas within Palma Bay are referred to as the Near Shore). The process begins in Area 1 and Area 4, where natural gas will be extracted via subsea wells from gas reservoirs below the seafloor. The Offshore Project components will consist of production wells and the pipeline system. Production wells are planned for AMA1's Golfinho and Prosperidade gas fields and for eni's Mamba gas field. Up to 60 production wells are planned for the Prosperidade and Mamba gas field and a further 60 production wells are planned for the Golfinho gas field.

The wells in each field will be connected to central collection systems on the sea bed so gas from multiple wells can be collected together. The collected gas will be transported by pipelines (running in a single corridor as they approach the near shore) from the offshore facility to the onshore facility. The offshore system is anticipated to produce up to 4 billion cubic feet of gas a day.

The offshore facility will be constructed by the drilling and installation of wells using dynamically positioned drill ships. Multi-purpose vessels will also be used to install the offshore central collection systems on the seafloor. Once operating, gas will be collected and transported to the onshore facility.

Figure 3 : Example of a Drill Ships and Construction Vessels

Example of a Dynamically Positioned Drill Ship

Example of a Light Construction Vessel

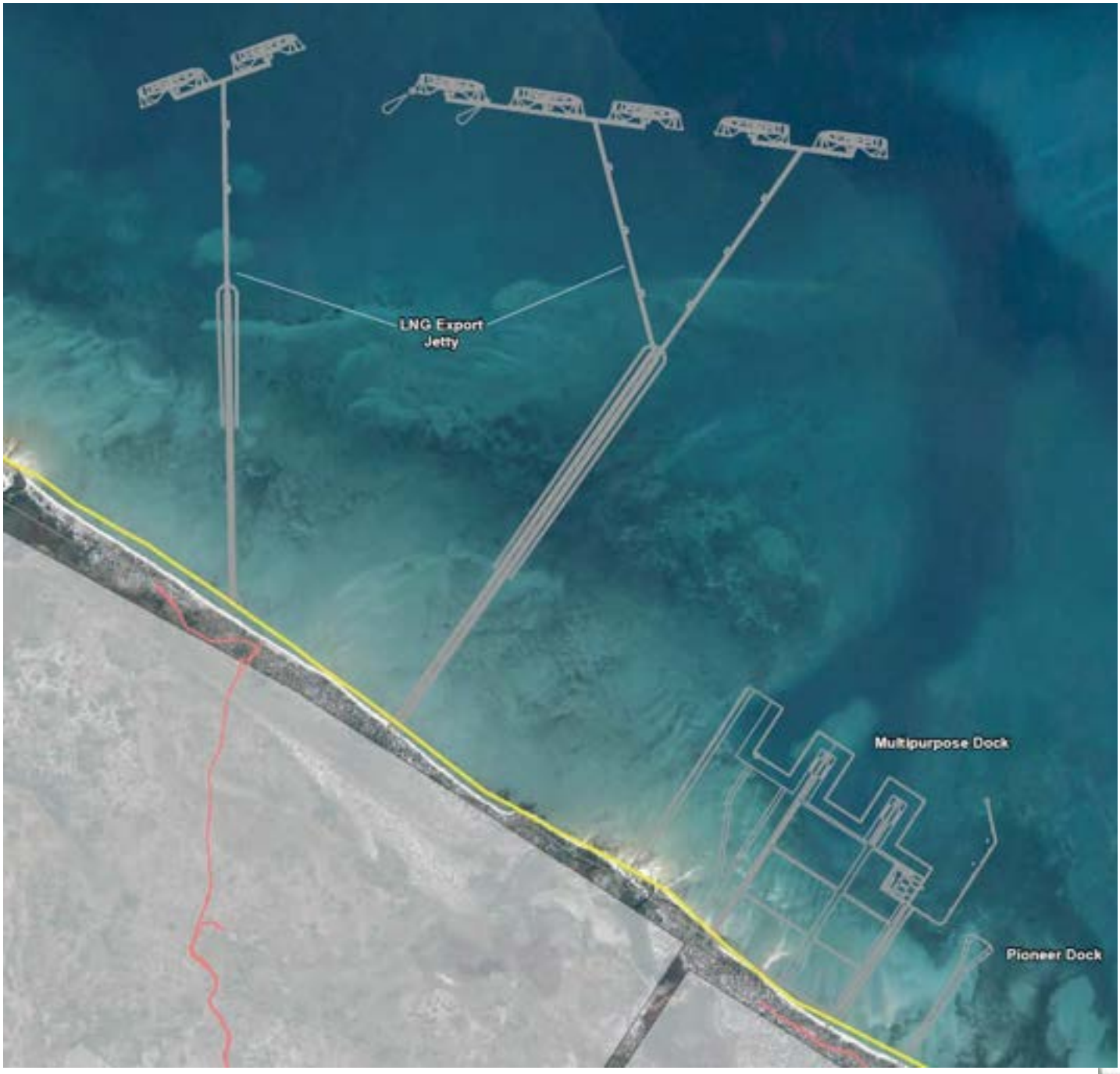
Example of a Deepwater Pipelay Vessel

Example of a Flexible Pipe and Umbilical Lay Vessel

The Near Shore refers to the shallow water within Palma Bay; from the islands of Tecomaji and Rongui to the shoreline. The Near Shore Project components will consist of port facilities (jetties and berths), a Multi-Purpose Dock to support construction activities (eg bringing in heavy equipment and materials), a shipping lane and the pipeline corridor within Palma Bay. Figure 4 below provides an indicative illustration of the near shore infrastructure.

Access channels to the port facilities will be widened and deepened by dredging the seabed in Palma Bay to allow large ships to reach the jetty and berths. Dredging will also be required in the Near Shore to enable pipe-laying. Some dredged material will be used for infill in the near shore while the rest will be disposed of at designated areas offshore.

Figure 4 : Illustration of Near shore Infrastructure



The precise layout of the various Onshore components will be defined during the current Front End Engineering and Design (FEED) process. Thus indicative layouts have been used as the base case of the impact assessment. Figure 5 provides an indicative illustration of the Onshore Project components. Vegetation will need to be cleared and the land leveled prior to construction of the Onshore Project footprint. The Project footprint area is currently approximately 3,600 ha, within the allocated approximately 7,000 ha DUAT area.

The Onshore Project components comprises facilities necessary to treat and process natural gas and supporting infrastructure such as worker accommodation facilities, construction areas, access roads and an airport. The LNG processing plant will receive gas from the offshore facilities, remove impurities in the gas and produce LNG by progressively cooling the gas to a temperature of -163^{o}C. The LNG will be stored in cooled storage tanks on site and transferred by pipeline to the jetties for loading onto ships. The processing plant will produce between 3,000 and 5,000 barrels of LNG a day. The process will also generate water that will be recycled into the process and natural gas condensate, a byproduct that will be sold.

Figure 5: Illustration of Onshore Infrastructure

The EIA process

The purpose of the EIA is to predict the significance of the Project's impacts on the existing (baseline) physical, biological and socio-economic environment; and to identify measures to minimise negative impacts and maximise positive ones. This information will be used to inform decision-making by the Government of Mozambique.

The EIA study comprised the following steps:

- An integrated environmental, socioeconomic and engineering Site Selection study was undertaken to determine the most appropriate site for the construction and operation of the LNG Facility;
- The potential impacts of the Project were initially identified during the 'Estudo de Pré-Viabilidade Ambiental e Definição de Âmbito' (EPDA) or Scoping Phase;
- The existing baseline conditions and any environmental or socio-economic sensitivities were determined through fieldwork and review of existing information;
- Stakeholder concerns raised during the EPDA Phase and Impact Assessment Phase were considered;
- The significance of impacts prior to mitigation measures being applied was assessed;

Figure 6: EIA Process Overview

- Specialist experience and knowledge coupled with modelling in some cases (eg noise, drilled cuttings dispersion) was used to inform the impact assessments;
- Mitigation measures were developed and refined during workshops and meetings with the Project engineers and contractors;
- Workshops and meetings were convened to ensure that the proposed mitigation measures were practical and implementable;
- The Onshore Project layout was revised and reduced based on identified baseline sensitivities, outcomes of the impact assessment and following inputs from environmental and social specialists;
- The significance of residual impacts, prior to mitigation measures being applied was assessed; and
- An Environmental and Social Management Plan (ESMP), Waste Management Plan and Decommissioning and Rehabilitation Plan were developed and a process for training and educating staff about these plans was prepared.

Stakeholder Engagement

Stakeholder engagement (including communication with local communities) is a critical part of the EIA process and activities were carried out at key stages of the EIA process to ensure that stakeholder concerns and comments are addressed in the EIA. Meetings were held with stakeholders during the EPDA and Impact Assessment Phases. In addition, focus group meetings were held during the Impact Assessment Phase with key stakeholders. The Draft EIA Report was made available for public comment between 27 August and 31 October 2013.

All comments received throughout the engagement process and commenting period were recorded, and responses are provided in a Public Participation Report (*Annex A* of EIA Report).

The Draft EIA Report was updated based on comments received prior to submission to MICOA in February 2014.

Impacts were identified by the EIA team with inputs by stakeholders (eg local communities, government departments and local communities). An impact is any change to a resource or receptor brought about by the presence of the Project component or by the execution of a Project-related activity. The impacts assessed fall into two main categories; environmental and socio-economic. Environmental impacts include both physical impacts of the Project such as changes in air quality and biological impacts such as changes to marine and land based habitats.

The socio-economic impacts are effects of the Project on people and their livelihoods. This includes positive impacts such as employment or increased demand for local goods and services as well as negative impacts such as loss of access to farm land or access to parts of Palma Bay for engaging in subsistence livelihoods activities. The following aspects were considered when determining the significance of identified impacts:

- **nature of impact:** positive or negative;
- **duration of impact:** temporary, short term, medium term, long term or permanent;
- **scale of impact:** onsite, local, regional, national or international/ transboundary; and
- **intensity of the impact:** negligible, low, medium, high.

Table 1 shows the definitions for the categories of significance used in this EIA.

Table 1 : Definition of Significance Levels

NEGLIGIBLE	The existing environmental and social conditions will not be affected or the affect is not detectable. A negligible impact is likely to be of no concern to the government, communities and organisations.
MINOR	The environmental and/or social conditions will be affected, but the impact small enough that it is unlikely to be of concern to the government, communities and organisations.
MODERATE	An impact of moderate significance is one within accepted limits and standards. The emphasis for moderate impacts is on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP).
MAJOR	A major impact is one where there will be a large change to communities or the natural environment. The aim of the EIA is to provide ways to stop these large impacts from occurring. At times this is not possible and it is up to the government to decide if this is acceptable when considering the benefits of the Project.

Mitigating Impacts:

The Project philosophy regarding mitigation is outlined in Table 2. The Project first sought to avoid impacts to the extent practical. If impacts could not be avoided they were mitigated through modifying the design or implementing mitigation at the impact site. In cases where these first two mitigation strategies were not possible, the Project would aim to remediate impacts wherever possible and finally investigate options for compensation or offsets where necessary or required.

Table 2 : The Mitigation Hierarchy for Planned Project Activities

AVOID AT SOURCE; REDUCE AT SOURCE Avoiding or reducing at source is 'designing' the project (embedded controls) so that a feature causing an impact is designed out (eg a waste stream is eliminated) or altered (eg reduced waste volume). Often called minimization.
ABATE ON SITE This involves adding something to the basic design to abate the impact - pollution controls fall within this category. Often called 'end-of-pipe'.
ABATE AT RECEPTOR If an impact cannot be abated on-site then measures can be implemented off-site. An example of this would be to use a silt trap to capture any sediment that may flow into streams.
REPAIR OR REMEDY Some impacts involve unavoidable damage to a resource, eg land disturbance. Repair involves restoration and reinstatement measures, such as re-vegetation
COMPENSATE IN KIND Where other mitigation approaches are not possible or fully effective, then compensation, in some measure, for loss, damage, and general intrusion might be appropriate.

The EIA has assessed the potential impacts of the proposed Project on the biophysical and socio-economic environment. Throughout the EIA process evolving project information has been fed into the assessment process, allowing for the EIA to be updated as the Project concept was developed. Thus, impacts have been assessed taking into account the mitigation measures that were built into project design. Potential 'cumulative' impacts (ie impacts acting in conjunction with each other on a common resource or receptor) and the risk of accidents (eg gas pipeline rupture) have also been assessed as an integral part of the assessment exercise.

The findings of the EIA process are presented in this section. A large number of potential impacts were assessed in the EIA process and the detailed findings are presented in the EIA Report.

BASELINE

The offshore project area is located in deep waters, in depths of around 1,000m to 2,300m. The offshore marine environment supports a wide range of larger animals such as whales and dolphins as well as many species of fish, turtles and sea birds. Deep water reef structures (mainly hard substrate structures) have been observed on the seabed.

The near shore environment, in and around Palma Bay, has clear water (low levels of suspended sediment), temperatures in the range of 30 to 35°C and a number of different habitats; rocky bottom, sand beaches, mangroves and mudflats. Figure 7 shows a range of the typical habitat types. Palma Bay supports sea grass beds close to the shore with coral reefs scattered within the bay and around the islands of Tecomaji and Rongui.

PROJECT ACTIVITIES

Project activities that could affect this baseline include dredging, disposal of dredge material, installation of subsea infrastructure, and the construction of the jetties and Multi-Purpose Dock.

Figure 7 Habitats in the Offshore and Near Shore Environment

Coral Habitat and Fish

Seagrass: *Enhalus acoroides* and *Thalassia hemprichii*

Intertidal Zone

Mangrove species: *R. mucronata* and *Avicennia marina*

Impacts due to discharge of drill cuttings:

Dispersion modelling of drill cuttings and the sensitivity of offshore benthic fauna and flora indicates that impacts from physical inundation (burial and change in sediment grain size) will be of MINOR significance before and after mitigation. The drilling of the offshore production wells will be the primary activity likely to result in potential impacts to water quality and marine ecology (such as whales, dolphins and benthos) in the offshore area. With the implementation of mitigation measures, all residual impacts are predicted to be of NEGLIGIBLE and MINOR significance in the offshore marine environment.

Deepwater reef structures and associated organisms, however, may be at risk of enduring more severe effects. This is because the recovery of reef structures is expected to take an appreciable amount of time due to generally slow growth rates of these organisms. Therefore the predicted impact to offshore reef communities may potentially be of MODERATE significance prior to mitigation. It should be noted that both the high and low-relief structures observed in the deep waters offshore largely comprise scattered rock and sediment, and do not apparently support high densities of fauna. With the implementation of mitigation, this impact will be reduced to MINOR.

Impacts due to discharge of residual muds:

Impacts on benthic marine organisms or those in the water column (ie plankton) from discharges of residual muds (small amounts of muds that remain on the drill cuttings after treatment) are predicted to be of MINOR significance because of low toxicities of the quantities and types of muds used/or discharged to the offshore environment. Impacts will be reduced to NEGLIGIBLE with the implementation of mitigation.

Impacts due to discharge of hydrotest water:

The impacts on marine ecology and/or marine ecological processes associated with the discharge of hydrotest water at depths of approximately 1,500m in the offshore gas fields during commissioning (ie the construction phase) will be NEGLIGIBLE, as the hydrotest water will be discharged in a phased approach, at pressures that will ensure that the water quality effects of the discharges are restricted to close proximity of the release points.

Impacts due to increased traffic:

Potential impacts from vessel and helicopter noise, lighting and movements on offshore marine ecology (birds, fish, benthic fauna etc) with the exception of marine mammals will be NEGLIGIBLE. Effects of vessel collisions or disturbance on whales may be more severe due to their conservational value or importance and the associated impact is predicted to be of MODERATE significance. However, mitigation measures specific to whales will ensure that vessel collisions with whales are avoided and thus impact significance is reduced to NEGLIGIBLE.

Impacts due to habitat modification:

The introduction of the subsea infrastructure, a hard structure, on to the seabed in the Offshore Project Area will result in changes to the character of the sea bed and consequently the diversity and structure of the benthic community. Such an impact will be of MODERATE significance, particularly at deep water reef structures, where benthic organisms including deepwater reef structures, may be affected. Mitigation measures will ensure that the subsea infrastructure is located to avoid areas of sensitive benthic communities to the extent practical. Thus reducing the impact significance to NEGLIGIBLE.

Summary of Key Near Shore Environmental Impacts

Construction activities in the Near Shore are likely to result in disruptions to seagrass, coral reefs and some loss of mangrove and estuary areas. These features play critical roles in ecological interrelationships and directly and indirectly support productivity and biodiversity in the Palma Bay area. The implementation of mitigation has helped to reduce the significance of such impacts but the potential remains for bay-scale productivity to be affected.

Impacts due to dredging: Pre-mitigation impacts to marine ecology from dredging activities in the Near Shore Project Area have been assessed as severe, with a number of MAJOR significant impacts being identified. Examples of such impacts include; the effects on seagrass, coral and associated biological communities from increased turbidity in the water column, cutting a trench through coral reef and rock, depositing fine sediment on benthos and modifications to the seabed. The significance of these MAJOR impacts is largely reduced through mitigation. Key mitigation measures include changing the proposed dredging/cutting techniques and avoidance of areas considered particularly sensitive (ie corals along the pipeline route) and measures to reduce turbidity.

The deposition of fine sediments from dredging activities can inundate seagrass beds and also cover corals with a veneer of sediment that may take considerable time to recover. The re-suspension of sediment and subsequent deposition is unavoidable and subsequent effects to benthos and coral are likely to remain as MAJOR significance post-mitigation.

Dredge material discharged in a dredge placement area at the head of the Afungi Canyon in Palma Bay will smother and possibly result in negative impacts to benthos within the designated 1km^2 placement area. The impact will be of MODERATE significance within dredge placement area itself pre-mitigation, and MINOR post-mitigation. Benthos will likely recover within 1 to 3 years after the cessation of dredging.

Impacts due to modification of the beach: The installation of Near Shore infrastructure across the intertidal beaches and extending into the shallow subtidal zone will modify beach structure and dependant ecological processes. This is likely to result in a loss of parts of the productive sand beach and subtidal zones and areas of seagrass meadow. It will allow the establishment of hard substrate communities in the lower intertidal and corals, sponges and associated organisms in the subtidal and may also facilitate colonisation by alien and potentially invasive species. The impacts to the marine biotopes and associated communities within the bay will be MODERATE for the construction and operational phases. With mitigation, including design mitigation, these impacts will be reduced to MINOR significance.

Impacts due to increased noise: Impacts to fish, whales, dolphins and turtles from noise associated with pile driving in Palma Bay are predicted to be of MODERATE significance although the extent of the effects differs among groups. Should a 'soft start' procedure be implemented prior to construction activities when megafauna are present in the bay, the impact will be reduced to MINOR.

Impacts due to alien invasive species: If invasive alien species are transferred into Palma Bay via ballast water, effects on biodiversity and marine ecology, including seagrass and corals may be of MODERATE significance. The progressive adoption of ballast water control measures and processing techniques as sanctioned by International Maritime Organisation (IMO) will further reduce the likelihood of releasing of non-indigenous organisms. However, due to the high magnitude of the effects that may arise should invasive species become established in northern Mozambique, the significance rating would remain as MODERATE.

Impacts due to discharges into the bay: Discharges from the proposed desalination and sewage treatment plants as well as from treated produced water and stormwater from the LNG Facility is are likely to have NEGLIGIBLE to MINOR significant impacts on near shore water quality and marine flora and fauna in Palma Bay prior to mitigation. All impacts from sources of discharge post-mitigation will be NEGLIGIBLE.

Impacts due to waste discharges: Discharged solid and liquid wastes from marine vessels during any phase of the Project could potentially result in impacts of MODERATE significance through the proliferation of litter and compromised water quality harming marine organisms, seabirds and biodiversity in Palma Bay. With effective mitigation of waste with appropriate facilities impacts will be reduced to NEGLIGIBLE.

Impacts due to loss of an estuary and its mangroves: The impacts on marine ecology resulting from the loss of the estuary and associated mangrove stand to the east of Afungi Project Site during the construction phase will be of MODERATE significance. The impact will remain as MODERATE significance post-mitigation given the loss of the multi -species mangrove stand.

Impacts due to the security exclusion zones: The establishment of security (exclusion) zones around the LNG Facility and the Near Shore Project infrastructure during construction and operations will displace artisanal fishing effort and locally increase exploitation pressure on the fish community outside of the zones resulting in impacts of MINOR significance. Mitigation measures to help reduce such impacts have yet to be identified.

Summary of Key Onshore Environmental Impacts

BASELINE

The onshore project area is located in an area that has three main habitat types, marshlands, wetlands and woodlands. All of these habitats are considered important due to the animal and plant life they support. Figure 9 shows some of the plants and animals in the Afungi Project Site. The wetlands are fed by drainage channels upstream of the site; the flows in these channels are highly variable with very high flow in the wet season and very low flow in the dry season. The wetlands are of particular importance as they provide habitat for frogs and lizards (amphibians). These amphibians are eaten by other animals and largely support the food chain in the area.

Figure 8 Examples of plants and animals in the Afungi Project Site

PROJECT ACTIVITIES

During the construction phase, the activities that will impact on the baseline are the clearance of vegetation, infilling of an estuary, and other general site preparation activities (eg levelling of land). During the operation phase, activities that could affect the baseline are associated with accidental spills, runoff and sedimentation.

REVISION TO ONSHORE PROJECT LAYOUT

Field studies conducted during the Baseline Phase of the EIA identified and mapped sensitive habitats for a variety of vegetation, terrestrial fauna and avian species. Once these species-specific sensitive habitat maps were overlaid (see Figure 9), it became apparent that certain areas within the Afungi Project Site were more sensitive than others. Most of the species relied heavily on the wetlands within the Onshore Project Footprint Area for the ecological functions they provide (food, water, breeding habitat, etc).

Through baseline studies and sensitivity mapping, it became obvious the Project could reduce adverse environmental impacts by revising the Onshore Project Footprint Area. With the sensitivity map in mind, the Project began to investigate methods to avoid or minimise potential footprint impacts. This was facilitated by a series of interactions held between the EIA and Project Engineering Teams. The EIA Team, in conjunction with AMA1, revised the base case Project layout (Figure 9) to avoid or minimise impacts on the identified high-sensitivity areas. Figure 10 shows the Revised Project Footprint Area. The potential FEED Contractors were then tasked with determining whether they could design the Project to work within the revised areas. Each of the potential FEED Contractors confirmed that they were able to work within the revised layout.

This mitigation exercise enabled the avoidance of some impacts and the minimisation of others to as low as reasonably practicable (ALARP). The Revised Project Footprint Area effectively reduces the disturbance of areas classified as High to Very High terrestrial ecological sensitivity from approximately 2,340ha to 1,695ha, thereby avoiding the disturbance of approximately 645ha of High to Very High sensitivity.

Revised Footprint Area

The Onshore Project Footprint (see Figure 9) was revised to minimise impacts to area considered to be of high sensitivity to habitats and various animals such as birds, mammals and frogs. This was a key mitigation measure developed and the revised Project footprint is shown below in Figure 10.

Figure 9 Base Case

Figure 10 Revised Footprint

Summary of Key Onshore Environmental Impacts

Impacts due to air emissions: Air dispersion modelling undertaken indicates that during the operational phase of the Two-Train LNG Facility, there will be minimal impacts to human and ecological receptors outside the Afungi Project Site from changes to air quality. Impacts to receptors outside of the Afungi Project Site will be of NEGLIGIBLE significance for all pollutants modelled pre- and post- mitigation with the exception of SO_2 which will be of MINOR significance prior to mitigation and NEGIGIBLE post-mitigation.

However, with the expansion of the LNG Facility to six trains, a potential impact of MODERATE significance may occur from increased levels of SO_2 pre-mitigation. Further consideration of the design of the LNG Facility (in terms of both stack height and turbine technology adopted) is recommended to avoid the potential of exceeding air quality standards during operations of an expanded six train facility.

Impacts due to emissions of greenhouse gasses: Assuming Mozambique's Greenhouse Gas (GHG) emissions will increase by 8 percent per year (based on World Bank GDP predicted growth figures), emissions from the Project will increase the country's global contribution of GHG emissions from between 0.4 percent per year up to 10 percent per year, depending on the year and period of development (ie construction or operation). The pre-mitigation impact of the Project on Mozambique's national GHG emissions is likely be of MAJOR significance both during the construction and operational phases of the Project. Given the scale and nature of the Project, while good practice can be employed to reduce the GHG emissions, the overall significance of the impact is not expected to significantly change post-mitigation.

Impacts due to noise generation: Noise modelling has shown that during normal construction and operational activities noise levels will remain in compliance with Mozambican and IFC noise limits/standards at Noise Sensitive Receptors at night and during the day. Impacts are therefore predicted to be of NEGLIGIBLE to MINOR significance pre-mitigation and similar post mitigation.

Impacts to the visual landscape: Project activities during the construction phase, including the movement of vessels in and out of Palma Bay and the presence of highly visible equipment and machinery onshore, are likely to have a visual impact of MODERATE to MAJOR significance on Palma Bay Seascape Unit (ie in the coastal area of Palma Bay). During the operational phase this impact will increase to MAJOR significance, with the introduction and long term presence of the LNG Facility and associated infrastructure on Afungi Peninsula and within Palma Bay. Further south in the Afungi Peninsula to Cabo Nondo Seascape Unit, visual impacts experienced as a result of the Project will be of MINOR significance during construction and MODERATE during operations.

Visual impacts at a number of viewpoint locations in the wider area which are considered to be particularly sensitive to change are mainly expected to be of MINOR to MODERATE significance during construction. During operations when Project infrastructure is more visible, significance of visual impacts is likely increase to MODERATE to MAJOR, especially in nearby areas such as Palma town, Maganja and within Palma Bay. However, areas further removed from the Afungi Peninsula (Quiwia and the islands of Tecomaji and Rongui) visual impacts are expected to be of MINOR to MODERATE significance during operations. Vamizi Island and Olumbe are expected to have MINOR to NEGLIGIBLE visual impact during operation due to their distance from the Project.

Impacts on soil: Impacts on soil and land capability will predominantly be felt during the construction phase during site clearance activities, and will include soil compaction and topsoil loss, water and wind soil erosion and alteration of natural drainage. Impacts of MODERATE significance will be reduced to MINOR with the implementation of appropriate mitigation measures. Spills or leaks of fuel are likely to have NEGLIGIBLE impacts on soil resources as procedures will be put in place to prevent, contain, clean-up and dispose of any spillage.

Impacts due to groundwater use: Potential impacts to groundwater will be predominantly be felt during the early stage of the construction phase when groundwater will be the only source of fresh water. Groundwater abstraction from the production water supply wells may result in the lowering of groundwater levels (drawdown) in and around abstraction boreholes; however this is deemed to be of low magnitude potentially having a NEGLIGIBLE impact to community wells in the area adjacent to the production water supply wells. Additionally, water abstraction for Project use may have a NEGLIGIBLE impact on environmental receptors reliant on surface water.

Impacts on surface water ecology: The loss of wetland and estuarine habitat during the construction phase has been assessed as being of MAJOR significance. This significance rating is due to the loss of the ecological functions provided by the wetlands and of important habitat for species of conservational value or importance. The reconfiguration of the Project layout will result in a much reduced area of wetland and estuarine habitat being lost and this coupled with the additional mitigation measures proposed will reduce impact significance to MODERATE.

With the implementation of mitigation, all other impacts to wetland and estuarine flora and fauna are predicted to be MINOR, reduced from MODERATE in most instances, with the exception of impacts associated with increased turbidity and changes to sediment patterns. Increased turbidity in the wetland and estuaries is mainly likely to occur during the construction phase from onshore activities (eg removal of vegetation, site levelling, infilling of wetlands) and activities in the Near Shore (eg dredging). A change in sedimentation patterns may affect connectivity of the wetlands, primary production, benthic invertebrates, fish species etc. Impact significance could potentially be MAJOR during this phase of the Project but reduced to MINOR to MODERATE with mitigation.

Impacts on vegetation: Much of the existing vegetation within the Afungi Project Site has been altered from its natural state (eg for subsistence agriculture) and fragmented. Site clearance activities during the construction phase are expected to result in further fragmentation and the removal or disturbance of some sensitive vegetation units. Site clearance is expected to result in an impact of MODERATE significance. Given the mitigated Revised Project Footprint layout, the areas of sensitive vegetation units to be lost will be reduced and impact significance is thus reduced to MINOR.

Impacts of MODERATE significance to ecological system functioning may occur due to the introduction of undesirable plant species during the construction phase, although with appropriate mitigation such impact will be reduced to NEGLIGIBLE.

Impacts on reptiles and amphibians: The impact of site clearance activities during the construction phase, in particular the infilling of wetland areas within the Afungi Project Site will be of MODERATE to MAJOR significance to reptiles and amphibians given the importance of freshwater wetlands in the functionality of their communities. However, the Revised Project Footprint Area reduces the amount of wetland disturbance and reduces this impact to MINOR significance.

Other impacts to reptiles and amphibians likely to arise during the construction and operational phases of the Project include mortality, disturbance and displacement due to the development of access roads and similar linear structures. Changes in water quality of the wetlands within the Afungi Project Site and adjacent areas also present potential impacts of MINOR to MODERATE significance to reptiles and amphibians. These impacts are reduced to NEGLIGIBLE to MINOR post-mitigation.

The influx of people into the wider area as a result of the Project is expected to put pressure on reptiles and amphibians population density through increased bush fires, reduced water quality from poor sanitation, subsistence poaching and hunting. Such activities could potentially result in reduced breeding success and depleted local populations of reptiles and amphibians and equating to impacts of MAJOR and MODERATE significance during the construction and operational phases respectively. Impacts to areas outside the Project's control are difficult to manage. However with the implementation of proper mitigation, the impact significance will be reduced to MODERATE and MINOR to MODERATE significance respectively.

Impacts on birds: Areas of important avian sensitivity are largely associated with estuarine salt marshes, freshwater wetlands, large intact forests and the inter-tidal zone and mangrove forests. Five International Union for Conservation of Nature (IUCN) listed bird species are known to occur within the Afungi Project Site and the loss of such bird habitat is considered MODERATE to MAJOR in significance. However the revision of the Project layout avoids or minimises impact to these sensitive areas. This in conjunction with additional mitigation measures serves to reduce the significance of the impact to MINOR to MODERATE.

Population influx may include the introduction of domestic animals (livestock and pets) into the area and the introduction of feral animals (dogs and cats). Feral animals are likely to prey on birds and livestock is likely to reduce habitat quality. As a consequence, avian impacts of MODERATE to MAJOR significance are possible during construction (when workforce is greatest); the impact significance is anticipated to be reducing to MODERATE during operations. With the introduction of mitigation measures, the impact will be reduced to MODERATE and MINOR to MODERATE during the construction and operational phases respectively. Other impacts to birds are reduced to NEGLIGIBLE to MINOR post-mitigation.

Impacts on mammals: Project activities likely to result in impacts of MAJOR significant to mammals are largely associated with site clearance activities. Burrowing mammals, tree dwelling species and smaller mammals are likely to be most affected as they are less able to escape construction equipment or vehicles than larger species. Impacts during the operational phase are likely to be MINOR to MODERATE. However with management through mitigation, impacts are reduced to MINOR significance during both development phases.

The presence of infrastructure including roads, fencing, trenches and pipelines will cause loss or fragmentation of mammalian habitat. These may act as deterrents to mammals and have the potential to affect mammalian movements and cause disruption of mammalian migration. Impacts are assessed to be of MODERATE significance during both the construction phase and operational phase of the Project but reduce to MINOR with mitigation.

The most significant potential impacts to mammals remaining following mitigation are the indirect impacts associated with the influx of people into the area. These impacts are likely to be similar to those described for other species above. The various mitigation measures to be implemented by the Project are likely to reduce mammalian impacts to MODERATE during construction and MINOR to MODERATE during operations. All other impacts to mammals will be reduced to MINOR post-mitigation.

BASELINE

The Afungi Project Site is located within Palma District. Most people over the age of 15 in the district have received no formal education and illiteracy is high in the area. Formal employment is scarce and almost non-existent within the private sector. The majority of the population in the Afungi Project Site are therefore highly dependent on natural resources such as fishing and small scale agricultural activities. Figure 11 shows a local community's dependence on natural resources.

There are very few health care facilities in Palma District yet communities are regularly at risk of health problems arising from water and sanitation. The communities largely use natural water sources such as open wells and streams. The sanitation in the area is poor with few formal toilets, this puts the water sources at risk with potential for out breaks of diarrhoea and cholera.

PROJECT ACTIVITIES

The main Project activities that could change socio-economic conditions include the removal of access to land on the Afungi Peninsula, removal of access to parts of Palma Bay, an increasing in-migrant population within the Project area, training and employment of local people and use of local goods and services.

Figure 11 Dependence on Natural Resource

Community using borehole

Fishing village in Afungi

Fish drying

Cassava crops

Impacts due to physical and economic displacement:

The Project expects that everyone residing within the Afungi Project Site will be permanently displaced resulting in loss of dwellings and infrastructure associated with the household, livelihood activities and community assets within the Afungi Project Site. Access to areas of collective natural resource value (eg forests, wooded grassland, flood plains/ lowlands, dune shrub vegetation, fruit trees, and coconut plantations) will be permanently lost due to the acquisition of land required for the Project. In addition, fishing and sea-based transportation will be affected by Project activities in Palma Bay during the construction and operational phases of the Project due to increased vessel traffic and safety exclusion zones around Project infrastructure. The impacts associated with physical and economic displacement are expected to be of MAJOR significance both during the construction and operational phases. Following the implementation of the Resettlement Action Plan (RAP), the significance will be reduced to MODERATE .

Impacts on tourism: The tourism establishments situated on the islands of Tecomaji, Rongui and Queramimbi will be affected by visual and noise impacts resulting from Project construction activities as well as the presence of the Project and vessel traffic during the operational phase. The disruption and loss of attraction to tourism destinations is expected to be an impact of MAJOR significance. This will be reduced to MODERATE with the implementation of mitigation measures including the design of facilities to minimise visual intrusion on tourism receptors and through appropriate ongoing engagement with tourism operators. While the Project activities are anticipated to negatively influence tourism, there will be a positive impact associated with potential increase in use of tourist facilities by the Project. A MODERATE positive impact is expected as a result of increasing demand for accommodation and use of resorts for leisure purposes during both the construction and operational phases.

Impacts due to in-migration: A wide range of direct and indirect negative environmental, social, and economic impacts on local receptors in Project's host communities such as social services, infrastructure and utilities, social dynamics and cultural life, economy and livelihoods and community health are associated with Project related in-migration, leading to a potential deterioration in the socio-economic environment of the Project's host communities. These impacts are likely to be MAJOR. With appropriate mitigation, including engagement and coordination with relevant authorities impact significance will be reduced to MODERATE.

Impacts on community health: Community health is likely to experience MAJOR significant impacts from the presence of the Project workforce, and due to Project related in-migration into the wider area as well such as an increase in communicable diseases (eg respiratory disease and sexually-transmitted infections and vector borne diseases such as malaria). Similarly, MAJOR significant impacts to community health may arise indirectly from Project activities or associated with Project related in-migration (such as increased pressure through demand on health infrastructure, food and nutrition related issues, community accidents and injuries and soil, water and waste borne diseases). With the implementation of mitigation measures, most impacts are reduced to MODERATE significance, and some MINOR. During the construction and operational phase, the potential for increased sexually-transmitted infections and high risk sexual practices may remain as MODERATE to MAJOR significance post-mitigation.

Enhancement measures to be implemented will promote community health benefits from the presence of the Project. MODERATE to MAJOR positive impacts on community health are anticipated particularly during the operational phase of the Project.

Impacts on local, regional and national economy: The Project will have a range of positive economic impacts at the local, regional, and national levels, including income growth (linked to employment and procurement opportunities), capacity development and increased government revenue. These will range from MINOR positive to MAJOR positive in significance and occur during both the construction and operational phases of the Project. The Project will implement measures to enhance these economic benefits.

There are high expectations associated with the Project to provide opportunities for employment and procurement of goods and services locally and regionally and general economic development. A potential negative impact is associated with unmet community expectations in relation to these opportunities and impact significance is expected to be MODERATE during all Project phases, even with the implementation of mitigation measures.

Impacts due to increase in marine vessel movement: Impacts to international maritime traffic and national and regional cabotage will range from NEGLIGIBLE to MODERATE significance due to the presence of Project vessels and the designation of exclusions zones around Project infrastructure, construction areas and vessels. All impacts will be reduced to NEGLIGIBLE to MINOR once mitigation measures are implemented.

Commercial fishing activities are expected to experience impacts of MINOR to NEGLIGIBLE significance. These potential impacts will be confined to the construction phase of the Project and are most likely to occur in the deep water offshore. Temporary exclusions zones in the offshore gas field and pipeline corridor may impede access to commercial fishing grounds. Impacts are expected to be NEGIGIBLE post-mitigation.

Impacts on archaeology: Impacts to onshore archaeology and cultural heritage are expected to be of MODERATE significance during site clearance and construction activities. However impacts will be reduced to MINOR significance with the implementation of the proposed mitigation. During the operational phase impacts will be NEGLIGIBLE.

Impacts to offshore archaeology and cultural heritage are expected to be MINOR during the construction and operational phases prior to mitigation and NEGLIGIBLE following the implementation of the mitigation measures.
All other impacts to mammals will be reduced to MINOR post-mitigation.

Summary of Unplanned Events

An unplanned event is defined as 'a reasonably foreseeable event' that is not planned to occur as part of the Project, but which may conceivably occur as a result of Project activities (eg accidents), even with a low probability. Unplanned events can occur at any phase of the Project onshore and offshore.

The consideration of unplanned events in the EIA has focused primarily on the risks of:

- large volume spills of chemicals or hydrocarbons; and
- failure of subsea infrastructure (such as well blowout or pipeline failure).

Although unlikely to occur should large volumes of hydrocarbon spill in the marine environment the potential consequence to biophysical and socioeconomic receptors could be MAJOR. Sensitive habitats (such as corals and mangroves), local communities dependent on fisheries, as well as tourism operators or aquaculture farms in the vicinity would likely be adversely impacted by such an unplanned event.

Impacts associated with the release of large volumes of natural gas in the marine environment (from failure to or damage of subsea infrastructure) will be less significant.

During the FEED process the Project will identify, assess, mitigate and manage health and safety hazards and risks associated with the Project through a Safety Case. The findings of which will inform decisions related to the design and layout of the Project to reduce the likelihood of unplanned events occurring.

The Emergency Response Plan for the Project sets out response and preparedness measures and incorporates an Oil Spill Contingency Plan. These measures serve to reduce the likelihood, extent and duration of adverse impacts if an unplanned event occurs and establish effective response mechanisms to minimize impacts should such an unlikely event occur.

Cumulative Impacts

It is likely that a number of Mozambique's offshore natural gas resources will be exploited for gas in the coming years resulting in rapid growth in Cabo Delgado Province as a result of the hydrocarbon industry. The cumulative impacts in the region, both positive and negative, as a result are likely to be significant over the life of the Project and beyond. The following have been considered as 'reasonably defined' future developments that could act together with the Project to cumulatively affect the environment:

- establishment of an Industrial Zone (IDZ) by the Government of Mozambique in the vicinity of, or incorporating, the Afungi Project Site.
- future phases of exploration and development of hydrocarbon resources by AMA1, eni and others.

Each of these developments alone has the potential to cause positive and negative biophysical and socio-economic impacts. Cumulatively, the developments will result in significant economic development of the Cabo Delgado Province and the country. The overarching negative cumulative impact of the industrialisation of this area will be the loss of some natural resources as the underdeveloped areas are transformed.

The establishment of the IDZ may result in direct and indirect environmental and social impacts at the local level, but in the long term, consolidating the Project and other operators within the IDZ will serve to confine impacts to one area and ideally allow for easier management of such impacts. Therefore, if managed properly, the IDZ could have an overall positive impact on both biophysical resources and on socio-economic receptors at the regional level given that the Mozambican hydrocarbon resources in this region will undoubtedly be developed. Strategic spatial planning by the Government of Mozambique and its agencies at this early stage is important to promote sustainable development in the region.

Environmental and Social Management Plan (ESMP)

A number of measures to manage residual impacts are captured in the Project Environmental and Social Management Plan (ESMP) and other specific management plans have been developed according to the requirements of Mozambican law and good international industry practice. The ESMP and other plans (listed below) will be implemented during construction and operation of the project.

Environmental Education and Training: This is included in Chapter 17 of the EIA Report and describes how Project staff will be made aware of the environmental and social management measures and controls that they will be required to implement.

Project ESMP: This is a tabulated list of environmental and social management measures and is included in Annex D of the EIA Report. The ESMP references the impacts identified in the impact assessment chapters and categorises the management measures according to phase in which they will be implemented and by responsibility for implementation. Specific monitoring requirements have been identified where required.

Waste Management Plan: The Waste Management Plan is included in Annex E of the EIA Report. It defines waste streams, estimates volumes, categorises wastes streams and describes the means by which the Project will manage waste. The Project has committed to following the waste hierarchy:

Reduce the amount of waste generated;

Re-use materials, where appropriate;

Recycle wastes, where appropriate;

Recover as many materials as practical from the remaining waste;

Treat wastes as necessary to render them less hazardous and/or to enable them to be reused or recycled; and

Dispose of residual wastes responsibly at authorised facilities

Decommissioning and Rehabilitation Plan: This plan outlines the Project's commitments to progressively rehabilitate and re-vegetate disturbed areas wherever possible. In line with good international industry practice and the requirements of Mozambican law, this plan provides the principles that will be followed for decommissioning and rehabilitation and commits the Project to reviewing and updating it at least two years before closure. The plan is included in Annex F of the EIA Report.

Emergency Response Plan: This plan is included in Annex H of the EIA Report. It details the emergency organisational structure and protocols that will be implemented to respond to any major incident in a safe, rapid, effective, and efficient manner within the region. Incidents are defined as an event or hazardous circumstance that poses a significant impact to people, the environment, or property.

Initial Resettlement Plan: The Project's Initial Resettlement Plan (IRP) is included in Annex I of the EIA Report. It describes the approach, principles and procedures that will be followed to manage all unavoidable displacement. The IRP provides the framework for the future development of a full Resettlement Action Plan (RAP). The RAP will be prepared in accordance with Mozambican legislation and the International Finance Corporation's Performance Standard 5: Land Acquisition and Involuntary Resettlement (IFC PS 5) in close consultation with the affected communities.

WHAT IS THE NEXT STEP IN THE PROCESS?

The Draft EIA Report has been finalised in light of all comments received during the public commenting period (27 August to 31 October 2013).

The Final EIA Report has been made submitted to MICOA for decision making (February 2014). If any person or organisation that is interested in or affected by the Project (Interested and Affected Parties (I&APs) has further comments on the Final EIA Report, they are requested to submit these directly to MICOA.

Abbreviations/Units, Acronyms and Glossary

ABBREVIATIONS/UNITS

%	Percent
%PTV	Percentage of pollution-tolerant valves
°C	Degrees Celsius
µg/m³	Micrograms (one-millionth of a gram) per cubic metre
2-D	Two-dimensional
3-D	Three-dimensional
amsl	Above mean sea level
bbl	Barrel
bbl/day	Barrels per day
BBOE	Billion barrels of oil equivalent
BCF	Billion cubic feet
cm	Centimetres
cmol (+)kg-1	Centimoles of positive charge per kilogram
dBA	Decibels (A-weighted scale)
ha	Hectare
hr	Hour
kg	Kilogram
km	Kilometre
km²	Square kilometres
l	Litre
LAmin	Minimum measured noise level in measurement period
LAeq	Equivalent Continuous Sound Level
LA90	Noise levels that are exceeded for 90% of each sample period
LAmax	Maximum measured noise level in measurement period
l/s	Litres per second
m	Metre
mg	Milligram
m bgl	Metres below ground level
m/s	Metres per second
m²	Square metres
m³	Cubic metres
m³/s	Cubic metres per second
mg.l-1	Milligrams per litre
ml	Millilitre
mm	Millimetre
MMtpa	Million metric tons per annum
Mm/yr	Millimetres per year
mS/m	Milli Siemens per metre
$MtCO_2e$	Million metric tons of carbon dioxide equivalent
MTPA	Million tonnes per annum
MZN	Mozambican metical
nm	Nanometre
NTU	Nephelometric Turbidity Unit
pH	Measure of acid or alkaline
ppm	Parts per million
ppmv	Part per million by volume
ppt	Parts per thousand
PSU	Practical salinity unit
rms	Root mean squared
s	Second
t	Tonne
TCF	Trillion cubic feet
tCO2e	Metric tons of carbon dioxide equivalent
USD	United States dollar

ACRONYMS

AC	Agulhas Current
ADI	Area of Direct Influence
ADNAP	Administração Nacional das Pescas (National Fishing Administration)
AFE	Afungi Test Site East
AFT	Afungi Test Site West
Ag	Silver
AII	Area of Indirect Influence
Al	Aluminium
ALARP	As low as reasonably practicable
ALE	Adult literacy and education
AMA1	Anadarko Moçambique Area 1, Lda
AMODER	Associação Moçambicana para o Desenvolvimento Rural (Mozambican Association for Rural Development)
ANC	antenatal care
ANE	Administração Nacional de Estradas (National Roads Administration)
Antarc IW	Antarctic Intermediate Water
APC	Anadarko Petroleum Corporation
APE	Elementary Polyvalent Agent
AQS	Air Quality Standard
ARA	Administração Regional de Águas (Regional Water Administrations)
Area 1	Rovuma Basin Offshore Area 1
ARI	Acute respiratory infection
ART	Antiretroviral treatment
As	Arsenic
ASA	Applied Science Associates Inc
AUV	Autonomous Underwater Vehicle
Ba	Barium
BDI	Biological Diatom Index
Be	Beryllium
BID	Background Information Document
BOD	Biochemical Oxygen Demand
BOP	Blowout Preventer
BTEX	Benzene, toluene, ethyl benzene and xylene (collective name)
C3MR	Propane Pre-cooled Mixed Refrigerant
C	Carbon
Ca	Calcium
$CaCO_3$	Calcium carbonate
CBD	Convention on Biological Diversity
CCDA	Complete Community Development Approach
Cd	Cadmium
CEC	Cation exchange capacity
CENACARTA	Centro Nacional de Cartografia e Teledetecção (National Centre for Cartography and Tele-detection)
CFM	Caminhos de Ferro de Moçambique EP (Mozambique Ports and Railways Company)
CGPCS	International Contact Group on Piracy off the Coast of Somalia
Ch	Champagne soil type
CH_4	Methane
CHA	Community health agent
CSW	Commercial sex worker
CITES	Convention for the Trade in Endangered Species
Cl	Chloride
CLO	Community Liaison Officer
Co	Cobalt
CO	Carbon monoxide

CO_2	Carbon dioxide
COD	Chemical Oxygen Demand
COLREGs	Convention on the International Regulations for the Prevention of Collisions at Sea
CORDIO	Coral Reef Degradation in the Indian Ocean
COT	Crown-of-thorns (starfish)
Cr	Chromium
CS	Cutter Suction (Dredger)
CSW	Commercial sex workers
CTD	Conductivity–temperature–depth
Cu	Copper
CW	(Indian Ocean) Central Water
DBH	Diameter at breast height
DD	Data Deficient
DEAS	District Economic Activities Service
DFMQAMRP	Darwin/Frontier Mozambique Quirimbas Archipelago Marine Research Programme
DINAGECA	National Department of Geography and Cadastre
DMR	Dual Mixed Refrigerant
DNAIA	Direcção Nacional de Avaliação do Impacto Ambiental (National Directorate of Environmental Impact Assessment)
DO	Dissolved oxygen
DOTS	Directly Observed Treatment Short Course
DP	Dynamically positioned
DPCA	Direcções Provinciais para Coordenação da Acção Ambiental (Provincial Directorate for Coordination of Environmental Affairs)
DRP	Decommissioning and Rehabilitation Plan
DUAT	Direito de Uso e Aproveitamento da Terra (Land Use and Benefit Rights)
DWAF	South African Department of Water Affairs and Forestry
EACC	East African Coastal Current
EAME	Eastern Africa Marine Ecoregion
EBI	Energy and Biodiversity Initiative
EC	Electrical conductivity
ECAQS	European Commission Air Quality Standard
ECAs	Export Credit Agencies
EEZ	Exclusive Economic Zone
EGPAF	Elizabeth Glaser Paediatric AIDS Foundation
EHA	Environmental health area
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EIR	Environmental Impact Report
EITI	Extractive Industry Transparency Initiative
EMC	East Madagascar Current
EMODRAGA	Empresa Moçambicana de Dragagem (Mozambican Dredging Company)
EMP	Environmental Management Plan
EMS	Environmental Management System
ENH	Empresa Nacional de Hidrocarbonetos (National Hydrocarbon Company)
eni	Eni East Africa S.p.A
ENSO	El Niño Southern Oscillation
EP1	First Degree of Primary Education
EP2	Second Degree of Primary Education
EPC	Engineering, Procurement and Construction
EPCC	Exploration and Production Concession Contract
EPDA	Estudo de Pré-viabilidade e Definição do Âmbito (Environmental Pre-feasibility Report and Scope Definition)
EPT	*Ephemeroptera*, *Plecoptera* and *Trichoptera*
EqIOW	Equatorial Indian Ocean Tropical Surface Water
EQT	Environmental Quality Target
ERM	Environmental Resources Management Southern Africa (Pty) Ltd
ERP	Emergency Response Plan

ESD	Equivalent spherical diameter
ESD/D	Emergency Shutdown and Detection
ESG1	First Cycle of Secondary Education
ESG2	Second Cycle of Secondary Education
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System (ESMS)
ESP	Exchangeable sodium percentage
ET	Evapotranspiration
ETB	Basic Technical Education
ETE	Elementary Technical Education
ETM	Intermediate Technical Education
EU	European Union
Fe	Iron
FEED	Front-end Engineering and Design
FEWS NET	Famine Early Warning System Network
FFB	Far-field site
FFP	Fundo de Fomento Pesqueiro (Fisheries Development Fund)
FGD	Focus group discussion
FH	Food for the Hungry
FIPAG	Fundo de Investimento e Património do Abastecimento de Água (The Mozambique Water Authority)
FPIC	Free, prior and informed consent
FPU	Floating Production Unit
FTU	Formazin turbidity units
GAPI	Instituição Financeira de Desenvolvimento de Moçambique (Mozambican Institute of Development Finance)
GDACE	Gauteng Department of Agriculture Conservation and Environment (South Africa)
GBDV	Gender-based domestic violence
GDEM	Global Digital Elevation Model
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
GIIGNL	The International Group of Liquefied Natural Gas Importers
GIS	Geographic Information System
GMDSS	Global Maritime Distress and Safety System
GNP	Gross national product
GOM	Government of Mozambique
GPS	Geographically Positioned System
GWP	Global warming potential
H_2O	Water
H_2S	Hydrogen sulphide
HAT	Highest Astronomical Tide
HCO_3	Bicarbonate
HF	High flow
HFO	Heavy fuel oil
Hg	Mercury
HH	Households
HHV	Higher Heating Value
HIA	Health Impact Assessment
HIV/AIDS	Human immunodeficiency virus/acquired immunodeficiency syndrome
HLV	Heavy Lift Vessel
HSB	Health seeking behaviour
HSS	Health systems strengthening
HYCOM	HYbrid Coordinate Ocean Model
I&APs	Interested and affected parties
IACM	Instituto de Aviação Civil de Moçambique (National Aviation Institute)
IADC	International Association for Drilling Contractors
IBAs	Important Bird Areas
ICOMOS	International Council on Monuments and Sites

IDPPE	Instituto Nacional de Desenvolvimento da Pesca de Pequena Escala (National Small-Scale Fishing Development Institute)
IDZ	Industrial Development Zone
IEC	Information, education and communication
IFC	International Finance Corporation
IHI	Index of Habitat Integrity
IIP	Instituto de Investigação Pesqueira (Fisheries Research Institution)
IMF	International Monetary Fund
IMO	International Maritime Organisation
Impacto	Impacto, Projectos e Estudos Ambientais Lda
INAHINA	Instituto Nacional de Hidrografia e Navegação (National Hydrography and Navigational Institute)
INAM	Instituto Nacional de Meteorologia (National Institute of Meteorology)
INAMAR	Instituto Nacional da Marinha (National Maritime Institute)
INAR	Mozambican National Institute for the Support of Refugees
INGC	Instituto Nacional de Gestão de Calamidades (National Institute for of Disaster Management)
INMARSAT	Convention on the International Maritime Satellite Organisation
INP	Instituto Nacional do Petróleo (National Petroleum Institute)
IOC	Indian Ocean Commission
IPCC	Intergovernmental Panel on Climate Change
IRPC	Corporate Income Tax
IRP	Initial Resettlement Plan
IRPS	Individual Income Tax
ISO	International Organization for Standardisation
ITCZ	Intertropical Convergence Zone
ITN	Insecticide-treated net
IUCN	International Union for Conservation of Nature
IWANQ	Mozambique Water Quality Standards
JAM	Joint Aid Management
K	Potassium
Ka	Katspruit soil type
Kd	Kroonstad soil type
KII	Key informant interview
KPI	Key Performance Indicator
L&FS	Life and Fire Safety
LAT	Lowest Astronomical Tide
LC	Least Concern
LCV	Light Construction Vessel
LEMO	League of Scouts of Mozambique
LF	Low flow
Li	Lithium
LIA	Late Iron Age
LNG	Liquefied Natural Gas
Lo	Kroonstad soil type
LOLE	Lei dos Órgãos Locais do Estado (Law for Local State Bodies)
LP	Liquefied petroleum
LULUCF	Land use, land use change and forestry
LZ	Lower Zone
MARPOL 73/78	International Convention for the Protection of Pollution from Ships
MBREMP	Mnazi Bay-Rovuma Estuary Marine Park
MC	Mozambique Current
MCA	Millennium Challenge Account
MCE	Mozambique Channel Eddies
MDEA	Methyldiethanolamine
MdP	Mocímboa da Praia
MEG	Monoethylene glycol
Mg	magnesium
MHWN	Mean High Water Neap
MHWS	Mean High Water Spring

MICOA	Ministério para a Coordenação da AcçãoAmbiental (Ministry for the Coordination of Environmental Affairs)
MINAG	Ministério da Agricultura (Ministry of Agriculture)
MIRAI	Macro-invertebrate Response Index
MIREM	Ministério dos Recursos Minerais (Ministry of Mineral Resources)
MISAU	Ministério da Saúde (Ministry of Health)
MITUR	Ministério do Turismo (Ministry of Tourism)
MLWN	Mean Low Water Neap
MLWS	Mean Low Water Spring
MMO	Marine mammal observer
Mn	Manganese
Mo	Molybdenum
MOF	Material Offloading Facility
MPA	Marine Protected Area
MPD	Multipurpose Dock
MPescas	Ministério das Pescas (Ministry of Fishing)
MR	Mixed refrigeration
MSI	Metocean Services International (Pty) Ltd
MSL	Mean sea level
MZ	Marginal Zone
Na	Sodium
NABM	Non-aqueous based muds
NaCl	Sodium chloride
NADW	North Atlantic Deep Water
Nb	Namib soil type
NCD	Non-communicable disease
NCEP	National Centre for Environmental Predictions
NEMC	North East Madagascar Current
NEMBA	National Environmental Management: Biodiversity Act (No. 20 of 2004)
NFB	Near-field site
NGO	Non-governmental organisation
NH_4	Ammonium
Ni	Nickel
NIDW	North Indian Deep Water
NMCP	National Malaria Control Programme
NOAA	National Oceanic and Atmospheric Administration
NO_2	Nitrogen dioxide
NO_3	Nitrate
NOx	Nitrogen oxides
NORM	Naturally occurring radioactive materials
NSR	Noise sensitive receptor
NT	Near Threatened
NTS	Non-technical Summary
NTU	Nephelometric Turbidity Unit
NW	North-west
OBM	oil-based muds
OGP	International Oil and Gas Producers Association
OILPOL	International Convention for the Prevention of Pollution of the Sea by Oil
OPRC	Oil Pollution Preparedness, Response and Cooperation Convention
OSCP	Oil Spill Contingency Plan
P	Phosphorus
PAC	Potentially affected communities
PAH	Polyaromatic hydrocarbon
PARP	Poverty Reduction Action Plan
PATI	Priority area for tourism investment
Pb	Lead
PC	Project Contribution
PCMRB	Petronas Carigali Mozambique Rovuma Basin
PCSW	Potentially contaminated surface water
PEC	Predicted Environmental Concentration

PES	Present ecological state
PESPA	Plano Estratégico do Subsector da Pesca Artesanal (Strategic Plan for the Artisanal Fisheries Subsector)
PGU	Power Generation Unit
PICT	Provider initiated counselling and testing
Pig	Pipeline integrity gauge
PIIM	Project Induced In-Migration
PLET	Pipeline End Termination Structure
PLONAR	Pose Little or No Risk to the Environment
PM	Particulate matter
PM10	Particulate matter < 10µm
PMT	Total Particulate Matter
PMTCT	Prevention of mother-to-child transmission
PMW	Palma West Site
PNA	National Water Policy
POM	Particulate organic matter
PPE	Personal protective equipment
PR	Propane Refrigeration
PSU	Practical salinity units
PTS	Permanent Threshold Shift
PTV	Pollution-tolerant valves
PTW	Permit to work
PPR	Public Participation Report
RAP	Resettlement Action Plan
RDT	Rapid diagnostic test
RHIA	Rapid Health Impact Assessment
RHMIS	Routine Health Information Management System
RO	Reverse osmosis
ROV	Remotely operated vehicle
RPF	Resettlement Policy Framework
RTA	Road traffic accident
SADC	Southern African Development Community
SAMSA	South African Maritime Safety Authority
SAR	IMO International Convention on Search and Rescue
SASS5	South African Scoring System, version 5
SAWQG	South African Water Quality Guidelines
Sb	Antimony
SBM	Synthetic-based muds
SCS (Method)	Storage Conservation Service (Method)
SDoH	Social determinants of health
Se	Selenium
SE	South-east
SEC	South Equatorial Current
SEL	Sound exposure level
SEMC	South East Madagascar Current
SEP	Stakeholder Engagement Plan
SES	Simplified Environmental Study
SI	Surface irradiance
SMA	Soil Moisture Accounting
SMR	Single Mixed Refrigerant
Sn	Tin
SO_2	Sulphur dioxide
SO_4	Sulphate
SOLAS 74	International Convention for the Safety of Life at Sea
SPI	Specific Pollution Sensitivity Index
SPS	Subsea Production System
Sr	Strontium
SS	Suspended solids
SSS	Side Scan Sonar

STCW	IMO International Convention on Standards of Training, Certification and Watch keeping for Seafarers
STH	Soil-transmitted helminth
STI	Sexually transmitted infection
Subt SIOW	Indian Ocean Subtropical Surface Water
S-Unit	Sand unit
TB	Tuberculosis
Tc	Travel time
TCN	Third country national
TDS	Total Dissolved Solids
TH	Traditional healer
ToR	Terms of Reference
TS	temperature/salinity
TSHD	Trailer Suction Hopper Dredger
TSS	Total Suspended Solids
TTS	Temporary Threshold Shift
TWC	Temporary workers camp
TWQR	Target Water Quality Range
U	Uranium
UEM	Universidade Eduardo Mondlane (Eduardo Mondlane University)
UN	United Nations
UNCLOS	UN Law of the Sea Convention
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNWQG	United Nations Water Quality Guidelines
US	United States of America
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
UV	Ultraviolet
UWS	Underwater Surveys
UXO	Unexploded Ordinance
UZ	Upper Zone
V	Vanadium
VAT	Value added tax
VEGRAI	Vegetation Response Assessment Index
VOC	Volatile Organic Compounds
VU	Vulnerable
WaMP	Water Management Plan
WB	World Bank
WBM	Water-based muds
WHO	World Health Organization
WIO	West Indian Ocean
WIOLAB	West Indian Ocean Land Based
WMP	Waste Management Plan
WMS	Watershed Modelling System
WQ	Water quality
W-Unit	Wetland unit
WWF	Worldwide Fund for Nature
Zn	Zinc
ZSL	Zoological Society of London
ZTV	Zone of Theoretical Visibility

GLOSSARY

Afungi Project Site	The location on Afungi Peninsula where the LNG Facility and associated infrastructure (roads, airstrip, accommodation, etc) will be located. This is the area where the Project has acquired the rights to use the land.
Afungi Project Site and Surrounds	This refers to Afungi Project Site and the areas around the Afungi Project Site where people's access to livelihood assets will be affected.
Afungi Site Improvement activities	The Site Improvement activities are intended to upgrade existing infrastructure and make minor preparations to facilitate the construction phase, should the Project be approved.
Alternative	Alternatives can refer to any of the following, but are not limited to: alternative sites for development, alternative projects for a particular site, alternative site layouts, alternative designs, alternative processes and alternative materials.
Anthropogenic	Caused by humans.
Aquifer	Fresh water (usually) held in underground layers of water-bearing permeable rock or unconsolidated sediments (gravels/sand/silt).
Arable	Land that can be cultivated for growing crops.
Area 1	Area 1 is the area licensed to AMA1 by the Ministry of Energy and Mineral Resources for the exploration and development of hydrocarbons.
Area 1 Gas Fields	The offshore AMA1 gas fields, namely Golfinho and Prosperidade, found in Area 1.
Area 4	Area 4 is the area licensed to eni by the Ministry of Energy and Mineral Resources for the exploration and development of hydrocarbons.
Area 4 Gas Fields	The offshore eni gas field covered in the EIA, namely Mamba, found in Area 4.
Area of Direct Influence (ADI)	The ADI comprises the areas offshore, near shore and onshore where the Project infrastructure will be located, ie the direct Project Footprint. The ADI comprises two broadly defined areas of interest: • Offshore Project Footprint Area; and • Afungi Project Site and Surrounds.
Area of Indirect Influence (AII)	The AII refers to areas where the Project Footprint has an indirect influence, and comprises: • Palma Bay and offshore deepwater in the vicinity of the production areas; • Palma Town and villages or settlements outside the Afungi Project Site that are indirectly impacted; • the islands at the mouth of Palma Bay: Tecomaji, Rongui and Queramimbi islands, and possibly islands further south along the coast eg Vamizi Island; and • the broader district, province and potentially region can also be included in the AII from a socio-economic perspective. Similarly, the AII potentially extends to a national level, as the Project may have benefits at a national scale.
Avifauna	Birds.
Bairros	Neighbourhoods.
Baseline	The current physical, biological, cultural and human conditions that will prevail in the absence of the Project, including interactions among them.
Bathymetry	Underwater depths. Bathymetry maps show underwater depths at various locations.
Benthic zone	The ecological region at the base of the water column, including sediment surface and very shallow subsurface sediment layers.

Benthos	Species living in or on ocean, sea, lake beds and/or river bottoms.
Berthing Area	The area of the Near Shore infrastructure where LNG Carriers will berth.
Biodiversity	The variability among living organisms – animals, plants, their habitats – from all sources including terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part. This includes diversity within species, between species, and of ecosystems.
Biomass	The total mass of living matter within a given unit of environmental area.
Biome	Major ecological community, a division of the world's vegetation that corresponds to a particular climate and is characterised by certain types of plants and animals.
Biota	The animal and plant life of a given region.
Biotope	An area of uniform environmental conditions providing a living place for a specific assemblage of plants and animals. Biotope is almost synonymous with the term habitat, but while the subject of a habitat is a species or a population, the subject of a biotope is an interdependent biological community.
Bioturbation	The displacement and mixing of sediment particles by fauna or flora.
Brine	Concentrated salt water from the Desalination Plant.
Bund	Containment wall to capture spills before loss to the environment.
Carbon dioxide equivalent	A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP).
Casing	A process carried out to isolate portions of a well so as to protect the aquifers of groundwater, as well as to provide a support structure to the well itself.
Catchment	An area from which surface run-off is carried away by a single drainage system.
Cetacea	Order of marine mammals containing dolphins, whales and porpoises.
Chemical inhibitors	A substance used to retard a chemical reaction.
Chlorophyll	Green pigment in algae and plants essential for photosynthesis.
Clean surface run-off	Run-off from areas deemed not at risk to oil or chemical contamination. Clean surface run-off will be allowed to discharge to the surrounding environment.
Condensate	Hydrocarbon liquid that condenses from natural gas when the pressure drops below dewpoint.
Coral bommies	A coral bommie (from 'bombora' – an Aboriginal word meaning outcrop or mountain or reef) is either an outcrop of coral reef, often resembling a column that is higher than the surrounding platform of reef, or an isolated piece of reef on sand.
Coral fringing reef	Coral reef on outside of shores or islands.
Coral rubble	Unconsolidated fragments of broken dead coral.
Corals	Marine invertebrates in the class Anthozoa of the phylum Cnidaria, typically living in compact colonies of many identical individual polyps. The group includes the important reef builders that inhabit tropical oceans, which secrete $CaCO_3$ to form a hard skeleton.
Crustaceans	Arthropods such as crabs and prawns that have joined appendages and hard outer shells.
Culvert	A man-made structure used to channel water.
Cumulative impacts	Impacts that result from the incremental impact of the proposed activity on areas or common resources used or directly impacted by the Project, from other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted when added to the impacts of other past, present or reasonably foreseeable future activities. Cumulative impacts can occur from the collective impacts of individual minor actions over a period of time, and can include both direct and indirect impacts.
Cuttings	Debris (pieces of sand, gravel and rock) that are brought to the surface from the well during drilling.

Dambos	*Dambos* are depressions within wetland systems where water levels are not dependent on surface rainfall run-off, but rather water welling up from below. *Dambos* are also found at higher elevations outside wetland systems and are presumably fed from arterial springs, and retain water for longer periods during the dry season.
Demersal	The part of the water column that is near to the seabed and the benthos. Demersal fish are those that spend the majority of their life cycle on or near to the seabed.
Demersal zone	That part of the sea or ocean or deep lake comprising the lower water column that is near to and affected by the sea/lake bed and benthos.
Dewatering	Removal of water from.
Dhows	A lateen-rigged ship with one or two masts, used in the Indian Ocean.
Diatoms	A single-celled algae that has a cell wall of silica.
Direct impacts	Impacts that result from a direct interaction between a planned Project activity and the receiving environment/receptors (eg between occupation of a site and the pre-existing habitats, or between an effluent discharge and receiving water quality). These impacts are usually associated with the construction, operation or maintenance of an activity, and are generally obvious and quantifiable.
Domestic cabotage	Transport between two points within a country.
Drilling fluids (drilling muds)	These are used to control subsurface pressures, lubricate the drill bit, stabilise the well bore and carry the cuttings to the surface.
DUAT process	The DUAT or *direito de uso e aproveitamento da terra* process refers to the process of obtaining right of use of land in Mozambique.
Dynamically positioned	The location or position of the vessel is maintained by the vessel's specialised propulsion/station-keeping system.
Early works	These works will involve site preparation activities and will expand on the activities started in the Afungi Site Improvement phase, and are anticipated to begin following MICOA approval of this EIA.
Ecosystem	A community of plants, animals and smaller organisms that live, feed, reproduce and interact in the same area or environment.
Ecosystem services	The benefits people obtain from ecosystems.
EIA Pre-assessment Application Phase (Screening)	This phase involves submitting a Pre-assessment Application to the Provincial Directorate of Environmental Affairs (Direcção Provincial de Coordenação de Acção Ambiental or DPCA), which then categorises the Project based on the level of environmental assessment required.
Emergency Response Plan	Plan to address contingencies associated with process upset and accidental circumstances.
Endemic	Restricted to a particular area. Used to describe a species or organism that is confined to a particular geographical region.
Engineering Team	The Project's Engineering Team (involves FEED Contractors involved in the design of the Project).
Environment	The surroundings within which humans exist, and that are made up of: (i) the land, water and atmosphere of the earth; (ii) micro-organisms, plant and animal life; (iii) any part or combination of (i) and (ii) and the inter-relationships among and between them; and (iv) the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being. This includes the economic, social, cultural, historical and political circumstances, conditions and objects that affect the existence and development of an individual, organism or group.
Environmental and Social Management Plan (ESMP)	A set of actions and measures to be carried out by the proponent, in order to manage the negative impacts and maximise the positive impacts resulting from the implementation of the proposed activity, prepared under the scope of the EIA.

Environmental Impact Assessment	The process of predicting and evaluating the social and environmental impacts and risks of a proposed Project, and identifying mitigation measures that will enable the Project to meet the requirements of stakeholders, applicable laws and regulations, and any additional requirements for social or environmental performance identified by the Project, and so that impacts are as low as technically and financially feasible.
Environmental management	Ensuring that environmental concerns are included in all stages of development, so that development is sustainable and does not exceed the carrying capacity of the environment.
Epifauna	Animals that live on the surface of the substrata.
Estuaries	A partly enclosed body of water that has one or more rivers flowing into it and is connected to the open sea. Estuaries thus receive fresh water from inland and salt water from the sea. Tides influence how much (and how far) salt water intrudes into the estuary and river.
Estudo de Pré-Viabilidade Ambiental e Definição de Âmbito (EPDA) phase or scoping phase	The scoping phase or EPDA phase, as it is known in Mozambique, aims to identify key issues and concerns associated with the proposed development. These could include Project-related activities that may have the potential to contribute to or cause potentially significant impacts to environmental and socio-economic receptors and resources in the area.
Exclusion Zone	Area from which vessels are prohibited from entering.
Exclusive Economic Zone (EEZ)	A concept adopted at the Third United Nations Conference on the Law of the Sea (1982), whereby a coastal State assumes jurisdiction over the exploration and exploitation of marine resources in its adjacent section of the continental shelf, taken to be a band extending 200 miles from the shore.
Fauna	Collectively, the animal life of a region.
Fishing Centres	Settlements of fishers, where fishers and fish traders live on a permanent or seasonal basis.
Flaring	The safe burning of excess unwanted gases.
Flora	Collectively, the plant life of a region.
Formation or produced water	Water trapped in the gas and rocks that is brought to the surface during operations.
Front-end Engineering Design (FEED)	The design phase of the Project.
Fugitive emissions	The unintended escape of greenhouse gas emissions.
Gender diglossia	A situation in which two different languages are used by men and women within a community.
Greenhouse gases (GHG)	Unless indicated otherwise, GHG emissions are made up of CO_2, CH_4, N_2O, HFCs, PFCs and SF_6.
Habitat	An ecological or environmental area that is inhabited by a particular species of animal, plant or other type of organism. It is the natural environment in which an organism lives, or the physical environment that surrounds (influences and is used by) a species population.
Hazardous waste	Substances classified as hazardous wastes possess at least one of four characteristics of signitability, corrosivity, reactivity or toxicity – or appear on special lists.
Herpetofauna	Amphibians and reptiles.
Hydrocarbons	Compounds that contain only hydrogen and carbon molecules. Petroleum-based products such as LNG and condensate contain hydrocarbons.
Hydrotesting	The filling of equipment or pipelines with water to test for any losses of pressure through leaks.
Ichthyofauna	Fish.
Impact	Any alteration of existing conditions, adverse or beneficial, caused directly or indirectly by the Project.

Indirect impacts	Impacts that result from other activities that are encouraged to happen as a consequence of the Project (eg in-migration for employment placing a demand on resources). Indirect impacts can also be referred to as induced or secondary impacts. These types if impacts include all of the potential impacts that do not manifest immediately when the activity is undertaken or which occur at a different place as a result of the activity.
Infauna	Animals that live in sediment.
Infectious disease	Illnesses that are attributable to specific infectious agents or their toxic products that arise through the transmission of these agents or their products from an infected person, animal or inanimate reservoir to a susceptible host. Examples include water-borne, water-related, food-borne, respiratory and sexually transmitted diseases.
Initial Resettlement Plan	Establishes the principles, approach and procedures that will be followed in planning resettlement and awarding compensation to people who are physically or economically displaced by a project. The IRP provides the framework for the future development of a full Resettlement Action Plan (RAP).
Interested and Affected Parties (I&APs)	Individuals, communities or groups, other than the proponent or the authorities, whose interests may be positively or negatively affected by the proposal or activity and/or who are concerned with a proposal or activity and its consequences.
Intertidal zone	The area of the shore that is above water at low tide and under water at high tide.
Intertropical Convergence Zone (ITCZ)	An area of low pressure that forms where the Northeast Trade Winds meet the Southeast Trade Winds near the equator. As these winds converge, moist air is forced upward, causing water vapour to condense and cool, resulting in heavy precipitation.
Invasive or alien species	Species introduced outside its normal distribution. Its establishment and spread modifies ecosystems, habitats or species. Aliens are called invasive when they spread rapidly and outcompete indigenous species.
Invertebrates	Species lacking a spinal column (eg crabs).
IUCN Red List	Also known as the IUCN Red Data List, this is the world's most comprehensive inventory of the global conservation status of biological species. Taxa are classified according to formal ranking systems assessing relative risks of extinction.
Keystone species	A species that has a disproportionate effect on its environment relative to its abundance, and which plays a critical role in maintaining the structure of an ecological community/biotope.
Land capability	A combination of terrain form, soil types, thickness and slope gradients in association with broad agricultural potential define the land capability of an area.
Land cover	The physical coverage of land, usually expressed in terms of vegetation cover or lack of it.
Landscape	A geographical mosaic composed of interacting ecosystems resulting from the influence of geological, topographical, soil, climatic, biotic and human interactions in a given area.
Liquefaction	The process by which natural gas is cooled to condense it to a liquid.
Liquefied Natural Gas (LNG)	A natural gas (predominantly methane, CH_4) that has been converted to liquid form for ease of storage or transport.
Littoral zone	That part of the sea that extends from the high water mark to the edge of the continental shelf (commonly defined as the 200m isobath).
LNG Export Jetty	The jetty infrastructure where LNG Carriers will berth to load LNG for export.
LNG Facility	The processing facility where natural gas will be liquefied, and associated facilities.
LNG Train	The LNG Plant's liquefaction and purification facilities.
Machambas	Small-scale farms (fragmented cultivated lands).
Macroalgae	Seaweeds including red, brown and green algae.
Mangrove	Kinds of trees up to medium height, and shrubs, which grow in saline coastal sediment habitats in the tropics and subtropics.

Marine ornamental fish	Small fish in families commonly used in marine aquaria, including Chaetodontidae, Labridae, Zanclidae, Acanthuridae, Serranidae, Pseudochromidae, Pomacentridae, etc.
Materials Offloading Facility (MOF)	The service port and transit point of equipment and materials used during the construction and operation phase of the Project.
Mesopelagic	The part of the pelagic zone that extends from a depth of 200 to 1,000m below the sea's surface.
Metocean	The combined study of meteorology and oceanography.
Microalgae	Microscopic single-celled algae in fresh, brackish (estuarine) and marine waters. Pelagic species comprise phytoplankton, while those on sediments are benthic microalgae.
Mitigate	The implementation of practical measures to reduce adverse impacts or enhance beneficial impacts of an action.
Mitigation measure	A feature, procedure or other action that the Project commits to implement to avoid or reduce the magnitude of an adverse impact, or to enhance the magnitude of a positive impact.
Monoethylene glycol (MEG)	A colourless, virtually odourless and slightly viscous liquid used to inhibit the formation of hydrates or condensate by altering the freezing point of the water found in raw natural gas.
Multipurpose Dock (MPD)	Marine structure comprising the MOF, the Subsea Construction Area (SSCA) and Marine Service Facility (MSF).
Nautical mile	A measurement of distance at sea equal to 1,852m.
Near Shore environment	The waters westward of Mozambique's Maritime Baseline.
Near Shore Project	The proposed marine infrastructure within Palma Bay necessary for construction, operation and maintenance of the Project. This includes logistic, support and export facilities (eg shipping channels, MOF and LNG Export Jetty).
No-go alternative	The no-go alternative is the option of not undertaking the proposed activity or any of its alternatives. This alternative also provides the baseline against which the impacts of other alternatives should be compared.
Offshore environment	The area beyond Mozambique's Maritime Baseline.
Offshore Project components	The proposed offshore production wells and the infrastructure necessary to develop the gas reserves. This includes the offshore pipeline system that will convey natural gas from the offshore production field to the onshore facilities.
Offshore Project Footprint Area	The areas in the offshore and near shore environment that may reasonably be expected to be physically touched by Project infrastructure, across all phases.
Oligotrophic	Low nutrient conditions.
Onshore environment	The terrestrial environment.
Onshore Project	The proposed onshore LNG facilities and supporting infrastructure (eg worker accommodation facilities, construction areas, access roads and airstrip).
Onshore Project Footprint Area	The area onshore that may reasonably be expected to be physically touched by Project infrastructure, across all phases.
Operational phase	The period of the Project's life when gas will be extracted, processed and exported.
Oxygen scavengers	Used to reduce the oxygen content in air or water to slow the process of corrosion.
Particulate matter	Fine particles of solid matter.
Pelagic	The part of the water column in the open sea that is not closely associated with the seabed.
Pelagic zone	Water body in oceans, seas or lakes that is not close to the bottom or shore, ie the water column extending from the surface to near the seabed.

Pioneer Dock	A Pioneer Dock will be established to allow the import of heavy equipment and materials to the site via sea.
Pipeline integrity gauge (PIG)	A cylindrical device inserted into a pipeline to inspect the pipe or to sweep the pipe clean of water, rust or other foreign matter.
Plankton	Microscopic animals (zooplankton) or plants (phytoplankton) that inhabit the pelagic zone of water bodies.
Potsherd	A broken piece of ceramic material, especially one found on an archaeological site.
Production zones	Agricultural areas.
Project activities	Activities that are planned as part of the Project, including all phases. This excludes unplanned events.
Protected areas	An area of land and/or sea especially dedicated to the protection of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.
Public consultation	Term used when referring to the activity of consulting with stakeholders or I&APs.
Public participation process	Term used when referring to the regulatory-driven stakeholder or I&AP engagement process.
Receptor	Humans and other animals that can be impacted by Project activities.
Regional cabotage	Transport in coastal waters.
Resettlement Policy Framework	Establishes the principles and procedures that will be followed in planning resettlement and awarding compensation to people who are physically or economically displaced by a project, including the process by which people can raise a grievance if they consider that have been adversely affected or unfairly treated.
Residual impact	Impacts that remain after mitigation measures, including those incorporated into the Project's design, have been applied.
Resource	An element of the physical, biological, cultural or human environment that is not a human or other animal (these are referred to as receptors), which can be impacted by the Project activities.
Revised Onshore Project Footprint Area	Following input from various specialists on the sensitivities (biophysical and socio-economic) of the Afungi Project Site, a revised site area was determined, known as the 'Revised Onshore Project Footprint Area '. This revised layout was considered in the assessment of the residual impact, as the change in layout is considered as a mitigation measure.
Salinity	The dissolved salt content in sea water.
Seagrass	Flowering rooted plants (angiosperms) from one of four plant families all in the order *Alismatales* (in the class of monocotyledons), which grow in marine, fully saline environments.
Seascape Unit (S-Unit)	Coastal landscape and adjoining areas of open water, including views from land to sea, from sea to land and along the coastline. Every S-Unit has three components: an area of sea (the seaward component), a length of coastline (the coastline component), and an area of land (the landward component).
Significance	An impact is significant if, in isolation or in combination with other impacts, it should be taken into account in the decision-making process. The degree of significance depends on the combination of impact magnitude and probability of impact occurrence.
Site selection process	A study that was undertaken to determine the preferred site for the onshore LNG Facilities. This included looking at a number of locations throughout Cabo Delgado Province from an environmental, social and engineering perspective.
Slug catcher	Liquids and gas do not form a homogeneous mixture as they flow through the pipeline. Liquids tend to pool in low areas of the pipeline until a sufficient volume accumulates to impede the flow of gases. Once this occurs, pressure is built up behind the liquid and the liquid is pushed through the pipeline. This phenomenon is referred to as 'slug flow'. A slug catcher is a device that receives the 'slugs' of liquid that accumulate over time and are pushed through the pipeline intermittently.

Sound exposure level	The total noise energy delivered over a measured duration averaged over one second.
Specialist studies	The technical studies undertaken by specialists for the purpose of the EIA (eg marine ecology, socio-economics, etc).
Stakeholder engagement	The process of engagement between stakeholders (the proponent, authorities and I&APs) during the planning, assessment, implementation and/or management of proposals or activities.
Stakeholders	See interested and affected parties (I&APs) above.
Study Area	The entire area under baseline investigation, where impacts may occur as a result of the Project. This may differ between specialist studies and may include areas outside the Afungi Project Site. For example, the Study Area for the landscape and seascape visual study includes a radius of 30km from the centre of the Afungi Project Site, as it is considered that the LNG Facility may be visible at such a distance. The Study Area comprises the ADI and AII.
Subtidal zone	The area below low tide that is almost always submerged.
Supratidal zone	The area above the high tide water line that extends upland. The area is seldom covered by water unless during flooding or storms, but can receive water from wave splash.
Surficial	The layer at the top of the sediment body, usually millimetres to centimetres thick.
Survey Area	The area over which physical surveys take place as part of the collection of primary baseline data. As in the case of Study Area, this is defined for each relevant resource/receptor and will differ for each specialist study, but these are typically confined to the Afungi Project Site or ADI.
The Project	The proposed LNG Project.
Thermocline	A layer of rapid temperature change in the water column.
Total suspended solids (TSS)	A measure of water quality that investigates the level of suspended solids in mg/l (turbidity).
Tungi Bay	Old name for Palma Bay.
Turbidity	The measure of the degree to which water losses transparency, due to the presence of suspended particles.
Unexploded ordinance (UXO)	Unexploded ordnances are explosive weapons (bombs, bullets, shells, grenades, landmines, naval mines, etc.) that did not explode when they were employed and still pose a risk of detonation, potentially many decades after they were used or discarded.
Unplanned event	A reasonably foreseeable event that is not planned to occur as part of the Project, but which may conceivably occur as a result of Project activities (eg accidents), even with a low probability.
Well	The hole drilled to obtain the gas.
Well blowout	A well blowout is an uncontrolled flow of reservoir fluids into the well bore and sometimes to the surface.
Wellhead	The topmost point of a well and the structure built over it.

Chapter 1

Introduction

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1 INTRODUCTION

1.1 THIS DOCUMENT

This document presents the Environmental Impact Assessment (EIA) Report for the proposed Liquefied Natural Gas (LNG) Project associated with the gas fields within Area 1 Offshore of the Rovuma Basin (Area 1) and Area 4 Offshore of the Rovuma Basin (Area 4) (hereinafter referred to as 'the Project').

The document has been prepared by Environmental Resources Management (ERM) Southern Africa (Pty) Ltd in association with Projectos e Estudos de Impacto Ambiental, Lda. (Impacto) on behalf of Anadarko Moçambique Área 1, Lda (AMA1) and Eni East Africa S.p.A (eni), two companies licensed for the exploration and development of Area 1 and Area 4 respectively. This EIA consists of three volumes as described in *Section* 1.6 below.

1.2 THE PROJECT PROPONENT

1.2.1 Context

AMA1 and eni are joint proponents for the Project. AMA1 has been leading the EIA process with the consultants since April 2011. AMA1 will continue to lead the EIA process on behalf of the proponents with the close cooperation and involvement of eni. Details about each of the companies' organisations are provided in *Sections* 1.2.2 and 1.2.3 below. This section describes the relationship between these two companies, both offshore in the Rovuma Basin and onshore on Afungi Peninsula.

AMA1 holds exploration rights to explore, develop and produce natural gas reserves in Area 1 Offshore in the Rovuma Basin. Likewise, eni holds rights to explore, develop and produce natural gas reserves in Area 4 of Rovuma Basin. These areas are positioned adjacent to one another and a number of gas reservoirs or gas fields (including both standalone reservoirs and straddling reservoirs) have been discovered within each of the areas. AMA1 and eni will each coordinate the development of their natural gas reservoirs in compliance with the applicable Mozambican laws and regulations. The Proponents will also coordinate the development of the straddling natural gas reservoirs in compliance with the applicable Mozambican laws and regulations and a Master Depletion Plan jointly prepared by the two Operators.

Onshore, the Mozambican company, Rovuma Basin LNG Land, Lda. ('RBLL') incorporated by AMA1 and Empresa Nacional de Hidrocarbonetos, E.P., is the holder of the Right to Use and Enjoy Land (the 'DUAT') for an area identified on the Afungi Peninsula in Cabo Delgado Province, where the infrastructure for the natural gas liquefaction, namely the LNG trains, the common infrastructures, marine facilities, LNG storage tanks (the "LNG Facility"), etc.

will be built and operated. AMA1 currently possesses exclusive rights to the land within the DUAT for the development of the Project, under the terms of the assignment of exploitation agreement executed between AMA1 and RBLL, being ongoing the entrance of eni in RBLL's capital, as well as the granting to eni of rights to use the referred land on equal terms with AMA1.

With a view towards optimising the development, construction and operation of the initial liquefaction facilities, AMA1 and eni have entered into a Term Sheet that provides for the coordinated development, construction and operation of the LNG Facility. The Project will be implemented by means of one or more coordinated Development Plans which will be approved by the Government of the Republic of Mozambique.

1.2.2 AMA1

AMA1, a wholly-owned subsidiary of Anadarko Petroleum Corporation (APC), is a commercial entity duly registered under the Republic of Mozambique. AMA1 is the operator of Area 1 and has operating offices in Cabo Delgado Province at Pemba, Mocímboa da Praia and Palma. The head office is in Maputo, situated at Rua Joseph Ki-Zerbo, no. 227.

APC is headquartered in The Woodlands, Texas, United States of America (USA). With more than 2.56 billion barrels of oil equivalent (BBOE) of proven reserves at year-end 2012, APC is among the largest independent oil and natural gas exploration and production companies in the world. The company has major onshore operations in the USA comprising the Rocky Mountain Southern and Appalachian regions. The company is an offshore deepwater producer in the Gulf of Mexico and Ghana with additional deepwater exploration interests in New Zealand, Colombia, Brazil, China, Indonesia, South Africa, Kenya, Liberia, Sierra Leone and Côte d'Ivoire.

AMA1 made a commitment to the government and people of Mozambique to further the exploration and development of the country's potential petroleum resources in an environmentally and fiscally responsible manner. APC is a member of the International Association of Oil & Gas Producers (OGP) and is committed to safe, responsible and economically beneficial operation.

1.2.3 eni

eni S.p.A is an Italian company with activities in close to 85 countries. eni is an affiliate of eni S.p.A. with a branch in Mozambique and offices in Maputo and Pemba. eni S.p.A. is one of the leading global operators in the deep-water sector worldwide and is currently involved, as operator or partner, in exploration activities in several deep waters in the Gulf of Mexico and along the coast of Brazil.

eni S.p.A. is a member of OGP and the International Oil Industry Environmental Conservation Association (IPIECA), an organisation

established to assist the oil and gas industry to improve its environmental and social performance.

In Mozambique, eni is committed to conserve biodiversity and preserve productive ecosystem services through all phases of its activities. More information on eni can be accessed on the internet at:

http://www.eni.com/en_IT/media/casebook/casebook-mozambique.html

1.3 THE PROJECT

1.3.1 Project Overview

The Project is designed to gather, process and export (in liquefied form) natural gas. This process begins offshore in Area 1 and Area 4, where natural gas will be extracted from below the seafloor via subsea wells. The gas will be collected and transported to the onshore LNG Facility by subsea pipelines. Once onshore, the gas will be processed, converted to liquid (through cooling the gas) and stored in storage tanks. The liquefied gas will then be transported through insulated pipelines to an export jetty, where it will be loaded into specialised LNG ships to be transported to international markets. These specially designed ships maintain the LNG in a cold liquid state for sea voyages of several thousand kilometres.

The location for the onshore LNG Facility and offshore Area 1 and Area 4 are shown in *Figure 1.1.* The Project will comprise the following key components listed below:

- offshore gas wells and subsea gathering systems;
- offshore gas subsea transmission pipeline system linking the offshore gas fields to the onshore LNG Facility;
- Multi-Purpose Dock (MPD);
- LNG Export facilities;
- onshore LNG facilities including gas reception, treatment, dehydration, condensate stabilisation and LNG process facilities;
- gas turbines for power generation and associated power distribution within the Project facilities;
- temporary and permanent worker accommodations and associated facilities;
- a 1.7km pioneer airstrip and a 3.5km permanent airstrip and associated facilities; and

- associated infrastructure including roads, water treatment, wastewater treatment and waste management infrastructure, storage facilities, office buildings, etc.

For purposes of this EIA, it is assumed that the Project will have an initial 30 year period. A full description of the Project is provided in *Chapter 4*.

40°10'0"E 40°20'0"E 40°30'0"E 40°40'0"E 40°50'0"E 41°0'0"E 41°10'0"E

10°30'0"S 10°40'0"S 10°50'0"S 11°0'0"S 11°10'0"S

TANZANIA

Golfinho

Prosperidade

Mamba Complex

Quionga

Assame

Calomba

Quiwia

Cabo Delgado Peninsula

Palma Bay

Palma

Tecomaji Island

Manguna

Nkalanga

Quitupo

Macala

Senga

Afungi Peninsula

Nkumbi

Matapata

Alenda

Maganja

Rongui Island

Queramimbi Island

Bawala

Olumbe

Vamizi Island

Metundo Island

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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Legend

- Villages / Settlements
- Regional Roads
- Proposed Pipeline Corridor Route
- Jetty
- Onshore Layout
- Afungi Project Site
- Prosperidade Gas Field
- Golfinho Gas Field *
- Mamba Complex Gas Field

** Indicative area not yet approved by INP*

MAIN MAP SCALE:

0 5 10 15 20

Kilometers

TITLE:

Figure 1.1:
Project Location and Onshore, Near Shore and Offshore Indicative

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 400 000

DRAWING: Fig1.1 Indicative Project Layout.mxd

REV:

ERM
Great Westerford Building
240 Main Road
Rondebosch, 7725
Cape Town, SOUTH AFRICA
Tel: +27 21 681 5400
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Impacto Projectos e Estudos Ambientais

ERM

Projection: UTM Zone 37 S. Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation. AMA1, 2012. Inset Map: Esri Data & Maps

SIZE: A3

T:\GIS Projects\0133576_Anadarko_Moz_LNG\Mapping\MXD\ESIA\Chapter1\Fig1.1 Indicative Project Layout.mxd

1.3.2 Hydrocarbon Exploration in Mozambique

Exploration for hydrocarbons (oil and gas) in Mozambique started in 1904 when the early explorers discovered thick sedimentary basins onshore in Mozambique. Poor technology and lack of funds halted those early exploration attempts (Instituto Nacional de Petróleo, 2012). From 1948 onwards, international oil and gas companies moved into Mozambique and carried out extensive onshore exploration but limited offshore exploration. In 1961, the Pande Gas Field, discovered by Gulf Oil, was the first field to be discovered in the country. This was followed by the Búzi and Temane gas fields in 1962 and 1967 respectively. Exploration activity on the Pande/Temane Block by another operator later led to the discovery of the Inhassoro Gas Field, all located in Inhambane Province, in southern Mozambique.

Between 1990 and 2003, exploration activities including 2-D seismic acquisition and the drilling of eight wildcat wells (1), (six onshore and two offshore) were undertaken in the Pande and Temane fields.

Onshore gas resources in Inhambane Province have been exploited since 2004. The natural gas is exported to South Africa and is also used to supply the local Mozambique market (Matola Industrial Park in Maputo Province). In Sofala and Inhambane provinces, exploration activities (seismic and/or drilling) were undertaken in the M-10 and Sofala Blocks in 1998 and 2007 by Arco and Bang respectively. Both Blocks have since been acquired and seismic and drilling exploration activities continue within Blocks 16 and 19, M-10 and Sofala, within Sofala and Inhambane provinces. Seismic acquisition followed by exploration drilling is proposed in Onshore Area A, in Inhambane Province.

Hydrocarbon exploration in Cabo Delgado Province in northern Mozambique, and specifically in the Mocímboa da Praia and Palma districts, started in the 1980s by French and American companies, and the results were subsequently analysed by Artumas. In 2008, Artumas conducted seismic acquisition and exploratory drilling to certify whether or not hydrocarbons exist in commercially viable quantities in the Rovuma Basin Onshore Block. Natural gas was found in a well drilled in Mocímboa da Praia (MOC-1). This Block was acquired by AMA1, which has undertaken similar exploration activities over the past several years.

In the offshore Rovuma Basin, exploration activities have recently been carried out by a number of operators in offshore blocks, namely AMA1 (Area 1), eni (Area 4), Statoil (Areas 2 and 5) and Petronas Carigali Mozambique Rovuma Basin Limited (PCMRB) (Areas 3 and 6). Significant commercial quantities of gas have been discovered in Areas 1 and 4.

(1) A wildcat well is a well that is drilled where the existence of gas has not been confirmed.

1.3.3 *Benefits of the Proposed LNG Project*

In 2011, Mozambique published the third edition of its medium-term national development strategy known as the Poverty Reduction Action Plan (PARP), 2011 to 2014. The strategy places emphasis on the need for economic growth as a means of reducing poverty. To achieve the objective of inclusive economic growth, the government has defined general objectives (1), to which government efforts will be directed. These are:

(i) to increase output and productivity in the agriculture and fisheries sectors;

(ii) to promote employment; and

(iii) to foster human and social development, while maintaining a joint focus on governance and macroeconomic affairs and fiscal management.

The strategy, policies and practices of the Ministry for Mineral Resources are in alignment with the goals of poverty reduction, with the following goals:

- to ensure the sustainable exploration and development of mineral resources;
- the industrial development of the country and the local utilisation of its mineral resources;
- to add value to mineral resources through in-country processing;
- to promote partnerships, including the participation of Mozambican private enterprises in the sector;
- the periodic update of the legal and fiscal framework to maintain investment attractiveness in Mozambique; and
- the training and institutional strengthening.

The natural gas discoveries made to date are among the world's most significant discoveries in the last 20 years. The purpose of this Project is to advance the sustainable exploration, development and production of these resources in Mozambique through the extraction, processing and export of the significant natural gas resources discovered in the offshore Rovuma Basin. The Project represents an economic opportunity that could be transformational for the economy of Mozambique by allowing the country to become one of the world's leading LNG exporting countries, potentially generating:

(1) Mozambique Poverty Reduction Strategy Paper, June 2011: http://www.imf.org/external/pubs/ft/scr/2011/cr11132.pdf

- substantial tax and profit-sharing revenues for Mozambique, contributing substantially to the country's gross national product (GNP);
- significant foreign exchange income from external markets and gas supplies for industrial and domestic development in Mozambique;
- infrastructure and quality-of-life improvements for Mozambique's people;
- the possibility for long-term technology and knowledge transfer, bringing economic development and improving the quality of life for its inhabitants;
- direct and indirect employment opportunities for Mozambicans; and
- significant, long-term foreign direct investment.

1.4 *THE REQUIREMENT FOR AN EIA*

In Mozambique, conducting an EIA process is a legal requirement under the Environmental Law (Law No. 20/1997 of 1 October) for any activity that may have direct or indirect impacts on the environment. These activities are regulated by the Environmental Impact Assessment Regulations (Decree No. 45/2004 of 29 September and Decree No. 42/2008 of 4 November, which amends some articles of Decree No. 45/2004).

Article 2 of Decree No. 45/2004 states that EIAs required for oil, gas and mineral resource-related activities or developments are regulated by specific regulations. The Environmental Regulations for Petroleum Operations is set out in Decree No. 56/2010 of 22 November. The Project will undertake all activities in accordance with the applicable Mozambican legislation. Therefore, the EIA process for this Project has complied with the Environmental Regulations for Petroleum Operations (Decree No. 56/2010 of 22 November) as well as the Petroleum Law (Law No. 3/2001 of 21 February), the Regulations on Petroleum Operations (Decree No. 24/2004 of 20 August) and the Licensing Regulations for Petroleum Installations and Activities (Ministerial Decree No. 272/2009 of December 30).

1.5 *ENVIRONMENTAL PRACTITIONER*

1.5.1 *Overview*

ERM, in association with Impacto, was commissioned in April 2011 to undertake the EIA for this Project.

1.5.2 *Environmental Resources Management Southern Africa (Pty) Ltd*

ERM is a global environmental consulting organisation employing over 4,000 specialists in more than 41 countries. Founded in 1971, ERM has built an organisation based on the supply of a full range of environmental and social policy, scientific, technical and regulatory expertise. ERM has been involved in numerous projects in southern Africa over the past 30 years and, in 2003, established a permanent presence in South Africa to meet the growing needs of clients. ERM has offices in South Africa (Cape Town, Johannesburg, Pretoria and Durban) and in 2013, opened an office in Maputo. In Southern Africa, ERM has a staff of over 180 dedicated environmental and social professionals, who have undertaken numerous EIAs in Mozambique in association with Impacto. ERM has extensive LNG experience globally. ERM has been involved in various phases of 12 other LNG developments across Africa including projects in Algeria, Angola, Libya, Nigeria, Equatorial Guinea and South Africa.

1.5.3 *Projectos e Estudos de Impacto Ambiental, Lda.*

Impacto is a fully registered Mozambican company based in Maputo. Impacto was officially registered on 14 August 1996 and currently has a staff of 25 consultants with considerable knowledge of the environmental and social issues throughout the country. Impacto is registered with the Ministry for the Coordination of Environmental Affairs (MICOA) to conduct EIAs in Mozambique, and has extensive experience in undertaking such studies. Over the past five years, Impacto has carried out EIAs for AMA1's onshore and offshore exploration activities in Cabo Delgado Province. Impacto has also undertaken several EIAs for eni (including EIAs seismic and exploration drilling in Area 4) as well as various other international oil and gas companies operating in the country including Statoil, Petronas, Sasol and DNO.

1.5.4 *Project Management Team*

The key project management team responsible for the management of the EIA process is outlined in *Table 1.1.* The team of specialists involved in the Project is outlined in *Chapter 3*.

Table 1.1 Project Management Team

Role	Name	Organisation
Partner in Charge	Andrew Bradbury	ERM
Partner in Charge	Antonio Emilio Leite Couto	Impacto
Project Manager	Kamal Govender	ERM
Assistant Project Manager	Uke Overvest	Impacto
Assistant Project Manager	Isobel Evans	ERM
Assistant Project Manager	Chris Zeisloft	ERM

1.6 STRUCTURE OF THIS REPORT

1.6.1 Structure of the Report

This EIA Report comprises 19 chapters, which have been organised into three volumes. In addition, the Report includes a set of annexes, which support the material covered in the chapters of the EIA Report.

The structure of the EIA Report is as presented in *Box 1.1* below.

Box 1.1 EIA Report Structure

Volume I	**Introduction, Project Description and Baseline**
Non-Technical Summary (NTS)	
Chapter 1	Introduction
Chapter 2	Regulatory Framework
Chapter 3	The EIA Process, Approach and Methodology
Chapter 4	Project Description
Chapter 5	Consideration of Alternatives
Chapter 6	Introduction and Geographical Context
Chapter 7	Environmental Baseline - Offshore and Near Shore
Chapter 8	Environmental Baseline - Onshore
Chapter 9	Socio-economic and Community Health Baseline
Volume II	**Impact Assessment, Management, Implementation and Conclusions**
Chapter 10	Introduction to Impact Assessment and Mitigation
Chapter 11	Offshore and Near Shore Environmental Impact Assessment and Mitigation
Chapter 12	Onshore Environmental Impact Assessment and Mitigation
Chapter 13	Socio-economic Impact Assessment and Mitigation
Chapter 14	Unplanned Events
Chapter 15	Cumulative Impacts
Chapter 16	Impact Assessment Summary
Chapter 17	Environmental and Social Management System and Environmental and Social Management Plan
Chapter 18	Conclusion
Chapter 19	References
Volume III	**Annexes**
Annex A	Public Participation Report
Annex B	MICOA Approval of EPDA and ToR
Annex C	Baseline Methodologies
Annex D	Tabulated ESMP
Annex E	Waste Management Plan
Annex F	Decommissioning and Rehabilitation Plan
Annex G	Baseline Support Material
Annex H	Emergency Response Plan
Annex I	Initial Resettlement Plan

Chapter 2

Regulatory Framework

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2 REGULATORY FRAMEWORK

2.1 INTRODUCTION

This EIA is being undertaken in terms of the Environmental Law (Law no. 20/97 of 1 October). This Law applies for any activity which could have direct or indirect impacts on the environment. The Environmental Law notwithstanding, the purpose of this Chapter is to provide an overview of the relevant legislative requirements and standards applicable to the Project.

Regulatory instruments of Mozambique and industry Environment, Health and Safety (EHS) performance standards relevant to the Project are described below. The Project will be in compliance with the following:

- applicable Mozambique laws and regulations.
- international treaties to which Mozambique is a signatory. These include various international treaties, conventions and protocols relating to issues such as biodiversity, climate change and marine pollution.

Moreover, the Project will be aligned with the International Finance Corporation (IFC) Social and Environmental Performance Standards and EHS Guidelines, to the extent reasonable.

Finally, Anadarko Petroleum Corporation (APC) and eni have developed company policies and specifications related to EHS performance, as well as EHS performance standards, which will be implemented by the Project and these are also considered in this chapter (*Section 2.7* and *2.8*).

2.2 MOZAMBICAN LEGAL/REGULATORY FRAMEWORK

2.2.1 Overview

The Mozambican regulatory framework establishes well-defined requirements and standards for the implementation and ongoing environmental and social management of industrial and civil infrastructure developments. Environmental protection functions are carried out by different authorities at both a national and regional level.

This section outlines the current legislative framework in Mozambique as it relates to the Project and highlights specific areas of Mozambican legislation that apply to the Project or have the potential to influence the Project during planning, development and operation. The descriptions provided should not be viewed as a comprehensive review of environmental legislation in Mozambique, but as a summary of the regulatory 'drivers' for the Project. Specifically the following are outlined in this section:

- a summary of key regulatory authorities and other relevant bodies; and
- a brief overview of the current EIA and petroleum regulatory regime in Mozambique.

2.2.2 *Relevant Authorities in Mozambique*

The key institutions and their main roles and responsibilities in relation to environmental protection and the petroleum industry in Mozambique are summarised in *Table 2.1*.

Table 2.1 Mozambican Institutional Authorities and their Responsibilities

Institution	Roles and Responsibilities
Ministry for the Coordination of Environmental Affairs (Ministério para a Coordenação da AcçãoAmbiental - MICOA)	MICOA is responsible for directing the implementation of environmental policy, coordinating, advising, auditing and encouraging the correct planning and use of the country's natural resources. In attaining these objectives, this Ministry, among other entities, is responsible for promoting development, in a sustainable manner, in the process of using renewable and non-renewable natural resources, and proposing policies and strategies for environmental development. MICOA is the pertinent competent authority for this EIA and is represented at provincial level by the Provincial Directorate for the Coordination of Environmental Affairs (DPCAA). The entity responsible for the management of Environmental Impact Assessment with MICOA is the National Environmental Impact Assessment Directorate (DNAIA). DNAIA is responsible for proposing the appropriate legislation to direct implementation and environmental management, for environmental licensing, for managing and coordinating the Environmental Impact Assessment (EIA) process, reviewing Environmental Impact Statements (EIS's), promoting the monitoring of environmental impacts and the performance of audits and carrying out the strategic environmental evaluation of policies, plans and programs. DINAPOT is the National Directorate of Planning and Spatial Development within MICOA. DINAPOT is responsible for, among others; proposing policies, appropriate legislation, standards, regulations and guidelines for spatial development; for identifying the best locations for mega project developments; assessing focal bodies in the preparation, implementation, control and management of land use and benefit; providing technical statements over spatial development management tools at national, provincial, district and municipal levels as well as over DUAT licenses in rural areas, settlements, villages and towns where special development management tools are absent. DINAPOT is also responsible for participating in the resettlement of communities as a result of development projects and natural disasters.
Ministry of Mineral Resources (Ministério dos Recursos Minerais - MIREM)	MIREM is responsible for directing and implementing policies in the context of geological research, the inventory of and exploration for mineral resources including coal and hydrocarbons. In achieving these objectives, this Ministry, among other entities, is responsible for inventorying underground resources in national territory and in the exclusive economic zone (EEZ), promoting and controlling prospecting and geological exploration activities and the rational use of mineral resources. MIREM is also responsible for promoting and controlling exploration, production, separation and processing activities for crude oil and natural gas and controlling transport of these for their delivery to export points or points for commercial sale within the country. Licenses required to extract inert material such as sand/gravel are granted by MIREM at a provincial level (Provincial Directorate of Mineral Resources and Energy).
National Petroleum Institute (Instituto Nacional do Petróleo - INP)	The INP is the regulatory entity responsible for administration and promotion of oil and gas operations. The INP is responsible, among other duties, for the following:

Institution	Roles and Responsibilities
	• Regulation and auditing of oil and gas exploration, production and transport activity as well as ensuring policies for development and standards related to oil operations; • Preservation of the public interest and the environment by establishing the required technical, commercial and environmental conditions, promoting the adoption of practices that encourage the efficient use of resources and the existence of quality standards that correspond to the service and protection of the environment; and • Organization, maintenance and consolidation of the accuracy of technical data and information related to the activities of the oil industry, national oil reserves and the information produced. INP has a delegation in Pemba, responsible for the regulation and auditing of oil and gas exploration, production and transport activities in northern Mozambique (including Cabo Delgado and Nampula Provinces).
Ministry of Agriculture (Ministério da Agricultura - MINAG)	MINAG is responsible for managing, planning and ensuring the implementation of policies in the fields of land management, agriculture, livestock, forestry, wildlife and agricultural water use. In implementing these objectives, this Ministry is responsible for, among other items, the administration, management, protection and conservation of resources essential to agricultural activity. In particular MINAG oversees land management, water, forestry, domestic animals and wildlife; the promotion of production, agro-industrialization and commercial sale of supplies and agricultural products and agricultural research, rural extension and technical assistance for producers. The National Directorate of Land and Forestry (DNFT) is the entity within MINAG that has authority, among others, for ensuring the implementation of national land policy, coordinating, promoting, developing, supervising and monitoring activities related to land registration including surveying lands on a large scale and storing satellite imagery. MINAG is represented at the provincial level by the Provincial Directorate of Agriculture. At a district level, issues related to agriculture fall under the realm of the District Services of Economic Activities. These are the competent authorities responsible for granting the Land Use and Benefit Rights (DUAT) for the proposed LNG site.
Ministry of Fishing (Ministério das Pescas - MPescas)	The MPescas is responsible for defining the principles, objectives, policies and plans for activities in relation to the management of fish and aquatic resources, of related activities and services and of fishing infrastructure, ensuring their implementation. The objectives of this Ministry are to: • Guarantee the responsible management, protection and conservation of fish resources, by promoting participatory management, among other initiatives; • Guarantee the protection and conservation of maritime resources and the sustainable exploration of fish resources; • Promote the development of fishing activity and related activities in qualitative as well as quantitative aspects; • Promote and develop fish production in territorial waters for the purpose of internal supply and exports; and • Promote the training of the sector in order to contribute to improving the quality of life of fishing communities. The MPescas is responsible for monitoring, controlling and inspection of fishing activities. Within the MPescas, the National Fishing Administration (ADNAP) is the entity directly responsible for the above activities, particularly focusing on inspection.

Institution	Roles and Responsibilities
	The National Small-scale Fishing Development Institute (IDPPE) is responsible for performing studies for the creation of development policies, strategies, plans and programs for small-scale fishing and for the study and promotion of projects for the development of small-scale fishing, relative to the socioeconomic aspects, fishing technology and technologies related to activities that complement fishing". The IDPPE is also responsible for promoting and coordinating development projects for small-scale fishing, seminars, field trips and courses intended to train and up skill professional and small-scale fishermen. The Fisheries Research Institute (IIP) supervises data collection and conducts most of research and studies on artisanal fisheries in Mozambique. This institute will be involved in the identification of fish species within the study area, where identification in-situ is not possible during field investigations. The Ministry of Fisheries is represented at the Provincial level by the Provincial Directorate of Fisheries. At District level, issues related to fisheries fall under the District Services of Economic Activities. These institutions shall be contacted in relation to all matters regarding fisheries and shall be involved in the monitoring of the project Environmental Management Plans (EMP), with regards to compliance of mitigation measures for the potential impacts on fisheries (especially artisanal).
Ministry of Tourism (Ministério do Turismo - MITUR)	The MITUR is responsible for the direction, planning and implementation of policies related to tourist activities, the hotel and similar industries and conservation areas for purposes of tourism. Its authority includes the following responsibilities: • Promotion of the sustainable development of tourism for the purpose of contributing to the social and economic development of the country; • Promotion of the preservation of wildlife and exploration of the same as one of the components necessary for the development of tourism; • Contribution to increasing Government revenue through the promotion and development of domestic and foreign tourism; • Promotion of increases in employment opportunities for the purpose of guaranteeing an improvement in standards of living for local populations; • Promotion of the development of tourism in order to contribute to strengthening the national unity to improve the knowledge of the country by its citizens and cultural exchanges with other nations; • Contribution to the establishment of a policy to license the expansion of gaming in hotels and similar establishments in order to improve the national tourism network and consequently to improve Government revenue; and • Promotion of professional training of workers to improve the quality of services provided by the sector. MITUR is represented at a provincial level by the Provincial Directorate of Tourism. At a district level, issues related to tourism fall under the responsibilities of the District Services of Economic Activities. MITUR will, together with MIREM and INP, mediate any potential conflicts of land use between tourism operators and the oil companies.
Ministry of Industry and	MIC is responsible for oversight of the trade and industry sectors.

Institution	Roles and Responsibilities
Commerce (Ministério da Indústria e Comércio - MIC)	MIC's responsibilities include: • Oversight of implementation of the State's manufacturing sector policy; • Encouragement, assistance and due location of entrepreneurial activities in the scope of the processing industry of national raw materials, in particular concerning production intended to replace imports or add greater value to exportable products; • Promotion of initiatives towards recovering and upgrading the existing national industrial park as well as profitability of new investments; • Oversight of State's policy in respect of agricultural trade, supply and provisions of services; • Promotion of actions required for an efficient distribution of consumable goods and production factors; • Oversight and boosting of the external trade in coordination with further State organisms; and • Promotion of an entrepreneurial basis for exports in the country and encouragement of initiatives destined for increasing and diversifying exports. MIC is represented at a provincial level by the Provincial Directorate of Trade and Industry. At a district level, issues related to the trade and industry sectors are the responsibility of the District Services of Economic Activities.
National Naval Institute (Instituto Nacional da Marinha - INAMAR)	INAMAR is responsible for activity in the areas of maritime safety, protection of port facilities and vessels, maritime transport, negotiation and stowage, maritime personnel, preservation of the marine environment and maritime administration. In attaining these objectives, this Institute is responsible, among others, for exercising maritime authority in maritime, lake and river jurisdictional areas, and in the public maritime domain, promoting the establishment and maintenance of maritime safety conditions for performing marine activities and promoting and encouraging specific and economic efficiency in the interest of the service providers and users. In the area of preservation of the marine environment, INAMAR is responsible for proposing legislation and regulations to prevent, reduce, control and combat pollution coming from vessels or from other floating or stationary resources at sea, directing and coordinating activities to prevent and fight marine pollution and participating in international forums to establish rules and standards in this respect. INAMAR is also responsible for authorizing and monitoring dredging activities at both ports and inland waters.
National Institute of Hydrography and Navigation (Instituto Nacional de Hidrografia e Navegação - INAHINA)	INAHINA is responsible for conducting technical and scientific activities in the context of oceanography, hydrography and maritime navigation in waters under national jurisdiction for the purpose of ensuring navigation and contributing to the development of the country in scientific areas and defense of the environment. INAHINA also provides technical recommendations to projects involving new dredging techniques, hydraulic maritime works and other works that could affect the hydrographic patterns of ports and coastlines.

Institution	Roles and Responsibilities
Mozambican Dredging Company (Empresa Moçambicana de Dragagem - EMODRAGA)	EMODRAGA is a public entity of the Mozambican Government responsible for conducting dredging throughout the country. Their main objective is to maintain the channels and access routes open to national ports. EMODRAGA also conducts construction dredging for enlarging or deepening access channels to ports and participates in hydraulic works in ports and waterways.
Ministry of Health (Ministério da Saúde - MISAU)	The primary objectives of the Ministry of Health are to: • Promote and encourage the resolution of health problems; • Project and develop programs for promoting and protecting health and prevention and combating disease; • Provide health care to the population through the public health sector; • Promote and support the private, non-profit sector; • Promote, supervise and support a community system for the provision of health care; and • Provide a policy for pharmaceutical formulation and guidance for its implementation. Community health is a priority of the Ministry of Health which has a National Office of Public Health as well as a Department of Community Health in order to develop various programs at the community level including providing better access to health services, community participation, provision of human and financial resources and education / training in preventive and curative care. The primary focus of these programs is around malaria and HIV / AIDS, infant health and malnutrition. MISAU is represented at national level by the National Directorate of Health, at provincial level by the Provincial Directorate of Health and at District Level by the District Directorate of Health.
National Aviation Institute (Instituto de Aviação Civil de Moçambique - IACM)	The IACM is an autonomous entity responsible for safety, security and regulation of civil aviation. The Institute exercises the role of the civil aviation technical and economic regulator setting and applying policies overseeing the sector by enforcing the country regulations and the recommendations of the International Civil Aviation Organization (ICAO). It is responsible for the certification of airport infrastructures, issues aeronautical and para-aeronautical permits and administers helicopter use.
Mozambique Ports and Railways Company, E.P. (Caminhos de Ferro de Moçambique - CFM)	CFM is responsible for governing the ports and railways in Mozambique. Pemba Port falls under CFM North division, comprising the Ports of Pemba and Nacala and the associated railway lines, serving Malawi.
National Roads Administration (Administração Nacional de Estradas - ANE)	The ANE is an autonomous public entity responsible for the management of the classified road network of Mozambique. ANE is responsible for the design, construction and maintenance of all classified roads as well as the selection of the contractors and respective contract management. As for non-classified roads, ANE is responsible for proposing the rules to be observed by the local municipalities in the development and maintenance of urban roads as well as proposing rules to be observed by the state local bodies during road rehabilitation and maintenance roads. The District Administration is, at district level, the entity responsible for non-classified roads.
Regional Water	The ARA's are the entities responsible for water resource management throughout the country and include ARA Sul, ARA-

Institution	Roles and Responsibilities
Administrations (Administração Regional de Águas - ARA)	Centro ARA-Zambeze, ARA-Centro Norte (from the Zambeze River Basin to the Lurio River Basin, inclusive) and ARA -Norte (from the Lurio River Basin to the northern limit of Mozambique). ARA-Norte is responsible for the management of water resources in the project area. Its responsibilities include, among others, analysis of requests for use and benefit of water, discharge of effluent, groundwater and issuing of permits.

2.2.3 Environmental and Petroleum Regulations

This section summarises the provisions of Mozambique's national legislation that is relevant to the petroleum industry and potential impacts of a Project on the environment. A number of laws and decrees governing environmental and social protection of natural resources that are linked directly or indirectly to the petroleum industry are set out below.

In Mozambique, an EIA process is a legal requirement under the Environmental Law (Law no. 20/97 of 1 October) for any activity which may have direct or indirect impacts on the environment. These are regulated by the Environmental Impact Assessment Regulations (Decree no. 45/2004 of 29 September and Decree no. 42/2008 of 4 November, which amends some articles of Decree no. 45/2004).

Article 2 of Decree no. 45/2004 states that EIAs required for oil, gas and mineral resource related activities or developments are regulated by specific regulations.

In Mozambique, there are regulatory requirements specific for petroleum (oil and gas) operations which outline the need for an EIA for petroleum activities. In respect of petroleum operations, the EIA process is set out by Decree no. 56/2010 of 22 November, which approved the Environmental Regulations for Petroleum Operations. The Project is committed to undertake all activities in accordance with the applicable Mozambican legislation. Therefore the EIA process for this Project complies with the Environmental Regulations for Petroleum Operations (Decree no. 56/2010 of 22 November), as well as the Petroleum Law (Law no. 3/2001 of 21 February) and the Regulations on Petroleum Operations (Decree no. 24/2004 of 20 August). This EIA is also in compliance with the Licensing Regulations for Petroleum Installations and Activities (Ministerial Decree no. 272/2009 of December 30), applicable to concessionaires, operators, their contractors and subcontractors and other individuals or entities involved in petroleum operations and activities in Mozambique. These are discussed further below.

Environmental Law (Law no. 20/97 of 1 October)

The Environmental Law aims to define the legal basis for the sound use and management of the environment and its components for the purpose of forming a system of sustainable development in Mozambique. The Environmental Law is applicable to all public or private activities, which may influence the environment either directly or indirectly.

The law requires that activities, that by their nature, location or dimensions, are likely to cause significant environmental impacts be licensed by MICOA, based on the outcomes of an EIA process. Some of the core principles for environmental management contained in the Environmental Law and applicable to this Project are:

- the rational management and use of environmental components that envisage the improvement of the quality of life of the citizens and the protection of biodiversity and ecosystems;
- the recognition and valuation of traditions and the knowledge of local communities;
- the priority for establishment of systems to prevent actions that are harmful to the environment;
- a holistic and integrated perspective of the environment;
- the importance of public participation;
- the polluter pays principle; and
- the importance of international co-operation.

Article 8 of the Environmental Law requires that the Government creates adequate mechanisms so as to involve the various sectors of civil society, local communities and environmental protection organizations in the preparation of policies and legislation for the management of the country's natural resources.

Article 9, related to environmental pollution prohibits the production and deposit of any toxic and polluting substances on soils, sub-soils, water or atmosphere as well as the conduct of activities that will tend to accelerate erosion and desertification, deforestation or any other form of environmental degradation beyond the limits established by law.

Petroleum Law (Law no. 3/2001 of 21 February)

The Petroleum Law (Law no. 3/2001 of 21 February) establishes the regime for the granting of rights for the conduct of petroleum operations in Mozambique.

The Preamble to the Law states that *"petroleum resources are assets whose proper use can contribute significantly to national development."*

Paragraphs 4 and 5 of Article 20 respectively discuss issues around compensation:

"4 The holder of a right to conduct petroleum operations who, by virtue of the exercise of petroleum operation rights in the contract area, causes damage to crops, soils, building and improvements or requires the relocation of the legal users or occupants of the land within the respective contract area, has the obligation to compensate the holders of title to the assets and the persons relocated.

5 Subject to the payment of the compensation due, the holder of the right to conduct petroleum operations may require the right of way in accordance with

the legislation in force in order to have access to the locations where petroleum operations are conducted.

Article 23 provides stipulations for environmental protection and safety applicable to petroleum operations in Mozambique. This article states that in addition to carrying out operations in accordance with good oilfield practice, all holders of exploration and production rights shall conduct petroleum operations in accordance with environmental and other applicable legislation in order to:

- ensure that there is no ecological damage or destruction caused by petroleum operations, but where unavoidable, ensure that measures for protection of the environment are in accordance with internationally acceptable standards. For this purpose, the holder of a right shall prepare and submit to the relevant authorities for approval environmental impact studies (including mitigation measures for the environmental impacts);
- control the flow and prevent the escape or loss of petroleum discovered or produced within the contract area;
- avoid damage to petroleum reservoirs;
- avoid destruction to land, the water table, trees, crops, buildings or other infrastructure and goods;
- clean up the sites after the closure of petroleum operations and comply with the environmental restoration requirements;
- ensure the safety of personnel in the planning and conduct of petroleum operations and take preventive measures if physical safety would be at risk; and
- report to the appropriate entity the amount of operational and accidental discharge, leakage and waste resulting from petroleum operations.

In addition, Article 23 states that "*[a] holder of a right under this Law shall act in a secure and effective manner when conducting petroleum operations in order to guarantee the disposal of polluted water and waste oil in accordance with approved methods, as well as the safe plugging of all boreholes and wells before these are abandoned*".

Regulations on Petroleum Operations (Decree no. 24/2004 of 20 August)

Among others, Article 90 of the Regulations on Petroleum Operations states that environmental impact assessments, including environmental mitigation measures, shall be carried out for all areas affected by the petroleum operations and establishes the following obligations to the operator:

- prevent (i) accidents and material damage in connection with its activities and the operation of the installations; (ii) damage or the threat of damage to third parties' personnel and assets; (iii) damage to animals, vegetation, marine life and monuments; (iv) pollution of the sea and any fresh water sources discovered in the course of petroleum operations; (v) air pollution; and (vi) damage to petroleum reservoirs;

- monitor and reduce the effect of all operational and accidental discharge, handling of waste and emissions into the air, sea, lakes, rivers and soil;

- take corrective measures and repair damage to the environment when petroleum operations endanger the physical safety of people or property or cause pollution or other environmental damage harmful to people, animals, marine life, monuments or vegetation;

- when selecting materials and chemicals, choose those that are less hazardous to health and the safest in use so that the risk to people, to the environment and to the installations is minimized; and

- give attention to the health of employees, as well as qualification requirements applicable to health personnel.

Local content is briefly discussed in Article 38, paragraph 3 outlining the responsibilities of the operators: *"The Operator shall give preference to the purchase of local goods and services provided that such goods and services are of internationally comparable quality, are available at the time, in the quantity required, and their prices, including taxes, are not more than ten percent higher than those of available imported goods"*.

Environmental Regulations for Petroleum Operations (Decree no. 56/2010 of 22 November)

Under the Environmental Regulations for Petroleum Operations,, petroleum operations are defined as *"all or some of the operations related to exploration, development, production, separation and treatment, storage, transport and sale or delivery of petroleum at the agreed supply point in the country, including the operations of natural gas processing and the closure of all operations concluded"*. These Regulations clearly set out the procedures for the EIA for petroleum operations and the measures to be followed with regard to prevention, control, mitigation and rehabilitation of the environment.

The Environmental Regulations for Petroleum Operations were established to promote the correct and efficient environmental management of petroleum resources with a view towards the sustainable development of Mozambique.

Article 5 of Decree no. 56/2010 defines three project categories (A, B and C) on basis of which the type of EIA is required, as follows:

- Activities that fall into **Category A** require an Environmental Impact Study (EIS).

- **Category B** comprises activities for which a Simplified Environmental Study (SES) is required with the exception of some cases as specified in Article 17 of the Regulations.

- Activities included in **Category C** are exempted from an EIS and SES being subject to rules of sound environmental management generally accepted and considered best practice in the petroleum industry.

Public Consultation is an integral part of the EIA process for projects classified as Category A as laid out in Article 19 of the Environmental Regulations for Petroleum Operations. The regulations require that at least 15 days' notice shall be given for public meetings and entitles all direct or indirectly interested or affected parties to take part in the EIA process. All reports produced within the scope of the EIS must be made available to MICOA and published on the internet. The proponent shall prepare a final report containing all the comments received during the Public Participation Process. For further information regarding the Public Participation Process undertaken for this Project, see *Annex A*.

Timeframes for Decision-making

In accordance with Decree no. 56/2010, MICOA must comply with the following time limits for decision-making:

- Pre-assessment – up to 7 business days;

- Environmental Pre-Feasibility Study and Scope Definition (EPDA) and Terms of Reference (ToR) – up to 20 business days; and

- EIS – up to 45 business days.

Fees Applicable

According to Decree no. 56/2010, a fee of 0.01% of the total amount of the investment is due for environmental licensing for a Category A project and is made available to the State Budget (60%), the Environment Fund (20%) and the National Institute of Petroleum (20%).

Licensing Regulations for Petroleum Installations and Activities (Ministerial Decree no. 272/2009 of December 30)

These regulations are applicable to concessionaires, operators, their contractors and subcontractors and other individuals or entities involved in Petroleum Sector Operations and Petroleum Sector Activities in the National Territory.

The Regulations establish procedures for applying for Construction, Operations, Alterations and Decommissioning Licenses as well as specific petroleum sector activities Licenses and technical supervisor.

Article 4 describes compulsory licensing requirements and states that the licenses under the scope of this regulation shall only be granted to natural or legal persons involved in the petroleum operations and petroleum activities. Such a license is issued by the National Petroleum Institute (INP), as per Article 6. Application for the licenses requires the applicant to provide, among others, an Environmental license or approved environmental impact assessment, where relevant.

2.2.4 Other Mozambican Legal Considerations

This section outlines other legal considerations related to the environmental legal framework, water use, waste, effluent management, air emissions, terrestrial and marine environment, transport, social receptors, protected areas and species and infrastructure relevant to the Project. The Project will take these requirements into consideration in the design, construction and operation of the Project activities.

Table 2.2 ***Other Relevant Mozambican Legal Considerations***

Regulations/Laws	Detail
Environmental Legal Framework (beyond the provisions outlined in *Section* 2.2)	
Constitution of the Republic of Mozambique, November 16, 2004	Article 98.1 specifies that any natural resources located in the soil and subsoil, in domestic waterway, in territorial ocean waters, on the continental shelf and in the exclusive commercial zone are the sole property of the State. Article 102 authorizes the State to promote knowledge and inventory and assessment of natural resources and determination of the conditions for their use and enjoyment with protection of the interests of the country.
National Environmental Policy (Resolution no. 5/1995, dated August 3)	This Policy establishes the bases for the sustainable development of Mozambique through an acceptable and realistic commitment to socio-economic development and environmental protection. It is intended to manage natural and environmental resources in general so as to maintain their functional and productive capacity for current and future generations.
Regulation regarding the Environmental Auditing Process (Decree no. 25/2011, dated June 15)	This Regulation defines environmental auditing as a management tool for the systematic, documented and objective evaluation of the operation and organization of the management system and the environmental protection and control processes.
Regulation for Environmental Inspection (Decree no. 11/2006, dated June 15)	This Regulation is intended to regulate supervisory, control and auditing activity related to compliance with environmental protection standards at the national level.
The Sea	
The Sea Act (Law no. 4/1996, dated January 4)	This Law defines the legal context of jurisdictional rights regarding strip of sea along the coast of Mozambique and contains provisions regarding the normative bases for regulating the administration and maritime activities of the country, and it establishes sovereignty rights of the State for purposes of exploration and enjoyment of its natural resources.
Regulation for the Prevention of Pollution and Marine and Coastal Environmental Protection (Decree no. 45/2006, dated November 30)	The purpose of this Regulation is to prevent and limit pollution resulting from illegal discharges by ships, platforms or from land-based sources along the Mozambique coast and to establish the legal bases for protection and conservation of areas that are in the public domain of seas, lakes, rivers, beaches and fragile ecosystems. A summary (for reference purposes) of the Rules of the International Convention for the Prevention of Pollution by Ships of 1973, as modified by the Protocol of 1979 (the "MARPOL 73/78") relative to discharges of hydrocarbons and harmful liquid substances is attached to the decree.
Regulation on Standards for Environmental Quality and Effluent Discharges (Decree no. 18/2004, dated June 2)	The purpose of the Regulation is to establish environmental quality and effluent emission standards for the purpose of controlling and maintaining the acceptable levels of pollutant concentrations in environmental components.
Decree no. 67/2010, dated December 31 (amendments to	This Decree amends the Standards for Receiving Entities (sea/ocean), now including Table 1 relative to potentially hazardous chemical substances and Table 1A, relative to potentially harmful chemical substances (pesticides).

Regulations/Laws	Detail
Appendix V to Decree no. 18/2004, dated June 2)	
Regulation on Maritime Commercial Transport (Decree no. 35/2007, dated August 14)	This Regulation deals with practical and operational aspects of legal nature for commercial shipping, including its licensing, in the waters under the jurisdiction of Mozambique.
Water Resources	
Regulation for the Prevention of Pollution and Marine and Coastal Environmental Protection (Decree no. 45/2006, dated November 30)	This Regulation prohibits the discard or discharge of any wastewater of a toxic or harmful nature as well as any other substances or waste that may in any way pollute water, meadow or banks in violation of the relevant legal provisions.
Regulation regarding Standards for Environmental Quality and the Discharge of Effluent (Decree no. 18/2004, dated June 2)	This Regulation defines the environmental quality and effluent emission standards for receiving bodies of water, treatment technologies, systems and methods. It governs the elimination of liquid industrial effluent into the receiving environment, which must be carried out through an appropriate entity. The final effluent must be discharged in accordance with certain emission or discharge standards. It requires the location of the point of discharge or emission be determined during the environmental licensing process so that there is no change to water quality in the receiving body. The discharge of liquid effluent or pollutants that affects or may affect swimming areas must be controlled based on sanitary quality monitoring of the respective waterways and beaches.
Regulation regarding the Quality of Water for Human Consumption (Ministerial Diploma no. 180/2004, dated September 15)	The purpose of this Regulation is to establish quality parameters for water intended for human consumption and the procedures for controlling the same in order to protect human health from the harmful effects resulting from any contamination that may occur at the various stages of the water supply system from source to the point where it is made available to the consumer.
National Water Policy (Resolution No. 46/2007, dated October 30) and Water Law (Law no. 16/1991, dated August 16)	Based on the principles of environmental sustainability, the Water Law establishes the water resources that correspond to the public domain, water management principles, the need to inventory all water resources that exist in the country, the general regime for their use, general rights of users and the corresponding obligations, among other items.
Regulation regarding water licensing and concessions (Decree no. 43/2007 dated October 30)	The Regulation on the water licensing and concessions regulates the process to obtain the rights of private use and benefit of water. This regulation gives special attention to environmental issues, requesting an EIA, Environmental License or its official exemption as a condition to obtain the rights for water use. The discharge of effluents, is also subject to a specific license or concession. The surface water body or aquifer where the effluent will be discharged must be identified, or where these will be discharged on land, the following parameters are identified: the discharge point, quantity, volume and frequency, as well as the nature and composition per volume unit and the known temperature, proposed treatment methods, equipment and facilities required. The methods proposed to measure the effluents and the expected impacts on the environment as well as the methods that will be used for analysis and control shall also be included.

Regulations/Laws	Detail
Atmospheric Emissions and Air Quality	
Decree no. 67/2010, dated December 31 (amendments to Appendix I and inclusion of Appendices 1A and 1B to Decree No. 18/2004, dated June 2)	This Decree, among other items, amends Air Quality Standards and adds Appendices 1A and 1B which cover Organic and Inorganic Carcinogenic Atmospheric Pollutants and Substances with Odorous Properties, respectively.
Regulation regarding the Management of Substance that Destroy the Ozone Layer (Resolution no. 78/2009, dated December 22)	This Regulation prohibits the import, export, production, sale and transit of substances that destroy the ozone layer including the following: • Chlorofluorocarbon (CFCs); • Halogenated substances (Halon-1211, Halon-1301 and Halon-2402); • Carbon tetrachloride (CCL_4); and • Other substances defined by the Montreal Protocol as Substances that destroy the ozone layer, ratified by Resolution no. 8/93, of 8 December)
The Environment Law (Law no. 20/97, dated October 1) and the Regulation regarding Environmental Quality and the Discharge of Effluent (Decree no. 18/2004, dated June 2)	This Law is intended to establish the environmental quality and effluent emission standards intended to control and maintain admissible levels of pollutant concentration in environmental components.
Solid Waste Management	
The Environment Law (Law no. 20/97, dated October 1)	This Law prohibits the import of trash or hazardous waste into Mozambique.
Regulation for Waste Management (Decree no. 13/2006, dated June 15)	This Regulation establishes the rules relative to the production, discharge into the soil and subsoil, into water or the atmosphere, of any toxic and polluting substances as well as the conduct of activities that accelerate the degradation of the environment so as to prevent or minimize their negative impacts on health and the environment.
Regulation for Biomedical Waste Management (Decree no. 8/2003, dated February 18)	This Regulation establishes the rules relative to biomedical waste management, aiming at safeguarding medical service employees' health and safety and the public in general as well as minimizing impact of such waste on the environment. This regulation is applicable to medical units, research institutions , companies or people that a) produce or handle biomedical waste; b) transport biomedical waste; c) remove biomedical waste; d) are employed in a medical unit that produces, handles or removes biomedical waste and e) are patients, employees or visitors in a medical unit that produces, handles transports or removes biomedical waste. It requires all medical units, research institutes and companies covered by this regulation to develop a biomedical waste management plan.
Protection of Biodiversity and Conservation Areas	
Land Law (Law no. 19/97, dated October 1) and Enabling	This Law establishes complete and partial protection zones. Complete protection zones include areas intended for nature conservation and protection activities and defence and safety of the State. Partial protection zones include, among

Regulations/Laws	Detail
Regulation of the Land Law (Decree no. 66/1998, dated December 8)	others; • Interior waters, the territorial sea and the maritime exclusive economic zone (EEZ); • The continental platform; • The strip along the maritime coast and around islands, bays and estuaries which is measured from the maximum high tide line to a mark 100m inland; • The strip of land up to 100m surrounding a source of water; • The strip of land up to 250m along the edge of dams and reservoirs; and • A 2km strip along the territorial border. For public infrastructure, the partial protection zones include, among others: • Secondary and tertiary roads and the 15m strip alongside them; • Primary roads and the 30m strip alongside them; • Aerial, surface, underground and underwater installations and pipelines for electricity, telecommunications, petroleum, gas and water and the 50m strip of land alongside of them; and • Airports and aerodromes and the 100m strip of land surrounding them.
Forests and Wildlife Law (Law no. 10/99, dated July 7)	This Law defines protection zones such as national parks, national reserves and zones for use and zones of historic and cultural value.
Fisheries Law (Law no. 3/90, dated September 26)	This Law defines the legal framework relative to the planning and management of fishing, the implementation of licensing systems, the adoption of resource conservation measures, the auditing of fish products quality intended for export and oversight of fishing activity auditing. Specific Fishing Policies and Strategies are included in Section G1.3 of Annex G (Volume III of the EIA Report).
Enabling Regulation of the Forests and Wildlife Law (Decree no. 12/2002, dated June 6)	This Act defines a list of protected animals – eg dugongs, certain species of coastal and marine birds and sea turtles.
Regulation regarding Sport and Recreational Fishing (Decree no. 51/99, dated August 31)	This Regulation defines a list of protected marine species, eg dugongs, whales and dolphins, sea turtles and some species of fish, bivalves and gastropods.
Decree that determines areas potentially adequate for marine aquaculture (Decree no.71/2011 of 30 December)	This Decree establishes marine reserves for the development of marine aquaculture in areas identified as having potential for aquaculture, including in Palma Bay. Management of these reserves is the responsibility of the Ministry of Fisheries. According to this Decree, " other socioeconomic projects are allowed to be undertaken within these reserves , if they present comparative advantages or are a complement to aquaculture activities, subject to approval by the Minister of Fisheries.

Regulations/Laws	Detail
Regulation regarding the Control of Invasive Alien Species (Decree no. 25/2008, dated July 1)	Article 8 of this Decree prohibits restricted activities involving invasive alien species without prior authorization and states that 'after hearing the Inter-institutional Group for the Control of Invasive Alien Species, the National Authority (MICOA) can prohibit the performance of any activity which, by its nature, may influence the propagation of invasive alien species'. 'Restricted activities' include the following: a) Importing any kind of invasive alien species, whether by sea land or air, into the country; b) Possessing any kind of invasive alien species; c) Developing, creating, or otherwise propagating any kind of invasive alien species; and d) Transporting, moving, or otherwise relocating any kind of invasive alien species. Article 11 of the Decree suggests that appropriate methods should be taken to control and eradicate listed invasive alien species.
Archeology and Cultural Assets	
Law for Protection of Cultural Assets (Law no. 10/88, dated December 22) and Enabling Regulation for the Protection of Archaeological Assets (Decree no. 27/94, dated July 15)	The purpose of these is to ensure the lawful protection of tangible and intangible cultural assets of Mozambique, eg monuments, buildings with historic significance, artistic and scientific sites and natural elements of scientific and noteworthy aesthetic interest.
Land	
Land Law (Law no. 19/97, dated October 1) and Enabling Regulation of the Land Act (Decree no. 6/1998, dated December 8) and National Land Policy (Resolution no. 10/95, dated October 17)	This Act establishes the terms for the establishment, exercise, modification, transmission and termination of rights for the use and enjoyment of land. It establishes as a fundamental principle, the sustainable use of natural resources to guarantee the quality of life for current and future generations, ensuring that total and partial protection zones maintain environmental quality and the special purposes for which they were established.
Law of Territorial Ordinance and respective Regulations (Law no. 19/2007 dated July 18 and Decree no. 23/2008 dated July 1)	This Law establishes sustainability principles to add value to physical space and equality in access to land and natural resources. It establishes preventive systems to minimize significant or irreversible impacts on the environment. The Law places responsibility on public or private entities for any intervention which may cause damage to, or affect the quality of the environment, by ensuring that any adverse effects to quality of life are reversed or compensated.
Labour	
Labour Law (Law no. 23/2007, dated August 1)	This Act defines the general principles and establishes the legal system applicable to individual and collective subordinate labour relationships.

Regulations/Laws	Detail
Regulation for the Contracting of Foreign Citizens in the Petroleum and Mining Sectors (Decree no. 63/2011, dated December 7)	Establishes the legal regime including mechanisms and procedures for contracting foreign citizens for work purposes in the Petroleum and Mining sectors provided that the performance of such activities has been approved by the competent authority. Decree no. 63/2011 establishes, inter alia, that short term assignments not exceeding 180 days, employment of foreign work force may be done without an authorisation from the Minister of Labour, but this must be communicated to the Ministry of Labour within fifteen days from the foreigner entering the country. Also, in petroleum and mining investment projects approved by the Government foresee a percentage of foreigners to be hired greater or lesser than the one foreseen in the quota regime provided, work authorization is not required and communication to the Ministry of Labour shall suffice.
Ports/Harbours	
Regulations for Harbour Operations (Portaria no. 18630/1965, dated April 24)	These regulations mainly govern harbour activities and operations and embarking/disembarking from vessels although a few articles refer to environmental protection, health and safety. Article 42 refers to the necessity to control land-based activities that, through run-off, may affect the marine waters of the harbour. Article 47 refers to the necessity to display the correct signalling flag on a vessel carrying any explosive or hazardous substance. The Regulation states in Articles 123 and 124 that all products undergoing deterioration that may pose a health hazard must be removed. Within the Regulations, only these few articles refer to environmental and safety issues. The regulations are considered out-of-date and are inadequate to ensure environmental health and worker safety and health.
Airports	
Civil Aviation Law (Law no. 21/2009, dated September 28)	This Law defines the basis and general principles for civil aviation in Mozambique in order to ensure safety, regularity and effectiveness in the aerial transport operations. One of the main objectives of this Law is to ensure compliance with international safety standards and implementation of the guidelines and practices recommended in the annexes to the International Civil Aviation Convention.
Technical regulations and implementation guidelines of the International Civil Aviation Convention (Decree no. 73/2009, dated December, 15)	This Decree defines the requirements for construction, modification, licensing and certification of airports/aerodromes. It adopts the technical regulations and implementation guidelines of the International Civil Aviation Convention.

2.2.5 *Regulations on the Resettlement Process resulting from Economic Activities (Decree no. 31/2012 of 8 August)*

New regulations on the resettlement process have recently been approved by Decree no. 31/2012 of 8 August. The regulation establishes the basic rules and principles on the resettlement process for the purpose of providing the opportunity to improve the quality of life of affected households.

Article 4 lists the principles guiding the resettlement process resulting from the public and private activities. These are:

- **Principle of Social Cohesion –**resettlement must ensure social integration and improve the living standards of those affected to a better living standard;
- **Principle of Social Equality –**all those affected by resettlement are entitled to restoration or creation of conditions equal to or above the previous living standard;
- **Principle of Direct Benefit –** those affected should be given the opportunity to benefit directly from the undertaking and its socioeconomic impacts;
- **Principle of Social Equity –** when resettling populations to new areas, access to their means of subsistence, to social services and availability resources must be taken into account;
- **Principle of Non-Change of the Income Level –** allow those resettled to have the opportunity to re-establish their previous basic income;
- **Principle of Public Participation –** ensure the resettlement process should include consultation with local communities and other interested parties affected by the activity;
- **Principle of Environmental Accountability** - whoever pollutes or degrades the environment is obliged to restore or compensate for resulting damages; and
- **Principle of Social Responsibility –** the investor is required to create social infrastructure aimed at promoting learning, leisure, sport, health, culture and other projects of community interest.

The Decree also notes that a Resettlement Action Plan should be completed in time to submit together with an EIA Report to MICOA. During a meeting on 14 June 2013 with the National Directorate of Planning and Spatial Development (DINAPOT), it was noted that the Mozambique LNG Project EIA commenced in 2011 before the promulgation of Decree no. 31/2012. Prior to the promulgation of Decree no. 31/2012, project proponents were only required to submit a Resettlement Policy Framework as part of the EIA

process. Given that the EIA for the Project began, and the ToR for the EIA was approved before the Decree was promulgated, DINAPOT advised the Project to submit an Initial Resettlement Plan (IRP) to MICOA with the EIA Report. The IRP is included in this EIA (*Annex I*) and was also available for public comment as part of the consultation process on the Draft EIA Report. The IRP describes the approach, principles and procedures that will be followed to manage all unavoidable displacement. It is structured according to Article 21 of Decree no. 31/2012 and provides the framework for the future development of a full Resettlement Action Plan (RAP). The RAP will be prepared in accordance with Mozambican legislation and the International Finance Corporation's Performance Standard 5: Land Acquisition and Involuntary Resettlement (IFC PS 5), in close consultation with the affected communities. The RAP will be consistent with the goals, objectives, principles and processes described in this IRP and will be designed to address the specific conditions, characteristics and needs of the people and enterprises affected by physical and economic displacement.

2.3 *INTERNATIONAL CONVENTIONS*

The Project is obliged to ensure that its operations comply with international conventions to which the Government of Mozambique is a signatory. These conventions are listed in *Table* 2.3 below.

Table 2.3 Relevant International Conventions

Year Ratified	Convention
	Air Quality
1985	Vienna Convention for the Protection of the Ozone Layer
1987	Montreal Protocol on Substances that Deplete the Ozone Layer (including 1990 and 1999 amendments)
1992 and 1997	United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, 1992 & 1997
	Habitats and Biological Diversity
2003	African Convention on the Conservation of Nature and Natural Resources. Revised Version
1968	African Convention on the Conservation of Nature and Natural Resources
1985	Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region, 1985, and the Protocol for Protected Areas, Wildlife and Vegetation; and Protocol for the Cooperation in the Combat of Pollution in Emergency Situations
1979	Convention on the Conservation of the Migratory Species of Wild Animals, 1979, and amendments
2001	Protocol for the Fisheries of the SADC
1975	Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)
2001	Agreement related with the application of the Dispositions of the United Nations Convention on the Law of the Sea regarding the Conservation and Management of Straddling and Highly Migratory Fish Species
2001	Protocol for the Fisheries of the Southern Africa Development Community, in annex, signed in Blantyre, on the 14th of August 2001
1992	Convention on Biological Diversity (CBD)
1998	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade
	Water Resources/Maritime Activity
1973/ 1978 and 1975	International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78) Annex I, Prevention of Pollution by Oil. MARPOL include the requirements for the International Oil Pollution Prevention (IOPP) Certificates
1954	The discharge of oil or oily mixtures into the sea from vessels is regulated by the terms of the International Convention for the Prevention of Pollution of the Sea By Oil (OILPOL).
1990	International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC)
1974	International Convention for the Safety of Life at Sea (SOLAS)
1972	Convention on the International Regulations for Preventing Collisions at Sea (COLREGs)
1992	International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND)
1982	UN Law of the Sea Convention (UNCLOS)
1976	IMO International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW)
1979	IMO International Convention on Search and Rescue (SAR)
1972, 1996	International Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, 1972 (London Convention) and the 1996 Protocol (the Protocol)
1992	International Convention on Civil Liability for Oil Pollution Damage, (CLC Protocol)
1974	Convention for the Prevention of Marine Pollution from Land-based Sources (Paris Convention)

Year Ratified	Convention
1979	International Maritime Organization. The Republic of Mozambique signed the Convention that established the International Maritime Organization and ratified it on the 17th of January 1979. .
2004	International Ship and Port Facility Security Code
2001	Regional Cooperation and Coordination of Maritime Search and Rescue and Global Maritime Distress and Safety System (GMDSS) and corresponding Annex 1 that establishes Sub Regional Search and Rescue Centres, for Coastal African Countries located both in the Indian and Atlantic Oceans
1989	Convention on the International Maritime Satellite Organisation (INMARSAT)
	Archaeology and Cultural Heritage
1972	UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage
	Hazardous Waste
1992	Basel Convention on the control of transboundary movements of hazardous wastes and their disposal
1991	Convention on the Ban of the Import into Africa and the Control of Transboundary Movements and Management of Hazardous Wastes within Africa, Bamako
	Aviation
1977	The Convention on International Civil Aviation, also known as the Chicago Convention.
	Piracy
2003	SUA Convention 1988 and SUA Protocol 1988 are two IMO instruments on the Suppression of Unlawful Acts against ships at sea.
	Other
2002	Stockholm Convention on Persistent Organic Pollutants adopted in Stockholm

2.4 GOOD INTERNATIONAL INDUSTRY PRACTICE

2.4.1 Introduction

In planning and implementing the Project, AMA1/eni will be aligned with good international industry practice, to the extent reasonable, notably the environmental and social performance requirements as defined by the Equator Principles (*Section* 2.4.3) and the International Finance Corporation (IFC) Social and Environmental Performance Standards.

2.4.2 International Finance Corporation (IFC) Performance Standards

The IFC has a Sustainability Policy and set of Performance Standards on Social and Environmental Sustainability. These came into force in July 2006 and were recently revised and updated in January 2012. The revised Performance Standards are listed in *Box 2.1*.

Box 2.1 IFC Performance Standards (PSs)

- PS 1: Assessment and Management of Social and Environmental Risks and Impacts;
- PS 2: Labour and Working Conditions;
- PS 3: Resource Efficiency and Pollution Prevention;
- PS 4: Community Health, Safety and Security;
- PS 5: Land Acquisition and Involuntary Resettlement;
- PS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- PS 7: Indigenous Peoples; and
- PS 8: Cultural Heritage.

The objectives of each of these IFC Performance Standards are presented in more detail in the box below.

Box 2.2 Objectives of IFC Performance Standards

PS 1: Assessment and Management of Social and Environmental Risks and Impacts

- To identify and evaluate environmental and social risks and impacts of the project.
- To adopt a mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimize, and, where residual impacts remain, compensate/offset for risks and impacts to workers, Affected Communities, and the environment.
- To promote improved environmental and social performance of clients through the effective use of management systems.
- To ensure that grievances from Affected Communities and external communications from other stakeholders are responded to and managed appropriately.
- To promote and provide means for adequate engagement with Affected Communities throughout the project cycle on issues that could potentially affect them and to ensure that relevant environmental and social information is disclosed and disseminated.

PS 2: Labour and Working Conditions

- To promote the fair treatment, non-discrimination, and equal opportunity of workers.
- To establish, maintain, and improve the worker-management relationship.
- To promote compliance with national employment and labour laws.
- To protect workers, including vulnerable categories of workers such as children, migrant workers, workers engaged by third parties, and workers in the client's supply chain.
- To promote safe and healthy working conditions, and the health of workers.
- To avoid the use of forced labour.

PS 3: Resource Efficiency and Pollution Prevention

- To avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities.
- To promote more sustainable use of resources, including energy and water.
- To reduce project-related GHG emissions.

PS 4: Community Health, Safety and Security

- To anticipate and avoid adverse impacts on the health and safety of the Affected Community during the project life from both routine and non-routine circumstances.
- To ensure that the safeguarding of personnel and property is carried out in accordance with relevant human rights principles and in a manner that avoids or minimizes risks to the Affected Communities.

PS 5: Land Acquisition and Involuntary Resettlement

- To avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs.
- To avoid forced eviction.
- To anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use by (i) providing compensation for loss of assets at replacement cost and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected.
- To improve, or restore, the livelihoods and standards of living of displaced persons.
- To improve living conditions among physically displaced persons through the provision of adequate housing with security of tenure at resettlement sites.

PS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resource

- To protect and conserve biodiversity.
- To maintain the benefits from ecosystem services.
- To promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.

PS 7: Indigenous Peoples

- To ensure that the development process fosters full respect for the human rights, dignity, aspirations, culture, and natural resource-based livelihoods of Indigenous Peoples.
- To anticipate and avoid adverse impacts of projects on communities of Indigenous Peoples, or when avoidance is not possible, to minimize and/or compensate for such impacts.
- To promote sustainable development benefits and opportunities for Indigenous Peoples in a culturally appropriate manner.
- To establish and maintain an ongoing relationship based on Informed Consultation and Participation (ICP) with the Indigenous Peoples affected by a project throughout the project's life-cycle.
- To ensure the Free, Prior, and Informed Consent (FPIC) of the Affected Communities of Indigenous Peoples when the circumstances described in this Performance Standard are present.
- To respect and preserve the culture, knowledge, and practices of Indigenous Peoples.

PS 8: Cultural Heritage

- To protect cultural heritage from the adverse impacts of project activities and support its preservation.
- To promote the equitable sharing of benefits from the use of cultural heritage.

2.4.3 Equator Principles

Private sector banks working in project finance developed 10 environmental and social Principles in 2003, called Equator Principles, to apply globally when addressing environmental and social risks in project financing. These

Principles, shown in *Box 2.3* reflect the IFC-inspired environmental and social best practice guidelines in the financing of large projects and have been revised to adhere to the new IFC Performance Standards. To date the Principles are adopted by over 80 financial institutions and are used in determining, assessing and managing environmental & social risk in project financing. The Principles were revised in 2006 and again in 2013. The *"Equator Principles III"* are in effect as of June 2013.

Box 2.3 ***The Equator Principles***

1. Review and categorisation
2. Environmental and social assessment
3. Applicable environmental and social standards
4. Environmental and social management system and Equator Principles action plan
5. Stakeholder engagement
6. Grievance mechanism
7. Independent review
8. Covenants
9. Independent monitoring and reporting
10. Reporting and transparency

2.4.4 IFC Environmental, Health and Safety (EHS) Guidelines

The IFC EHS Guidelines are technical reference documents providing general and industry-specific examples of good international practice in environmental management. These guidelines represent the performance standards normally considered acceptable by the IFC and most finance institutions and generally considered to be achievable in new facilities at reasonable cost by existing technology. When host country regulations differ from the levels and measures presented in the EHS Guidelines, the IFC recommends that projects should achieve whichever is more stringent (see *Section 2.6*).

The IFC EHS Guidelines (1) considered relevant to the Project are summarised in *Box 2.4*.

(1) The IFC EHS Guideline can be found here:
http://www1.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/IFC+Sustainability/Sustainability+Framework/Environmental,+Health,+and+Safety+Guidelines/

Box 2.4 Relevant IFC EHS Guidelines

1. Environment

1.1 Air Emissions and Ambient Air Quality
1.2 Energy Conservation
1.3 Wastewater and Ambient Water Quality
1.4 Water Conservation
1.5 Hazardous Materials Management
1.6 Waste Management
1.7 Noise
1.8 Contaminated Land

2. Occupational Health and Safety

2.1 General Facility Design and Operation
2.2 Communication and Training
2.3 Physical Hazards
2.4 Chemical Hazards
2.5 Biological Hazards
2.7 Personal Protective Equipment (PPE)
2.8 Special Hazard Environments
2.9 Monitoring

3. Community Health and Safety

3.1 Water Quality and Availability
3.2 Structural Safety of Project Infrastructure
3.3 Life and Fire Safety (L&FS)
3.4 Traffic Safety
3.5 Transport of Hazardous Materials
3.6 Disease Prevention
3.7 Emergency Preparedness and Response

4. Construction and Decommissioning

4.1 Environment
4.2 Occupational Health and Safety
4.3 Community Health and Safety

Industry Sector Guidelines

Offshore Oil and Gas Development
Liquefied Natural Gas (LNG) Facilities
Ports, Harbours and Terminals

2.5 REQUIREMENTS OF OTHER INTERNATIONAL INSTITUTIONS OF RELEVANCE

2.5.1 Introduction

Good International Industry Practice guidelines and standards have also been produced by a number of marine, conservation and oil and gas industry bodies, in terms of the environmental impacts and impact assessment methods associated with onshore and offshore gas extraction. This section summarises key documents, principles and approaches that are of relevance to the Project and with which the Project will align, to the extent reasonable.

2.5.2 *International Association of Drilling Contractors*

The International Association of Drilling Contractors (IADC) Guide is designed to supplement company Health, Safety and Environmental programs and operating procedures. It is based on experience and careful study over many years. Practicability has been substantiated by the adoption of the safe operating procedures by many drilling contractors and government regulatory bodies. It provides a basis for the drilling contractor to develop a Health, Safety and Environmental programme.

Of particular interest for the present Project is Chapter 12, related to Offshore Safety, covering aspects such as medical evacuation and rough weather procedures; and Chapter 14, related to the Protection of the Environment covering air emissions, waste management, spill prevention and control amongst others.

The Guide also covers aspects related to Fire Prevention and Control, Personal Protective Equipment and Emergency Action Plan(s).

2.5.3 *International Oil & Gas Producers Association (OGP)*

The OGP is an association of oil and gas companies, associations and major upstream service companies whose members produce more than half the world's oil and about one third of its gas. It was formed to develop effective communications between the upstream industry and the network of international regulators. It represents the industry in the International Maritime Organisation and the Commission for Sustainable Development and works with the World Bank and with the International Organization for Standardization (ISO). Part of its remit is to help achieve continuous improvements in safety, health and environmental performance. It has produced a number of guidelines relating to the environmental impact of oil and gas developments including 'Guidelines for waste management with special focus on areas with limited infrastructure' [(1)].

2.6 *NUMERICAL STANDARDS AND GUIDELINES RELEVANT TO THE PROJECT*

A comparison between Mozambican and international limits and standards relevant to the Project are presented in this Section in a tabular manner. These include IFC General EHS Guidelines and relevant EHS sector specific guidelines (see *Section 2.4.4*), World Health Organisation (WHO) Guidelines and Mozambican legislative requirements.

Often host country limits and standards differ from corresponding international limits and standards. In accordance with good international industry practise, projects in all cases must comply with host country standards (in this case, the Mozambican limits and standards). International

(1) OGP Guidelines for waste management with special focus on areas with limited infrastructure - Report No. 413, rev1.1 September 2008 (updated March 2009)

good practice in EIA suggests that where international standards are more stringent, projects should seek to benchmark against these international standards.

2.6.1 *Air Quality*

Air quality standards for the purposes of this guideline are framed within the Regulations on the Emission of Effluents and Environmental Quality Standards (Decree no. 18/2004 dated June 2) and Decree no. 67/2010, dated December 31 (amendments to Appendix I and inclusion of Appendices 1A and 1B to Decree no. 18/2004). However, these guidelines are not applicable to non-stationary sources (eg vehicles). The IFC EHS LNG Facility Guidelines defer to the WHO Air Quality Guidelines Global Update, 2005 as set out in *Table 2.4* (1).

Table 2.4 Air Quality Guidelines

Pollutant	Averaging Period	Guideline Value (µg/m³)	
		WHO	Mozambique Decree no. 67/2010
SO_2	1-year		**40**
	24-hour	125 (Interim target-1) 50 (Interim target-2) 20 (guideline)	**100**
	1-hour		**800**
	10-minute	500 (guideline)	**500**
NO_2*	1-year	**40 (guideline)**	10
	24-hour		
	1-hour	**200 (guideline)**	190
TSP	1-year		**60**
	24-hour		**150**
PM_{10}	1-year	**70 (Interim target-1)** **50 (Interim target-2)** **30 (Interim target-3)** **20 (guideline)**	
	24-hour	**150 (Interim target-1)** **100 (Interim target-2)** **75 (Interim target-3)** **50 (guideline)**	
$PM_{2.5}$	1-year	**35 (Interim target-1)** **25 (Interim target-2)** **15 (Interim target-3)** **10 (guideline)**	
	24-hour	**75 (Interim target-1)** **50 (Interim target-2)** **37.5 (Interim target-3)** **25 (guideline)**	
CO	8-hour average		**10 000**
	1-hour average		**30 000**
	15-minute		**100 000**
	30-minute		**60 000**
Ozone	8-hour daily maximum	160 (Interim target-1) 100 (guideline)	**120**

(1) World Health Organization (WHO). Air Quality Guidelines Global Update, 2005. PM 24-hour value is the 99th percentile.

Pollutant	Averaging Period	Guideline Value (µg/m³)	
		WHO	Mozambique Decree no. 67/2010
	1-hour average		**160**
	24-hour		**50**
Benzene	One-year mean		**4.4 x 10-6**

*MICOA has authorised the Project to use the WHO NO_2 standard instead of the Mozambican NO_2 standard.

The Project will comply with the limits shown in **bold**.

Mozambique does not have specific standards for air emissions from ships and vessels. As such the Project will comply with Annex VI of the MARPOL Convention, adopted in September 1997. The regulations in this annex set limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibit deliberate emissions of ozone depleting substances.

Greenhouse Gases/Carbon Emissions

According to the methodology of the UN Framework Convention on Climate Change (UNFCCC), the total GHG emission forecast is presented as tonnes of CO_2 equivalent (CO_2-e). IFC Performance Standard 3 for Resource Efficiency and Pollution Prevention states that where more than 25,000 tonnes CO_2-equivalent is produced annually for a single project or development, the Project will quantify direct emissions from the facilities owned or controlled within the physical project boundary, as well as indirect emissions associated with the off-site production of energy used by the project. In the absence of a GHG emissions threshold in Mozambique, the Project will align with IFC requirements.

2.6.2 Noise

Noise emission standards have not been established within Mozambique. In such a case, standards considered applicable to this Project are those described by the IFC EHS General Guidelines; the WHO Noise Guidelines [1]. Noise impacts should not exceed the levels presented in *Table 2.5*, or result in a maximum increase in background levels of 3dB at the nearest identified noise sensitive receptor.

(1) Guidelines values are for noise levels measured out of doors. Source: Guidelines for Community Noise, World Health Organization (WHO), 1999.

Table 2.5 ***Applicable Noise Standards for the Project***

Receptor	One Hour LAeq (dBA)	
	Daytime 07:00 – 22:00	Night time 22:00 – 07:00
Ambient Conditions	Maximum increase in background levels of 3 dB at the nearest receptor location off-site	
Residential/Institutional/Educational (1)	55	45
Industrial/Commercial	70	70

2.6.3 Potable Water

Potable water quality guidelines considered relevant to the Project include the Mozambican Water Quality Standards for Human Consumption (Ministerial Diploma no. 180/2004, of 15 September) and the IFC EHS General Guidelines. With respect to the latter, the guideline does not provide specific standards but refers to the World Health Organisation (WHO) Guidelines for drinking-water quality (WHO, 2011). The specific water quality standards are presented in *Table 2.6* below.

Table 2.6 ***Potable Water***

Constituent	Unit	WHO (2011)	Mozambican Guideline (Ministerial Decree no. 180/2004)
Major Ions			
Calcium as Ca	mg/l		**50**
Magnesium as Mg	mg/l		**50**
Potassium as K	mg/l		
Sodium as Na	mg/l	200	**200**
Fluoride as F	mg/l	1.5	**1.5**
Sulphate as SO_4^2	mg/l	500	**250**
Chloride as Cl	mg/l	250	**250**
Nitrate as NO_3	mg/l	50	**50**
Nitrite as NO_2	mg/l	3	**3**
Ortho Phosphate as PO_4	mg/l		
Ammonium as NH_4	mg/l		**1.5**
Total Nitrogen as N	mg/l		
Total Alkalinity as $CaCO_3$	mg/l		
Total Hardness as $CaCO_3$	mg/l		**500**
Trace Elements (Metals)			
Aluminium as Al	µg/l	200	**200**
Antimony as Sb	µg/l	**20**	
Arsenic as As	µg/l	10	**10**
Barium as Ba	µg/l	700	**700**
Beryllium as Be	µg/l	**12**	
Bismuth as Bi	µg/l		
Boron as B	µg/l	2400	**300**
Cadmium as Cd	µg/l	3	**3**
Total Chromium as Cr	µg/l	50	**50**
Cobalt as Co	µg/l		
Copper as Cu	µg/l	2000	**1000**

(1) For acceptable indoor noise levels for residential, institutional, and educational settings refer to WHO (1999).

Iron as Fe	µg/l	2000	**300**
Lead as Pb	µg/l	10	**10**
Lithium as Li	µg/l		
Manganese as Mn	µg/l	400	**100**
Mercury as Hg	µg/l	6	**1**
Molybdenum as Mo	µg/l	70	**70**
Nickel as Ni	µg/l	70	**20**
Selenium as Se	µg/l	40	**10**
Zinc as Zn	µg/l	3000	**3000**
Hydrocarbons			
Benzene	mg/l	**0.01**	
Toluene	mg/l	**0.7**	
Ethylbenzene	mg/l	**0.3**	
Xylenes	mg/l	**0.5**	
Naphthalene	mg/l		**0.0001***

Notes: * Guideline value for polycyclic aromatic hydrocarbons

The Project will comply with the limits shown in **bold**.

2.6.4 Soil

Soil quality guidelines have not been established under Mozambican Law or by the IFC Performance Standards. Therefore the Project will apply international good practice with respect to housekeeping, proper storage and spill/leak prevention to avoid contamination beyond baseline soil levels described in *Chapter 8*.

2.6.5 Effluent and Wastewater

The guidelines considered applicable for the treatment and/or discharge of effluent and wastewater includes:

- Regulations on the Emission of Effluents and Environmental Quality Standards (Decree no. 18/2004, dated June 2);
- Decree no. 67/2010, dated December 31 (amendments to Appendix I and inclusion of Appendices 1A and 1B to Decree no. 18/2004, dated June 2);
- Regulation for the Prevention of Pollution and Marine and Coastal Environmental Protection (Decree no. 45/2006, dated November 30) including MARPOL Convention, Annex II and IV ; and
- IFC EHS Guidelines for LNG Facilities, to the extent reasonable.

Mozambique does not have EHS guidelines or standards specifically for LNG facilities and as such, the Project will propose effluent and wastewater standards based on existing Mozambican standards for other similar industries and IFC guidelines.

Discharge standards for the following wastewater streams are described further below:

- hydrotest water.
- stormwater runoff.
- cooling water.
- produced water.
- domestic/ residential sewage.

While Mozambique has not established specific guidelines or standards for all these wastewater streams, in the absence of such, the Project will propose effluent and wastewater standards based on existing Mozambican standards for other similar industries and IFC guidelines.

Hydrotest Water

Effluent levels for discharge of hydrotest waters to surface waters or land in accordance with IFC EHS Guidelines for LNG Facilities are set out in *Table 2.7*.

Table 2.7 Hydrotest Fluids Discharge Limitations

Parameters	Units	Effluent Limits
Total hydrocarbon content	mg/l	10
pH		6 - 9
BOD	mg/l	25
COD	mg/l	125
TSS	mg/l	35
Phenols	mg/l	0.5
Sulfides	mg/l	1
Heavy metals a.	mg/l	5 Total
Chlorides	mg/l	600 average, 1200 maximum

Stormwater Runoff from Process Areas

Stormwater runoff should be treated through an oil/water separation system able to achieve amaximum oil and grease concentration in accordance with all the applicable standards, regulations (national and international) and/or approval or authorization. Management of stormwater runoff from vessels will be in accordance with MARPOL.

Cooling Water

In accordance with IFC EHS Guidelines for LNG facilities, the effluent should result in a temperature increase of no more than 3°C at edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100m from point of discharge. Free chlorine (total residual oxidant in estuarine / marine water) concentration in cooling / cold water discharges (to be sampled at point of discharge) should be maintained at 0.2 parts per million (ppm).

Produced Water

Oil and gas reservoirs contain water (formation water) that is produced when brought to the surface during hydrocarbon production. The disposal of produced water will be in compliance with all the applicable standards, regulations (national and international) and/or approval or authorization.

Domestic /Residential Sewage

In Mozambique, sewage discharges are regulated by Annex IV of Decree no. 18/2004, dated June 02. Annex V of this Decree applies to any domestic effluent discharges into the sea or ocean. Similarly the Regulation for the Prevention of Pollution and Protection of the Marine and Coastal Environment, Decree no. 45/2006, dated 30 November, which references the standards set out in MARPOL s Annex IV -Prevention of pollution by sewage. The disposal of sewage wastewater will be in compliance with all the applicable standards, regulations (national and international) and/or approval or authorization.

2.6.6 Waste Management

The section provides guidelines for the design, construction and operation of facilities for the management of hazardous and non-hazardous waste, including landfills, incinerators and other waste management systems.

The Mozambican Waste Management Regulations (Decree no. 13/2006) establish rules on the production, emission or disposal of any toxic or polluting substance so as to prevent or minimize its negative impacts on health and the environment. This applies for all individual or collective persons, public or private, and lays down powers on waste management.

The IFC EHS Guidelines for Waste Management Facilities (December 2007) applies to projects that generate, store or handle any quantity of waste and is applicable to general and hazardous waste management. The planning, design, construction and operation of any general waste landfill site should be in compliance with the Mozambique Waste Management Regulations and will follow IFC EHS Guidelines for Waste Management Facilities (December 2007), to the extent reasonable.

The Regulation on Waste Management (Decree no. 13/2006, dated June 15) makes reference to landfill sites within Appendix 1 where details on landfill specifications and dimensions are cited.

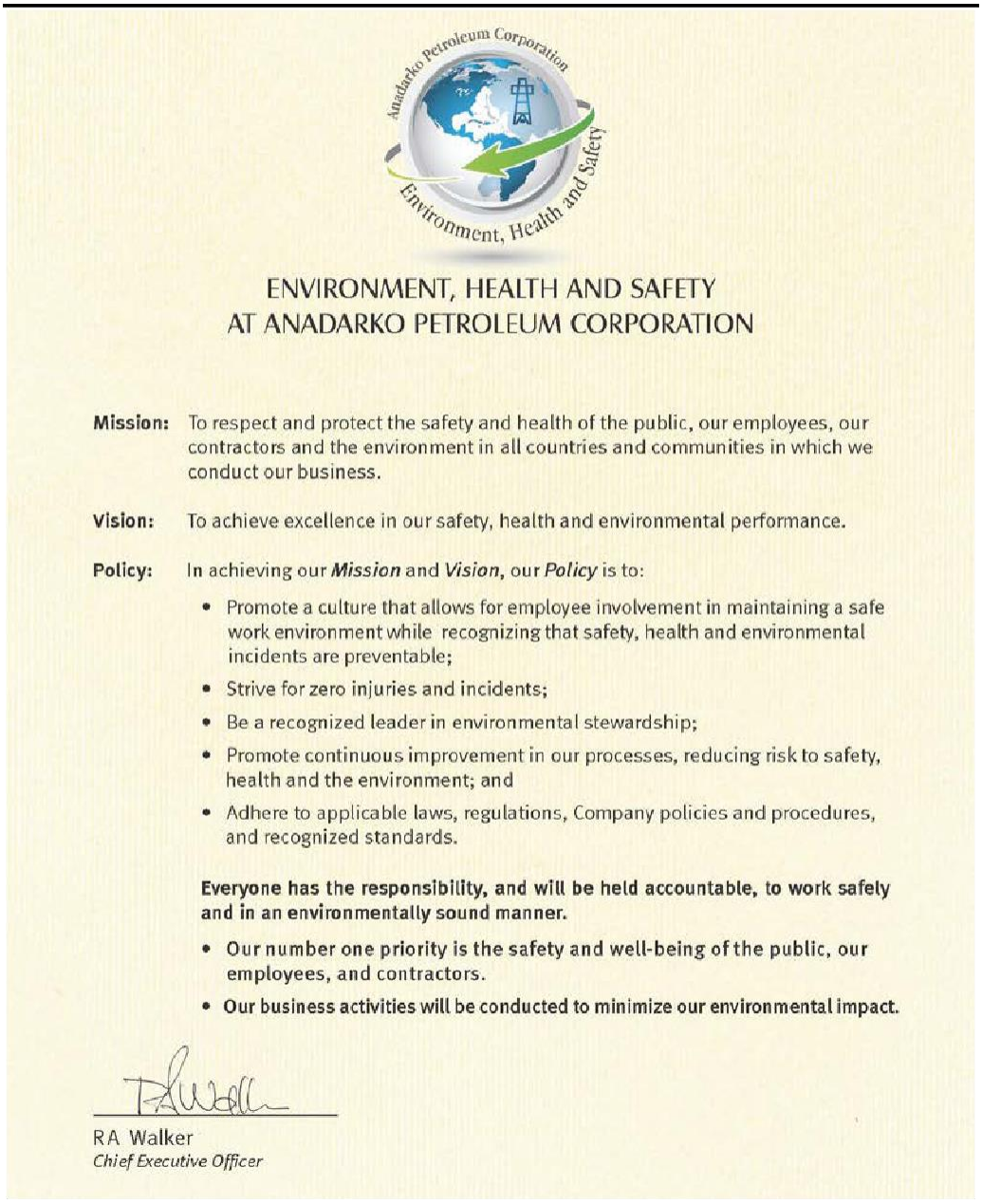
The Mozambican Waste Management Regulations (Decree no. 13/2006) establish rules on the production, emission or disposal of any toxic or polluting substance to prevent or minimize negative impacts on health and the environment. Wastes are classified as hazardous or non-hazardous. Wastes are classified as hazardous base its flammability, corrosiveness, reactivity, toxicity and pathogenicity characteristics. This regulation defines

the obligations of the bodies that produce and manage waste, laying down rules for the collection, movement, preparation (establishing the identification code of hazardous waste), treatment and re-use of waste. Finally, the regulation defines the infractions and respective sanctions for failure to comply.

2.7 *ANADARKO COMPANY POLICY*

AMA1's objective is to gather, process, and export (in liquefied form) natural gas found in Area 1. As a subsidiary of Anadarko Petroleum Corporation (APC), AMA1 recognises the responsibility it has to conduct its business as a responsible corporate member of society, to observe the laws of Mozambique to respect and protect the safety and health of the public, employees, contractors and the environment and adopts APC's EHS Policy. APC's EHS Policy is provided in *Figure 2.1*.

Figure 2.1 APC's EHS Policy



ENVIRONMENT, HEALTH AND SAFETY
AT ANADARKO PETROLEUM CORPORATION

Mission: To respect and protect the safety and health of the public, our employees, our contractors and the environment in all countries and communities in which we conduct our business.

Vision: To achieve excellence in our safety, health and environmental performance.

Policy: In achieving our ***Mission*** and ***Vision***, our ***Policy*** is to:

- Promote a culture that allows for employee involvement in maintaining a safe work environment while recognizing that safety, health and environmental incidents are preventable;
- Strive for zero injuries and incidents;
- Be a recognized leader in environmental stewardship;
- Promote continuous improvement in our processes, reducing risk to safety, health and the environment; and
- Adhere to applicable laws, regulations, Company policies and procedures, and recognized standards.

Everyone has the responsibility, and will be held accountable, to work safely and in an environmentally sound manner.

- **Our number one priority is the safety and well-being of the public, our employees, and contractors.**
- **Our business activities will be conducted to minimize our environmental impact.**

RA Walker
Chief Executive Officer

2.8 ENI´S COMPANY POLICY

The Health, Environment and Safety Policy of eni S.p.A. states that its businesses and operational activities must be conducted in a manner to promote excellence in the following actions:

- protection of health and safety of its employers and local communities;
- development and contribution towards well-being of communities with which company works;
- protection of environment and adoption of principles and values for environmental sustainability; and

- continuous improvement of quality of processes, services and product inherent to company's activities and operations.

eni's EHS Policy for Mozambique is provided in *Figure 2.2*.

Figure 2.2 eni's EHS Policy

Eni East Africa

Mozambique branch

Health Safety & Environment Policy

Eni East Africa - Mozambique Branch is an Oil & Gas Company representing its shareholders in hydrocarbon, exploration, development and production activities from onshore and offshore locations in Mozambique.

Statement:

Eni East Africa - Mozambique Branch is committed to conduct all business in line with the eni Code of Ethics, eni ten policies and eni HSE Management System Guideline, and to pursuing the goal of no Harm to People, protecting the Environment and promoting Sustainable Development principles.

This commitment statement applies to all operational and project activities under **Eni East Africa - Mozambique Branch** 's control through their whole life-cycle, including activities carried out by contractors.

In accordance to this statement, Eni East Africa - Mozambique Branch is committed to:

- Manage HSE matters with the same level of attention as other critical business activities in a way that protects not only production, equipment and materials, but also the safety and the health of all our employees and contractors, and the environment.
- Establish an HSE culture within the organization - through positive and continuous commitment from the top and line management - in which all **Eni East Africa - Mozambique Branch** employees and contractors feel responsible for the prevention of incidents involving themselves, their co-workers or the environment.
- Prevent all causes of incidents, near misses and unsafe conditions identifying, evaluating and controlling the risks and the impacts associated with all our activities, through the application of the best HSE practices.
- Continually assess and mitigate the potential health impacts of our operations, granting all measures to ensure healthy working condition.
- Conduct a responsible environmental management into all our operations phases to support sustainable development, biodiversity conservation, the prevention of pollution and the reduction of waste generation in compliance with current applicable HSE legislation and other requirements that apply to the oil industry in the Country.
- Remain committed to sustainable development and the welfare of our host communities.
- Achieve continuous improvement in health, safety, environment and quality performances, through the implementation of requirements of the HSE Integrated Management System in projects, and complying with relevant legislation and other requirements to which **Eni East Africa - Mozambique Branch** subscribes.
- Develop and maintain communication channels with our stakeholders and publicly report on our HSE performance, within the applicable petroleum industry regulations and legislations in Mozambique.

The HSE Statement (Policy) and objectives are communicated to every person working in **Eni East Africa - Mozambique Branch** through Management interaction and communication and training.

pol ens hse 001 EEA r01

A Eni East Africa - Mozambique Branch é uma Empresa do ramo de Gás & Petróleo representando os respectivos accionistas em hidrocarbonetos e actividades de exploração, produção e desenvolvimento em offshore de Moçambique.

Declaração:

A **Eni East Africa - Mozambique Branch** compromete-se a dirigir as suas actividades de acordo com o Código de Ética da eni, das dez políticas da eni, e das HSE Management System Guideline da eni, orientando-se de modo à não prejudicar as Pessoas, proteger o Meio Ambiente e os princípios de Desenvolvimento Sustentável.

A presente Declaração de compromisso aplica-se à todas as actividades do projecto e operações sob controlo da **Eni East Africa - Mozambique Branch**, durante todo o seu ciclo de vida, incluindo as actividades levadas a cabo por contratados.

De acordo com a presente declaração, Eni East Africa - Mozambique Branch compromete-se a:

- Gerir os assuntos de HSE com o mesmo nível de atenção que as outras actividades críticas do negócio por forma a proteger não só a produção, o equipamento e os materiais, mas também a segurança e a saúde de todos os nossos trabalhadores e contratados, assim como o meio ambiente.
- Estabelecer uma cultura de HSE dentro da organização (através de compromisso positivo e contínuo a partir do topo e da gestão directa) na qual todos os trabalhadores e contratados da **Eni East Africa - Mozambique Branch** se sintam responsáveis pela prevenção de incidentes em que estejam envolvidos eles mesmos, seus colegas ou o meio ambiente.
- Prevenir todas as causas de incidentes, perdas e condições pouco seguras, identificar, avaliar e controlar os riscos e o impacto associado com todas as nossas actividades através da aplicação das melhores práticas de HSE.
- Avaliar continuamente e mitigar o potencial impacto da saúde das nossas operações, tomar todas as medidas para garantir condições saudáveis de trabalho.
- Desenvolver uma gestão ambiental responsável em todas as nossas fases de operações para apoiar o desenvolvimento sustentável, a conservação da biodiversidade, a prevenção da poluição e a redução na geração de resíduos em conformidade com a actual legislação de HSE e outros requisitos que se aplicam à indústria petrolífera no País.
- Continuar comprometido com o desenvolvimento sustentável e o bem-estar das comunidades.
- Realizar um melhoramento contínuo em saúde, segurança, meio ambiente e desempenho de qualidade através da implementação de requisitos do sistema de Gestão Integrada de HSE em projectos, e cumprir com a respectiva legislação e outros requisitos a que a **Eni East Africa - Mozambique Branch** subscreve.
- Desenvolver e manter canais de comunicação com os nossos accionistas e fazer relatórios de desempenho sobre a nossa execução de HSE dentro dos regulamentos da indústria petrolífera e das legislações aplicáveis em Moçambique.

A Declaração (Política) de HSE e os objectivos são comunicados à todas as pessoas que trabalham na **Eni East Africa - Mozambique Branch** através da interacção, comunicação e formação de Gestão.

Managing Director
Director Geral

May 2013

Chapter 3

The EIA Process, Approach and Methodology

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3 THE EIA PROCESS APPROACH AND METHODOLOGY

3.1 OVERVIEW OF THE EIA PROCESS

This chapter outlines the approach to the EIA and the process and methodology that has been followed. The framework for policy, legislation and standards within which the EIA was undertaken has been described in detail in *Chapter 2*.

The purpose of the EIA is to:

- assess the potential impacts of the Project and Project-related activities on the biophysical and socio-economic environment;
- design mitigation to avoid or minimise negative impacts and enhance potential benefits; and
- report the significance of the residual impacts that remain following mitigation.

3.1.1 EIA Requirements

The EIA process followed was designed to assess potential environmental, social and health impacts of the Project, to provide required documentation to MICOA during the approvals process, and to comply with the relevant Mozambican environmental requirements listed below and described in detail in *Chapter 2:*

- Environmental Regulations for Petroleum Operations (Decree no. 56/2010 of 22 November);
- General Guideline for the Environmental Impact Studies (Ministerial Diploma no. 129/2006 of 19 July); and
- Guidelines for Public Participation Process (Ministerial Diploma no. 130/2006 of 19 July).

3.2 OVERVIEW OF APPROACH

3.2.1 EIA Process

One of the objectives of the EIA process is to support decision making regarding the environmental licensing of a proposed activity and/or development. In achieving this, the EIA process consists of the following three key phases:

- **Phase 1- EIA Pre-assessment Application (Screening):** This phase, also known as screening, involves submitting a Pre-assessment application to Provincial Directorate of Environmental Affairs (Direcção Provincial de Coordenação da Acção Ambiental or DPCA) who then categorises the Project based on the level of environmental assessment required.

- **Phase 2- Environmental Pre-Feasibility Study and Scope of Definition (Scoping):** The scoping phase or EPDA [1] phase as it is known aims to identify key issues and concerns associated with the proposed development. These could include project-related activities which may have the potential to contribute to or cause potentially significant impacts to environmental and socio-economic receptors and resources in the area. The EPDA Report also defines the Terms of Reference (ToR) for the specialist studies and Impact Assessment phases to follow. The ToRs for specialist studies are intended to close any gaps in available information such that a reliable baseline can be established.

- **Phase 3- Impact Assessment:** This phase involves two discrete components:

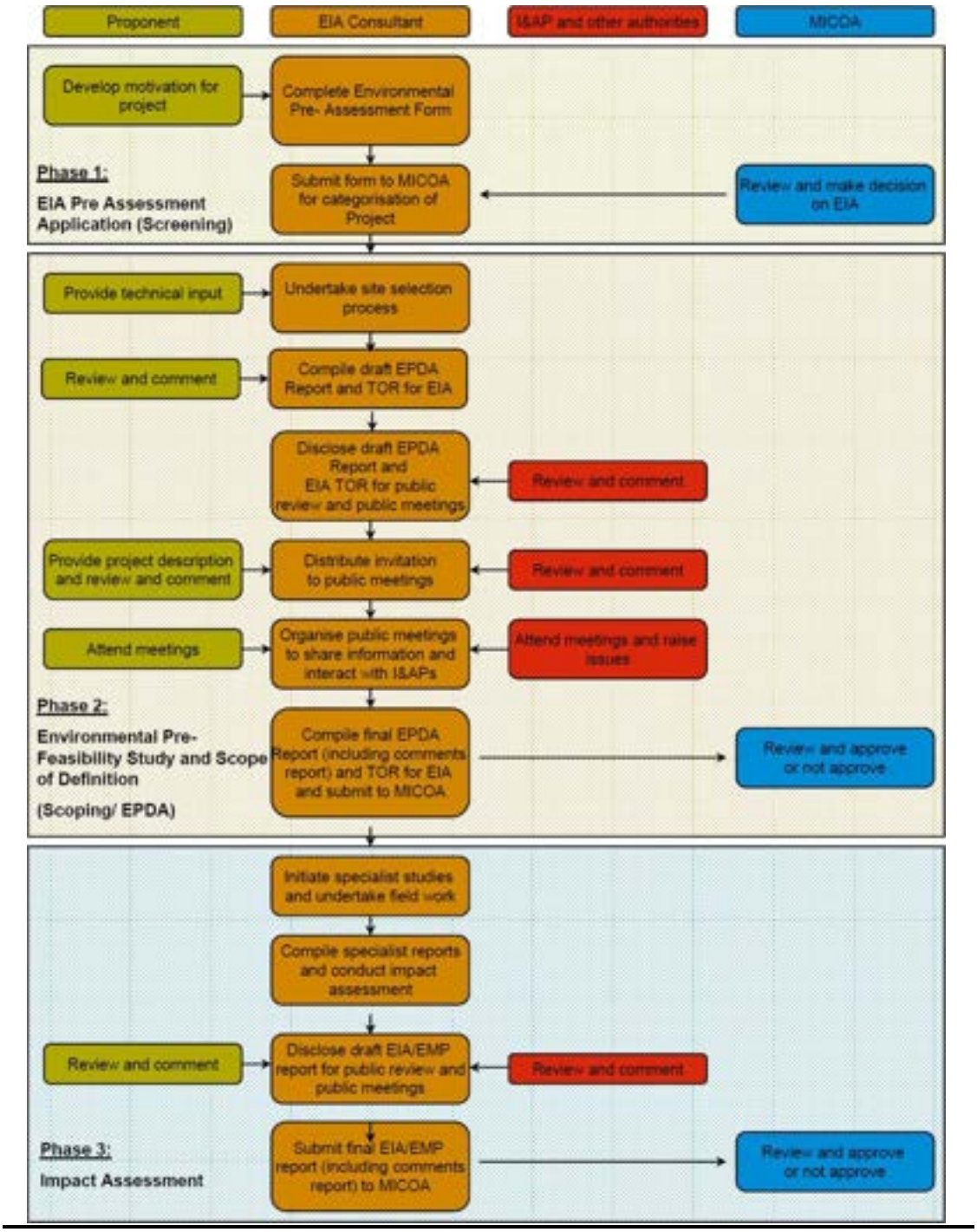
    - **Specialist Studies:** Based on the findings of the scoping phase and any identified data gaps, specialist studies are undertaken to investigate and establish the existing baseline conditions and legislative requirements pertaining to the Project and its surroundings and also to highlight receptors and resources sensitive to potential impacts.

    - **Environmental Impact Assessment Report and Environmental and Social Management Plan:** The EIA Report identifies and evaluates the likely extent and significance of the potential impacts on identified environmental and social receptors and resources according to defined assessment criteria. The EIA Report also details recommended measures to avoid, minimise, reduce or compensate for any potential adverse environmental effects and reports the significance of the residual impacts that remain following mitigation. The impact assessment informs the development of an Environmental and Social Management Plan (ESMP). The ESMP presents specific measures and commitments by the Project to address identified impacts.

The phases of the EIA process are illustrated in *Figure 3.1* and are described in detail below.

(1) From the Portuguese, Estudo de Pré-Viabilidade Ambiental e Definição de Âmbito.

Figure 3.1 Flow Diagram of EIA Process



3.3 PHASE 1: EIA PRE-ASSESSMENT APPLICATION (SCREENING)

The screening phase initiated the EIA by liaising with the relevant authority to identify the level of environmental impact assessment required.

The screening process involved the submission of an Environmental Pre-assessment form (Ficha de Informação Ambiental Preliminar) to the provincial department of the Ministry for the Coordination of Environment Affairs (MICOA); namely the Provincial Directorate of Environmental Affairs

(Direcção Provincial de Coordenação de Acção Ambiental or DPCA). MICOA then categorises a project as either Category A, B or C. Decree no. 56 / 2010 of 22 November defines Category A activities as those activities related to the development, production, construction and operation of oil or gas pipeline systems and decommissioning and other activities to be carried out in sensitive ecosystems and conservation areas. Category B activities are defined as those activities that are related to exploration in areas that are not conservation areas and/ or sensitive ecosystems. Category C refers to activities which by their nature do not entail negative impacts on the Environment and public health.

The application for the Project was submitted to the DPCA of Pemba on 24 June 2011. On 22 August 2011, the Project was classified as a *Category A* project and is therefore subject to a comprehensive Environmental and Social Impact Assessment process.

3.4 *PHASE 2: ENVIRONMENTAL PRE-FEASIBILITY STUDY AND SCOPE OF DEFINITION (EPDA/SCOPING)*

3.4.1 *Objectives and General Considerations*

The objectives of the EPDA Phase were to:

- complete a site selection process to identify the proposed Project Area for the onshore facility;
- gather baseline data about the Project Area in order to understand the sensitivity of the affected biophysical and social environment;
- identify potential significant positive and negative environmental and socio-economic impacts. This involved the systematic consideration of the potential for interaction between activities involved in developing the Project and aspects of the physical, biological and socioeconomic environment that may be affected;
- initiate a dialogue with Interested and Affected Parties (I&APs) by presenting details of the proposed development to stakeholders to enable contributions to Project planning by commenting on potential issues and concerns about the proposed development;
- develop the Terms of Reference (ToR) for the specialist studies portion of the Impact Assessment Phase; and
- compile specific environmental and social project information together with the results of the stakeholder consultation into a Final EPDA Report together with the ToR for the EIA, and submitting these to MICOA via the National and Provincial Directorates of Impact Assessment for review and consideration.

The Final EPDA Report was submitted to MICOA on 21 November 2011.

It should be noted that although scoping was initiated early in the EIA process, it is an activity that has continued as new issues and information emerged during further studies, site visits and stakeholder consultations, and as a result of development of the Project design. The ToR for the EIA and for specialist studies have evolved in response to this new and updated information.

The activities undertaken as part of the EPDA Phase are described below.

3.4.2 Site Selection and Preliminary Baseline Data Gathering

A high-level analysis of baseline sensitivities was undertaken as part of the initial Project planning, in particular to identify an appropriate location for the onshore facility and near shore infrastructure prior to commencing the EIA process. Initial environmental and socio-economic baseline information was gathered in early 2011 via review of existing reports including previous EIAs and studies [1] undertaken during the exploration of Area 1. The aim of the preliminary baseline sensitivity analysis was to highlight key baseline sensitivities, red flags, or fatal flaws from a socio-economic and biophysical perspective of several sites along the northern coast of the Cabo Delgado Province that had been identified as potentially suitable sites for the onshore facility.

Preliminary site visits were then conducted in May 2011 and August 2011 of several potential LNG sites by environmental and social specialists and by the Engineering Team in June 2011 and August 2011. The purpose of these site visits was to gather environmental and social information on alternative sites as well as investigate the suitability of the site from a technical perspective to supplement the site selection evaluation (refer to *Chapter 5*). These preliminary investigations formed the basis for the baseline information gathered for EPDA Phase and the site selection process.

Workshops were held between the EIA Team, including a number of key environmental (terrestrial ecologist and marine ecologist) and a social specialist and the Engineering Team to understand the sensitivities and constraints of the various site locations under consideration. The evaluation process considered technical, environmental, health, and social impacts associated with using each alternative for development of an onshore LNG facility. The available information indicated that the Afungi site was the preferred alternative (refer to *Chapter 5*).

(1) The other EIAs are in the public domain and were undertaken by Impacto. These include two EIAs for deep water seismic and exploration drilling (2007 and 2008 respectively), as well a shallow water seismic and exploration drilling EIA undertaken in 2008. Other studies were undertaken or commissioned by government or by independent scientists. All reports and studies used are in the public domain and referenced in this report.

3.4.3 *Public Participation during the EPDA Phase*

Public participation is a critical component of the EPDA phase allowing for the identification of public expectations and concerns that need to be considered and addressed as part of the EIA process. In this regard, the key objectives of the public participation process undertaken during the EPDA Phase were as follows:

- identify stakeholders;
- consult with relevant government departments and key stakeholders;
- notify the public of planned meetings in Palma, Pemba and Maputo through newspaper and radio advertisements and letters of invitation;
- distribute the Draft EPDA Report to public for comment;
- arrange and facilitate public meetings in key locations;
- gather public comment on the Draft EPDA Report; and
- consider and consolidate public comments into the Final EPDA Report.

For the purposes of this EIA process, a stakeholder is defined as 'any individual or group who is potentially affected by a project or can themselves affect a project'.

The stakeholder consultation process undertaken to date is described in detail in the Public Participation Report (PPR) in *Annex A*. Copies of all relevant documentation such as meeting minutes, attendance registers, advertisements and letters of invitation are included in the PPR. A summary of the activities undertaken during and after the EPDA Phase is presented in *Table 3.1*.

Table 3.1 Summary of Public Participation Process (PPP) during EPDA Phase

Activity	Purpose and discussion	Date of activity
Compilation of stakeholder database	Identify stakeholders to be included in the consultation process	July- August 2011
Compilation and distribution of draft EPDA Report for public review (including on Impacto website)	Provide information on the EIA process, the proposed development and dates of public meetings	July- September 2011
Distribution of invitations to public meetings	To invite stakeholders to public meetings	September 2011

Activity	Purpose and discussion	Date of activity
Press advertisements for public meetings	To invite stakeholders to public meetings	September 2011
Public meetings: Palma, Pemba and Maputo	To present the proposed EIA process and project to the public and to allow the public to identify issues of concern	27- 30 September 2011
Written comments received	Written comments received during the scoping process	September- October 2011
Update the Stakeholder Database	Registration of new interested and affected parties (I&APs)	October 2011
Submission of Final EPDA Report and EIA ToR to MICOA	For MICOA´s decision	21 November 2011

3.4.4 EPDA Report

The results of the baseline data review and the public participation activities were compiled into a Final EPDA Report prepared in accordance with the requirements of Decree no. 56/2010. This Final EPDA Report was made available to registered I&APs and to MICOA as defined in the applicable law for review for a period of 20 working days.

3.4.5 Authority Review of the EPDA Report

MICOA formed a technical review committee to undertake a review of the Final EPDA Report which included key stakeholders from government at national and provincial levels and various institutions. The committee reviewed the report and the Final EPDA Report was granted approval by MICOA on 3 January 2012. A copy of the approval letter (reference 001/GM/MICOA/12) is included in *Annex B*.

3.5 PHASE 3: IMPACT ASSESSMENT

3.5.1 Specialist Studies

The environmental and socioeconomic sensitivities and issues identified during the scoping phase were used to develop the Terms of Reference (ToR) for the specialist studies to be undertaken during the Impact Assessment phase of the EIA. The outcomes of these studies formed the basis for the baseline description and impact assessment of the potential impacts on the affected environment.

The objectives of the specialist studies were to:

- describe the existing environmental and socio-economic conditions;

- identify those resources or receptors in areas potentially affected by the Project;
- understand stakeholder concerns, perceptions and expectations regarding the proposed Project;
- assess the impact on the environment using predefined criteria; and
- develop mitigation measures for potential negative impacts.

The specialist studies undertaken as part of the EIA process are listed in *Table 3.2*.

Table 3.2 Specialist Studies

Specialist Study	Key Specialist	Organisation
Air quality	Chris Hazell- Marshall Yves Verlinden	ERM
Noise	Rod Linnett Jamie Hogg Steve Mitchell Marilena de Stefano Justin Kmelisch	ERM
Climate change	Simon Clark Lisa Constable David Bonellie	ERM
Landscape and visual	Eimear O'Connor John Flannery	ERM
Soils, landuse, land capability	Hendrik Smith Louw Potgieter	Digby Wells Environmental
Groundwater	Hugo Marais Heinrich Schreuder Hanco Roux Andreas Stoll	ERM
Surface water - hydrology	Gary Morgan	ERM
Waste	Peter Braithwaite Keith Grant	ERM
Surface water ecology/ wetlands	Kathy Taggart Andrew Cauldwell Amanda Austin Chris Renshaw Crystal Rowe Fred de Villiers	Natural Scientific Services CC
Terrestrial mammals	Samuel Laurence	Enviro-Insight
Reptiles and amphibians	Luke Verburgt	Enviro-Insight
Avifauna (terrestrial, marine)	Lucas Niemand	Enviro-Insight
Terrestrial flora/ habitats	Ben Orban	Enviro-Insight
Specialist Study	**Key Specialist**	**Organisation**

Marine ecology	Robin Carter Nina Steffani Andrea Pulfrich Henry Gilham Erich Koch	Lwandle Technologies (Pty) Ltd
Fish	Emidio Andre	Impacto
Marine mammals/ coastal habitats	Adriano Macia	Impacto
Marine modelling	Steven Luger Rhydar Harris	Prestedge Retief Dresner Wijnberg
Socioeconomic studies	Bento Salema Joyce Malalane Nilza Mazivila	Impacto
Tourism	Bento Salema	Impacto
Archaeology and cultural heritage	Leonardo Adamowicz	Impacto
Marine traffic	Eugenio Muianga	Impacto
Fisheries	Atanasio Brito	Impacto

As part of the ToR, a number of the specialists undertook field studies to gather data to further assist in defining the baseline so as to inform impact assessments. The following table indicates the field work schedule which was planned to incorporate wet season and dry seasons where applicable.

Table 3.3 ***Specialists Fieldwork***

Specialist Study	**Dates of Fieldwork**
Air quality	20 – 27 February 2012 10 - 12 April 2012
Noise	20 – 27 February 2012
Climate change	Study based on existing data and interaction with Technical Team
Landscape and visual	26 – 31 January 2012
Soils, landuse, land capability	9- 22 December 2011
Groundwater	07- 14 February 2012 20 August- 17 September 2012 12 – 21 December 2012
Surface water - hydrology	14-18 May 2012
Waste	Study based on existing data and interaction with Technical Team
Specialist Study	**Dates of Fieldwork**
Surface water ecology/ wetlands	12 – 16 October 2011 21 February – 1 March 2012 21-26 June 2012

Terrestrial ecology including : o Terrestrial mammals o Reptiles and amphibians o Avifauna (terrestrial, marine) o Terrestrial flora/ habitats	08 – 20 December 2011 27 March - 06 April 2012
Marine ecology including: o Fish o marine mammals o coastal habitats	05 -19 November 2011 19 March – 02 April 2012 04 – 21 June 2012
Marine modelling	Study based on existing data and interaction with Technical Team
Socioeconomic studies including tourism and fisheries	29 November – 06 December 2011 11 - 19 January 2012
Archaeology and cultural heritage	20 October – 01 November 2011
Marine traffic	Study based on existing data and interaction with Technical Team

The results of the specialist reports have been integrated into the baseline, impact assessment chapters and ESMP in this EIA Report, see *Chapters 6* to *17*. The methodologies for the various specialist studies undertaken are summarised below and detailed in *Annex C*.

3.5.2 Impact Assessment Methodology

During scoping, a preliminary analysis was undertaken of the ways in which the Project may interact (positively and negatively) with environmental and socioeconomic resources or receptors. The impacts that were identified as potentially significant during the scoping process provided focus for the specialist studies for the detailed EIA. Each of the potential impacts identified is assessed using the following methodology.

The assessment of impacts is an iterative process considering four questions:

1. **Prediction**: What will happen to the environmental resources or human receptors as a consequence of the Project?
2. **Evaluation**: Does this impact matter? How important or significant is it?
3. **Mitigation**: If it is significant can anything be done about it to avoid, reduce or manage the impacts?
4. **Residual Impact**: Is the impact after mitigation still significant?

Where significant residual impacts remain, further options for mitigation may be considered and impacts re-assessed until they are as low as reasonably practicable (ALARP) for the Project and would be deemed to be within acceptable levels.

The methodology used for assessing impacts is detailed in *Section 3.6*.

3.5.3 EIA Report and ESMP

The results of the specialist studies have been integrated into this EIA Report and have provided input to the development of the Environmental and Social Management Plan (ESMP).

The EIA report provides an assessment of the impacts associated with the proposed Project and makes recommendations for the mitigation of adverse impacts and the enhancement of positive impacts. The ESMP is presented in *Annex D*, is in a tabular format and contains clear, practical management measures to be implemented during the construction, operation and decommissioning of the Project. Should the environmental licence be issued, the ESMP will form part of conditions of the license to ensure that the Project is conducted and managed in an environmentally and socially responsible manner.

3.5.4 Public Participation during the Impact Assessment Phase

The Draft EIA Report and ESMP were made available for public comment between 23 August and 27 September 2013. At the request of MICOA, the commenting period was extended by approximately one month to 31 October 2013. This request was to provide all stakeholders with additional time to effectively review the Draft EIA Report given the documents size and complexity.

Public meetings were held in Palma, Pemba and Maputo between 09 and 12 September 2013 to present the findings of the Impact Assessment Phase and to elicit comment on the Draft EIA Report and ESMP. During the meeting held in Palma on 11 September 2013, it was requested that the EIA Team facilitate further meetings in Palma District at a community level. Three additional public meetings were held in Maganja, Quitupo and Senga with community representatives between 16 and 18 October 2013.

A summary of the activities undertaken during and after the IA Phase is presented in *Table 3.4*. The stakeholder consultation process undertaken during the Impact Assessment Phase is further described in the PPR in *Annex A*.

Table 3.4 Summary of Public Participation Process (PPP) during EIA Phase

Activity	Purpose	Date of activity
Focus Group Meetings: Provincial Government (Pemba), Tourism Operators (Pemba) and Central Government (Maputo)	To present the EIA progress to the key groups of stakeholders to allow them to identify issues of concern	30 January – 01 February 2012
Distribution of draft EIA Report for public review	Provide information on the EIA process, the proposed development and dates of public meetings	27 August 2013
Distribution of invitations to public meetings - Maputo, Pemba and Palma	To invite stakeholders to public meetings	27 August 2013
Press advertisements for public meetings – Maputo, Pemba and Palma	To invite stakeholders to public meetings	27 August 2013
Public meetings: Palma, Pemba and Maputo	To present the findings of the EIA process to the public and to allow the public to raise concerns / queries	09 – 12 September 2013
Focus Group Meeting: Tourism Operators and Fisheries (Pemba)	To present the findings of the EIA process particularly, potential impacts to tourism operators and fisheries, to allow these key stakeholders opportunity to voice concerns / comments	10 September 2013
Distribution of invitations to public meetings - Maganja, Quitopo and Senga	To invite stakeholders to public meetings	02 October 2013
Press advertisements for public meetings – Maganja, Quitopo and Senga	To invite stakeholders to public meetings	02 - 16 October 2013
Public meetings: Maganja, Quitopo and Senga	To present the findings of the EIA process to the public and to allow the communities to voice concerns / issues	16 – 18 October 2013
Written comments received	Written comments received	27 August – 31 October 2013
Submission of Final EIA Report (including ESMP) to MICOA	For MICOA´s decision	February 2014

At a high level, key issues raised to date by stakeholders relate to:

- Land acquisition (process followed and communication).

- Displacement (physical and economic).
- Job creation and training for local communities.
- Economic benefits and community development.
- Impacts on livelihoods (tourism, fishing and agriculture).
- Impacts on biodiversity and ecosystems (marine and terrestrial).
- Impacts on health, safety and security.
- Implementation of mitigation and management measures (effectiveness of mitigation or capacity of authorities to monitor).

All comments received (verbal and written) have been consolidated into the PPR which is appended to the EIA Report in *Annex A*. Similarly, copies of all relevant documentation such as meeting minutes, attendance registers, advertisements and letters of invitation are included in the PPR.

3.6 EIA METHODOLOGY

3.6.1 Overview

The purpose of impact assessment is to identify and evaluate the likely significance of the potential impacts on identified receptors and natural resources according to a defined assessment criteria, to develop and describe measures that will be taken to avoid, minimize, reduce or compensate for any potential adverse environmental effects and to report the significance of the residual impacts that remain following mitigation.

The adequate assessment and evaluation of the potential impacts and benefits associated with the Project necessitates the development of a scientific methodology that will reduce the subjectivity involved in making such evaluations. A clearly defined methodology is used in order to accurately determine the significance of the predicted impact on, or benefit to, the surrounding natural and/or social environment. For this, the Project must be considered in the context of the area and the people that will be affected.

Nonetheless, an impact assessment is based on the professional judgment and experience of various specialists and EIA practitioners. The evaluation of significance is thus contingent upon subject matter expertise, professional judgement and dependent upon the environmental and community context. Ultimately, impact significance involves a process of determining the acceptability of a predicted impact to the receiving environment.

3.6.2 Impact Prediction

There are a number of ways that impacts may be described and quantified.

An impact is essentially any change to a resource or receptor brought about by the presence of the Project component or by the execution of a Project related activity. There are a number of ways that impacts may be described and quantified, including:

- Nature of impact: positive or negative.
- Type of impact: direct, indirect or cumulative.
- Duration of impact: temporary, short-term, Medium-term, long-term or permanent.
- Scale of impact: On-Site, Local, regional, national, international/ transboundary.

The types of impacts and terminology used in the assessment are outlined in *Table 3.5*.

Table 3.5 Defining the Nature of the Impact

Term	Definition
Nature of Impact	
Positive	An impact that is considered to represent an improvement on the baseline or introduces a positive change.
Negative	An impact that is considered to represent an adverse change from the baseline, or introduces a new undesirable factor.
Type of Impact	
Direct impact	Impacts that result from a direct interaction between a planned project activity and the receiving environment/receptors (*eg* between occupation of a site and the pre-existing habitats or between an effluent discharge and receiving water quality).
Indirect impact	Impacts that result from other activities that are encouraged to happen as a consequence of the Project (*eg* in-migration for employment placing a demand on resources). Indirect impacts can also referred to as induced or secondary impacts.
Cumulative impact	Impacts that act together with other impacts (including those from concurrent or planned future third party activities) to affect the same resources and/or receptors as the Project.

The EIA will consider routine and non-routine events that may lead to potential impacts. 'Non-routine' events generally relate to accidents or unplanned events (such as oil/fuel spills, emergency flaring or venting of gas, etc.) that may result in adverse impacts. In these cases the probability of the event occurring needs to be considered.

3.6.3 Assessing Significance

For the purposes of this EIA, the following definition has been adopted: *'An impact is significant if, in isolation or in combination with other impacts, it should be taken into account in the decision-making process'.*

It is generally accepted that significance is a function of the **magnitude** of the impact and the **likelihood** of the impact occurring. It is widely accepted that Impact Magnitude (or Severity) is a function of the extent, duration and intensity of the impact.

The criteria used to determine significance are summarised in *Table 3.6* [(1)]. The prediction takes account of mitigation measures that are already an integral part of design.

Table 3.6 Significance Criteria

Impact magnitude – the degree of change brought about in the environment	
Extent	**On-site –** impacts that are limited to the direct area of disturbance and immediate surrounds. **Local –** impacts that affect an area in a radius of up to 10km around the site. **Regional –** impacts that affect regionally important environmental resources or are experienced at a regional scale as determined by administrative boundaries, habitat type/ecosystem. **National –** impacts that affect nationally important environmental resources or affect an area that is nationally important/ or have macro-economic consequences. **Transboundary/International –** impacts that affect internationally important resources such as areas protected by international conventions.
Duration	**Temporary –** impacts are predicted to be of short duration and intermittent/occasional (typically less than 1 year). **Short-term –** impacts that are predicted to last between 1 and 5 years. **Medium-term –** impacts that are predicted to last between 5 and 10 years. **Long-term –** impacts that will last longer than 10 years and cease when the Project stops operating. **Permanent –** impacts that cause a permanent change in the affected receptor or resource (eg removal or destruction of ecological habitat) that endures substantially beyond the Project lifetime.
Intensity [(2)]	BIOPHYSICAL ENVIRONMENT: *Intensity can be considered in terms of the sensitivity of the biodiversity receptor (ie habitats, species or communities).* **Negligible –** the impact on the environment is not detectable. **Low –** the impact affects the environment in such a way that natural functions and processes are not materially affected. **Medium –** where the affected environment is altered but natural functions and processes continue, albeit in a modified way. **High –** where natural functions or processes are altered to the extent that it will temporarily or permanently cease. ***Where appropriate, national and/or international standards are to be used as a measure intensity of the impact.*** SOCIO-ECONOMIC ENVIRONMENT: *Intensity can be considered in terms of the ability of project affected people/communities to adapt to changes brought about by the Project.* **Negligible –** there is no perceptible change to people's livelihood

(1) In some cases, specialists have slightly modified the means of assessing significance based on what is most appropriate to their subject matter. Where this is the case it has been clearly outlined.
(2) The frequency of the activity causing the impact also has a bearing on the intensity of the impact, ie the more frequent the activity, the higher the intensity.

Low - people/communities are able to adapt with relative ease and maintain pre-impact livelihoods.
Medium - people/communities are able to adapt with some difficulty and maintain pre-impact livelihoods but only with a degree of support.
High - Those affected people/communities will not be able to adapt to changes and continue to maintain-pre impact livelihoods.

Impact likelihood – the likelihood that an impact will occur	
Unlikely	The impact is unlikely but may occur at some time during normal operating conditions.
Likely	The impact is likely to occur at some time during normal operating conditions.
Definite	The impact will occur at some time during normal operating conditions.

Once a rating is determined for magnitude and likelihood, the risk matrix in *Table 3.7* can be used to determine the impact significance for positive or negative impacts.

Table 3.7 Impact Significance

SIGNIFICANCE RATING				
	LIKELIHOOD	**Unlikely**	**Likely**	**Definite**
MAGNITUDE	**Negligible**	**Negligible**	**Negligible**	**Negligible**
	Low	**Negligible**	**Minor**	**Minor**
	Medium	**Minor**	**Moderate**	**Moderate**
	High	**Moderate**	**Major**	**Major**

Table 3.8 outlines the various definitions for significance of an impact and is based on the significance rating matrix.

Table 3.8 Significance Definitions

Significance Definitions	
Negligible significance	An impact of negligible significance is where a resource or receptor will not be affected in any way by a particular activity, or the predicted effect is deemed to be imperceptible or is indistinguishable from natural background levels.
Minor significance	An impact of minor significance is one where an effect will be experienced, but the impact magnitude is sufficiently small and well within accepted standards, and/or the receptor is of low sensitivity/value/vulnerability/importance.
Moderate significance	An impact of moderate significance is one within accepted limits and standards. The emphasis for moderate impacts is on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP). This does not necessarily mean that "moderate" impacts *have* to be reduced to 'minor' impacts, but that moderate impacts are being managed effectively and efficiently.
Major significance	An impact of major significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. A goal of the EIA process is to get to a position where the Project does not have any major residual impacts, certainly not ones that would endure into the long term or extend over a large area. However, for

some aspects there may be major residual impacts after all practicable mitigation options have been exhausted (ie ALARP has been applied). An example might be the visual impact of a development. It is then the function of regulators and stakeholders to weigh such negative factors against the positive factors, such as employment, in coming to a decision on the Project.

Once the significance of the impact has been determined, it is important to qualify the **degree of confidence** in the assessment. Confidence in the prediction is associated with any uncertainties, for example, where information is insufficient to assess the impact. Degree of confidence can be expressed as *low*, *medium* or *high*.

3.6.4 Mitigation

An impact assessment is designed to ensure that decisions on projects are made in full knowledge of their likely impacts on the environment and society. A vital step within the process is the identification of measures that will be taken by a project to mitigate its impacts.

In some instances, mitigation can be incorporated into the Project design (*built-in mitigation*) in order to avoid or reduce the negative impacts or enhance the positive impacts. The ongoing EIA process has therefore involved identifying where significant impacts could occur and then working with the Engineering Team to identify and develop technically and cost-effective means of mitigating those impacts to levels that are deemed acceptable. A description of these mitigation measures is included within the ESMP.

Where a significant impact is identified, a hierarchy of options for mitigation is typically explored as outlined in *Box 3.1*.

Box 3.1 *Mitigation Hierarchy*

THE MITIGATION HIERARCHY FOR PLANNED PROJECT ACTIVITIES
Avoid at Source; Reduce at Source **Avoiding or reducing at source is essentially 'designing' the project so that a feature causing an impact is designed out (*eg* a waste stream is eliminated) or altered (*eg* reduced waste volume). Often called minimization.**
Abate on Site **This involves adding something to the basic design to abate the impact - pollution controls fall within this category. Often called 'end-of-pipe'.**
Abate at Receptor **If an impact cannot be abated on-site then measures can be implemented off-site - an example of this would be to use the stand-by vessel to help control the level of interference with fishing activity.**
Repair or Remedy **Some impacts involve unavoidable damage to a resource, *eg* land disturbance. Repair essentially involves restoration and reinstatement type measures, such as base camp closure.**

3.6.5

process outlined above. The result is a significance rating for the residual impact.

The degree of significance attributed to residual impacts is related to the weight the EIA Team considers should be given to them in making decisions on the Project and developing conditions. The ESMP addresses mitigation and management of residual impacts.

Any residual **major impacts**, whether positive or negative, are considered to warrant substantial weight) when compared with other environmental, social or economic costs and benefits) for those making decisions on the Project. Conditions will be expected to be imposed to ensure residual negative impacts are strictly controlled and monitored and residual positive impacts are fully delivered.

Residual **moderate impacts** are considered to be of lesser importance to making decisions, but still warrant careful attention to conditions regarding mitigation and monitoring, to ensure best available techniques are used to keep adverse impacts within levels deemed to be acceptable and to ensure beneficial impacts are delivered.

Minor impacts are brought to the attention of decision-makers but are identified as warranting little if any weight in the decision. Mitigation will be achieved using normal good practice and monitoring will be expected to be carried out to confirm that impacts do not exceed predicted levels.

3.6.6 Cumulative Impacts

Cumulative impacts occur when a Project activity acts together with other activities (other projects) to impact on the same environmental or social resources or receptor. Cumulative impacts have been defined as *"the incremental impact, on areas or resources used or directly impacted by the project, from other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted* (1)*"*. By definition, the impact assessments in this EIA Report consider the cumulative impacts of past and present projects in that all impacts are assessed against the present day baseline. The present day baseline includes impacts of past and present projects that have shifted the original natural conditions to the present day conditions. Thus, the cumulative impacts section considers potential reasonably defined developments that could act together with the proposed Project to impact on common receptors.

The following 'reasonably defined' activities have been identified:

- establishment of an Industrial Development Zone (IDZ) by the Government of Mozambique in the vicinity of, or incorporating, the Afungi Project Site; and
- future phases of exploration and development of hydrocarbon resources by AMA1, eni and others.

3.7 MANAGEMENT AND MONITORING

A wide range of different measures to mitigate impacts have been identified in the EIA Report and the Project is committed to their implementation, success

(1) As defined by IFC Performance Standard 1, January 2012.

and continuous improvement (see *Chapter 17*). These measures are set out in the Project Description and other chapters of the report and, to assist the reader, they have been brought together in the ESMP (*Annex D*) which describes how the mitigation commitments will be delivered, together with the role of monitoring, inspection, audit and reporting. In line with Mozambican legislative requirements, additional details in the form of outline topic-specific plans (eg for waste management see *Annex E*) are provided for issues of critical importance.

3.8 DEALING WITH AND MANAGING GAPS AND UNCERTAINTY

3.8.1 General Considerations for an Evolving Project

Through the course of the EIA process, the EIA Team interacted with the Engineering Team so that environmental and social considerations were factored into Project design. However, as with most complex projects, the refinement of the Project design is an ongoing and sometimes lengthy process. Thus there is a need for a mechanism to ensure that the final design does not result in impacts that have not been adequately addressed in the EIA. Thus, in order to compensate for potential late design changes, the EIA Team has been conservative wherever appropriate and has generally considered the 'worst case scenario' in assessing impacts and developing mitigation measures. The approach has been to take a conservative view of the likely residual impacts, to identify standards of performance which the Project will meet where firm predictions cannot be made and to propose monitoring measures to confirm predictions and to identify whether additional or amended mitigation is required.

Should the Project design change substantially after submission of the EIA Report such that there are resultant significant impacts that have not been considered in this report, the Project commits to updating this EIA through an addendum.

3.8.2 Managing Uncertainty

The accuracy of predictions depends on the assessment method, degree of understanding of the environmental and social context and the level of Project detail available. In this regard, all assumptions and any resulting uncertainties have been made explicit in this EIA Report. In all instances, the significance criteria have been applied conservatively so as to develop appropriate mitigation measures that address any uncertainties. The success of mitigation will be monitored and modified as part of the Project's ESMP. Where necessary, corrective actions will be implemented to achieve desired mitigation outcomes.

Chapter 4

Project Description

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4 PROJECT DESCRIPTION

4.1 INTRODUCTION

The purpose of this chapter is to describe the components of the Project from construction to operation and eventual decommissioning. This chapter explains the Project in terms of the following main sections:

- *Section 4.2:* Overview of the Project;
- *Section 4.3:* Offshore Project component description;
- *Section 4.4:* Onshore Project component description;
- *Section 4.5:* Near Shore Project component description;
- *Section 4.6:* Management of Emissions, Discharges and Solid Wastes; and
- *Section 4.7:* Decommissioning and Closure.

The Project design is currently being refined during a Front End Engineering and Design (FEED) process. Where specific information is currently unavailable or has not yet been defined, conservative assumptions and estimates have been inserted into this project description, which has been used as the base case for this EIA.

4.2 OVERVIEW OF THE PROJECT

The Project is designed to collect, transport, process and export (in liquefied form) natural gas in northern Mozambique. This process begins offshore, where natural gas will be extracted from gas reservoirs below the seafloor via subsea wells. The gas will be collected and transported to the onshore LNG Facility by pipelines. Once onshore, the gas will be processed, converted to liquid (through cooling the gas) and stored in storage tanks. The liquefied gas will then be transported through insulated pipelines to one of two export jetties [1], where it will be loaded into LNG vessels to be transported to international markets. These specially designed ships maintain the LNG in a liquid state for sea voyages of several thousand kilometres. The indicative Project layout is illustrated in *Figure 4.1*.

(1) Hereafter the two jetties are referred to as the 'LNG Export Jetty'.

40°10'0"E 40°20'0"E 40°30'0"E 40°40'0"E 40°50'0"E 41°0'0"E 41°10'0"E

TANZANIA

Golfinho

Prosperidade

Mamba Complex

Quionga

Assame

Calomba

Quiwia

Cabo Delgado Peninsula

Palma Bay

Issa

Palma

Tecomaji Island

Manguna

Nkalanga

Macala

Quitupo

Afungi Peninsula

Senga

Nkumbi

Maganja

Aienda

Matapata

Rongui Island

40°20'0"E

40°30'0"E

Querimbi Island

Bawala

Olumbe

Vamizi Island

Metundo Island

bing

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Legend

- Villages / Settlements
- Regional Roads
- Proposed Pipeline Corridor Route
- Jetty
- Onshore Layout
- Afungi Project Site
- Prosperidade Gas Field
- Golfinho Gas Field *
- Mamba Complex Gas Fields

** Indicative area not yet approved by INP*

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 4.1:
Indicative Project Layout

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 400 000

DRAWING: Indicative Project Layout.mxd

REV: A

ERM
Great Westerford Building
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impacto Projectos e Estudos Ambientais

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10°20'0"S

10°30'0"S

10°40'0"S

10°50'0"S

11°0'0"S

11°10'0"S

Projection: UTM Zone 37 S. Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
AMA1, 2012. Inset Map: Esri Data & Maps

SIZE:
A3

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4.2.1 *Primary Project Components*

The main components of the Project are grouped together and discussed as offshore, onshore and near shore components of the overall Project. These are defined below, and a detailed discussion of these Project components is provided in *Sections 4.3* to *4.6*:

- The Offshore Project components will consist of the Area 1 and Area 4 offshore production wells and the infrastructure necessary to develop the gas reserves. This also includes the offshore pipeline system, which will convey natural gas from the offshore production fields to the onshore facilities.
- The Onshore Project components will comprise the LNG facilities and supporting infrastructure (eg worker accommodation facilities, construction areas, access roads and airport).
- The Near Shore Project components will consist of the marine infrastructure within Palma Bay necessary for construction, operation and maintenance of the Project. This includes logistic, support and export facilities (eg shipping channels, Pioneer Dock, Multi-Purpose Dock and LNG Export Jetty).

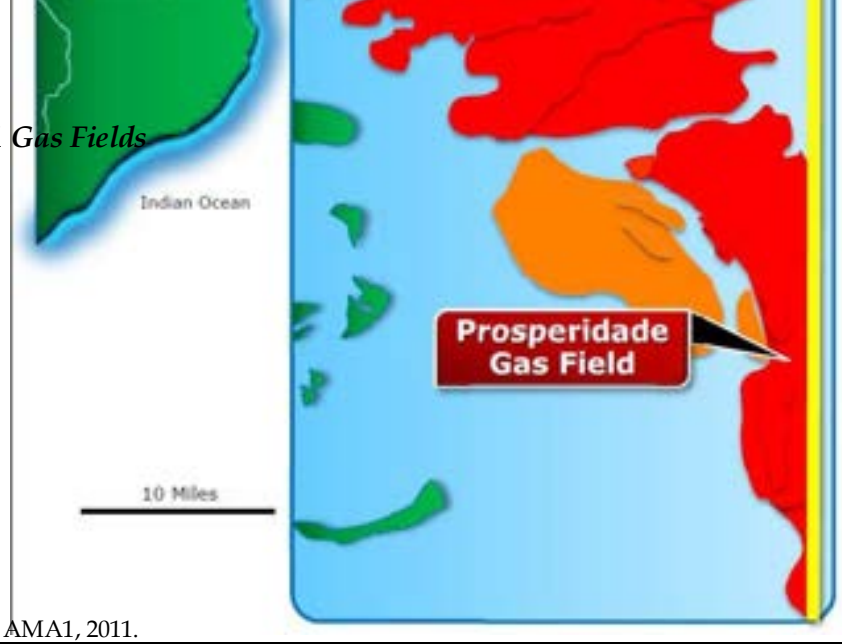
4.2.2 *Project Location and Footprint*

Offshore Project Location

AMA1 was granted exclusive rights to explore and exploit commercial quantities of hydrocarbons in Offshore Area 1 of the Rovuma Block, in the Rovuma Basin, offshore northern Mozambique, on 20 December 2006. To date, the AMA1 development consists of Golfinho Gas Field (1), in the northern portion of Area 1, and the Prosperidade Gas Field, located to the south (*Figure 4.2*) gas fields are predominately located in the northern and eastern part of Area 1, approximately 50km offshore and in water depths of approximately 1,500m. They include the Windjammer, Barquentine, Lagosta, Camarão, Golfinho and Atum gas discoveries, where in excess of 65 trillion (10^{12}) cubic feet (TCF) of recoverable natural gas has been identified to date. These subsea gas fields cover an area of approximately 350km^2. Future exploration and production activities conducted by AMA1 will also be located within Area 1.

(1) Note: As of the date of this publishing, the extents of the Golfinho Gas Field have not been formally approved by INP.

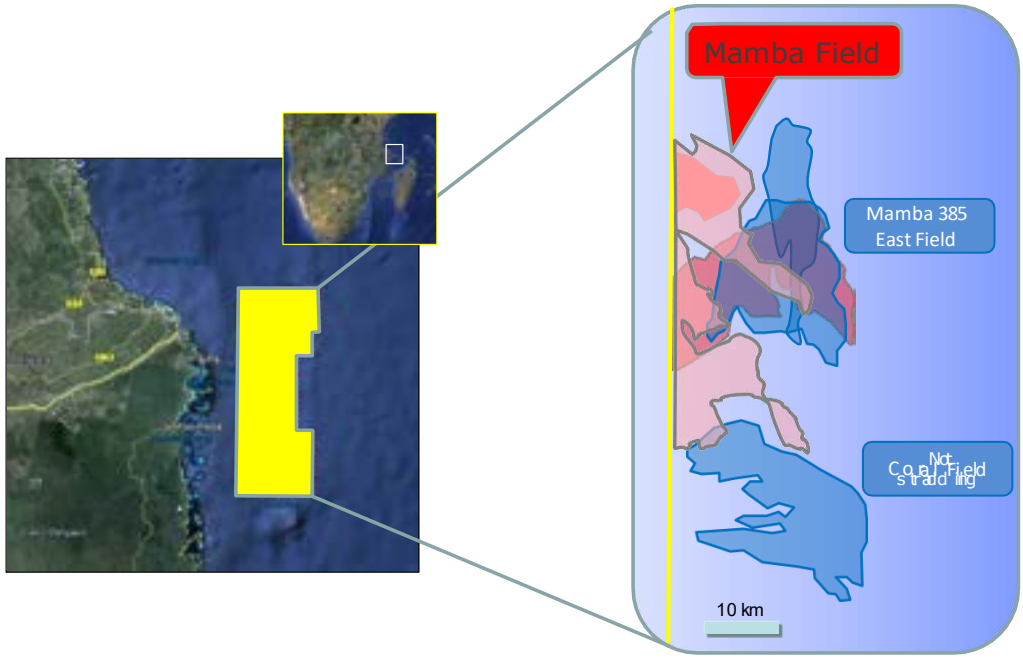
Figure 4.2 *Area 1 Gas Fields*



Source: AMA1, 2011.

Eni East Africa S.p.A. ("eni") was granted exclusive rights to explore and exploit commercial quantities of hydrocarbons in offshore Area 4 of the Rovuma Block, in the Rovuma Basin, offshore Northern Mozambique, 20 December 2006. To date eni development consists of Mamba Gas Fields, in the western and eastern portion of Area 4 and Coral Gas Field located in the south (*Figure 4.3*). These fields are predominately located in the western part of Area 4, approximately 55km offshore and in water depths ranging between 1,500m and 2,300m. They include the Mamba South, Mamba North, Mamba North East and Coral gas discoveries where approximately 80 TCF of natural gas in place has been identified to date. These subsea gas fields cover an area of approximately 1,100km^2. Future exploration and production activities conducted by eni will also be located within Area 4.

Figure 4.3 Area 4 Gas Fields



Natural gas produced from these subsea reservoirs will be transferred to the onshore LNG Facility via an approximately 45km subsea pipeline corridor, as indicated in *Figure 4.4* below. The current route of this pipeline will cross between the islands of Rongui and Tecomaji and make landfall on the north-eastern coastline of the Afungi Peninsula.

40°10'0"E 40°20'0"E 40°30'0"E 40°40'0"E 40°50'0"E 41°0'0"E 41°10'0"E

TANZANIA
Quionga
Assame
Calomba
Issa
Palma
Manguna
Nkalanga
Macala
Senga
Nkumbi
Matapata
Alenda
Quitupo
Quiwia
Cabo Delgado Peninsula
Palma Bay
Tecomaji Island
Afungi Peninsula
Maganja
Rongui Island
Queramimbi Island
Bawala
Olumbe
Vamizi Island
Metundo Island
bing
© Harris Corp, Earthstar Geographics LLC State of Michigan

40°10'0"E 40°20'0"E 40°30'0"E 40°40'0"E 40°50'0"E 41°0'0"E 41°10'0"E

Legend

- ! Villages / Settlements
- Regional Roads
- Jetty
- Onshore Layout
- Afungi Project Site
- Proposed Pipeline Corridor Route
- Gas Fields

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 4.4:
Gas Fields and Pipeline Corridor

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 400 000

DRAWING: Gas Fields and pipeline corridor.mxd

REV: A

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Projection: UTM Zone 37 S, Datum: WGS84 Source: Bing Maps ©2010 Microsoft Corporation. AMA1, 2011. Inset Map: Esri Data	SIZE: A3

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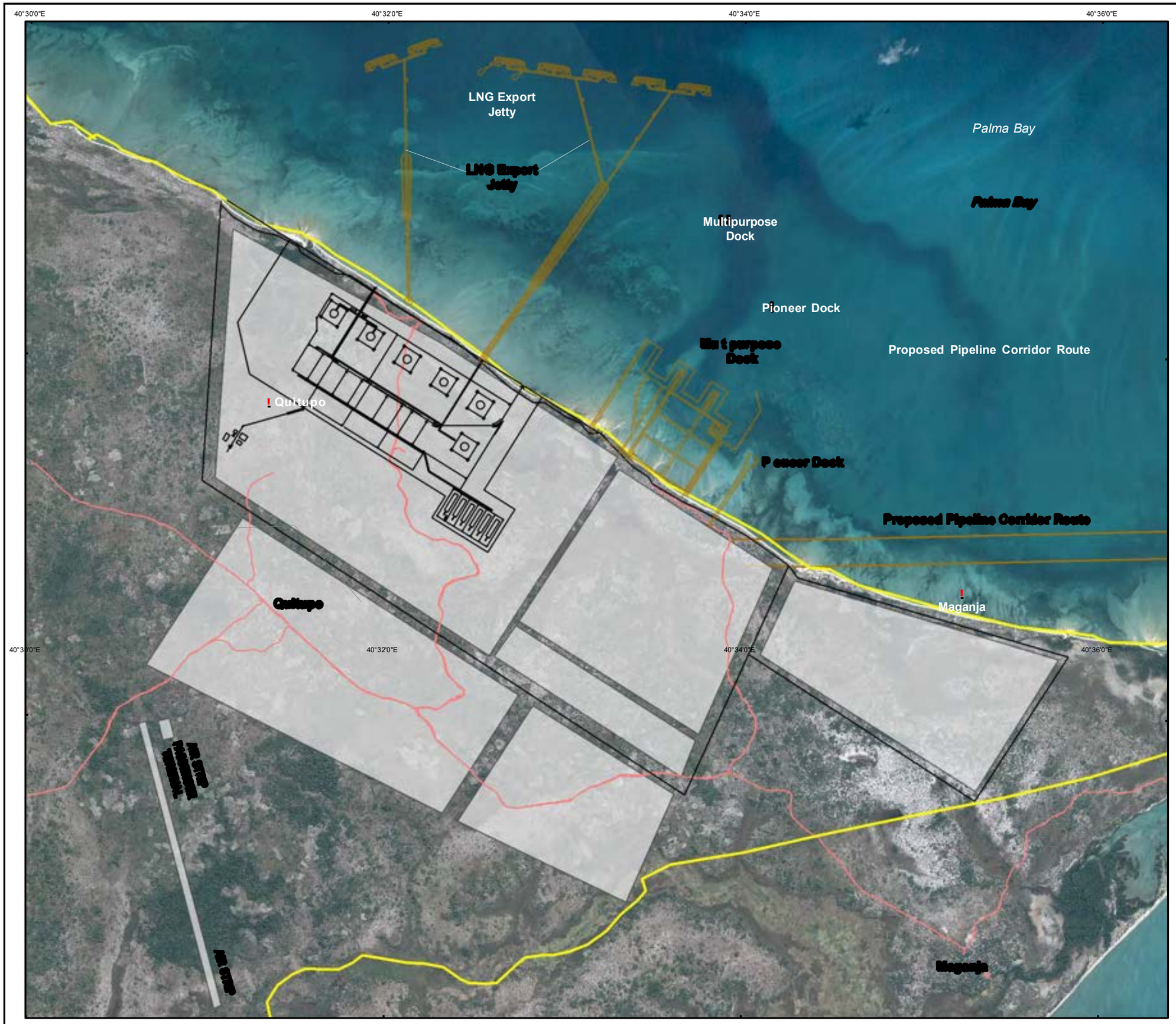
Onshore Project Location

The land area obtained for the onshore component of the Project is approximately 7,000ha. Rovuma Basin LNG Land, Lda. ('RBLL') incorporated by AMA1 and Empresa Nacional de Hidrocarbonetos, E.P. (ENH), is the holder of the Right to Use and Enjoy Land (known as a 'DUAT') for the aboye mentioned land area. AMA1 currently possesses exclusive rights to the land within the DUAT for the development of the Project, but other operators may be granted rights to use the referred land and under such understanding eni will enter in the capital of RBLL and will be granted equal rights as AMA1. This 7,000ha area is referred to Afungi Project Site. The onshore component of the Project includes the LNG Facility, storage tanks, temporary and permanent worker housing, construction and maintenance areas, supplemental construction laydown areas, airstrip, power generation facilities (gas turbines), waste disposal facilities, water and wastewater treatment facilities and buffer zones. The footprint of the onshore infrastructure, including the airstrips, is approximately 3,600ha of the overall 7,000ha of land obtained. *Figure 4.5* provides the conceptual layout of these facilities and the boundary of the Afungi Project Site.

Near Shore Project Location

The Near Shore components of the Project will be located on the coastline adjacent to the LNG Facility. *Figure 4.5* provides the conceptual layout of the Near Shore components including the Pioneer Dock, Multi-Purpose Dock (MPD), LNG Export Jetty and marine access routes. These facilities will be located in such a way that they take advantage of existing deeper water channels or proximity to deeper water. The natural channels will likely need to be deepened and widened by dredging to accommodate the Project vessels.



Legend

- ! Villages / Settlements
- Local Roads
- Near Shore Project Footprint
- Onshore Project Footprint
- Afungi Project Site

MAIN MAP SCALE:

0 1 2
Kilometers

TITLE:

Figure 4.5:
Indicative Onshore and Near Shore Project Layout

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 37 000

DRAWING: Indicative Onshore and Near Shore Project Layout.mxd

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Projection: UTM Zone 37 S, Datum: WGS84
Source: Promap, 2012. AMA1, 2011.
Inset Map: Esri Data & Maps

SIZE: A3

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10°48'0"S

10°48'0"S

LNG PROCESSING AREA

CONSTRUCTION LAYDOWN/ STAGING AREA

PIPELINE INLET GAS AREA

OPERATIONS HOUSING AREA

CONSTRUCTION SUPPORT FACILITY AREA

OPERATIONS SUPPORT AREA

10°50'0"S

10°50'0"S

4.2.3 *Project Time Frame*

The current estimated duration of the design, construction and commissioning of the first LNG Train for the Project is approximately 48 to 54 months from Project sanction. This estimate is based on a scheduled initial start-up for the LNG Facilities in early 2018 and first export shipment of LNG by the fourth quarter of 2018 (*Figure 4.6* provides an overview of the indicative Project schedule). The following section provides information on the timing of the planned Project activities.

In parallel to exploration and appraisal and the EIA, the Project basic design will be developed through the FEED process. FEED began in late 2012 and is still ongoing. After FEED, the detailed Project design will be carried into the Engineering, Procurement and Construction (EPC) phase.

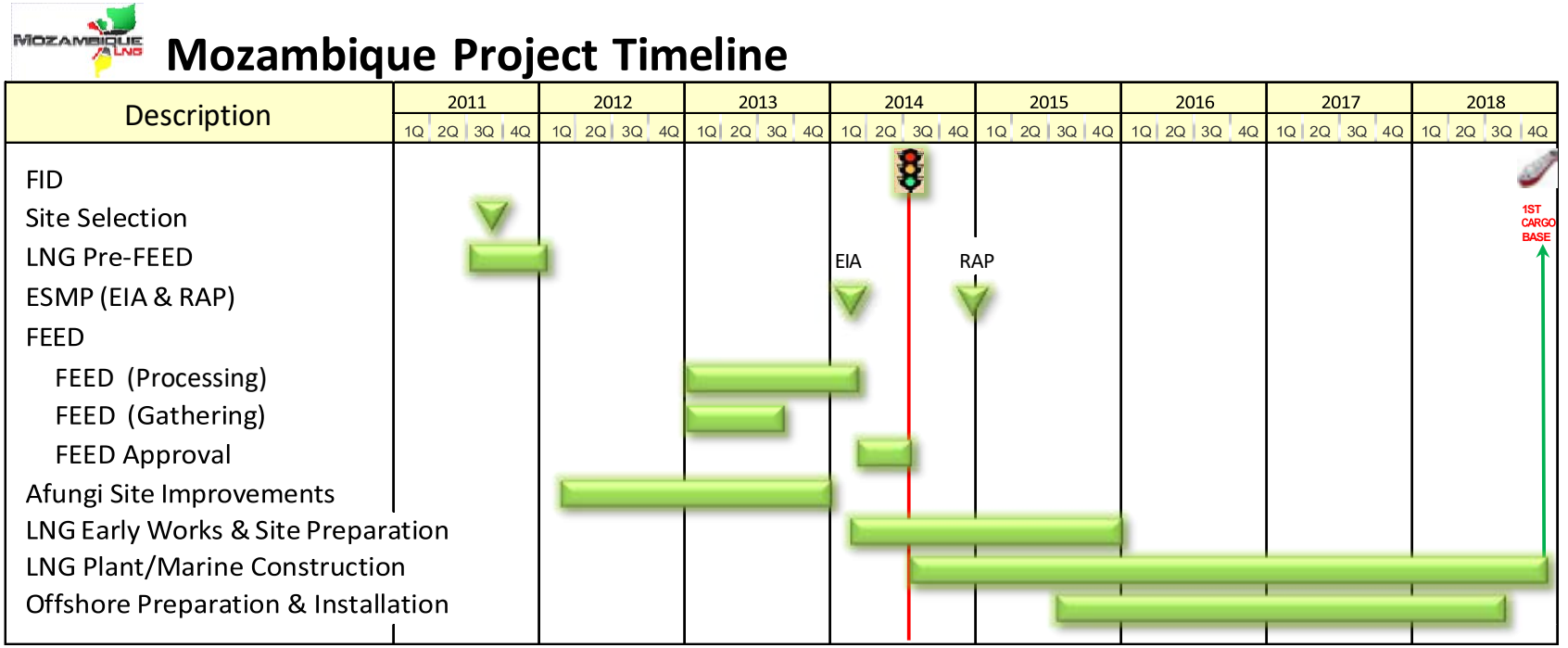
The following sections provide detail on activities that are planned for construction and operation of the Project.

4.3 *OFFSHORE PROJECT DESCRIPTION*

4.3.1 *Introduction*

The Offshore Project components will consist of the Area 1 and Area 4 offshore production wells, the infrastructure necessary to produce the offshore gas reserves, and the offshore pipeline system to convey natural gas from the offshore production fields to the onshore LNG Facility. The Offshore Project will be designed to initially produce and deliver 6 billion cubic feet (BCF) of natural gas per day to the LNG Facility located onshore. This is based on the initial development of approximately 60 production wells. Gas will be transported from the offshore gas fields to the LNG Facility via multiple subsea pipelines. The pipeline routes for Area 1 and Area 4 will join in deep water and be routed in a single corridor to the LNG Facility onshore.

Figure 4.6 *Indicative LNG Project Schedule*



4.3.2 Components of the Offshore Drilling Campaign

Up to 120 subsea wells may ultimately be drilled in the gas fields in Areas 1 and 4 during the life of the Project.. These subsea production wells will become part of the Subsea Production System (described in *Section 4.3.4*) and will be the source of the gas to be delivered to the onshore LNG Facility. The production wells will be drilled at an anticipated frequency of one well every 75 days, potentially using multiple drilling rigs.

Dynamically positioned [1] (DP) drill ships - *Saipem 10,000*, *Deepwater Millennium* and *Bedford Dolphin* - have been performing exploratory drilling activities within Area 1 and Area 4 and are proposed to conduct the drilling of the production wells. .The final choice of rigs depends on the availability of technically capable drilling rigs and the timing for commencement of production drilling activities. However, in any event, drill rigs with similar performance specifications to those currently in use will be used. An example of these DP drill ships is provided in *Figure 4.7*. These vessels are self-propelled and well site positioning is maintained using both acoustic beacons and satellite-based global positioning systems. DP drill ships provide a number of advantages over conventional semi-submersible drill rigs, including self-propulsion, capability for storing large amounts of equipment, faster mobilisation compared to the semi-submersible rigs, and operating where mooring and anchoring are not feasible. Since no anchoring is required, there will be no direct impact to the seafloor associated with anchor placement or dragging.

The drill ships will be mobilised to site either under tow by a vessel or under own propulsion in open navigable seaways. At this time, it is not anticipated that the vessels will enter any of the ports in Mozambique, except if needed to clear customs.. Supplies to the drill ships will be primarily routed through the AMA1 and eni supply bases at Pemba. Typical supplies include fuel, water, food, drilling fluid chemicals, oil well cement and chemicals, well tangibles (drill pipe, wellheads), equipment, tools and other items. Some supplies may be delivered directly to the rig.

(1) The term dynamically positioned means that the location or position of the vessel is maintained by the vessel's specialised propulsion/station-keeping system.

Figure 4.7 Example of a Dynamically Positioned Drill Ship

A shallow hazard study will be carried out to provide a pre-drilling assessment of shallow geological hazards at each proposed production well location. This assessment will be based on 3-D exploration seismic data and will be limited to the seafloor and shallow geologic section. Before drilling commences, a remotely operated vehicle (ROV) will be launched from the drilling vessel to scan the area approximately within a 500m radius around the location at the seabed. The main objective is to identify the presence of potential obstructions and environmentally sensitive features. Such features are described in the marine ecology study of this EIA. Environmentally sensitive features will be avoided, to the extent practical, to minimise impact to the environment during drilling operations.

4.3.3 Drilling and Commissioning of Offshore Wells

Prior to drilling all production wells, a drilling programme will be prepared. This will contain all the technical information regarding the drilling and safety systems and procedures in place for the well. This document will be provided to the Government of Mozambique (INP, 2012) for review and comment prior to commencing drilling. The drilling process will be conducted by means of a standard top drive rotary system suspended from the derrick of the drilling vessel. The drill string is fastened to the rotary top drive and consists of uniform lengths of hollow steel pipe, screwed together with a drill bit at the bottom end. The drill string is lowered from the derrick into the borehole. Once the bit reaches the bottom of the borehole, rotation is applied by the top drive.

Wells are drilled in sections, with the diameter of each section decreasing as depth increases. At the start of the drilling operations, the top or surface

section of the well is drilled 'open hole'; that is, the drilling mud and cuttings are not returned to the drilling rig. Before drilling the lower sections of the well, a marine riser is run between the drilling rig and the seabed, with the drill string passing down the centre of the riser.

Once the Blowout Preventer (BOP) is in place on the wellhead, the marine riser is connected from the rig to the BOP. The BOP is a series of valves and diverters that are designed to deal with erratic pressures and uncontrolled flow, should these be encountered within the reservoir. Once a marine riser and BOP have been installed, the drilling mud can flow back up to the rig where it is cleaned before reuse.

Drilling mud continuously circulates down the drill pipe and back to the drillship. Drilling mud serves several functions, including maintaining the hydrostatic pressure on the fluid column, lubricating the drill bit and drill string, and stabilising the well bore. The recirculation of the mud brings the cuttings from the bottom of the well to the surface, where they are removed from the mud system. The composition of the drilling mud is constantly changing during the drilling process, both from the addition of natural materials from the cuttings and from additives introduced to maintain the desired mud properties. Depending on different wells and on different drilling phase water based mud or synthetic and low toxic oil based muds might be used.

As stated above, once the cuttings and drilling mud reach the drill ship, the cuttings are separated from the mud system and the clean drilling mud is circulated back down the hole. Drill cuttings are cleaned by passing them through the solids control equipment, which separates the cuttings from the drilling mud.

A process known as casing is carried out to isolate portions of the well to protect the aquifers of groundwater, as well as to provide a support structure to the well itself. Casing also serves to guarantee safety and efficiency during drilling operations. It involves placing a string of protective steel pipe (casing) in the well and setting it in place by pumping specially formulated cement between the outside of the casing pipe and the well bore wall. After a string of casing is in place, a smaller drill bit is used to drill a narrower well section. The process of drilling then continues until the desired depth is reached.

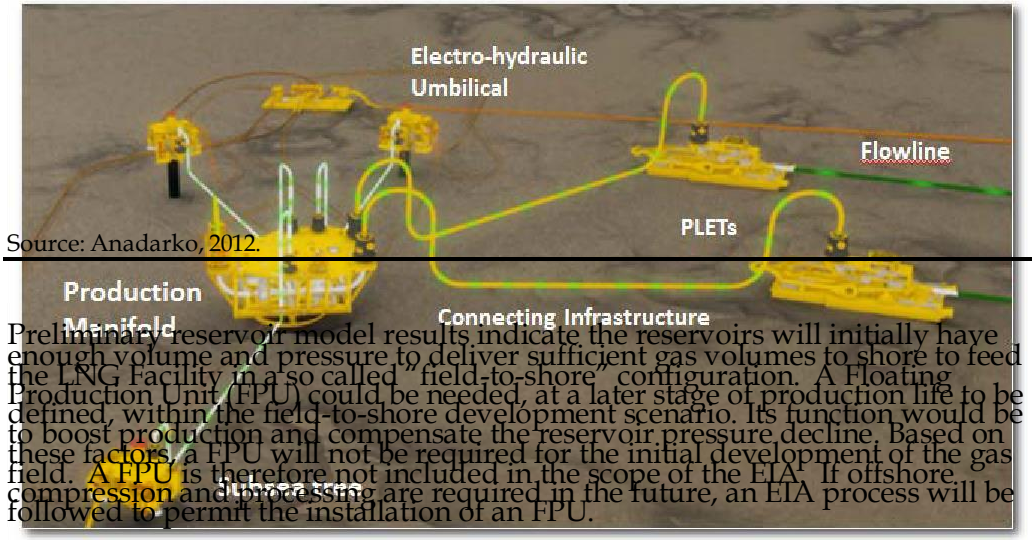
The length and diameter of each section of the well will be established prior to drilling in the drilling programme. The exact details are determined by the geological conditions through which the well is drilled.

After the drilling phase the well is completed making the well ready for production. This activity principally involves preparing the bottom of the well to the required specifications, installing the production tubing and 'down hole' tools associated with the safety valve.

4.3.4 *Subsea Production System Process Overview*

Natural gas from the subsea production wells flows through the subsea production system and connecting infrastructure to a manifold that mixes flow from other wells and directs the gas into the pipelines to shore. These components are depicted in *Figure 4.8* below, and the associated process is described in more detail in the sections that follow.

Figure 4.8 ***Indicative Layout of the Subsea Production System***



Source: Anadarko, 2012.

Preliminary reservoir model results indicate the reservoirs will initially have enough volume and pressure to deliver sufficient gas volumes to shore to feed the LNG Facility in a so called "field-to-shore" configuration. A Floating Production Unit (FPU) could be needed, at a later stage of production life to be defined, within the field-to-shore development scenario. Its function would be to boost production and compensate the reservoir pressure decline. Based on these factors, a FPU will not be required for the initial development of the gas field. A FPU is therefore not included in the scope of the EIA. If offshore compression and processing are required in the future, an EIA process will be followed to permit the installation of an FPU.

4.3.5 *Components of the Subsea Production System*

The Subsea Production System consists of a manifold design connecting subsea production wells. In some cases a design with clustered wells could be used. This design allows for multiple wells to originate from a single location, thereby limiting disturbance to the seabed by reducing the number of drill centre locations. This design simplifies the flowline layout, and allow for future expansion. The gas reservoir target depths for the production wells are based on current reservoir simulations developed from information gathered during the exploration and appraisal phase of the Project. Further optimisation of well locations and refinement of the subsea architecture will

be made as reservoir engineering work continues. The current subsea layout includes the following primary components, described in more detail below:

- subsea production trees;
- chemical injection distribution network;
- subsea flowline infrastructure;
- electro-hydraulic control umbilicals; and
- subsea pipeline.

Subsea Production Trees

Subsea production trees are the assembly of control valves, gauges and chokes (to regulate gas flow pressure) that control gas flow in a completed well. The trees are installed at the wellhead to guarantee security barriers in case flow interruption is necessary. The valves act as a fail-safe, and are hydraulically operated by means of a spring return to close automatically in case of hydraulic system depressurisation.

The subsea trees will be designed for remote installation and control through the assistance of a ROV. The subsea control system will be located onshore, within the LNG Facility. Electro-hydraulic controls connect to the trees via the umbilicals to control and regulate the flow of each well. Chokes allow the production flowlines to be operated at a consistent pressure. The trees are connected to the chemical injection distribution network to prevent hydrate formation, as described below.

Chemical Injection Distribution Network

The gas reservoir is water saturated. Once extracted, the gas cools rapidly and the water condenses. This can result in problems for downstream equipment. The water can form hydrates with CO_2 and hydrocarbons, which can potentially impede gas flow within the subsea production system and pipelines. To avoid the risk of interrupted gas flow due to hydrate formation, a monoethylene glycol (MEG) injection and recovery system is required. MEG is used to inhibit the formation of hydrates by altering the freezing point of the water found in the raw natural gas. Although MEG is the selected inhibitor for hydrate control of the subsea production, it is possible that during well start-up, and/or in the event of pipeline blockage, hydrate control will be achieved by discontinuous injection of methanol(1). Hydrate control methods will be further assessed during FEED.

In this closed-loop process, lean MEG (ie MEG with a water concentration of approximately 10 percent) is delivered to the wellhead via a dedicated pipeline connected to umbilicals, and is injected to prevent hydrate formation. The rich MEG (MEG with a higher concentration of water) flows to the onshore through pipelines together with the natural gas and is separated in

(1) The use and storage of methanol shall be object of a risk assessment.

the slug catcher [1]. The natural gas continues through the LNG processing system while the MEG is routed through a recovery system to separate water, dissolved salts and any solids and is recirculated through the closed-loop system. Storage for rich and lean MEG will be provided to handle variations in production and provide hydrate mitigation during minor maintenance intervals.

The primary waste effluents from the MEG recovery system are salt and water. The anticipated salt generation is expected to be approximately 2,200kg/day and the water generation will likely be 1,600 barrels (bbl)/day for each LNG Train. This saline fluid can be handled separately or combined into a single stream for discharge into the bay. This approach and alternative methods for the disposal of saline fluid and any solids resulting from treatment of the MEG wastewaters will be investigated and finalised during FEED, in accordance with good international industry practice.

Subsea Connecting Infrastructure

The subsea production infrastructure will be connected by manifolds, pipeline end termination structures (PLETs) and jumpers. A production manifold is a steel structure that gathers the flow from several wells and merges them into the main subsea pipeline, thus reducing the number of flowlines necessary. Each flowline will begin and end at a PLET connection. PLETs include jumpers, which are rigid or flexible pipes used to connect subsea trees to flowlines and flowlines to manifolds.

Electro-hydraulic Control Umbilicals

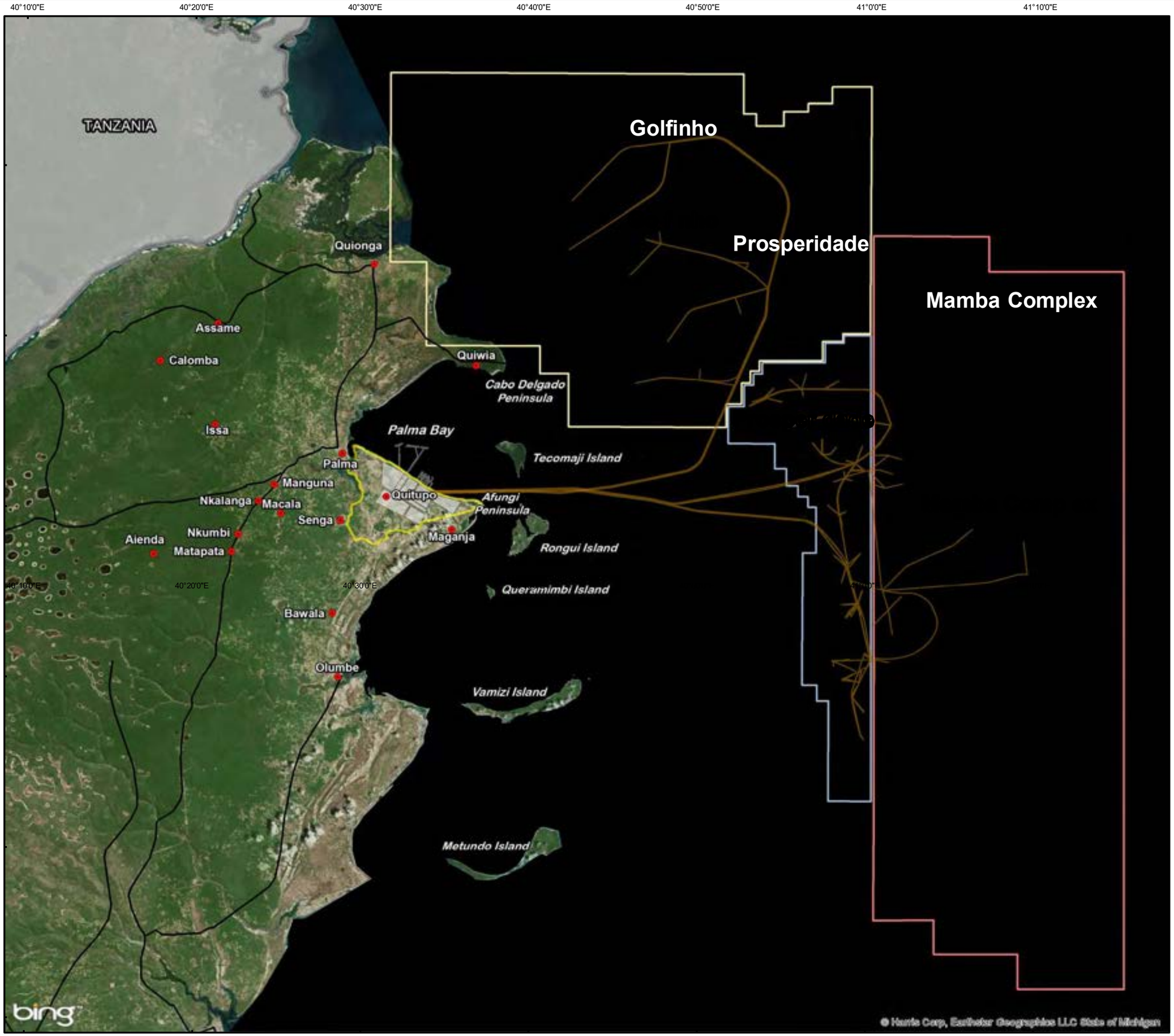
Umbilical cables control the subsea equipment remotely. They transfer hydraulic pressure and electrical power to operate subsea equipment and retrieve data through electrical and/or optical fibre cables. Umbilicals will also provide chemical injection into the subsea wells to ensure flow by preventing hydrate formation and corrosion. The chemical injection process occurs within a closed system; therefore there is no chemical loss to the marine environment.

Subsea Pipeline Corridor

Produced gas from the subsea wells will be transferred to the onshore LNG Facility via subsea gas gathering pipelines travelling within the selected gas pipeline corridor. As the pipelines approach the coastline, they will be routed in a single pipeline corridor and enter Palma Bay between the islands of Rongui and Tecomaji. Based on the alternative routes investigated (see Alternatives Analysis, *Chapter 5*) and studies conducted to date, this is the

(1) Liquids and gas do not form a homogeneous mixture as they flow through the pipeline. Liquids tend to pool in low areas of the pipeline until a sufficient volume accumulates to impede the flow of gases. Once this occurs, pressure is built up behind the liquid and the liquid is pushed through the pipeline. This phenomenon is referred to as slug flow. A slug catcher is a device that receives the slugs of liquid that accumulate over time and are pushed through the pipeline intermittently.

preferred route to bring the pipeline from deep water into the shallow bay. The approximate alignment of the pipeline corridor is indicated *Figure 4.9*.



Legend

- Villages / Settlements
- Regional Roads
- Jetty
- Onshore Layout
- Afungi Project Site
- Proposed Pipeline Corridor Route
- Prosperidade Gas Field
- Golfinho Gas Field *
- Mamba Complex Gas Fields

** Indicative area not yet approved by INP*

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 4.9:
Alignment of Gas Gathering Pipelines and Main Gas Pipeline Corridor into Palma Bay

CLIENT:

Anadarko
Moçambique Área 1, Lda

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 400 000

DRAWING:	REV:
Alignment of Gas Gathering Pipelines.mxd	A

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Fax +27 21 686 073

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Projection: UTM Zone 37 S. Datum: WGS84 Source: Bing Maps ©2010 Microsoft Corporation AMA1. 2012. Inset Map: Esri Data & Maps	SIZE: A3

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4.3.6 Construction of the Subsea Production System

Prior to construction, several activities will be performed during the FEED phase. A number of meteorological and oceanographic (metocean) buoys have been deployed within Palma Bay and the offshore development area to gather wind, wave and current information. In addition, geotechnical investigation will be conducted to characterise the seafloor and soil strata down to approximately 60m below the seafloor. Locations for subsea equipment and pipeline routes will be mapped and assessed to identify environmental and design constraints. This information will be used to define the optimum pipeline route within the identified corridor and placement of the Subsea Production System infrastructure. This routing will be finalised during FEED.

It is anticipated that a workforce of 400 to 750 construction workers and equipment technicians could be involved during the subsea system construction phase. These personnel will be housed on the offshore construction vessels or in the construction camps associated with the onshore component (discussed in *Section 4.4.4*). The construction of the Subsea Production System will last approximately 18 to 24 months and is scheduled to commence in the fourth quarter of 2015. During this construction phase, there could be 10 to 20 construction vessels active in the field at any given time.

A temporary exclusion zone will be required during construction in order to maintain the safety of the workforce and the community. The extent of this exclusion zone is anticipated to be a 500m radius around all construction vessels and construction corridors.

Installation Vessels

The installation of the Subsea Production System will be performed either DP drill ships or by purpose-built installation vessels (known as Light Construction Vessels or LCVs) common to the industry. The subsea equipment and materials will be transported to Mozambique either by Heavy Lift Vessels (HLVs), installation vessels or both. Some components may be transported by commercial freight vessels as needed.

Support services for the LCVs will be responsibility of the installation contractors. The vessels will require periodic refuelling and replenishment of provisions. It is expected that the larger LCVs will make their own fresh water but the smaller vessels may require the delivery of fresh water. All construction vessels will be compliant with the International Convention for the Protection of Pollution from Ships (MARPOL 73/78) regulations. *Figure 4.10* below provides an example of the type of vessels to be used for the construction and installation of all components of the Subsea Production System.

Figure 4.10 Typical Installation Vessel

Light Construction Vessel

Deepwater Pipelay Vessel

Flexible Pipe and Umbilical Lay Vessel

Source: Anadarko, 2012.

~~LCVs are generally 100m to 120m in length, equipped with a 150t and 200t~~ capacity cranes and operate with a DP system. It is envisioned that all

construction vessels will be DP so that no anchoring is required, thereby limiting potential impact to the seabed.

At the subsea well locations, infrastructure will likely be supported by mudmat structures [1] and suction piles [2] installed by the LCV. The LCVs will use specialised connection systems to connect the manifolds, jumpers and PLETs.

Similar to the pipelines, the umbilicals will be laid with a purpose-built, DP vessel. The shore approach for the umbilicals will be located within the pipeline corridor.

Installation of Subsea Pipelines and Umbilicals

The production pipelines and umbilicals will be laid in predetermined corridors; the pipeline will terminate at the LNG Facility and the umbilicals will terminate at the onshore control centre. The pipeline can be installed in segments and later tied in to ready the system for commissioning. The pipelines will be installed by a using purpose-built, DP lay barge, and the S-lay and J-lay methods are anticipated to be employed. The S-lay method is the traditional method for installing offshore pipelines in relatively shallow water. It is commonly referred to as the S-lay method because the profile of the pipe as it is laid forms an elongated 'S' between the vessel and seafloor. In deeper water, near the well field locations, the J-lay method may be used to install the pipelines. The choice of installation methods is dependent on ambient conditions such as the flow velocity of the currents in the area.

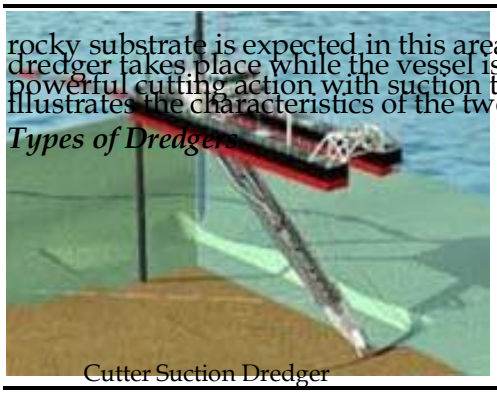
In the shallow areas of the shore approach, from the islands shoreward, it is anticipated that a dredged channel, approximately 300m wide by 5m deep, will be required to accommodate access by the lay barge to install the pipelines. Approximately 6.6 million m^3 of dredge material is expected. The area of disturbance for the lay barge dredge channel will lie within the designated pipeline corridor. The specific methods for dredging this channel will be determined once the seabed substrate composition is defined during detailed engineering. In water depths of greater than 25m at Lowest Astronomical Tide (LAT), the pipelines will be laid directly onto the seabed without the need for dredging.

It is anticipated that trailing suction hopper dredgers will be used for the majority of the dredging within Palma Bay. These dredging vessels can load their own holds using centrifugal pumps with pipes that drag along the bottom while the ship is moving. A cutter suction dredger will likely be used to dredge the channel between the islands of Rongui and Tecomaji, as a harder

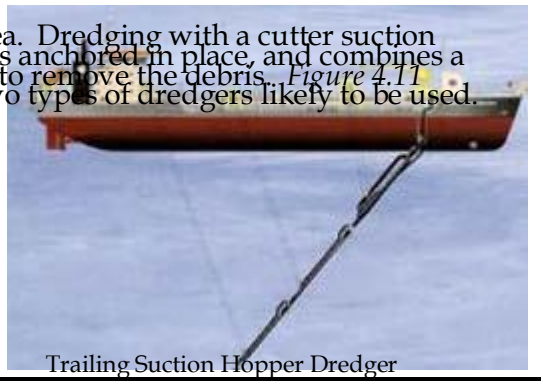
(1) A mudmat is a support foundation designed and installed to provide additional support. Mudmats are used when seabed soil is too soft to bear the load of subsea structures. The commonly used plate mudmats, often made with carbon steel, consist of a top plate and a number of perpendicular vertical stiffeners that function as load-bearing beams.
(2) Suction piles are tubular piles driven into the seabed. A pump is used to suck water out at the top of the pile, thereby pulling the pile further down to anchor it in place.

rocky substrate is expected in this area. Dredging with a cutter suction dredger takes place while the vessel is anchored in place, and combines a powerful cutting action with suction to remove the debris. *Figure 4.11* illustrates the characteristics of the two types of dredgers likely to be used.

Figure 4.11 ***Types of Dredgers***



Cutter Suction Dredger



Trailing Suction Hopper Dredger

Three options are being considered for the disposal of the dredge material:

- disposal of dredge material at a predetermined offshore location;
- temporary stockpile of dredge material adjacent to the pipeline corridor for future backfill; and
- storage and dewatering of dredge material onshore in sediment ponds.

4.3.7 *Commissioning of the Subsea Production System and Pipeline*

The commissioning activities specified herein are the base case to be further optimised during FEED. Commissioning entails numerous systematic conformity checks to verify that each component is correctly installed and ready for operation. All subsea structures and equipment are pressure tested at the place of fabrication to verify that they will function as intended in the deepwater environment. Once installed, the commissioning activities are organised by subsystem, following an approved sequence that optimises the start-up phase. Commissioning of the subsea facilities comprises the following main activities:

- post-installation surveys;
- integrity testing; and
- dewatering and nitrogen purging.

Post-installation Surveys

A visual inspection of the subsea infrastructure and pipelines will be conducted to ensure there has been no damage during installation. The

post-installation survey will likely be conducted by ROV, due to the water depths associated with the Subsea Production System.

Integrity Tests

Integrity testing will be conducted to verify that the control systems are fully functional. These tests will confirm that the mechanical, electrical, hydraulic, fibre optic, chemical injection and emergency shutdown controls operate properly.

During pipeline construction, all welds will be tested to check integrity. Pipelines will be cleaned and internal diameters checked using a pipeline inspection gauge (commonly referred to as a 'pig'). The pipelines will undergo pressure testing (hydrotesting [1]) using seawater, with the possible additions of chemicals [2] such as biocides and corrosion inhibitors. In this process, the pipeline is flooded and held at a predetermined test pressure for a predetermined period to check for material defects or leaks.

A plan for the disposal of water used for hydrotesting will be developed with careful consideration given to the impact, if any, of remaining chemicals on the environment. To the extent possible, hydrotest water will be reused to hydrotest the onshore facilities. In the event this is not practical (due to the timing of the various construction phases of the overall Project), the hydrotest water used in the testing of the Subsea Production System will only be discharged [3] after treatment to the guideline standards provided by the International Finance Corporation (IFC) [4].

Dewatering and Nitrogen Purging

Following the completion of hydrotesting, the system will be dewatered. Drying of the pipeline is essential to prevent corrosion and hydrate formation. It is also necessary to meet operational requirements. Air drying will likely be conducted by foam pigs pushed through the pipelines by filtered, oil-free, super-dry air. Upon completion of the dewatering operations, the pipelines will be purged with nitrogen to remove all air. The line pressure will be regularly monitored and recorded during the interval between the completion of purging and start-up.

4.3.8 Operation of the Subsea Production System

Once operational, the Subsea Production System will supply the natural gas to the onshore LNG Facility for treatment, liquefaction and storage prior to

(1) Hydrotesting is a frequent activity with well-established industry practices for testing the integrity of pipelines, both onshore and offshore.
(2) Dyes and additives such as corrosion inhibitors and biocides are usually added to hydrotest fluids to allow the identification of leaks and to protect the pipelines against corrosion. The chemicals to be used are widely employed in pipeline testing worldwide, and are selected for low toxicity in the aquatic environment.
(3) In this case, the expected volume of hydrotest water is approximately 120,700m³ (55,700m³ for the Prosperidade gas field and approximately 63,000m³ for Mamba) and will be discharged at the manifolds in water depths of approximately 1,500m.

(4) IFC Environmental, Health and Safety Guidelines for LNG Facilities.

shipment. The Subsea Production System is controlled by an onshore control system, which operates valves and chokes, monitors sensors and gathers data. All necessary utilities will be supplied by the onshore control system. Pressurised biodegradable hydraulic control fluid, necessary to open subsea valves on the trees and manifolds, will be delivered through tubes in the umbilicals. Chemicals injected in the gas stream subsea to inhibit hydrate formation, corrosion and scale build-up will similarly be distributed by the umbilicals. The chemical injection is a closed loop process and will be contained within the production system.

4.3.9 Future Expansion of Offshore Components

Future expansion of the Subsea Production System may be needed, based on future exploration activities, global demand for LNG and potential cooperation with other oil and gas operators within the region. As the Subsea Production System is being designed to match the capacity of the onshore LNG Facility, expansion of the production capacity of the Project may require the expansion of the Subsea Production System.

The initial onshore control system is designed to accommodate the delivery of up to 6 BCF/day via the supply pipelines. The pipeline system will be designed to allow for the tie-in of additional pipelines to accommodate future expansion. But should additional pipelines be tied in, the maximum delivery rate of 6 BCF/day will be exceeded, which will necessitate the upgrade of the onshore control system. Present assessments indicate the earliest possibility for such expansion would be 10 years after the start of production (2028). In the event that supply and demand necessitates the need for the expansion of this system, an EIA process will be initiated to permit such activities.

As discussed previously, the reservoir and fluid properties of the gas fields indicate the Project will not require the offshore compression and processing capabilities of an FPU for the initial development. If necessary, the installation of an FPU will be defined at a later stage of production life. Therefore, a floating processing facility is not included in the scope of the EIA. If required for future expansion, an EIA process will be followed to permit the installation of an FPU.

4.4 ONSHORE PROJECT DESCRIPTION

4.4.1 Introduction

The Onshore Project component will include the LNG processing facilities and supporting infrastructure (eg worker accommodation facilities, construction areas, access roads, utilities, control systems and airport). The onshore component of the Project will be initially designed to receive, pretreat and liquefy lean offshore gas sufficient to supply the LNG Facility. The current plan is initially to construct two Trains and ramp up to six Trains (with a total nominal capacity of approximately 30 MTPA) as gas production increases,

although the size of the individual Trains could vary. The construction schedule will be further defined.

4.4.2 *Overview of Onshore Facilities*

The LNG Facility will convert natural gas, supplied via pipeline from the Subsea Production System, into a liquid [1] and store it for delivery for export via LNG Carriers. AMA1 and eni intend to initially construct two LNG trains, with the construction of additional trains at a later stage. It is anticipated that construction will begin towards the end of 2014. While this EIA covers up to 6 trains (which is a reasonably foreseeable number of trains), space for the construction of up to 14 LNG Trains (in total) has also been allocated. This is to cover any future growth on the Afungi Project Site and is aligned with ENH's plans for consolidating future gas projects into one LNG Park. This area will include laydown space, warehouses, fabrication shops and office space. Therefore, the land allocation includes space for up to 14 LNG Trains, the other associated utility systems, operations/ maintenance work areas, a 7,000 to 10,000 person construction camp, and an airport consisting of a 3.5km airstrip and associated infrastructure. The total area granted for the Project is approximately 7,000ha. A conceptual image of the proposed Onshore Project Footprint Area is provided in *Figure 4.12* and is discussed in the section that follows. As discussed throughout this EIA Report, AMA1 and eni have strived to minimise the Project layout. The final LNG Facility layout will be produced as part of FEED.

(1) The process of converting the gas to a liquid, referred to as cryogenic liquefaction, involves treatment of the gas followed by a refrigeration process that will reduce the temperature of the gas (to -163 degrees Centigrade) until it condenses into a liquid.

40°30'0"E
40°32'0"E
40°34'0"E
40°36'0"E

Quitupo

Maganja

40°30'0"E
40°32'0"E
40°34'0"E
40°36'0"E

Quitupo

Maganja

Legend

- Villages / Settlements
- Local Roads
- Onshore Project Footprint
- Afungi Project Site

MAIN MAP SCALE:

0 1 2
Kilometers

TITLE:

Figure 4.12:
Indicative Onshore Project Footprint Area

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 37 000

DRAWING: Indicative Onshore Project Footprint Area.mxd

REV: A

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Projection: UTM Zone 37 S, Datum: WGS84 Source: Promap, 2012. AMA1, 2011. Inset Map: Esri Data & Maps	SIZE: A3

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10°48'0"S

10°48'0"S

LNG PROCESSING AREA

CONSTRUCTION LAYDOWN/ STAGING AREA

PIPELINE INLET GAS AREA

CONSTRUCTION SUPPORT FACILITY AREA

OPERATIONS SUPPORT AREA

OPERATIONS HOUSING AREA

10°50'0"S

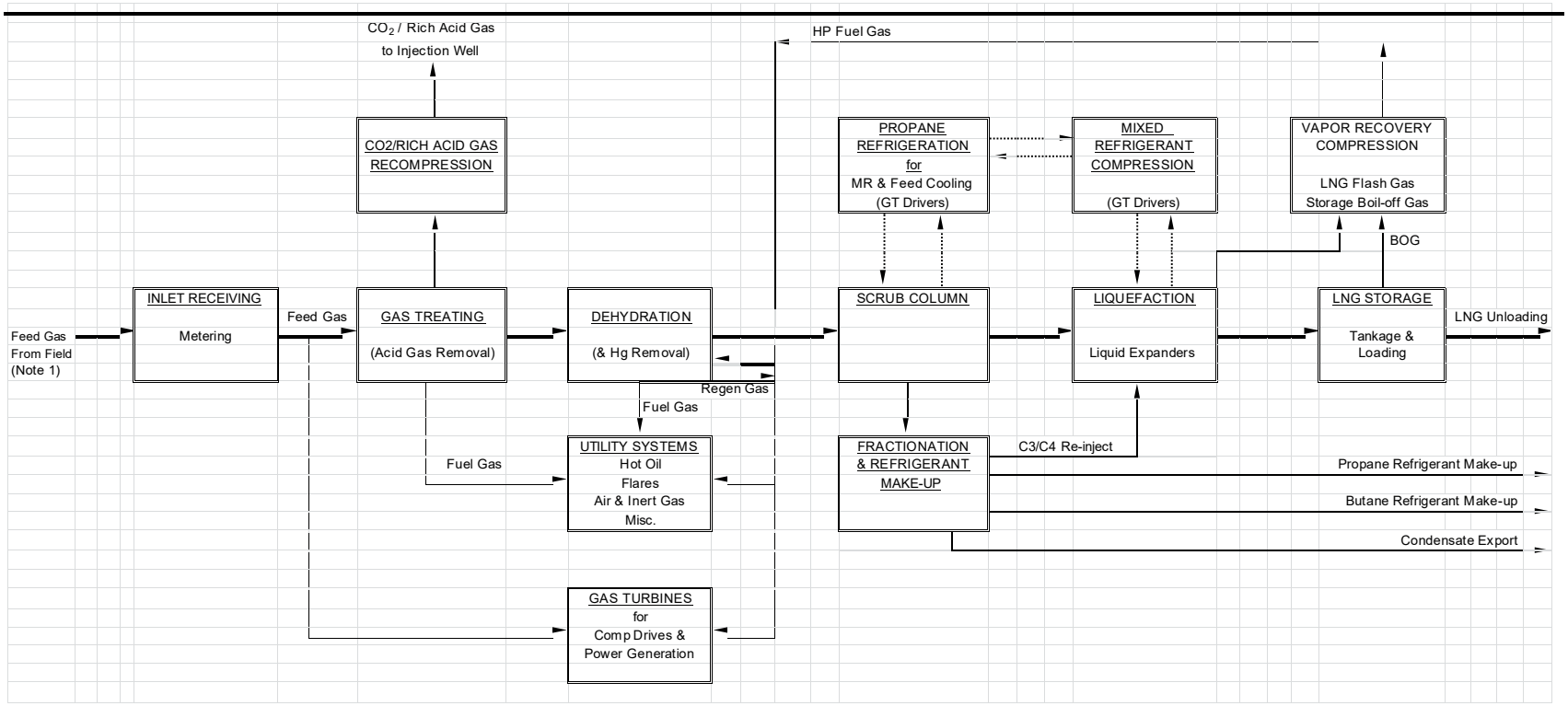
10°50'0"S

4.4.3 Components of the Onshore Project – LNG Processing Facilities

LNG is produced by cooling natural gas below its condensing temperature of negative 163°C and storing it at near atmospheric pressure. Once liquefied, the gas volume is one six-hundredth of its volume in its gaseous form, making it more economical to transport and store.

The LNG Facility will receive raw natural gas and associated liquids from the subsea gas pipelines. This raw gas will undergo pre-treatment to remove acid gas (carbon dioxide – CO_2 – and possible presence of hydrogen sulphide – H_2S), heavier hydrocarbons, water (dehydration) and mercury. The equipment to remove mercury is a precautionary measure, as tests to date do not indicate mercury will be of concern in the gas produced from the offshore reservoirs. The treated and dehydrated gas stream will then be routed to a liquefaction unit in which it will undergo multiple stages of chilling, with each sequential stage resulting in the gas stream being cooled and partially liquefied at the lower temperatures provided by the refrigeration cycle. The product from the final chilling stage will be higher pressure LNG, which will then be transferred, after pressure reduction to LNG storage tanks for storage prior to export. *Figure 4.13* provides a diagrammatic representation of the LNG process.

Figure 4.13 Typical LNG Process Flow



Inlet Facilities and Slug Catcher

The inlet facilities and slug catcher includes facilities required to receive gas supplied by the offshore pipeline transport systems (feed gas) and separate them into gas, heavy hydrocarbon liquid (mainly condensate) and rich MEG, and regulate the pressure to that required by the processing facilities. The actual gas composition from the offshore fields will determine the quantities of liquids that are produced. Depending upon the quantities produced, the heavier hydrocarbons may be used as plant fuel or exported. In light of this uncertainty, the current plan is to develop process and storage facilities for condensate.

Condensate Handling System

Current assessments of the gas composition indicate the production of approximately 3,000 to 5,000 barrels per day (bpd) of condensate per LNG Train is likely to be derived as a by-product of gas processing. Gas and liquids entering the facility from the gas pipelines are received in the inlet slug catchers and separated into individual streams. The liquid (condensate) is mixed with other liquid hydrocarbons collected from latter stages of the LNG liquefaction process described below. The condensate then undergoes further processing prior to storage in dedicated condensate storage tanks. Preliminary planning is for up to three condensate storage tanks, each with 300,000 to 650,000bbl capacity. Condensate will ultimately be offloaded to marine tankers for export.

Gas Pretreatment

Following condensate separation, the feed gas will be directed to the acid gas removal unit. This unit will remove potential impurities, such as CO_2 and H_2S, from the feed gas stream to produce a gas stream suitable for further processing. If present, these compounds would otherwise freeze when the gas is liquefied, and could impede the liquefaction process.

Dehydration

Prior to liquefaction, all moisture needs to be removed from the gas stream to prevent hydrate formation, which would result in freezing and the blockage of flow in the liquefaction process. Treated gas from the acid gas removal unit will be cooled to condense and remove the bulk of the water, which will then be returned to the acid gas removal unit. The gas will then be treated further to remove the remaining water to below 1 part per million by volume (ppmv) in the gas.

Mercury Removal

Should there be any mercury in the gas, it will be removed in the Mercury Guard Bed Unit to prevent aluminium in downstream equipment from becoming brittle. Mercury that is removed is captured on the absorbent bed

and remains there until the saturated bed is ultimately changed out and disposed of by the bed supplier during regularly scheduled maintenance.

Liquefaction

Liquefaction of natural gas into LNG will be performed using one of the two proprietary liquefaction process technologies common to the industry [1]. While the desired technology is at present unknown, the processes are similar to the extent that neither introduces a new aspect into the Project that would result in the potential for additional impacts – therefore any potential impacts will not be dependent on the liquefaction process technologies.

The decision on the preferred technology will be a product of the FEED studies. The Air Products and Chemicals Incorporated process uses propane and multi-component refrigerants [2] and a main cryogenic heat exchanger to liquefy the gas into the LNG product. The ConocoPhillips Optimized Cascade™ process uses a cascade process where natural gas is chilled in successively colder heat exchangers that use propane, ethylene and methane as refrigerants.

After liquefaction, the product leaving the process is LNG ready for storage.

LNG Storage

The LNG tanks will store the final liquefied product until it is transferred, via insulated pipeline, to specially designed LNG carrier vessels for shipping to global markets. Studies are presently ongoing to determine total LNG storage tank capacity. At present, it is estimated three LNG storage tanks of approximately 180,000m^3 net capacity will be installed for up to four trains.

All tanks will be of full-containment design. [3]

Flare System

High pressure/low pressure flare systems including flare headers will be incorporated into the LNG Facility design to, in the event of an emergency:

- provide over pressure protection of the equipment and piping;
- direct all flammable or toxic gas releases to a safe and environmentally acceptable disposal route;

(1) Air Products or ConocoPhillips liquefaction technologies are used at 90 percent of all LNG facilities. Both technology options are technically acceptable and will be evaluated further during the ongoing engineering design stage.
(2) Within the Air Products and Chemicals Incorporated suite of technologies, there are several options: Single Mixed Refrigerant (SMR), Dual Mixed Refrigerant (DMR) and Propane Pre-cooled Mixed Refrigerant (C3MR).
(3) Full-containment tanks typically feature a primary liquid containment open-top inner tank and a concrete outer tank. The outer tank provides primary vapour containment and secondary liquid containment. In the unlikely event of a leak, the outer tank contains the liquid and provides controlled release of the vapour.

- dispose of flammable or toxic gas releases in a manner that poses minimum risk to personnel or to the environment;
- provide non-emergency depressurisation capabilities for offshore associated gas and non-associated feed gas pipelines; and
- provide depressurisation capabilities for routine maintenance and start-up and shutdown activities.

4.4.4 *Onshore Components of the Project – Supporting Project Infrastructure*

The LNG Facility will be supported by the following key facilities and infrastructure:

- temporary and permanent accommodation facilities;
- temporary and permanent utilities:
  - fuel gas system,
  - power generation and distribution,
  - water desalination plant,
  - water wells and water treatment,
  - sewage and waste treatment facilities, and
  - communication infrastructure;
- buildings to accommodate:
  - administration,
  - recreation,
  - training facilities,
  - health facilities,
  - control rooms,
  - warehouses,
  - maintenance shop, and
  - security;
- infrastructure to support logistics:
  - roads, and
  - airport;
- storage facilities for the following:
  - refrigerants,
  - water, and
  - fuel.

While exact locations and layouts are unknown at this stage, the above infrastructure will be within the LNG processing area, operations housing area, construction support facility area and operations support area, as indicated in *Figure 4.12*.

4.4.5 Construction of the Onshore Project

A phased approach to construction will be employed for the Onshore Project. The Engineering, Procurement and Construction (EPC) Contractor will be responsible for the detailed final design of the LNG Facility (Onshore and Near Shore Projects) and supporting infrastructure, in addition to the procurement and delivery to site of nearly all equipment and materials. In addition, the EPC Contractor will provide all required fabrication, supervision, inspection, testing, project management, commissioning and start-up. The Contractor will provide experienced personnel and be responsible for compliance with all applicable Mozambican safety and environmental regulations, standards and permit conditions, as well as adherence to AMA1 and eni policies to comply with all legal requirements applicable during the construction phase of the Project. Moreover, all contractors and subcontractors will be contractually obliged to comply with relevant management measures in the Environmental and Social Management Plan (EMP) *(Annex D)*, with monitoring and reporting at both Contractor and AMA1/eni levels. The following text provides a description of the phases of construction in the order in which they will occur.

Afungi Site Improvements

The site improvement activities are intended to upgrade existing infrastructure and make minor preparations to facilitate the construction phase, should the Project be approved. The site improvement activities are part of the Usage Plan presented under the scope of Land Use and Benefit Rights (DUAT) process (and hence outside the scope of this EIA), but are noted here to provide an understanding of the initial site activities. At present, it is envisioned that this scope of work will include the following activities:

- limited clearance of vegetation and unexploded ordinances (UXOs) in the site improvement areas;
- improvement of the existing Afungi Peninsula access road from the main road (247) into the centre of the LNG site;
- improvement of Palma Hill Road (from the city centre to the old dock);
- improvement of existing roads on Afungi Peninsula;
- establishment of a radio tower for communication purposes;
- drilling of six water wells on the site;
- establishment of a concrete block production facility; and
- establishment of a Pioneer Camp.

During the Afungi Site Improvement phase, the Project will establish the rudimentary infrastructure necessary to support a limited workforce. It is currently envisioned that the following utilities will be established for the Pioneer Camp:

- electrical power generation;
- potable water (to be sourced from wells or desalination plant);
- sewage treatment;
- waste handling and disposal; and
- fuel storage for power generation, construction equipment and vehicles.

A Pioneer Camp area of approximately 3.5 ha will be established to accommodate approximately 400 personnel. This Camp is anticipated to be constructed in the southern portion of the Afungi Project Site and will be self-sufficient in power, communications, water treatment, sewage treatment and waste management. The majority of this infrastructure is anticipated to be modular. Therefore limited site preparation activities will be required in advance of the establishment of these components. The modular equipment will be transported to site (likely by road), assembled in place, and be in an operational state in a matter of days or weeks.

Road transport is anticipated for the delivery of raw materials necessary for foundations such as aggregate and gravel. Given the uncertainties associated with volumes of traffic and transportation routes at this early stage, the Project will develop a Methods Statement that addresses traffic and safety issues associated with the road transport of materials. This will be developed once there is more certainty on the origin of materials, volume of traffic and associated transportation routes.

The establishment of a block manufacturing facility was identified as a crucial activity for this phase of the Project. This will create training and job opportunities in the area, while allowing the Project to develop a stockpile of locally produced building materials for Early Works construction (discussed in the next section). An additional block manufacturing facility may be constructed in the town of Palma. This facility will manufacture the pavers to be used for Palma Hill Road, and blocks that can be used for possible construction projects to improve the Palma community as well as for the LNG Facility and associated infrastructure.

The Afungi Site Improvement phase of the Project is anticipated to require a workforce of approximately 400, which may include more than 200 Mozambican nationals.

Early Works

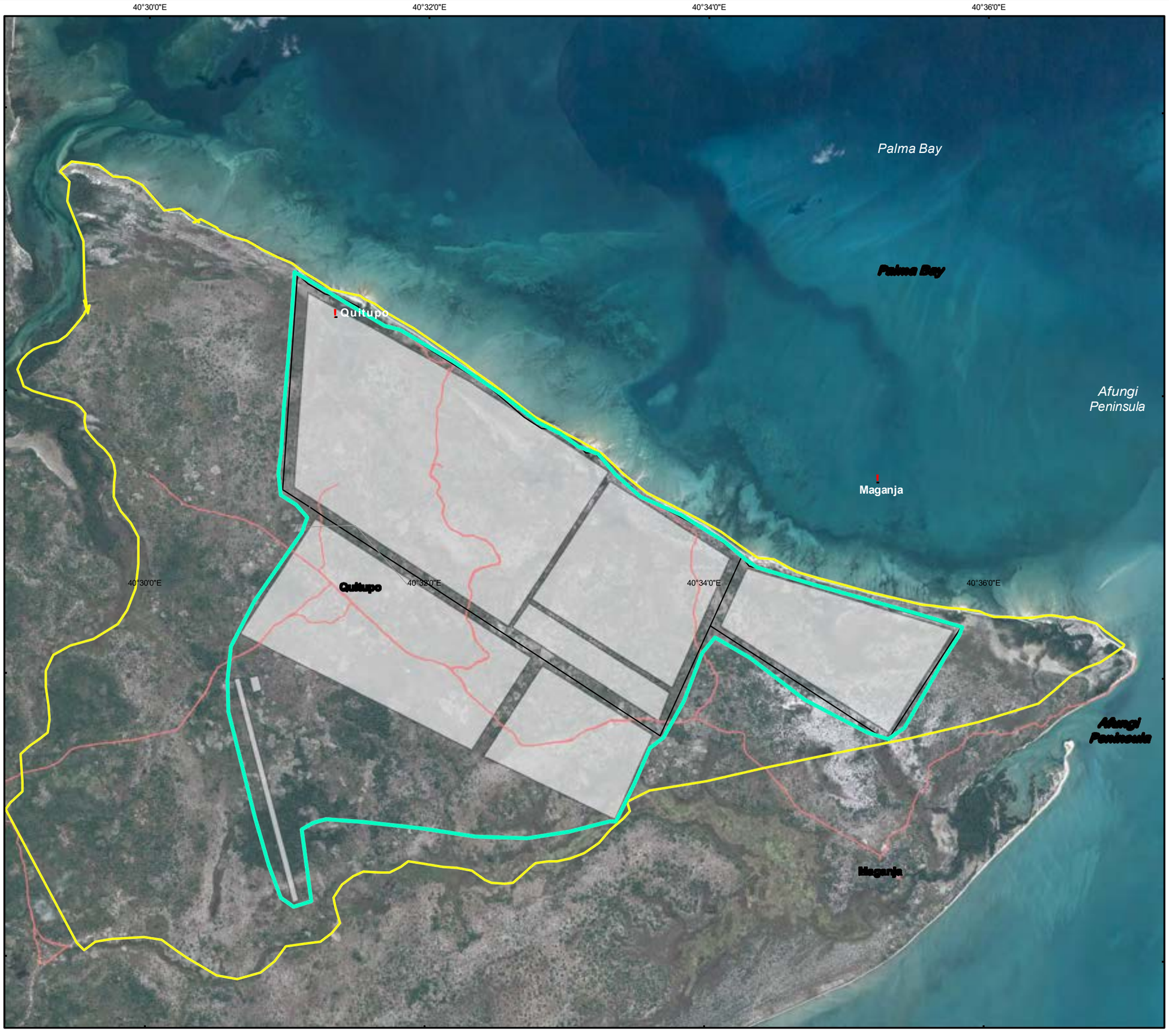
Site preparation activities will be required in advance of the primary construction phase. This phase of work will expand on the activities started in the Afungi Site Improvement phase and are anticipated to begin following MICOA approval of this EIA. The aim of the Early Works activities include

site preparation to create a stable and level platform on which the Project infrastructure can be erected, and the development of logistical infrastructure (marine and airport facilities) to bring materials and personnel to the site. The site preparation work will comprise land drainage, site clearance, site reclamation and the construction of infrastructure. Planned activities include:

- clearing vegetation and UXOs within the Project Footprint Area;
- erecting security fencing;
- expansion of the Pioneer Camp/establish Construction Camp;
- establishment of the Pioneer Dock;
- establishment of preliminary framework for Multi-Purpose Dock;
- dredging of an access channel and turning basin in Palma Bay;
- site levelling and grading;
- constructing access and haul roads; and
- establishment of a Pioneer Airstrip (1,700m improved grass airstrip).

Before the area can be safely developed by the Project, it must be completely cleared of UXOs through the use of mechanical flails [1]. In order to verify the Project Footprint Area is free from explosives, the vegetation will be removed down to ground level, and will include the excavation and removal of all stumps larger than 10cm in diameter. The removal of grass and scrub vegetation will effectively occur simultaneously with flailing activity, as the flail will uproot this vegetation and remove vegetation less than 20cm in diameter. The trees that remain after the passing of the flail will be removed by mechanical means such as bulldozers or excavators. *Figure 4.14* indicates the area subject to this degree of UXO and vegetation clearance. The remainder of the Afungi Project Site will undergo limited UXO clearance without the removal of trees or the use of mechanical flails.

(1) UXO clearance will normally employ a combination of mechanical flails followed by mine detection dog teams. A flail works by rotating a band of chains and/or spines, which strike the ground and serve to detonate or disable any surface UXO present. Any detonations during flailing as well as any indications by the mine detection dog teams will require a manual clearance team to cover the immediate area. Once the flailing is completed, mine clearance teams will work the area using electronic current detection equipment to a depth of 2.5m to ensure that the area is free from explosives.



Legend

- Villages / Settlements
- Local Roads
- Onshore Project Footprint
- Afungi Project Site
- UXO Clearance Area

MAIN MAP SCALE:

0 1 2 3
Kilometers

TITLE:

Figure 4.14:
Early Works Layout –
UXO Clearance Areas

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 48 000

DRAWING: Early Works Layout – UXO Clearance Areas.mxd

REV: A

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Projection: UTM Zone 37 S, Datum: WGS84 Source: Promap, 2012. AMA1, 2012. Inset Map: Esri Data & Maps	SIZE: A3

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10°46'0"S

10°46'0"S

10°48'0"S

10°48'0"S

10°50'0"S

10°50'0"S

Following the clearance of vegetation and UXOs, the site will be graded and levelled. During this process, topsoil will be stripped and stockpiled separately from subsoil for future use in rehabilitation and revegetation. Simultaneously, the Pioneer Dock will be established to allow the import of heavy equipment and materials to the site [1], and dredging will be conducted in Palma Bay to provide marine access to the Pioneer Dock. This is discussed in detail in *Section 4.5.4* but bears note here as the dredged material from the creation of these access channels may be hydraulically placed in settling basins onshore. Once dewatered, the dredge material may be used onsite to provide additional fill material (sand) for the construction of the Near Shore Project infrastructure, and to achieve the required height and stability to allow the construction of the LNG Facility and ancillary supporting infrastructure.

As the initial stages of the site preparation works commence (ie UXO clearance and vegetation removal), it will be important to define the boundary of the proposed facility area. Fencing will be erected for security and safety purposes and signs will be posted around the perimeter of the construction area advising the public not to enter the site. In addition, security staff will be used to prevent unauthorised access to the site.

A heavy-haul road from the MPD will be developed to transport materials and equipment shipped in for the construction phase of the Project at the site. This road will be located entirely within the Project Footprint Area and is proposed to be approximately 3km to 5km in total length and 12m to 16m wide. The road will connect the construction areas to the Pioneer Dock and MPD.

Site-specific best management practices will be developed to prevent erosion, manage stormwater, facilitate insect control and reduce the likelihood of adverse environmental impact during this and future phases of construction and permanent operations.

The early works phase of the Project is anticipated to require a workforce of approximately 1,000; 400 of whom are planned to be Mozambican nationals.

Construction Phase

The timing of the construction phase will be further refined during FEED, and the construction and installation procedures will need further development through discussions with potential EPC Contractors. However, the current estimated duration of the construction phase is anticipated to span approximately 48 to 54 months and is planned to begin in 2014. The primary objective of the Project during this phase of construction will be to develop the infrastructure necessary for the development and operation of the Project.

(1) Once the Pioneer Dock has been established, it is envisaged that the majority of material and equipment will arrive on site via sea; however, the network of improved roads may still be used, although to a lesser degree.

Constructing the onshore facilities includes, but is not limited to, earthworks; piling; concrete foundations; welding; installation of pipe racks, tanks, piping, power and control systems; construction of the permanent airport; all roads; erection of permanent buildings; and utilities and services. Large cranes will be used to offload and assemble large equipment items on site. Tower cranes will be assembled on site for the erection of various facility items, particularly piping erection and equipment setting. Smaller mobile cranes will move construction materials and equipment around the site. Essentially, all major construction equipment and components required will be imported into Mozambique. Portions of the LNG Facility are likely to be constructed using modules prefabricated at other locations, transported to site and interconnected. The following discussion provides an overview of the activities associated with the construction phase.

Concurrent with site preparation, foundations will be installed to support the facilities and equipment. Various laydown areas, workshops and other temporary buildings will be required. Piles or ground improvement methods will likely be used during the construction of the LNG Facility and tank foundations, to support the heavy equipment and modules. Lighter structures and equipment will be supported by foundations laid directly on compacted soil. Concrete for these foundations will likely be supplied by onsite concrete batching plants. It is expected that the requisite raw materials, such as aggregate and gravel, may be sourced from an existing quarry in Mozambique. In the event that no existing quarry is identified, the materials may be sourced from a foreign market. In either case, the material will likely be transported to the site by sea [1]. Once foundations have been established, the piping, electrical and mechanical installations for the process equipment and ancillary facilities will begin.

Materials and equipment required for construction of the LNG Facility include processing equipment such as heat exchangers, gas turbines, gas compressors and power generators; steel for onsite construction of the LNG storage tanks, flares, pipe racks and insulation; and package utility plants such as the water treatment plant. Some of the components of the LNG Facility, power generation unit and primary utilities may be modularised and arrive onsite as skid-mounted packages, while others will be constructed completely onsite using a stick-build [2] construction approach. The interconnecting pipe racks, utilities and other equipment may also be either modularised or erected onsite using a stick-build approach.

Supporting infrastructure such as worker accommodations, offices, health facilities, warehouses and similar structures will likely be constructed using a stick-build process. Virtually all of the building materials and prefabricated modules will be brought to the site by sea.

(1) In the event that sea transport of aggregate and gravel is not feasible, a Method Statement and transportation safety analysis will be conducted for the road transport of raw materials.

(2) The stick-build process refers to construction onsite from the ground up.

An airport will be developed within the Afungi Project Site. The airport will include a 3.5km runway designed to accommodate commercial jet airliners and heavy transport aircraft such as the Antonov-124 (1). The airport will include a control tower, terminal, administrative buildings, hangers, refuelling areas and access roads connecting the airport to the LNG Facility and to Palma. However, much of this infrastructure will be added over time as the Project expands beyond the first two LNG Trains. The location of the airport was selected for safety reasons and takes prevailing wind directions into account.

A supply of water will be required for all phases of construction for dust control, soil compaction, concrete works and for the hydrotesting of storage tanks and other equipment and piping. A supply of potable water for the construction workers is also required. Surface water run-off will likely be stored for use in dust control, as fire water and for hydrotesting purposes. This water source will be supplemented by desalinated seawater as necessary.

Virtually all material transported into the area during the construction phase will be transported to the site by sea. Most of the on-land vehicle traffic will be within the Project Footprint Area. The local transportation system may see some heavy-haul vehicles and light truck traffic. However, volumes are expected to be minimal. There will also be traffic from the local labour force and non site-related travel of the onsite staff.

The construction phase of the Project is anticipated to require a workforce of approximately 7,000 to 10,000. Approximately 20% of the workforce for the construction of the first LNG Train is envisaged to be Mozambican nationals. The construction of subsequent LNG Trains will see an increase of local labour as training and capacity of the workforce is enhanced.

4.4.6 Commissioning of the Onshore Project

It is anticipated that the commissioning period for the LNG Facility may extend as long as six to eight months, including a two-month start-up. The key issues during commissioning are flaring (discharge of burned gas), venting (discharge of unburned gas), and the disposal of hydrotest water used in integrity testing.

Flaring and Venting

Flaring occurs during the commissioning period as separate components of the LNG Facility are tested. Until the final gas quality is reached, all hydrocarbons entering the production facility must be flared or vented to the atmosphere. Venting of the pipe system may be necessary during commissioning. Such venting will be conducted in a manner that does not

(1) The Antonov-124 is a large, heavy-load aircraft requiring specific airstrip design standards.

cause undue risk to the environment and local community (ie when atmospheric conditions will carry the unburned gas away from populated areas). Venting will be minimised wherever practical, and will be conducted in a manner that reduces the likelihood of adverse impacts on the environment to ALARP (as low as reasonably practicable) levels.

A limited amount of flaring will be inevitable during the commissioning phase. The largest flare volumes will occur during the start-up period. The amount of flaring will be confirmed during the ongoing FEED process. Anecdotal evidence from similar projects indicates flaring during commissioning and start-up may initially occur for roughly 50 hours per week, falling to 30 hours per week by the end of the first month and 10 hours per week by the end of the second month. Thereafter, commissioning and start-up will be complete and the operational phase will ensue.

Once operational, there will be no routine flaring or venting during standard operating conditions. However, facilities for the immediate release of gas, through venting and/or flaring, are necessary to ensure the safety of the facility in emergency situations as well as during shutdown, start-up and maintenance activities. Gas flared from non-routine flaring is expected to be less than 1 percent of the total emissions.

Hydrotesting

A large volume of water is required to hydrotest the LNG storage tanks during the commissioning phase. To the maximum extent possible and depending upon timing of offshore and onshore construction, the water used for integrity testing of the subsea pipeline system could also be used for hydrotesting of the LNG storage tanks, LNG processing system, pipelines and other facility components. If necessary, additional water will be sourced from either impounded stormwater or desalinated sea water. After testing, the water will be returned to storage ponds and may be used for dust control and for making concrete in the batch plant operations. The remaining hydrotest water will undergo treatment prior to discharge into Palma Bay.

4.4.7 Operation of the Onshore Project

LNG processing requires a series of feed gas pretreatment stages, followed by liquefaction, storage and finally export. The pretreatment process is standard for LNG applications and includes inlet gas treatment, acid gas removal, dehydration and mercury removal. Impurities (including CO_2, water and mercury) are removed before the gas enters the liquefaction section of the LNG Facility. Liquefaction of natural gas into LNG will be performed using one of the two proprietary liquefaction process technologies common to the industry. After liquefaction, the product leaving each process is LNG ready for storage and eventual transport to the global market.

The LNG Facility will be designed for a 30-year minimum service life. During that time, operations will be continuous and operated in compliance with

applicable Mozambican regulations and relevant IFC Environmental, Health and Safety Guidelines [1]. Activities associated with LNG production over the life of the Project will include:

- operation and maintenance of the LNG processing equipment and supporting facilities (power, water and waste management);
- operation and maintenance of the permanent operations camp;
- operation and maintenance of logistics facilities (to and from the Project area via land, sea and air); and
- site security.

It is anticipated that the LNG Facility will be routinely operated by two 12-hour or three eight-hour shifts per day. Typical operational staff will consist of approximately 400 personnel; the facility will be manned and operational 24 hours per day. In addition to the core operational workforce, personnel will be required to perform shutdowns of the LNG Trains for maintenance. Routine maintenance will occur once every two to three years and will result in the shutdown of a single Train for up to a month for maintenance. During this time, gas flow will be reduced and routed to the remaining Trains for processing, storage and export. Major shutdowns are generally scheduled every few years and will require an additional workforce of 300 to 500 personnel, depending on scope. Minor shutdowns may occur more frequently and will require an additional staff of approximately 50 to 100 personnel.

The LNG Facility is expected to reach 98 to 99 percent reliability, excluding planned maintenance. Therefore, the facility would be down due to unplanned shutdowns only 1 to 2 percent of the time. To minimise flaring during shutdowns, the LNG Facility is being designed to stop the production coming from the Subsea Production System. Gas would be routed to the flare for only a fraction of the time (only if needed), while the facility is shutting down or being brought back up. Additional design features are included to minimise flaring (eg installation of spare equipment to allow continuous operation when individual units are down). Purge gas for the flare will be regulated to provide a minimum flow and prevent the entrance of air, which can create an explosive mixture.

Air traffic volume for construction and operational requirements will average two to three flights per week. Additionally, it is possible that the Project may provide bus transport for Mozambican workers from the surrounding area to

(1) Including the Environmental, Health and Safety Guidelines for Liquefied Natural Gas (LNG) Facilities; Environmental, Health and Safety Guidelines for Offshore Oil and Gas Development and the Environmental, Health, and Safety Guidelines for Ports, Harbors, and Terminals.

the Project site. Aside from these buses, Project vehicles are likely to be predominately confined to the Afungi Project Site.

Permanent worker accommodations will be designed and constructed to comply with the relevant Mozambican Codes and Standards as a minimum. These facilities will provide accommodation for approximately 400 workers. The camp will be operational at least six months prior to LNG production start-up. Facilities and buildings associated with the operational phase of the Project are anticipated to include:

- worker accommodation;
- kitchen and dining areas;
- laundry facilities;
- lounge area, game rooms, fitness centres and recreational areas;
- medical clinic;
- camp office and reception area;
- maintenance workshop;
- training centre;
- warehousing; and
- guard house.

Operation of the LNG Facility will require a high level of skilled and semi-skilled personnel.. Initially, it could be expected that some of these jobs will be filled by Mozambique citizens, with an increase in the proportion of local workforce in each subsequent year as training and experience enhance local capacity.

4.4.8 Future Expansion

The Project intends to pre-invest in key components of infrastructure (such as pipelines and additional space for onshore facilities) to facilitate the safe construction of future expansion without requiring the operational facilities to be shut down. Similar to the expansion of the Subsea Production System, the timeline for future expansion of the Project and the construction of additional LNG Trains is dependent on supply and demand. The timing of this development will be dictated by a number of factors, such as the results of future exploration campaigns, potential collaboration with other oil and gas operators, and global demand for LNG. However, current estimates presume this expansion may begin as early as 2020.. Where required, such expansion actions will undergo an EIA process to satisfy regulatory requirements.

4.5 NEAR SHORE PROJECT DESCRIPTION

4.5.1 Introduction

The Near Shore Project components comprise the marine facilities associated with the export of LNG, and logistics support facilities needed for construction and to maintain the operational effectiveness of the Project infrastructure. The marine facilities will evolve over time to support the operational phases of the Project.

The final Near Shore Project design will also be developed as part of the same FEED process used for the design of the Onshore Project components. The designs of the jetties, mooring and dolphin systems (1) will be in alignment with industry-recognised codes and standards.

4.5.2 Near Shore Facilities System Overview

The Near Shore Project comprises the interconnection of the marine facilities in Palma Bay (not associated with bringing gas to shore) and Onshore components of the overall Project. This component of the Project includes the MPD, LNG Export Jetty, mooring dolphins, navigation channel, navigation aids and the LNG loading facilities and serves as the central hub for the development of all aspects of the Project, from construction to the eventual export of LNG to the global market. The proposed locations of these components are depicted in *Figure 4.15*.

(1) A dolphin is an isolated marine structure for the berthing and mooring of vessels.

40°32'0"E

40°34'0"E

LNG Export Jetty

LNG Export Jetty

Multipurpose Dock

Pioneer Dock

40°32'0"E

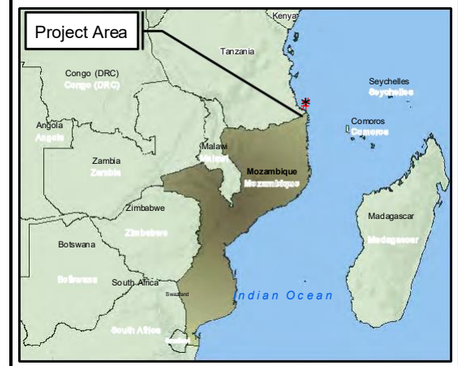
40°34'0"E

Multipurpose Dock

Pioneer Dock

Legend

- Local Roads
- Near Shore Components
- Onshore Project Footprint
- Afungi Project Site



MAIN MAP SCALE:

0 250 500 750 1 000

Meters

TITLE:

Figure 4.15:
Layout of Near Shore Components

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 20 000

DRAWING: Layout of Near Shore Components.mxd

REV: A

ERM
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Impacto Projectos e Estudos Ambientais

ERM

Projection: UTM Zone 37 S, Datum: WGS84
Source: Promap, 2012. AMA1, 2012.
Inset Map: Esri Data & Maps

SIZE:
A3

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10°48'0"S

10°48'0"S

During the construction phase of the Project, the marine facilities will be developed to accommodate the import of construction materials. The MPD will be located adjacent to the proposed LNG Facility; this will serve as a heavy-load construction dock. The MPD will be designed to accommodate vessel mooring, equipment offloading, laydown and storage areas, as well as routine vessel maintenance. However, the Project will contain no dry dock facilities.

During the operational phase of the Project, the MPD will include facilities to accommodate the marine harbour fleet. It is anticipated that the marine harbour fleet will consist of escort tugs, line handlers, pilot boats and response boats/equipment necessary to provide safe navigation and manoeuvring of the LNG Carriers and, potentially, other offshore infrastructure support vessels.

The LNG Export Jetty will be located along the Afungi coastline north of the LNG Facility. It is anticipated ultimately to comprise two 2,000 to 3,000m long causeway and trestle jetty structures with associated berthing and LNG loading facilities. The LNG Export Jetty will initially include two independent berths located at the end of the first trestle; a second trestle with up to four additional berths will be added in the future. Each berth will be designed to accommodate the LNG Carriers and will have a minimum water depth alongside of 15m at Lowest Astronomical Tide (LAT).

Support vessels, including a pilot boat, tug boats and general support vessels, will be active in the area during normal operations to assist with the safe navigation and manoeuvring of the LNG Carriers.

A safety exclusion zone of 500m will be established around the Near Shore facilities during construction. Once operational, a permanent safety exclusion zone of 500m will be established around the MPD and LNG Export Jetty and moving exclusion zones of 1,000m in front and 500m to each side will be established around all LNG carrier vessels during transit. No transport vessels or fishing will be allowed within the safety zones.

4.5.3 Components of the Near Shore Facilities

The Near Shore Facilities will comprise the following elements:

Pioneer Dock

The Pioneer Dock may be a temporary facility or it may be expanded or incorporated into the permanent Near Shore infrastructure. In the event that this is a temporary structure, it will be decommissioned and removed once the permanent facilities are developed.

Multi-Purpose Dock

The MPD will be established to support the primary construction phase of the Project and will avoid the need to transport heavy, large or unwieldy loads by road. The MPD is anticipated to be approximate 600m wide, extend 800m to 1,500m from the shoreline and stand approximately 10m above LAT. Vessel handling and materials offloading equipment will likely consist of 14 25t safe working load bollards (to facilitate vessel mooring) and two 80t bollards for Roll-on/Roll-off vessels (to accommodate the offloading of large modular equipment).

The MPD will likely include a marine services facility on the eastern side of the MPD and will be sheltered by a breakwater. This area will accommodate the marine harbour fleet consisting of escort tugs, line handlers, pilot boats and response boats/equipment. Refuelling of support vessels will occur within the protected breakwater area of the marine services facility. It is expected that support vessels will be refuelled at a dedicated fuelling berth for both diesel (tugs) and gasoline (utility boats). No fuel storage tanks are proposed on the MPD itself; fuel will be transferred to the fuelling berth, via dedicated pipelines, from onshore fuel storage tanks. LNG Carriers will not be refuelled at the MPD.

LNG Export Jetty and Berthing Area

The LNG Export Jetty will link the LNG and condensate storage tanks with the LNG export berths. The design of the LNG Export Jetty will comprise up to two LNG berths connected to the onshore facilities by a combination causeway/trestle. The causeway will extend from the shoreline to the approximately 2m LAT depth contour, at which point an elevated roadway/pipeway trestle structure will extend to a water depth of approximately 15m LAT. The trestle is likely to be approximately 7 to 10m above LAT and have a total width of approximately 14m to accommodate a roadway and pipe rack, separated by concrete barriers. The causeway and trestle will be designed to support a minimum of:

- LNG loading and vapour return lines;
- condensate loading and vapour return lines;
- utilities;
- roadway capable of accommodating trucks carrying heavy loads, ambulances, small cranes and pedestrian traffic; and
- mooring and berthing facilities.

The vessel berthing area will be designed such that the largest vessels anticipated can moor without tidal restrictions. The LNG berth is proposed to comprise a loading platform, four breasting dolphin systems and six mooring

dolphins, designed in accordance with industry standards. These structures will be supported on piles, and access to the dolphins will be provided by catwalks. Loading of LNG will be conducted using multiple loading arms and one vapour return line, to allow vapours to flow back into onshore storage tanks for recovery instead of venting to the atmosphere. Each berth shall be fully outfitted with all processes and utilities, piping systems and equipment, so that either berth can be used to load LNG. For safety reasons, only one ship at a time will be loaded with LNG; however, a second vessel will be allowed to move to the berths.

The LNG Export Jetty will be designed to load one LNG carrier at a time initially. A second Export Jetty will be constructed to facilitate the loading of two LNG Carriers at the same time. The LNG Export Berth will be able to load LNG Carriers corresponding to approximate loading frequencies of:

- Train 1 – 5 MTPA: average one vessel per week;
- Train 2 – 10 MTPA: average two vessels per week;
- Train 3 – 15 MTPA: average four vessels per week;
- Train 4 – 20 MPTA: average six vessels per week;
- Train 5 – 25 MTPA: average eight vessels per week; and
- Train 6 – 30 MPTA: average 10 vessels per week.

Condensate will be offloaded to marine tankers of up to 650,000bbl capacity through either a berth in the MPD or the LNG Export Jetty. The offloading system options will be evaluated to minimise interference with other marine traffic, dredging requirements and overall cost. The frequency of condensate offloading is assumed to be once in two to three weeks.

Turning Basin and Access Channel

The LNG Export Jetty will be accessed by an approximately 15m LAT deep and 160m wide approach navigation channel, constructed by widening and deepening an existing channel in Palma Bay. The turning basin and areas access the channel will be dredged to a depth and size sufficient to enable LNG Carriers to manoeuvre safely and moor at the facility. The turning basin is likely to require the dredging of a 600m turning circle to allow large vessels to be positioned, by support vessels, to the berthing area of the LNG Export Jetty.

Vessels

The LNG carrier vessels typically range between 125,000 and 267,000m³ in capacity, with typical dimensions of length of 350m, beam width of 50m and draft of approximately 12m. Support vessels, including a pilot boat, up to four tug boats and general support vessels, will be active in the area during normal operations to assist with the safe navigation and manoeuvring of the ENG Carriers. Support vessels from the marine harbour fleet will be used during the operation of the LNG Facility and will be based at the adjacent MPD. Anticipated vessel types include:

- escort tugs;
- line handlers;
- pilot boats; and
- security and response boats.

4.5.4 *Construction of the Near Shore Project*

The construction of the Near Shore Project is anticipated to begin the first quarter of 2014 and extend for a duration of approximately 18 months. The activities associated with this development are discussed in the text below.

Dredging

The coastline of the Afungi Project Site is subject to a daily tidal fluctuation of approximately 4m. This, in addition to the shallow depth of Palma Bay, necessitates dredging to provide continuous vessel access. Dredging will be required to deepen and widen the existing natural channel to create a shipping approach channel to accommodate LNG vessel traffic. Dredging will also be required for construction of the export terminal facilities and MPD. A turning basin will be established to enable vessel access to the MPD and the berthing area adjacent to the export terminal facilities. As discussed in *Section 4.3.6*, dredging will also be required for the pipeline shore approach. Dredge material from these areas will likely be used for the development of the MPD and associated causeways. On completion of the dredging works for the turning basin and shipping channel, new permanent navigation aids for the shipping approach channel and turning basin will be installed.

It is anticipated that trailing suction hopper dredgers will be used for the majority of the dredging in the area of the access channel, turning basin, MPD and berthing area, as preliminary investigations indicate the seabed is primarily composed of sand. A portion of the dredged materials will be pumped ashore via a pipeline into purpose-built settling basins. Once dewatered, the dredge material may be used onsite to provide additional fill material (sand) for construction of the Near Shore Project infrastructure, and onsite to achieve the required height and stability to allow the construction of the LNG Facility and ancillary supporting infrastructure. The remainder will be disposed of in a predetermined offshore location.

While final dredging volumes will be established during further engineering, Pre-FEED estimates indicate that dredge volumes for the Near Shore Project are likely to be approximately 5.3 million m^3. The equipment choice for dredging will be dependent on future planned geotechnical characterisation of the ocean floor within Palma Bay. Preliminary estimates indicate that maintenance dredging requirements will be minimal and occur at the most in the order of every three to five years.

Multi-Purpose Dock

Preliminary design for the MPD proposes a 300m-wide, dredge-filled causeway, rising from ground level at the shoreward end to approximately 2m above LAT at the seaward end; this will be confirmed during FEED. The MPD is likely to be constructed via dredge material mechanically placed into a sheet pile [1] barrier. The sheet piles used in the construction of the MPD (and other components of the Near Shore Project) will be brought to site via barge. Conventional pile-drivers (impact or vibratory) will be used to drive sheet piles into the seafloor. Dredged material will initially be pumped into an onshore placement area, dewatered and mechanically placed into the causeway (ie by truck haul and/or conveyor system). To account for likely erosion, bunds may be over-constructed and maintained during construction until the final rock armouring is complete [2]. The causeway surface will be finished with concrete to provide a cambered surface to support the movement of heavy cargo.

As the MPD will provide for the offloading of heavy cargo, it will require a dredged depth of approximately 10m below LAT to accommodate the heavy lift and Roll-on Roll-off vessels. Dredge requirements for the support vessel staging and mooring areas are likely to be 6m LAT.

LNG Export Jetty and Berthing Area

The LNG Export Jetty will consist of a combination causeway/trestle structure. As with the MPD, the causeway will likely be constructed via use of dredge material mechanically placed into a sheet pile barrier. The trestle will be a pile-supported structure with either steel pipe or concrete piles located at 15 to 30m spacing. The piles will be driven to a depth of 20 to 35m below LAT with conventional hydraulic or diesel impact hammers mounted on barges. Pile driving will move progressively seawards from the causeway; the surface of the trestle will be formed by connecting prefabricated sections to the top of the piles. These sections will be lifted into place by barge-mounted cranes and attached to brace the structure. The trestle will extend to the LNG vessel berthing area, which will consist of four breasting dolphins, six mooring dolphins and an approximately 40 x 30m loading platform.

The LNG export berth will be built at the seaward end of the trestle once the trestle is complete. The breasting and mooring dolphins will be supported by piles driven into place by barge. Once the piles are in place, a barge-mounted crane will be used to install precast supporting structures followed by decking, catwalks and mechanical and electrical works, as well as the LNG loading arms, vapour return lines and associated export berth utilities.

(1) Sheet piling is a construction form that utilises interlocking sheets of steel to create a continuous barrier in the ground. Primary applications of sheet piles include retaining walls and cofferdams erected to enable permanent works to proceed.

(2) Rock source to be determined – requires input from Quarry Study.

4.5.5 *Future Expansion*

The timeline for future expansion of the Near Shore Project (eg additional berthing areas) and the construction of additional LNG Trains is at present unknown and will be dictated by the results of future exploration campaigns, potential collaboration with other oil and gas operators, and global demand for LNG.

4.5.6 *Commissioning of the Near Shore Project Facilities*

The commissioning activities planned for the Near Shore Project components will be similar to those proposed for the Offshore and Onshore components of the Project. The piping system used to deliver LNG to the export facility will be commissioned at the same time as the LNG Facility and will simultaneously undergo hydrostatic, integrity and systems control testing. The boil-off gas recovery system will be tested to verify capability to recover vapours associated with the LNG storage, holding and loading operations; these vapours will either be routed to the fuel system or compressed and recycled back to the process. Occasionally, an LNG vessel would need to be cooled before accepting LNG. This usually happens when the vessel comes from a dry dock. In such a case, before cooling the vessel, a mixture of methane and inert gas would be flared for a few hours. Venting or flaring of boil-off gas is not expected during routine marine loading operations; however, limited amounts of venting and/or flaring are likely during commissioning.

4.5.7 *Operation of the Near Shore Project Facilities*

During the operational phase of the Project, the Near Shore components will serve primarily as the point of export for the processed LNG. However, this component of the Project is also essential to maintain the operational effectiveness of the overall Project infrastructure. As such, it will continue to serve as the primary hub for the import of materials necessary for the maintenance and future expansion of all aspects of the Project.

Multi-Purpose Dock

During operation of the LNG Facility, the MPD will be used only occasionally to unload equipment and materials for maintenance activities and construction of new LNG Trains. Normal quarantine and customs procedures will apply. The MPD will serve as a port, fuelling and staging area for support vessels (1). These vessels will be active in the area during normal operations in order to assist with the safe navigation and manoeuvring of LNG Carriers.

(1) All waste from the vessels will be handled in accordance with MARPOL 73/78 requirements. Solid waste will be delivered to the onshore facilities as an integrated part of the onshore waste management system.

It is anticipated that each LNG Carrier will have service vessels that provide support for operations in the form of tugs [1] and supporting vessels. The main tug activities will include:

- providing potential escort services for the LNG Carriers as they transit to the facilities;
- providing assistance to the LNG Carriers during berthing and unberthing operations at the LNG Export Jetty; and
- providing firefighting, rescue services and spill response as required.

The supporting vessels will likely consist of small utility boats to facilitate general operations and provide security. The main functions of the utilities boat(s) will include:

- mooring line transfer (depending on terminal operating procedures);
- general maintenance of facilities; and
- security.

Besides assisting during the LNG carrier berthing and unberthing operations, the utility boats may be in operation on a daily basis, fulfilling the various functions outlined above. It is conservative to assume that four utility boats may be required to support operations. Dedicated patrol boats will enforce the moving exclusion zone around LNG carrier vessels during the time that they are under pilot control.

LNG Export Jetty and Berthing Area

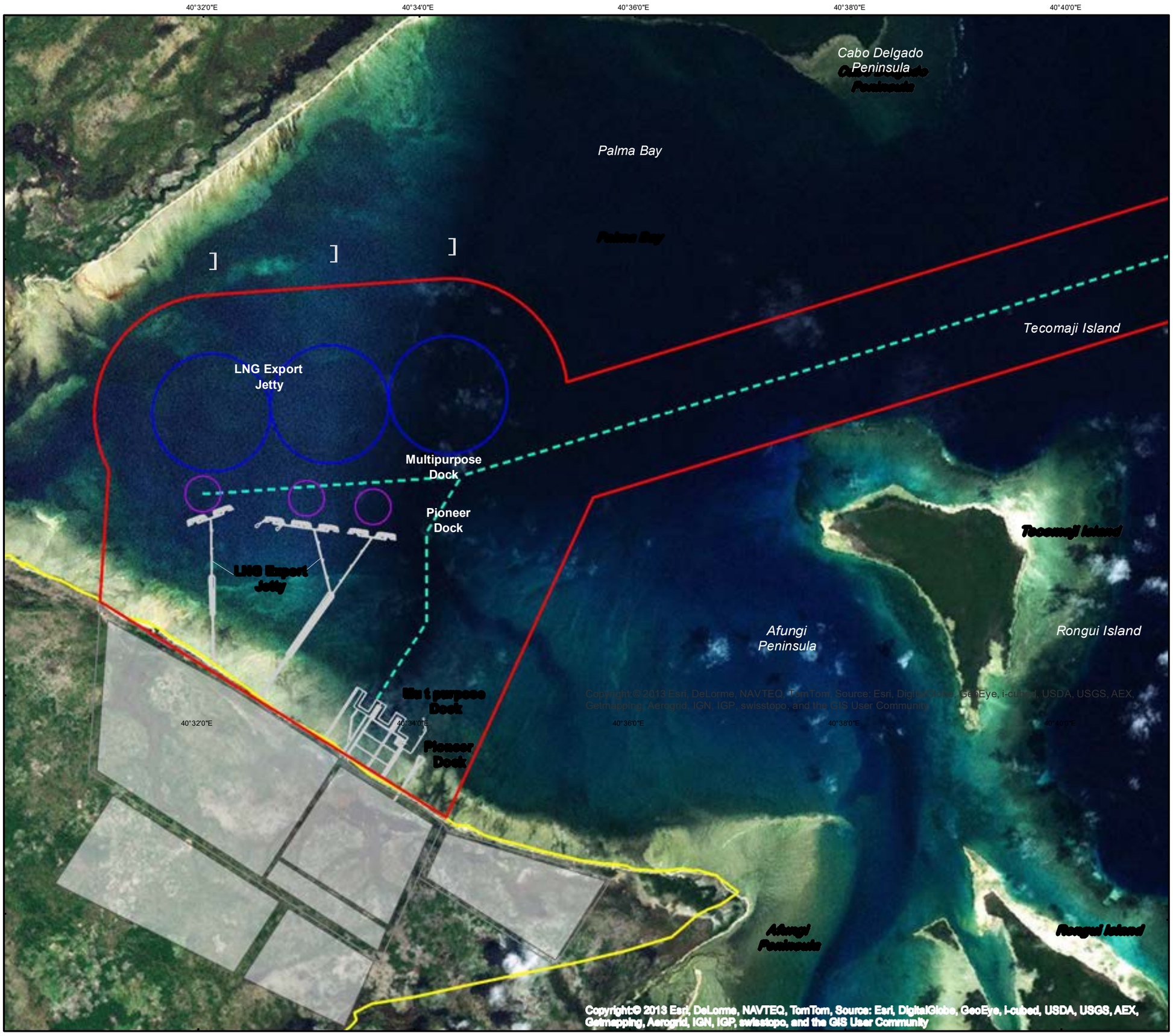
By the fourth quarter of 2018, the first LNG Train is expected to be operational. Initially, it is anticipated that the LNG Export Jetty will receive about four or five LNG Carriers and one or two marine tankers (for condensate export) per month. As LNG production increases, export vessel traffic will follow.

LNG Carriers will be met by pilot vessels before entering Palma Bay through the natural deepwater channel between Tecomaji Island and the Cabo Delgado Peninsula. The LNG Carriers will be escorted by pilot vessels to the LNG Export Jetty, where they will be manoeuvred into the berthing area by a fleet of tugs. This proposed route is illustrated in *Figure 4.16*. Fixed navigational aids (buoys) will be in place to delineate the channel boundaries and to mark shallow areas to be avoided. For marine safety reasons, only one LNG carrier at a time will be allowed to move to and from the LNG Export Jetty.

(1) Although the need for tug escort has not yet been verified, for the purposes of this document it is conservative to assume that it will be required. Tugs will likely be stationed at the MPD. At least three to four harbour tugs will be required for berthing and unberthing the LNG carriers. In addition, it is conservative to assume that two escort tugs may be required to assist LNG carriers as they transit to and from the LNG Export Jetty berthing area.

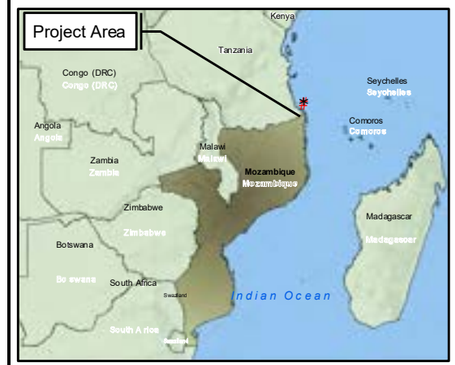
For safety and security reasons, vessels will be required to maintain a state of readiness for immediate departure at all times while moored at the LNG Export Jetty. While vessels are berthed, the Project will enforce a safety and security exclusion zone of 500m around the moored LNG Carriers. During LNG loading, this exclusion zone may be increased to 1,000m.

Once at the LNG Export Jetty berthing area, the terminal systems will load the LNG Carriers at approximately 12,000m³/h, resulting in an average turnaround time (from entrance to exit of Palma Bay) of approximately 24 hours. The loading of LNG will be conducted using three loading arms and one vapour return line, to allow vapours to flow back into onshore storage tanks. Once loaded, LNG will be stored aboard the LNG Carrier in insulated tanks located within the hull of the vessel, at -158°C.



Legend

- Near Shore Components
- Onshore Project Footprint
- Afungi Project Site
- Vessel Turning Areas
- Vessel Approach Route
- Vessel Anchoring Areas
- Limits of the Marine Operations



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Meters

TITLE:

Figure 4.16:
LNG Carrier Access Route and Manoeuvring Areas

CLIENT:

Anadarko Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 62 500

DRAWING: LNG Carrier Access Routes & Manoeuvering Areas.mxd

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10°42'0"S

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Projection: UTM Zone 37 S, Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
AMA1, 2012. Inset Map: Esri Data & Maps

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4.6 MANAGEMENT OF EMISSIONS, DISCHARGES AND SOLID WASTES

The management strategies presented herein have been based on conservative estimations generated by the Pre-FEED Contractors.. The emissions, discharges and waste streams will change as the Project progresses through its life cycle and are, therefore, described here per Project phase. It should be noted that the optimum methods to address all Project emissions, discharges and wastes will be further investigated during FEED. The facilities will be designed to avoid and, if not possible, minimize all potential impacts on the environment and its surroundings.

4.6.1 *Management of Emissions to Air*

The emissions inventory provided below is based on input from the Pre-FEED engineering studies conducted to date. Evaluations will be made during FEED on all aspects of the Project design to ensure all components are designed to maximise efficiency to the most practicable extent. These studies will be undertaken to optimise the efficiency of the Project and develop options for built-in mitigation measures to be implemented to reduce the rate and/or duration of air emissions throughout the life cycle of the Project.

Key Sources of Construction Emissions

Emissions during construction will vary in magnitude, frequency and duration for the various construction activities required. It is therefore difficult to accurately quantify emissions associated with construction of the Project components (1). The main sources of air emissions (continuous and non-continuous) during the construction phase will be from the exhausts of machinery associated with construction equipment, both onshore and offshore, as well as vessels used for supply and logistics. Air emissions will be associated with the following activities:

- combustion emissions from the operation of construction machinery and generators;
- particulate (dust) emissions from exposed areas;
- marine vessel emissions and generator operation; and
- welding operations.

These activities will result in the following main emissions during construction:

- sulphur dioxide (SO_2);
- nitrogen oxides (NO_x);
- carbon monoxide (CO);
- carbon dioxide (CO_2);

(1) In order to provide a concise emissions inventory for the construction phase of the Project, all components would need to be identified. The present stage of the Project does not allow for such an assessment, as the Project will be built by various construction and installation contractors using equipment and methodologies yet to be identified.

- hydrocarbons; and
- particulate matter (PM).

Key Sources of Operational Emissions

The main sources of normal operating atmospheric emissions include combustion products from:

- gas turbines used as compressor drivers;
- gas turbines used for power generation;
- incinerators; and
- process heaters.

Other emission sources include:

- combustion products from flares;
- compressor seal losses;
- fugitive emissions from piping system components and hydrocarbon storage tanks; and
- miscellaneous sources such as losses and venting at analysers, sampling points and the routine testing of back-up or emergency diesel engines etc.

The key potential pollutants of environmental concern to be emitted from the Project include NO_x, SO_2, CO, CO_2 and aromatic hydrocarbons such as benzene, toluene, ethyl benzene and xylene (collectively known as BTEX).

The Mozambican requirements and IFC EHS Guidelines will be provided to the FEED Contractors as guidance so the Project will be designed to meet the required emission standards.

Table 4.1 provides an overview of the expected annual emissions for one, two and six Trains [(1)], while *Table 4.2* provides a more detailed breakdown by source for a single Train per year. The data is based on information available at Pre-FEED. The Pre-FEED study estimates emissions from all normally operational combustion sources for one Train. These estimates have been scaled up to consider additional Trains (multiplying estimated emissions for one Train by two and six respectively). These estimates will be verified during the FEED phase.

(1) The table provides estimated emissions for the trains and not the associated facilities, machinery and equipment associated with the operational phase.

Table 4.1 Estimated Emissions for One, Two and Six LNG Trains

Number of Trains	Estimated Annual Emissions (t/yr)						
	NO_x (1)	SO_2 (2)	CO (3)	PMT (3)	PM_{10} (3) (4)	VOC (3)	CO_2 (5)
1	490.99	67.93	133.95	42.83	41.79	14.79	1,035,135.00
2	936.63	135.87	235.75	82.29	80.22	27.89	1,998,540.00
6	2,719.18	407.60	642.94	240.16	233.95	80.30	5,852,155.00

Note:

(1) NO_x emissions estimates based on the following:

(a) Gas turbine drives: 51mg/Nm^3, dry basis at 15% oxygen, per World Bank/IFC standards.

(b) Acid gas incinerator and hot oil heater: AP-42 emission factor assuming low NO_x burners.

(c) Flares: AP-42 emissions factor.

(2) SO_2 emissions by material balance based on 100% conversion of vent/fuel gas sulphur to SO_2.

(3) Pollutant emissions per United States Environmental Protection Agency (USEPA AP-42 emission factors for respective emission source.

(4) Flares/incinerator assumed to be smokeless - PM emissions considered negligible.

(5) CO_2 emissions by material balance based on 100% conversion of vent/fuel gas carbon to CO_2. It should be noted CO_2 emissions differ from CO_2e emissions (which are used in the GHG assessment in Section 12.3). CO_2e means "CO_2 equivalent" and is a common unit of measurement for all greenhouse gases (eg methane, CO, etc)

(6) Four generators operating at 100% load.

Source: Anadarko, 2012.

Table 4.2 Estimated Annual Emissions for LNG Trains by Source

Source	Duty (HHV)	Estimated Emissions (t/yr) (1)						
	MW	NO_x (1)	SO_2	CO	PMT	PM_{10}	VOC	CO_2
MR compressor turbine drive	47	99.21	Negligible	21.09	9.27	9.27	2.94	175,480.00
PR compressor turbine drive	47	99.21	Negligible	21.09	9.27	9.27	2.94	175,480.00
Power generator turbine drives	4 x 29 (Train 1)	278.96	Negligible	52.02	22.92	22.92	7.31	433,093.00
	3 x 33 (Train 2–6)	238.08	Negligible	44.40	19.56	19.56	6.23	369,623.00
Acid gas incinerator	3.5							
From acid gas		2.58	67.93	4.29	0.39	0.09	0.26	186,811.00
From fuel gas			Negligible					27,331.00
Hot oil heater	15	6.56	Negligible	10.93	0.97	0.24	0.73	56,009.00
Flare header purge gas								
Warm flare	0.94	1.93	Negligible	10.42	Negligible	Negligible	0.26	3,513.00
Cold flare	0.95	1.93	Negligible	10.60	Negligible	Negligible	0.26	3,565.00
LP flare	0.15	0.35	Negligible	1.75	Negligible	Negligible	0.09	578.00
Warm	0.10	0.18	Negligible	1.05	Negligible	Negligible	0.00	368.00
Source	**Duty (HHV)**	**Estimated Emissions (t/yr) (1)**						
	MW	**NO_x (1)**	**SO_2**	**CO**	**PMT**	**PM_{10}**	**VOC**	**CO_2**

liquid flare								
Cold liquid flare	0.06	0.09	Negligible	0.70	Negligible	Negligible	0.00	237.00
TOTAL for Train 1		490.99	67.93	133.95	42.83	41.79	14.79	1,062,467.00
TOTAL for Trains 2-6		450.11	67.93	126.33	39.47	38.43	13.72	998,996.00

(1) Based on 8,760 operating hours per year (on-stream factor of 100%).

Source: Anadarko 2012.

4.6.2 Management of Effluent Discharges

The following provides an overview of potential options the Project is considering to manage the effluent discharges resulting from construction and operational activities.

Key Sources of Construction Discharge

During the construction phase, the Project will have the following sources of discharge:

- sewage treatment plant effluent;
- concrete batch plant effluent;
- equipment and vehicles washdown pad effluent;
- brine and filter backwash from desalination plant;
- potentially contaminated stormwater and washdown water from waste management area; and
- hydrotest wastewater from the tanks and pipelines testing.

Table 4.3 provides estimated effluent rates from various sources during construction.

Table 4.3 Estimated Effluent Rates during Construction of the First Two Trains

Source	Flow Rate (for Construction of Two Trains)	Frequency
Treated effluent from the Sewage Treatment Plant	2–60m³/hr	Continuous
Concrete batch plant effluent	0.5–1m³/hr	Continuous from month 7 to month 25
Equipment and vehicles washdown pad effluent	1–2m³/hr	Intermittent
Brine and filter backwash from Desalination Plant	433m³/hr	Continuous
Potentially contaminated stormwater and washdown water from waste management area	5m³/hr	Intermittent
Hydrostatic test wastewater from the tanks and pipelines testing	70m³/hr when routed through the sedimentation pond	Intermittent

Source: Bechtel Pre-FEED Documents.

During the construction phase, sewage will be treated by a temporary sewage treatment system (potentially a modular treatment system). Effluent from the tanks will be treated to meet all the applicable standards, regulations (national and international) and/or approval or authorization prior to discharge into Palma Bay via a pipeline attached to the Pioneer Dock. If required, some treated effluent can be used for dust suppression and/or site-required irrigation.

The brine rate from the desalination plant will be at the peak during the first 18 months of filling and compaction activities. Brine and filter backwash may also be discharged from the Pioneer Dock into Palma Bay. A potential option for brine discharge includes a high pressure discharge to facilitate quick mixing with marine water, stormwater and/or sewage effluent, minimising any effects associated with the high salt concentration.

The optimum methods to address all Project discharges will be further investigated during FEED.

It is currently planned that hydrotest water from the first LNG tank will be used for testing the second tank and pipelines, and returned back to the hydrotest pond. Water from the pond may be used for dust control and concrete batch plant, if uncontaminated. AMA1 and eni will develop a hydrotest Water Management Plan for the discharge of hydrotest water. Such a plan will be aligned with the IFC guideline on the discharge of effluents [1]. The quality of hydrotest water will be monitored to achieve the targets in *Table 4.4*.

(1) IFC Environmental, Health and Safety Guideline for LNG Facilities, Table 1.

Table 4.4 Hydrotest Water Quality Guideline

Parameter	Guideline
Total hydrocarbon content	10mg/l
pH	6–9
Biochemical Oxygen Demand (BOD)	25mg/l
Chemical Oxygen Demand (COD)	125mg/l
Total Suspended Solids (TSS)	35mg/l
Phenols	0.5mg/l
Sulphides	1mg/l
Heavy metals (total)	5mg/l
Chlorides	600 mg/l (average) 1,200mg/l (maximum)

Source: IFC Environmental, Health and Safety Guideline for LNG Facilities.

A water management system will be in place to capture potentially contaminated stormwater run-off and keep it separate from normal clean water run-off. Clean water run-off will be channelled into existing natural drainage channels. Potentially contaminated water will be captured and treated for reuse or discharge into Palma Bay. The optimum solution will be further investigated during FEED.

Key Sources of Operational Discharge

The Offshore Project will operate in a closed loop whereby chemical injections will be contained within the production system. The only discharge from the Subsea Production System will be small quantities of water-based biodegradable hydraulic fluid.

Key sources of operational discharge are constrained to the Onshore and Near Shore aspects of the Project and consist of the following sources:

- process wastewater and drains;
- treated sewage effluent;
- brine and filter backwash from the desalination plant;
- salt and produced water from the MEG Unit; and
- run-off water from process areas.

Table 4.5 shows estimated effluent rates from identified sources of discharges from onshore facilities.

Table 4.5 Estimated Effluent Rates during Onshore Operations

Source	Flow Rate (m^3/hr)	Frequency	Estimated Characteristics
Process wastewater	5–51[1]	Continuous (peak flows include stormwater)	pH: 6–7 BOD_5: 10–20mg/l TSS: 5–10mg/l Oil: 5–15mg/l
Source	**Flow Rate (m^3/hr)**	**Frequency**	**Estimated Characteristics**
Sewage Treatment Plant	3.5–15	Continuous	pH: 6.5–7.5 BOD_5: 10–20mg/l Oil and grease: 5–10mg/l Total nitrogen: 30–40mg/l as N Total Kjeldahl nitrogen: 1–5mg/l Ammonia nitrogen: 1–5mg/l Total phosphorus– 5–10mg/l TDS: 250 mg/l

Brine and filter backwash from Desalination Plant	62-93	Continuous	pH: 6.5–7.5 units TDS: 55,500–60,000mg/l N^{+}: 17,000mg/l Alkalinity: 170mg/l Cl: 30,650mg/l Mg^{++}: 2,000mg/l TSS: 0mg/l SiO_2: 16mg/l
Salt and produced water from the MEG Unit	1,600bbl water/day/ LNG Train	Continuous	2,200kg of salt/day/LNG Train
Contaminated run-off	80–160	Intermittent	TSS: 50–100mg/l Oil: 5–15mg/l

Note: Peak rates provided are based on maximum pumping rates from the effluent treatment equipment.

Source: Anadarko Pre-FEED Documents.

Treated domestic sewage will meet all the applicable standards, regulations (national and international) and/or approval or authorization before discharge.

In the operational phase, a water management system will be in place to capture run-off from potentially impacted areas and process wastewater, and keep this separate from normal clean water run-off. Clean water run-off will be channelled into natural drainage channels. Potentially contaminated water will be captured and treated for reuse or discharge.

Brine, from desalination and the MEG Unit, may be discharged through a piped outfall located on the LNG Export Jetty. A diffuser may be used at the end of the pipe to achieve maximum dilution and dispersion within a short distance from the outfall.

Stormwater

Potentially contaminated surface water (PCSW) run-off includes stormwater, fire water and washdown water originating from dirty, industrial areas. With the exception of the LNG processing areas, all surface run-off from the affected areas will be collected by a PCSW sewer system, which will drain directly to a stormwater retention basin and will undergo subsequent treatment.

Due to the potential for run-off from the LNG processing areas to be impacted, all the LNG processing areas will be constructed with a perimeter bund and the contained area sloped to one or more internal collection sumps. .

PCSW from LNG processing areas that exhibit evidence of an oil sheen will be directed to a stormwater retention basin. This basin will be lined with suitable materials to prevent groundwater impacts. Run-off collected in the stormwater retention basin originating from both the LNG processing and non-processing areas will be pumped at a reduced controlled rate to an oil-water separator for treatment prior to discharge in accordance with all the applicable standards, regulations (national and international) and/or approval or authorization. Two 100% stormwater return pumps will be provided. Pump capacity will be established during FEED to empty the basin completely in a reasonable period of time.

Clean Surface Run-off

Clean surface run-off is run-off from areas deemed not at risk to oil or chemical contamination. Clean surface run-off will be allowed to discharge to the surrounding environment.

4.6.3 Management of Solid Wastes

A Waste Management Plan (WMP) has been developed for the Project (*Annex E*). This Plan outlines the waste management philosophies and framework for how the Project will manage wastes associated with the various phases of the Project. The following provides an overview of the expected types and potential volumes of waste to be generated in each phase of the Project. This waste inventory is based on input from the Pre-FEED engineering studies conducted to date. Evaluations will be made during FEED on all aspects of the Project design, construction and operation to avoid and, if not possible, minimise the generation of waste.

Offshore Construction Phase Wastes

There will be several different activities associated with the construction of the Offshore Project, including:

- drilling and installation of production wells;
- Subsea Production System installation;
- pipeline construction; and
- pre-commissioning and commissioning of pipelines and the Subsea Production System.

Whenever a well is drilled, fragments of rock, known as cuttings, are created. These cuttings are coated with the drilling mud that is used to lubricate the drill bit and transfer the cuttings to the surface. The drilling muds are recycled by separating the muds from the cuttings using vibrating screens, known as shale shakers. Some drilling fluids will remain adhered to the cuttings, but the majority will be separated by the shale shakers and returned

to the drilling fluid system. Drilling fluids will therefore be recirculated continuously. Following treatment, the cuttings will be discharged to the sea unless site-specific drilling and mud cuttings dispersion modelling indicates unacceptable environmental impacts, in which case the cuttings will be sent to shore for treatment and disposal either at Pemba or the Afungi Project Site. If the cuttings need to be transferred to shore for disposal, they will be stored in 25t skips. The collection, treatment and recycling of the returned drilling muds are part of the standard drilling process. The optimum alternative solution for the final disposal of cuttings will be further investigated and GIIP will be applied.

Along with drill cuttings, the drilling operation will generate a range of other wastes such as:

- tubing caps;
- waste lube oil;
- wood wastes;
- packaging wastes (plastics, cardboard, paper);
- fluorescent tubes;
- contaminated rags;
- waste paints and solvents;
- metal wastes (steel cuttings, metal wires, pipe cuttings);
- domestic waste; and
- wet/dry cell batteries.

These wastes will be segregated and stored in different containers on board the drilling vessel, and will be transported back to shore at either Pemba or the Afungi Project Site (depending where the supply vessels are based) for treatment and disposal, with the wastes generated onshore in accordance with the WMP.

Based on aggregated data for the waste returned to shore from one of the drilling rigs (eg *Bedford Dolphin*) over a 48-day period, estimates have been made for the rate of waste generation from the drilling rigs, as shown in *Table 4.6* (this assumes that two rigs are operational).

Table 4.6 Estimated Wastes Generation from One Drill Ship

Types of Wastes	Waste from *Bedford Dolphin* rig over 48 days	Unit mass (t)	Tonnes per rig (48 days)	Annual generation rig (t)	Waste generation over planned 900-day drilling programme (t)
Uncompressed bulk bags of general waste	108.00	0.30	32.40	246.40	607.62
Metal drums	24.00	0.02	0.48	3.70	9.12
1,000l tote tanks	19.00	0.05	0.95	7.20	17.76
1,000l totes of waste oil/sludge/liquid hazardous waste	10.00	1.00	10.00	76.00	187.42
Plastic drums	8.00	0.01	0.08	0.60	1.48
Baskets of scrap wood	7.00	0.70	4.90	37.30	91.98
Baskets of scrap metal	6.00	2.00	12.00	91.30	225.15
Sections of drill line/crane cable/other cable	3.00	1.00	3.00	22.80	56.22
Pallet box of shaker screens	1.00	1.00	1.00	7.60	18.74

Source: AMA1, based on manifest of waste generated during AMA1 exploration drilling activities; similar quantities are anticipated per drill ship for production drilling activities in Areas 1 and 4.

Pipeline construction activities will typically generate the following types of wastes:

- end millings from the pipe end bevelling process;
- flux and welding rods from the welding process;
- offcuts and waste process materials from the pipe-laying process;
- lubricating oils (from machinery and lifting equipment, etc);
- contaminated rags/materials/containers;
- waste paints and solvents;
- wet cell batteries;
- chemical wastes;
- steel cuttings wastes; and
- coating wastes.

Other wastes such as household wastes (food wastes; packaging wastes; and wood, paper and cardboard wastes), sewage and grey water will also be produced by construction vessels.

No specific data are available for expected quantities of wastes from pipeline construction activities (these will be generated during FEED), but it is anticipated that a workforce of up to 750 construction workers and equipment technicians will be involved during the subsea construction phase. These personnel will be housed in offshore construction vessels or in the Construction Camps associated with the onshore development. The construction of the Subsea Production System will last approximately 18 to 24

months. Based on these estimates, and in the absence of Project-specific data, waste generation for the workforce involved in the offshore construction has been estimated, as indicated in *Table 4.7*.

Table 4.7 Estimated Waste Generation for Offshore Construction Workforce

Types of Wastes	Classification	Approximate Annual Waste (t)	Approximate Total Waste (t)
Food	Non-hazardous	130	200–270
Miscellaneous combustibles	Non-hazardous	14	21–27
Textiles	Non-hazardous	14	21–27
Paper and cardboard	Non-hazardous	44	62–82
Plastics	Non-hazardous	28	41–55
Glass	Non-hazardous	14	21–27
Metals	Non-hazardous	14	11–15
Miscellaneous non-combustibles	Non-hazardous	14	21–27
Kitchen oil/grease	Non-hazardous	2.6	4–6
Medical	Hazardous	0.13	0.2–0.3

All vessels involved with the construction of the Offshore Project will be compliant with MARPOL 73/78 regulations.

Commissioning of the Offshore Project components will include pipeline integrity testing, followed by dewatering and nitrogen purging. The pipelines will undergo pressure testing using filtered sea water, with the addition of chemicals such as biocides and corrosion inhibitors. A plan for disposal of the water used for the hydrotesting will be developed, with careful consideration given to the impact, if any, of remaining chemicals on the environment. It is currently envisaged that the water used for the pipeline hydrotesting will also be used to hydrotest the onshore facilities. Any discharge of hydrotest fluids to sea will be in compliance with IFC guidelines in the absence of a Mozambican standard.

Onshore and Near Shore Construction Phase Wastes

The types and quantities of wastes that will be generated over the planned 48 to 54-month construction period for the LNG Facility have been estimated during Pre-FEED.

From these data, the annual waste generation during construction has been estimated as presented in *Table 4.8*. This table also indicates the provisional classification of each waste type and the planned method of managing each type of waste. The estimates assume an average workforce of 4,490, so the amounts of domestic waste have been adjusted to take into account the current estimate for the workforce.

Table 4.8 Onshore and Near Shore Construction Phase: Wastes Inventory

Types of Wastes	Estimated Total Quantity (t)	Approx. Annual Generation (t)	Classification	Management Method
Sewage treatment solids	14,900.0	3,400.0	Hazardous	Landfill or incineration
Food	6,600.0	1,500.0	Non-hazardous	Compost, landfill or incineration
Paper	3,500.0	790.0	Non-hazardous	Recycle or incineration
Plastic	1,100.0	260.0	Non-hazardous	Recycle or landfill
Glass	580.0	130.0	Non-hazardous	Recycle or landfill
Metal	760.0	170.0	Non-hazardous	Recycle
Others	4,000.0	900.0		Landfill
Vehicle batteries	20.0	4.4	Hazardous	Recycle
Construction debris – inert	5,000.0	1,130.0	Inert (non-hazardous)	Recycle or landfill
Containers – metal (used)	210.0	48.0	Non-hazardous	Reuse or recycle
Containers – plastic (used)	60.0	13.0	Non-hazardous	Reuse or recycle
Filters – oil (used)	8.0	2.0	Hazardous	Landfill or incineration
Filters – air (used)	100.0	22.0	Non-hazardous	Landfill
Gas cylinders (empty)	20.0	4.0	Non-hazardous	Reuse
Grit from sand blasting operations	20.0	4.0	Non-hazardous	Landfill
Medical wastes	10.0	2.0	Hazardous	Incineration
Packaging material – cellulose	480.0	110.0	Non-hazardous	Incineration
Tyres – used	85.0	20.0	Non-hazardous	Recycle, incineration or landfill
Welding rods (used)	80.0	17.0	Non-hazardous	Landfill

Source: AMA1, Air Emissions, Liquid Effluents and Solid Wastes – Construction Phase, Document EV-AAA-EV1-0003 (adjusted to account for increased workforce and including Near Shore Project contribution).

Offshore Operational Phase Wastes

During the operational phase, there will be very little waste generated offshore, and this will comprise primarily maintenance and repair wastes. It is expected that very little pigging will need to be undertaken during the operational phase. If it is required, only small quantities of hydrates, hydrocarbon sludge, oily water, contaminated rags and damaged pigs will be generated.

It is anticipated that the total amount of wastes generated offshore will not amount to more than a few tens of tonnes per annum.

Onshore Operational Phase Wastes

The following wastes will be generated from operation of the LNG Facility:

- liquid sludge, dehydrated sludge and waste cake;
- used filter cartridges, oil-absorbing media;
- filtration media or catalysts;
- used mercury guard [1];
- potentially hazardous chemical packaging;
- non-hazardous packaging from chemical products and equipment (eg wood pallets, steel drums, plastic containers);
- salts from MEG units;
- waste from power generation unit;
- packaging and food wastes; and
- paper and used print cartridges from the process and office areas.

Quantities of process wastes and their management routes have been determined from discussion with the Pre-FEED Contractors; these data are presented in *Table 4.9*. The Project will place emphasis on developing strategies to minimise waste generation. Details will be developed to quantify these waste quantities further during FEED.

Table 4.9 Anticipated Process Materials and Resulting Wastes per LNG Train

Waste Source	Material	Quantity	Replacement Period	Estimated Annual Waste Generation (t)
Feed gas dehydration	Molecular sieve – 3A type (or equivalent), 1/8" beads	45,000.0kg/65.5m^3	3 years	15.0
Feed gas dehydration	Molecular sieve – 3A type (or equivalent), 1/16" beads	45,000.0kg/65.5m^3	3 years	15.0
Feed gas dehydration	Silica gel beads – 2–5mm	3.7kg/5.4m^3	3 years	-
Acid Gas Removal Unit	Activated carbon	21.2m^3	6 years	1.2
Mercury Removal Unit	Catalyst (sulphur impregnated activated carbon)	42,500.0kg/74.3m^3	3 years	14.2
Plant instrument air driers	Activated alumina	3,500.0kg	2 years	1.8
Oily sludge	Oil and sludge	Dependent on site run-off rate	N/A	-
Oily Water Treatment Unit filters	Activated carbon	10.0m^3	Annual	3.2

In addition, there will be very small quantities of potentially hazardous wastes from maintenance and repair activities such as:

- waste lubricating oil;
- seals, insulating wool, empty paint drums from pipe maintenance;
- chemical reagents, drums from sampling and instrument calibrations; and
- used fluorescent tubes and cleaning products from building maintenance.

There will also be some wastes generated by the operation of the gas turbine units that will be used to generate power for the Project. These wastes will comprise mainly gas turbine washings (isopropanol or equivalent) and lubricating oils from the maintenance of turbines.

The various offices associated with the Project will generate relatively small amounts of a limited range of wastes. These will include non-hazardous materials, such as paper and cardboard, as well as wood/metal furniture, which can be recycled if suitable facilities are available, and very small quantities of more hazardous wastes such as printer cartridges and fluorescent lamps (containing mercury).

Accommodation facilities will give rise to wastes from food preparation and consumption, maintenance and recreational activities. These wastes will include food, plastic bottles, paper and cardboard, and sewage. There will also be some hazardous waste such as fluorescent bulbs, used batteries and medical waste.

There will be approximately 400 personnel for standard operations (working two 12-hour or three eight-hour shifts per day). Major shutdowns will generally be scheduled every few years and will require an additional workforce of 300 to 500 personnel, depending on scope. Minor shutdowns may occur more frequently and will require an additional staff of approximately 50 to 100 personnel. For the purposes of estimating the amount of waste that will be generated, it has been assumed that, on average, there will be approximately 450 staff during the operational phase.

Using typical rates of waste generation per employee for similar projects, estimated rates of waste generation for the operational phase of this Project have been developed as shown in *Table 4.10*.

Table 4.10 General (Non-process) Operational Wastes

Types of Wastes	Source	Classification	Approximate Rate of Waste Generation (t/yr)
Food	Accommodation areas	Non-hazardous	82.00
Miscellaneous combustibles	Accommodation areas	Non-hazardous	8.00
Textiles	Accommodation areas	Non-hazardous	8.00
Paper and cardboard	Offices and accommodation areas	Non-hazardous	49.00
Plastics	Accommodation areas	Non-hazardous	16.00
Glass	Accommodation areas	Non-hazardous	8.00
Metals	Accommodation areas	Non-hazardous	8.00
Miscellaneous non-combustibles	Accommodation areas	Non-hazardous	8.00
Kitchen oil/grease	Accommodation areas	Non-hazardous	2.00
Printer cartridges	Offices	Hazardous	0.20
Batteries (small)	Offices and accommodation areas	Hazardous	0.02
Fluorescent and sodium lamps	Offices and accommodation areas	Hazardous	0.10
Medical	Clinic/First Aid posts	Hazardous	(included in previous table)
Tyres	Vehicles	Non-hazardous	0.80
Lead-acid batteries	Vehicles	Hazardous	0.80
Waste oil	Vehicles	Hazardous	0.70
Oil filters	Vehicles	Hazardous	0.10

An incinerator will be used onsite for the treatment of medical and combustible wastes in accordance with an approved Waste Management Plan. In this case, the onsite waste incinerator will be designed to provide an organic destruction removal efficiency of ≥99 percent for a resulting ash organic content of ≤1 percent carbon by weight. The incinerator will be of the two-stage type, with a minimum combustion temperature of 815°C in the primary stage and 982°C in the secondary stage. The incinerator shall be designed in accordance with GIIP. The inert ash will be disposed of at the onsite landfill.

Near Shore Operational Phase Wastes

During the operational phase of the Project, the Near Shore infrastructure will serve as the point of export for the processed LNG and as the hub for the import of materials necessary for the operation and maintenance of all aspects of the Project.

There will be small amounts of waste generated by the operation fleet (tugs and other vessels), such as lubricating oils and lead-acid batteries.

At this stage, the frequency of dredging to maintain the navigation channel and the quantities of material likely to be dredged are not known but are expected to be minimal, based on sediment modelling conducted within

Palma Bay. Maintenance dredging is likely to occur approximately every three to five years.

4.6.4 Noise and Light Emissions

Onshore lighting requirements will be developed during the FEED phase and will incorporate site safety requirements, while taking measures to minimise the impact on the surrounding community. The lighting design and illumination requirement will be restricted to the minimum required for security and safe working conditions. The specific design criteria for lighting will be developed during detailed engineering, when the required design data and site equipment arrangement plans become available for such development.

IFC noise standards will be applied for the operational phase of the Project. Noise abatement measures will be implemented to achieve ambient noise levels, indicated in *Table 4.11* below, or will not result in a maximum increase in the background level of 3dB(A) at noise receptors during operations. The indicated noise standards apply at the nearest offsite receptor (community).

Table 4.11 Noise Standards

Receptor	One Hour LAeq (dBA)	
	Daytime	Night-time
	07:00 to 22:00	22:00 to 07:00
Residential, institutional, educational	55	45
Industrial, commercial	70	70

Source: KBR Pre-FEED Documents.

Measures will be taken during design to minimise the potential adverse environmental and social impacts associated with noise and light.

4.7 DECOMMISSIONING AND CLOSURE

Decommissioning refers to the process of dismantling the operating assets after completion of the operating life cycle of the Project. This process will be in accordance with the Decommissioning and Rehabilitation Plan (*Annex F*). Due to the long-term operation of the LNG Facility (30 years), the Project will review and update the decommissioning plan as the Project nears the end of its lifespan.

Typical decommissioning of the subsea system would encompass flushing the pipelines and umbilical tubes clean, removing subsea manifolds and plugging the wells, and retrieving the subsea trees and jumpers. The pipeline and umbilicals are likely to be capped and abandoned in place.

For the Near Shore and Onshore infrastructure, decommissioning entails the demolition of buildings, removal of infrastructure, and rehabilitation and

revegetation. Where contaminated soil is found, this will be rehabilitated or disposed of appropriately. Decommissioning and demolition will also be influenced by the needs of local communities. Where buildings or infrastructure (eg roads, jetties) can be utilised by local communities, they will be left intact. All other infrastructure will be demolished and removed. Land will be shaped, scarified and revegetated as appropriate.

Chapter 5

Consideration of Alternatives

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5 CONSIDERATION OF ALTERNATIVES

5.1 INTRODUCTION

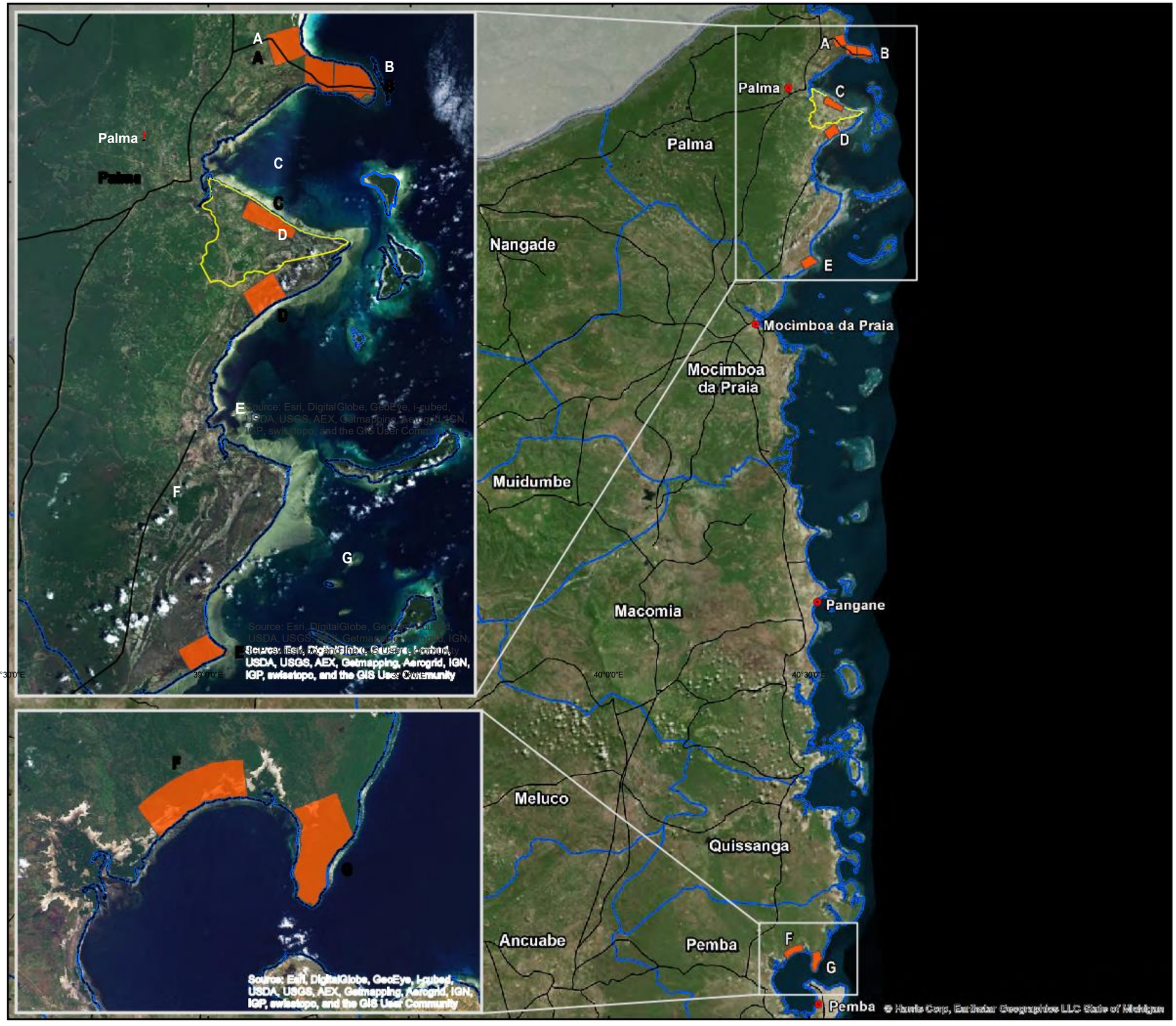
This section describes the alternatives considered during the course of the Project design and the EIA process. As a result of ongoing consultation between the EIA Team, the Project technical team and the Pre-FEED Contractors, the EIA process itself has already contributed significantly to the evaluation and selection of alternatives and enabled mitigation to be incorporated into the Project design. The following alternatives have been considered:

- site alternatives;
- layout alternatives;
- technology and process alternatives; and
- no-go alternative.

5.2 SITE ALTERNATIVES

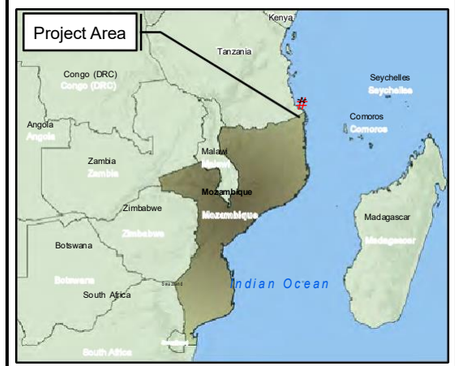
AMA1's Engineering Team analysed the northern Mozambique coastline of Cabo Delgado Province between Pemba and the Tanzanian border in early 2011 to identify potentially suitable locations (1) for an LNG Facility. From this exercise, seven potential locations along the coast were identified (labelled A to G in *Figure 5.1*). For various technical, environmental, financial and security reasons, four locations were subsequently determined to be not suitable. Three broad geographic location alternatives were identified as potentially suitable: Londo Peninsula in Metuge District, and Afungi Peninsula and Cabo Delgado Peninsula in Palma District. These three options were then presented to the EIA Team to investigate further from an environmental and social perspective. The EIA Team undertook a desktop study and initial field visits in May 2011 to all three localities to support their analysis.

(1) For the site selection process, the term 'location' refers to a broad area (eg the Afungi Peninsula) on which one or more LNG sites could fit.



Legend

- Towns
- Regional Roads
- District Boundary
- Boundary with Tanzania
- Afungi Project Site
- Initial Locations Considered



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 5.1:
Seven Initial Locations Considered

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 1 500 000

DRAWING: Seven Initial Locations Considered.mxd

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Projection: UTM Zone 37 S Datum: WGS84 Source: Bing Maps ©2010 Microsoft Corporation. AMA1, 2011. Inset Map: Esri Data & Maps	SIZE: A3

13°0'0"S

11°0'0"S

11°30'0"S

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13°0'0"S

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During this process, the Londo Peninsula location was eliminated by AMA1, ERM and Impacto for various environmental and technical reasons including, but not limited to:

- proposed location is below the international flight path to the Pemba airport;
- proximity to the Quirimbas National Park;
- proximity to a large population centre (ie Pemba);
- distance from the offshore gas field;
- technical difficulties associated with the potential subsea pipeline route (numerous subsea canyons); and
- environmental sensitivity associated with a potential onshore pipeline route.

This narrowed the EIA Team's focus to two alternative broad locations: Afungi Peninsula and Cabo Delgado Peninsula.

A marine ecology specialist then evaluated both locations, based on the following criteria (1):

- seagrass beds;
- shallow coral reef structures;
- sand beaches;
- mangroves;
- estuaries;
- linked biotopes;
- shore and near shore modification (dredging);
- pipeline shore landing;
- export facility – trestle jetty and dolphin berth; and
- possible discharges from the LNG Facility.

A terrestrial ecology specialist evaluated the two locations according to the following criteria(2):

- protected areas (legislative issue);
- wetlands;
- regionally important woodlands;
- coastal forests;
- mangroves;
- estuaries;
- mammals;
- avifauna; and

(1) The evaluation included a consideration of sensitivity and ecological value of the various criteria.

(2) The evaluation included a consideration of sensitivity and ecological value of the various criteria.

- herpetofauna.

A socio-economic specialist considered the following criteria for the evaluation of the two potential locations:

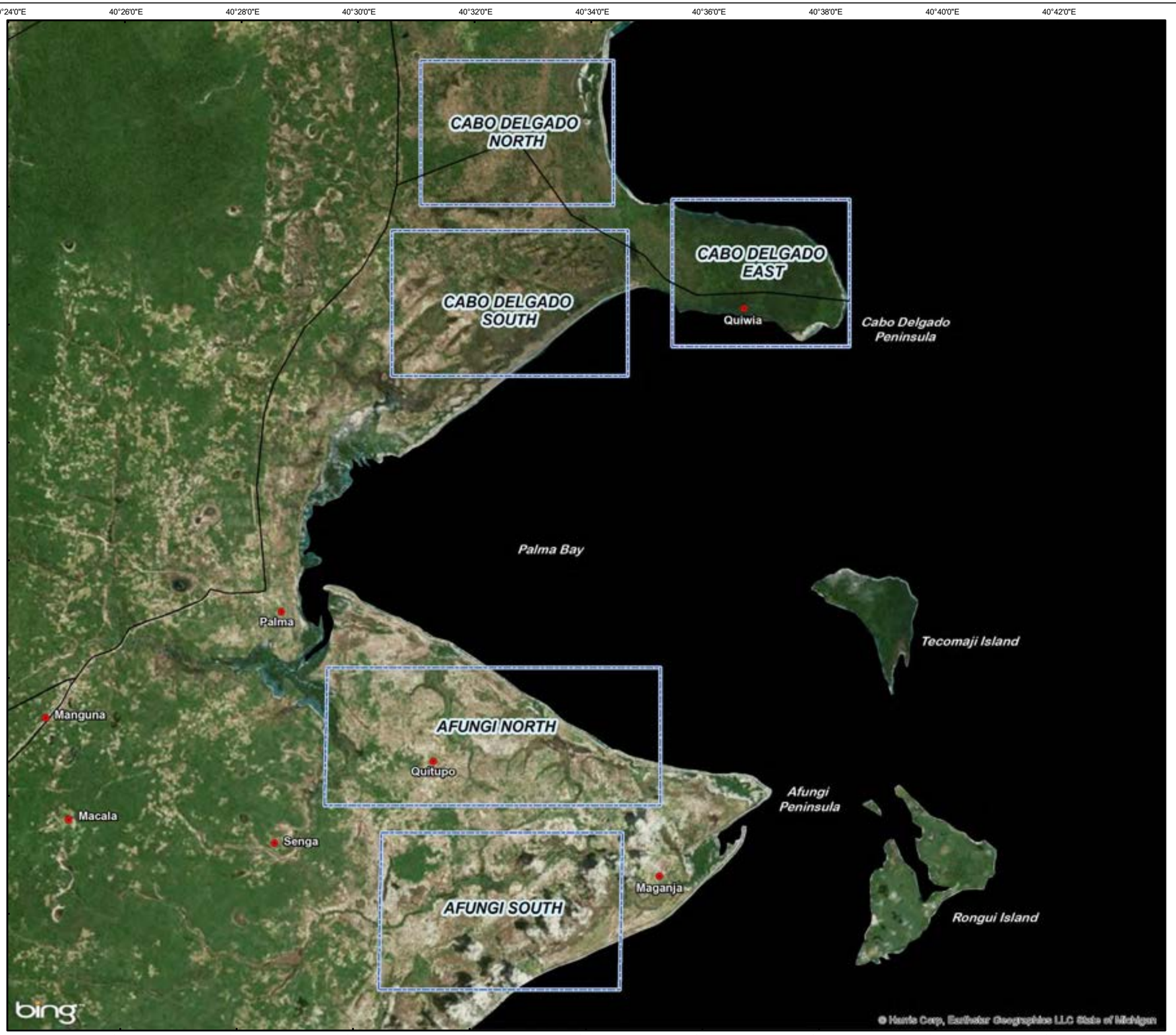
- local government support of the Project;
- human settlements within site;
- number of inhabitants;
- proximity to a large population centre;
- community migration/seasonal use;
- marine access routes;
- subsistence agriculture;
- presence of fishing centres;
- overlap with land uses (other than subsistence agriculture);
- adjacent land uses;
- cultural, religious and/or historical importance of the sites;
- tourism ventures;
- recreational activities and sites; and
- ecotourism uses (community benefit).

An absolute scoring system [1] was used to rate the two alternative locations (Afungi and Cabo Delgado peninsulas) according to the above range of environmental and social criteria. The locations were scored between 1 and 5 where 1 was usually a sensitive and important environmental or social criterion and 5 was less sensitive or disturbed. Thus higher scores indicated a preference for development. This allowed the specialists to determine the suitability of the locations for the LNG Facility, and to develop a ranking of potential localities from the perspective of the subject areas (marine, terrestrial and socio-economic).

The EIA Team was then tasked with identifying preferred sites within the Afungi and Cabo Delgado peninsulas. *Figure 5.2* shows the five potential sites considered within the two peninsula locations.

The marine ecology preliminary results indicated that Cabo Delgado South and Afungi South were preferred (*Figure 5.2*). Afungi North was added as an option for consideration, on the basis of the two estuary areas identified in the extreme east and west of Afungi North being protected (excluded) from the development. Thus, of the five sites considered, three potential sites were selected by the marine ecologist for further investigation: Cabo Delgado South, Afungi South and Afungi North.

(1) An absolute scoring system allows the two locations to be assessed independently (ie they are not compared to each other).



Legend

- Villages / Settlements
- Regional Roads
- Potential LNG Sites

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 5.2:
Potential LNG Sites on Cabo Delgado and Afungi Peninsula

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 115 000

DRAWING: Potential LNG Sites.mxd

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10°38'0"S
10°40'0"S
10°42'0"S
10°44'0"S
10°46'0"S
10°48'0"S
10°50'0"S

Table 5.1 ***Marine Ecology Scoring***

Biotope/Sand Beaches/Attribute	Cabo Delgado North	Cabo Delgado South	Cabo Delgado East	Afungi North	Afungi South
Seagrass	5	3	4	2	2
Shallow coral reef structures	3	4	1	5	5
Sand beaches	5	5	5	5	5
Mangroves	5	4	5	3	5
Estuary	5	4	5	3	5
Dredging scale	1	3	4	1	1
Blasting/excavation scale	1	4	1	5	5
Maintenance dredging	1	4	4	3	3
Score	**26**	**31**	**29**	**27**	**31**

The terrestrial ecologist indicated a preference for Cabo Delgado South (particularly the western portion, further away from the coral rag forest) and Afungi Peninsula (with a preference for the northern portion as it avoided the wetlands to the south and is more disturbed by human activity). *Table 5.2* shows the terrestrial ecology scores.

Table 5.2 ***Terrestrial Ecology Scoring***

Habitat/Attribute	Cabo Delgado North	Cabo Delgado South	Cabo Delgado East	Afungi
Protected areas	3	3	3	3
Wetlands	2	2	3	2
Woodlands	3	4	1	3
Coastal forest	4	5	3	4
Mangrove	1	3	3	2
Estuary	1	4	5	1
Mammals	1	1	1	4
Avifauna	1	1	1	3
Potential herpetofauna habitat	1	1	1	1
Score	**17**	**25**	**22**	**23**

The socio-economic specialist preferred Afungi South and the western portion of Cabo Delgado South.

Table 5.3 ***Socio-economic Scoring***

Aspect	Cabo Delgado North	Cabo Delgado South	Cabo Delgado East	Afungi North	Afungi South
Local government support of project	3	3	3	3	3
Human settlements	3	4	4	2	4
Number of inhabitants	2	5	5	1	5
Proximity to a large population centre	3	3	3	1	2
Aspect	**Cabo Delgado North**	**Cabo Delgado South**	**Cabo Delgado East**	**Afungi North**	**Afungi South**
Community migration/seasonal use	1	1	1	1	1
Marine access routes	1	2	2	1	2
Subsistence agriculture	2	3	3	1	3
Presence of fishing centres	3	3	3	1	3

Overlap with land uses other than subsistence farming	1	3	3	1	4
Adjacent land use	2	1	1	1	2
Cultural/religious and historical importance of the site	1	2	1	1	2
Tourism ventures	1	2	2	2	3
Recreational activities and sites	2	2	1	2	2
Ecotourism use (community benefit)	0	0	0	0	0
Score	**25**	**34**	**32**	**18**	**36**

A site selection workshop was then held in June 2011, where the above results were shared with the Engineering Team, and the EIA Team was updated with the technical considerations for site selection. The Afungi South site was screened out due to technical reasons associated with the construction of a harbour and jetty and excessive dredging requirement. One of the main outcomes of this workshop was the selection and delineation of the south-western Cabo Delgado and northern Afungi sites (referred to as the Cabo Delgado and Afungi Sites, *Figure 5.3*) as the two alternative sites to be analysed further. These two sites were then visited by the specialists for more detailed fieldwork in July 2011, and were subjected to a comparative analysis (assigned a value of 1 or 0 for each criterion [1]) to determine which site was preferable from the marine ecology, terrestrial ecology and socio-economic perspective. This new evaluation method allowed the team to compare the two sites to see which was better than the other [2]. The results of the comparative analysis are presented in the following sections.

(1) 1 indicates that for a particular criterion, one site is preferred over the other. The least preferred site is assigned a 0.

(2) This evaluation method is slightly different from that used in the first round. In the first round, each site was assessed independently of the others, ie the potential existed for all sites to be deemed unsuitable. In the second round, once two suitable sites were selected, the purpose was to see which site was preferred from an integrated environmental, social and technical perspective.

40°20'0"E 40°25'0"E 40°30'0"E 40°35'0"E 40°40'0"E

Quionga

Palma

Olumbe

Cabo Delgado Peninsula

Palma Bay

Tecomaji Island

Afungi Peninsula

Rongui Island

Queramimbi Island

R. Mecumbi

Palma

Manguna

Nkalanga

Macala

Nsenga

Nkumbi

Matapata

Quitupo

Maganja

Mute

Olumbi

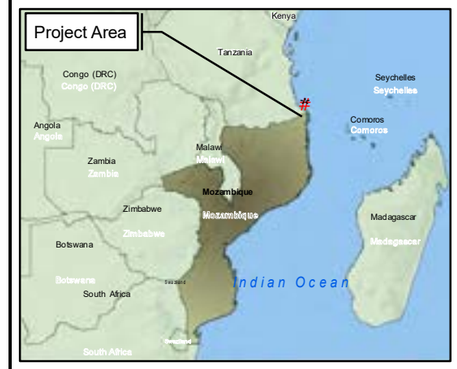
40°20'0"E 40°25'0"E 40°30'0"E 40°35'0"E 40°40'0"E

Legend

- Administrative Post Centre
- District Centre
- Locality Centre
- Villages
- Rivers

Roads

- Tertiary
- Local
- Non Classified
- District Boundary
- Administrative Post Boundary
- Palma District
- Quionga District
- Project Areas



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 5.3:
Afungi and Cabo Delgado Sites

CLIENT:

Anadarko
Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 160 000

DRAWING: Afungi and Cabo Delgado Sites.mxd

REV: A

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10°45'0"S

10°50'0"S

10°55'0"S

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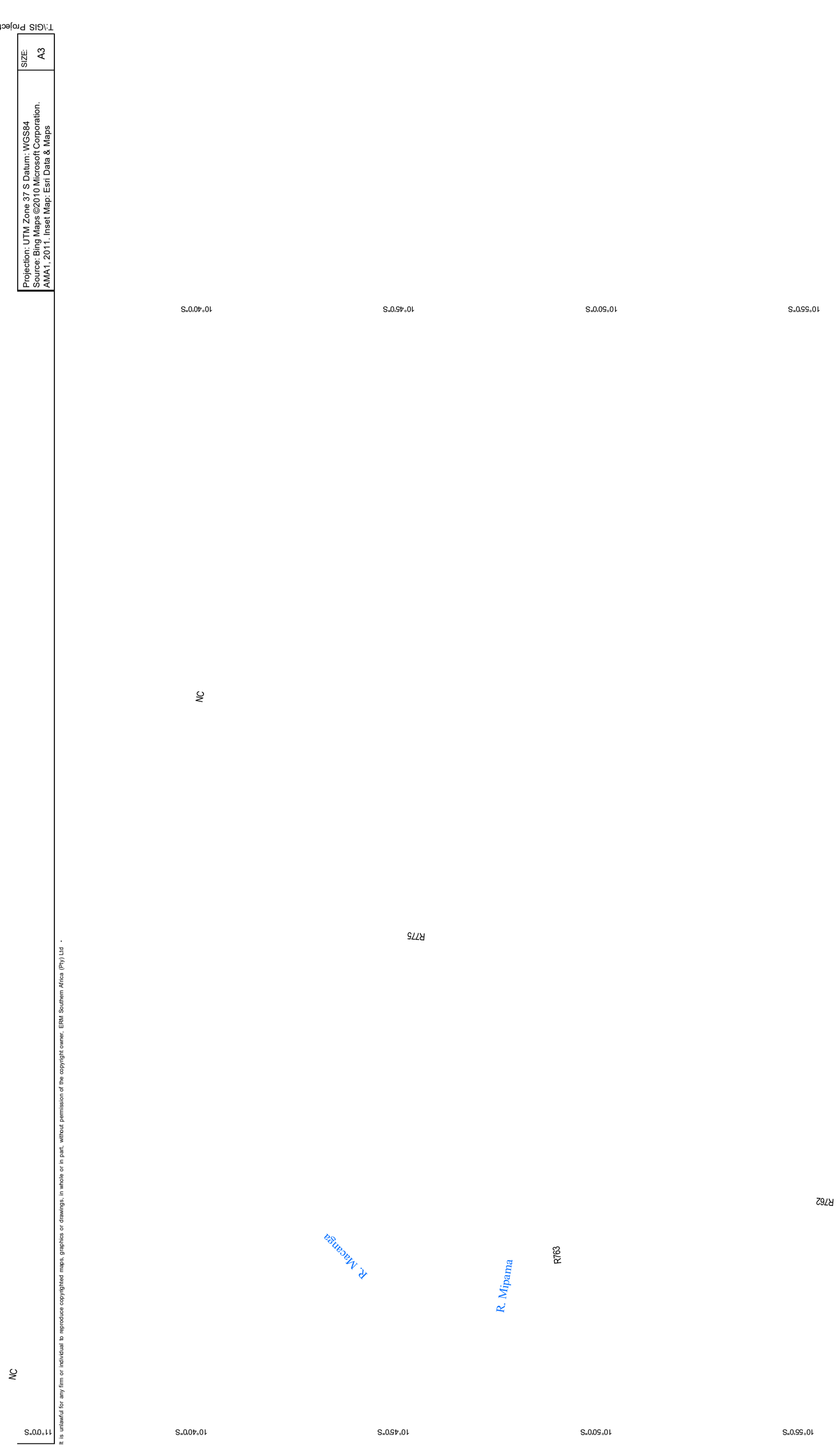

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5.2.1 *Terrestrial Ecological Assessment*

From a terrestrial ecology perspective, Afungi was strongly preferred (Afungi scored 10 while Cabo Delgado scored 2) for the development of the LNG Facility (*Table 5.4*). Afungi presented fewer concerns related to sensitive areas, wetlands, regionally important woodlands, mammals, avifauna and herpetofauna. In addition, the Cabo Delgado site would require an onshore pipeline routed from Afungi Peninsula around the town of Palma to supply the gas from the offshore well field. Cabo Delgado was less disturbed and exhibited greater integrity and areas of intact wetland systems, as well as higher habitat diversity which supported a variety of mammals, avifauna and herpetofauna. Areas close to the site were also ecologically significant with sensitive habitats and biodiversity, thus raising a concern about increasing disturbances to these areas as a result of improved access and/or people moving to the area looking for work.

Table 5.4 Terrestrial Ecology Comparison

Criteria	Cabo Delgado	Afungi
Protected areas	0	1
Wetlands	0	1
Woodlands	0	1
Coastal forests	0	0
Mangroves	1	0
Estuaries	1	0
Mammals	0	1
Avifauna	0	1
Herpetofauna	0	1
Health and safety	0	1
Current impact levels	0	1
Future effects of in-migration	0	1
Pipeline	0	1
Score	**2**	**10**

5.2.2 *Marine Ecological Assessment*

From a marine ecology perspective, there was a slight preference for Afungi over Cabo Delgado (*Table 5.5* shows that Afungi scored 1 while Cabo Delgado scored 0). This is due to risks to a larger area of seagrass at Cabo Delgado, together with possible dredging issues. Where a site is indistinguishable from the other for a particular criterion, a '0' is assigned to both. One of the important points influencing site selection was the potential impacts on the mangroves to the east and west of the Afungi site. All information from the Engineering Team to date has indicated that there will be no impacts (direct footprint impacts or indirect effluent impacts) on these mangroves.

Table 5.5 Marine Ecological Comparison

Criteria	Cabo Delgado	Afungi
Shallow coral reefs	0	0
Sand beaches (turtles nesting)	0	0
Mangroves	0	0

Criteria	Cabo Delgado	Afungi
Estuaries	0	0
Seagrass	0	1
Linked biotopes	0	0
Score	**0**	**1**

5.2.3 *Socio-economic Assessment*

From a socio-economic perspective, Cabo Delgado was slightly preferred over Afungi (Cabo Delgado scored 3 while Afungi scored 2). Afungi was less preferred due to the larger number of inhabitants, agriculture land use and overlap with other land uses. However, Cabo Delgado presented significant issues such as the location of two villages along the coast (Quiwia and Macongo), the relatively large area of land used in lowland cropping systems and cash crops, such as cashew and coconut trees, and the importance of the coast to households' livelihoods strategies, such as fishing and coconut tree plantations. Cross-cutting issues on the two sites are:

- access to fishing areas, both inshore and offshore;
- access to highland and lowland areas for agriculture production; and
- loss of productive trees, such as coconut and cashew trees.

The conclusion drawn was that both sites presented potential impacts that would need to be mitigated and managed.

Table 5.6 ***Socio-economic Comparison***

Criteria	Cabo Delgado	Afungi
Local government support of project	0	0
Human settlements	0	0
Number of inhabitants	1	0
Number of structures (residential and non-residential)	0	0
Proximity to a large population centre	0	0
Community migration/seasonal use	0	0
Marine access routes	0	0
Subsistence agriculture	1	0
Presence of fishing centres	0	0
Overlap with land uses other than subsistence farming	1	0
Adjacent land use	0	0
Cultural/religious and historical importance of the site	0	0
Tourism ventures	0	1
Recreational activities and sites	0	0
Ecotourism use (community benefit)	0	0
Length of onshore pipeline	0	1
Score	**3**	**2**

The results of the three specialist investigations were consolidated and integrated with the results of the technical inputs from the Engineering Team at a second site selection workshop in September 2011. The outcome of this

second and final workshop was the selection of the Afungi North site from an integrated environmental, social and technical perspective.

5.3 LAYOUT ALTERNATIVES

Once the Afungi North site was selected, the layout alternatives that were considered further were:

- the routing of the gas pipeline corridor to the Project site; and
- the siting of the various onshore Project components.

5.3.1 *Routing of the Gas Pipeline Corridor to the Project Site*

Three potential alignments were initially considered for the gas pipeline corridor in Palma Bay. The corridor is wide enough to accommodate pipelines for up to 6 trains. Option 1 was to route the corridor north of Tecomaji Island. Option 2 was to route the corridor between Tecomaji and Rongui Islands, while option 3 routed the corridor south of Rongui Island, making landfall on the southern shoreline of Afungi Peninsula (*Figure 5.4*). All three options were screened from a technical and ecological perspective.

40°30'0"E

40°40'0"E

Assame

Issa

Quiwia

Cabo Delgado Peninsula

Palma Bay

Palma

Tecomaji Island

Manguna

Nkalanga

Macala

Quitupo

Afungi Peninsula

Senga

Maganja

Nkumbi

Rongui Island

Matapata

Queramimbi Island

Bawala

bing

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40°30'0"E

40°40'0"E

Legend

- Villages / Settlements
- Regional Roads
- Jetty
- Onshore Layout
- Afungi Project Site

Alternative Pipeline Route

- Option 1
- Option 2
- Option 3

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 5.4:
Pipeline Corridor Alternatives

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 125 000

DRAWING: Pipeline Corridor Alternatives.mxd

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SIZE:
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10°40'0"S

10°40'0"S

10°50'0"S

10°50'0"S

Option 1 presented technical concerns associated with crossing deep offshore canyons as well as with routing the corridor within the proposed shipping channel. Crossing canyons would make pipe-laying difficult and may be unstable, risking the integrity of the pipes. Pipes within the shipping lane would need to be armoured to protect them from potential damage by ship anchors. This would increase costs and introduce a safety concern. The reef north of Tecomaji is extensive, with coral cover increasing with depth. Therefore, from a marine ecology perspective, a corridor north of Tecomaji would require extensive mitigation. Closer to the island, the reef base comprises masses of dead coral rubble. In places, the coral rubble is barren and devoid of obvious recolonisation by macrobenthos (1), while in some areas there is prolific overgrowth by a foliose algae and healthy regrowth of both massive and branched hard coral forms. In the deeper water further north of the island, there are is a high diversity of coral forms.

Option 2 presented a relatively shallow gradient moving from deep water into Palma Bay. Shallow gradients are preferred from a technical perspective, as more intensive engineering design and construction is required to traverse steep gradients. Steep slopes can be unstable and avoiding them minimises risks to the pipelines. Sand seafloor dominates the area between Tecomaji and Rongui islands, with a semi-continuous stretch extending more than 1.1km across the centre of the transect. Isolated bommies (columns of coral reef on sand or on a platform of reef) are concentrated on the northern portion of the surveyed area, close to Tecomaji Island. Coral reef can be found closer to Rongui Island. The hard substrata between Tecomaji and Rongui are low relief clusters of what appears to be a dead coral base.

Option 3 presented significant constraints from a construction perspective. The pipeline corridor would have to negotiate a reef wall and then cross the head of a submarine canyon before reaching the sand flats south of Afungi. The pipeline would have to rise from depths of 350m up to the reef wall, about 30m deep, then abruptly drop off to an approximately 280m depth. Thereafter, the corridor would have to transition a second slope to shallow water before crossing over to the Afungi Peninsula. The depth variation happens within approximately 2km, which means that laying pipes would be difficult and, even if they could be laid, could incur stabilisation and flow assurance issues. After making landfall, the pipeline corridor would have to cross the southern portion of Afungi Peninsula to access the LNG Facility on the north of Afungi. From a terrestrial/surface water ecology and social perspective, this would have entailed crossing wetland areas, disturbance of terrestrial habitats and potential disturbance to homes and/or agricultural fields. From a marine ecology perspective, the reef towards the seaward drop-off south of Rongui Island was significantly more extensive than at the inshore areas. While the reef is dominated by large expanses of coral rubble, regrowth of branched, massive and encrusting coral forms, as well as a diversity of soft coral and encrusting sponge, was evident.

(1) Large organisms that live at the bottom of the sea (on the seafloor or on coral).

From the above analysis, Option 2 stood out as being acceptable (and preferred) from both a technical and a marine ecology perspective. It was therefore selected as the projected route for the pipeline corridor.

5.3.2 The Siting of Various Onshore Infrastructure

The placement/layout of some of the onshore infrastructure was influenced by recommendations from the specialist studies, as described later in the EIA impact chapters (see *Chapter 10* for more details). The FEED process will also involve detailed design and layout of the facilities, taking into account the recommendations from this EIA.

External factors could also influence the final Project design. Should the Government of Mozambique decide to create an Industrial Development Zone (IDZ) in Palma District, it may request that the Project locate the airstrip or housing area within the IDZ's spatial plan. These alternatives are outside the scope of this EIA and, should these components need to be relocated, the EIA will be amended or a new environmental assessment process followed.

5.4 TECHNOLOGY AND PROCESS ALTERNATIVES

5.4.1 Pretreatment Technologies

There are currently several gas pretreatment technologies and proprietary design options used at various LNG facilities worldwide. The technical evaluation of each of these processes will be undertaken during the ongoing engineering design of the Project, as part of the FEED process. However, some commitments regarding pretreatment have been made.

- An activated methyldiethanolamine (MDEA) system will remove acid gas (CO_2).
- The gas will be dehydrated via molecular sieve and possibly refrigeration.
- A mercury removal system will be implemented as a precaution, even though there is as yet no evidence of mercury in the gas.
- A system to remove pentane and heavier hydrocarbons will be implemented.

The FEED process will entail detailed process design to assess the best available technology options and the most cost-effective approach, and to minimise environmental and social impacts. The FEED process is projected to last just over a year, from late 2012 to early 2014.

5.4.2 *Liquefaction*

As discussed in *Chapter 4*, liquefaction of natural gas into LNG will likely be performed using one of two proprietary liquefaction process technologies. While the desired technology is at present undecided, the processes are similar to the extent that neither introduces a new aspect into the Project that would result in the potential for additional impacts – therefore, any potential impacts will not be dependent on the liquefaction process technologies. The decision on the preferred technology will be a product of the ongoing competitive FEED studies. The two technologies being considered are:

- the Air Products and Chemicals Incorporated process, which uses propane and multi-component refrigerants [1] and a main cryogenic heat exchanger to liquefy the gas into the LNG product; and
- the ConocoPhillips Optimized Cascade™ process, which uses a cascade process where natural gas is chilled in successively colder heat exchangers that use propane, ethylene and methane as refrigerants.

5.4.3 *LNG Tanks*

The types of LNG tanks include single containment, dual containment and full containment. Based on a technical risk assessment of equipment layout, the Engineering Team has taken a precautionary approach and committed to full containment. Full-containment tanks typically feature a primary liquid containment open-top inner tank and a concrete outer tank. The outer tank provides primary vapour containment and secondary liquid containment. In the unlikely event of a leak, the outer tank contains the liquid and provides controlled release of the vapour.

The number of tanks required will be determined during FEED, but the current estimate is that four tanks will be required to support the operation of up to six 5 MMtpa [2] liquefaction Trains. Actual phasing of the tanks will depend on the sequencing of the Trains and their final design capacity.

5.4.4 *Cooling Systems*

The LNG plant process systems could be air or water cooled. From an environmental perspective, air-cooled systems reduce the facility's water requirements, which is in keeping with the international good practice of reducing natural resource use wherever possible. Moreover, air cooled system avoid the need to discharge heated water into receiving environments onshore or off shore.

The Engineering Team has decided that air cooling will be the primary cooling method for all processes. There is a possibility that water cooling may be used

(1) Within the Air Products and Chemicals Incorporated suite of technologies, there are several options: Single Mixed Refrigerant (SMR), Dual Mixed Refrigerant (DMR) and Propane pre-cooled Mixed Refrigerant (C3MR).

(2) Million metric tonnes per annum.

in limited situations (eg closed loop oil cooling processes) depending on the final facility design. The current assumption is that any water cooling (if it cannot be avoided or is required by special process or mechanical systems) would be done with an open recirculating system utilising cooling tower(s). Priority will be given to sea water instead of freshwater sources. Process design during FEED will work to minimise water consumption.

5.4.5 Discharge Management

The current project base case allows for discharge of treated effluents into Palma Bay. Through the course of FEED, the optimal solution for treatment and disposal of effluents will be investigated.

5.5 NO-GO ALTERNATIVE

The no-go alternative implies that the proposed Project would not be executed. Assessment of the no-go alternative will require an evaluation of the relative trade-offs between the economic and social development benefits associated with the Project against the environmental and social costs of the Project.

Assuming that the offshore wells and onshore LNG Facility would not be developed, the onshore and offshore environment would remain in its current state and there would be no negative environmental and social impacts associated with the development. All assessments in *Chapters 11* to *15* are made against the current baseline conditions ie against the 'no-go'. Thus, should the Project not go ahead, the identified positive and negative impacts will not materialise and the status quo will continue.

A high-level no-go analysis is provided in the following sections.

5.5.1 Alignment with Government Policy

The Government of Mozambique has embarked on a concerted growth strategy to address a number of social and economic challenges faced by the country. Included in this strategy are policies to exploit its mineral resources (including natural gas). Hydrocarbon exploration in Cabo Delgado Province in northern Mozambique, and specifically in the Mocímboa da Praia and Palma districts, started in the 1980s. The natural gas discoveries made to date in the offshore gas fields of Area 1 and Area 4 are among the world's most significant discoveries in the last 20 years. To guide the development of gas reserves in the country, Mozambique has compiled a Natural Gas Master Plan for Mozambique (currently in draft form). As presented at a Stakeholder Workshop in September 2012, the vision of the Plan is to develop natural gas resources in a manner that maximises benefits to Mozambique society by supporting:

- growth in domestic public and private sector institutional competencies;

- growth in domestic industry and businesses, especially small and medium-scale industries;
- increased employment across the country, especially in less-developed provinces;
- infrastructure to support expanded economic activities, especially in less-developed provinces; and
- expanded access to training and education.

In addition, the vision is to improve the quality of life for the people of Mozambique, while minimising adverse social and environmental impacts.

Not proceeding with the Project, while taking all due consideration of potential environmental and social impacts, runs counter to the vision of the country's Natural Gas Master Plan.

5.5.2 Economic Benefits not Realised

For the initial LNG development (two trains estimated 10mtpa), the Project could result in an overall investment of up to US$25 -30 billion, making this potentially the largest investment project in Mozambique to date. Assuming export of the LNG to the premium markets, such as Japan and the Far East, the Government of Mozambique should see a significant increase in Gross Domestic Product (GDP) and through its royalty, tax and equity gas rights. Mozambique will benefit from a substantial increase in Government revenue for the next several decades. This economic benefit could be used to improve the health, education and quality of life of the people of Mozambique.

As the number of trains and volume of LNG export, increases the economic benefits can be compounded several times, provided that the natural gas resources are fully developed over time. It has been the stated intention of the Government of Mozambique to encourage industrial development using natural gas in the area of the Project, further expanding the social and economic benefits derived from development of Mozambique's offshore natural gas resources in the Rovuma Basin.

The no-go alternative would result in status quo conditions and the loss of substantial and long lasting social and economic benefits for the people of Mozambique.

5.5.3 Unmet Local Expectations

To date, local communities have expressed support for the Project and have voiced the need for socio-economic development in the form of training, employment and community development projects. Should the Project not go ahead, the local communities in Palma District would feel disappointed as

significant investment in local human resources and the local economy would not occur. Potential positive socio-economic impacts are described and assessed in *Chapter 13*.

5.5.4 Negative Socio-economic Impacts Averted

Chapter 13 also details the potential negative socio-economic impacts associated with the Project. At a high level, these impacts relate to people who would need to be relocated; to a decrease in, or loss of access to, natural resources; to the disruption of normal land and sea transport routes; to the potential or perceived land-use conflict with tourism investments in the area; to the potential for conflict with local communities and increased pressure on local social services and infrastructure as a result of in-migration; and to the perceived 'sense of place'. Should the Project not go ahead, these potential negative impacts would be avoided.

5.5.5 Negative Biophysical Impacts Averted

Potential impacts on the marine and terrestrial biophysical environments are detailed in *Chapters 11* and *12*.. Potential biological impacts are associated with the degradation or loss of habitats and with a disturbance to, or loss of, sensitive or conservation-worthy plant and animal species. These impacts range from a local scale (eg loss of a wetland) to a regional scale (potential impacts on migratory birds). In addition, the potential in-migration of people into Palma District would also place additional pressure on natural resources (water, plants and animals) in the area.

From a physical perspective, the Project will affect air quality and ambient noise levels, and will increase Mozambique's contribution to global greenhouse gas emissions. Should the Project not go ahead, these potential negative biophysical impacts would be avoided.

5.6 CONSIDERATION OF ALTERNATIVES THROUGH FEED

Various other technological and process alternatives will be evaluated as part of the FEED processes in alignment with the EIA philosophy of avoidance, minimisation and mitigation and with Good International Industry Practice.

Chapter 6

Baseline- Introduction and Geographical Context

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6 BASELINE – INTRODUCTION AND GEOGRAPHICAL CONTEXT

6.1 OVERVIEW AND STRUCTURE OF THE EIA BASELINE

This baseline volume of the EIA Report describes the existing marine and terrestrial environmental characteristics of the Afungi Project Site and surrounding areas. It provides descriptions of the nature, value and sensitivity of the physical, biological and socio-economic resources and receptors potentially affected by the Project.

The purpose of this chapter is to define the Project's Areas of Direct and Indirect Influence (see *Section 6.5*) and provide a general overview of the physical characteristics that provide the context for both the onshore and offshore activities proposed.

6.1.1 *Structure of the EIA Baseline Chapters*

The description of the affected environment has been divided into the following chapters and sections:

- *Chapter 6* – Baseline Introduction and Geographical Context:
  - Overview and Structure of EIA Baseline Chapters;
  - Summary;
  - Sources of Information;
  - Geographical Setting;
  - Areas of Influence and Study Area;
  - Climate and Meteorology;
  - Air Quality;
  - Noise;
  - Landscape and Seascape Character and Visual Amenity; and
  - Nature Conservation.
- *Chapter 7* – Offshore and Near Shore Environmental Baseline:
  - Introduction;
  - Summary;
  - Sources of Information;
  - Regional Context- Quirimbas Archipelago;
  - Offshore Environment: Physical Conditions;
  - Offshore Environment: Major Biological Features;
  - Near Shore Environment: Physical Conditions;
  - Near Shore Environment: Marine Habitats; and
  - Near Shore Environment: Major Biological Features.
- *Chapter 8* – Onshore Environmental Baseline:
  - Introduction;
  - Geology and Terrain;
  - Soils and Land Capability;

- Groundwater;
- Hydrology;
- Surface Water Ecology;
- Vegetation;
- Herpetofauna;
- Avifauna;
- Mammals; and
- Summary of Key Onshore Environmental Sensitivities.

- *Chapter 9* – Socio-economic and Community Health Baseline:
  - Introduction;
  - Summary
  - Sources of Information;
  - Socio-economic Study Area;
  - Overview of Palma District;
  - Cabo Delgado Province: Administrative and Political Overview;
  - Cabo Delgado Province: Socio-demographic Indicators;
  - Cabo Delgado Province: Economic Activities;
  - Palma District Political and Administrative Organisation;
  - Palma District and Afungi Project Site: Socio-demographic Indicators;
  - Palma District and Afungi Project Site and Surrounds: Use of Natural Resources;
  - Palma District, Afungi Project Site and Surrounds: Land Use and Occupation Patterns;
  - Palma District: Non-governmental Organisations (NGOs) and Donors;
  - Palma District and Afungi Project Site: Social Services;
  - Palma District and Afungi Project Site: Economic Activities and Livelihoods;
  - Afungi Project Site and Surrounds: Cultural and Religious Profile;
  - Afungi Project Site and Surrounds: Expectations Regarding the Project;
  - Shipping and Navigation; and
  - Archaeology and Cultural Heritage.

6.2 SUMMARY

The proposed LNG Facility will be located on Afungi Peninsula, on the southern shores of Palma Bay, close to the town of Palma. Area 1 extends up to 50km offshore in the Rovuma Basin, and the Mamba Gas Field located in Area 4, extends approximately 30km further offshore. Both Area 1 and Area 4 border with Tanzania in the north. The Project's Areas of Direct and Indirect Influence include elements of the offshore, near shore and onshore environment where Project activities will take place or will potentially impact, either positively or negatively.

The area experiences one wet season and one dry season annually. The average annual temperature and humidity is 25.9°C and 75.8 percent respectively, with peaks during the wet season from December to April. From March to September, wind patterns in the Palma area are predominantly

south-south-easterly, while from October to February, they are predominantly north-easterly.

The baseline concentrations of air pollutants onshore, including nitrogen dioxide (NO_2) and nitrogen oxides (NO_X), are low. The current offshore air quality is considered to be acceptable and within Mozambican or international standards. Noise levels at the ocean are relatively steady between daytime and night-time, whereas inland night-time levels are quieter. Dominant sound sources across the Afungi Project Site are from wildlife activities such as birdsong, frogs, insects and daily human activities. In locations where these sources are not present, or are to a lesser extent, noise levels tend to be lower.

Palma Bay is a large distinct natural bay. The wider area includes remote wooded landscapes, located inland of coastal settlements. The islands to the northern extreme of the Quirimbas Archipelago (ie Rongui, Tecomaji, Vamizi islands, etc) form an important part of the overall seascape in the area. There are no gazetted protected areas within the Area of Direct Influence (ADI). However, there are a number of designated and proposed conservation areas in the greater region, both terrestrial and marine, including Quirimbas National Park and Mnazi Bay–Rovuma Estuary Marine Park.

6.3 *SOURCES OF INFORMATION*

The majority of the data outlined in the baseline descriptions have been derived from surveys (primary data collection) carried out by environmental, social and health specialists specifically for the EIA, in accordance with the Terms of Reference (ToR) detailed in the EPDA Report. Where required (primarily the biophysical studies), fieldwork was undertaken during both the wet and dry seasons. The methodologies applied by the various specialists are presented in *Annex C*. The various specialists and organisations involved in the EIA and their respective studies are outlined in *Chapter 3*. It should be noted that the specialists' baseline descriptions have been incorporated directly into relevant sections of this EIA Report, hence no separate specialist reports are appended.

The baseline also draws upon a comprehensive review and analysis of existing information (known as secondary information), including data collected for EIAs for the exploration phase of the Project, from EIAs for other projects in Cabo Delgado Province, including onshore and offshore projects, and from other relevant reports and studies [(1)].

(1) The other EIAs are in the public domain and were undertaken by Impacto. Other studies were undertaken or commissioned by Government or by independent scientists. All reports and studies used are in the public domain and referenced in this report.

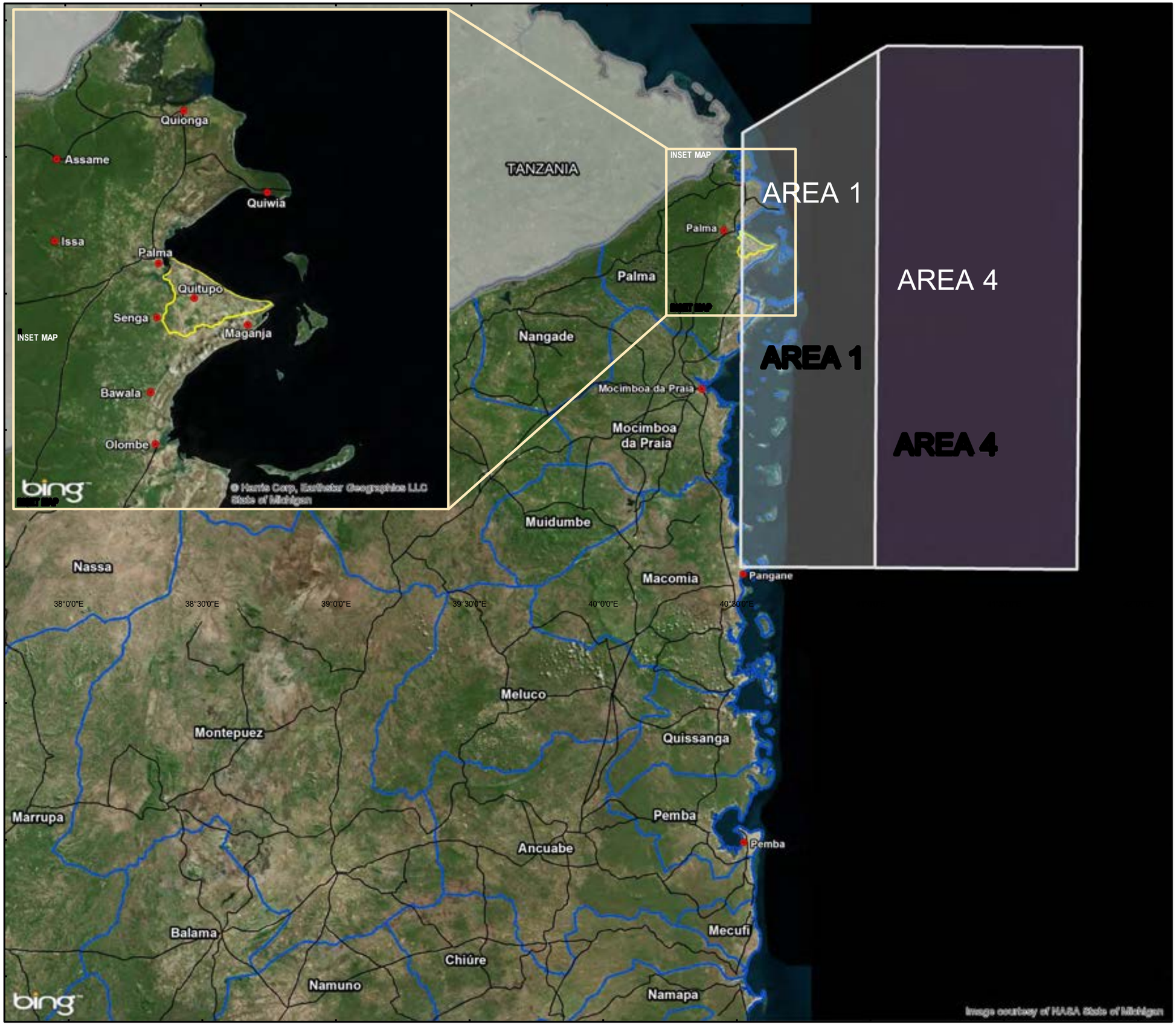
The analysis and review of primary and secondary data have allowed the offshore and onshore environmental baselines and their sensitivities to be defined accurately.

6.4 GEOGRAPHICAL SETTING

Area 1 and Area 4 are located in the Rovuma Basin and extend from Pangane north to the Rovuma River, a natural boundary with the Republic of Tanzania. Area 1 extends up to 50km offshore and Area 4 extends up to 60km further offshore, as shown in *Figure 6.1*. Area 1 comprises an area of approximately 10,500km^2.

The proposed LNG Facility will be located on Afungi Peninsula, close to the town of Palma, as shown in *Figure 6.2*. The peninsula is located on the southern shores of Palma Bay, a large distinct natural bay in the north-east of Cabo Delgado Province. The Afungi Project Site falls in Palma District, within the Administrative Post of Palma.

The distances by road from Palma to Mocímboa da Praia and Pemba are 70km and 320km respectively.



Legend

- Towns
- Regional Roads
- Afungi Project Site
- Area 1
- Area 4
- District Boundary
- Boundary with Tanzania

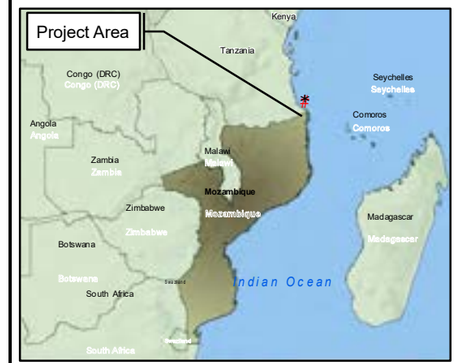


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Figure 6.1:
Regional Locality extent of Area 1 and Area 4

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Moçambique Área 1, Lda
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Legend

- ! Villages / Settlements
- Local Roads
- Regional Roads
- Afungi Project Site

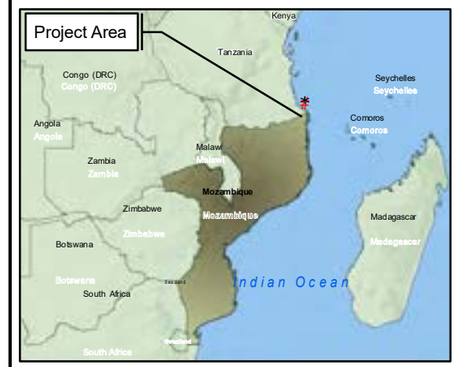

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Figure 6.2: Locality Map

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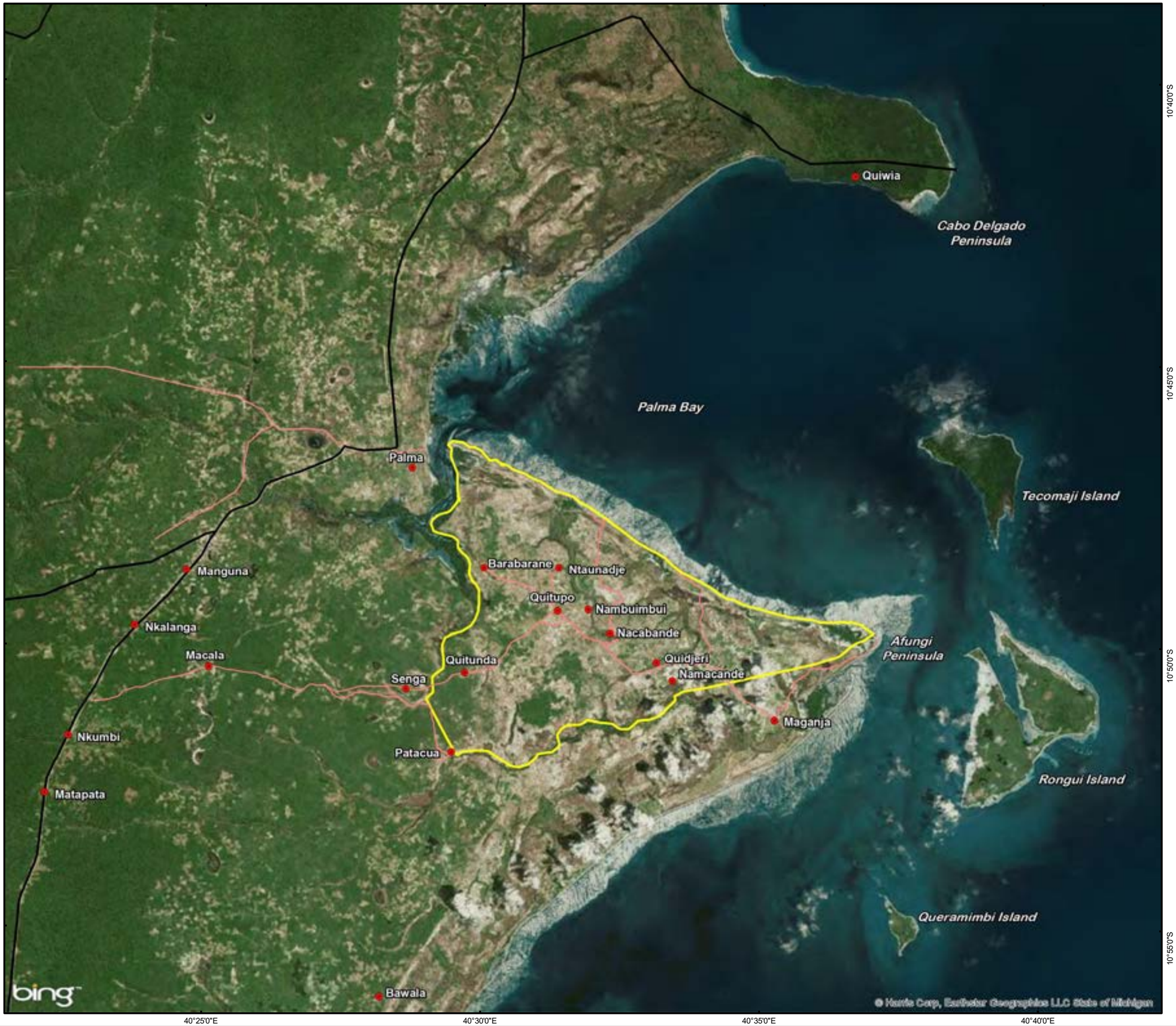

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6.5 AREAS OF INFLUENCE AND STUDY AREA

6.5.1 Areas of Influence

This section defines the Areas of Direct and Indirect Influence. The Project Area can be divided into Areas of Direct Influence (ADI) and Areas of Indirect Influence (AII).

The ADI comprises the areas offshore, near shore and onshore where the Project infrastructure will be located, ie the direct Project Footprint. Offshore, the ADI comprises the immediate vicinity of each natural gas well in the Golfinho, Prosperidade and Mamba gas fields and the subsea production infrastructure located within Area 1 and in the vicinity of the Mamba Gas Field in Area 4, including the route of the proposed gas pipelines that will connect the offshore infrastructure to Palma Bay. Near shore, the ADI comprises areas disturbed by dredging, near shore infrastructure such as trestles/causeways and MPD. In addition, it includes the routes that the Project vessels (eg LNG Carriers, support vessels, etc.) will travel between the offshore gas fields in Area 1 and Area 4 and Palma Bay. The offshore and near shore ADIs are referred to as the Offshore Project Footprint Area in this EIA Report.

The ADI comprises two broadly defined areas of interest:

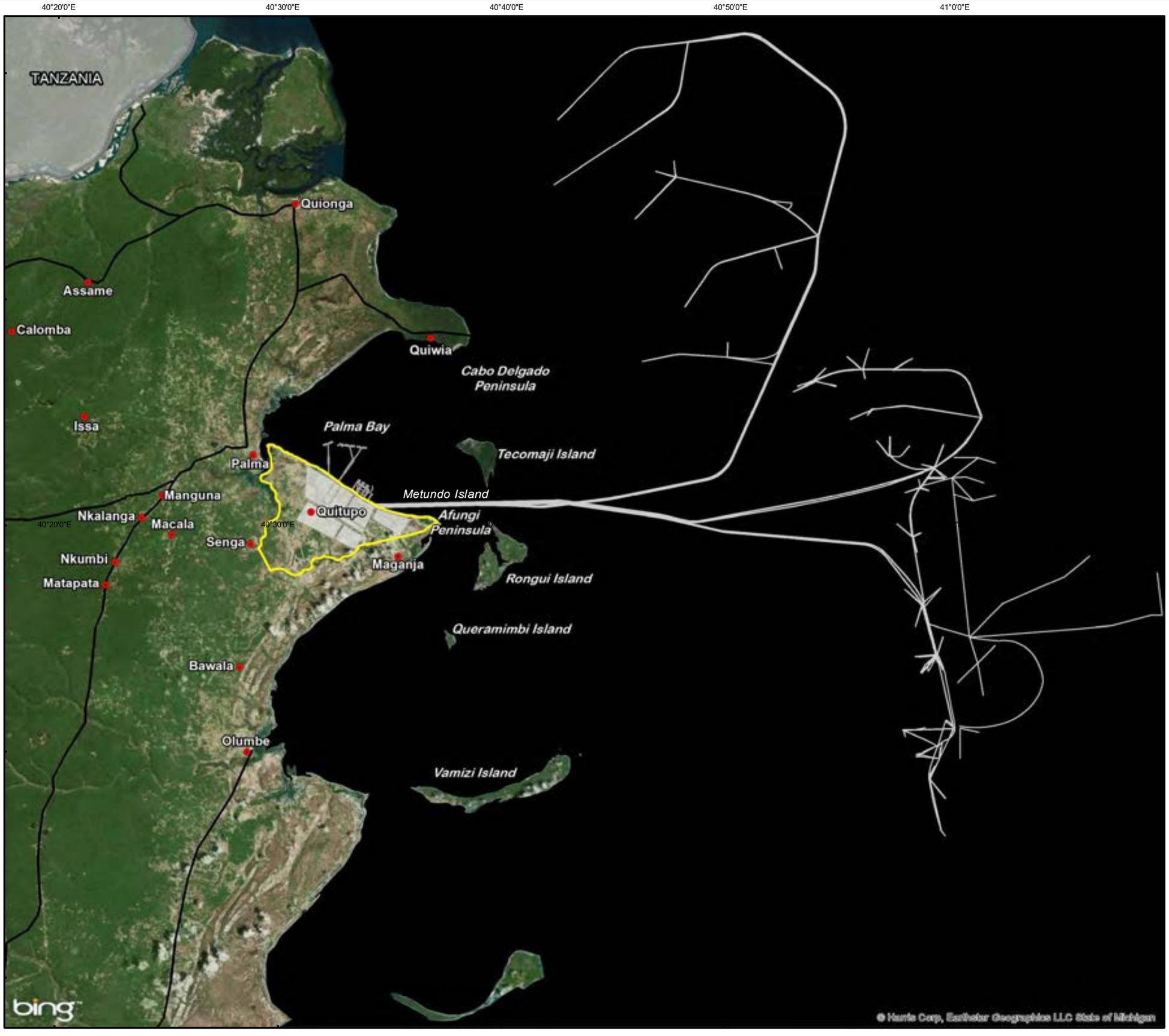
- Offshore Project Footprint Area
  - the offshore environment (Golfinho, Prosperidade and Mamba gas fields, pipeline routes, shipping routes, etc) with wider consideration of certain issues (eg visual impacts) where appropriate; and
  - the near shore, where the MPD, trestles/causeways, pipeline landfall, vessel navigation channels, exclusion zones around infrastructure, etc will be situated in Palma Bay.
- Afungi Project Site and Surrounds
  - the onshore environment at Afungi Peninsula where the LNG Facility and associated infrastructure (roads, airstrip, accommodation, etc) will be located, and
  - the areas around the Afungi Project Site (the surrounds) where people's access to livelihood assets will be affected.

These broadly defined ADIs are shown in *Figure 6.3.*

The AII refers to areas where the Project Footprint has an indirect influence, and comprises:

- Palma Bay and offshore deepwater in the vicinity of the Golfinho, Prosperidade and Mamba gas fields;

- Palma Town and villages or settlements outside of the Afungi Project Site that are indirectly impacted;
- the islands at the mouth of Palma Bay: Tecomaji, Rongui and Queramimbi, and possibly islands further south along the coast eg Vamizi Island; and
- the broader district, province and potentially the region, which can also be included in the AII from a socio-economic perspective. Similarly, the AII potentially extends to a national level, as the Project may have benefits on a national scale.



Legend

- Villages / Settlements
- Regional Roads
- Proposed Pipeline Route
- Afungi Project Site
- Area of Direct Influence

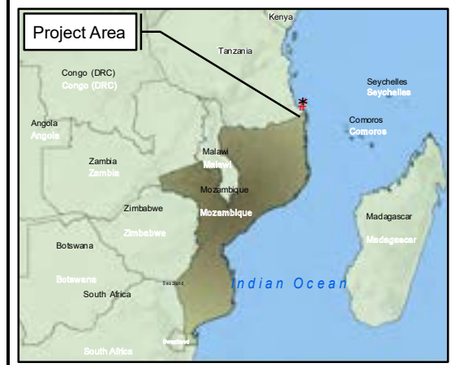


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Figure 6.3:
Areas of Direct Influence

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6.5.2 *Study Area versus Survey Area*

Due to the complexity and scale of the Project, the zone of influence (and hence the extent of the area under baseline investigation) varies depending on the receptor or resource under consideration. Specialists have used the following terminology to describe the area under baseline investigation:

- **Study Area**: this term is used when referring to the entire area under baseline investigation where impacts may occur as a result of the Project. Often, this will include areas outside the Afungi Project Site.. For example, the Study Area for the landscape and seascape visual study includes a radius of 30km from the centre of the Afungi Project Site, as it is considered that the LNG Facility may be visible at such a distance. The Study Area comprises the ADI and AII.

- **Survey Area**: this term is used when referring to areas where field investigations or surveys by the specialists were undertaken. These areas will differ for each specialist study, but are typically confined to the Afungi Project Site or ADI.

Throughout the baseline chapters, the Study Area or Survey Area under consideration or investigation is defined for each specialist study where applicable.

6.6 *CLIMATE AND METEOROLOGY*

The proposed Project has the potential for the release of certain air emissions during construction and operations. Winds and other climatic criteria are also key factors in the dispersion of atmospheric and sea surface pollutants. Moreover, meteorological and climatic conditions dictate much of the design of offshore facilities, particularly through their role in determining wave height; therefore, the baseline climate environment must be understood. This section describes the historical trends and climatic patterns in the Project Area.

6.6.1 *Seasons*

The climate in the Study Area is strongly influenced by the Intertropical Convergence Zone (ITCZ) [(1)]. In January, the ITCZ is located about 15°S of the equator and the East African coast is under the influence of north-easterly winds [(2)]. In July, the ITCZ is situated at about 15°N, and most of East Africa is under the influence of south-easterly and southerly winds [(3)]. The climate is thus subject to alternating and distinctive wet (November to April) and dry (May to October) seasons.

(1) The ITCZ, is an area of low pressure that forms where the north-east trade winds meet the south-east trade winds near the equator. As these winds converge, moist air is forced upward, causing water vapour to condense and cool, resulting in heavy precipitation.

(2) South of the equator, the winds may become more north-westerly due to the effect of the earth's rotation.

(3) These seasonal wind regimes are known as monsoons.

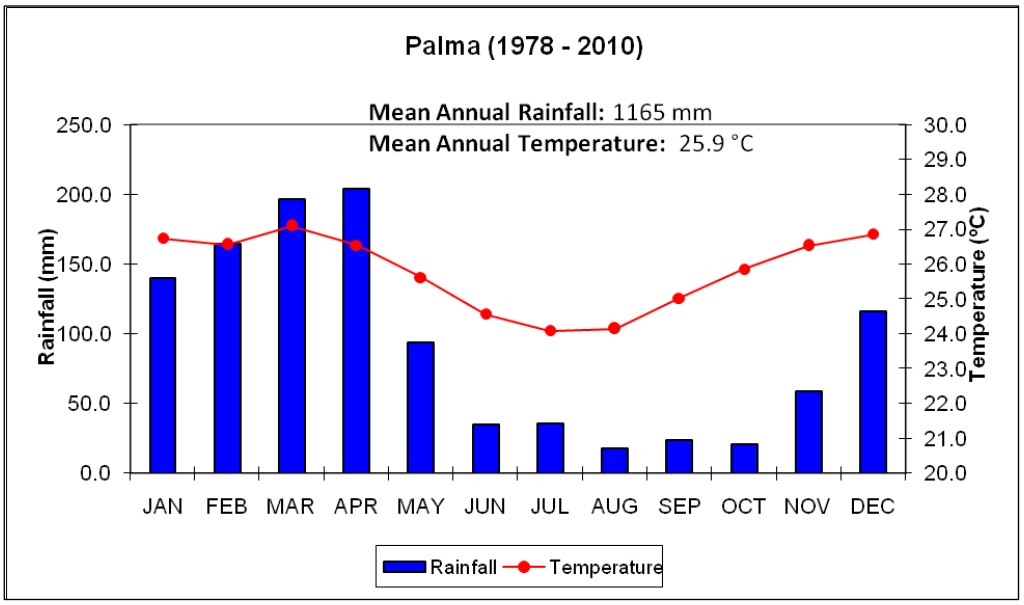
The two distinct seasons apparent in the region are shown in *Figure 6.4*: a distinct warm wet season (November to May) and a cooler drier season (June to October). These climate data were obtained from the National Institute of Meteorology (INAM) in Mozambique, which collected climate data from 1951 to early 2010 in the town of Palma [1].

6.6.2 *Rainfall and Temperature*

Mean annual rainfall for Palma town is 1,165mm, with the highest rainfall occurring during the months of March and April (196mm and 204mm respectively). Lowest rainfall occurs during the months of August, September and October (18mm, 24mm and 21mm respectively).

The average annual temperature in Palma is 25.9°C. There is little variation in average monthly temperatures, and these range between 24.1°C in August and 27.1°C in March. Average monthly rainfall and temperatures for the Palma area are shown in *Figure 6.4*.

Figure 6.4 Climate (Temperature and Rainfall) in Study Area



Source: INAM.

6.6.3 *Humidity*

High relative air humidity is typical for the region, with higher relative humidity in the wet season (January to April). The mean annual value of the relative humidity is close to 76 percent, varying between 68 percent and 82 percent. The monthly relative humidity at Palma over the year is shown in *Table 6.1*.

(1) These are the most recent data available from INAM.

Table 6.1 ***Mean Monthly and Annual Relative Humidity, Palma***

	Jan (%)	Feb (%)	Mar (%)	Apr (%)	May (%)	Jun (%)	Jul (%)	Aug (%)	Sep (%)	Oct (%)	Nov (%)	Dec (%)	Annual (%)
Mean	81.1	81.5	81.7	80.1	77.8	75.3	74.1	70.6	68.2	68.9	72.3	78.2	75.8

Source: INAM data for period 1951–2010.

6.6.4 Winds

Onshore

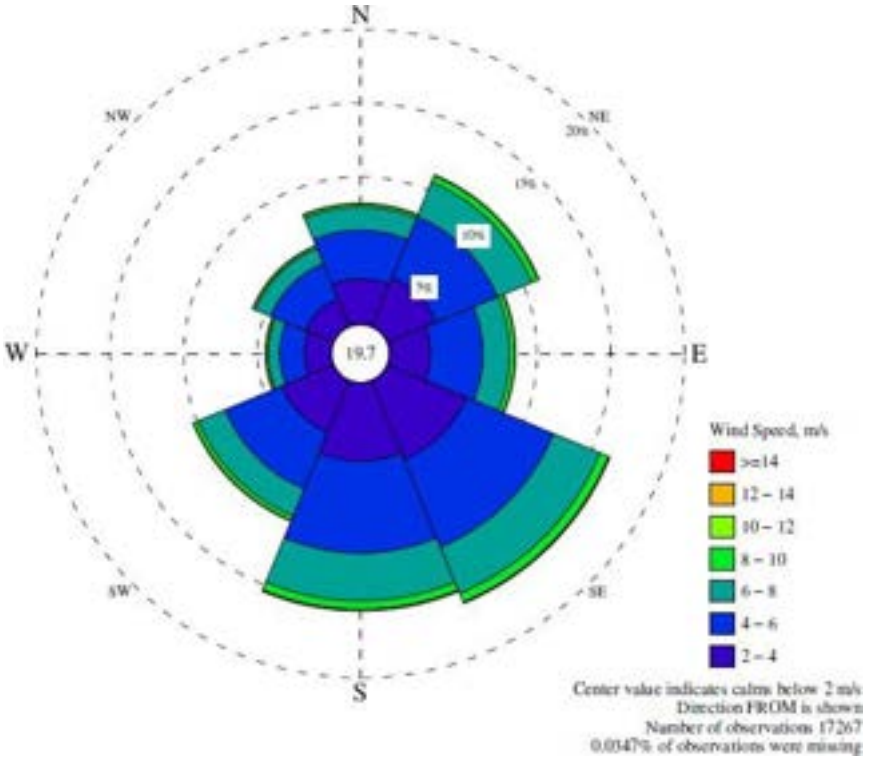
From March to September, wind patterns in Palma are predominantly south-south-easterly, while from October to February, they are predominantly north-easterly. The wind patterns for the area for 1960 to 2009 are illustrated in *Figure 6.5*. The mean annual wind speed recorded for this period is 4.1m/s, as shown in *Table 6.2*.

Table 6.2 ***Mean Monthly and Annual Wind Speed, Palma***

	Jan (m/s)	Feb (m/s)	Mar (m/s)	Apr (m/s)	May (m/s)	Jun (m/s)	Jul (m/s)	Aug (m/s)	Sep (m/s)	Oct (m/s)	Nov (m/s)	Dec (m/s)	Annual (m/s)
Min	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	3.7	3.3	3.3	3.8	3.9	4.1	4.3	4.5	4.6	4.8	4.6	4.0	4.1
Max	26.7	12.8	9.2	12.2	11.4	12.2	25.3	13.3	11.9	10.3	11.4	16.7	26.7

Source: INAM data for period 1960–2009.

Figure 6.5 Wind Rose for Palma



Source: INAM data for period 1960–2009.

Offshore

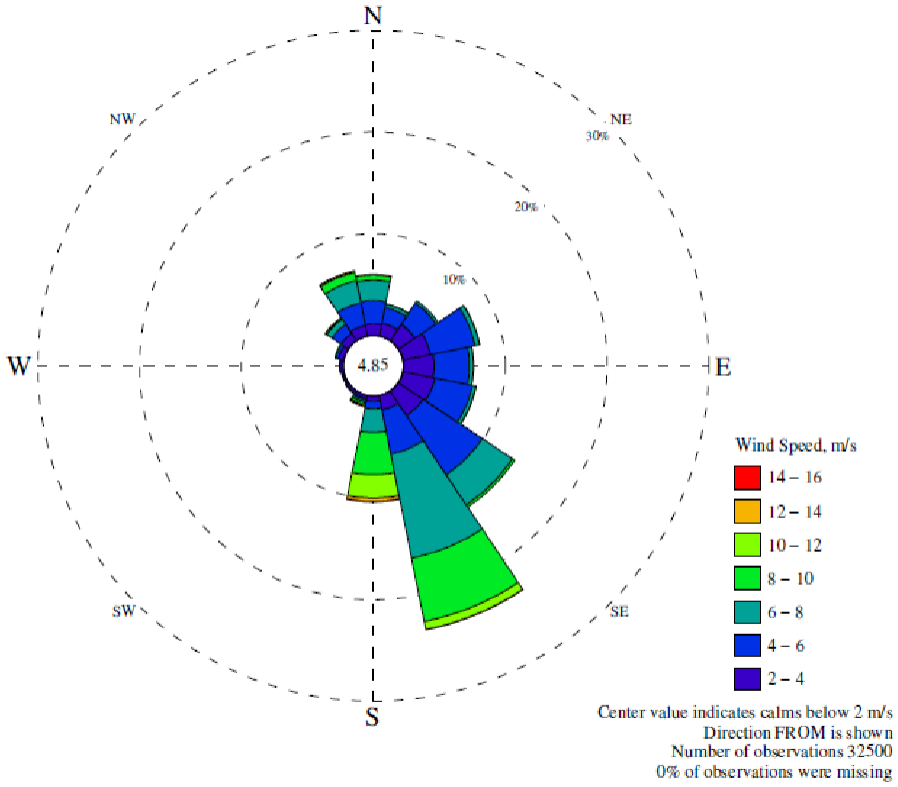
Figure 6.6 shows the annual wind pattern for the location 10.8125°S 40.6250°E, approximately at the south-east entrance to Palma Bay, offshore off Vamizi Island, for the period 1987 to 2009. Three main wind axes are evident: south-south-easterly, north-north-westerly and east-north-easterly. Wind speeds are strongest from the south-south-easterly sector, with winds from east-north-easterly generally being weak. There is a marked monsoon pattern, with southerly winds dominating in the mainly dry season (May to October). Northerly and easterly winds are most common in the warm wet season (November to April). The mean annual wind speed recorded for this period is 5.5m/s, as shown in *Table 6.3*.

Table 6.3 Mean Monthly and Annual Wind Speed, at 10.8125°S 40.6250°E

	Jan (m/s)	Feb (m/s)	Mar (m/s)	Apr (m/s)	May (m/s)	Jun (m/s)	Jul (m/s)	Aug (m/s)	Sep (m/s)	Oct (m/s)	Nov (m/s)	Dec (m/s)	Total (m/s)
Min	0.6	0.7	0.4	0.7	1.0	1.3	1.0	1.1	1.2	1.0	0.8	0.7	0.4
Mean	5.2	4.8	4.0	5.3	6.6	7.0	7.1	6.2	5.2	4.9	4.8	4.9	5.5
Max	12.3	18.4	11.2	12.9	13.0	13.6	14.2	13.0	13.7	13.4	16.6	9.5	18.4

Source: Moffatt & Nichol, 2012. Data from the Tanzania–Mozambique Metocean Study Joint Industry Project, period 1987–2009.

Figure 6.6 Annual Wind Rose for Offshore Mozambique at 10.8125°S 40.6250°E



Source: Moffatt and Nichol, 2012. Data from the Tanzania–Mozambique Metocean Study Joint Industry Project, period 1987–2009.

6.6.5 *Extreme Weather – Cyclones and Tropical Storms*

Historically and statistically, northern Cabo Delgado Province is not a cyclone-prone region. Over the last 50 years, 30 cyclones (1) have struck the Mozambican coast, affecting mainly the central sector of the coastline and bringing torrential rains, flooding and severe wind damage. No cyclones struck the Mozambican coast between 2009 and 2010. However, a few cyclones and tropical depressions struck the country's coast between 2011 and 2012, mostly in southern and central Mozambique. Only one cyclone struck the northern Mozambican coastline (north of Pemba) in the last 50 years; this cyclone made landfall near Mocímboa da Praia in 1959.

The average occurrence of cyclones in the Mozambique Channel is just over three per annum, according to Tinley (1971, cited in ERM and Consultec, 2006). The Project Area has been classified as an area of low risk for tropical cyclones by INAM, as represented in *Figure 6.7*. The main cyclone season is between November and April.

(1) A tropical storm is upgraded to a cyclone (or hurricane) when maximum sustained surface winds reach greater than 33m/s.

In 2008, a moderate tropical storm, named Asma, struck Mocímboa da Praia, 70km south of the Afungi Peninsula. It brought unseasonal heavy rains to the northern area of Mozambique and southern Tanzania, which destroyed up to 94 houses in the town (INAM, 2011).

Mozambique has adopted a cyclone alert or warning system that rapidly provides information and warnings via national, local and naval radio stations in the event of a risk of a cyclone reaching the Mozambique coast. See further details in *Box 6.1*.

Box 6.1 Cyclone Warning System in Mozambique

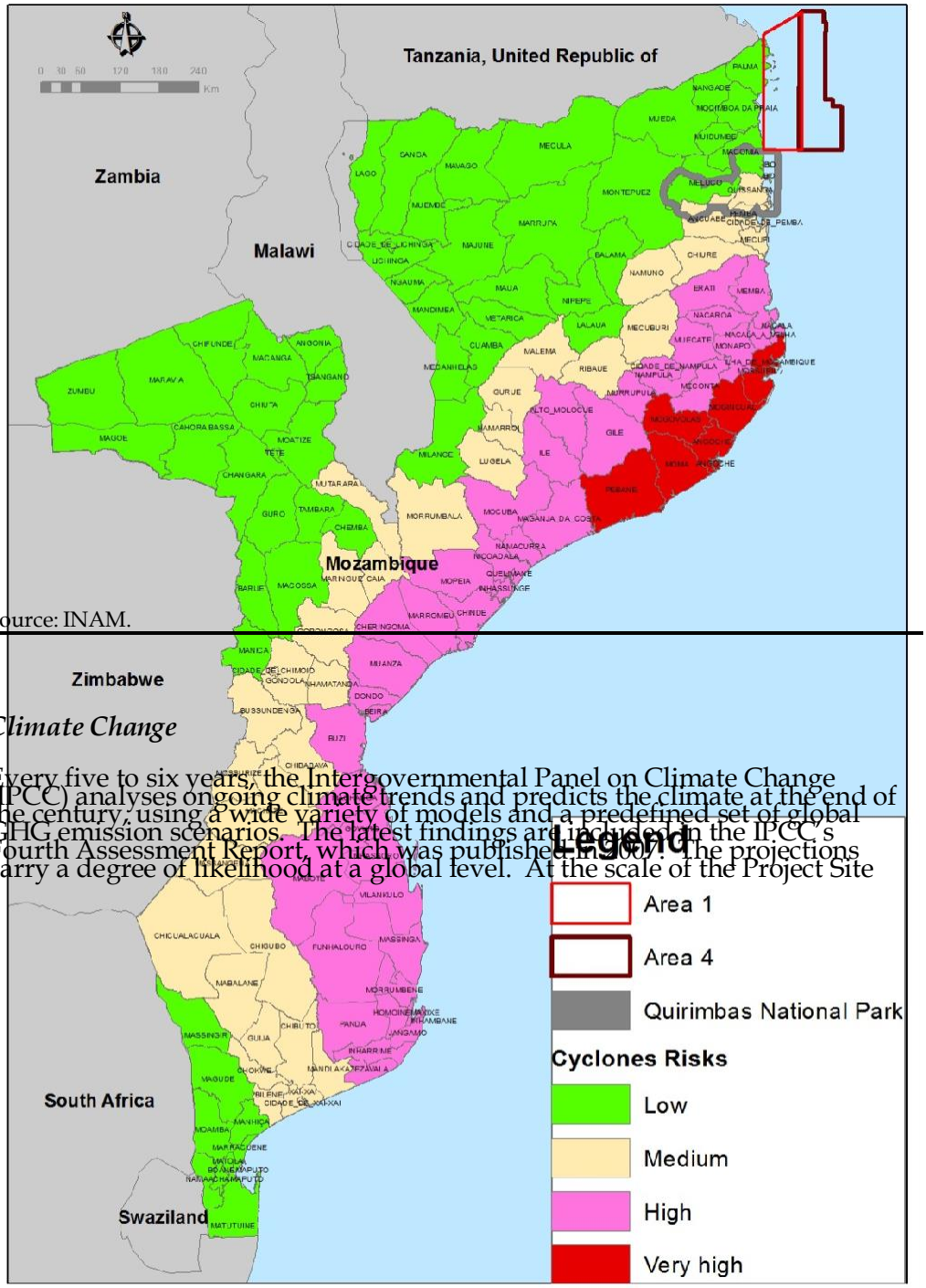
A Cyclone Warning System for Mozambique came into force on 1 November 2002. This system, which was developed by INAM and the National Institute for Disaster Management (INGC) in collaboration with the United States Agency for International Development (USAID) Famine Early Warning System Network (FEWS NET), comprises a cyclone severity category system and a colour alert system.

Categories of cyclone severity range from 1 for a moderate tropical storm to 5 for the most severe tropical cyclones. (Note: Cyclone Atang, which in 2002 made landfall at the border between Mozambique and Tanzania, was classified as a Category 4 cyclone in the Mozambican Channel but was downgraded to a Category 1 storm when it reached the coast. A Category 5 cyclone is rare and has not been recorded in Mozambique).

The colour alerts provide communities with an indication of the time available to prepare for the onset of high winds, as follows:

- **Blue**: a tropical cyclone may affect the area within 24 to 48 hours. High winds are not yet a threat, but communities should start to take precautions. Some ships may leave harbour. Check fishing boat moorings.
- **Yellow**: a tropical cyclone is moving closer and is highly likely to affect communities within 24 hours. Communities are advised to start taking action quickly. Make ships and fishing boats safe. Listen for cyclone advice updates.
- **Red**: high winds are imminent (within six hours) or may already be experienced. In this critical stage, communities are advised to take final safety measures before the onset of high winds. Ensure doors and windows are safely secured, and stay indoors. Roads and bridges may close. Radio will broadcast warning messages around the clock.

Figure 6.7 Frequency of Cyclones per District



Source: INAM.

6.6.6 *Climate Change*

Every five to six years, the Intergovernmental Panel on Climate Change (IPCC) analyses ongoing climate trends and predicts the climate at the end of the century, using a wide variety of models and a predefined set of global GHG emission scenarios. The latest findings are included in the IPCC's Fourth Assessment Report, which was published in 2007. The projections carry a degree of likelihood at a global level. At the scale of the Project Site

and the presumed operational lifetime of the Project, it is far more difficult to establish climate change projections and likely consequences. This notwithstanding, a number of studies indicate that climate changes are occurring in north-eastern Mozambique that may have repercussions for the baseline conditions.

Temperatures in northern Mozambique have increased by 1.1˚C during both summer and winter over the period 1960 to 2005 (INGC, 2009). In addition, the annual mean maximum temperature in the north of the country was rarely above 30˚C prior to 1990, whereas it has been found to have been consistently above 30˚C after 1990. Changes in rainfall patterns in north-eastern Mozambique have been recorded in recent years (Tadross, 2009). Rainfall is projected to increase across the country during December to February and March to May, although this may be largely offset by the increase in evapotranspiration rates as a result of warmer temperatures (INGC, 2009). Recent models indicate that there will likely be a declining trend in the number of cyclones taking place within the Indian Ocean, but that the intensity of cyclone events will likely increase (Emanuel et al., 2008).

Mozambique's low-lying expansive coastline makes it particularly vulnerable to anticipated climate change impacts. The country has a greater proportion of coastline lying lower than 20m above sea level than other East African coastal countries (INGC, 2009) and, as a result, sea level rise is of significant concern. Moffat and Nicol undertook a study of sea level in 2012 rise for Palma Bay and concluded the rise in sea level expected during the lifespan of the Project (ie 30 years) is 4mm/yr, meaning an increase in the sea level of 12cm over the life of the Project (Moffat & Nicol, 2012). However, under the least favourable conditions, the Afungi Project Site may experience sea level rise at a rate of 7mm/yr, generating an increment in the sea level of 21cm.

6.7 AIR QUALITY

A baseline air quality survey has been undertaken at various sampling points within and around the Afungi Project Site, as shown in *Figure 6.8* and outlined in *Table 6.4*. Monitoring of nitrogen dioxide (NO_2) and nitrogen oxides (NO_X) concentrations were taken at each location, over a period of eight months.

Table 6.4 Description of Monitoring Locations

Air Quality Monitoring Station	Description of Sampling Locations
1	The coastal area of Palma – opposite Baza House
2	Maganja – medical clinic
3	Quitupo Village – 500m to west of village, adjacent to road
4	Senga Village – located 50m from dwellings, adjacent to road
5	Senga Village – located north of village
6	Palma – old town
7	Palma – new town adjacent to road frequented by Project vehicles
8	Quiderji Village, adjacent to road
9	Quitunda Village, adjacent to road
10	Between Quitupo and Barabarane villages

The air quality monitoring results indicate that:

- typical baseline NO_2 concentrations are around 1.8µg/m^3, ranging from 3.3 to 4.8µg/m^3 in urban areas of Palma to 0.3 to 0.6µg/m^3 in rural areas; and
- typical baseline NO_x concentrations are around 6.2µg/m^3, ranging from 3.9 to 10.8µg/m^3 in urban areas of Palma to 3.4 to 12µg/m^3 in rural areas.

These results are obtained from a sample period of eight month and are therefore comparable to the annual mean air quality standard. For comparison, the WHO (as cited by IFC) annual mean air quality standards for NO_2 (human health) and NO_x (ecological receptors) are 40µg/m^3 and 30µg/m^3 respectively. The Mozambique national annual mean air quality standard for NO_2 is 10µg/m^3 (see *Chapter* 2). The monitoring results observed illustrate that the baseline concentrations of NO_2 and NO_x are substantially below the WHO and national air quality standards - even in urban areas of Palma, where there are existing sources of emissions. This is as expected, given the absence of major local sources of emissions.

The baseline concentrations of sulphur dioxide (SO_2) are likely to be substantially below the air quality standards throughout the Study Area, as there are no major local sources of emissions. Again, the baseline may be slightly higher in Palma, where concentrations may be somewhat elevated due to the presence of localised emission sources.

In terms of other pollutants, particulate matter < 10µm (PM_{10}) in the form of dust is of interest from construction activities. No specific baseline monitoring is being undertaken, but it is likely that these pollutants will also be substantially below air quality standards for the majority of the time. Concentrations of PM_{10} may increase during periods of warm, dry weather when natural sources will increase. However, man-made PM_{10} is expected to remain low due to the absence of significant local sources. The baseline conditions of PM_{10} and particulate matter < 2.5µm ($PM_{2.5}$) may be slightly elevated in the Study Area during the dry season (April to November), due to local natural sources (eg dust). Limited short-term elevated levels due to the

burning of crops can also occur and elevate PM_{10} levels. Within Palma, the baseline concentrations may be somewhat elevated due to road traffic (this is, however, very limited).

Although no further information is available on air quality in the offshore environment, it can be safely assumed that the current offshore air quality is acceptable and that all levels are well within Mozambican or international standards such as IFC/World Bank Standards.

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AQ 3
AQ 10
AQ 9
AQ 2
Palma
AQ 1
Palma Bay
AQ 15
AQ 8
AQ 5
Quitupo
AQ 12
AQ 7
AQ 14
AQ 13
Senga
AQ 6
AQ 4
Maganja

bing

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Legend

- A — Air Quality Sampling Points
- ! — Villages / Settlements
- Local Roads
- Afungi Project Site

MAIN MAP SCALE:

0 1 2 3
Kilometers

TITLE:

Figure 6.8:
Air Quality Sampling Points

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 53 000

DRAWING: Air Quality Sampling Points.mxd

REV: A

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6.8 NOISE

6.8.1 Study Area

Representative measurement locations were chosen in the outskirts of a number of settlements within the Afungi Project Site, as well as around Palma and Maganja (*Figure 6.9*), to capture the baseline noise level without being affected by village noise sources such as people, vehicles or the movement of animals. Ambient (background) noise levels were measured at these locations by undertaking long-term measurements during the day and night, and a series of attended short-term measurements during the day over the period 20 to 27 February 2012 at the measurement locations shown in *Figure 6.9*, to capture the existing day and night-time noise baseline. The Study Area for noise receptors is shown in *Figure 6.9*.

Meteorological conditions during the measurement period were observed as predominantly sunny; however, light rain did occur over the period of measurement. An anemometer recorded the average wind speed to be under 5.2km/h during the short-term measurements and recorded an average temperature of 34°C.

6.8.2 Long-term Measurements

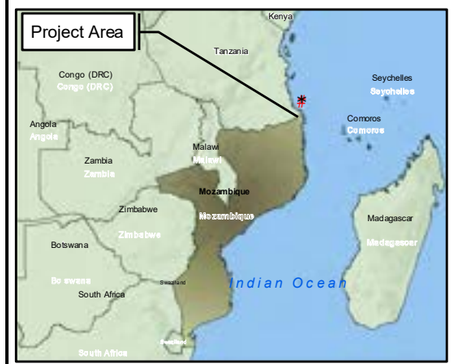
Long-term measurements were collected at a total of four locations (see *Figure 6.9*). At each long-term location, a minimum of 24 hours of continuous noise monitoring was conducted to provide a description of the noise levels and to understand the variation between the daytime and night-time periods (see *Annex C*). Location D (NML 1) is situated along the coastline north-east of the Project Site, Maganja (NML 2) to the south-east, Quitupo (NML 3) to the west, with the final location (NML 4) being the road closest to the airstrip, south-west of the Project Site. These four locations were deemed representative of the acoustic environment for the typical rural villages, located in and around the Afungi Project Site.

Long-term Measurement Results

The results of measurements recorded at each of the four long-term noise monitoring locations (NML 1, NML 2, NML 3 and NML 4) are summarised in *Table 6.5* and presented graphically in *Annex C*.

Legend

- Noise Sensitive Receptors
- Noise Monitoring Receptors
- Villages / Settlements
- Local Roads
- Regional Roads
- Afungi Project Site



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 6.9:
Noise Sensitive Receptors and Noise Measurement Locations

CLIENT:

Anadarko
Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: RL	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 120 000

DRAWING: Noise Monitoring Receptor Locations.mxd

REV: A

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Table 6.5 Long-term Unattended Noise Monitoring Results

Measurement Location	Measurement Parameter (dBA)				
Location D NML 1	**LAmax**	**LA10**	**LAeq**	**LA90**	**LAmin**
Daytime	50	41	46	35	32
Night-time	58	44	40	36	33
Maganja NML 2	**LAmax**	**LA10**	**LAeq**	**LA90**	**LAmin**
Daytime	59	43	45	35	31
Night-time	59	40	44	32	30
Quitupo NML 3	**LAmax**	**LA10**	**LAeq**	**LA90**	**LAmin**
Daytime	57	49	55	41	37
Night-time	62	55	59	49	42
The road NML 4	**LAmax**	**LA10**	**LAeq**	**LA90**	**LAmin**
Daytime	59	49	53	42	38
Night-time	55	49	51	43	39

6.8.3 Short-term Attended Measurements

A series of attended short-term (daytime) measurements were undertaken to identify the nature, character and dominant noise sources surrounding and within the Project Site. Short-term measurements had also been undertaken beforehand at each long-term location to verify the long-term measurements. Short-term measurements were recorded at a total of 11 locations.

Short-term Measurement Results

Table 6.6 summarises the daytime ambient noise levels at each of the operator-attended monitoring locations.

Table 6.6 Short-term Operator-attended Noise Monitoring Results

Location ID	Description	Wind speed Ave. (km/h)	LAeq (dBA)	LA90 (dBA)	LAmax (dBA)	Temp (°C)
NML 1	Location D	calm	39	24	60	36
NML 2	Maganja Village	6	38	32	56	34
NML 3	Quitupo Village (between points 3 and 8)	14	48	44	64	35
NML 4	Road closest to airstrip	calm	46	40	58	33
NML 5	Shoreline of beach (near point B)	8	40	31	58	34
NML 6	East of Maganja	14	41	35	59	34
NML 7	Helipad	5	31	23	49	34
NML 8	Location between C and B	calm	38	33	52	36
NML 9	Location C	5	38	34	49	36
NML 10	Near Village 5, 6, 7	calm	34	25	55	31
NML 11	Road to Maganja	5	39	34	51	34

Ambient noise levels at each location were found to vary throughout the day, based on levels of human activity in the villages. The hourly values presented in *Table 6.5* and *Table 6.6* are for periods when human activities and insect noise were less evident.

The L_{Aeq} parameter provides a description of the overall ambient noise level, and the L_{A90} parameter is an indicator of the background noise level or the underlying noise level. Conclusions from the review of the noise survey results (long-term and short-term monitoring) are summarised below.

- For the receptors closer to the ocean (NML 1, NML 2), both ambient L_{Aeq} and background L_{A90} noise levels are relatively steady between daytime and night-time, as there is less influence from human activities. Night-time noise levels are generally lower than daytime.

- Receptors further inland are more influenced by human activities and, in conjunction with insect noise, are likely to be the cause of night-time noise levels being generally higher than daytime for receptors NML 3 and NML 4.

- From observations during short-term operator-attended noise measurements, the dominant sound sources are wildlife activities such as birdsong, frogs, insects and daily human activities. In locations where these sources are not present, or are present to a lesser extent, noise levels tend to be lower. At receptors further afield from the ocean and the Project Site, daytime L_{Aeq} noise levels were observed to approach 30dBA, and L_{A90} noise levels approached 25dBA.

- Maganja and Nsemo are the two closest villages to the Afungi Project Site that are not planned to be resettled. NML 2, 5 and 6 can be used to estimate ambient noise levels at these villages. From *Table 6.5* and *Table 6.6*, it can be seen that existing background (L_{A90}) noise levels at NML 2, 5 and 6 range from 31 to 35dBA, which are lower than the IFC night-time threshold level of 45dBA. This low baseline night-time noise level means that Maganja and Nsemo would be sensitive to increased noise.

6.9 LANDSCAPE AND SEASCAPE CHARACTER AND VISUAL AMENITY

6.9.1 Study Area

The Study Area for the landscape, seascape and visual baseline is defined as a 30km radius area from the centre of the Afungi Project Site. The basis for defining this Study Area is outlined in detail in the methodology developed for the landscape, seascape and visual impact assessment (see *Annex C*). Both landscape and seascape have been considered in the Study Area, as the proposed location for the Onshore LNG Facility is in a coastal location and as a consequence incorporates land, sea and coastline environments, as well as the nearby islands.

The Study Area is shown in *Figure 6.10*. From the coastal settlement of Quionga in the north, approximately 15km from the Tanzanian border, it extends southwards to include the coastal settlement of Palma and further south to Olumbe. The Study Area includes vast areas of remote wooded

landscapes located inland of the coastal settlements. These settlements and various bays overlooking the Indian Ocean are defined by the prominent headlands and peninsulas along the Cabo Delgado coast. The islands to the northern extreme of the Quirimbas Archipelago (ie Rongui, Tecomaji, Vamizi, etc) are located relatively close to Afungi Peninsula and form an important part of the overall seascape in the Study Area. The gas fields in the deep waters offshore in Area 1 and Area 4 and shipping routes to be used by Project vessels (eg LNG Carriers and support vessels) also form part of the Study Area.

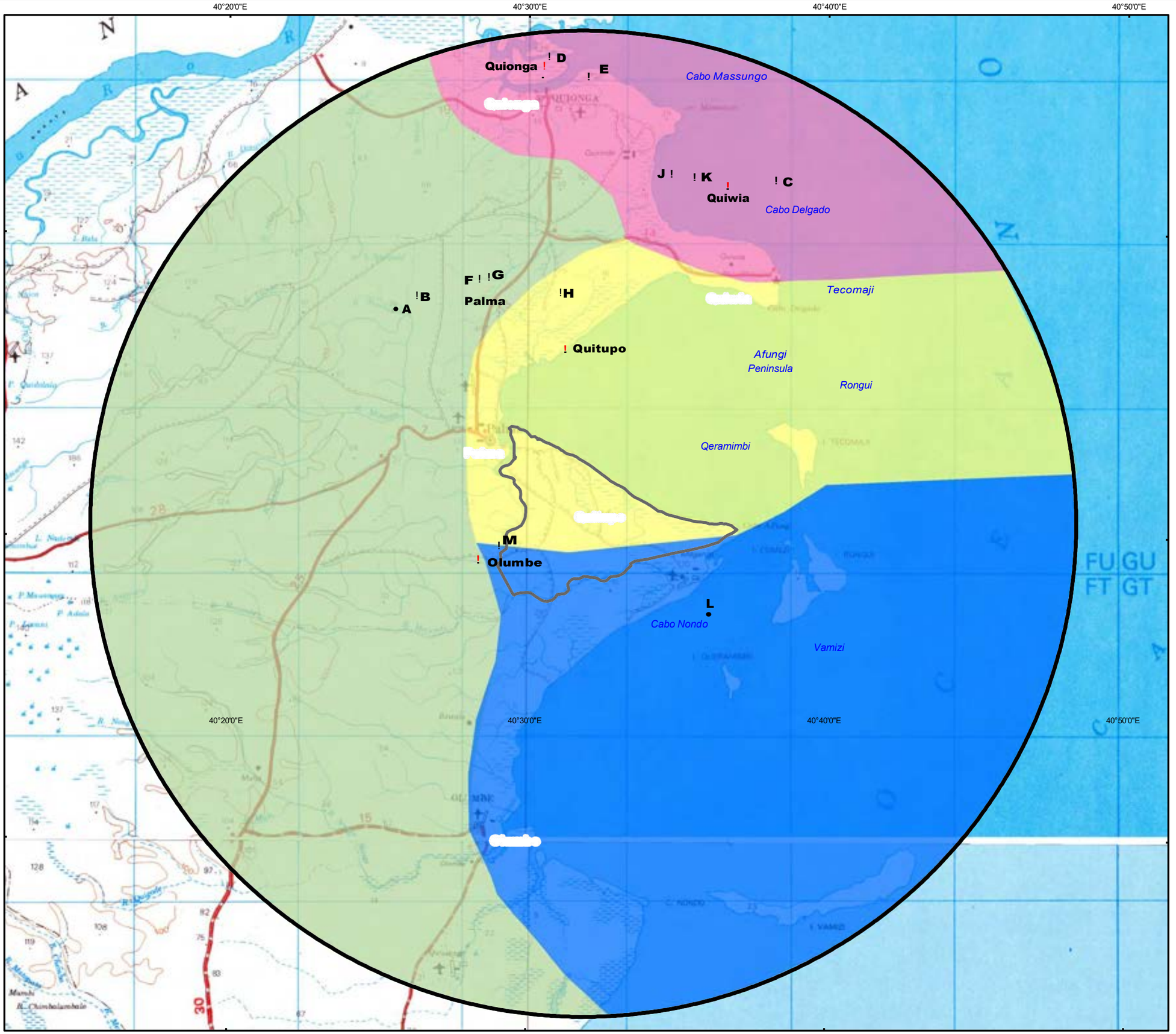
One landscape character area (1) and three seascape character units (2) have been identified within the Study Area:

- Wooded Inland Landscape Unit;
- Quionga to Cabo Delgado Seascape Unit;
- Palma Bay Seascape Unit; and
- Afungi Peninsula to Cabo Nondo Seascape Unit.

These are illustrated in *Figure 6.10* and described in the sections that follow.

(1) A landscape area is the land-based element only. It starts at the coastline and extends inland.

(2) A seascape unit is the coastal landscape and adjoining areas of open water, including views from land to sea, from sea to land and along the coastline. Every seascape unit has three components: an area of sea (the seaward component), a length of coastline (the coastline component) and an area of land (the landward component).



Legend

- Afungi Project Site
- 30km Buffer Study Area

Seascape Character Units

- Afungi Peninsula to Cabo Nondo Seascape Unit
- Palma Bay Seascape Unit
- Quionga to Cabo Delgado Seascape Unit

Landscape Character Areas

- Wooded Inland Landscape Unit

Photo Points

A - Undulating Woodland and Scrub Landscape west of Palma

B – Wooded landscape with watercourse catchment near the Afungi Peninsula

C- Coral at Cabo Delgado

D - Estuarine Saltmarsh near Quionga

E- Inland watercourse catchment east of Quionga

F- Palma Bay Seascape Unit

G- Urban Centre of Palma

H- Coastline at north shoreline of Afungi Peninsula

J- Vegetated coastline and beach near Quiwia

K- Wooded Peninsula near Cabo Delgado

L- Vamisi Island (western tip)

M- Coastal landscape and seascape near Olumbe

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 6.10:
Landscape and Seascape Character - Photo Points Locations

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: EO	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 225 000

DRAWING: Landscape and Seascape Character-Photo Points.mxd

REV: A

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Projection: UTM Zone 37 S, Datum: WGS84 Source: DINAGECA. ERM, 2012.	SIZE: A3

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6.9.2 *Wooded Inland Landscape Unit*

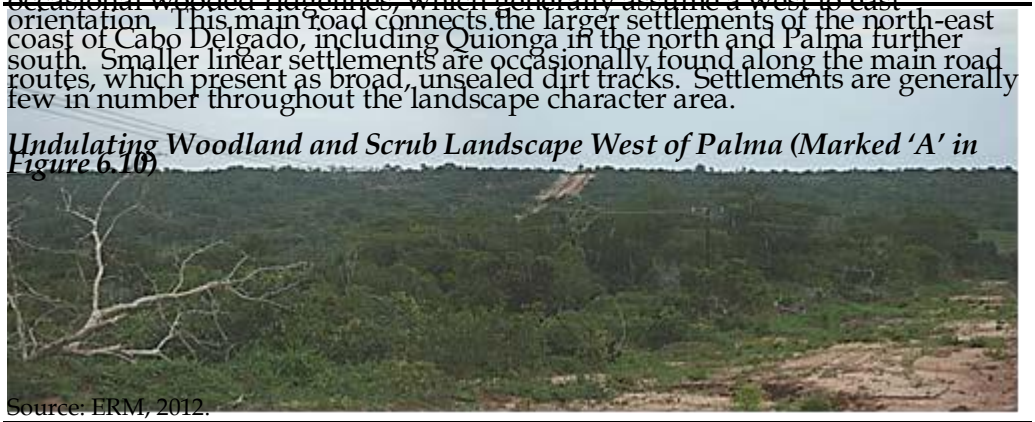
This landscape character area features two main landscape types, undulating woodland and scrub understorey, and the inland watercourse or river catchment landscape. These are described in turn below.

Undulating Woodland and Scrub with Scattered Farmland

This land cover comprises mainly dense woodland or dry forests with shrub understorey. These wooded areas generally comprise an upper canopy of deciduous species, mainly Caesalpinoideae (eg *Guibourtia schliebenii*, *Hymenaea verrucosa*, *Mickletwaitia carvalhoi*), with sclerophyllous evergreen species in the sub-canopy. Man-made clearings are present within these wooded areas and these feature plantations of cassava and occasionally fruit orchards, which are cultivated by hand. Cash crops such as mango and cashew are found scattered throughout the area. This is a gently undulating landscape and the variation in topography arises from the presence of rivers and watercourses, which usually have an east to west orientation. As a result, ridgelines with an east to west orientation are often located in the vicinity of these catchments.

Existing roads are dirt, typical of the region. The main access route in the area runs in a north to south direction (as shown in *Figure 6.10*) and crosses occasional wooded ridgelines, which generally assume a west to east orientation. This main road connects the larger settlements of the north-east coast of Cabo Delgado, including Quionga in the north and Palma further south. Smaller linear settlements are occasionally found along the main road routes, which present as broad, unsealed dirt tracks. Settlements are generally few in number throughout the landscape character area.

Figure 6.11 ***Undulating Woodland and Scrub Landscape West of Palma (Marked 'A' in Figure 6.10)***



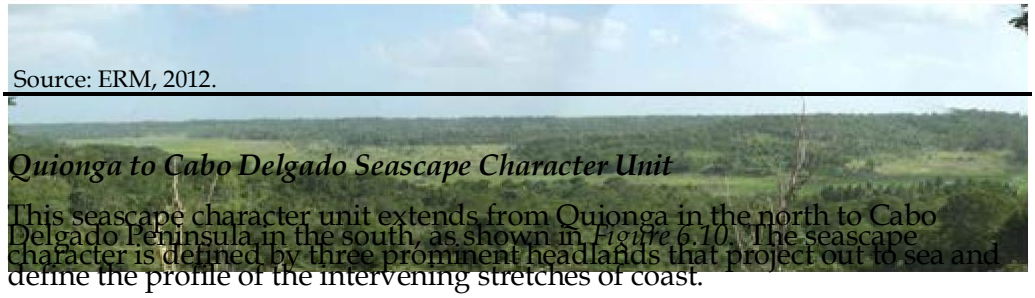
Source: ERM, 2012.

Inland Watercourse Catchment

A number of watercourses, including rivers and streams, flow generally from west to east within the undulating wooded inland character unit. The watercourses are at low elevation and dissect the landscape from west to east,

resulting in an undulating topography. The catchments of these watercourses are often present and visible as low-lying open areas featuring the watercourse itself surrounded by areas of low-lying, damp grassland or wetlands, some of which are cultivated.

Figure 6.12 ***Wooded Landscape with Watercourse Catchment near Afungi Peninsula (Marked 'B' in Figure 6.10)***



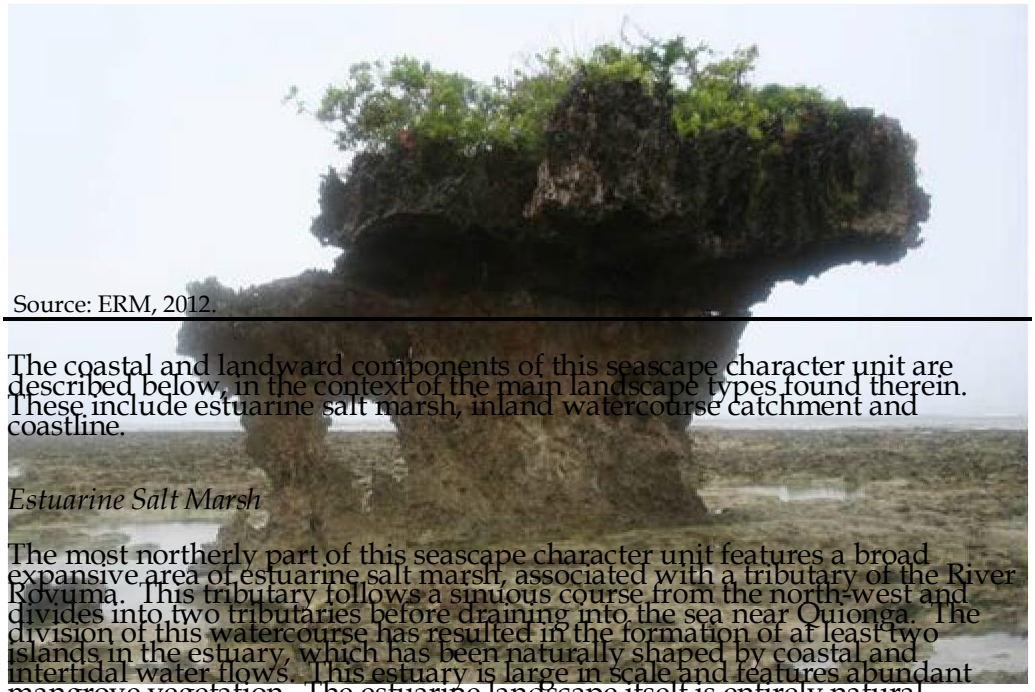
Source: ERM, 2012.

6.9.3 Quionga to Cabo Delgado Seascape Character Unit

This seascape character unit extends from Quionga in the north to Cabo Delgado Peninsula in the south, as shown in *Figure 6.10*. The seascape character is defined by three prominent headlands that project out to sea and define the profile of the intervening stretches of coast.

The first of these headlands lies north-east of the settlement of Quionga and represents the mouth of the estuary near this settlement. From this headland, a shoreline with an undulating edge extends south-east to the next main headland, Cabo Massungo. Further south, a C-shaped bay defined by a long sandy beach is located, and this leads to the most southerly headland within this character unit, Cabo Delgado Peninsula. The seaward component of this seascape unit features no islands. The seaward component commands views inland of the variable profile of the coastline, in particular Cabo Delgado Peninsula, as this is a prominent feature in the landscape, projecting further out to sea than any other part of the mainland along this stretch of coastline. The seaward component near Cabo Delgado Peninsula features large stands of carbonaceous rock formed by ancient coral deposits. These are located in the intertidal area during low tide and are tall (up to 8m in height), as shown in *Figure 6.13*. The tidal range is high and during high tide, these formations are mostly covered, and appear much smaller in the seascape.

Figure 6.13 Carbonaceous Rock Formed by Ancient Coral Deposits at Cabo Delgado (Marked 'C' in Figure 6.10)



Source: ERM, 2012.

The coastal and landward components of this seascape character unit are described below, in the context of the main landscape types found therein. These include estuarine salt marsh, inland watercourse catchment and coastline.

Estuarine Salt Marsh

The most northerly part of this seascape character unit features a broad expansive area of estuarine salt marsh, associated with a tributary of the River Rovuma. This tributary follows a sinuous course from the north-west and divides into two tributaries before draining into the sea near Quionga. The division of this watercourse has resulted in the formation of at least two islands in the estuary, which has been naturally shaped by coastal and intertidal water flows. This estuary is large in scale and features abundant mangrove vegetation. The estuarine landscape itself is entirely natural, featuring no signs of man-made influences and, as a result, it is very rural and remote in character.

The settlement of Quionga, which features both colonial and local building styles, overlooks the estuary from a short distance further south. The settlement itself is mostly enclosed within a wooded landscape setting, featuring numerous cashew nut trees. Some clearings are present in which rice and cassava are cultivated.

Figure 6.14 Estuarine Salt Marsh near Quionga (Marked 'D' in Figure 6.10)

Source: ERM, 2012.

Inland Watercourse Catchment

Watercourses flow through the inland part of this seascape unit and are similar to those found within the undulating, wooded, hinterland landscape character area described in *Section 6.9.2*. These are low-lying open areas, featuring the watercourse itself and expanses of low-lying grasslands, which are often used for cultivation.

Figure 6.15 Inland Watercourse Catchment East of Quionga (Marked 'E' in Figure 6.10)

Source: ERM, 2012.

Coastline

The coastline extends eastwards from Quionga, featuring beaches until it reaches the headland at Cabo Massungo. Thereafter, the profile of the coast follows a C-shaped pattern, defined again by the beach edge until it reaches Cabo Delgado Peninsula. Inland from the beach, dense wooded vegetation is a common feature.. The woodland at Cabo Delgado Peninsula is considered unique and comprises an almost impenetrable thicket of dry forest on raised coral rock.

When looking seaward from the coast, no islands can be seen from within this seascape unit. The promontories associated with Cabo Massungo and Cabo Delgado are strong defining landmarks in the overall seascape. These and the coastline further inland present to the eye as gentle low-lying topography, with little variation in relief.

6.9.4 Palma Bay Seascape Unit

The Palma Bay seascape character unit comprises a large-scale V-shaped bay extending from Cabo Delgado Peninsula in the north to Afungi Peninsula in the south. Cabo Delgado Peninsula comprises large areas of regionally important miombo and coastal coral rag forest, with some pockets of fragmented closed-canopy dry forests. The peninsula's vegetation is dense and largely undisturbed. Further south towards Palma, there are intermittent areas of miombo woodland, fragmented by cultivation and undifferentiated open savannah.

The Afungi Project Site is located on Afungi Peninsula and comprises a mosaic of woodland with understorey thicket of scrub vegetation and open areas of grassland. Clearings are present throughout the area, which features open areas of grassland, albeit with some signs of succession as evidenced by the presence of shrub vegetation. Plots used for subsistence farming are common within the Afungi Project Site. The topography is gently undulating and is defined by the presence of watercourses with an east to west orientation. A locally prominent ridgeline with a north to south orientation is located in the vicinity of the settlement of Palma which, located on this particular ridge, commands views out over the bay.

The relatively large settlement of Quitupo is located in a clearing within the woodland near the centre of the peninsula. The settlement features mostly simple buildings with thatched roofs, which blend visually into the wooded setting. However, much of the land surrounding the village has been cleared for subsistence crop farming.

The most westerly or inland point of the bay is marked by the settlement of Palma, which features a busy fishing harbour. The bay itself comprises a large seascape that is visually limited by the peninsulas to the north and south. The seaward element of this seascape features regular and almost continuous fishing activity. Dhows sail up through the bay from various directions heading for the port at Palma to land the catch of the day. Transportation of people and merchandise by sea frequently occurs along the coast, with the community of Palma and of the fishing centres located in the Palma District travelling to the north and south of the Study Area. The sea is the dominant mode of transport, used for trade and the transportation of merchandise in particular (refer to *Chapter 9*). Other boat-based activities include recreational vessels transporting visitors and tourists associated with the nearby tourism resorts located on the islands for sightseeing, snorkelling, fishing and diving. Visitors to the islands also pass through this seascape.

The islands of Tecomaji and Rongui are located in relatively close proximity, 4km and 5km respectively, to Afungi Peninsula. These islands have a relatively flat topography and are therefore seen from the Indian Ocean and the coast as gentle landmasses of relatively low profile. The islands are densely vegetated, with woodland and shrub understorey. Small tracks cross the island landscapes, but are few in number. Settlements are also few and are generally located on the coast. The north and north-western shoreline of Tecomaji is currently being developed as a tourist destination by 'Tecomaji Lodge', with local-style, eco-like dwellings being built close to the beach. In addition, a luxury lodge is planned for Rongui Island. This will form part of the well-known Maluane Project, a recognised national conservation project (see *Section 6.10.1*).

These islands features coral fringing reefs, some of which are visible in the intertidal zone.

Figure 6.16 Palma Bay Seascape Unit (Marked 'F' in Figure 6.10)

Source: ERM, 2012.

The coastal and landward components of this seascape character unit are described below in the context of the main landscape types found therein. These include the urban area of Palma, coastline, estuarine salt marsh and wooded peninsula landscape types.

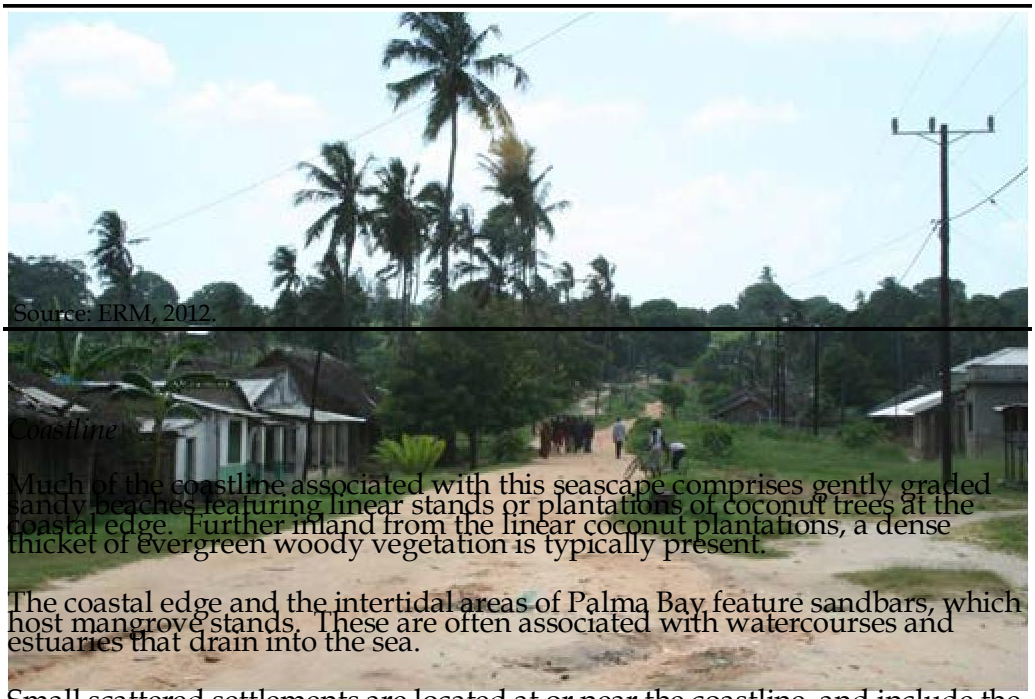
Urban Area of Palma

The settlement of Palma itself extends inland from the bay and occupies a high point or ridgeline with a north to south orientation. The coastal area of Palma comprises a series of buildings that date back to former Portuguese occupation. The town centre overlooks Palma Bay, and the northerly promontory of Afungi Peninsula presents as a focal point, together with the vegetation cover along the peninsula.

The streets of the wider urban area of Palma follow a grid pattern and have dirt surfaces. Dwellings and shops – single-storey buildings made of the local building materials of clay and straw, with thatched roofs – line these streets, forming a very low-rise built-up area. By contrast, the colonial architecture in

the town centre, left by the Portuguese, is of a larger scale and is more elaborate in terms of design style and use of materials.

Figure 6.17 ***Urban Centre of Palma (Marked 'G' in Figure 6.10)***



Source: ERM, 2012.

Coastline

Much of the coastline associated with this seascape comprises gently graded sandy beaches featuring linear stands or plantations of coconut trees at the coastal edge. Further inland from the linear coconut plantations, a dense thicket of evergreen woody vegetation is typically present.

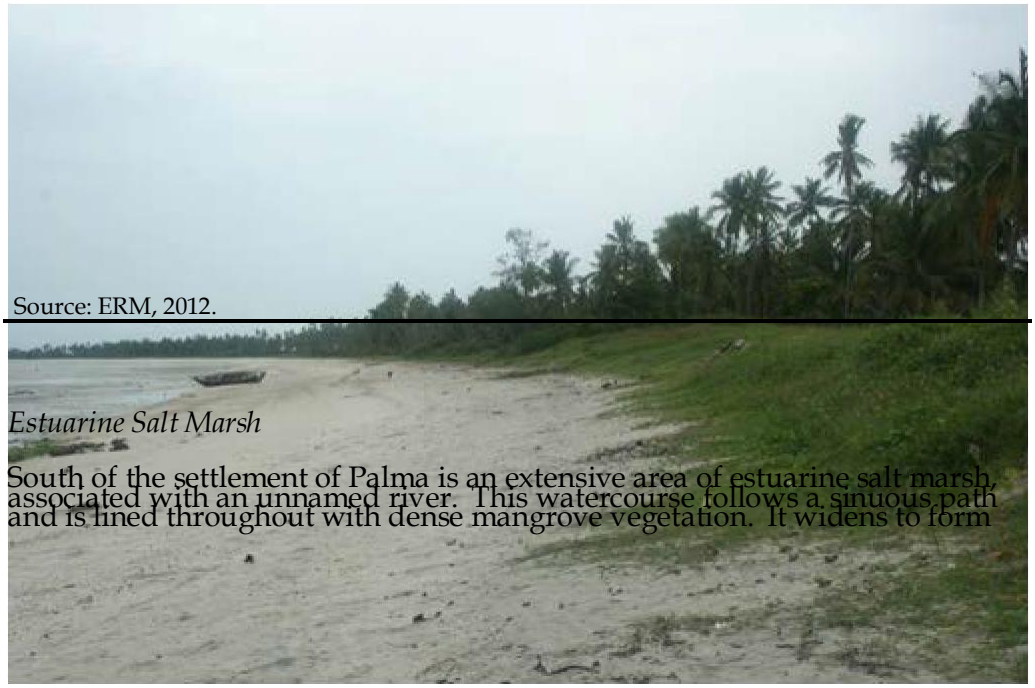
The coastal edge and the intertidal areas of Palma Bay feature sandbars, which host mangrove stands. These are often associated with watercourses and estuaries that drain into the sea.

Small scattered settlements are located at or near the coastline, and include the settlement of Quiwia, which overlooks Palma Bay from the north. This settlement is almost camouflaged, with its thatched roofs blending into a backdrop of woody vegetation.

Figure 6.18 *Coastline at North Shoreline of Afungi Peninsula (Marked 'H' in Figure 6.10)*

Source: ERM, 2012.

Figure 6.19 *Vegetated Coastline and Beach near Quiwia (Marked 'J' in Figure 6.10)*



Source: ERM, 2012.

Estuarine Salt Marsh

South of the settlement of Palma is an extensive area of estuarine salt marsh, associated with an unnamed river. This watercourse follows a sinuous path and is lined throughout with dense mangrove vegetation. It widens to form

the estuarine salt marsh, featuring abundant mangrove vegetation, at the coastal edge.

Channels associated with minor watercourses drain into the Indian Ocean at various points, forming small estuaries along the coastline. These locations are marked by the presence and visibility of extensive mangrove vegetation at varying stages of maturity.

Wooded Peninsula

The Palma Bay Seascape Unit extents to the eastern tip of Cabo Delgado Peninsula, which is densely vegetated with dry coastal forest as described in *Section 6.9.3*, and features a unique thicket of woody vegetation.

Figure 6.20 Wooded Peninsula near Cabo Delgado (Marked 'K' in Figure 6.10)

Source: ERM, 2012.

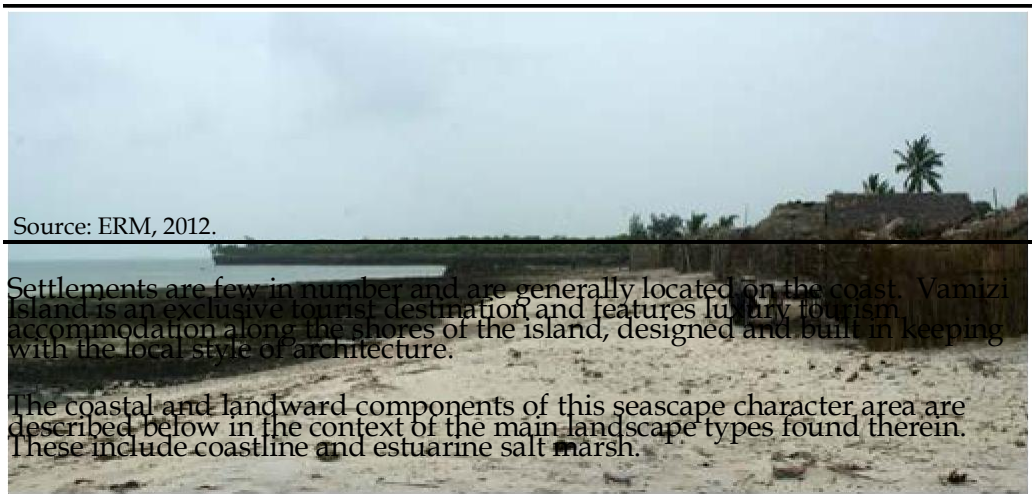
At the tip of this wooded peninsula is an abandoned Portuguese settlement, featuring a collection of colonial-style buildings and a lighthouse. Dwellings associated with a more recent local settlement are located nearby. These feature simple mud-built houses with thatched roofs, which effectively camouflage themselves against the backdrop of woody vegetation. The wooded cape overlooks the Indian Ocean, with extensive areas of beach in the foreground featuring large stands of carbonaceous rock, formed by ancient coral deposits and associated vegetation.

6.9.5 Afungi Peninsula to Cabo Nondo Seascape Character Unit

This seascape character unit extends from Afungi Peninsula in the north to Cabo Nondo in the south. The seaward component is defined by a large-scale gently sweeping coastline, which extends from the cape in the north-east to Olumbe in the south-west. The coastline curves gradually in a south-easterly direction towards the headland, Cabo Nondo. The seaward component of this seascape unit incorporates islands, including the southern part of Rongui and Queramimbi.

Vamizi Island is an elongated narrow landmass, the westerly tip of which is visually associated with Cabo Nondo due to its proximity to the mainland, approximately 4km distant. Vamizi Island, like Tecomaji and Rongui islands, is densely vegetated inland. The coastline features mostly sandy beaches, and fringing coral reefs are found in the intertidal and subtidal zones.

Figure 6.21 Vamizi Island (Western Tip) (Marked 'L' in Figure 6.10)



Source: ERM, 2012.

Settlements are few in number and are generally located on the coast. Vamizi Island is an exclusive tourist destination and features luxury tourism accommodation along the shores of the island, designed and built in keeping with the local style of architecture.

The coastal and landward components of this seascape character area are described below in the context of the main landscape types found therein. These include coastline and estuarine salt marsh.

Coastline

The shoreline extending southwards from Afungi Peninsula is largely defined by white sandy beaches. Occasional isolated dwellings and small settlements are located at or near the shoreline. These settlements comprise single-storey dwellings built of clay with thatched roofs, which are often visually camouflaged against the backdrop of evergreen vegetation.

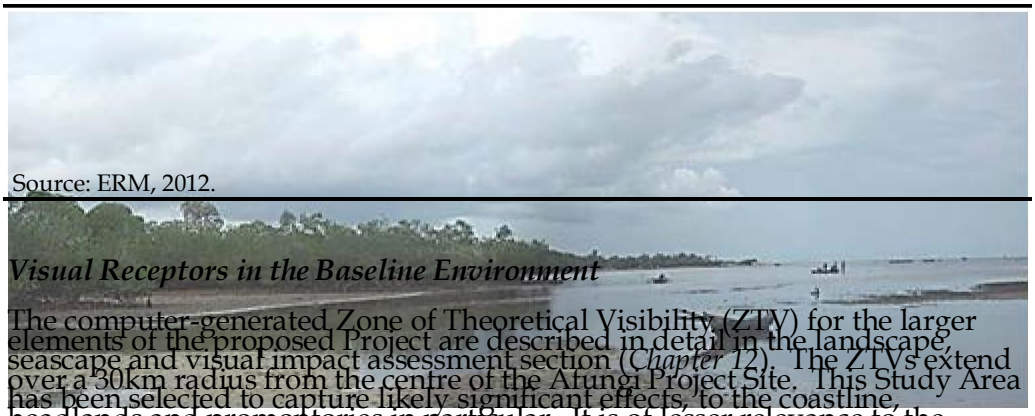
The settlement of Maganja, which has a population of approximately 1,900 inhabitants (see *Chapter 9*), is located on the northern part of this seascape character area, in a clearing within a densely wooded area near the tip of Afungi Peninsula. It is located 700m inland from the beach, separated by an extensive wetland area with intermittent dry palm plantations.

Estuarine Salt Marsh

A striking example of the estuarine salt marsh landscape type is found on the northern limit of this seascape character area, near the settlement of Maganja. It also dominates the outline profile of the tip of Afungi Peninsula, and is also found further south, at the southern end of the Study Area, near the settlement of Olumbe. This large settlement overlooks the estuary associated with the River Nonge – an extensive, densely vegetated watercourse that follows a winding path out towards the beach and estuary in the vicinity of Olumbe.

An intertidal area east of Olumbe features extensive tracts of mangrove vegetation, which extend in finger-like fashion out to sea from the beach at the edge of this coastal settlement.

Figure 6.22 Coastal Landscape and Seascape near Olumbe (Marked 'M' in Figure 6.10)



Source: ERM, 2012.

6.9.6 Visual Receptors in the Baseline Environment

The computer-generated Zone of Theoretical Visibility (ZTV) for the larger elements of the proposed Project are described in detail in the landscape, seascape and visual impact assessment section (*Chapter 12*). The ZTVs extend over a 30km radius from the centre of the Afungi Project Site. This Study Area has been selected to capture likely significant effects, to the coastline, headlands and promontories in particular. It is of lesser relevance to the inland landscape, because this is mostly wooded and the potential for wide-ranging impacts is limited.

A wide variety of visual receptors occur within the Study Area. These receptors will vary considerably in both type and number, depending on the intricacies of the coastline and adjacent islands. They will include local residents, those travelling through the area and those visiting the area for recreational and amenity purposes. Many of these will be onshore receptors, but there is potential for offshore receptors, including those travelling or working on boats and those engaged in recreational sea-based activities, such as diving, sailing or island hopping by boat.

Local residents are judged to have a generally high level of sensitivity to changes that the proposed Project development site will have on the natural views to which they have become accustomed. The ZTVs indicate that residents who live within the coastal settlements of Palma, Quiwia and Maganja are most likely to have views of the proposed LNG Facility.

Those engaged in travel to or through the Study Area, both on land and at sea, are considered to have an average medium to low level of sensitivity to the proposed change, depending upon the purpose and objective of the traveller, on account of the transitory nature of views in any one direction.

Tourist visitors and recreational users comprise a wide variety of individual visual receptor groups, whose principal objective is the enjoyment of the outdoor environment, the open countryside and the tourism/amenity resources offered by the coastline and islands. These visual receptor groups will have slightly different objectives and thus differing levels of sensitivity to any change in the character of the landscape or seascape of the Study Area.

The sensitivity of this receptor group is usually considered to be high.

Tourism is recognised as an important element in the local and regional economy of the Study Area, although it currently only comprises 7 percent of the economic activity of the region (see *Chapter 9*). Tourism is dependent upon high-quality coastlines and seascapes as valued recreational resources. People in this receptor group include visitors to the island of Vamizi and eventually Tecomaji (on which tourism accommodation is nearing completion). These visitors will potentially be affected, as users of island beaches for recreation or users of the ocean for water sports (diving, snorkelling and fishing) or boating.

Workers are generally less sensitive to effects, as they are focused on the tasks they are carrying out. Outdoor workers associated with farming, offshore and inshore fishing and shipping are also considered to have a low sensitivity to the proposed changes.

Viewpoint locations for the main areas from which the development may be seen, and the different viewer types and viewing opportunities they offer (residents, passers-by, walkers, etc), are shown in *Figure 6.23*. The viewer types and a description of the existing views are presented in *Table 6.7* below.

40°20'0"E
40°30'0"E
40°40'0"E
40°50'0"E

Quionga
Cabo Massungo
3
Quiwia
Cabo Delgado
1
Palma
4
Tecomaji
8
Quitupo
Afungi Peninsula
5
Rongui
2
Qeramimbi
9
Olumbe
7
6
Cabo Nondo
Vamizi
FU GU FT GT

Legend

- Afungi Project Site
- 30km Buffer Study Area

Seascape Character Units

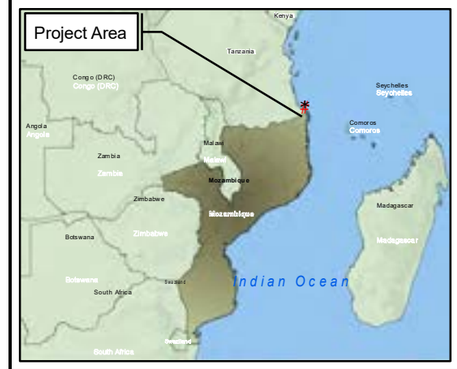
- Afungi Peninsula to Cabo Nondo Seascape Unit
- Palma Bay Seascape Unit
- Quionga to Cabo Delgado Seascape Unit

Landscape Character Areas

- Wooded Inland Landscape Unit

Viewpoints for Visual Impact Assessment

1. Palma
2. Maganja
3. Quiwia
4. Tecomaji
5. Rongui
6. Vamisi west
7. Vamisi east
8. Location at sea within Palma Bay
9. Olumbe



MAIN MAP SCALE:

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Figure 6.23:
View Point Locations

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: EO	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 225 000

DRAWING: View Point Locations.mxd

REV: A

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Projection: UTM Zone 37 S, Datum: WGS84
Source: DINAGECA. ERM, 2012
Inset Map: Esri Data & Maps

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Study Area

Table 6.7 Visual Baseline at Selected Viewpoints

Viewpoint No.	Description of Viewpoint	Viewer (Receptor) Type and Number	Description of Existing View
1	Palma Town – location in the town centre	H = residents of Palma (Many)	View from an elevated location over Palma Bay and Afungi Peninsula (including the site for the proposed LNG Facility), which features abundant vegetation. In this view, the most northerly tip presents as a landmark promontory with a sandy beach.
2	Settlement of Maganja	H = residents of Maganja (Moderate)	Wooded vegetation in the foreground, including mature mango trees and an understorey of cashew nut trees.
3	Settlement of Quiwia and adjacent beach	H = residents of Quiwia R = users of the beach (Moderate)	Seascape associated with Palma Bay. Settlement of Palma as a small visible element in the distance to the south-west. Further south, the outline of the island of Tecomaji is visible, though the visibility of this will vary depending on weather conditions. The northern shoreline and most easterly headland of Afungi Peninsula are visible in the far distance. The visibility of Afungi Peninsula, including the site for the proposed LNG Facility, will vary with weather conditions.
4	Tecomaji Island	R = tourist users of the beach (Few)	Views to the north of the seascape are associated with Cabo Delgado Peninsula in the distance, and include the headland, identifiable by the lighthouse. Further west, the coastal settlement of Palma is visible as a relatively small element in the large seascape of Palma Bay. The northern shoreline of Afungi Peninsula (including the site for the proposed LNG Facility) is clearly visible in the distance.
5	Rongui Island	R = tourist users of the beach (Few)	This view sweeps in a north-easterly direction over Palma Bay. The southern part as well as the headland of Afungi Peninsula are visible in the near distance. Tecomaji Island is visible further north and, barely visible in the very far distance, is the shoreline associated with Cabo Delgado Peninsula.
6	Vamizi Island (beach on north-western tip)	R = tourist users of the beach (Few)	The view takes in the expansive seascape south of Afungi Peninsula, including the islands of Rongui and Queramimbi. The southern shore of this peninsula is visible in the far distance, although visibility of this will vary with weather conditions.
7	Vamizi Island (beach on north-eastern tip)	R = tourist users of the beach (Few)	This view is the same as Viewpoint as above. From this particular location, Afungi Peninsula is a little further away from the viewer.

Viewpoint No.	Description of Viewpoint	Viewer (Receptor) Type and Number	Description of Existing View
8	Location at sea within Palma Bay	R = tourists on boats W = working fishermen at sea Locals travelling to and from Palma (Many)	Viewers at this location will command views over the seascape and the C-shaped shoreline of Palma Bay. The settlement of Palma will be visible as a small element in this vast-scale seascape.
9	Settlement of Olumbe	H = residents of Olumbe at or near the beach (Many)	Views are available of the immediate seascape to the north and east. The short-range view in the direction of the site features extensive linear tracts of semi-mature mangrove vegetation. Consequently, these visually screen any views of the seascape further north (including the site for the proposed LNG Facility).

Key: viewer type: H = housing (residential); R = recreational; T = road users; W = workers.

Viewer numbers: residential and recreational: many >50, moderate 15–50, few 0–15; road users and workers: many >1000, moderate >500, few <500.

6.10 NATURE CONSERVATION

Baseline chapters may make reference to the protection status of the species and habitats found, as well as the notable presence of key conservation areas. An introduction to these is presented below.

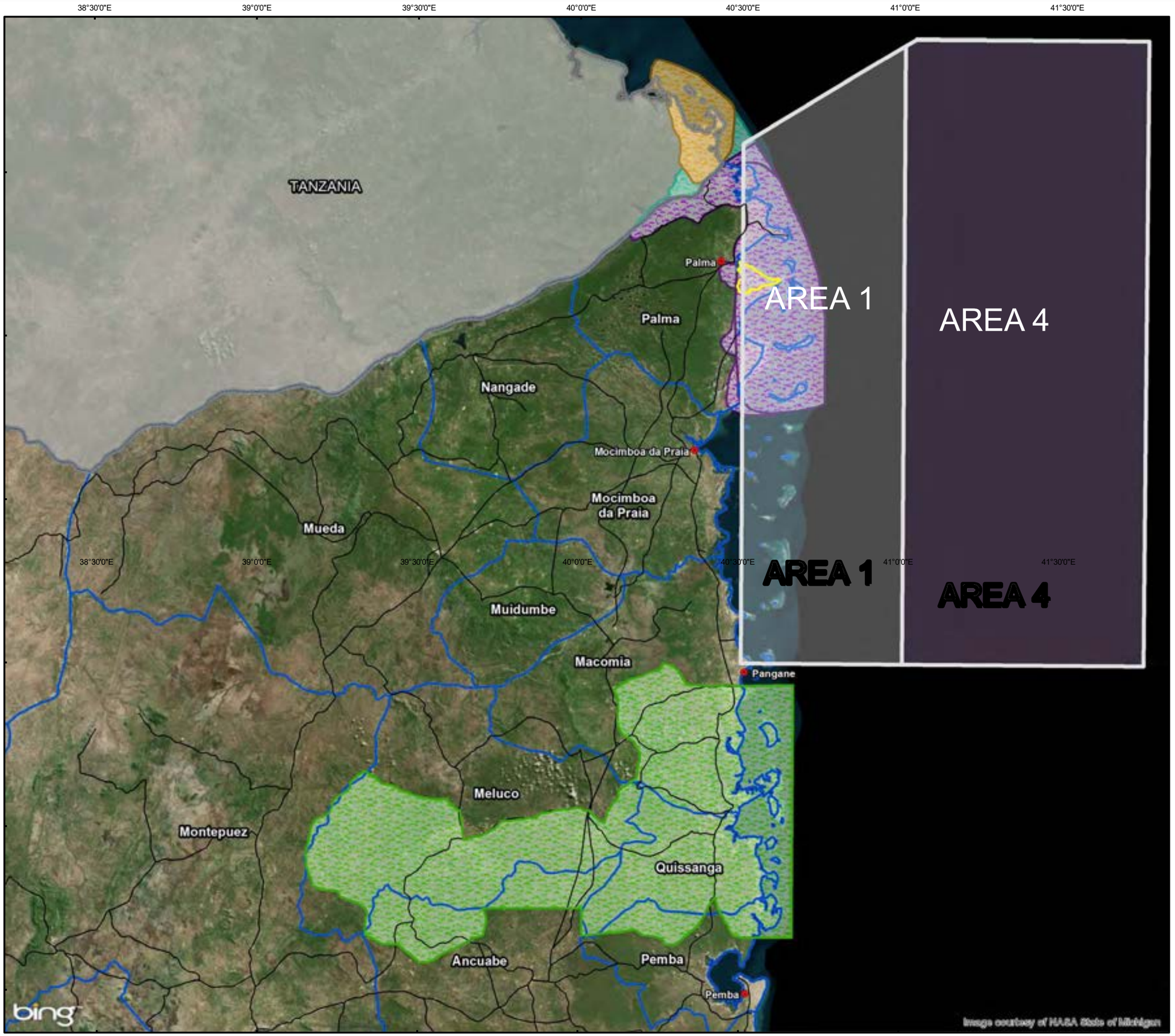
6.10.1 Protected Areas

There are no gazetted protected areas within the ADI. There are, however, a number of designated and proposed conservation areas in the greater region (AII), both terrestrial and marine, which are described below. The location and extent of these are shown in *Figure 6.24*.

Eastern Africa Marine Eco-region

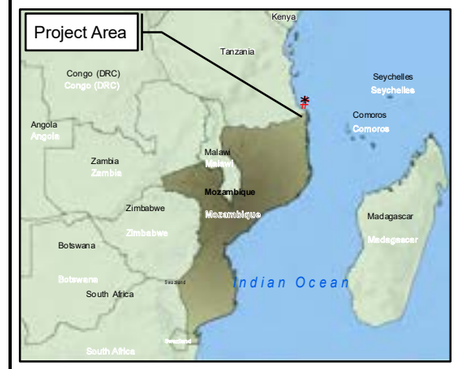
The Study Area lies within the Eastern Africa Marine Eco-region (EAME), which extends from Mozambique to Somalia. It falls within the Mtwara-Quirimbas complex, one of 21 biodiversity hotspots in the eco-region. This marine eco-region is of global importance due to its high biological diversity and because of the way the marine and coastal habitats are linked, both physically and ecologically (EAME, 2004). The Eastern African Marine Eco-region in the Western Indian Ocean is one of about ten marine eco-regions worldwide, for which a special focus towards the preservation of biodiversity is being developed.

TRANSMAP (2007) attempted to assess local and regional biodiversity across areas of the East African Marine Eco-region in the Quirimbas Archipelago from Pemba, Mozambique to Mtwara, Tanzania. Inter-governmental bodies have been working to create transboundary networks of Marine Protected Areas (MPAs) connecting local MPAs in each country for integrated conservation and sustainable development. An assessment of the biological diversity of key habitats (intertidal flats, seagrass, mangroves, coral reefs) and species, in particular fauna, was undertaken. Areas or hotspots identifying specific sites that would justify special protection within both countries were identified. However, the criteria or specifications used to select the different areas proposed by the study were limited to specific ecological features; namely the occurrence, abundance and distribution of species of special concern considered in the study (TRANSMAP, 2007).



Legend

- Towns
- Regional Roads
- Afungi Project Site
- Area 1
- Area 4
- District Boundary
- Quirimbas National Park
- Existing Mnazi Bay-Rovuma Estuary Marine Park
- Proposed Rovuma National Reserve
- Proposed Extension to Mnazi Bay-Rovuma Estuary Marine Park



MAIN MAP SCALE:

Kilometers

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Figure 6.24:
Designated and Proposed Conservation Area

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 1 250 000

DRAWING: Designated and Proposed Conservation Area.mxd

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13°00'E

10°30'S

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11°30'S

12°00'S

12°30'S

Projection: UTM Zone 37 S, Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
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Quirimbas National Park

The Quirimbas National Park covers a total area of 9,130km², of which 1,185km² is marine environment. It is located approximately 8km south of the southern boundary of Area 1, and approximately 130km to the south of Afungi Peninsula. The Quirimbas National Park was established in 2002 as an initiative of the 40 villages within the Park and the Government of Mozambique, supported by the Worldwide Fund for Nature (WWF). It comprises the 11 most southern islands of the Quirimbas Archipelago, banks and coral reefs, seagrass and sand/mudflat habitats, coastal forest, mangroves and marine life, including sea turtles and dugongs.

Mnazi Bay–Rovuma Estuary Marine Park

The Mnazi Bay–Rovuma Estuary Marine Park is located approximately 50km to the north of Afungi Peninsula in southern Tanzania. The Park was gazetted in 2000 and is the second marine park in Tanzania formed under the Marine Parks and Reserves Act, 1994. The Marine Park encompasses Mnazi Bay, nearby islands and approximately 21km of the Rovuma River estuary, which forms the border with Mozambique. The Marine Park was established to conserve the rich coastal resources in the bay and estuary including mangroves, seagrass beds, coral reefs, seaweed and marine fauna including turtles, dolphins, seahorses, whales and sharks.

Proposed Rovuma/Palma National Reserve – Transfrontier Conservation Area

MICOA, under the auspices of the Global Environment Facility (GEF)-funded Marine and Coastal Biodiversity Management Project, commissioned a study in 2007 to investigate the possibility of establishing the proposed Rovuma/Palma National Reserve, which would extend to the Mozambique–Tanzania border to link up with the Mnazi Bay–Rovuma Estuary Marine Park and thus create a Transfrontier Conservation Area. The study recommends modifications to the boundaries of the Mnazi Bay–Rovuma Estuary Marine Park to form a contiguous Transfrontier Conservation Area with the proposed Mozambican conservation area. The extent of the existing and proposed boundaries of the Mnazi Bay–Rovuma Estuary Marine Park and the proposed boundaries of the Rovuma/Palma National Reserve are shown in *Figure 6.24*. Since 2007, when the study to investigate the possibility of establishing this proposed national reserve was undertaken, there has been no progress implementing the proposal. It is not clear when, or if, the proposed reserve will be formally declared.

Other Proposed Protected Areas

In 2010, a study was undertaken by Timberlake et al. to assess the extent, botanical composition and conservation importance of coastal dry forests in northern Mozambique. The study proposed a number of new areas to be conserved in Cabo Delgado Province; none of these fall within the proposed Project Site within Afungi Peninsula.

Cabo Delgado Peninsula, located north of Palma Bay, was considered a 'second priority' site requiring conservation, based on the presence of mostly dry coastal thicket on coral rag (a fairly widespread vegetation type along the East African coastline). This vegetation is in particularly good condition and, given its isolated geographical position, is considered easy to conserve. Although this area, and the other areas identified as priority sites, are not officially declared as conservation areas, the report strongly recommends that these coastal forest areas be awarded some form of protection due to their biological importance. The Cabo Delgado Peninsula is not within the Project ADI.

The Maluane Project

Although the northern fringes of the Quirimbas do not fall within the Quirimbas National Park, a concession of 230km^2 around the islands of Vamizi, Rongui and Macaloe receives protection through the private sector-financed Maluane Project. The Project was initiated in 2001 to ensure biodiversity conservation and socio-economic development within the concession area. The initiative was developed as a partnership between the Zoological Society of London (ZSL), local communities and the private sector, and a group of individual investors. It is due to last 50 years. The Maluane Project falls under the authority of the Government of Mozambique.

6.10.2 Threatened Species

A number of species of special concern have been identified in the Afungi Project Site. Some of these are protected by Mozambican Laws and Regulations, including:

- Forestry and Wildlife Regulations (Decree no. 12/2002);
- Recreation and Sport Fishery Regulation (Decree no. 51/1999); and
- Hunting Law no. 7/1978 and Decree no. 117/1978.

Some species present are listed in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. .The IUCN has been successful in identifying species most in need of conservation attention and in creating awareness of loss of biodiversity. Based on criteria established by the IUCN, species are categorised according to their global threat status (see *Box 6.2*).

Species of conservation concern, both marine and terrestrial, are addressed in *Chapters 7* and *8* of this baseline volume according to their relevant faunal taxonomic groups, and are not described further in this section. Throughout the baseline and impact assessment chapters of this EIA Report, specialists have made use of IUCN terminology for describing the threat status and importance of various species.

Box 6.2 IUCN Terminology for Threat Status of Species

The IUCN defines evaluation categories of the status of species, according to the IUCN-specific assessment criteria, namely:

- DD = Data deficient (insufficient available information for listing as threatened);
- LC = Least concern (unclassifiable in any other category, widespread or abundant);
- NT = Near-threatened (not currently threatened but might become so in the near future);
- VU = Vulnerable (high risk of extinction in the wild);
- EN = Endangered (very high risk of extinction in the wild);
- CR = Critically endangered (extremely high risk of extinction in the wild);
- EW = Extinct in the wild; and
- EX = Extinct.

For further information on IUCN categories, refer to the IUCN website at http://www.iucnredlist.org/).

Chapter 7

Environmental Baseline - Offshore and Near Shore

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7 ENVIRONMENTAL BASELINE – OFFSHORE AND NEAR SHORE

7.1 INTRODUCTION

This chapter provides a description of physical and biological aspects of the Project's offshore and near shore marine environment, and is structured as follows:

- *Section 7.2:* Summary;
- *Section 7.3:* Sources of Information;
- *Section 7.4:* Regional Context – Quirimbas Archipelago;
- *Section 7.5:* Offshore Environment – Physical Conditions;
- *Section 7.6:* Offshore Environment – Major Biological Features;
- *Section 7.7:* Near Shore Environment – Physical Conditions;
- *Section 7.8:* Near Shore Environment – Marine Habitats; and
- *Section 7.9:* Near Shore Environment – Major Biological Features.

7.2 SUMMARY

7.2.1 Offshore Environment

The offshore gas fields, Golfinho, Prosperidade and Mamba are located in deep oceanic water offshore of the extremely narrow continental shelf, in depths of around 1,000 to 2,300m. Deep canyons are found within the area, characterised by mostly unconsolidated sediment. Temperature, salinity [(1)] and dissolved oxygen profiles in the Offshore Study Area show a well-developed upper mixed layer underlaid by a strong thermocline. Water column turbidity levels are mostly low, <0.5mg/l, with elevated levels in the very near surface layers and a minor elevation in turbidity at depths corresponding to the base of the upper mixed layer/ top of the thermocline. The sediments of the seabed are poorly sorted, indicating multiple sources of sediments and a low energy environment near the seabed.

Low and high-relief reef structures are present in deep waters, and are likely to be found throughout the area of the offshore gas fields. Biodiversity is highest on the high-relief reefs, although they do not apparently support high densities of fauna.

Pelagic and mesopelagic fish species are widely distributed. In the deep waters, a number of fish and benthic species have been observed appear to be new to science and have not previously been taxonomically described. Megafauna such as whales, dolphins and turtles, together with pelagic seabirds, are present in the region, and include species regarded as

(1) Salinity refers to the dissolved salt content in sea water.

Endangered, Vulnerable or Near Threatened according to the IUCN Red List of Threatened Species (IUCN, 2011). The distribution ranges of these fauna are truly vast compared to the distance scales of the gas fields that are proposed for development.

7.2.2 Near Shore Environment

The depth of the channel in the central area of Palma Bay extends to 50m. The islands of Tecomaji and Rongui sit on the edge of the continental shelf, where water depths of greater than 350m occur within 2.5km from the islands.

Palma Bay is a generally clear water environment with low turbidity levels. Temperatures and salinity are typically around 30°C and 35 practical salinity units (PSU) respectively. Surficial sediments are mainly sand or muddy sand. Sediment transport rates are small in the bay, due to the benign wave climate. Heavy metal concentrations observed were low. Small crater-like formations, 10m in diameter and 1 to 3m deep with rock pavement or rock with corals in their centres, have been observed in the approximate centre of Palma Bay.

The main shoreline types in Palma Bay are intertidal rock, steep supratidal sand beach, mangroves and intertidal sand/mudflats. The intertidal zone appears to be highly productive and biologically diverse. There are both extensive and minor stands of mangroves located in Palma Bay.

Seagrass beds and meadows, supporting a wide range of fauna including sea urchins, starfish, sea cucumbers, sponges, colonial ascidians and pen shells, are distributed throughout Palma Bay on sandy substrates from the mid-tide level in the intertidal zone to 6 to 8m depth. The species present are widely distributed on the East African coast, and particularly in the Quirimbas Archipelago.

Coral reefs in Palma Bay comprise *Porites*-dominated bommies with minor amounts of branching (Acropora) and other forms. They are distributed in and among the seagrass beds mainly in the west and south of Palma Bay; in diverse bommies in the bommie fields on the inshore side of Tecomaji, Rongui and Queramimbi islands; and in highly diverse reef and fringing reef at Cabo Delgado Peninsula and to the east of the islands. There are important structural reef features north of Tecomaji, between Tecomaji and Rongui and south of Rongui Island. These are biologically diverse, although evidence of damage (from extreme weather and fishing activities) is evident in each area. There are varying degrees of reef development between Tecomaji and Rongui, and the southern area between the islands has a relatively minor stretch of continuous reef, with more stretches of sand in the centre and on the northern side.

Fish species associated with reefs and seagrass beds are abundant and diverse. Five species of turtle are found in the Quirimbas Archipelago, all of which are protected species. The mainland beaches in Palma Bay are steep and the high tide levels extend to the top of the beach, making them unsuitable for turtle

nesting. A number of whale and dolphin species have been recorded in the near shore, and several species are known to enter Palma Bay eg humpback whales and bottlenose dolphins.

Palma Bay has been identified as a location with potential for aquaculture; namely, fish farming and seaweed production (INAQUA, 2011). In 2011 approximately 10ha of the bay was declared as a 'Marine Reserve' by Decree no. 71/2011 of 30 December. There are currently no known proposed or active aquaculture farms within the bay. This is detailed further in *Chapter 9*.

7.3 SOURCES OF INFORMATION

7.3.1 Literature Sources

The information provided in this baseline chapter has been gathered from a wide range of sources. It draws upon a review and analysis of existing information, including data collected for EIAs from the exploration phase of the Project (for Area 1 and Area 4), and from other available reports and studies. These are referenced where applicable throughout the text. Most secondary data available are at a regional level ie the Quirimbas Archipelago, and are useful to describe the offshore environment.

7.3.2 Baseline Surveys and Study Area

Location-specific information and data for the offshore and near shore (ie Palma Bay) are sparse and, therefore, intensive primary investigations of these areas have been carried out for this EIA Report. The types of marine surveys undertaken and the extent of the Survey Area are outlined in *Section 7.5.1* and *Section 7.7.1*, for the offshore and near shore respectively. The survey findings are described throughout this chapter. The survey methodologies applied by the marine specialists are presented in *Annex C*.

In this chapter, the near shore comprises the area from the mainland to approximately 1.5km east of Tecomaji and Rongui islands, ie roughly to the edge of the continental shelf/drop-off into deep water. Offshore is considered to be from there eastwards. The Study Area comprises the near shore and offshore marine environment that may be affected by the Project, such as the near shore infrastructure, the subsea infrastructure, and the proposed activities in the Golfinho, Prosperidade and Mamba gas fields.

7.4 REGIONAL CONTEXT – QUIRIMBAS ARCHIPELAGO

Palma Bay is situated within the Quirimbas Archipelago. This is located in the East African Coral Coast Ecoregion of the Western Indian Ocean (WIO)

Province of the WIO biogeographic Realm [1] (Spalding *et al*, 2007). The East African Coral Coast Ecoregion is considered an area of relatively homogenous species composition, however, is clearly distinct from adjacent systems. It extends across approximately 1,700km (more than 15° latitude). The Quirimbas Archipelago forms a subset within the ecoregion and extends for approximately 400km from just south of the Rovuma River to Pemba.

The Quirimbas Archipelago comprises 32 islands with associated coral reefs, seagrass beds, mangroves, sandy beaches and mudflats. Rodrigues *et al*. (2000) indicates that over 50 coral genera occur in reefs in the region while, detailed survey data obtained around Nacala, Pemba and Vamizi Island (approximately 10km south of Palma Bay) indicates the presence of 207 to 254 coral species (Obura, 2012). Species discovery analysis indicates that actual species numbers may be as high as 300. This is a highly diverse fauna and from this and comparisons of species richness distributions through the Western Indo-Pacific realm and oceanography, Obura (2012) concludes that the northern Mozambique Channel forms the core region from which there has been dispersal of corals to the adjacent ecoregions within the WIO biogeographic Province.

Extensive mangrove forests along the mainland shoreline and islands and seagrass beds in the shallow subtidal zone also contribute to the Archipelago's productivity. A total of 10 species of seagrass (Whittington et al., 2000) and eight species of mangroves are known to occur in Cabo Delgado Province (CSA, 2007).

The broad distributions of potential habitats for coral reefs, seagrass beds and mangroves in the region are shown in *Figure 7.1*. This coarse data from remote sensing was mapped and subsequently subjected to ground-truthing by a marine ecologist, and the findings are described in *Sections 7.8.2* to *7.8.4*.

There are formally declared protected areas in the southern part of the region (Quirimbas National Park), while in southern Tanzania the Rovuma River mouth area lies within the Mnazi Bay–Rovuma Estuary Marine Park (MBREMP). See *Chapter 6* for further information on the designated and proposed protected areas of interest.

(1) A global hierarchy of 12 realms, 62 provinces and 232 ecoregions were established as the Marine Ecoregions of the World (MEOW) classification by Spalding, 2007.

39°30'0"E 40°0'0"E 40°30'0"E 41°0'0"E

TANZANIA

Palma

Palma

Nangade

Mocimboa da Praia

Mocimboa da Praia

Mueda

Muidumbe

Pangane

Macomia

Montepuez

Meluco

bing

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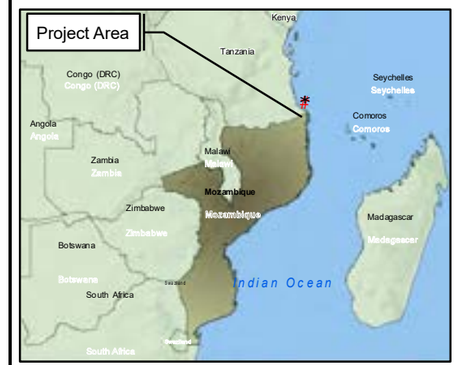
39°30'0"E 40°0'0"E 40°30'0"E 41°0'0"E 41°30'0"E

Legend

- Towns
- Regional Roads
- Afungi Project Site
- District Boundary
- Boundary with Tanzania
- Sensitive Marine Habitats (Coral, Seagrass and Mangroves)



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 7.1:
Mapped Sensitive Habitats
(Coral, Seagrass and Mangroves)
in the Quirimbas Archipelago

CLIENT:

Anadarko
Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 830 000

DRAWING: Mapped Sensitive Habitats.mxd

REV: A

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7.5 OFFSHORE ENVIRONMENT – PHYSICAL CONDITIONS

7.5.1 Baseline Survey and Study Area

To gain information on the oceanography within the offshore environment, upper water column profiles of temperature, conductivity (salinity), dissolved oxygen concentrations, turbidity, chlorophyll fluorescence (chlorophyll a) and ultraviolet (UV) fluorescence [1] were measured in June 2012 on the Rylan-1 cruise commissioned by AMA1 with Lwandle Technologies (Pty) Ltd (referred to as Lwandle) marine specialists present. The location of the conductivity–temperature–depth (CTD) sampling stations are confined to Area 1 as are shown in *Figure 7.2*.

There is no published information or publicly available survey data on seabed features in the offshore gas fields. Surficial sediment sampling was conducted by box core (deepwater sites) and Day grab (shallow-water sites) in June 2012 by Lwandle, to determine sediment properties and the composition of the benthic community in the Golfinho and Prosperidade gas fields and the proposed pipeline corridor. The locations of sediment sampling stations are shown in *Figure 7.2*. Sediments were analysed for particle size distribution and texture, heavy metal concentrations and benthic data (eg species present, abundance, biomass etc).

Remotely Operated Vehicles (ROV) seabed video surveys have been conducted by AMA1 and eni in the Golfinho, Prosperidade and Mamba gas fields as part of their gas field exploration activities. The data has been analysed by Lwandle to examine the characteristics of the seabed and other features (eg deep water reef, fish etc).

The main features of the acquired data are discussed in *Sections 7.5.3* and *7.5.4*.

(1) A proxy for hydrocarbon concentrations.

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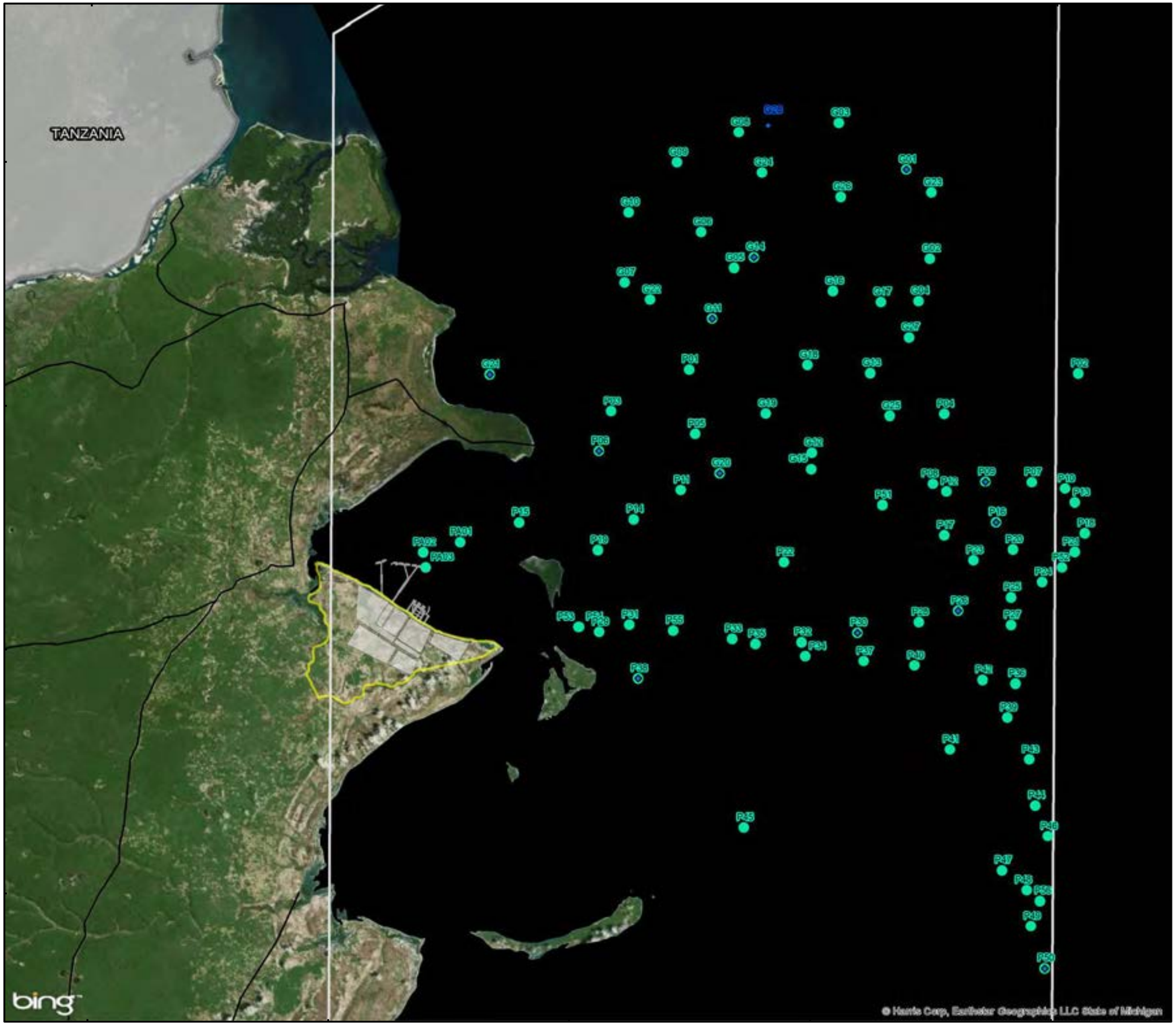

40°20'0"E 40°30'0"E 40°40'0"E 40°50'0"E 41°0'0"E

Legend

- Regional Roads
- Jetty
- Onshore Layout
- Afungi Project Site
- Seabed Sampling Stations
- CTD Stations
- Area 1

SCALE:

Kilometers

TITLE:

Figure 7.2:
Conductivity-Temperature - Depth (CTD) and Sediment (including benthos) Sampling Locations Offshore

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 280 000

DRAWING: CTD and Sediment Sampling.mxd

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10°50'0"S

10°30'0"S

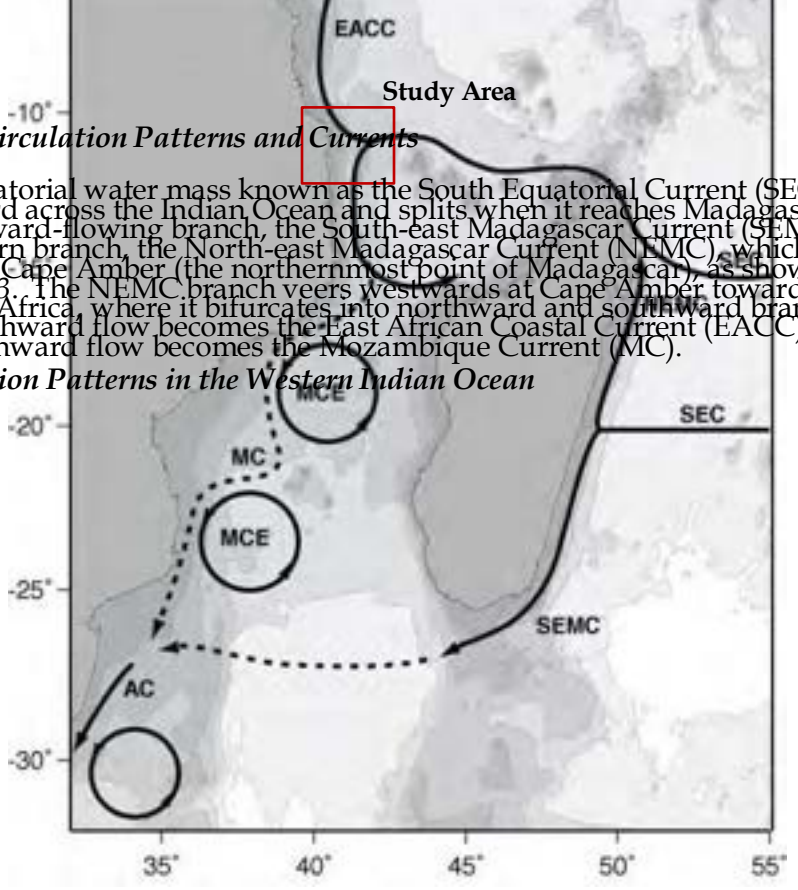
10°40'0"S

10°50'0"S

7.5.2 *Major Circulation Patterns and Currents*

The equatorial water mass known as the South Equatorial Current (SEC) flows westward across the Indian Ocean and splits when it reaches Madagascar, into a southward-flowing branch, the South-east Madagascar Current (SEMC), and a northern branch, the North-east Madagascar Current (NEMC), which flows north to Cape Amber (the northernmost point of Madagascar), as shown in *Figure 7.3*. The NEMC branch veers westwards at Cape Amber towards the coast of Africa, where it bifurcates into northward and southward branches. The northward flow becomes the East African Coastal Current (EACC), while the southward flow becomes the Mozambique Current (MC).

Figure 7.3 ***Circulation Patterns in the Western Indian Ocean***



Key:

SEC = Southern Equatorial Current, NEMC = North-east Madagascar Current, SEMC = South-east Madagascar Current, EACC = East African Coastal Current, AC = Agulhas Current, MC = Mozambique Current, MCE = Mozambique Channel Eddies.

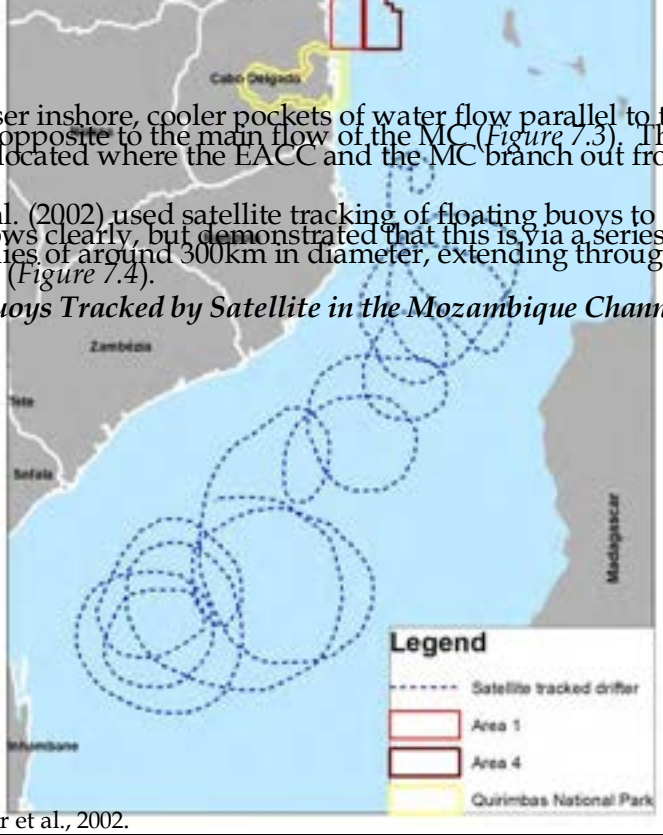
Source: Schouten et al., 2003.

Saetre and da Silva (1982, 1984) postulated that the current in the Mozambican channel occurs in the form of various large-dimension clockwise and counter-clockwise eddies, rather than a continuously flowing southward current. From this idea, the model of an overall southward-flowing MC was developed, but with several smaller semi-basin and regional circulation

patterns. Closer inshore, cooler pockets of water flow parallel to the coast, but in a direction opposite to the main flow of the MC (*Figure 7.3*). The offshore gas fields are located where the EACC and the MC branch out from the SEC.

De Ruijter et al. (2002) used satellite tracking of floating buoys to show southward flows clearly, but demonstrated that this is via a series of counter-clockwise eddies of around 300km in diameter, extending throughout the water column (*Figure 7.4*).

Figure 7.4 ***Patterns of Buoys Tracked by Satellite in the Mozambique Channel***



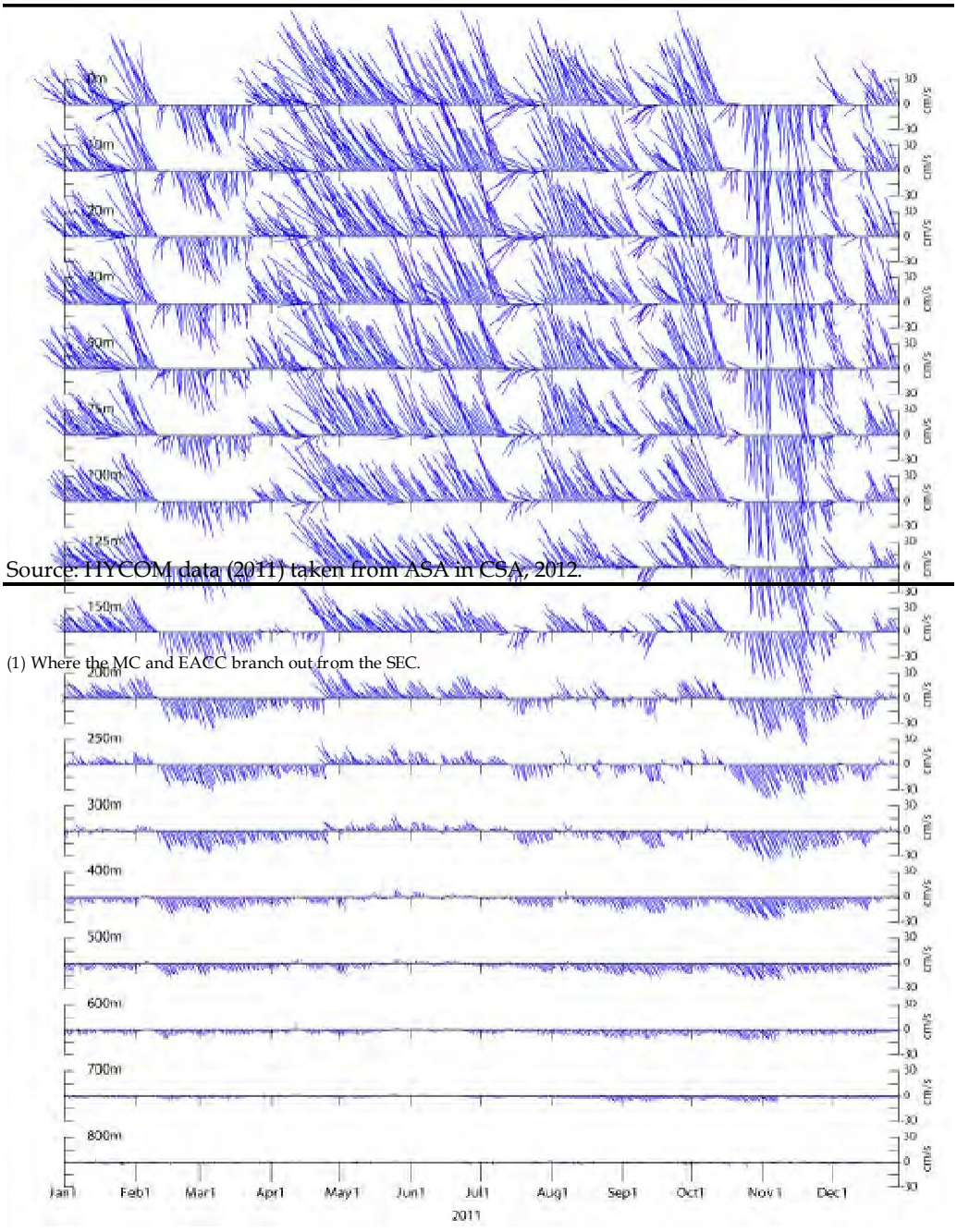
Source: De Ruijter et al., 2002.

Ridderinkhof et al. (2003) placed current-measuring devices along a narrow part of the channel (around 17°S), which clearly indicated a current of 1m/s in a southerly direction along the western side of the channel. These data, therefore, indicate an overall southward-flowing current of varying velocities via a series of anti-cyclonic eddies rather than a consistent southerly flow.

Similar variability is evident in current patterns of in the areas of the gas fields, offshore of northern Mozambique. *Figure 7.5*shows the distribution of currents with depth at 10.53279°S, 040.70442°E, located in the Golfinho Gas Field. A strong current velocity gradient with depth is apparent, with current speeds of >70cm/sec at the surface and <15–20cm/sec towards the base of the

water column. There is also evidence of current directions changing from north/north-west to due south. Northerly flows are dominant between April and September (dry season) and southerly flows in other months. This is attributed to the location of the measured site in relation to the bifurcation [1] of the EACC and the MC (*Figure 7.3*). When this migrates north, currents flow mainly south, whereas northerly flow occurs when the bifurcation location moves south.

Figure 7.5 Vertical Current Velocity Profile at 10.53279°S, 040.70442° E in Golfinho



Source: HYCOM data (2011) taken from ASA in CSA, 2012.

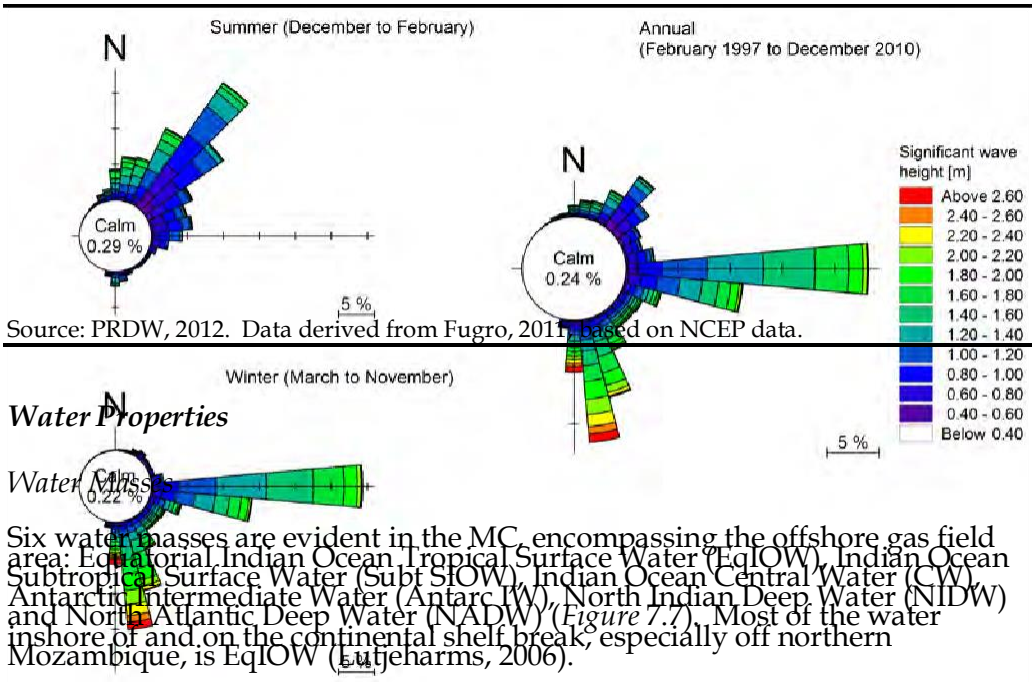
(1) Where the MC and EACC branch out from the SEC.

Offshore Wave Conditions

The wave climate offshore of Palma Bay at the location S11.0°, E41.25° was extracted from the National Centre for Environmental Predictions (NCEP) hindcast model database for the period from 1997 to 2010.

Figure 7.6 illustrates these data and that offshore wave conditions have two distinct seasonal patterns. Wave conditions are predominantly from the north-east direction during the summer monsoon months, from December to February. During the winter months from March to November, the predominant swell directions are from the south and the east, with the largest significant wave heights coming from the south.

Figure 7.6 ***Offshore Wave Rose – Seasonal (Left) and Annual (Right) Based on NCEP Wave Data (February 1997 to December 2010)***



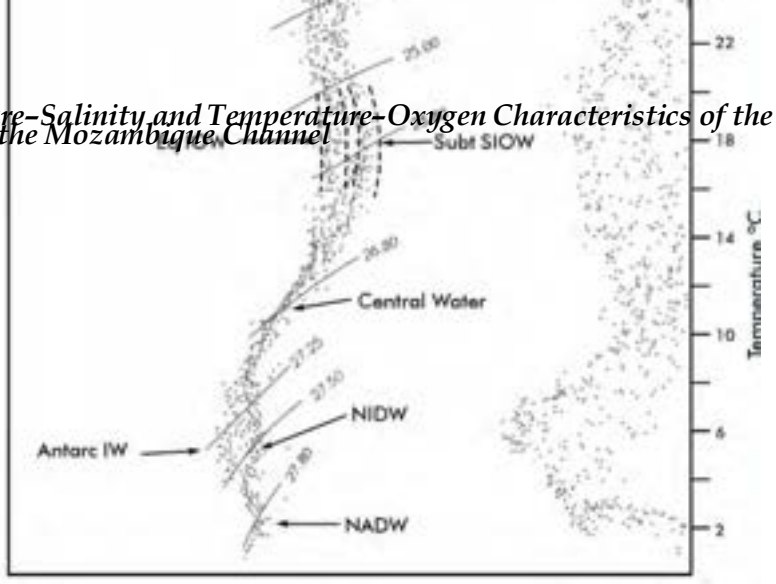
Source: PRDW, 2012. Data derived from Fugro, 2011, based on NCEP data.

7.5.3 *Water Properties*

Water Masses

Six water masses are evident in the MC, encompassing the offshore gas field area: Equatorial Indian Ocean Tropical Surface Water (EqIOW), Indian Ocean Subtropical Surface Water (Subt SfOW), Indian Ocean Central Water (CW), Antarctic Intermediate Water (Antarc IW), North Indian Deep Water (NIDW) and North Atlantic Deep Water (NADW) (*Figure 7.7*). Most of the water inshore of and on the continental shelf break, especially off northern Mozambique, is EqIOW (Lutjeharms, 2006).

Figure 7.7 ***Temperature–Salinity and Temperature–Oxygen Characteristics of the Water Masses in the Mozambique Channel***

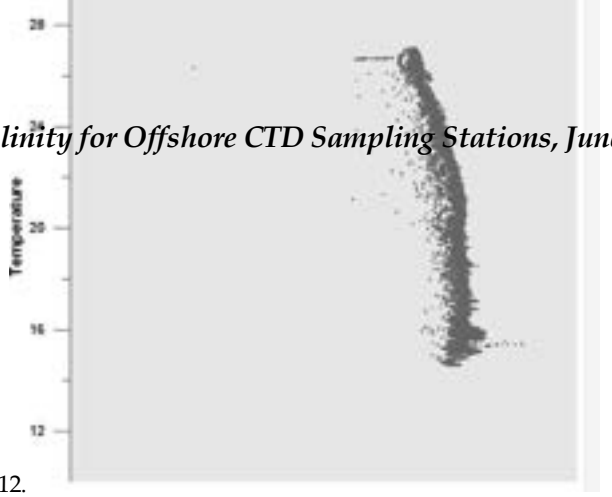


Key:
EqIOW = Equatorial Indian Ocean Tropical Surface Water, Subt SIOW = Indian Ocean Subtropical Surface Water, CW = Indian Ocean Central Water, Antarc IW = Antarctic Intermediate Water, NIDW = North Indian Deep Water, NADW = North Atlantic Deep Water.

Source: Lutjeharms, 2006.

The composite temperature/salinity (TS) plot for data from the offshore sampling stations obtained in June 2012 is illustrated in *Figure 7.7*. Comparison with the regional TS plot (*Figure 7.7*) indicates that the water mass is predominantly EqIOW, with a minor contribution of Subt SIOW towards the base of the measured water column (approximately 200m depth).

Figure 7.8 ***Temperature–Salinity for Offshore CTD Sampling Stations, June 2012***

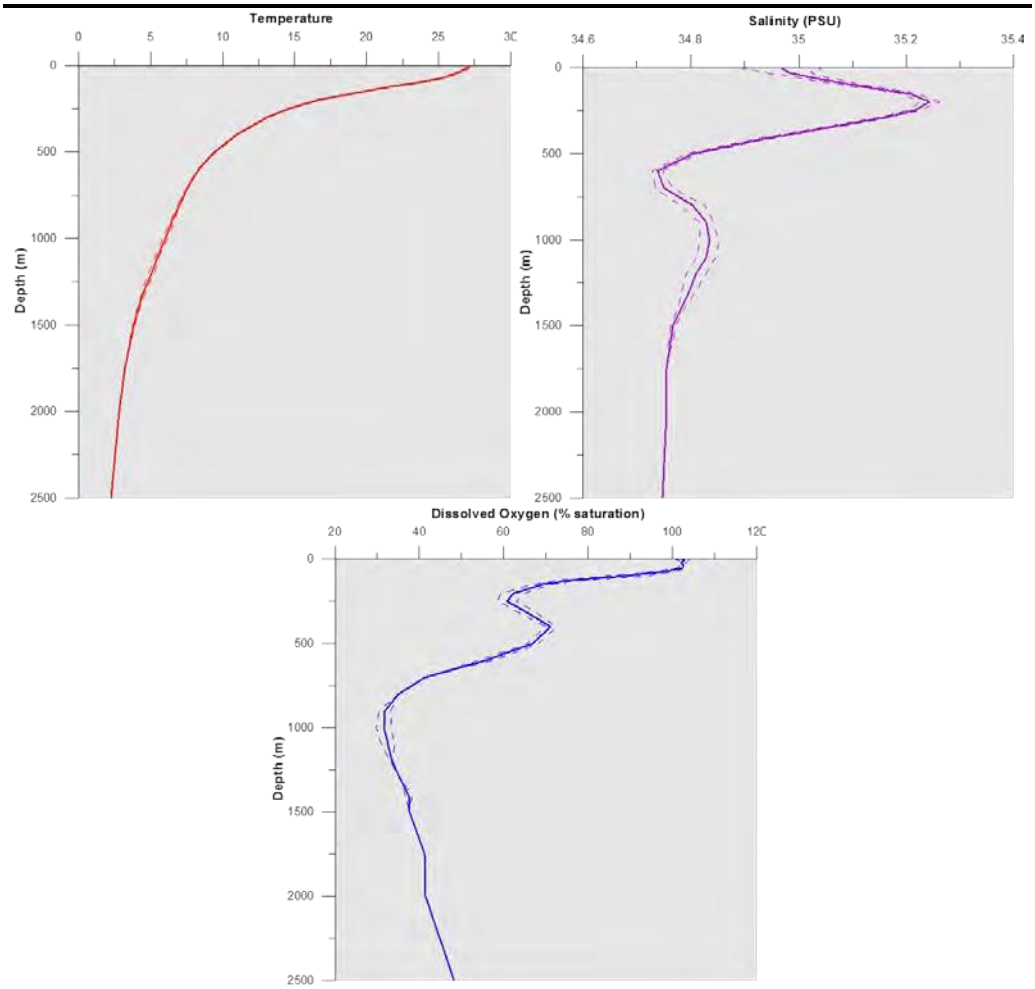


Source: Lwandle, 2012.

Temperature, Salinity and Dissolved Oxygen

There is no systematic and detailed information on the physical and chemical parameters of the waters in the north of the Mozambique Channel. Some scientific data were obtained during the cruise of the Dr Fridtjof Nansen between 1977 and 1978, and are described by Saetre and da Silva (1982). More recent data for the region are provided by Di Marco et al. (2002). Formalised water column profile data are available from the World Ocean Atlas (2009), and *Figure 7.10* shows vertical profiles of mean (+/- SE) values for temperature, salinity and dissolved oxygen concentrations for the one degree square area centred on 10.5°S, 41.5°E.

Figure 7.9 *Vertical Profiles of Temperature, Salinity and Oxygen Offshore, Northern Mozambique*



Key:

Solid lines indicate mean values and dashed lines indicate Standard Errors of the mean.

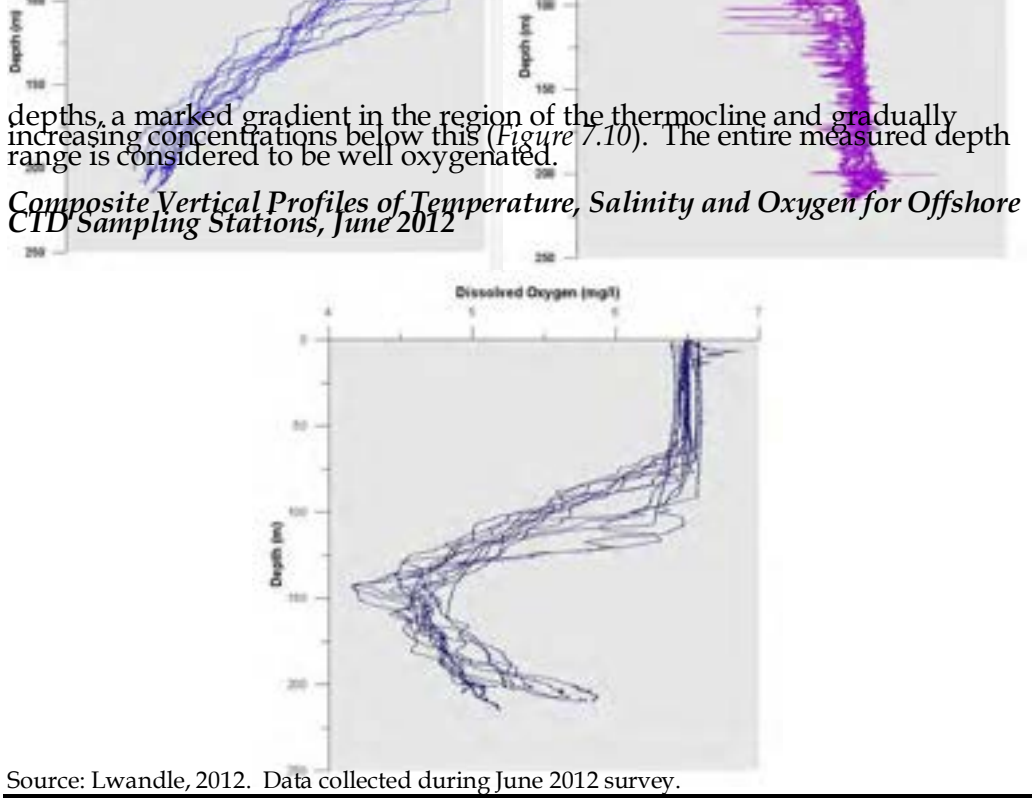
Source: Lwandle, 2012. Data supplied by SADCO following extraction from the World Ocean Atlas 2009.

The observed patterns for temperature, depth and salinity are consistent with the regional distributions shown in *Figure* 7.9.

The vertical temperature profiles show a well-developed upper mixed layer of water at 27°C that extends to 60 to 120m depth. This overlies strong thermoclines, with temperatures dropping from 27°C to 14°C at depths of 220m at approximately 0.105°C/m. At the stations where the upper mixed layer was deepest, there were corresponding enhanced thermoclines indicating that surface wind/wave mixing was largely responsible for the observed patterns. The two-layer system evident in the temperature profiles is largely replicated in the composite salinity profiles, as shown in *Figure 7.10*. Relatively low salinity is apparent in the upper mixed layer depths, and salinity increases in the region of the thermocline. The dissolved oxygen profiles indicate uniformly high concentrations in the upper mixed layer

depths, a marked gradient in the region of the thermocline and gradually increasing concentrations below this (*Figure 7.10*). The entire measured depth range is considered to be well oxygenated.

Figure 7.10 ***Composite Vertical Profiles of Temperature, Salinity and Oxygen for Offshore CTD Sampling Stations, June 2012***



Source: Lwandle, 2012. Data collected during June 2012 survey.

Turbidity

Water column turbidity levels measured during the offshore survey were mostly low, <0.5mg/l. However, quite strongly elevated levels were observed in the very near surface layers, with a minor elevation in turbidity at depths corresponding to the base of the upper mixed layer/ top of the thermocline, as shown in *Figure 7.11*.. This may be due to the accumulation of detritus at or close to density interfaces; however, there are no supporting data for this.

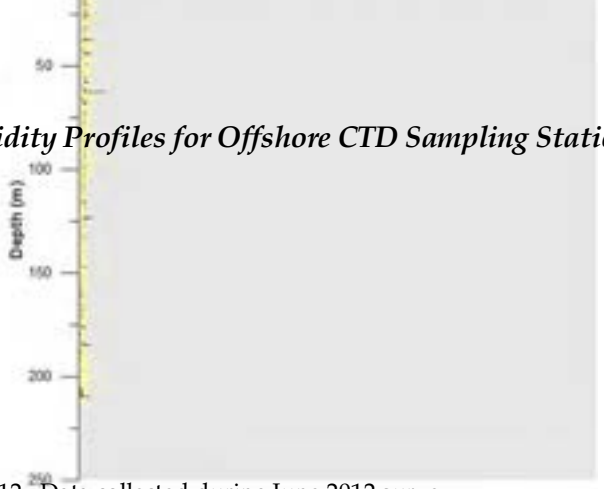


Figure 7.11 Composite Turbidity Profiles for Offshore CTD Sampling Stations, June 2012

Source: Lwandle, 2012. Data collected during June 2012 survey.

Hydrocarbons

Fluorescence in the UV (10 to 400nm) wave length is used to detect hydrocarbon compounds in water. UV fluorescence profiles measured in the June 2012 offshore survey are all centred around zero, indicating that, if hydrocarbon compounds were present in the water column, they were at concentrations below the detection level of the sensors used (1 to 3ppm).

7.5.4 Seabed Features

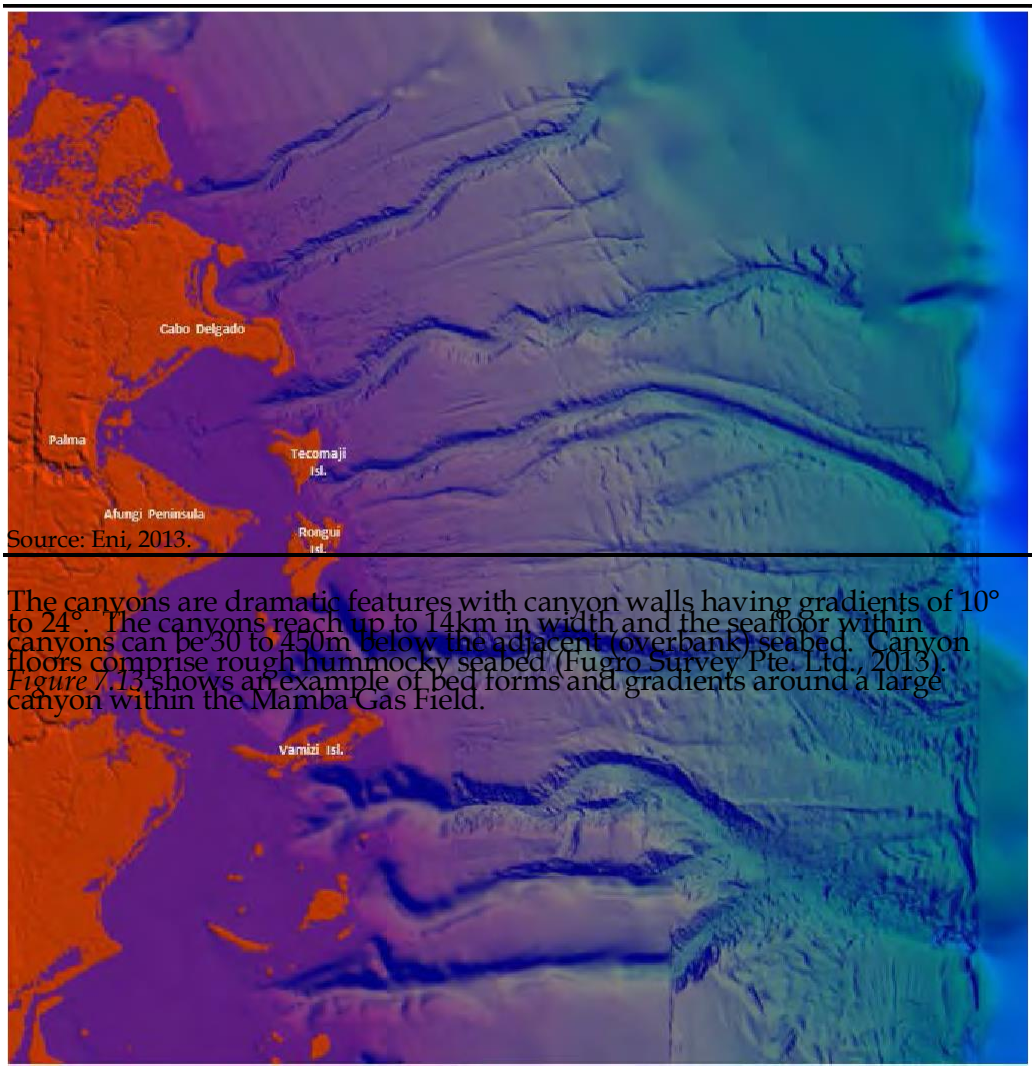
Topography

The coastline of northern Mozambique is bordered by a narrow continental shelf. This shelf drops off into deep waters via a very steep slope. Both the shelf and slope are incised by a number of deep canyons that extend out to the abyssal plain [(1)] as shown in *Figure 7.12*. The seabed of the plain in the deep waters, outside of the canyons, comprises rough hummocks [(2)], undulating sediment surfaces, rough seabed, older sediment outcrops, escarpments, slumped sediments and fault-like features. Typical seabed gradients are <4° dipping east north east (Fugro Survey Pte. Ltd., 2013).

(1) Smooth, almost level area of the deep-ocean floor in which the gradient is very low.

(2) A small but steep, irregular hill rising above the general level of the surrounding land; a low mound or ridge of earth, a knoll.

Figure 7.12 Regional Topography



Source: Eni, 2013.

The canyons are dramatic features with canyon walls having gradients of 10° to 24°. The canyons reach up to 14km in width and the seafloor within canyons can be 30 to 450m below the adjacent (overbank) seabed. Canyon floors comprise rough hummocky seabed (Fugro Survey Pte. Ltd., 2013). *Figure 7.13* shows an example of bed forms and gradients around a large canyon within the Mamba Gas Field.

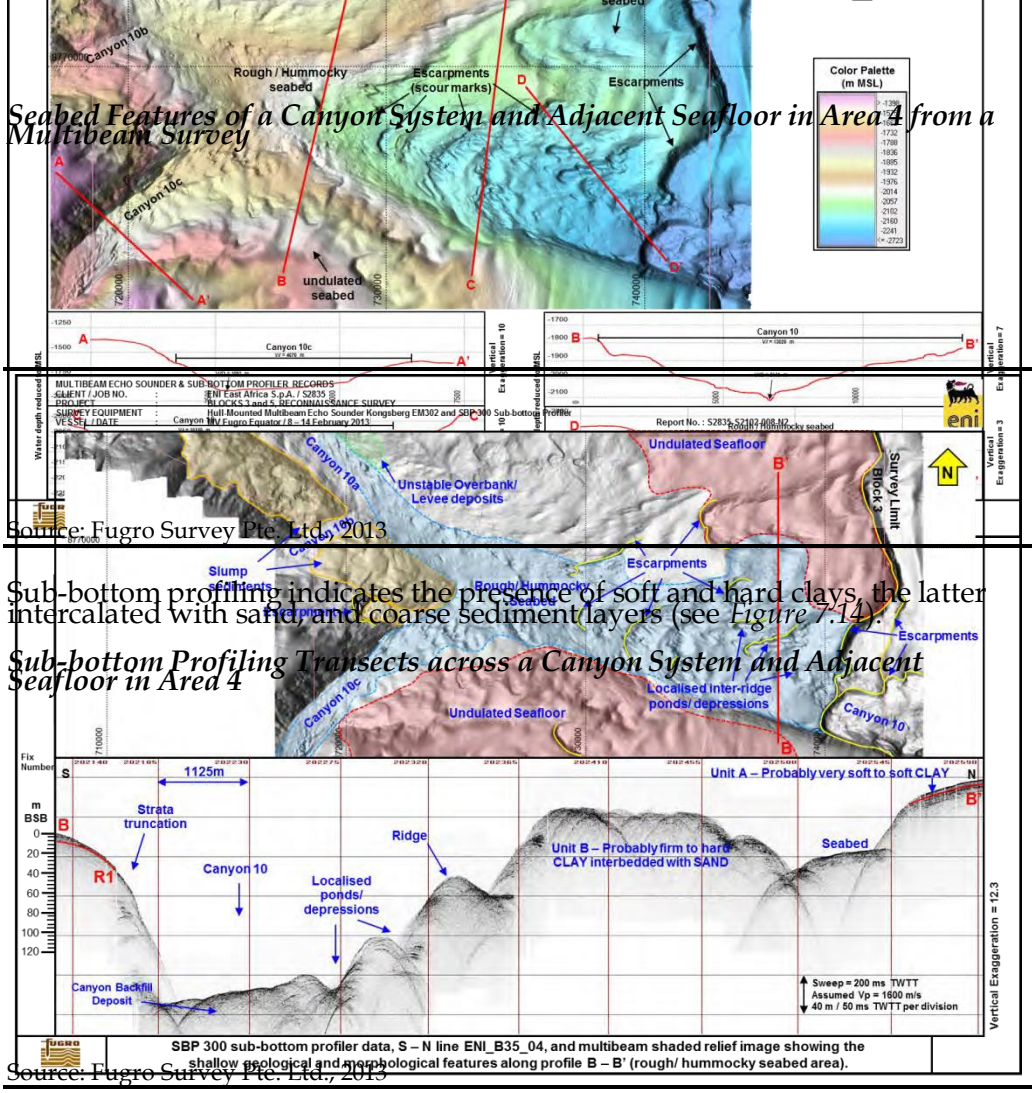


Figure 7.13 ***Seabed Features of a Canyon System and Adjacent Seafloor in Area 4 from a Multibeam Survey***

Source: Fugro Survey Pte. Ltd., 2013

Sub-bottom profiling indicates the presence of soft and hard clays, the latter intercalated with sand, and coarse sediment layers (see *Figure 7.14*).

Figure 7.14 ***Sub-bottom Profiling Transects across a Canyon System and Adjacent Seafloor in Ared 4***

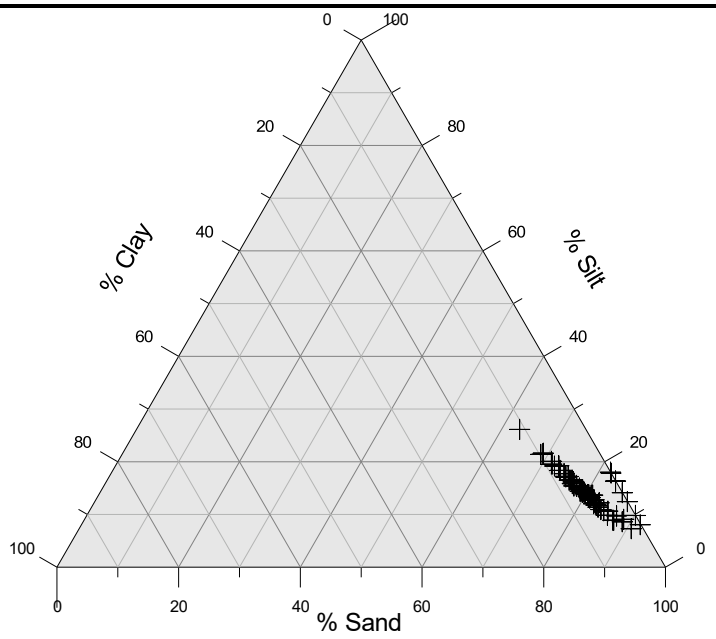
Source: Fugro Survey Pte. Ltd., 2013

Sediment Texture

Sediment samples taken at 75 sampling stations (see *Figure 7.15*) within the Offshore Survey Area were dominated by sand (77 percent), with silt (12 percent), mud (5 percent) and gravel (6 percent) comprising minor proportions. Sediments were mainly silty sand and mixtures of sand, as illustrated in *Figure 7.15*. Silt and clay are rare within the sediments.

In all samples, the sediments were poorly sorted, indicating multiple sources of sediments and a low energy environment near the seabed. Microphotography of the sediments showed the presence of coral debris, quartzitic grains and illite (L Lenhoff, UWS, *in litt.*). Biogenic material (eg foraminifera) comprised a very minor proportion of the sediment samples examined.

Figure 7.15 Ternary Diagram Showing Sediment Texture in the Offshore Survey Area, June 2012

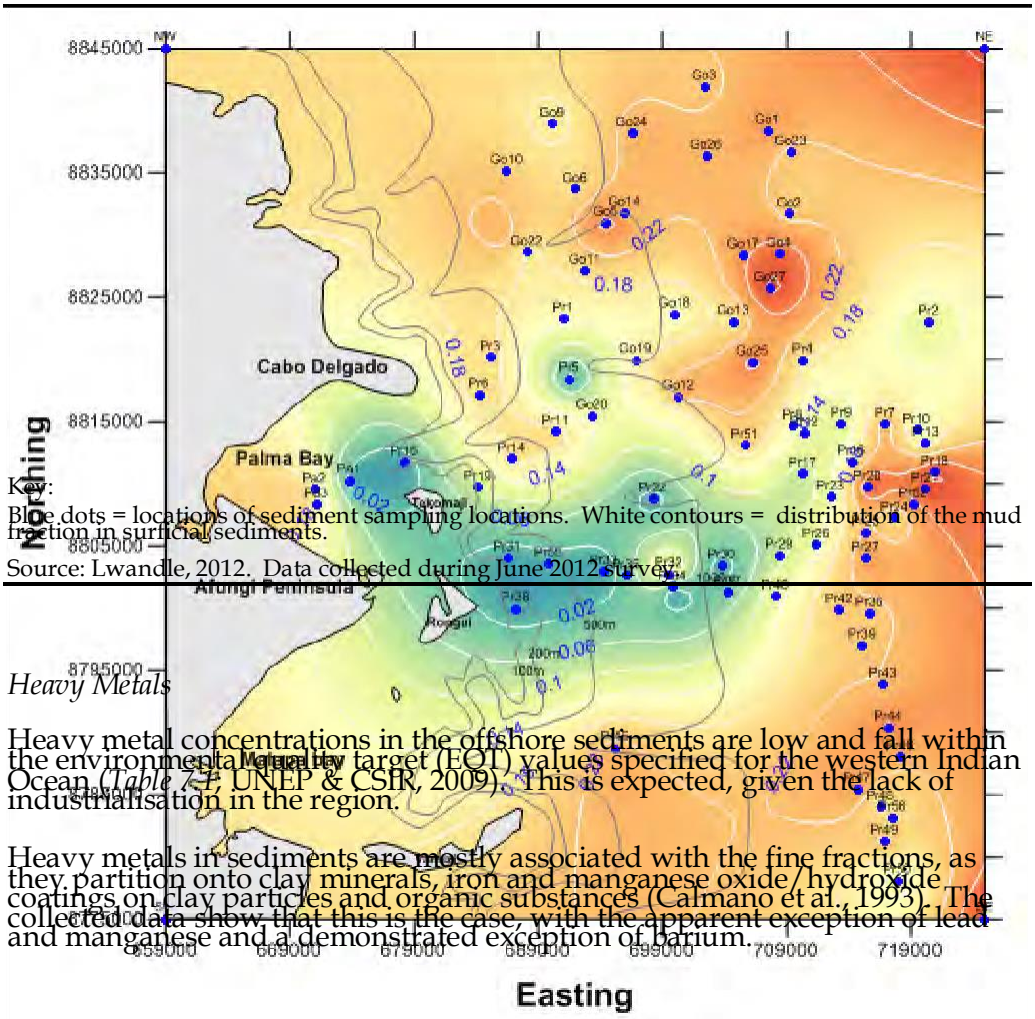


The black crosses indicate the various sediment types observed.

Source: Lwandle, 2012.

The distribution of the mud fraction in the Offshore Survey Area is shown in *Figure 7.16*. It is evident that, offshore of Palma Bay, higher proportions of mud occur in the deeper areas of the gas fields. Analysis of video footage of the Mamba gas fields, indicate that the sedimentary environment is similar to that of the deeper area of the Prosperidade Gas Field. This may be due to topography or higher current speeds associated with the steeper topography in the west of the Offshore Survey Area. Minimal mud was found in the offshore areas of Palma Bay and extending offshore between Tecomaji and Rongui islands.

Figure 7.16 Distribution of the Mud Fraction in Surficial Sediments in the Offshore Survey Area



Key:

Blue dots = locations of sediment sampling locations. White contours = distribution of the mud fraction in surficial sediments.

Source: Lwandle, 2012. Data collected during June 2012 survey.

Heavy Metals

Heavy metal concentrations in the offshore sediments are low and fall within the environmental quality target (EQT) values specified for the western Indian Ocean (*Table 7.5*; UNEP & CSIR, 2009). This is expected, given the lack of industrialisation in the region.

Heavy metals in sediments are mostly associated with the fine fractions, as they partition onto clay minerals, iron and manganese oxide/hydroxide coatings on clay particles and organic substances (Calmano et al., 1993). The collected data show that this is the case, with the apparent exception of lead and manganese and a demonstrated exception of barium.

Table 7.1 *Heavy Metal Concentrations (mg/kg) in Sediments from Offshore Survey June 2012 Compared to Sediment EQT Concentrations for the WIOLAB Region*

Metal	Mean	Standard Dev	n	WIOLAB EQT
Aluminium (Al)	27748.8	15381.6	77	
Cadmium (Cd)	Nd			0.68
Nickel (Ni)	15.4	7.8	77	15.9
Silver (Ag)	Nd			0.73
Arsenic (As)	2.5	1.4	28	7.24
Barium (Ba)	244.5	570.8	77	
Beryllium (Be)	1.1	0.2	33	
Cobalt (Co)	6.3	3.0	74	
Chromium (Cr)	28.1	11.2	77	52.3
Copper (Cu)	12.5	7.2	76	18.7
Iron (Fe)	18159.5	9003.9	77	
Lead (Pb)	4.8	1.5	57	30.2
Lithium (Li)	26.4	11.1	75	
Manganese (Mn)	315.6	243.8	77	
Molybdenum (Mo)	ND			
Selenium (Se)	ND			
Strontium (Sr)	1715.0	698	77	
Vanadium (V)	31.3	14.8	77	
Zinc (Zn)	33.8	16.4	77	124

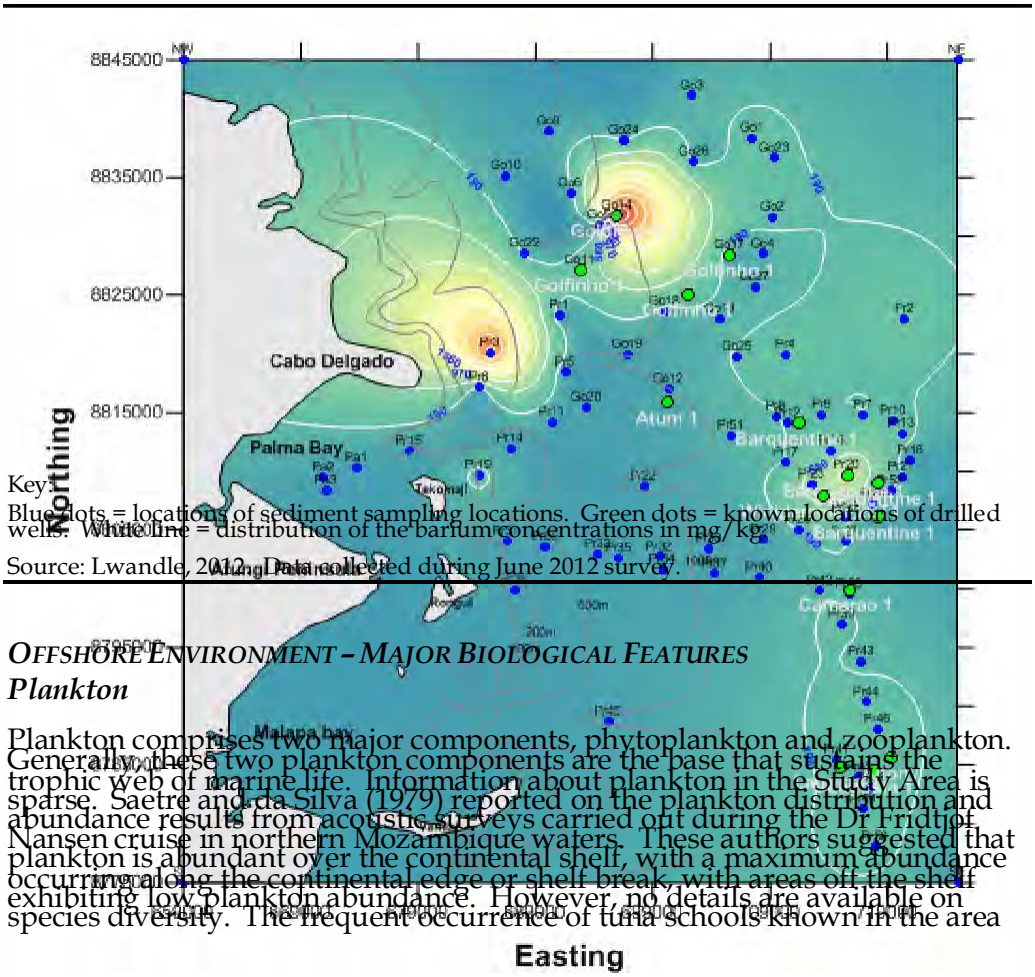
Key:

ND = below detection limit, EQT = environmental quality target concentration.

Source: Lwandle, 2012. Data collected during June 2012 survey.

Barium levels at a number of sampling stations in Area 1 were highly enriched relative to the apparent baseline conditions. A possible source of the barium is the barite used as a weighting agent in drilling fluids. This source is confirmed to an extent in the comparative distribution of sediment barium concentrations and known drilled well positions in the Golfinho and Prosperidade gas fields (see *Figure 7.17*). It is evident that barium concentration is strongly elevated at the Golfinho 1 well, and less so at the Barquentine and Lagosta well complexes. The strongly elevated concentration recorded at sample site Pr3 is not linkable to the well position data for these well complexes, but may be the result of previous exploration activities in this region.

Figure 7.17 Distribution of Barium Concentrations (mg/kg) in Sediments, June 2012, and Locations of Wells in Area 1



Key:
Blue dots = locations of sediment sampling locations. Green dots = known locations of drilled wells. White line = distribution of the barium concentrations in mg/kg.

Source: Lwandle, 2012. Data collected during June 2012 survey.

7.6 OFFSHORE ENVIRONMENT – MAJOR BIOLOGICAL FEATURES

7.6.1 Plankton

Plankton comprises two major components, phytoplankton and zooplankton. Generally, these two plankton components are the base that sustains the trophic web of marine life. Information about plankton in the Study Area is sparse. Saetre and da Silva (1979) reported on the plankton distribution and abundance results from acoustic surveys carried out during the Dr Fridtjof Nansen cruise in northern Mozambique waters. These authors suggested that plankton is abundant over the continental shelf, with a maximum abundance occurring along the continental edge or shelf break, with areas off the shelf exhibiting low plankton abundance. However, no details are available on species diversity. The frequent occurrence of tuna schools known in the area

was also found to substantiate the high productivity of plankton (Saetre & da Silva, 1979).

Water samples collected from the offshore CTD sampling stations in June 2012(see *Section 7.5.1*) were analysed for chlorophyll fluorescence, and composite profiles (*Figure 7.18*) show low phytoplankton biomass in the upper water column overlying a subsurface chlorophyll maximum below 50m depth. This is consistent with a euphotic but nutrient-limited upper mixed layer, with nutrients diffusing through the thermocline from aphotic but relatively nutrient-rich deeper waters. This is an ubiquitous feature of open ocean chlorophyll distributions (eg Parsons et al., 1977).

Figure 7.18 ***Composite Chlorophyll Depth Profiles for the Offshore CTD Sampling Stations, June 2012***

Source: Lwandle, 2012. Data collected during June 2012 survey.

7.6.2 Benthos

One hundred and ten benthos taxa were observed in the samples analysed from the offshore sampling stations (see *Figure 7.2*). This included taxa from the major groups of Polychaeta, Crustacea, Mollusca and Echinodermata. Minor groups such as Sipunculida, Cnidaria and Nemertea were also represented. As shown in *Table 7.2*, polychaetes were the most taxonomically diverse group with 36 families represented.

Table 7.2 ***Total Numbers of Families and Species/Nominal Taxa per Higher Taxon Group (Phylum, Class, or Order) from all Sites Sampled in the June 2012 Survey***

Higher Taxa	Taxon Rank	Number of Families	Number of Taxa/Species
Sipunculida	Phylum	1	1*
Nemertea	Phylum	1	1*
Platyhelminthes	Phylum	1	1
Higher Taxa	**Taxon Rank**	**Number of Families**	**Number of Taxa/Species**
Polychaeta	Class	36	63
Gastropoda	Class	3	3
Bivalvia	Class	4	4
Aculifera	Class	1	1
Ophiuroidea	Class	1	3*
Holothuroidea	Class	2	2
Anthozoa	Class	1	1*
Amphipoda	Order	7	9
Cumacea	Order	1	2
Isopoda	Order	5 (including the order Asellota)	13
Tanaidacea	Order	8	9
Decapoda	Order	4	5

Several Tanaidacea (crustacea) species observed appear to be new to science and have not previously been taxonomically described. These specimens have been sent to an acknowledged expert on Tanaidacea taxonomy for confirmation of this. Whether these are unique to the area is unknown as the East African benthos has not been researched to the extent that any confident statements can be made on the geographic ranges of the sampled organisms. Generally deep water benthos species have distribution ranges that extend over multiple degrees of latitude (eg Rex et al., 2000) and it is unlikely that benthos observed in Area 1 are different in this respect. Distribution patterns in the sampled area are only weakly defined with the data available and there are similarly weak associations with key variables in the sediments.

The dominant fauna in terms of abundance and biomass are listed in *Table 7.3*.

Table 7.3 Benthos Abundance and Biomass from June 2012 Survey

Abundance		
Higher Taxon	**Taxon**	**Total abundance (0.1m²)**
Polychaeta	*Aphelochaeta* spp. (*Monticellina* spp.?)	52.78
	Syllidae	36.00
	Aponuphis spp.	33.84
	Exogone spp.	33.25
	Paraprionospio spp.	29.00
	Aricidea spp.	24.5
	Nephtys spp.	24.03
	Ampharetidae	23.03
	Maldanidae	19.03
Sipunculida	Sipunculida	18.75
Biomass		
Higher Taxon	**Taxon**	**Total biomass (g/0.1m²)**
Echinodermata	*Thelenota ananas*	31.35
Mollusca	*Bullia* spp.	3.99
Sipunculida	Sipunculida	0.70
Mollusca	Bivalvia C (recruit) Veneridae	0.35
	Amphiuridae A	0.34
Polychaeta	Maldanidae	0.24
	Aponuphis spp.	0.17
Mollusca	Arcidae	0.10
Abundance		
Higher Taxon	**Taxon**	**Total abundance (0.1m²)**
Platyhelminthes	Platyhelminthes	0.10
Nemertea	Nemertea	0.09

In general, the benthos was sparsely distributed across the Offshore Survey Area with some stations recording zero counts. The offshore benthos survey indicates that the fauna are sparsely distributed throughout Area 1 but are diverse.

Typically low abundances were observed in the majority of the offshore sample sites, with elevated levels in Palma Bay and stations Pr3 and Pr 29. Polychaeta comprise most of the numerically abundant fauna with the only other group represented being Sipunculida (peanut worms). Benthic biomass were more uniformly distributed, with low biomass in the deeper water areas and markedly elevated levels within Palma Bay (although this is attributed to the presence of a single specimen of sea cucumber *Thelenota ananas* (Echinodermata, Holothuiroidea (sea cucumber)) and two *Bullia* (Mollusca, Bivalvia) specimens. Results suggest abundance and biomass are reduced with increasing water depth.

Despite a moderately large number of samples it is probable that the species present were undersampled and that the derived taxonomic list for the area is likely to be incomplete.

Figure 7.19 shows a number of benthos specimens observed offshore including the species identified that have not been previously been described taxonomically.

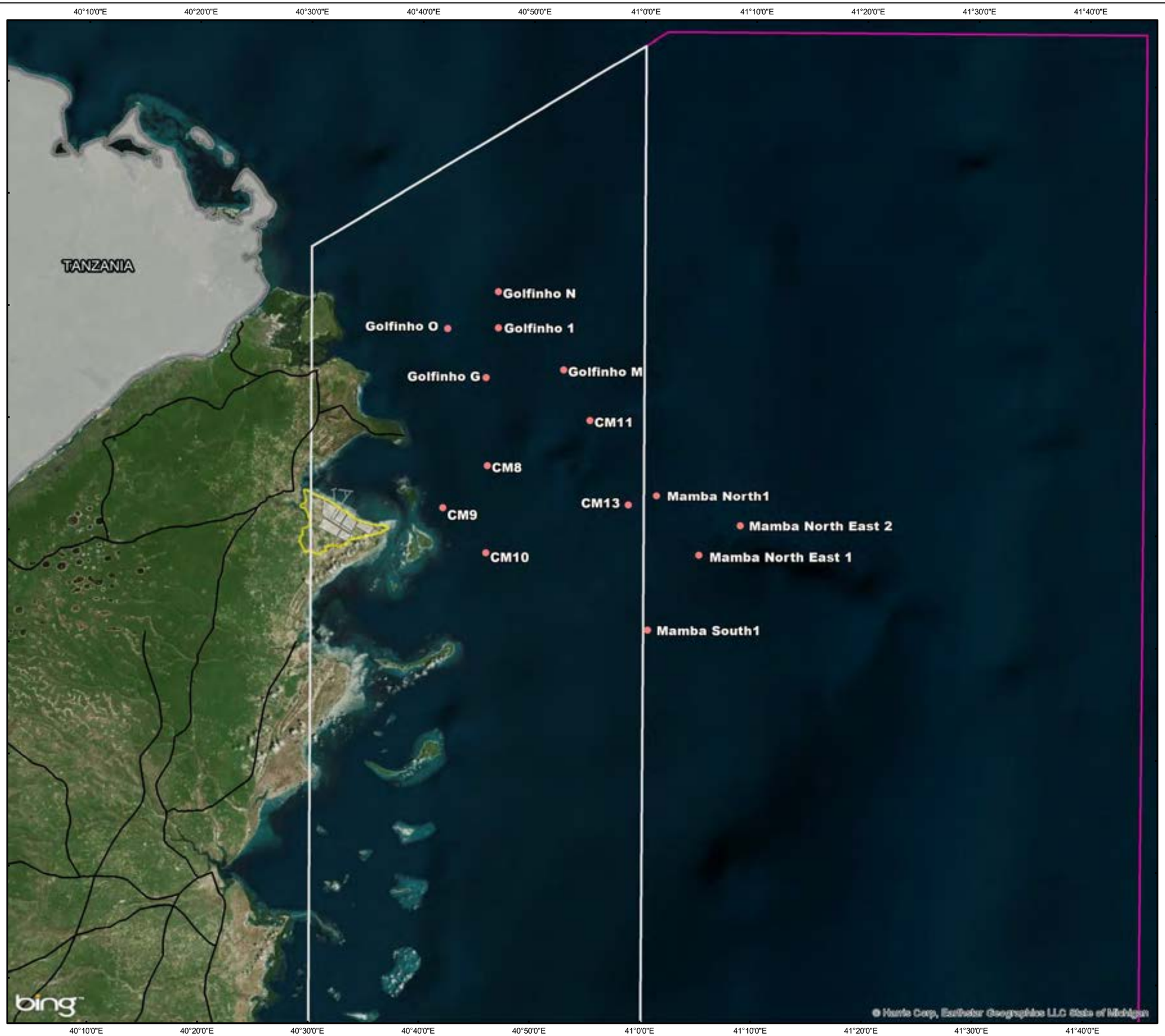
Figure 7.19 Benthos Specimens from Area 1, Offshore Mozambique

Note: Apseudes sp. and Parapseudes sp. (centre panels) are apparently new Tanaidacea (Crustacea) species.

Source: Lwandle, 2012.

7.6.3 *Reef Structures*

There are no published scientific reports on the distributions or features of reefs in deep water off the northern Mozambique coast. CSA, as part of its gas field exploration and simulation modelling for drill cuttings and mud discharges, analysed ROV seabed video surveys around five sites in the Golfinho Gas Field in 2012. This work has been augmented by ROV video records from five current meter deployment sites off Palma Bay and a further four sites within the Mamba Gas Field. The locations of these are illustrated in *Figure 7.20*, and the water depths for each and types of transects deployed are listed in *Table 7.4*.



Legend

- Regional Roads
- Jetty
- Onshore Layout
- Afungi Project Site
- Seabed ROV Video Surveys
- Area 1
- Area 4

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 7.20:
Locations of Seabed ROV Video Surveys

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: KG	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 600 000

DRAWING: Locations of Seabed ROV Video Surveys.mxd

REV: A

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Projection: UTM Zone 37 S. Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.Lwandle Technologies, 2012. Inset Map: Esri Data & Maps

SIZE: A3

T:\GIS Projects

10°10'0"S
10°20'0"S
10°30'0"S
10°40'0"S
10°50'0"S
11°0'0"S
11°10'0"S
11°20'0"S

Table 7.4 Seabed ROV Video Surveys in the Gas Fields Offshore of Palma Bay

Site	Approximate Location (WGS 1984 UTM Zone 37S)		Water Depth (m)	No. of Transects	Transect Lengths and Layout
	X	Y			
Golfinho 1	694835	8835250	1010	17	400 m, grid
Golfinho G	692805	8827130	845	8	400 m, radial
Golfinho M	705570	8828395	1290	8	400 m, radial
Golfinho N	694820	8841230	1075	8	400 m, radial
Golfinho O	686515	8835175	730	8	400 m, radial
CM8	693024	8812646	655	4	~500 m, orthoganal
CM9	685690	8805685	390	4	~500 m, orthoganal
CM10	692767	8798344	515	4	~500 m, orthoganal
CM11	709885	8820012	1459	4	~500 m, orthoganal
CM13	716142	8806133	1510	4	~500 m, orthogonal
Mamba South 1	719325.230	8785615.230	1605	8	400 m, radial
Mamba North 1	720799.494	8807702.420	1710	10	400 m, radial
Mamba North East 1	727761.986	8797923.935	1863	9	400 m, radial
Mamba North East 2	734528.570	8802752.640	2019	7	400 m, radial

Source: Lwandle, 2012. Data from CSA (2012) and MSI (2012, *in litt.*) and eni, 2013.

These surveys detected low-relief reefs at Golfinho 1, G and O, CM 9, 10 and 13 and high-relief, rugose reefs at Golfinho 1 and CM10, indicating that reefs occur across the full depth range (390 to 1,510m) for which observations have been made. It is probable that they are found throughout the area of the offshore gas fields. Video records in the Mamba Gas Field show no evidence of reef structures in the vicinity of the four locations surveyed. Depths at these two well locations reach 1,685m and 2,000m respectively. The lack of reef structures cannot be extrapolated for the entire Mamba Gas Field, since the area of the seafloor was limited to the immediate surroundings of these two well locations.

Although the video records are not of high quality, it appears that biodiversity is higher on the high-relief reefs with that on the low-relief reefs being considerably lower. However, even the high-relief reefs do not apparently support high densities of fauna, which has been visually estimated to attain six to eight organisms per square metre (CSA, 2012). The observed fauna include Gorgoniid octocorals, Scleractinian cup corals and *Lophelia*, crinoids, sponges and Antipatharian (black) corals. It should be noted that only larger, easily visible organisms would have been identifiable in the video records, due to suboptimal video records. Some of the fauna observed are extremely slow growing eg black corals have estimated growth rates of <0.1mm per year (Roark et al., 2009). Thus, although biodiversity may be low and deepwater corals not well developed, these high-relief reefs are ecologically important features. *Figure 7.21* and *Figure 7.22* show examples of a high-relief reef at approximately 1,000m depth and a low-relief reef at 390m depth.

Figure 7.21 *ROV Images of High-relief Reef Structures at Approximately 1,000m Depth in Golfinho Gas Field*

Image quality is insufficient for firm taxonomic classification.
Source: Lwandle, 2012. Images provided by AMA1.

Figure 7.22 *ROV Images of Low-relief Reef Structures at Approximately 390m Depth in Golfinho Gas Field*

Image quality is insufficient for firm taxonomic classification.
Source: Lwandle, 2012. Images provided by AMA1.

Very little is known about the deepwater reefs in the waters off Mozambique, or off the east African continental shelf in general, as little to no research has been undertaken. Deepwater reefs, including coral and rugose reefs, typically act as biodiversity reserves, supporting habitat complexity distinct from that of the surrounding seabed. Species not unique to reefs often benefit by using these structures as a refuge eg for nursery grounds for fish. Deepwater reefs support a host of communities, however the extent of the function and importance of the deepwater reef structures in the Project Area are not fully understood.

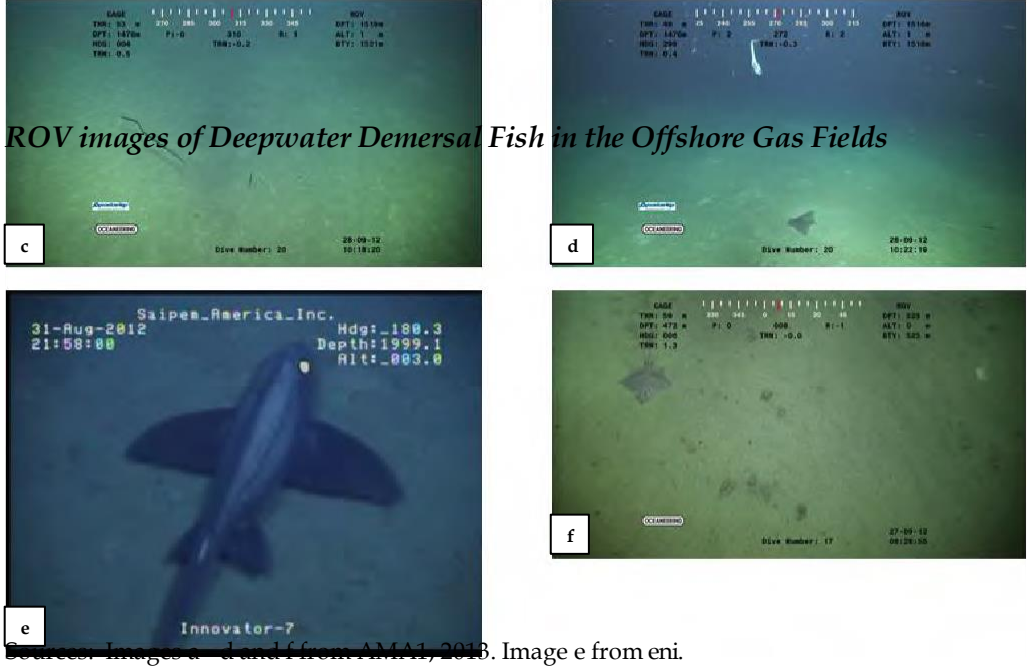
7.6.4 Fish

The fish fauna of northern Mozambique waters offshore of the continental shelf break are not well known, as is the case in much of the world's oceans, with knowledge mostly confined to the commercially important large pelagic tuna, mackerel and bonito (Scomberidae). Important species include yellowfin tuna (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*) which are categorised as Near Threatened and Least Concern respectively according to the IUCN Red List of Threatened species (IUCN, 2012). Information on other species that are probably present comes from tuna fishery bycatch data (Romanov, 2002). Bycatch records identify up to 45 taxa of fish fauna, depending on whether the tuna schools were free swimming or associated with whale sharks (*Rhincodon typus*) which are categorised as Vulnerable (IUCN, 2012) or whales (mainly Balaenoptera, such as sei whales). These include Dasyatidae (stingray), Mobulidae (manta ray), Lamnidae (mako), Carcharinidae, Sphyrnidae (hammerhead), Exocoetidae (flying fish), Belonidae (needlefish), Lampidae (opah), Spyraenidae (barracuda), Carangidae (many species), Coryphaenidae (dorado), Kyphosidae (chub), Gempylidae (cutlass fish), Ephippidae (batfish), Scombridae (wahoo, mackerel, tuna), Istiophoridae (sailfish, marlin), Xiphidae (swordfish), Nomeidae (bluebottle fish), Monocanthidae (filefish) and Diodontidae (puffer). All of the above have very wide distributions in the western Indian Ocean.

Mesopelagic fish that probably occur in the offshore area include *Benthosema fibulatum*, *Symbolophorus evermanni*, *Diaphus garmani*, *D. nielseni*, *D. perspicillatus* and *Lampanychtus* sp. (Saetre & da Silva, 1979). This group is well represented between 50 and 300km offshore, but appears to diminish in abundance beyond this range. Overall biomass has been estimated at 5,600 tonnes. Similar to the larger pelagic species, mesopelagics are generally widely distributed in the western Indian Ocean and worldwide.

Figure 7.23 shows a selection of deepwater demersal fish observed in the ROV video footage undertaken during offshore gas exploration activities. Given the quality of the video footage and that no specimens have been obtained, fish identification have been difficult. It is believed that some of the species observed eg the fish that resembles angel shark in the figure below, may be previous described taxonomically and possibly therefore new to science.

Figure 7.23 *ROV images of Deepwater Demersal Fish in the Offshore Gas Fields*



Sources: Images a – d and f from AMA1, 2013. Image e from eni.

Tentative classifications courtesy of David Japp (Capricorn Fishing CC, South Africa) and David Ebert (Pacific Shark Research Centre, Moss Landing Marine Laboratories, California State University:

(a) Malacocephalus sp. (Rat Tail)

(b) Alephocephalus sp. (A. australis (?), Slickhead)

(c) Anguilliformes (Ophichthidae sp (?), snake eel)

(d) Myliobatidae sp.

(e) Not yet identified, resembles angel shark (Squatinidae) but swimming motion and tail indicate that it may be a bony fish (Osteichthyes).

(f) Raja sp. (R. alba or R. dissimilis).

7.6.5 Whales and Dolphins

According to Peddemors et al. (1997), at least 21 species of marine mammals have been recorded in the Mozambique Channel, 17 of which probably occur in the Study Area (*Table 7.5*). A sperm whale (*Physeter macrocephalus*) was recorded during the 2008 marine mammal monitoring programme undertaken as part of a seismic survey in the deepwater of Area 1, carried out between January and May 2008 (Marine Team Offshore (1), 2008). This species

(1) The Marine Team Offshore refers to the team commissioned by AMA1 to undertake a marine mammal monitoring programme during a seismic survey in deepwater areas of Area 1 in 2008.

and several other species were observed by marine mammal observers in Area 4, during a seismic survey conducted between February and June 2010 (RPS Energy 2010). The species observed in the vicinity of the Mamba Gas Fields during the seismic campaigns are listed in *Table 7.5*.

In addition, a subsequent sighting of a sei whale (*Balaenoptera borealis*) has been observed in the Study Area (Mario Rassul, AMA1, pers. comm., 2011). Sei whales are considered to be Endangered, sperm whales Vulnerable, Indian Ocean humpback dolphins Near Threatened and the balance of the species are of Least Concern (eg humpback whales, which have been downgraded from Threatened status) or Data Deficient, according to the IUCN Red List of Threatened Species (IUCN, 2012).

Figure 7.24 shows the marine mammal sightings observed during the 2008 marine mammal observations undertaken during the offshore seismic surveys (Marine Team Offshore, 2008). *Table 7.5* indicates the periods when the various whale and dolphin species may be expected to occur offshore, based on previous observations.

Table 7.5 Marine Mammals in the Mozambique Channel, Expected Occurrences and Sightings

Common Name	Species	Conservation Status*	Resident/ Occurrences	Sightings in Area 4
Humpback whale	*Megaptera novaeangliae*	Least Concern	Seasonal: July–November	Yes
Minke whale	*Balaenoptera acutorostrata*	Least Concern	Seasonal: July–November	Yes
Common dolphin	*Delphinus delphis*	Least Concern	All year	Yes
Pygmy killer whale	*Feresa attenuata*	Data Deficient	All year	Yes
Short finned pilot whale	*Globicephala macrorhynchus*	Data Deficient	All year	Yes
Risso's dolphin	*Grampus griseus*	Least Concern	All year	Yes
Pygmy sperm whale	*Kogia breviceps*	Data Deficient	All year	Yes
Blainville's beaked whale	*Mesoplodon densirostris*	Data Deficient	All year	
Killer whale	*Orcinus orca*	Data Deficient	Seasonal	
Melon-headed whale	*Peponocephala electra*	Least Concern	All year	Yes
Sperm whale	*Physeter macrocephalus*	Vulnerable	All year/males migratory	Yes
Bryde's whale	*Balaenoptera brydei*	Data Deficient	Unknown	Yes
False killer whale	*Pseudorca crassidens*	Data Deficient	All year	Yes
Indian Ocean humpback dolphin	*Sousa chinensis*	Near Threatened	All year	Yes - nearshore
Spotted dolphin	*Stenella attenuata*	Least Concern	All year	Yes
Striped dolphin	*Stenella coeruleoalba*	Least Concern	All year	
Long-snouted spinner dolphin	*Stenella longirostris*	Data Deficient	All year	Yes
Rough-toothed dolphin	*Steno bredanensis*	Least Concern	All year	
Bottlenose dolphin	*Tursiops truncatus*	Least Concern	All year	Yes
Long-beaked common dolphin	*Delphinus capensis*	Data Deficient	All year	
Common Name	**Species**	**Conservation Status***	**Resident/ Occurrences**	**Sightings in Area 4**
Risso's dolphin	*Grampus griseus*	Least Concern	Unknown	Yes
Cuvier's beaked whale	*Ziphius cavirostris*	Least Concern	All year	Yes
Sei whale	*Balaenoptera borealis*	Endangered	Seasonal (austral winter)	Yes

Source: Expected occurrences from Peddemors et al., 1997. Sightings in Area 4 from RPS Energy, 2010 during seismic surveys. * The conservation status is based on the IUCN Red List of Threatened Species (2012).

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TANZANIA

Palma

Palma

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Mocimboa da Praia

Mocimboa da Praia

Mueda

Muidumbe

Macomia

Pangane

Meluco

Montepuez

Quissanga

Ancuabe

Pemba

Pemba

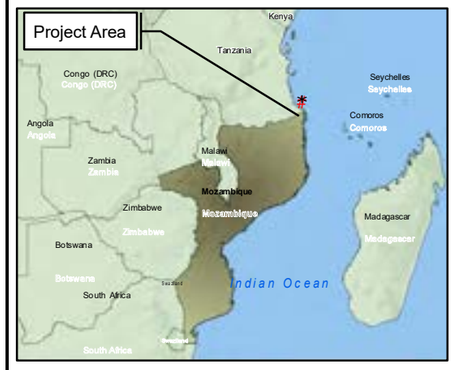
bing

Image courtesy of NASA Goddard Space Flight Center

39°0'0"E 39°30'0"E 40°0'0"E 40°30'0"E 41°0'0"E 41°30'0"E 42°0'0"E 42°30'0"E

Legend

- Marine Mammal Sightings
- Turtle Sightings
- Towns
- Regional Roads
- Afungi Project Site
- Area 1
- Area 4
- District Boundary
- Boundary with Tanzania



MAIN MAP SCALE:

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Figure 7.24:
Marine Mammals (blue dots) and Turtle Sightings (green dots) and Detections

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 1 250 000

DRAWING: Marine Mammals.mxd

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Projection: UTM Zone 37 S Datum: WGS84 Source: Bing Maps ©2010 Microsoft Corporation. Inset Map: Esri Data & Maps	SIZE: A3

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7.6.6 Seabirds

Six taxonomic families of seabirds (broadly defined as species that spend a large portion of their lives on or over sea water) are found in the offshore waters of northern Mozambique (*Table 7.6*). Some species of this group primarily inhabit continental slope habitats (eg albatrosses, petrels and their allies, boobies and gannets, and tropicbirds). Most seabird species in the Mozambique Channel, however, inhabit waters of the continental shelf and shelf edge and adjacent coastal and inshore habitats (Newman, 2002; Sinclair & Ryan, 2003).

Two species that are known to occur in the area, wandering albatrosses and Cape gannets (the latter probably being juvenile vagrants), are currently listed by the IUCN as Vulnerable, while the Indian yellow nose albatross is listed as Endangered, and the shy albatross and Jouanin's petrel as Near Threatened (IUCN, 2012).

Common and lesser crested terns were the most common seabirds sighted along the western edge of the Survey Area within waters of the continental shelf edge, during an offshore habitat characterisation survey undertaken for AMA1 (CSA, 2007).

Table 7.6 Offshore Seabirds of Northern Mozambique

Common Name	Species	Conservation Status*	Seasonality	Local Presence
Wandering albatross	*Diomedea exulans*	Vulnerable	N/A	Uncommon visitor
Indian yellow-nosed albatross	*Thalassarche carteri*	Endangered	Winter	Common visitor
Shy albatross	*Thalassarche cauta*	Near Threatened	Winter	Common visitor
			Summer	Uncommon visitor
Great-winged petrel	*Pterodroma macroptera*	Least Concern	N/A	Common visitor
Pintado petrel	*Daption capense*	Least Concern	Winter	Common visitor
Jouanin's petrel	*Bulweria fallax*	Near Threatened	N/A	Uncommon visitor
Wedge-tailed shearwater	*Puffinus pacificus*	Least Concern	N/A	Infrequent visitor
Flesh-footed shearwater	*Puffinus carneipes*	Least Concern	N/A	Uncommon visitor
Cory's shearwater	*Calonectris diomedea*	Least Concern	N/A	Common visitor
Audubon's shearwater	*Puffinus lherminieri*	Least Concern	N/A	Uncommon visitor
Wilson's storm petrel	*Oceanites oceanicus*	Least Concern	N/A	Common visitor
Black-bellied storm petrel	*Fregetta tropica*	Least Concern	Winter	Uncommon visitor
Cape gannet	*Morus capensis*	Vulnerable	N/A	Vagrant
Masked booby	*Sula dactylatra*	Least Concern	N/A	Common visitor
Red-footed booby	*Sula sula*	Least Concern	N/A	Uncommon visitor
White-tailed tropicbird	*Phaethon lepturus*	Least Concern	N/A	Common visitor
Red-tailed tropicbird	*Phaethon rubricauda*	Least Concern	N/A	Uncommon visitor
Lesser frigate bird	*Fregata ariel*	Least Concern	N/A	Rare visitor
Greater frigate bird	*Fregata minor*	Least Concern	N/A	Common resident
Sandwich tern	*Sterna sandvicensis*	Least Concern	Summer	Common visitor
Lesser crested tern	*Sterna bengalensis*	Least Concern	Summer	Common visitor
Common tern	*Sterna hirundo*	Least Concern	Summer	Common visitor
Sooty tern	*Sterna fuscata*	Least Concern	N/A	Uncommon visitor
Lesser noddy	*Anous tenuirostris*	Least Concern	N/A	Uncommon visitor
Pomerine jaeger	*Stercorarius pomarinus*	Least Concern	N/A	Common visitor
Parasitic jaeger	*Stercorarius parasiticus*	Least Concern	N/A	Common visitor
Long-tailed jaeger	*Stercorarius longicaudus*	Least Concern	N/A	Common visitor

Source: Harrison, 1983; Newman, 2002; Sinclair and Ryan, 2003.

* The conservation status is based on the IUCN Red List of Threatened Species (2012).

7.7 NEAR SHORE ENVIRONMENT – PHYSICAL CONDITIONS

7.7.1 Baseline Surveys and Survey Area

Location-specific information and data for Palma Bay are sparse. Therefore, as part of the LNG Facility site selection process, and subsequent environmental baseline data gathering and design data procurement, intensive investigations of the area have been carried out. These include bathymetric and sub-bottom profiling undertaken by UWS, metocean measurements within the bay and offshore undertaken by Metocean Services International (Pty) Ltd (MSI) and also dry season (November 2011) and wet season (March 2012) marine ecology surveys (Lwandle Technologies (Pty) Ltd). These are discussed below, with the main focus being on marine ecology surveys, which are augmented by contributions on the marine ecology of the region (Adriano Macia, Impacto) and fish and fisheries (Atanasio Brito, Impacto).

The marine ecology surveys were undertaken in the near shore environment, ie Palma Bay, by Lwandle. They comprised water column measurements of temperature, salinity, dissolved oxygen, turbidity and pH. In addition, water sampling was carried out to assess the concentration and distribution of dissolved inorganic nutrients, and surveys on seagrass, coral and sandy beach ecology were conducted. The findings are described in *Sections 7.7* to *7.8* of this chapter.

Figure 7.25 provides a schematic view of the distribution of measurement stations and sites in relation to the marine facilities planned for the LNG Facility. The location of these stations and sites is collectively referred to as the Survey Area.

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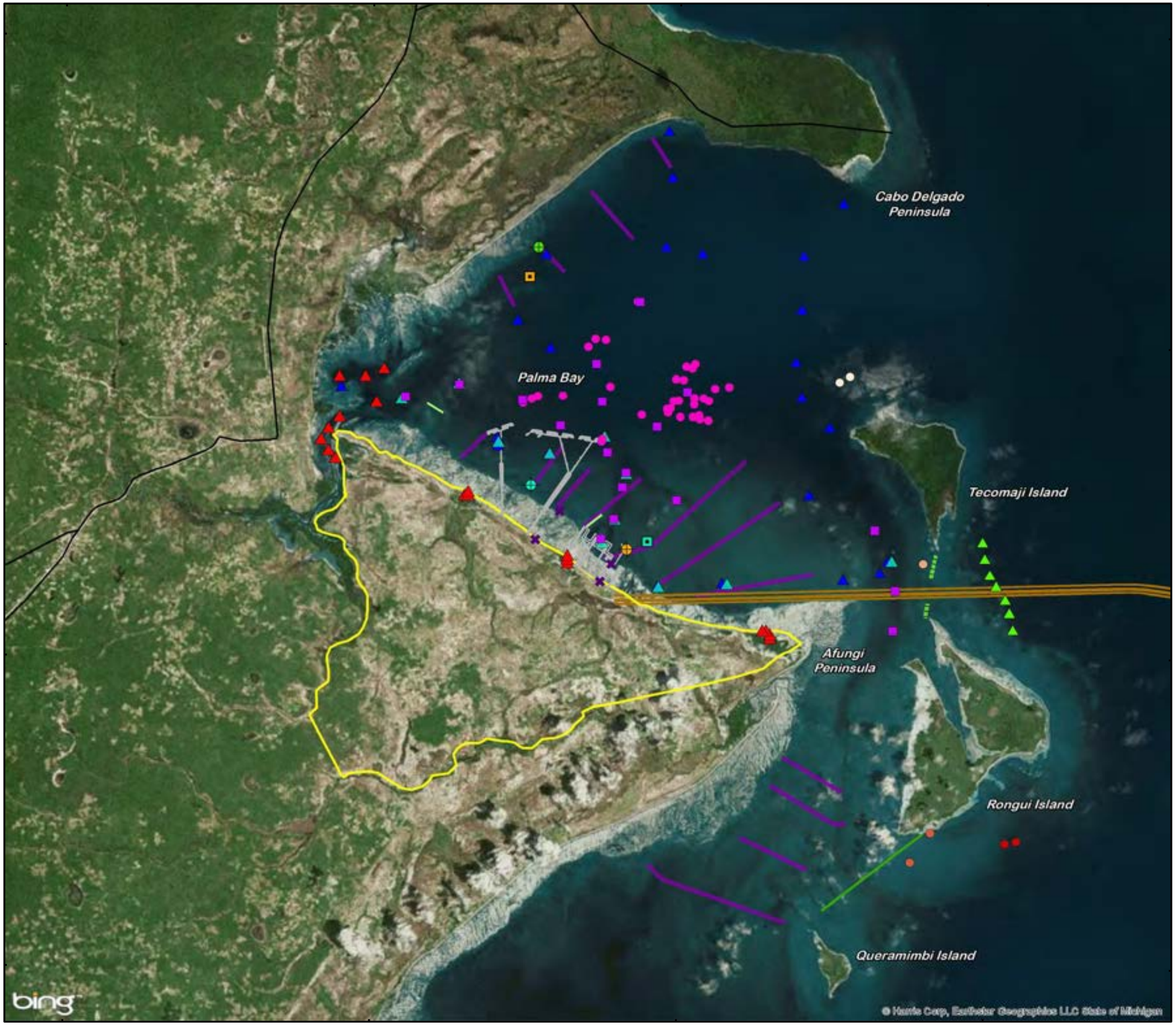

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Legend

- Conductivity Temperature Depth
- Inorganic Nutrient Sampling Sites
- Inorganic Nutrient Sampling Sites - Estuaries

Seagrass Bed Sampling Stations

- Afungi Test Site East (AFE)
- Afungi Test Site West (AFT)
- Palma West (PMW)
- Sand Craters
- Surficial Sediment Sampling Locations

Coral Reef Sampling Sites

- Far Field Bommie (FFB)
- Near Field Bommie (NFB)
- Seabed Observations at Deeper Waters between Tecomaji and Rongui Islands
- Tecomaji North Observations
- Tecomaji South Observations
- Rongui South Observation
- Rongui South Transect
- Boat Based Survey
- Tecomaji and Rongui Transect
- Rongui and Queramimbi Transect
- Seagrass Transects
- Regional Roads
- Proposed Nearshore Infrastructure
- Proposed Pipeline Corridor Route
- Afungi Project Site

MAIN MAP SCALE:

Kilometers

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Figure 7.25: Marine Ecology Survey Area - Nearshore

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 110 000

DRAWING: Marine Ecology Survey Area.mxd

REV: A

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Projection: UTM Zone 37 S Datum: WGS84 Source: Bing Maps ©2010 Microsoft Corporation. Lwandle Technologies, 2012. Inset Map: Esri Data & Maps	SIZE: A3

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7.7.2 *Bathymetry*

Bathymetry and topographic data have been obtained from the following sources:

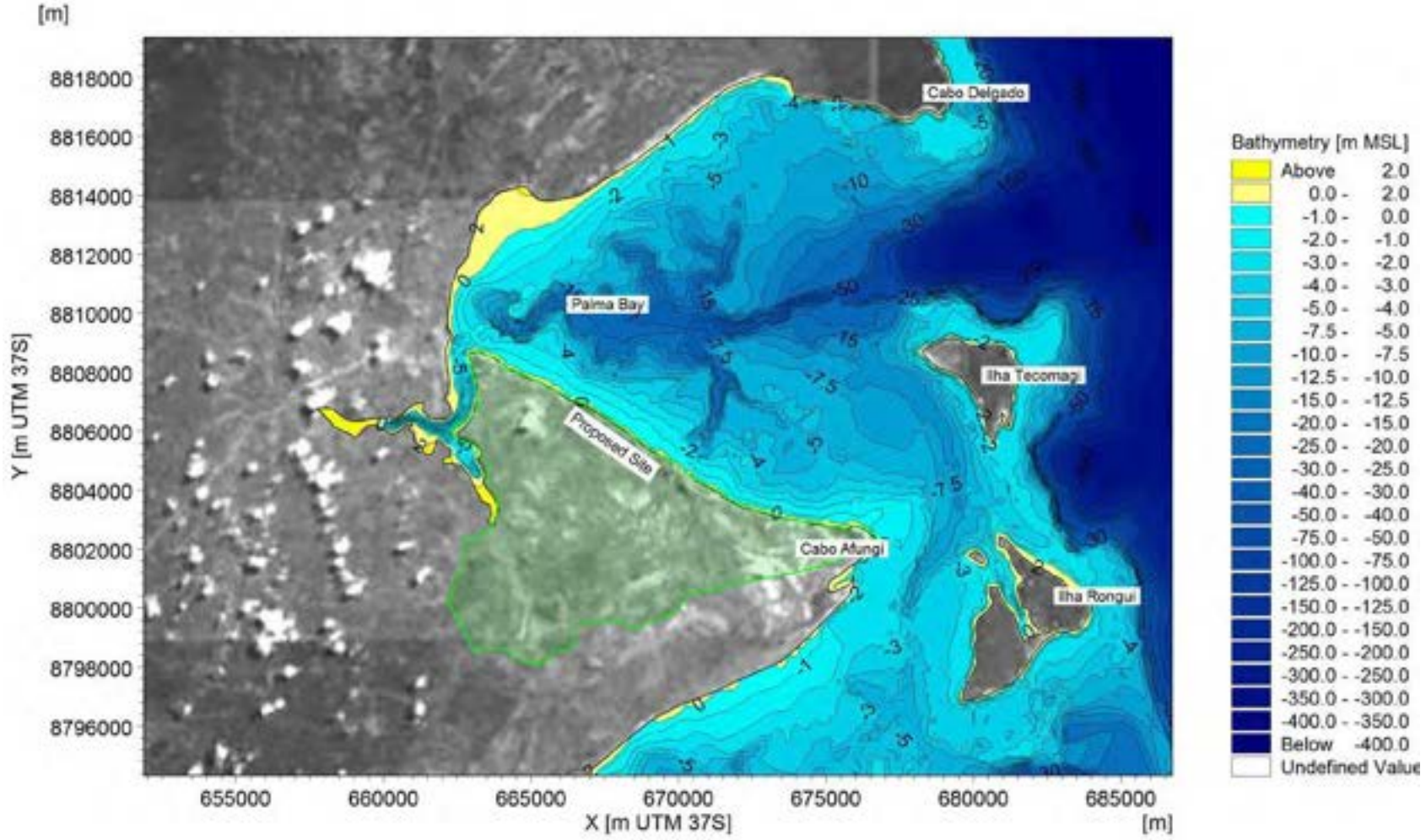
- single and multibeam bathymetric survey for Palma Bay undertaken by Underwater Surveys (Pty) (known as UWS) Ltd for Anadarko (P Vrey, pers. comm., 10 Feb 2012); and
- C-Map charts (DHI, 2011a).

All vertical levels in this report are relative to mean sea level (MSL). The horizontal projection is UTM Zone 37S. The vertical datum for the topography and the bathymetry has been analysed and corrected by PRDW with respect to measured tidal data in Palma Bay (PRDW, 2012). The general layout of Palma Bay and its bathymetry are shown in *Figure 7.26*.

The bathymetry of Palma Bay suggests that the bay is a drowned river/estuary system. There is a central channel linked to a continental shelf-edge canyon that exits the bay between the northern tip of Tecomaji Island and the Cabo Delgado Peninsula. The depth of the channel in the central area of the bay reaches up to 50m. Subsidiary channels join this, originating from the western shoreline of Palma Bay and from the northern shore of Afungi Peninsula.

The islands of Tecomaji and Rongui sit on the edge of the continental shelf, where there are water depths of greater than 350m within 2.5km of the islands.

Figure 7.26 Bathymetry of Palma Bay



7.7.3 *Tides and Currents*

Tidal water levels were measured by Underwater Surveys (Pty) Ltd at the mouth of the Palma estuary (10° 46' 31.83" S, 40° 29' 09.19" E) for almost three months, from 2 August 2011 to 25 October 2011. Analysis of the data by Lwandle has provided the following predicted tidal levels.

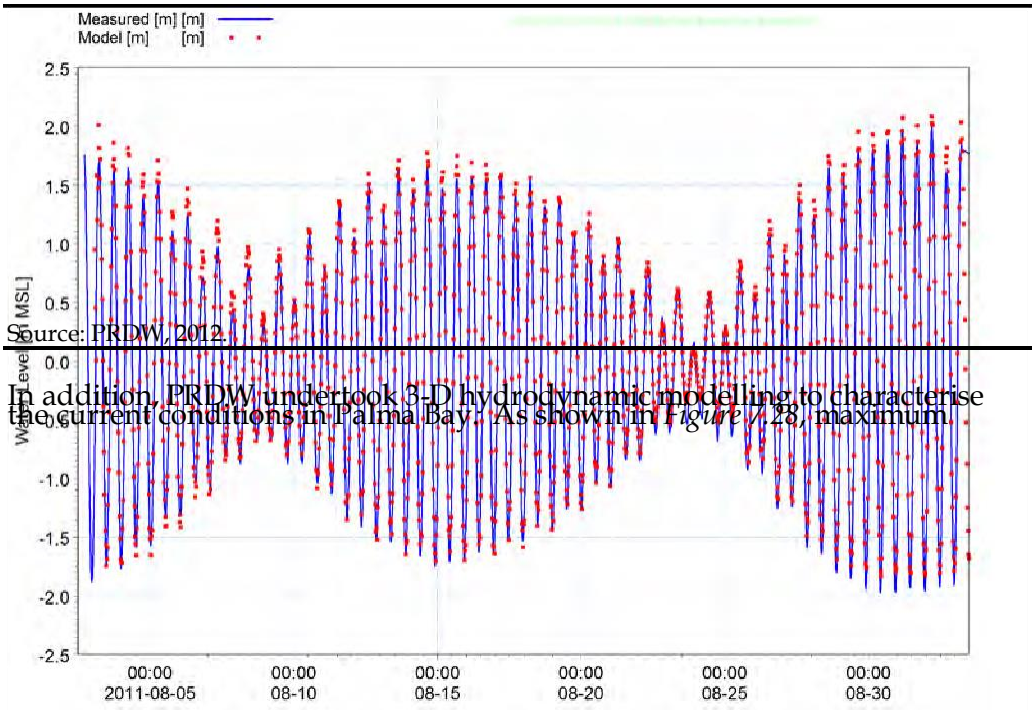
Table 7.7 ***Tidal Levels at Palma River Mouth***

Level	Height (m)
Highest Astronomical Tide (HAT)	2.21
Mean High Water Springs (MHWS)	1.80
Mean High Water Neaps (MHWN)	0.48
Mean sea level (MSL)	0.00
Mean Low Water Neaps (MLWN)	-0.52
Mean Low Water Springs (MLWS)	-1.77
Lowest Astronomical Tide (LAT)	-2.03

Source: Lwandle, 2012. Data derived from Underwater Surveys (Pty) Ltd.

Calibration of these measured water levels was undertaken by PRDW, using the Mike 21 Flow Model FM based on the flexible mesh approach (DHI, 2011b). Model results are plotted with measured data and shown in *Figure 7.27*.

Figure 7.27 ***Hydrodynamic Model Calibration: Model versus Measured Water Levels at Palma Bay***

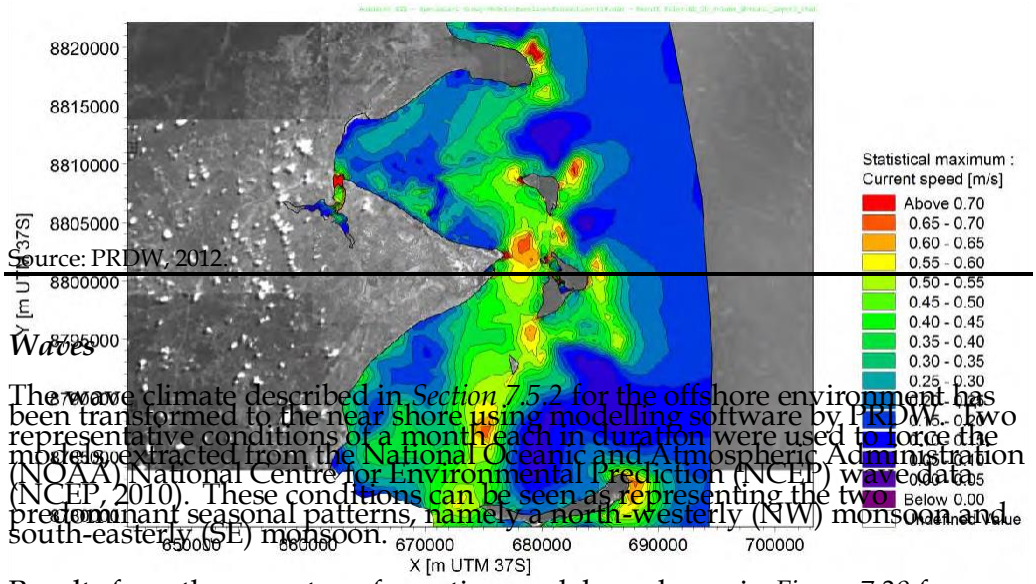


Source: PRDW, 2012.

In addition, PRDW undertook 3-D hydrodynamic modelling to characterise the current conditions in Palma Bay. As shown in *Figure 7.28*, maximum

current speeds can be seen in the relatively shallow water between the islands of Rongui and Tecomaji, where the maximum current speeds of 0.65 to 0.70m/s were observed. Statistical mean currents (not shown) for Palma Bay are low, between 0.05 and 0.2m/s.

Figure 7.28 ***Statistical Maximum Expected Surface Current Speeds for the South-easterly Monsoon Season***



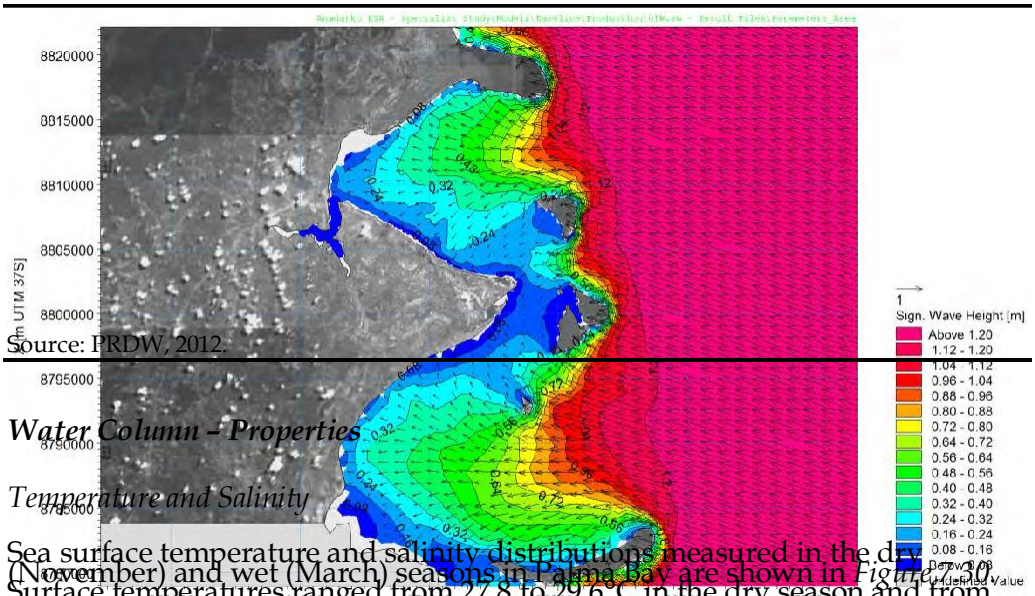
Source: PRDW, 2012.

7.7.4 *Waves*

The wave climate described in *Section 7.5.2* for the offshore environment has been transformed to the near shore using modelling software by PRDW. Two representative conditions of a month each in duration were used to force the models extracted from the National Oceanic and Atmospheric Administration (NOAA) National Centre for Environmental Prediction (NCEP) wave data (NCEP, 2010). These conditions can be seen as representing the two predominant seasonal patterns, namely a north-westerly (NW) monsoon and south-easterly (SE) monsoon.

Results from the wave transformation model are shown in *Figure 7.29* for a single wave condition (20 August 2009). It can be seen from the image that the limited depth within Palma Bay, coupled with the fringing reefs and the islands of Rongui and Tecomaji, offer protection in Palma Bay.

Figure 7.29 Wave Transformation in Palma Bay



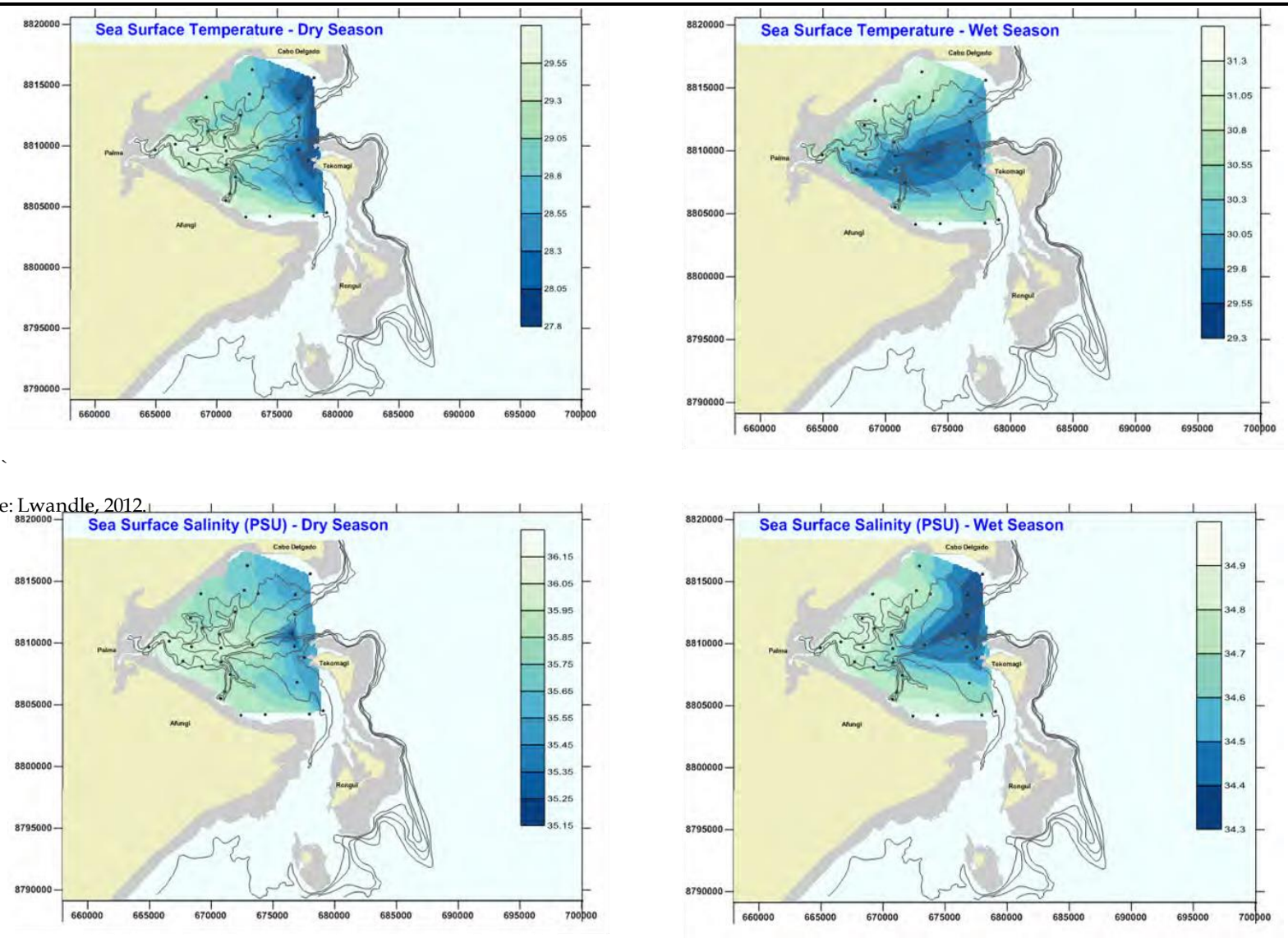
Source: PRDW, 2012.

7.7.5 *Water Column – Properties*

Temperature and Salinity

Sea surface temperature and salinity distributions measured in the dry (November) and wet (March) seasons in Palma Bay are shown in *Figure 7.30*. Surface temperatures ranged from 27.8 to 29.6°C in the dry season and from 29.4 to 31.3°C in the wet season. Higher temperatures were recorded in the inner reaches of the bay during both seasons. Sea surface salinities ranged from 35.14 to 36.13 PSU in the dry season and were lower at 34.34 to 34.89 PSU in the wet season, consistent with the increased rainfall and surface run-off typical of the wet season. However, as with the temperature distributions, the highest salinities occurred in the inshore areas of Palma Bay. The conjunction of the higher temperatures and higher salinity values implies reduced water turnover rates, with temperatures being increased by surface heating and salinities by evaporation.

Figure 7.30 Sea Surface Temperature and Salinity Distributions in Palma Bay in the Dry (November 2011) and Wet (March 2012) Seasons

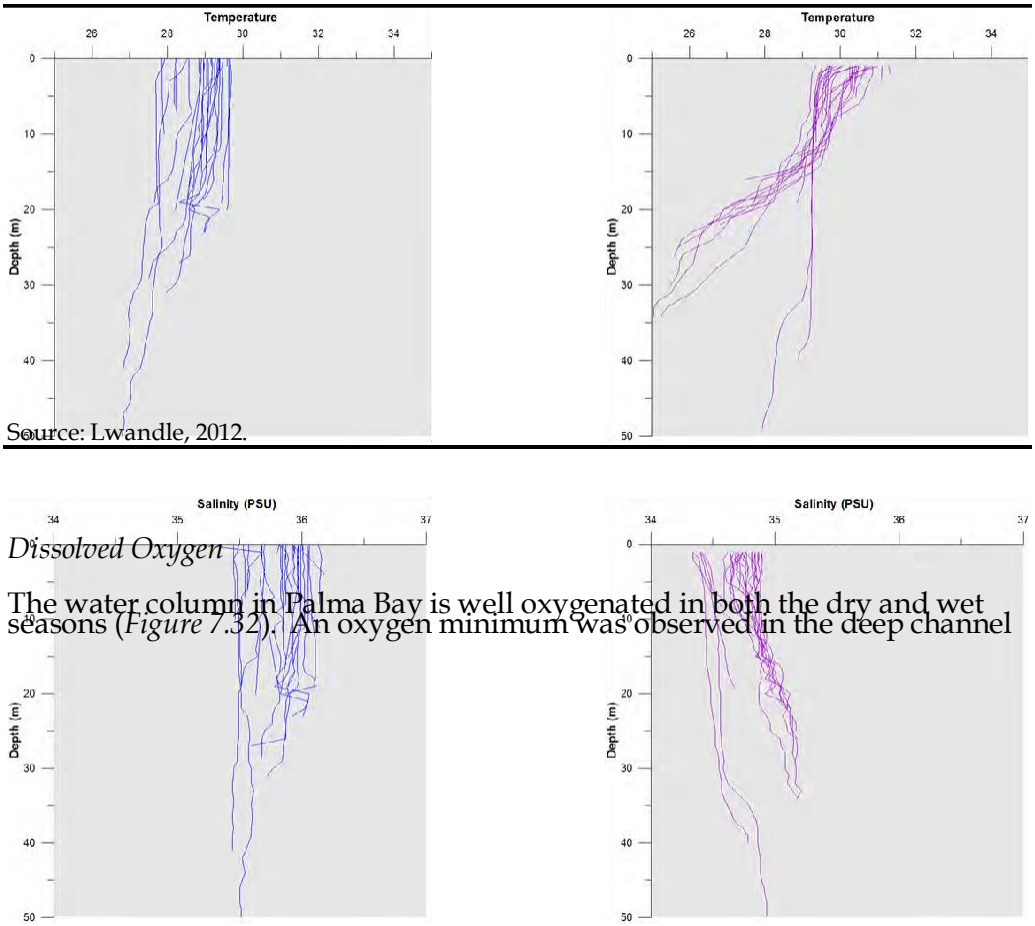


Source: Lwandle, 2012.

Distributions of temperatures and salinities across the water column show minimal vertical gradients in the dry season, but stronger gradients in the wet season (*Figure 7.31*). The wet season temperatures show the presence of relatively cool water at depth in the shallower profiles, and that bottom temperatures in these are lower than those measured at approximately 50m depth in the deeper areas in the entrance to Palma Bay. This implies that the cool waters that were present in the bay on the day of measurement were a remnant of a previous upwelling event. There are no concurrent data to identify upwelling mechanisms but, given the close proximity of the continental shelf break to the bay, upwelling events are probably at least episodic, if not frequent.

Upwellings are important for fuelling primary production in Palma Bay (and probably the inshore areas south towards Pemba) by increasing inorganic nutrient concentrations and promoting water exchange between the bay and the adjacent continental shelf and slope water body.

Figure 7.31 ***Vertical Profiles of Temperature and Salinity Measured in Palma Bay in the Dry Season (Left) and Wet Season (Right)***



Source: Lwandle, 2012.

Dissolved Oxygen

The water column in Palma Bay is well oxygenated in both the dry and wet seasons (*Figure 7.32*). An oxygen minimum was observed in the deep channel

areas in the centre of the bay during both seasons. This is not solely linked to water depth, as deeper water on the eastern side of the bay has higher dissolved oxygen concentrations. This feature is interpreted as being due to local oxygen demand by, for example, the remineralisation of organic matter of probable seagrass origin in this area. The observed lower oxygen concentrations are consistent with the extended residence times of sea water in this portion of the bay, indicated by the temperature and salinity distributions (above).

Turbidity

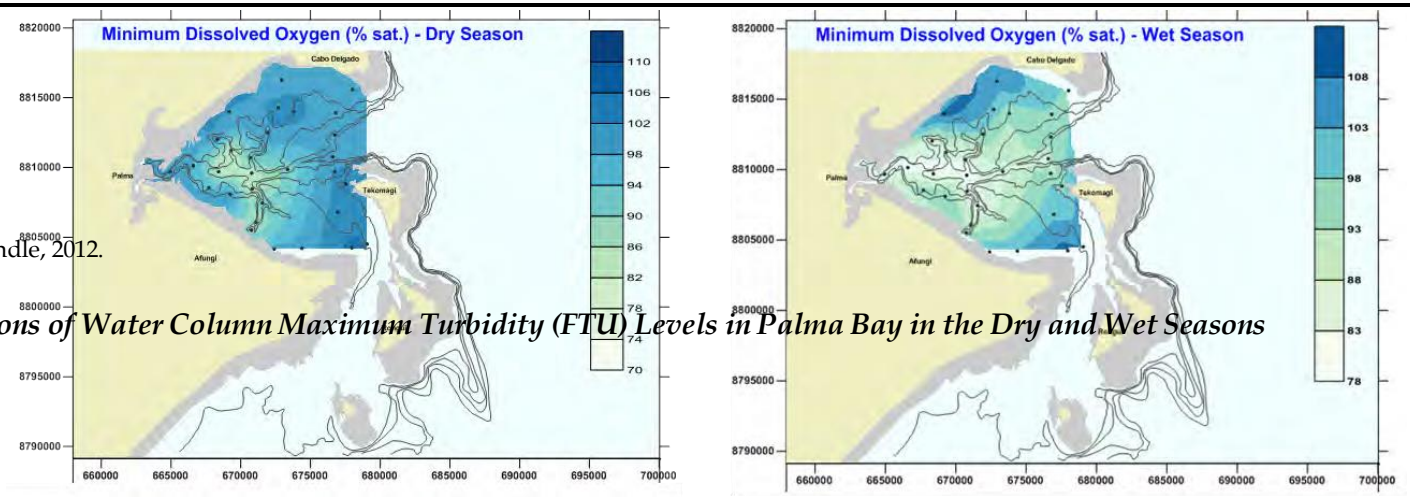
As is expected for an area that supports hard corals and seagrasses, Palma Bay is generally a clear water environment with low turbidity levels in the water column (*Figure 7.33*). Turbidity is caused by colloidal suspensions (particle size between 0.001µm and 0.1µm), which usually gives water a murky appearance. Both turbidity and colour (1), together with suspended solids, influence the clarity of water, ie the depth of light penetration or visibility in water.

Turbidity distribution patterns were similar between each of the two seasonal surveys conducted, although the dry season maximum turbidities were higher than those of the wet season. The locations of the turbidity maxima are aligned with the dissolved oxygen minima (*Figure 7.32*), indicating that the material generating the elevated turbidities is mainly organic detritus.

Observations during dive surveys adjacent to the Afungi Peninsula indicate that, at high tides during onshore winds (north-north-easterly), turbidity levels can be high with diver visibility <0.5m. Water colour during these events is a light khaki green, probably linked to suspended organic particles.

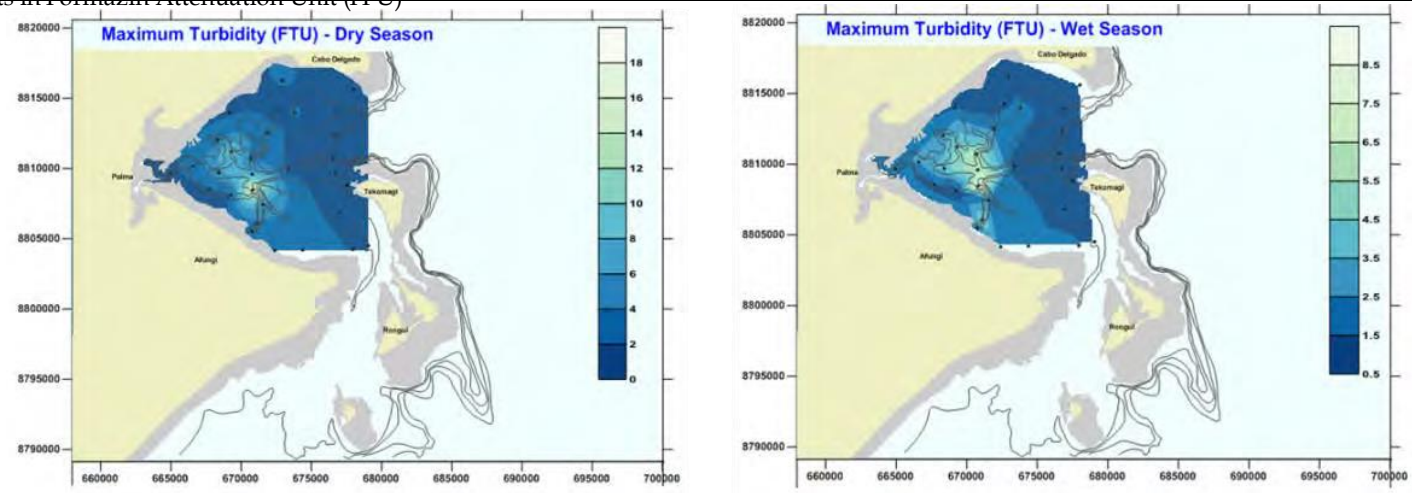
(1) Colour is caused by substances that dissolve in water; as a result, the colour of the water changes.

Figure 7.32 ***Distribution of Water Column Minimum Dissolved Oxygen Concentrations in Palma Bay in the Dry and Wet Seasons***



Source: Lwandle, 2012.

Figure 7.33 ***Distributions of Water Column Maximum Turbidity (FTU) Levels in Palma Bay in the Dry and Wet Seasons***



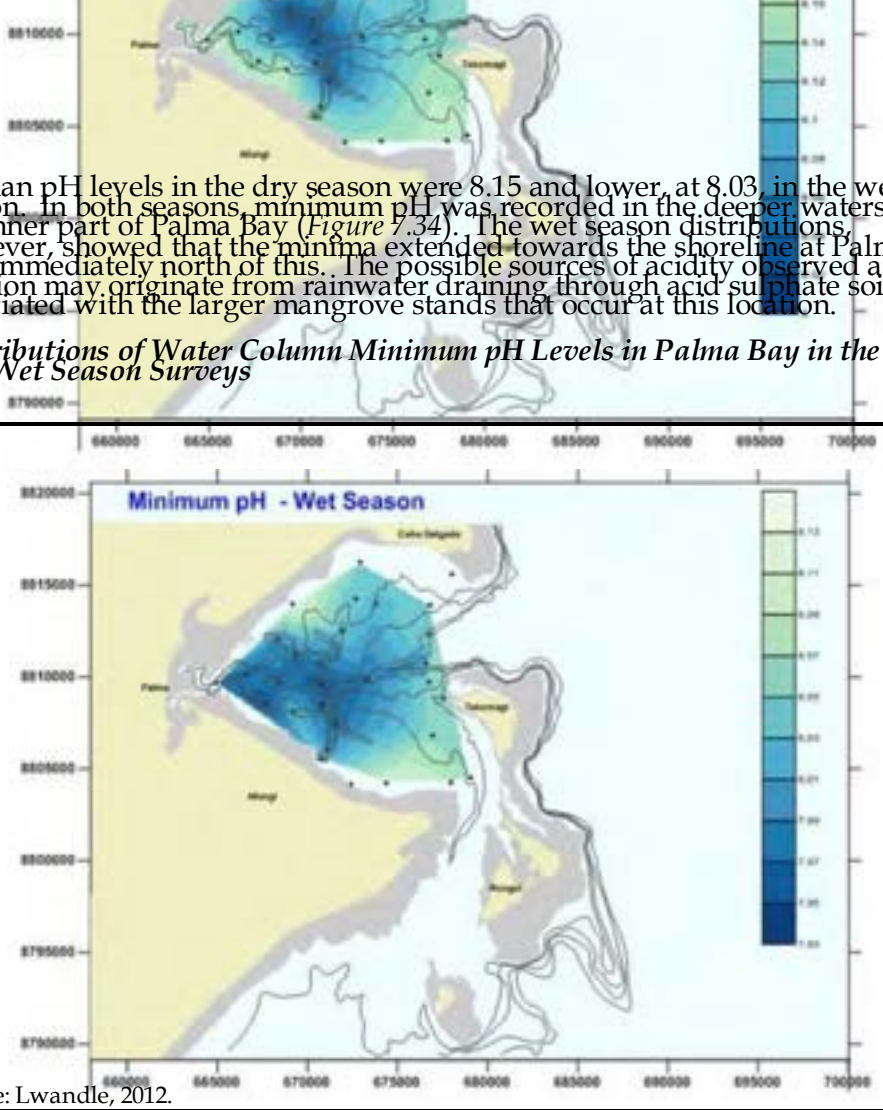
Source: Lwandle, 2012.

Legend: Units in Formazin Attenuation Unit (FPU)

pH

Median pH levels in the dry season were 8.15 and lower, at 8.03, in the wet season. In both seasons, minimum pH was recorded in the deeper waters in the inner part of Palma Bay (*Figure 7.34*). The wet season distributions, however, showed that the minima extended towards the shoreline at Palma and immediately north of this. The possible sources of acidity observed at this location may originate from rainwater draining through acid sulphate soils associated with the larger mangrove stands that occur at this location.

Figure 7.34 Distributions of Water Column Minimum pH Levels in Palma Bay in the Dry and Wet Season Surveys



Source: Lwandle, 2012.

Nutrients

Measured inorganic nutrient concentrations were low, both in Palma Bay and the four estuaries draining the Afungi Peninsula, as shown in *Table 7.8*. This is consistent with the generally oligotrophic (1) character of tropical coastal waters. The locations within the bay and the four estuaries of Afungi Peninsula sampled are shown in *Figure 7.35*.

Table 7.8 Measured Inorganic Nutrient Concentrations (mg/l) in Palma Bay and Afungi Peninsula Estuaries Measured in the Wet Season Survey (March 2012)

Sample	Nitrogen (NO_3 + NO_2)	Silica	Phosphorus PO_4-P
P-Bay001	0.018	0.17	<0.004
P-Bay002	0.012	0.18	<0.004
P-Bay003	0.037	0.16	<0.004
P-Bay004	0.009	0.21	<0.004
P-Bay005	0.02	0.14	<0.004
P-Bay006	0.027	0.18	<0.004
P-Bay007	0.032	0.2	<0.004
P-Bay008	0.03	0.13	<0.004
P-Bay009	0.037	0.1	<0.004
P-Bay010	0.037	0.21	<0.004
P-Bay011	0.041	0.26	<0.004
A-Est001	0.037	1.16	<0.004
A-Est002	0.039	0.79	<0.004
A-Est003	0.037	0.74	<0.004
A-Est004	0.037	0.49	<0.004
A-Est005	0.039	0.4	0.007
A-Est006	0.042	0.56	0.008
A-Est007	0.037	0.62	0.006
A-Est008	0.035	0.5	0.007
A-Est009	0.041	0.96	0.004
A-Est010	0.042	3.35	<0.004
A-Est011	0.03	3.4	0.006
A-Est012	0.033	5.86	0.005
A-Est013	0.03	6.13	0.004
A-Est014	0.034	6.7	<0.004
A-Est015	0.034	0.21	<0.004
A-Est016	0.034	0.26	<0.004
A-Est017	0.038	0.29	<0.004
A-Est018	0.016	0.24	<0.004

Source: Lwandle, 2012.

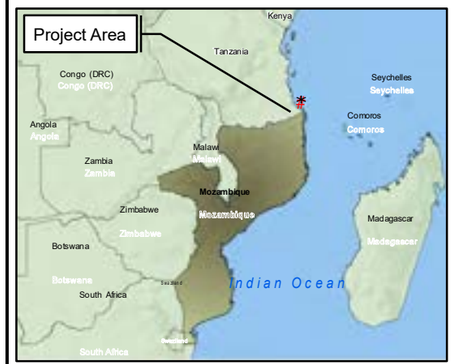
(1) A water body poor in nutrients and rich in oxygen.

40°25'0"E 40°30'0"E 40°35'0"E 40°40'0"E

40°25'0"E 40°30'0"E 40°35'0"E 40°40'0"E

Legend

- Inorganic Nutrient Sampling Sites - Estuaries
- Inorganic Nutrient Sampling Sites
- Regional Roads
- Proposed Nearshore Infrastructure
- Proposed Pipeline Corridor Route
- Afungi Project Site



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 7.35:
Inorganic Nutrient Sampling Sites,
Wet Season Survey, March 2012

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DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
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DRAWING: Inorganic Nutrient Sampling Sites.mxd

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Inorganic nitrogen and reactive silica concentrations recorded in the four estuary areas sampled (see *Table 7.9*) were statistically significantly higher than those measured in the open surface waters of Palma Bay (*Table 7.9*), but the gross differences were slight. Despite this, it is apparent that the estuaries contribute directly to productivity in Palma Bay through the enhancement of nutrient concentrations.

Table 7.9 Comparisons between Inorganic Nitrogen and Silica Concentrations in Surface Waters in Palma Bay and Afungi Peninsula Estuaries

Nutrient	Palma Bay (n = 11)		Afungi Peninsula Estuaries (n = 18)		ANOVA	
	Mean (mg/l)	Standard Deviation	Mean (mg/l)	Standard Deviation	F	*P*
NO_3+NO_2-N	0.027	0.011	0.035	0.006	6.50	0.02
Si	0.176	0.044	1.814	2.241	5.79	0.02

Source: Lwandle, 2012.

Chlorophyll

Chlorophyll (measured as chlorophyll fluorescence) distributions reflect generally low levels throughout Palma Bay in both the dry and wet seasons. Low chlorophyll levels accord with the oligotrophic status of these tropical waters. The distributions closely parallel those of turbidity (*Figure 7.33*), with the peak values being located in the inner part of the bay in the region of the dissolved oxygen minimum. Differences between the measured distributions in the two seasons are slight.

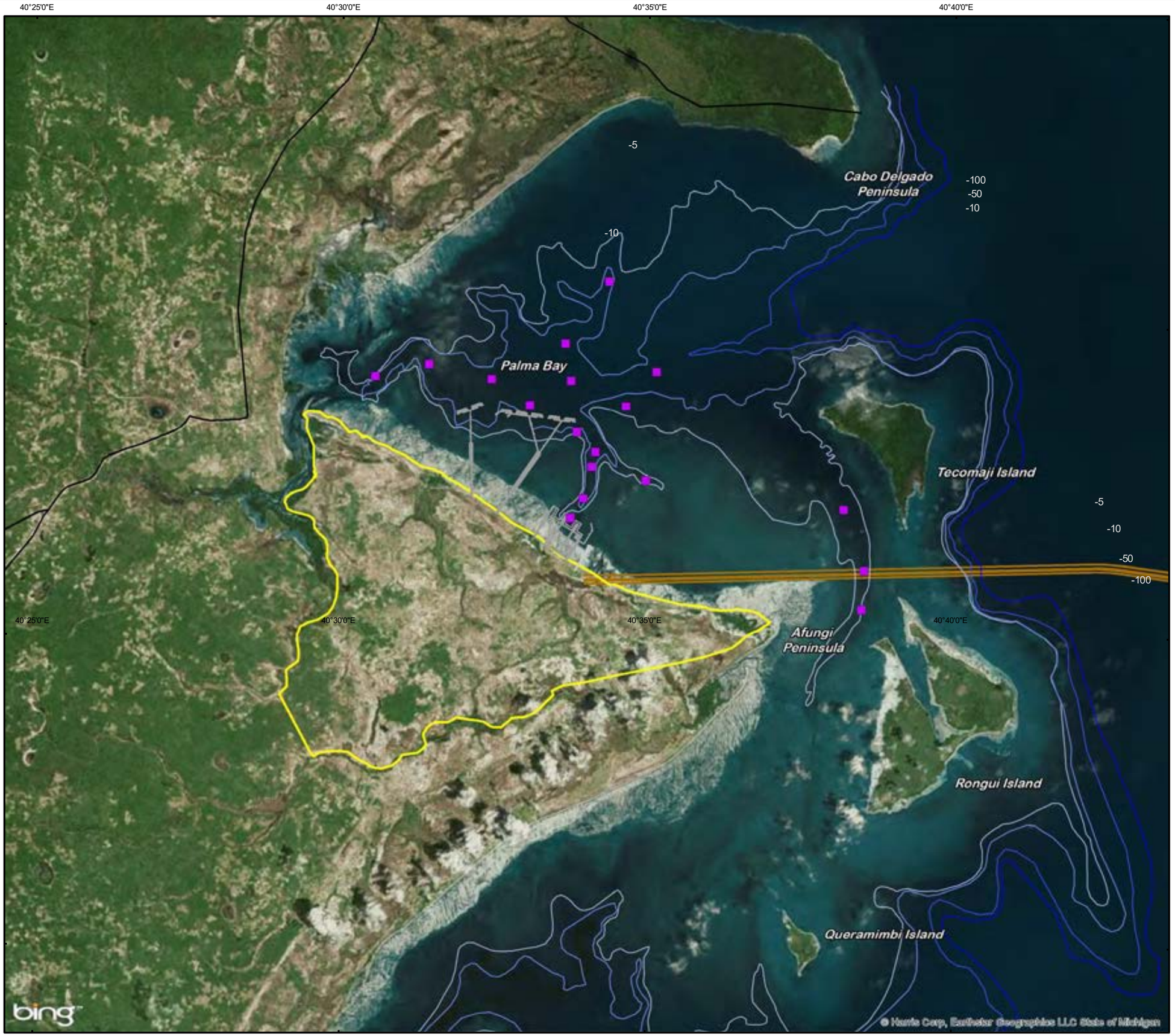
7.7.6 Sediment Properties and Seabed Features

Sediment Texture

Surficial (1) sediment samples taken from the centre and southern parts of Palma Bay (*Figure 7.36*) indicate that sediments are mainly sand or muddy sand, as illustrated in *Figure 7.37*.

Gravel-sized sediments were present in some of the samples, but visual inspection indicated that most of these were shell fragments. In general, the sampled sediments were classified as poorly sorted, gravelly, muddy sand in terms of texture. This implies that the area is subject to episodic events in distributing sediments, such as cyclones with accompanying large waves and land run-off, as opposed to, for example, consistent wave action sorting and distributing sediments.

(1) The layer at the top of the sediment body, usually millimeters to centimeters thick.

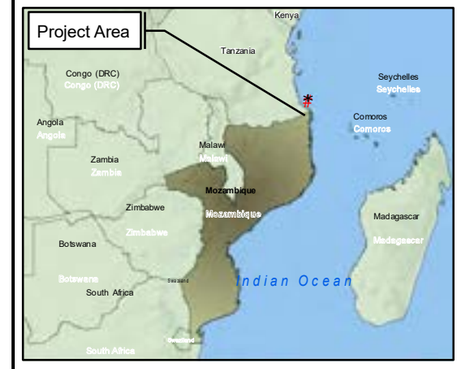


Legend

- Surficial Sediment Sampling Locations
- Regional Roads
- Proposed Nearshore Infrastructure
- Proposed Pipeline Corridor Route
- Afungi Project Site

Bathymetry (Metres below Mean Sea Level)

- -5
- -10
- -50
- -100



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 7.36:
Surficial Sediment Sampling Locations, Wet Season Survey, March 2012

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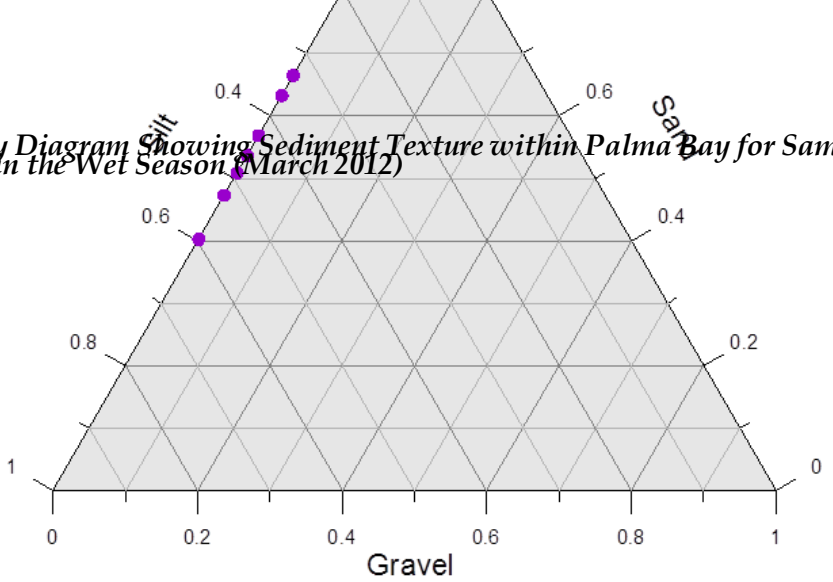
Figure 7.37 ***Ternary Diagram Showing Sediment Texture within Palma Bay for Samples Taken in the Wet Season (March 2012)***



Key:

The purple dots indicate the various sediment types observed.

Source: Lwandle, 2012.

Heavy Metals

Heavy metal concentrations in the sampled sediments were low and well within the environmental quality objectives identified for the WIOLAB region (*Table 7.10*). This is to be expected for a non-industrialised area with mainly sandy sediments.

Table 7.10 ***Sediment Heavy Metal Median Concentrations (mg/kg) Compared to Sediment Environmental Quality Target (EQT) Concentrations for the WIOLAB Region***

Heavy Metal	Median	90th Percentile	WIOLAB EQT
Aluminium (Al)	1535.69	4913.34	-
Arsenic (As)	1.86	3.53	7.24
Barium (Ba)	nd	nd	-
Beryllium (Be)	nd	nd	-
Cadmium (Cd)	nd	nd	0.68
Cobalt (Co)	0.86	1.20	-
Chromium (Cr)	6.37	23.33	52.30
Copper (Cu)	nd	nd	18.70
Iron (Fe)	1732.95	5320.12	-
Mercury (Hg)	nd	nd	0.13
Lithium (Li)	12.60	25.33	-
Manganese (Mn)	16.29	27.52	-

Heavy Metal	Median	90th Percentile	WIOLAB EQT
Molybdenum (Mo)	1.97	2.11	-
Nickel (Ni)	3.29	5.68	15.90
Lead (Pb)	nd	nd	30.20
Antimony (Sb)	nd	nd	-
Tin (Sn)	6.09	6.09	-
Uranium (U)	5.97	10.65	-
Vanadium (V)	4.83	12.31	-
Zinc (Zn)	4.70	8.38	124.00

Source: CSIR, 2006.

Seabed Features

The subtidal sediments both within Palma Bay and immediately offshore of the fringing reefs between Tecomaji and Rongui islands are heavily bioturbated (*Figure 7.38*). Worm holes are frequent and, from the size of the casts observed in the offshore area, large benthic fauna are known to occupy the sediments. In soft sediment, benthos size can be equated with longevity, and the presence of large fauna indicates that the host environment is physically and biologically stable.

Figure 7.38 Subtidal Sandy Sediments in Palma Bay (Left) and Offshore of Rongui Island (Right)

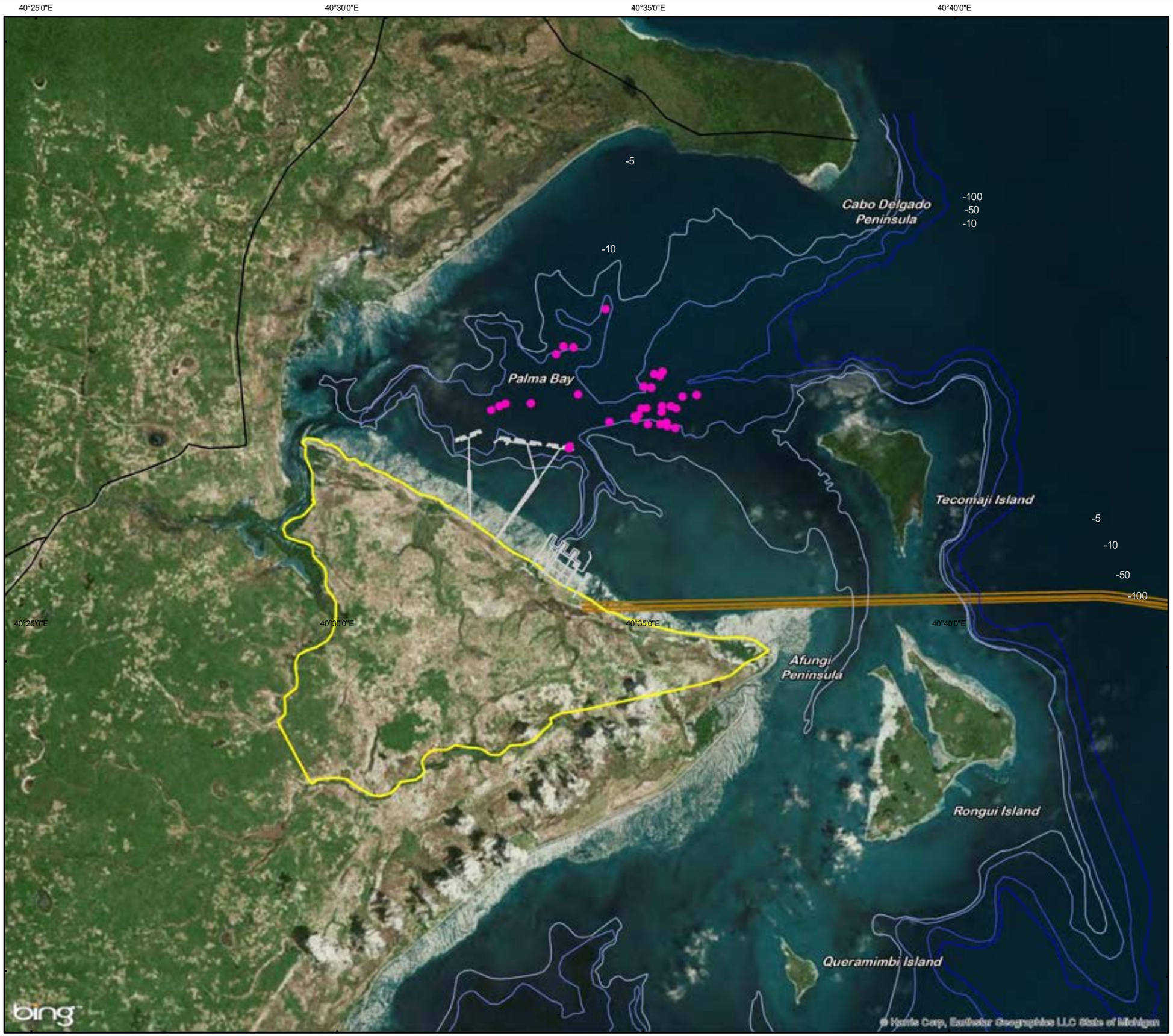
Source: Lwandle, 2012.

Small crater-like formations in the approximate centre of Palma Bay are noteworthy features that have been revealed by multibeam bathymetric survey (UWS, 2011). Thirty-three of these formations have been recorded and their distributions are shown in *Figure 7.39*.

Diver inspections on 14 of these small crater-like formations showed a more or less uniform structure of a sand crater of up to 10m in diameter and 1 to 3m deep, with rock pavement or rock with corals in their centres (inset in *Figure 7.39*). All of these latter features hosted numerous fish, ranging from cleaner wrasse (*Labroides dimidiatus)* to the very much larger javelin grunter (*Pomadasys kaakan)*.

The craters appear to be maintained by turbulence such as scour associated with tidal flows, or they may be locations of fresh water outflows from aquifers (Neil Summers, AMA1 pers. comm. 2012). If the latter applies, then the outflows may be tidally pulsed, as no low-salinity water was detected by short-term (10 to 15 minutes) CTD recordings in the centres of seven of the craters inspected.

These features are enigmatic and deserve closer inspection, especially if they are a fresh water source to the bay as, if so, they can transfer land-derived contaminants and pollutants into the system. There are no data to show whether such features occur in other areas of the Mozambique or East African shallow littoral zone.

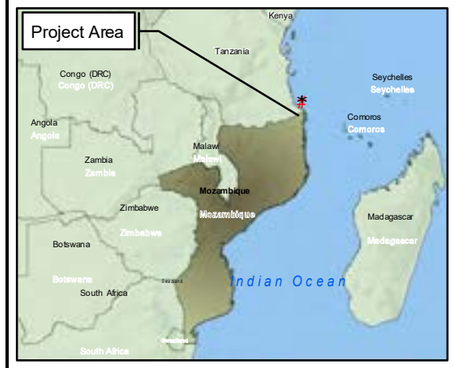


Legend

- Sand Craters
- Regional Roads
- Proposed Nearshore Infrastructure
- Proposed Pipeline Corridor Route
- Afungi Project Site

Bathymetry (Metres below Mean Sea Level)

- -5
- -10
- -50
- -100



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 7.39:
Distribution of 'Sand Craters' in Central Palma Bay

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DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
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DRAWING: Distribution of Sand Craters.mxd

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7.7.7 Sediment Transport

Moffat and Nichol (AMA1, 2012) assessed the sediment transport regime of Palma Bay, using a combination of a desktop assessment based on aerial photographs and a two-dimensional sediment transport numerical model using available wind and wave data. The findings of this study indicate that the sediment transport rates are small around the Project location, due to the benign wave climate (AMA1, 2012). The longshore sediment transport is from east to west.

7.7.8 Main Shoreline Types

The main shoreline types in Palma Bay, as shown in *Figure 7.40*, are:

- intertidal rock platform (on southern side of Cabo Delgado Peninsula);
- supratidal sand beach [(1)] (extending south towards Palma town);
- mangroves (in Palma estuary); and
- intertidal sand/mudflats (on north side of Afungi Peninsula).

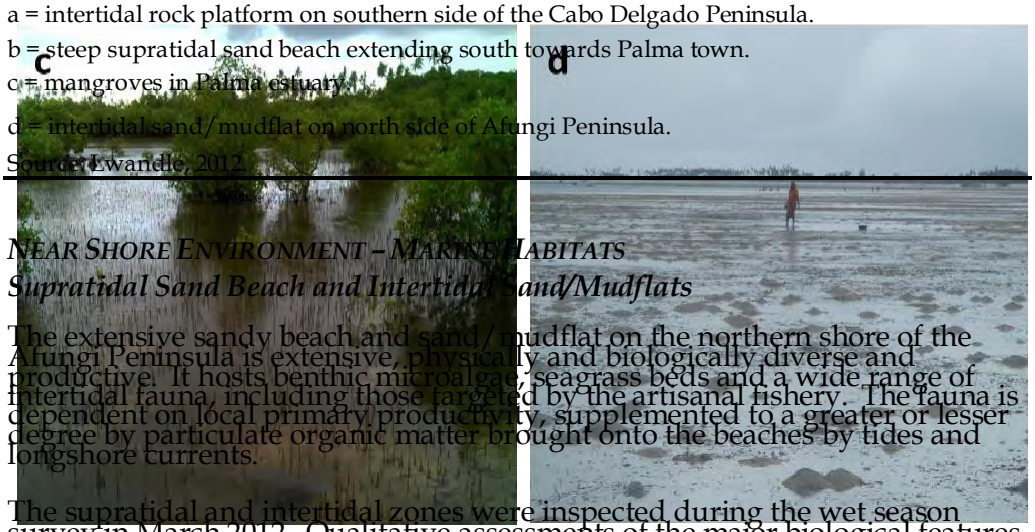
Palma Bay is bounded in the north by Cabo Delgado Peninsula, the base of which is coral-derived limestone (coral rag). The shoreline is highly eroded rock (*Figure 7.40a*). This shoreline type extends to the western extremity of the peninsula. From there to immediately north of Palma town, the shoreline is sandy with a steep primary dune (*Figure 7.40b*). It is evident from the seagrass strand lines that high tide levels extend right to the top of these beaches. This shoreline type also occurs at the top of the intertidal zone on Afungi Peninsula.

An estuary is found adjacent to Palma town, and several others are observed along the northern and eastern shores of Afungi Peninsula. These support mangrove stands and associated biologically productive intertidal mudflats (*Figure 7.40c*), the most extensive of which are at Palma and on the eastern extremity of Afungi. Both the northern and south-eastern sides of Afungi Peninsula are characterised by extensive intertidal sand/mudflat areas (*Figure 7.40d*), which host a wide range of fauna and, at their lower extremities, seagrass.

(1) The supratidal zone is the area above the high tide water line that extends upland. The area is seldom covered by water unless during flooding or storms, but can receive water from wave splash.

Figure 7.40 Main Shoreline Types in Palma Bay

a = intertidal rock platform on southern side of the Cabo Delgado Peninsula.
b = steep supratidal sand beach extending south towards Palma town.
c = mangroves in Palma estuary.
d = intertidal sand/mudflat on north side of Afungi Peninsula.
Source: Lwandle, 2012.



7.8 NEAR SHORE ENVIRONMENT – MARINE HABITATS

7.8.1 Supratidal Sand Beach and Intertidal Sand/Mudflats

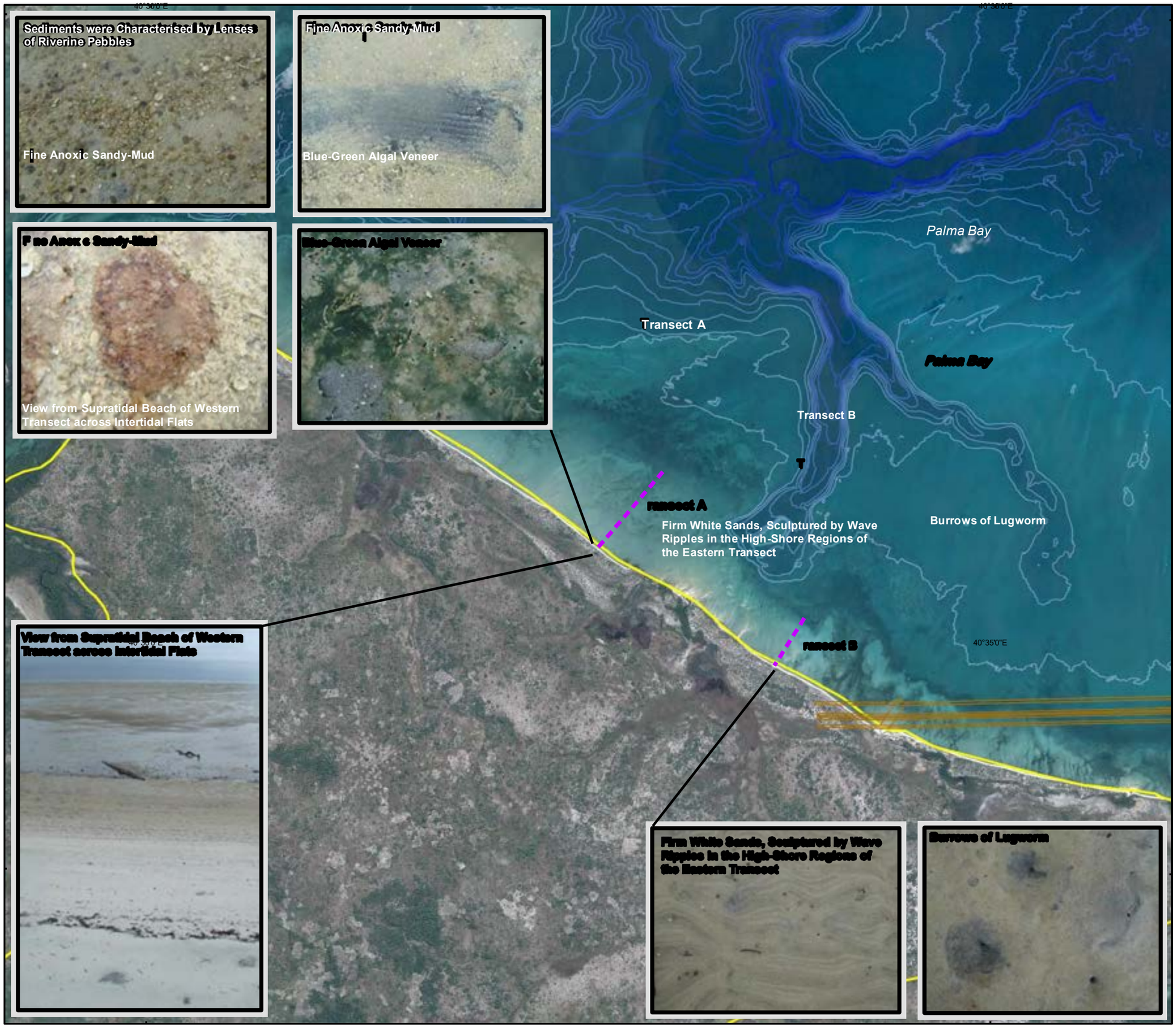
The extensive sandy beach and sand/mudflat on the northern shore of the Afungi Peninsula is extensive, physically and biologically diverse and productive. It hosts benthic microalgae, seagrass beds and a wide range of intertidal fauna, including those targeted by the artisanal fishery. The fauna is dependent on local primary productivity, supplemented to a greater or lesser degree by particulate organic matter brought onto the beaches by tides and longshore currents.

The supratidal and intertidal zones were inspected during the wet season survey in March 2012. Qualitative assessments of the major biological features

were made on two transects located on the shores adjacent to Afungi Peninsula, extending from the primary dune in the supratidal to the bottom of the intertidal zone (*Figure 7.41*).

On the western transect (Transect A), the narrow supratidal zone was characterised by relatively fine white sand (0.1 to 0.2mm), which in the upper intertidal zone gave way to lenses of smooth riverine pebbles (<20mm) interspersed with very fine sandy mud (*Figure 7.41*). From the middle intertidal zone onwards, sediments were dominated by muds, but became sandier towards the lower intertidal zone. The sediments were aerated to within only 1cm of the surface, the subsurface sediments being anoxic and containing hydrogen sulphide. At low tide, the entire middle and lower intertidal zone was covered by shallow pools of standing water.

The seagrass bed started at approximately 300m seaward of the high water mark, with the dominant species being *Halophila ovalis* and *Halodule uninervis* both of which are categorised as Least Concern (IUCN, 2012). Scattered between the sparse seagrass beds in the upper and mid-intertidal zones were areas of fine sandy mud, covered in a veneer of blue-green algae mixed with bacteria to form slime mounds (*Figure 7.41*). *Thalassia hemprichii* (also categorised as Least Concern (IUCN, 2012)) only became evident from seawards of the mid-tide level (*Figure 7.42*), increasing in density towards the lower intertidal zone as sediments became sandier.

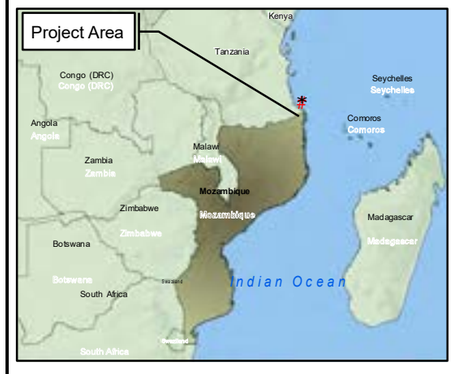


Legend

- Intertidal Transects
- Proposed Pipeline Corridor Route
- Afungi Project Site

Bathymetry (Metres below Mean Sea Level)

-2	-16
-4	-18
-6	-20
-8	-24
-10	-26
-12	-28
-14	-30



MAIN MAP SCALE:

0 1,000 2,000

Meters

TITLE:

Figure 7.41:
Location of Intertidal Transects on Afungi Peninsula

CLIENT:

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DRAWING: Location of Intertidal Transects.mxd

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10°45'0"S

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10°50'0"S

10°50'0"S

Figure 7.42 *View Across the Intertidal Seagrass Bed on the Western Transect (Left), which Hosted Three Co-occurring Seagrass Species (Right)*

Source: Lwandle, 2012.

Associated with the seagrass was a diversity of gastropod molluscs [white moon shell *(Polinices mammilla)*, necklace shells *(Natica* spp.), gold ring cowrie *(Cypraea annulus)*, dog whelks *(Nassarius coronatus)* and mangrove whelks *(Terebralia palustris)*], holothurians *(Synapta maculata* and *Stichopus hermanni)*, clusters of sand-boring anemones *(Cerianthus maua)* and isolated specimens of the single large anemone *(Stichodactyla* sp.), usually accompanied by juvenile damselfish (black and white). The burrowing sand crab *(Matuta lunaris)* and the shy crab *(Calappa hepatica)* were present in low numbers. Some of the species recorded are illustrated in *Figure 7.43*.

Of the bivalve molluscs observed, only the pen shell (*Pinna muricata)* was represented by live specimens, buried in the sand among the seagrass. Other bivalves collected were dead, but in good condition (indicating that they most likely occur as infauna in either the intertidal or shallow subtidal areas), including *Modiolus philippinarum*, the razor clam *(Solen cylindraceus)*, true bubble shell *(Bulla ampulla)*, *Anadara antiguata*, *Tellina virgata* and *Loripes clausus*. Various red, orange and black creeping and encrusting sponges, associated with seagrass and hard substrata, were also observed, as was an encrusting green ascidian. Macroalgae in the lower intertidal zone were represented by isolated clumps of *Acanthophora spicifera* and the creeping *Codium prostratum*. The funnel-shaped depressions and coiled castings of a lugworm (*Arenicola* sp.) were abundant on the sand flats in the mid and low intertidal zone.

Figure 7.43 Invertebrate Species Occurring in the Seagrass Beds

Top left: Dog whelks. Top right: Mangrove whelks. Bottom left: Large anemones. Bottom right: Sand crabs.

Source: Lwandle, 2012.

Although only 2.2km further east (see *Figure 7.41*), the eastern transect (Transect B) was biophysically substantially different from the western transect. The upper and middle intertidal zones of the eastern transect were dominated by firm white sands, sculptured by wave ripples (*Figure 7.41*), with muddy sand being entirely absent. Bioturbation was limited, and the anoxic sediments were within a few millimetres of the surface. The edges of drainage runnels, however, revealed a dense network of fine tubes of a polychaete species, to 10 to 15cm depths into the sediments.

The middle intertidal area at the eastern transect lacked the extensive shallow pools of water and the blue-green algal mats that characterised the western transect. The landward edge of the seagrass bed was located approximately 500m from the high water mark and the bed itself was not as extensive. *Halophila ovalis* and *Halodule uninervis* dominated in the sparse beds on the firm, flat sand in mid-intertidal zone, with *Thalassia hemprichii* again prevalent in the lower intertidal zone. Invertebrate diversity associated with the seagrass was similar to that recorded on the western transect. The urchin *Diadema* sp. was present in clusters in the lower intertidal zone. The burrows and castings of lugworms were restricted to this area and were primarily associated with the *Thalassia* beds. There appeared to be a higher abundance of pen shell (*Pinna muricata*) in the intertidal areas to the east of the channel, as these were being harvested by artisanal fishers, shucked and the shells

discarded in 'middens' (*Figure 7.44*). Evidence of harvesting of the false oyster (*Hyotissa hyotis)* and the lugworm was also observed.

Figure 7.44 *Evidence of Artisanal Harvesting of* **Pinna muricata** *(Left) and Lugworms (Right)*

Source: Lwandle, 2012.

The species and genera that have been observed in the supratidal and intertidal zones of the beach on the northern shore of Afungi Peninsula and in the sediments have wide regional distributions.

7.8.2 Mangroves

Extensive mangrove stands with associated intertidal sand/mudflats are located immediately north and south of Palma town and on the eastern end of Afungi Peninsula, with minor stands associated with small estuaries distributed around Palma Bay, as shown in *Figure 7.45*. The largest estuary within Palma Bay is that at the south of Palma town. This supports a relatively extensive stand of mangroves and is fronted by apparently highly productive sand and mudflats. There is an equally extensive stand of mangroves adjoining this system to the north, based on fresh water flows from the extensive wetlands behind the western shore of Palma Bay. The estuary and associated mangroves on the eastern extremity of Afungi Peninsula is less extensive than those at Palma town but, according to the associated fauna, is equally productive.

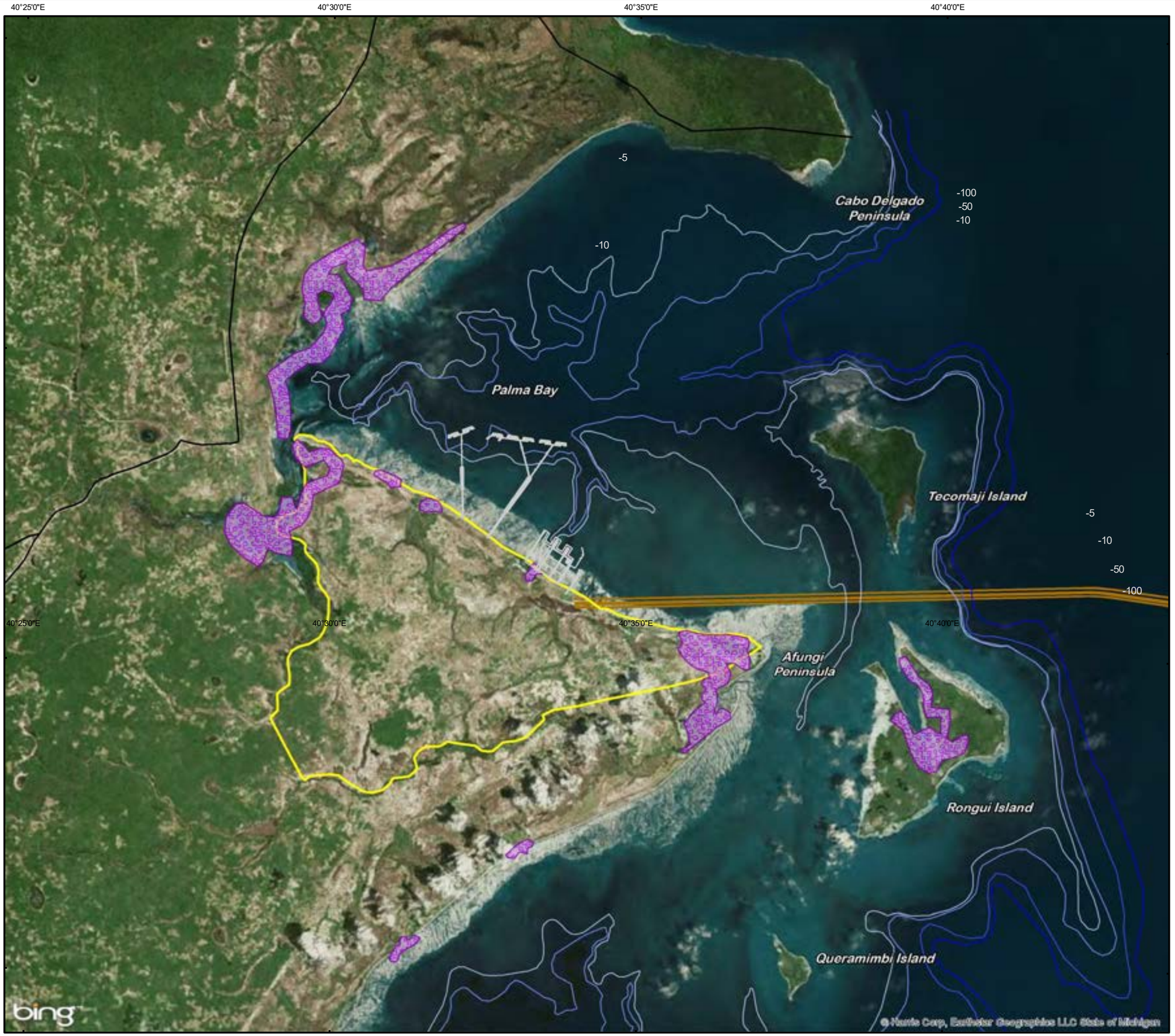
Eight species of mangrove tree species have been identified in Cabo Delgado Province, including Palma Bay. These include *Rhizophora mucronata*, *Ceriops tagal*, *Bruguiera gymnorrhiza*, *Avicennia marina*, *Lumnitzera racemosa*, *Sonneratia alba*, *Xylocarpus granatum* and *Pemphis acidula* (CSA, 2007). These mangrove species are categorised as Least Concern (IUCN, 2012)

The mangroves have a distinct pattern of zonation where, generally, *Sonneratia alba* is the seaward pioneer adapted to the open coastal and coral platforms, occupying sites that are tidally flooded daily. *Rhizophora mucronata* and *Xylocarpus granatun* are generally located on stream fringes, while *Bruguiera*

gymnorrhiza and *Ceriops tagal* occur behind these, sometimes forming broad belts. *Pemphis acidula* is a beach shrub or mangrove tree located around the high water mark along the northern coast. *Avicennia marina* is located landward of this and fringes the upper high water mark as trees or dwarf mangroves. These may give way to a dwarf *Avicennia marina* zone. Upshore of the mangroves are saline tidal flats fringed by succulent herbaceous species, such as *Arthrocnemum australasicum*, *Arthrocnemum indicum*, *Arthrocnemum perenne*, *Salicornia perriere*, *Chenolea diffusa* and *Suaeda monoica,* which occur in these saline areas (CSA, 2007).

Mangroves typically host a wide range of invertebrate meiofauna and macrofauna. Of the macrofauna, crustaceans and molluscs are the dominant groups. Crustacea include the families Ocypodidae (fiddler crabs), Sesarminae (marsh crabs), Portuninae (mangrove/mud crabs, *Scylla serrata*) and some Penaeid shrimps (*Fenneropenaeus indicus*, *Metapenaeus monoceros* and *Penaeus monodon*). Molluscs include mud creepers (*Terebralia palustris),* pencil bait (*Solen capensis)* and mud snails (*Cerithidea decollata).* Littorinidae are well represented with *Littoraria scabra*, *L. pallescens*, *L. intermedia* and *L. subvittata* all being common or abundant on mudflats associated with mangrove stands.

Large bivalves such as oysters (*Saccostrea forskali* and *S. cuculata*) and barnacles (*Balanus amphitrite*) typically attach to mangrove stems, branches or roots and rocks.



Legend

- Regional Roads
- Proposed Nearshore Infrastructure
- Proposed Pipeline Corridor Route
- Afungi Project Site
- Mangrove Stands

Bathymetry (Metres below Mean Sea Level)

- -5
- -10
- -50
- -100

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 7.45:
Distribution of Mangrove Stands in Palma Bay

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 110 000

DRAWING: Distribution of Mangrove Stands.mxd

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Projection: UTM Zone 37 S Datum: WGS84 Source: Bing Maps ©2010 Microsoft Corporation. Lwandle Technologies, 2012. Inset Map: Esri Data & Maps	SIZE: A3

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7.8.3 Seagrass

Seagrass species observed in the bay include Enhalus acoroides, Halodule uninervis, Halophila ovalis, Syringodium isoetifolium, Thalassia hemprichii and Thalassodendron ciliatum [1] . Thalassia was widespread while Enhalus and Thalassodendron had a clumped distribution. The other species observed were more cryptic and relatively rare. Seagrass beds occur on sandy sediments extending from the middle intertidal zone of the beaches on the northern side of Afungi Peninsula, to approximately 8m depth in the centre of Palma Bay.

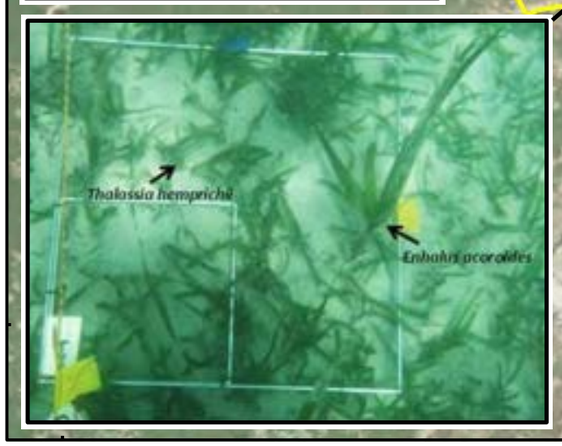
Three sampling sites were selected for the quantitative seagrass bed survey: two test or impact sites in the extensive Afungi seagrass bed bordering the proposed development area, and one reference site on the western shore of Palma Bay (*Figure 7.46*). The sites Afungi Test Site West (AFT) and Afungi Test Site East (AFE) are directly west and east of the area that will be dredged for the construction of the jetty and to deepen the entrance channel for vessels, and may thus be potentially affected by the dredging activity. The reference site Palma West (PMW) is located in the seagrass bed on the western shore of Palma Bay, more than 8km away from the location of the proposed developments.

The seagrass cover at the reference site PMW, north of Palma, was most dense, with a mean of 51 percent cover compared to 40 percent cover at AFT and only 28 percent at AFE. Average cover was relatively similar at PMW and AFT but was more patchy at AFE, ranging from 27 to 56 percent.

Site PMW was dominated by *Thalassodendron ciliatum* with lower understorey cover of *Thalassia hemprichii (see Figure 7.46)*. The other two sites contained dense mixed beds of *Thalassia* and *Thalassodendron*. AFE was the only site where all four seagrass species observed were encountered, ie *Thalassia*, *Thalassodendron*, *Enhalus* and *Halophila*, though the latter three species had very low percentage cover. *Figure 7.46* shows seagrass coverage at the various sites. The seagrass bed at AFE showed 30 percent cover of mostly *Thalassia hemprichii* and sparse cover of *Enhalus acorbides*. Dense cover of *Thalassodendron ciliatum* with understorey stands of *T. hemprichii* were evident at PMW.

The different morphologies of the two dominant seagrasses are shown in *Figure 7.47*. Based on this, the canopy height was lower at AFT and AFE, where the seagrass bed was an almost-exclusive *Thalassia* bed. At PMW, the seagrass bed was mixed but dominated by *Thalassodendron*, and therefore canopy height was higher, ranging between 24 and 28cm.

(1) These species are all categorised as 'Least Concern' according to the IUCN Red List of Threatened Species 2012 (IUCN, 2012).



Legend

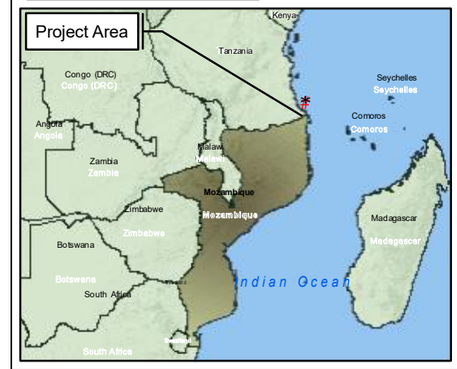
Seagrass Bed Sampling Stations

- Afungi Test Site East (AFE)
- Afungi Test Site West (AFT)
- Palma West (PMW)

- Seagrass Transects
- Seagrass Habitat
- Regional Roads
- Proposed Nearshore Infrastructure
- Proposed Pipeline Corridor Route
- Afungi Project Site

Bathymetry (Metres below Mean Sea Level)

- -5
- -10
- -50
- -100



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 7.46:
Distribution of Seagrass Habitat and Seagrass Bed Sampling Stations

CLIENT: Anadarko Moçambique Área 1, Lda

DATE: Jan 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 110 000

DRAWING: Sea grass Habitat and stations.mxd

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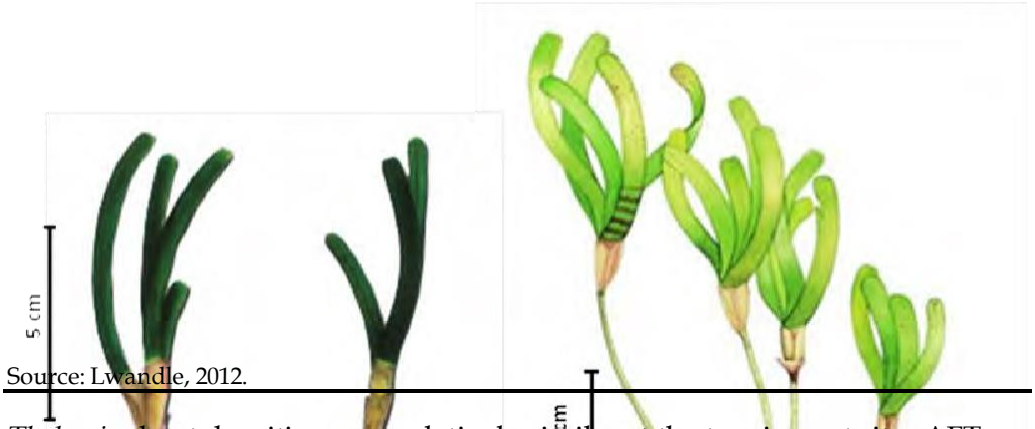
Figure 7.47 *Morphology of the Seagrasses* **Thalassia hemprichii** *and* **Thalassodendron ciliatum**



Source: Lwandle, 2012.

Thalassia shoot densities were relatively similar at the two impact sites AFT and AFE, ranging from 20 and 35 shoots/0.0625m² (area of small quadrat) for AFT and AFE respectively. Shoot densities of other species were very low (<10 shoots/0.0625m²), reflecting their low cover at these sites. At PMW, shoot density of the two dominant species, *Thalassodendron* and *Thalassia*, was on average very similar across the transects, with a mean value of 12/0.0625m² for both species.

Seagrass biomass is divided into above ground biomass, ie leaves, stems and sheaths, and below ground biomass, ie roots and rhizomes. At the Afungi sites AFT and AFE, below ground biomass was typically greater than biomass above ground. In contrast, at PMW, the above ground biomass was greater than below ground biomass. These results reflect the morphological differences between the dominant seagrass species at each site. *Thalassia hemprichii* has shoots from 10 to 40cm (in this study always <20cm) with a thick (3 to 5mm) rhizome and a dense root system (*Figure 7.47*). Consequently, the below ground biomass can easily be greater than the above ground biomass. *Thalassodendron ciliatum*, in contrast, has a long stem and can reach up to 75cm (together with the leaves) (*Figure 7.47*). Its root system, however, is less dense and the relative mass of the below ground parts is thus less than that of the stem and leaves.

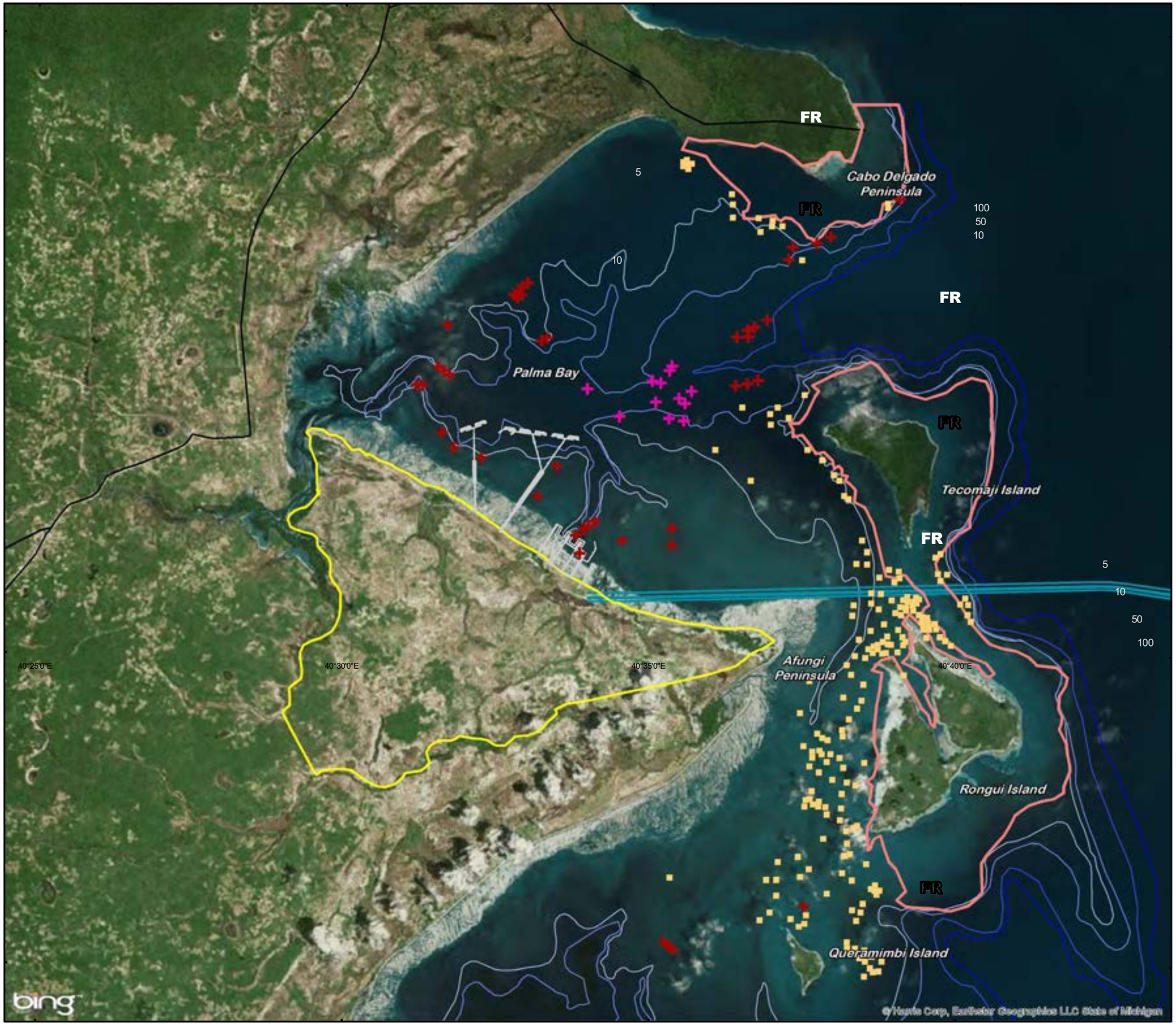
Many large invertebrates were commonly encountered in the seagrass beds in Palma Bay, including several species of sea urchins, starfish and sea cucumber, a large variety of sponges and colonial ascidians, and occasional hard coral. Particularly common was the pen shell (*Pinna muricata*), living partially buried in the sand with only the top third exposed. These often occurred in relatively dense clusters.

7.8.4 Coral

Corals are marine invertebrates in the class Anthozoa of the phylum Cnidaria, typically living in compact colonies of many identical individual polyps. The group includes the important reef builders that inhabit tropical oceans, which secrete calcium carbonate ($CaCO_3$) to form a hard skeleton.

Much of the seabed within Palma Bay is soft sediment, specifically sand, with coral outcrops distributed around the bay. The most well-developed of these outcrops are located adjacent to Cabo Delgado Peninsula and around the islands in the mouth of Palma Bay (*Figure 7.48*). Coral reef structures in Palma Bay comprise fringing reefs and bommies. A coral bommie (1) is either an outcrop of coral reef, often resembling a column that is higher than the surrounding platform of reef, or an isolated piece of reef on sand. Fringing reefs usually occur parallel to shorelines. These coral habitats in Palma Bay are further discussed in *Sections 7.8.5* and *7.8.6*.

(1) Short for 'bombora' - an Aboriginal word meaning outcrop or reef.

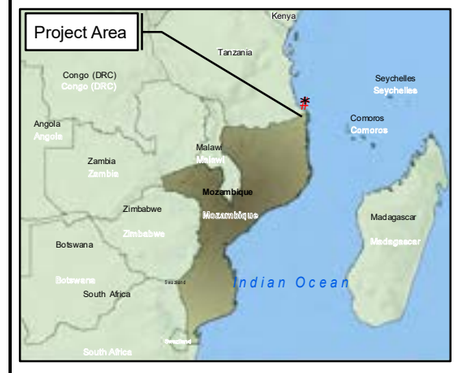


Legend

- Small Coral Bommie
- Larger (Porites) Coral Bommie
- Sand Crater with Coral
- Fringing Reef (FR)
- Regional Roads
- Proposed Nearshore Infrastructure
- Proposed Pipeline Corridor Route
- Afungi Project Site

Bathymetry (Metres below Mean Sea Level)

- -5
- -10
- -50
- -100



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 7.48:
Distribution of Coral Reef in Palma Bay

CLIENT:

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Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 110 000

DRAWING: Distribution of Coral Reef.mxd

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Projection: UTM Zone 37 S Datum: WGS84 Source: Bing Maps ©2010 Microsoft Corporation. Lwandle Technologies, 2012. Inset Map: Esri Data & Maps	SIZE: A3

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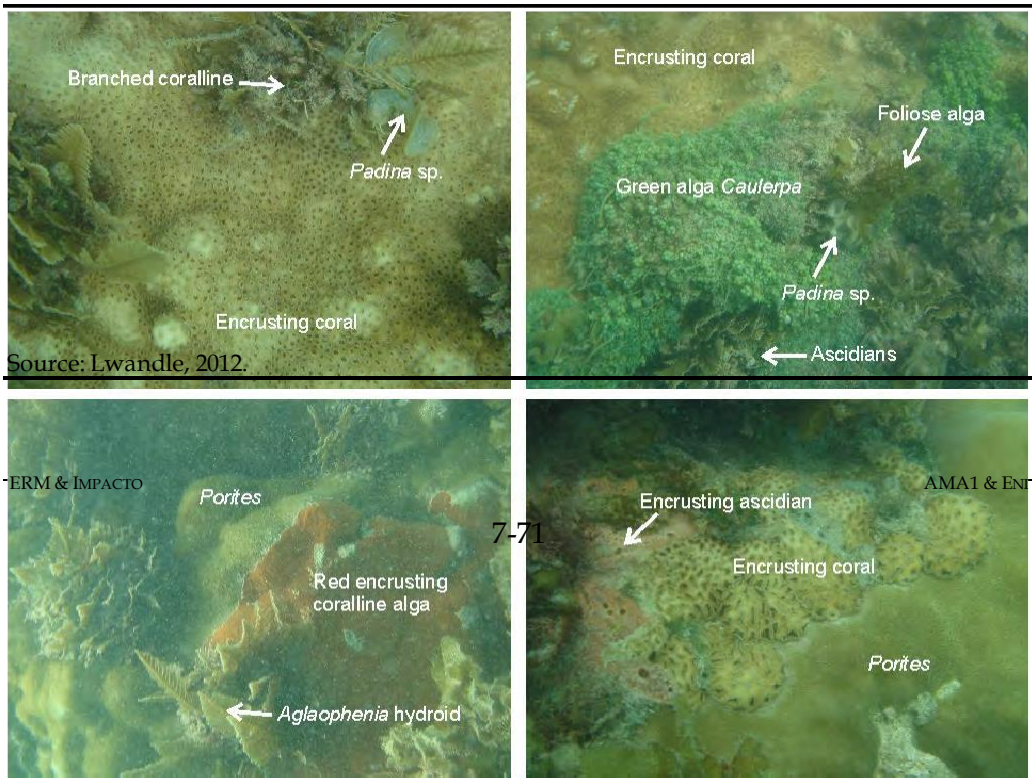
7.8.5 *Shallow Coral Reefs and Outcrops*

Shallow coral reefs and outcrops are scattered throughout Palma Bay, as shown in *Figure 7.48*. Count, visual and photographic observations of coral reef features were undertaken at two locations within Palma Bay: a near-field site (NFB), which is situated sufficiently close to the proposed marine facilities area to be exposed to potential dredging effects, and a far-field site (FFB) in the same depth range, but at a distance unlikely to be impacted by the dredging (*Figure 7.50*).

At both locations, the reef structures comprised individual *Porites*-dominated bommies, which rose to a height of 2 to 3m above the surrounding sandy seabed. Areas of dead coral on these bommies were dominated by silt-covered hydroid fuzz and red encrusting coralline algae.

At the far-field site near Cabo Delgado Peninsula, patches of reef not formed by live *Porites* coral were characterised by massive colonies including *Platygyra* spp. and *Labophyllia hemprichii*. Macroalgae including *Sargassum* spp., *Padina* sp. and *Turbinaria* spp. were the dominant growth on dead coral. The hydroid *Aglaophenia cupressina* and red encrusting coralline algae, encrusting sponge, encrusting ascidians (*Didemnum* sp.) and encrusting, massive and branched coral forms were also present (*Figure 7.49*). Bommie density was approximately 3/1,000m².

Figure 7.49 ***Encrusting and Erect Biota Present on the Far-field* Porites *Bommies***



Source: Lwandle, 2012.

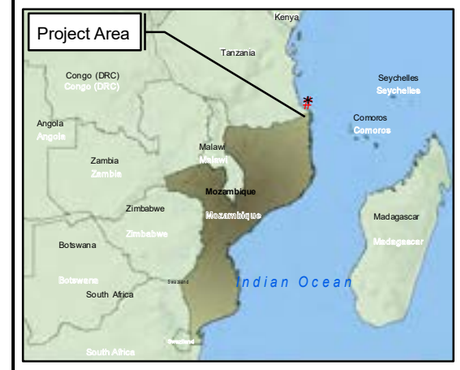
Legend

Coral Reef Sampling Sites

- Far Field Bommie (FFB)
- Near Field Bommie (NFB)
- Regional Roads
- Proposed Nearshore Infrastructure
- Proposed Pipeline Corridor Route
- Afungi Project Site

Bathymetry (Metres below Mean Sea Level)

- -5
- -10
- -50
- -100



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 7.50:
Near (NFB) and Far (FFB) Field Coral Reef Sampling Site Locations

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 110 000

DRAWING: Near and Far Field Coral Reef.mxd

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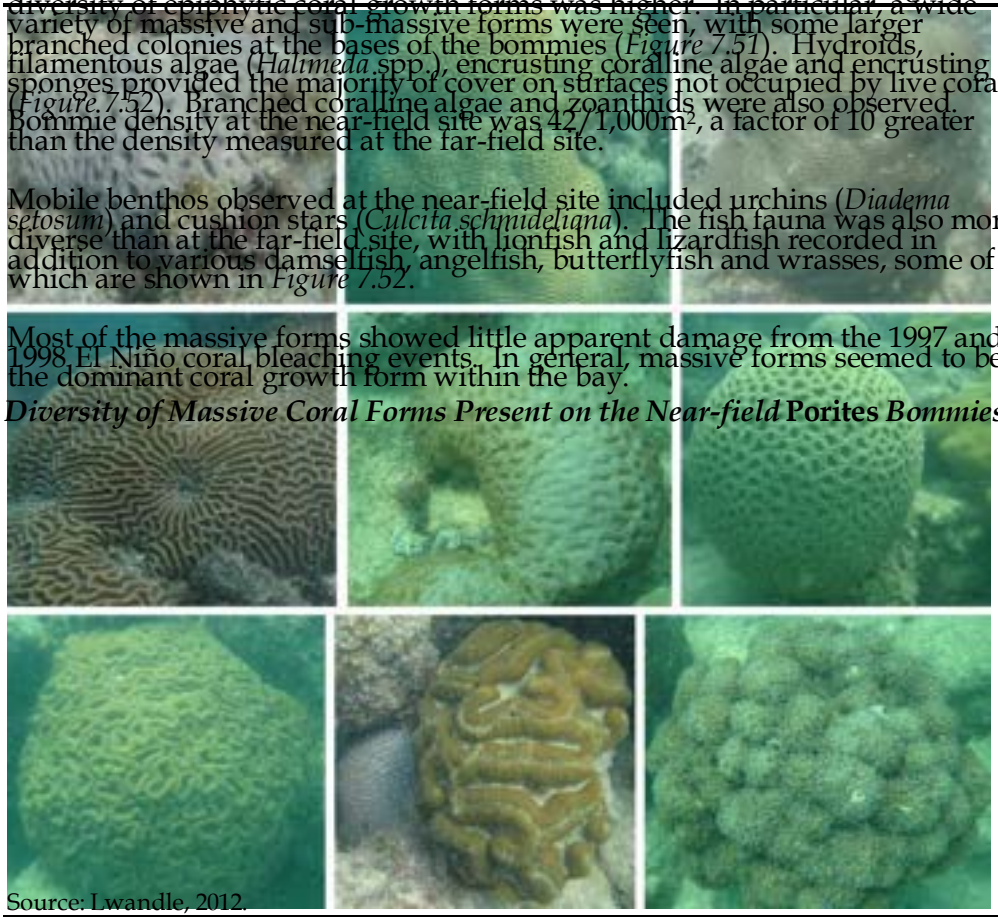
At the near-field site adjacent to the shores of Afungi Peninsula, the coral bommies were similar to those at the far-field site in structure, although the diversity of epiphytic coral growth forms was higher. In particular, a wide variety of massive and sub-massive forms were seen, with some larger branched colonies at the bases of the bommies (*Figure 7.51*). Hydroids, filamentous algae (*Halimeda* spp.), encrusting coralline algae and encrusting sponges provided the majority of cover on surfaces not occupied by live coral (*Figure* 7.52). Branched coralline algae and zoanthids were also observed. Bommie density at the near-field site was 42/1,000m², a factor of 10 greater than the density measured at the far-field site.

Mobile benthos observed at the near-field site included urchins (*Diadema setosum*) and cushion stars (*Culcita schmideliana*). The fish fauna was also more diverse than at the far-field site, with lionfish and lizardfish recorded in addition to various damselfish, angelfish, butterflyfish and wrasses, some of which are shown in *Figure 7.52*.

Most of the massive forms showed little apparent damage from the 1997 and 1998 El Niño coral bleaching events. In general, massive forms seemed to be the dominant coral growth form within the bay.

Figure 7.51 ***Diversity of Massive Coral Forms Present on the Near-field* Porites *Bommies***



Source: Lwandle, 2012.

Figure 7.52 ***Biota Present on the Near-field Porites Bommies***

Source: Lwandle, 2012.

All of the bommie areas are fished intensively and there is evidence of damage from anchoring, lines, nets, baskets and even trampling. Damage includes detachment of large *Acropora* colonies and smashed *Lobophyllia* (massive coral). From this and probably other causes, a high proportion of the coral bommie reef structure is actually dead material comprising >60 percent of reef cover.

Isolated colonies of Acropora were associated with the bommies. In a marine habitat survey at three locations along the Cabo Delgado coastline from Vamizi Island south to Medjumbe Island CSA (2007) identified *Acropora aspera* amongst these. This species is categorised as Vulnerable according to the IUCN (2011) red list. The CSA (2007) data indicate that *A. aspera* was one of the dominant species at each of the three sites they sampled and although not specifically recorded in Palma Bay it is probable that it occurs there.

7.8.6 Fringing Coral Reef

As shown in *Figure 7.48*, the fringing coral reef areas are found around and between the three islands in and immediately south of Palma Bay – Tecomaji, Rongui and Queramimbi. The coral genera, species and growth forms recognised in Palma Bay are similar to those recorded throughout the Quirimbas Archipelago and in the Indo-Pacific region. They therefore represent a locally important biodiversity resource, as opposed to being unique at the regional, national or international scale. The fringing reefs around these islands were surveyed to provide comparative information to be used in the selection of a pipeline route. The sites/transects surveyed are

shown in *Figure 7.54*, and are listed in groups according to their geographical location below:

- North of Tecomaji Island:
  - Tecomaji North Observations;
- Between Tecomaji and Rongui islands:
  - Tecomaji South Transects,
  - Tecomaji to Rongui Transect,
  - Deeper Waters between Tecomaji and Rongui islands; and
- South of Rongui Island:
  - Rongui South Transects,
  - Rongui South Observations, and
  - Rongui to Queramimbi Transect.

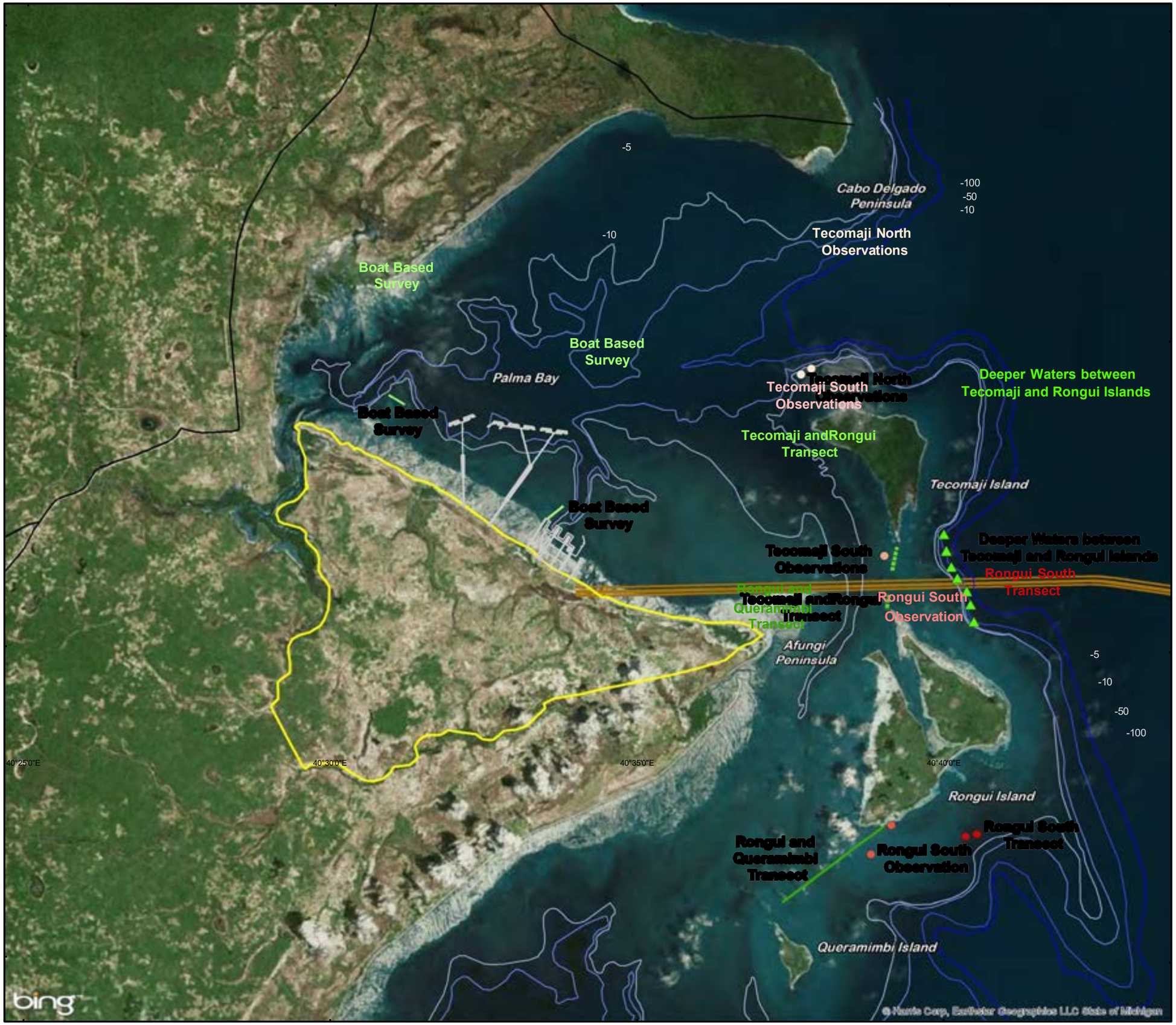
The fringing reef habitats are described according to these geographical areas in the sections below.

North of Tecomaji Island

Tecomaji North Observations

Visual and photographic observations of coral reef features were undertaken towards the seaward drop-off at two locations to the north of Tecomaji Island: Tecomaji North Deep at approximately 7m, and Tecomaji North Shallow at approximately 5m).

Figure 7.53 and *Figure 7.55* illustrate examples of the biodiversity recorded in the Tecomaji North Shallow and Deep areas respectively. The reef at both of these sites was considerably more extensive than seen at the two inter-island inshore sites (discussed below), with coral cover increasing with depth. Although still present in patches at the shallow site, sand was less common, with the reef base comprising masses of dead coral rubble. In places, the coral rubble remained barren and devoid of obvious recolonisation by macrobenthos, whereas prolific overgrowth by a foliose algae and healthy regrowth of both massive and branched hard coral forms was also apparent in places. A high diversity of coral forms was observed north of Tecomaji. These included massive, branched, tabular, plate, solitary and encrusting species (*Figure 7.53*). Other macrobenthos present included the giant anemones (*Heteractis magnifica* and *Sarcophyton* spp.), giant clams (*Tridacna* sp.), zooanthids, ascidians (*Didemnum molle*) and a crown-of-thorns (COT) starfish (*Acanthaster planci*). The presence of COT starfish is of significance as it is a corallivore, ie a carnivorous predator that preys on reef coral polyps, and has been implicated in coral reef degradation. Ichthyofauna was also diverse, with a variety of larger Chaetodontid (butterflyfish) and Pomacanthid (angelfish) species being prevalent, as well as the ever-present damselfish, anemonefish and small wrasses.



Legend

- Seabed Observations at Deeper Waters between Tecomaji and Rongui Islands
- Tecomaji North Observations
- Tecomaji South Observations
- Rongui South Observation
- Rongui South Transect
- Boat Based Survey
- Tecomaji and Rongui Transect
- Rongui and Queramimbi Transect
- Regional Roads
- Proposed Nearshore Infrastructure
- Proposed Pipeline Corridor Route
- Afungi Project Site

Bathymetry (Metres below Mean Sea Level)

- -5
- -10
- -50
- -100

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 7.53:
Boat, Diver and ROV Fringing Coral Reef Survey Sites

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 110 000

DRAWING: Boat Diver and ROV Fringing.mxd

REV: A

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Impacto Projectos e Estudos Ambientais

ERM

T:\GIS Projects\

Projection: UTM Zone 37 S Datum: WGS84 Source: Bing Maps ©2010 Microsoft Corporation. Lwandle Technologies, 2012. Inset Map: Esri Data & Maps	SIZE: A3

10°40'0"S

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10°50'0"S

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Figure 7.54 *Tecomaji North Shallow Area Showing the Coral Regrowth and Some Examples of Species Mentioned in the Text*

Source: Lwandle, 2012.

Figure 7.55 Tecomaji North Deep Area Showing Coral Rubble, Macro-algal Growth and Some Examples of the Coral Diversity

Source: Lwandle, 2012.

Between Tecomaji and Rongui Islands

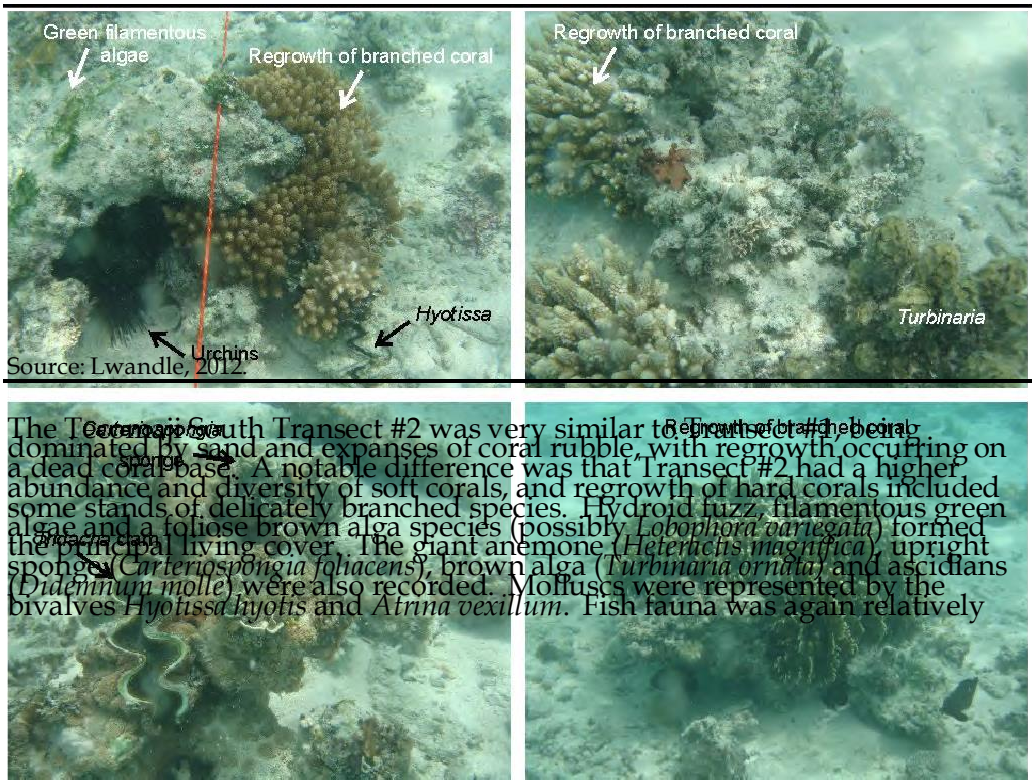
Tecomaji South Transects

Sand, and sand with coral debris, dominated most of the transects surveyed south of Tecomaji Island, essentially similar to the Rongui south transects. A further similarity between this location and south of Rongui is the increased representation of massive and branched corals on the inner Transect #3.

The area around the Tecomaji South Transect #1 was dominated by sand and expanses of coral rubble. The hard substrata in the area are low-relief clusters of what appeared to be a dead coral base, covered by a carpet of encrusting coralline algae, hydroid fuzz and tufts of green filamentous algae, with a veneer of loose sand. Regrowth of branching coral forms is evident in places,

indicating recovery following the coral bleaching event in the late 1990s (see later text). The dead base-reef was comparatively barren, with partial cover by areas of soft coral and the anemone *Heteractis magnifica*. Other sessile invertebrates included upright (*Carteriospongia foliacens*) and encrusting sponges, and ascidians (*Didemnum molle*). The giant clam *Tridacna* sp. and *Hyotissa hyotis* were both present, usually deeply embedded within the old coral structure. Mobile invertebrates included cushion stars (*Culcita schmideliana*), urchins (*Diadema setosum*), which usually occurred on sand and sheltered under small coral overhangs, and the sea cucumber *Synapta maculata*. Macroalgae were primarily represented by the brown alga *Turbinaria ornata*. Fish fauna was comparatively scarce, and limited to anemonefish associated with *H. magnifica* and a few species of damselfish associated with the new branched coral growth.

Figure 7.56 Tecomaji South Transect #1 – Biodiversity



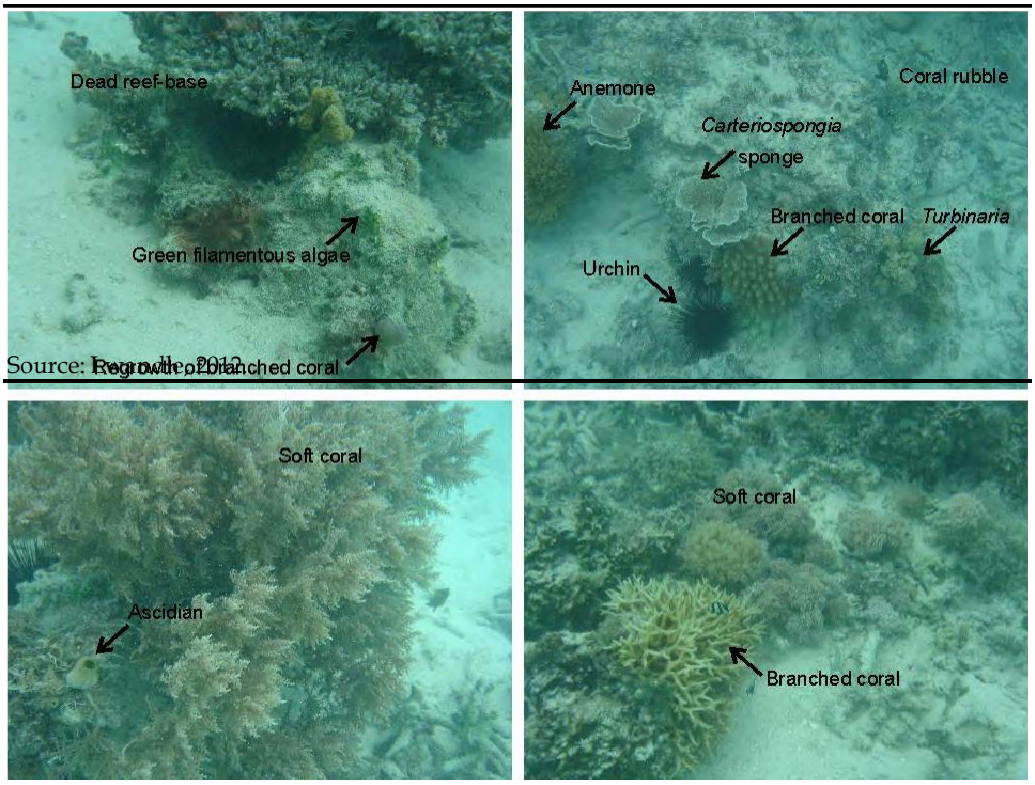
Source: Lwandle, 2012.

The Tecomaji South Transect #2 was very similar to Transect #1, being dominated by sand and expanses of coral rubble, with regrowth occurring on a dead coral base. A notable difference was that Transect #2 had a higher abundance and diversity of soft corals, and regrowth of hard corals included some stands of delicately branched species. Hydroid fuzz, filamentous green algae and a foliose brown alga species (possibly *Lobophora variegata*) formed the principal living cover. The giant anemone (*Heteractis magnifica*), upright sponges (*Carteriospongia foliacens*), brown alga (*Turbinaria ornata*) and ascidians (*Didemnum molle*) were also recorded. Molluscs were represented by the bivalves *Hyotissa hyotis* and *Atrina vexillum*. Fish fauna was again relatively

sparse and associated primarily with the small clumps of coral regrowth and stands of soft coral.

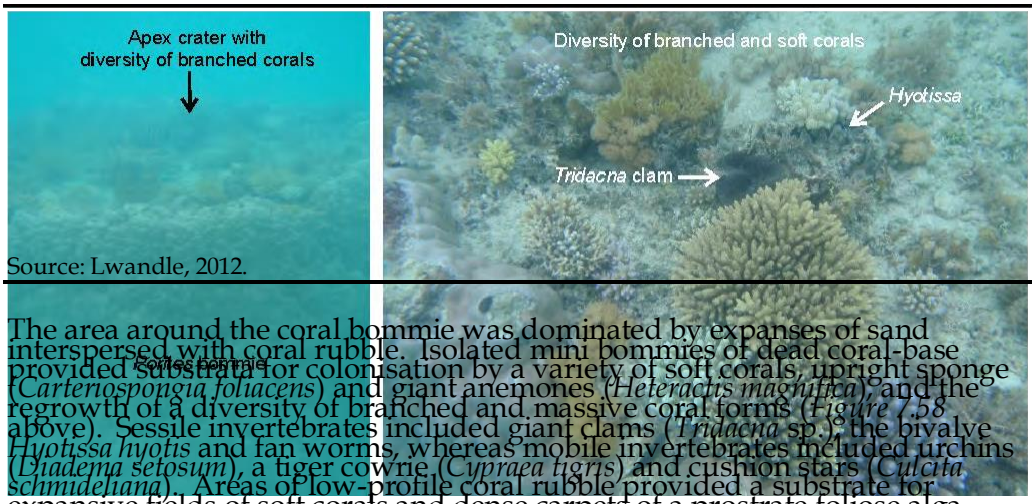
At Transect #3, the most prominent feature was a massive *Porites* bommie, which rose to a height of some 3m above the surrounding sandy seabed. The steep, almost monospecific sides gave way to a flat crater at the apex, which provided a habitat for a wide diversity of small, relatively young colonies of branched corals, soft corals, hydroids and the associated fish fauna, comprising primarily damselfish. Giant clams (*Tridacna*, sp.), the bivalve *Hyotissa hyotis* and the tropical crayfish *Palinurus versicolor* were also present, the latter having found shelter in a small crevice in the walls of the bommie.

Figure 7.57 ***Tecomaji South Transect #2 – Biodiversity***



Source: Reproduced 2012

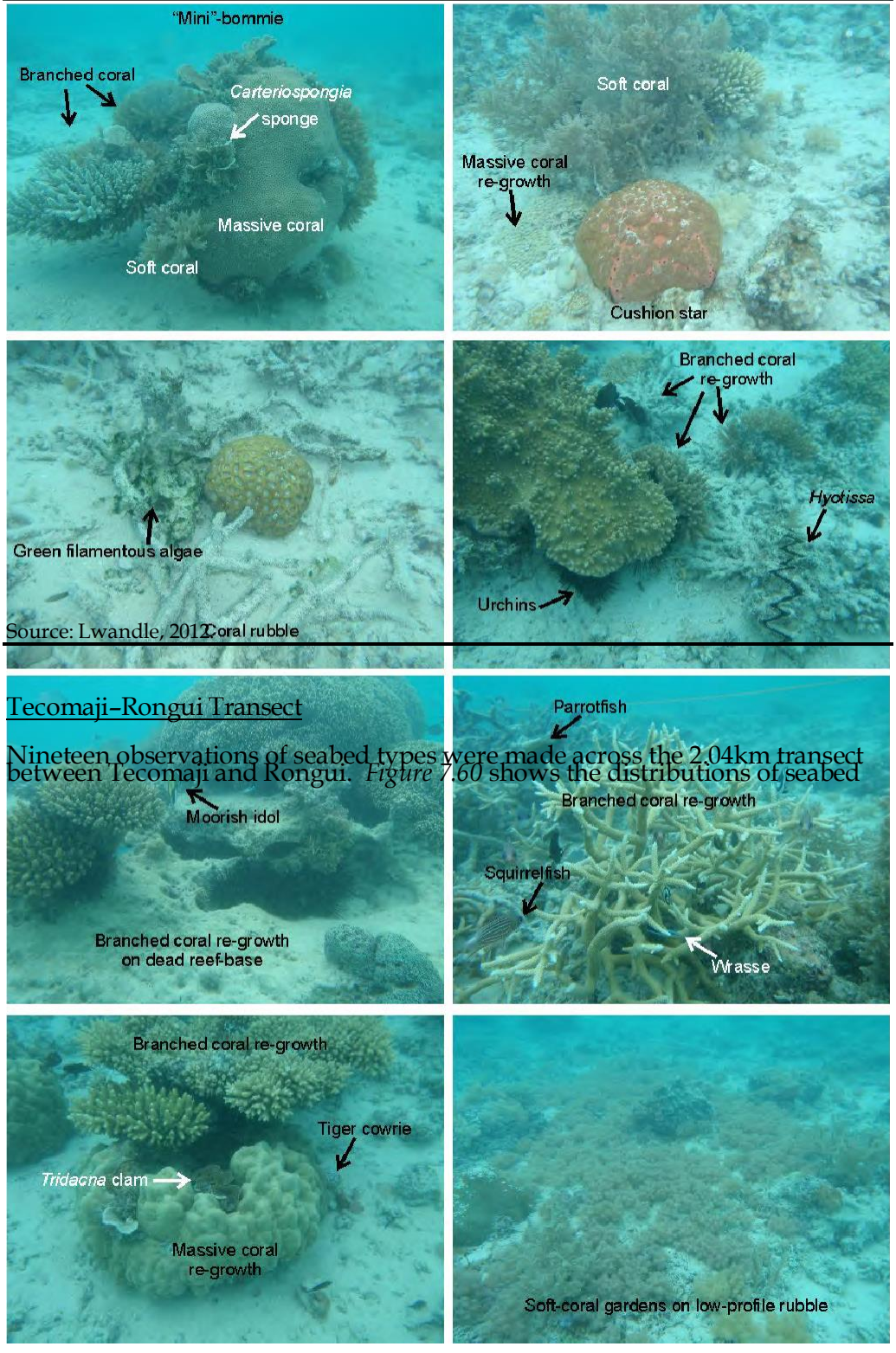
Figure 7.58 Tecomaji South Transect #3 – Biodiversity



Source: Lwandle, 2012.

The area around the coral bommie was dominated by expanses of sand interspersed with coral rubble. Isolated mini bommies of dead coral-base provided substrata for colonisation by a variety of soft corals, upright sponge (*Carteriospongia foliacens*) and giant anemones (*Heteractis magnifica*), and the regrowth of a diversity of branched and massive coral forms (*Figure 7.58* above). Sessile invertebrates included giant clams (*Tridacna* sp.), the bivalve *Hyotissa hyotis* and fan worms, whereas mobile invertebrates included urchins (*Diadema setosum*), a tiger cowrie (*Cypraea tigris*) and cushion stars (*Culcita schmideliana*). Areas of low-profile coral rubble provided a substrate for expansive fields of soft corals and dense carpets of a prostrate foliose alga (possibly *Lobophora variegata*) and green filamentous algae. Ichthyofauna included a diversity of damselfish, anemonefish, crown squirrelfish, wrasses, bullhead parrotfish, butterflyfish, pufferfish and moorish idols.

Figure 7.59 *Tecomaji South Transect 3# Showing the Mini Bommies, Coral Regrowth and Some Examples of Species Mentioned in the Text*



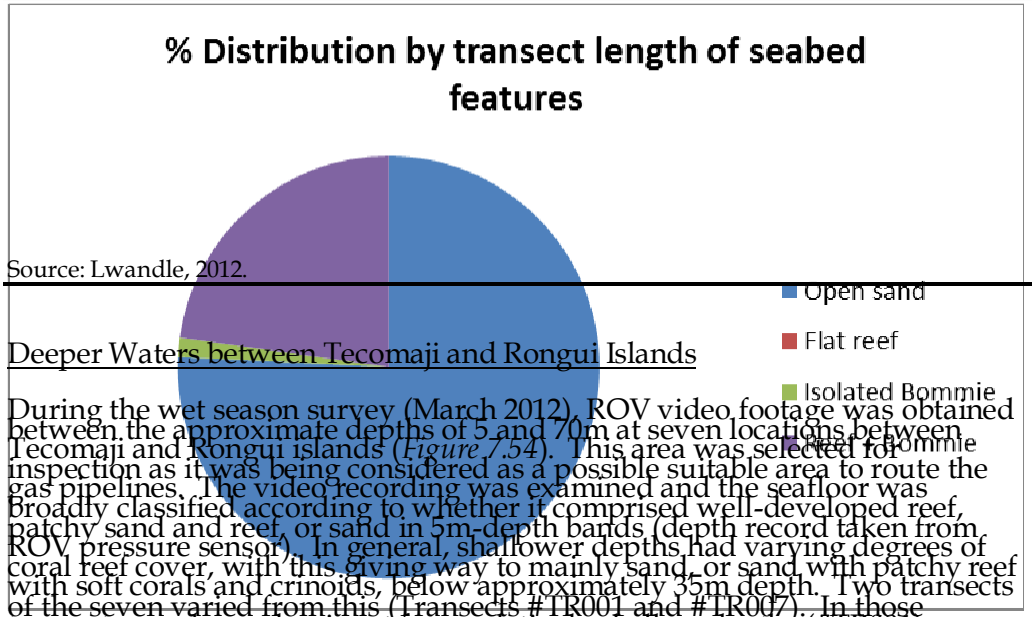
Source: Lwandle, 2012

Tecomaji–Rongui Transect

Nineteen observations of seabed types were made across the 2.04km transect between Tecomaji and Rongui. *Figure 7.60* shows the distributions of seabed

types observed. The dominant types are open sand seafloor and coral reef with bommies, which were observed on the southern end of the transect. The latter was distributed in two sections of approximately 340m and 180m lengths. Sand seafloor completely dominated the transect, with a semi-continuous stretch extending more than 1.1km across the centre of the transect. Isolated bommies were concentrated on the northern portion of the surveyed area close to Tecomaji Island.

Figure 7.60 ***Proportional Distribution of Seabed Types on the Tecomaji–Rongui Inter-island Transect***



Source: Lwandle, 2012.

Deeper Waters between Tecomaji and Rongui Islands

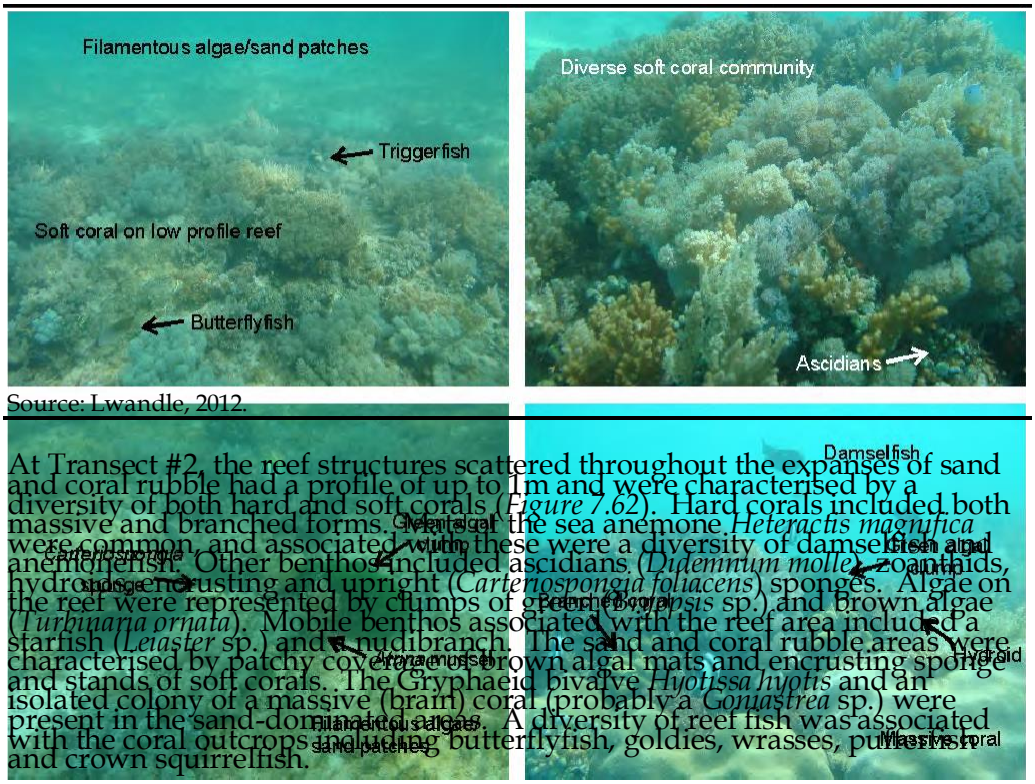
During the wet season survey (March 2012), ROV video footage was obtained between the approximate depths of 5 and 70m at seven locations between Tecomaji and Rongui islands (*Figure 7.54*). This area was selected for inspection as it was being considered as a possible suitable area to route the gas pipelines. The video recording was examined and the seafloor was broadly classified according to whether it comprised well-developed reef, patchy sand and reef, or sand in 5m-depth bands (depth record taken from ROV pressure sensor). In general, shallower depths had varying degrees of coral reef cover, with this giving way to mainly sand, or sand with patchy reef with soft corals and crinoids, below approximately 35m depth. Two transects of the seven varied from this (Transects #TR001 and #TR007). In those transects, sand was dominant from relatively shallow depths (#TR001) or, along with patchy reef, completely dominant (#TR007). This reflects the overall distribution of seafloor types in the shallower areas between these islands.

Rongui South Transects

The distributions of coral and sand on these transects are essentially similar to those in the Tecomaji South Transects. Sand, and sand with coral debris, dominated most of the transects surveyed south of Rongui in terms of proportions of these seabed types along the 100m lengths surveyed. This is consistent with the results of the inter-island surveys, which show that distances between coral bommies are usually >20m. Macroalgae were also common. When attached to corals this is symptomatic of coral senescence or mortality, and the observations are consistent with the high proportions of coral debris observed in the transects. The differences between the individual transects are slight, but massive and branching corals have a higher representation on the inner Transect #3.

The photos of Transect #1 show that the hard substrate areas of this transect were primarily characterised by low-profile, platform-like 'reef' (possibly dead coral-based reef) with some higher-profile outcrops. These reefs were interspersed between lawns of filamentous blue-green algae, and green algae and patchy sand veneer (*Figure 7.61*). Cushion stars (*Culcita schmideliana*) were present on the sandy substrate. The low-profile reef was dominated by thick stands of a wide diversity of soft corals. Other benthic organisms living between the soft corals included ascidians (*Didemnum molle*), hydroids, encrusting and upright (eg *Carteriospongia foliacens*) sponges and mussels (*Atrina vexillum*). Areas of higher relief provided habitat for isolated clumps of branching and massive (primarily *Porites* sp.) hard corals, hydroids and clumps of the green alga (*Bryopsis* sp.). Dominant ichthyofauna included a variety of damselfish species, with some triggerfish and butterflyfish also present.

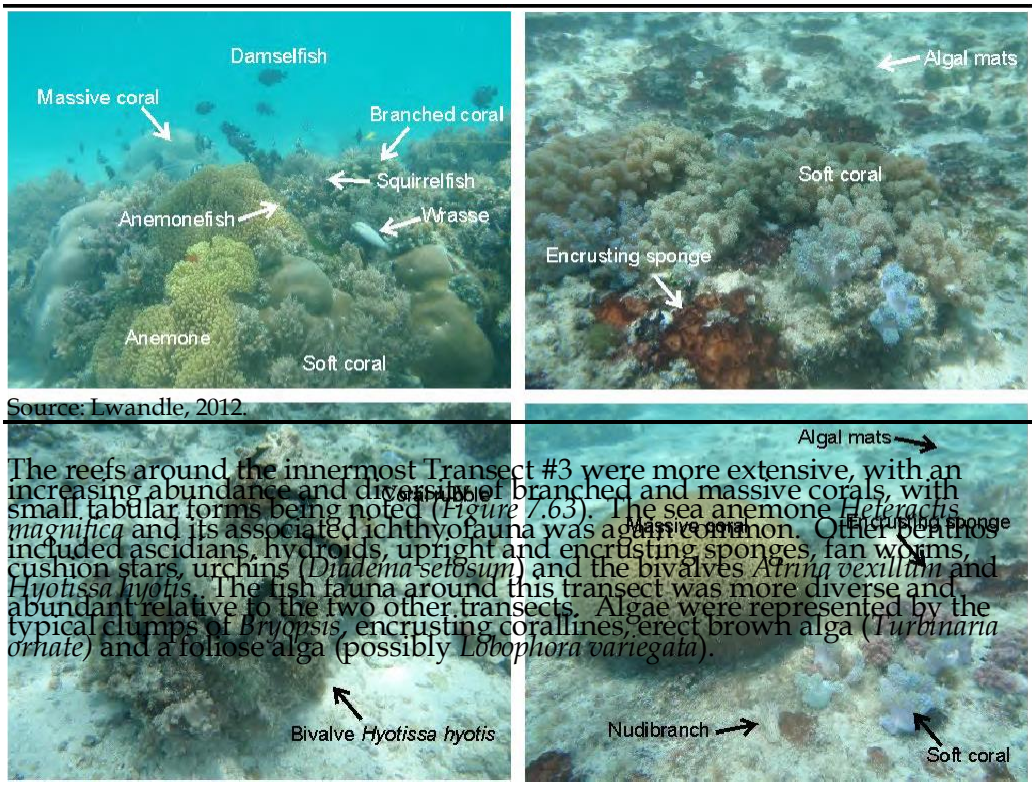
Figure 7.61 Biodiversity Recorded along Rongui South Transect #1



Source: Lwandle, 2012.

At Transect #2, the reef structures scattered throughout the expanses of sand and coral rubble had a profile of up to 1m and were characterised by a diversity of both hard and soft corals (*Figure 7.62*). Hard corals included both massive and branched forms. Most of the sea anemone *Heteractis magnifica* were common, and associated with these were a diversity of damselfish and anemonefish. Other benthos included ascidians (*Didemnum molle*), zoanthids, hydroids, encrusting and upright (*Carteriospongia foliacens*) sponges. Algae on the reef were represented by clumps of green (*Halimeda* sp.) and brown algae (*Turbinaria ornata*). Mobile benthos associated with the reef area included a starfish (*Leiaster* sp.) and a nudibranch. The sand and coral rubble areas were characterised by patchy coverage of brown algal mats and encrusting sponge and stands of soft corals. The Gryphaeid bivalve *Hyotissa hyotis* and an isolated colony of a massive (brain) coral (probably a *Goniastrea* sp.) were present in the sand-dominated areas. A diversity of reef fish was associated with the coral outcrops including butterflyfish, goldies, wrasses, pufferfish and crown squirrelfish.

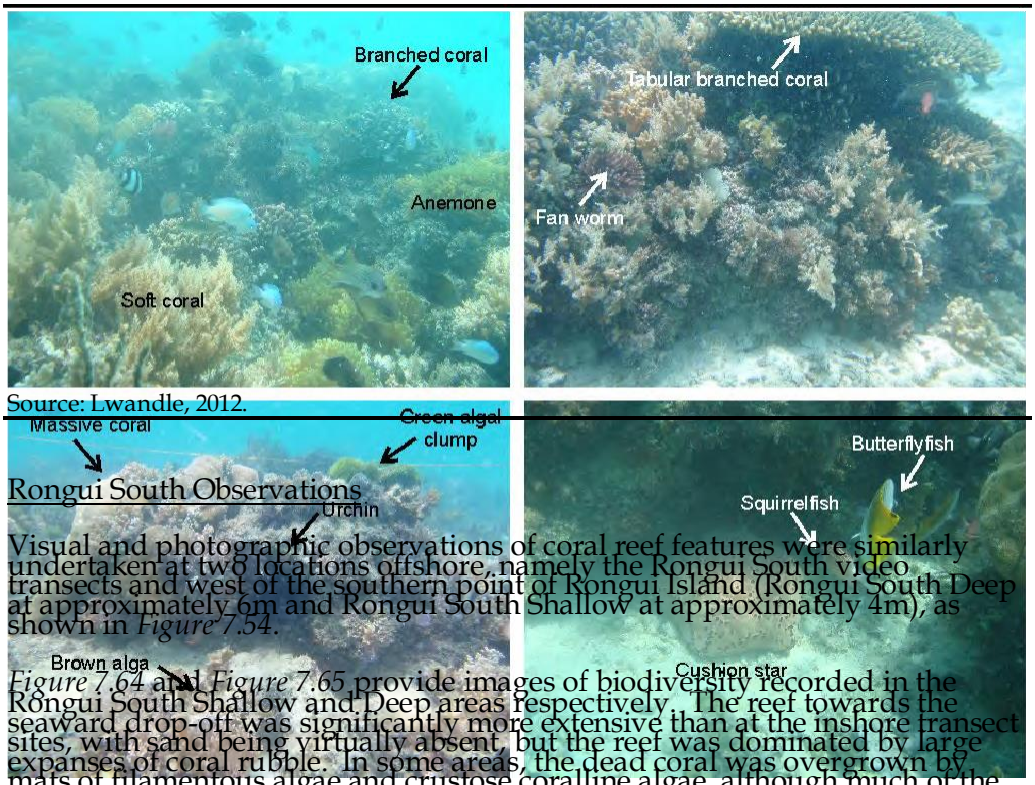
Figure 7.62 Biodiversity Recorded along Rongui South Transect #2



Source: Lwandle, 2012.

The reefs around the innermost Transect #3 were more extensive, with an increasing abundance and diversity of branched and massive corals, with small tabular forms being noted (*Figure 7.63*). The sea anemone *Heteractis magnifica* and its associated ichthyofauna was again common. Other benthos included ascidians, hydroids, upright and encrusting sponges, fan worms, cushion stars, urchins (*Diadema setosum*) and the bivalves *Atrina vexillum* and *Hyotissa hyotis*. The fish fauna around this transect was more diverse and abundant relative to the two other transects. Algae were represented by the typical clumps of *Bryopsis*, encrusting corallines, erect brown alga (*Turbinaria ornate*) and a foliose alga (possibly *Lobophora variegata*).

Figure 7.63 Biodiversity Recorded along Rongui South Transect #3



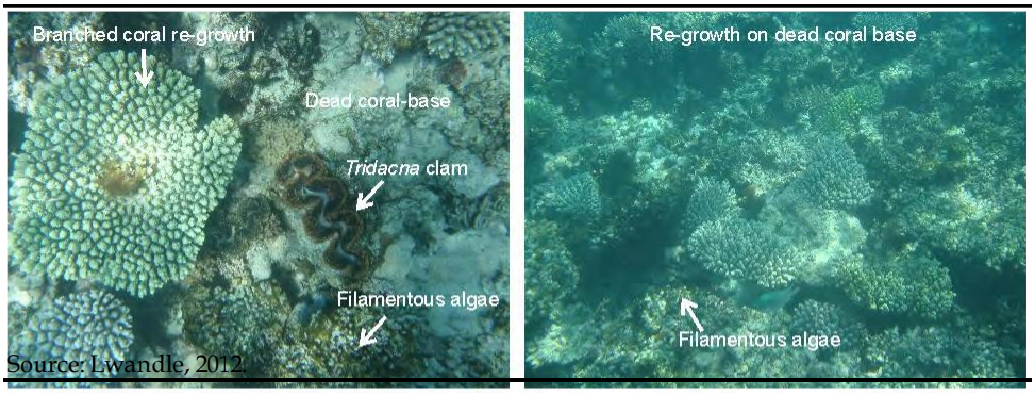
Source: Lwandle, 2012.

Rongui South Observations

Visual and photographic observations of coral reef features were similarly undertaken at two locations offshore, namely the Rongui South video transects and west of the southern point of Rongui Island (Rongui South Deep at approximately 6m and Rongui South Shallow at approximately 4m), as shown in *Figure 7.54*.

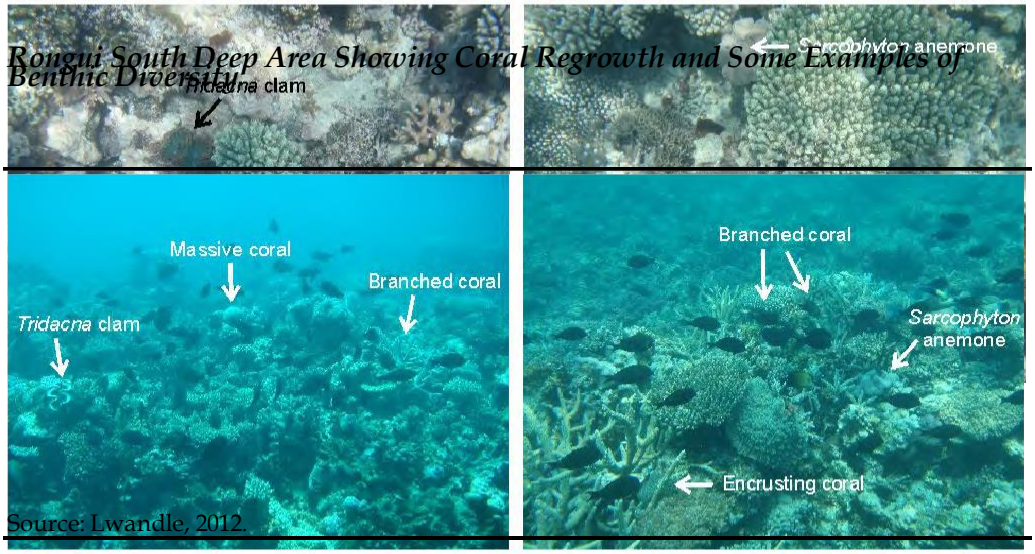
Figure 7.64 and *Figure 7.65* provide images of biodiversity recorded in the Rongui South Shallow and Deep areas respectively. The reef towards the seaward drop-off was significantly more extensive than at the inshore transect sites, with sand being virtually absent, but the reef was dominated by large expanses of coral rubble. In some areas, the dead coral was overgrown by mats of filamentous algae and crustose coralline algae, although much of the rubble remained barren. The erect brown alga (*Turbinaria ornata)* was also present.

Figure 7.64 *Rongui South Shallow Area Showing Coral Rubble, Filamentous Algal Growth and Some Examples of Benthic Diversity*

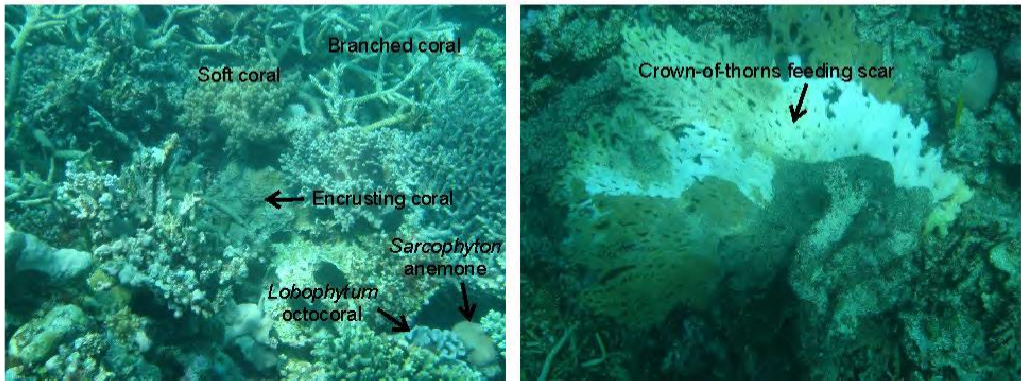


Source: Lwandle, 2012.

Figure 7.65 *Rongui South Deep Area Showing Coral Regrowth and Some Examples of Benthic Diversity*



Source: Lwandle, 2012.



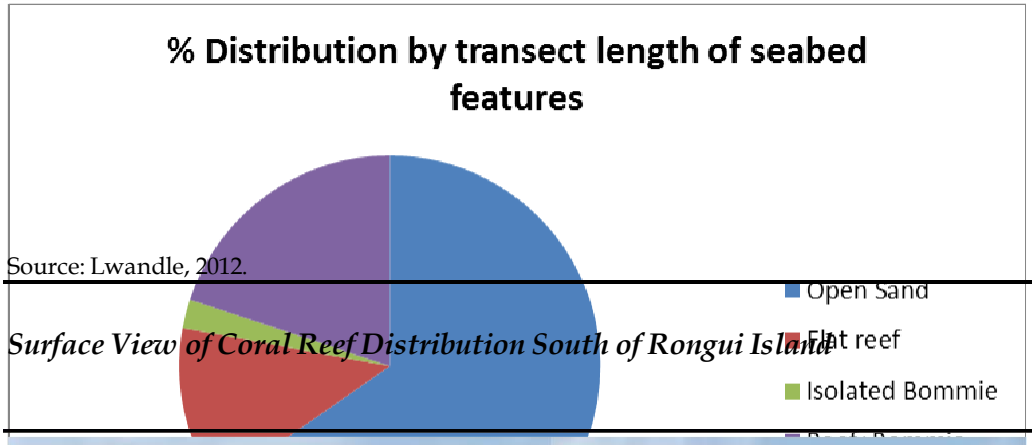
Regrowth of branched, massive and encrusting coral forms, as well as a diversity of soft coral and encrusting sponge, was evident throughout the area. Other macrobenthos present included giant anemones (*Heteractis magnifica* and *Sarcophyton* spp.), encrusting octocorals (*Sinularia* spp. and *Lobophytum* spp.), giant clams (*Tridacna* sp.) and urchins (*Diadema setosum*). The upright sponge (*Carteriospongia foliacens)* and cushion star (*Culcita schmideliana*) were primarily recorded in the shallower area. The bleached tips of some branching coral forms and bleached bands on tabular corals suggest that predation by COT starfish occurs to some extent in the area. As in the deeper areas off Tecomaji North, the fish fauna was characterised by a variety of larger Chaetodontids (butterflyfish) and Pomacanthids (angelfish), as well as damselfish, anemonefish and small wrasses. A pipefish was also seen.

Rongui–Queramimbi Transect

Fifty individual observations of coral reef and associated or isolated coral bommies were made along the 3.8km transect between Rongui and Queramimbi islands. The proportions of the seabed types recorded between the two islands are shown in *Figure 7.66*. The bulk of the transect was sand, interspersed with coral bommies, but the most extensive continuous feature on the transect was the approximately 730m-long stretch of coral reef with bommies. Despite being numerous, isolated bommies comprise a small fraction of the surveyed transect length. Two flat coral reef areas, probably with coral rubble (1), made up stretches of approximately 220m lengths on the southern side of the transect. Inter-bommie distances (bommie spacing) were variable, ranging from approximately 240m to 10m or less. *Figure 7.67* shows a typical view of bommie spacing as visible from the survey boat.

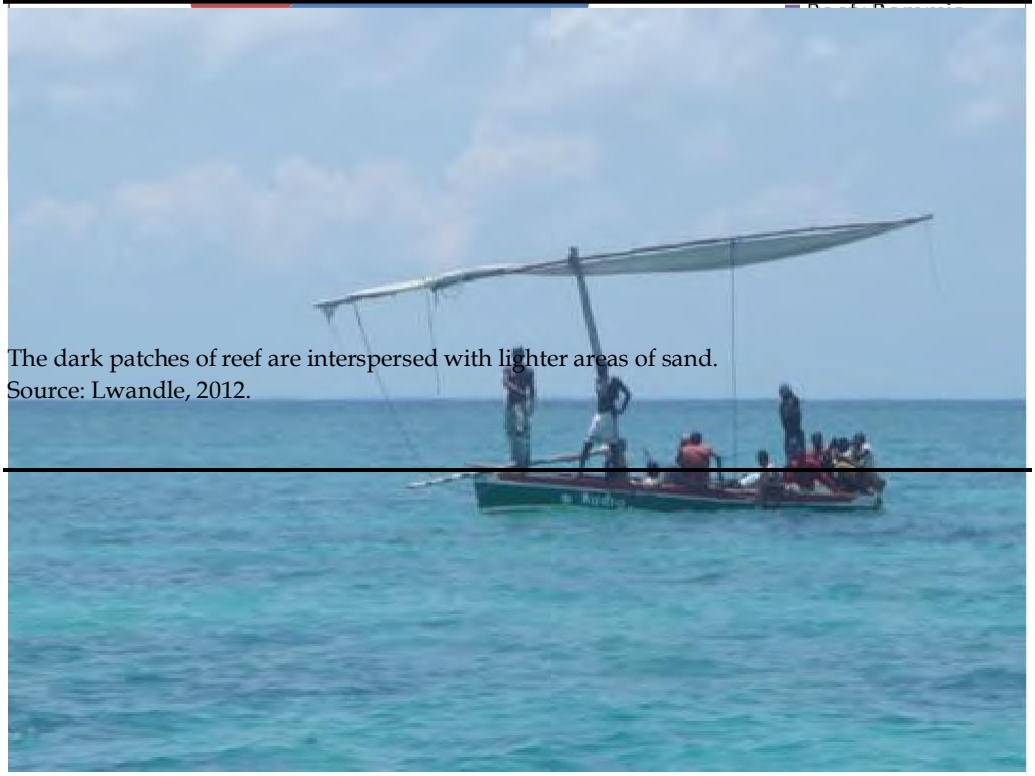
(1) Unconsolidated fragments of broken dead coral.

Figure 7.66 Proportional Distribution of Seabed Types on the Rongui–Queramimbi Inter-island Transect



Source: Lwandle, 2012.

Figure 7.67 Surface View of Coral Reef Distribution South of Rongui Island



The dark patches of reef are interspersed with lighter areas of sand.
Source: Lwandle, 2012.

Disturbance/Damage to Fringing Coral Reefs

A major and prominent feature of the fringing coral reef areas surveyed around the islands was the substantial amount of coral debris and dead coral-base present. There are three possible causes for this:

- destructive fishing methods using dynamite [1];
- reef damage through cyclones or heavy storms; and
- coral bleaching.

Dynamite fishing is extremely effective in shallow-water areas, where it is used to stun fish, which are then collected from the surface or the seabed. The explosions are highly damaging to the benthic reef communities, with branching coral forms being particularly vulnerable. The blasts usually affect an area of 4 to 5m in diameter and can reduce mature coral growth to rubble within a few seconds (Richmond, 1997). Considering the comparatively small areas usually affected by dynamite fishing compared to the extent of the coral rubble around Tecomaji and Rongui islands, it is unlikely that the coral damaged observed can be attributed to this fishing method.

Tropical storms (cyclones, hurricanes or typhoons) are the most severe form of mechanical disturbance of coral reefs. In a study conducted on the Great Barrier Reef in Australia following the Category 4 Tropical Cyclone, Ingrid, it was found that winds in excess of 33m/s caused catastrophic damage on inshore and offshore reefs. While offshore reefs had the deepest depth of damage, inshore reefs had the greatest rates of coral breakage and dislodgement. For example, on a severely affected inshore reef, hard coral cover and taxonomic richness decreased while massive coral cover remained unaltered (Fabricius et al., 2008). Harmelin-Vivien (1994), however, points out that cyclone-induced damage to reef communities is highly variable and related to factors including cyclone characteristics, location of the reef to the storm path, reef topography, characteristics of the pre-storm communities, their location and depth on the reef and the time elapsed since the previous disturbance.

The most recent cyclones to affect the Mozambique coastline were Cyclone Jokwe (Category 3 storm), which raged across central and northern Mozambique in March 2008, and Cyclone Favio (Category 4 storm), which struck the central province of Inhambane in February 2007. Of these, Cyclone Jokwe may have affected the Study Area, with similar (although probably not as extreme) effects as described by Fabricius et al. (2008).

North of Tecomaji Island and south of Rongui Island, the occasional specimen of COT starfish was observed. This starfish has gained notoriety as a threat to coral reef ecosystems, particularly in the Great Barrier Reef off the coast of

(1) The use of dynamite in fishing is forbidden in Mozambique; however, the Fisheries Council of Palma confirmed the use of dynamite around the corals in Palma Bay and elsewhere (2012).

Australia. It feeds on live coral polyps by climbing onto a reef structure and then extruding its stomach onto the coral. This releases digestive enzymes that allow the starfish to absorb nutrients from the liquefied coral tissue. Overpopulation of COT has been blamed for widespread reef destruction, although it has been pointed out that the starfish has an important and active role in maintaining coral reef biodiversity, driving ecological succession by preventing fast-growing corals from overpowering the slower-growing coral varieties. However, when coinciding with other factors negatively affecting the reef ecosystem, such as coral bleaching or coral specific diseases, overpopulation of COT can cause permanent and devastating damage.

In 1995, the reefs of Mozambique experienced a COT starfish outbreak, which in the following three years resulted in 80 percent coral mortality in the Bazaruto area and reduction of coral cover to 2 to 5 percent in the Inhambane area (Motta et al., 2002). Towards the end of this infestation, the western Indo-Pacific was subject to a wide-scale El Niño Southern Oscillation (ENSO) between 1997 and 1998. The elevated sea temperatures associated with this ENSO resulted in regional coral bleaching, the extent and impacts of which showed a strong north–south gradient. The bleaching and mortality started in the south in February/March 1998, terminating in the north in May that year (Schleyer et al., 1999; Motta et al., 2000; Motta et al., 2002; Obura et al., 2000). The northern Mozambican reefs, previously known for their great biodiversity, suffered most, with coral mortality on some patch reefs as high as 99 percent being reported. Reefs in sheltered bays, which experience higher levels of nutrients and turbidity from land run-off, as well as variance in surface water temperatures, were least affected (Motta et al., 2000; Obura et al., 2000).

Following the event, there were significant increases in foliose, turf, calcareous and coralline algae growing on the newly dead coral surfaces which, in turn, influenced the abundance of herbivorous fish populations. Subsequent coral monitoring surveys conducted in Mozambique as part of the Coral Reef Degradation in the Indian Ocean (CORDIO) programme have found evidence of recovery on some reefs on which soft corals are the primary colonisers (Motta et al., 2000, Motta et al., 2002).

The coral species that suffered the highest bleaching and mortality were typically fast-growing branching species with high sexual or asexual reproduction rates and competitive overgrowth (eg *Acropora*, *Pocillopora*, *Stylophora* and *Seriatopora*, which showed up to 100 percent bleaching). Many of the surviving species were the slower-growing massive, sub-massive and encrusting forms, which rarely dominate reef communities (Obura et al., 2000). Obura et al predicted that the bleaching event would have profound impacts on the structure and growth rates of the Mozambican coral reefs for many years, with the possibility of eventual collapse of the reef structure (Motta et al., 2000). Any future ENSO events may thus have very different impacts on the evolving reef community structure, due to overall species changes in these coral communities. Large-scale El Niño events may be 'selecting' specific gene pools that are more resistant to temperature impacts.

Video footage and photographic data collected from the coral reefs in the Palma Bay area, confirm the above findings to a large degree. Soft corals appeared to be the primary colonisers in damaged shallow reef areas, although there was also evidence of substantial recovery of branching forms on both the reef flats and towards the drop-offs. The coral rubble comprised primarily broken branched coral forms (which are, however, also the most sensitive to cyclone damage), and collapse of the reef structure was evident at the sites surveyed towards the drop-offs.

7.9 NEAR SHORE ENVIRONMENT – MAJOR BIOLOGICAL FEATURES

7.9.1 Fish

There are no survey data available for fish within Palma Bay. However, being part of the Quirimbas Archipelago, it is probable that the fish species recorded for coral reef and seagrass biotopes to the south of Palma Bay will occur in the bay.

Of the larger pelagic species, Spanish mackerel (*Scomberomorus commerson*) have been recorded off Cabo Delgado (Saetre & da Silva, 1979). It is noteworthy that juvenile Spanish mackerel (2 to 3cm in length) were caught off the Cabo Delgado coast in April 1978 during the Dr Fridtjof Nansen survey, indicating spawning activity for this species during this period of the year at that location or nearby. Surface schools of yellowfin tuna (*Thunnus albacares*) have been observed in the region and are fished at industrial and artisanal scales (see *Chapter 9* for information on fisheries). Other large pelagic species in the coastal waters include sailfish (*Istiophorus platypterus*), marlin (*Makaira indica, M. mazara, Tetrapterus angustirostris, T. audax*), wahoo (*Acanthocium solandri*), albacore (*Thunnus alalunga*), skipjack tuna (*Katswomus pelamis*), bonito (*Gymnosarda unicolor*), narrow-banded Spanish mackerel (*Scomberomorus japonicus*), swordfish (*Xiphias gladius*), great barracuda (*Sphyraena barracuda*), giant trevally (*Caranx ignobilis*) and bluefin trevally (*Caranx melampygus*).

Sharks caught in these waters include the bull shark (*Carcharhinus leucas*), blacktip shark (*C. limbatus*), dusky shark (*C. obscurus*), hammerhead sharks (*Sphyrna* spp.) and tiger shark (*Galeocerdo cuvier*).

These larger pelagic species described above are wide ranging and will certainly occur in the area, even if confined to deeper waters at the entrance to Palma Bay. The summary below focuses on coral reef and seagrass bed associated species likely to be present in the bay area (Impacto, 2008). Data related to fish associated with coral reefs and seagrass beds are based mainly on data derived from the Darwin/Frontier Mozambique Quirimbas Archipelago Marine Research Programme (DFMQAMRP) (April 1996 to December 1997).

Fish Associated with Coral Reefs

The species diversity of fish associated with coral reefs is high. Pereira (2000) has drawn up a checklist of reef-associated fishes of Mozambique that lists 601 species comprising 27 families.

Detailed surveys of the southern Quirimbas islands have been carried out under the auspices of the DFMQAMRP. The researchers identified 375 reef-associated fish species from 57 families (*Table 7.11*). The number of reef-associated fish species in the northern Quirimbas (eg Palma Bay) is likely to be higher.

Table 7.11 Number of Species per Family of Reef Fishes Recorded for the Southern Quirimbas Archipelago Islands

Family	Common Name	No. of Species
Acanthuridae	Surgeon fishes	22
Antennaridae	Frog fish	1
Anthiinae	Fancy sea basses	3
Apogonidae	Cardinal fishes	10
Aulostomidae	Trumpet fishes	1
Balistidae	Trigger fishes	12
Belonidae	Needle fish	2
Blenniidae	Blennies	6
Bothidae	Lefteye flounders	2
Caesionidae	Fusiliers	8
Callionymidae	Dragonets	2
Carangidae	King fishes	11
Carcharhinidae	Requiem sharks	3
Chirocentridae	Wolf herrings	1
Chaetodontidae	Butterfly fishes	21
Cirrhitidae	Hawk fishes	4
Clupeidae	Herrings, shads	2
Cynoglossidae	Tongue fishes	1
Dactylopteridae	Flying gurnards	1
Dasyatidae	Sting rays	2
Echeneidae	Shark suckers	2
Engraulidae	Anchovies	1
Entriscidae	Shrimp fish	1
Fistulariidae	Cornet fishes	2
Gerreidae	Mojarras	2
Gobiidae	Gobies	5
Grammistidae	Soap fishes	1
Haemulidae	Rubberlips and grunters	10
Hemiramphidae	Halfbeaks	3
Holocentridae	Squirrel fishes	8
Kyphosidae	Drummers	1
Labridae	Wrasses	45
Lethrinidae	Emperors	15
Lutjanidae	Snappers	13
Microdesmidae	Worm fishes	1
Monacanthidae	File fishes	5
Mullidae	Goat fishes	16
Muraenidae	Moray eels	2
Nemipteridae	Threadfin breams	2
Ostraciidae	Box fishes	2
Pegasidae	Sea moths	1
Family	**Common Name**	**No. of Species**
Pinguipedidae	Sand perches	2
Platacidae	Bat fishes	2
Platycephalidae	Flatheads	3
Plotosidae	Cat fishes	1
Pomacanthidae	Angel fishes	12
Pomacentridae	Damsel fishes	20

Priacanthidae	Bigeyes	2
Rhynchobatidae	Guitar fish	1
Scaridae	Parrot fishes	18
Scombridae	Mackerel	1
Scorpaenidae	Scorpion fishes	6
Serranidae	Groupers	21
Solenostomidae	Pipe fishes	1
Siganidae	Rabbit fishes	4
Stegostomatidae	Zebra sharks	1
Syngnathidae	Seahorses	5
Synodontidae	Lizard fishes	2
Teraponidae	Tiger fishes	2
Tetraodontidae	Puffer fishes	13
Tetrarogidae	Wasp fishes	1
Triglidae	Sea robins	1
Zanclidae	Moorish idol	1

Source: Whittington et al., 1998.

Fish Associated with Seagrass Beds

Gell (1997) identified 195 species of fish from 52 families caught by seine nets and basket traps over seagrass beds in the Quirimbas Archipelago. The family Lethrinidae accounted for the largest proportion of fish (31.5 percent, while family Siganidae accounted for 22 percent and Scaridae represented 11 percent. There were 29 species of wrasse (Labridae) identified, and the family accounted for over 9 percent of all fish caught.

Although the dominant species varied considerably from day to day and even between hauls, nearly 70 percent of the catch samples by weight were accounted for by the following five species: *Siganus sutor* (Siganidae, 25.1 percent), *Lethrinus lentjan* (Lethrinidae, 23.9 percent), *Leptoscarus vaigiensis* (Scaridae, 8.8 percent), *Lethrinus variegatus* (Lethrinidae, 8 percent) and *Gerres oyena* (Gerreidae, 3.5 percent).

7.9.2 Turtles

Five species of marine turtle have been documented to occur along the Mozambican coast, as follows:

- green (*Chelonia mydas*);
- hawksbill (*Eretmochelys imbricata*);
- loggerhead (*Caretta caretta*);
- leatherback (*Dermochelys coriacea*); and
- olive Ridley (*Lepidochelys olivacea*).

All of these species are considered to be vulnerable to extinction by the IUCN (2011). The leatherback and hawksbill turtles are considered Critically Endangered, the loggerhead and green turtles Endangered and the olive Ridley Vulnerable.

The distribution of sea turtles in the region, documented by CSA (2007), indicates that turtles were four times more abundant in the waters of Quirimbas National Park than on the northern part of the Archipelago, outside the Park. The turtles observed outside the Park were most numerous in the deep waters around the Macaloe and Medjumbe islands, located more than 100km south of Palma Bay.

Recent studies undertaken by the Maulane Group in conjunction with the London Zoological Society on the islands of Vamizi, Rongui and Macaloe, indicate that green and hawksbill turtles nest on the islands (Hill & Garnier, 2003). Turtle nesting occurs throughout the year. On Vamizi Island, turtle nesting peaks in January and August, while on Macaloe Island, the turtles have their nesting peak between November and May.

Mainland beaches in Palma Bay are steep and the high tide levels extend to the top of the beach (eg *Figure 7.40*). These beaches are therefore unsuitable for turtle nesting, as nests will have a high probability of flooding. Turtle nesting has been recorded on Rongui Island (Hill & Garnier, 2003) and is also reported to occur on Tecomaji Island (Luke Verburgt, Enviro-Insight, pers. comm., 2012).

7.9.3 Whales and Dolphins

Seventeen species of whales and dolphins have been recorded in near shore waters in the region (*Section 7.6.5*). Three of these are known to enter Palma Bay, namely humpback whales, humpback dolphins and bottlenose dolphins. The balance may episodically occur in the bay or around the fringing islands.

Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) are common in the region and enter sheltered coastal waters inshore of the offshore islands. Indo-Pacific humpback dolphins (*Sousa chinensis*) also occur in these areas and are considered to be restricted to shallow water (<50m, Best, 2007). Humpback whales (*Megaptera novaeangliae*) are seasonal visitors to the inner continental shelf areas for calving and breeding. This species is generally present in northern Mozambique waters between July and November (see *Table 7.5*).

All whales and dolphins are generally wide ranging (Best, 2007), and it is expected that all the species listed in *Table 7.5* may enter shallow coastal waters. Sperm whales are probably the exception here, as they appear to be confined to deep water offshore of the continental shelf break.

Humpback whales are seasonally present in northern Mozambique between July and November, using the region and further north to Kenya for calving

and mating (Best, 2007). Humpback dolphins are an inshore species, and pairs and groups of up to 15 to 20 individuals were observed recently (2011/2012) in Palma Bay (Lwandle field surveys; Luke Verburgt, Enviro-Insight, pers comm.). It is probable that individuals or groups are resident in the system, but the overall distribution of the population is widespread along the African coast, extending from at least the equator to 35°S (Best, 2007). A school of 30 to 40 bottlenose dolphins have been observed in the mouth of Palma Bay (between Cabo Delgado Peninsula and Tecomaji Island) (Lwandle field surveys) and it is considered to be highly probable that they are frequent visitors to the bay. As with humpback dolphins, bottlenose dolphins are widely distributed along the African coast. However, unlike them, they also extend into deeper water, having been recorded from the Walters Shoal, south of Madagascar (Best, 2007).

7.9.4 Seabirds

The coastal seabirds recorded from the region are listed in *Table 7.12*. Nineteen species are known to occur in the coastal area, but it is likely that some offshore species (*Table 7.12*) extend into the coastal waters because of the very narrow continental shelf, eg frigate birds. These seabirds may occur in Palma Bay.

Common and lesser crested terns were the most common seabird sighted within waters of the continental shelf edge during a 2007 CSA offshore habitat characterisation survey (CSA, 2007).

Table 7.12 Coastal Seabirds of Northern Mozambique and their 2011 IUCN Listing Status

Common Name	Species	Seasonality	IUCN Listing Status
Lesser frigate bird	*Fregata ariel*	n/a	LC
Greater frigate bird	*Fregata minor*	n/a	LC
Grey-headed gull	*Larus cirrocephalus*	n/a	LC
Lesser black-backed gull	*Larus fuscus*	n/a	LC
Little tern	*Sterna albifrons*	n/a	LC
Caspian tern	*Sterna caspia*	n/a	LC
Gull-billed tern	*Sterna nilotica*	n/a	LC
Sandwich tern	*Sterna sandvicensis*	Summer	LC
Lesser crested tern	*Sterna bengalensis*	Summer	LC
Swift (greater crested) tern	*Sterna bergii*	n/a	LC
Common tern	*Sterna hirundo*	Summer	LC
Sooty tern	*Sterna fuscata*	n/a	LC
Whiskered tern	*Chlidonias hybridus*	n/a	LC
White-winged tern	*Chlidonias leucopterus*	Summer	LC
African skimmer	*Rynchops flavirostris*	n/a	NT
Pink-backed pelican	*Pelecanus rufescens*	n/a	LC
Eastern (great) white pelican	*Pelecanus onocrotalus*	n/a	LC
Common Name	**Species**	**Seasonality**	**IUCN Listing Status**
Reed cormorant	*Phalacrocorax africanus*	n/a	LC
White-breasted (great) cormorant	*Phalacrocorax carbo*	n/a	LC

Key:

LC = Least Concern; NT = Near Threatened; VU = Vulnerable.

Source: Newman, 2002; Sinclair and Ryan, 2003; IUCN, 2011.

During the marine ecology dry (November 2011) and wet (March 2012) surveys undertaken by Lwandle, seabird sightings were limited to swift and common terns. The intertidal shore-based birds observed during the avifaunal surveys undertaken by Enviro-Insight are detailed in *Chapter 8*.

Chapter 8

Environmental Baseline – Onshore

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8 ENVIRONMENTAL BASELINE – ONSHORE

8.1 INTRODUCTION

This chapter provides a description of physical and biological aspects of the Project's onshore environment, and is structured as follows:

- *Section 8.2:* Geology and Terrain;
- *Section 8.3:* Soils and Land Capability;
- *Section 8.4:* Groundwater;
- *Section 8.5:* Hydrology;
- *Section 8.6:* Surface Water Ecology;
- *Section 8.7:* Vegetation;
- *Section 8.8:* Herpetofauna;
- *Section 8.9:* Avifauna;
- *Section 8.10:* Mammals; and
- *Section 8.11:* Summary of Key Environmental Sensitivities.

In order to describe the baseline conditions in the Afungi Project Site (illustrated in *Figure 8.1*), specialists undertook surveys over two seasons and mapped out areas of sensitivity within the Afungi Project Site with respect to their individual disciplines. The terrestrial ecology baseline (*Sections 8.6* to *8.10*) outlines the sensitivities found and identifies habitats that provide important ecological functions or support species of conservation importance [(1)]. It is crucial to note that the sensitive habitats discussed in this chapter indicate sensitivity to change and are not necessarily an indicator of importance relative to other similar habitats that extend for several tens of kilometres south of the Rovuma River. The relative importance of habitats is considered when assessing the degree of significance of potential impacts on those habitats. Together, sensitivity and relative importance are used to provide guidance to the Project with respect to informing site layout mitigation measures.

Reference is made throughout this chapter to the conservation status of species according to the IUCN Red List of Threatened Species (IUCN, 2012), which is further detailed in *Chapter 6*.

(1) The identified habitat types have been characterised as modified or natural and the presence of alien/invasive species have been recorded.

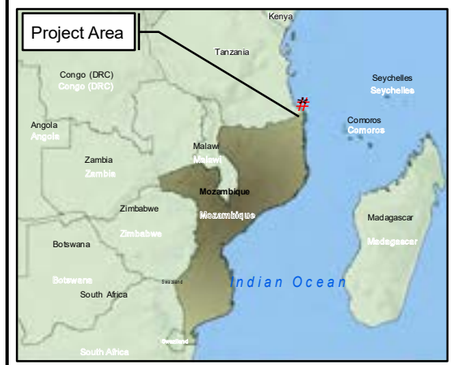
40°25'0"E 40°30'0"E 40°35'0"E 40°40'0"E

Quiwia
Cabo Delgado Peninsula
Palma Bay
Palma
Tecomaji Island
Barabarane
Ntaunadje
Manguna
Quitupo
Nambuimbui
Nkalanga
Nacabande
Afungi Peninsula
Macala
Quitunda
Quidjeri
Senga
Namacande
Maganja
Nkumbi
Patacua
Rongui Island
Matapata
Queramimbi Island
Bawala
bing
© Harris Corp, Earthstar Geographics LLC State of Michigan

40°25'0"E 40°30'0"E 40°35'0"E 40°40'0"E

Legend

- Villages / Settlements
- Local Roads
- Regional Roads
- Afungi Project Site



MAIN MAP SCALE:

Kilometers

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Figure 8.1:
Afungi Project Site

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 120 000

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10°40'0"S

10°45'0"S

10°50'0"S

10°55'0"S

Projection: UTM Zone 37 S Datum: WGS84 Source: Bing Maps ©2010 Microsoft Corporation. AMA1, 2011. Inset Map: Esri Data & Maps	SIZE: A3

8.2 GEOLOGY AND TERRAIN

8.2.1 Regional Geology

The onshore portion of the Rovuma Basin, consisting of unconsolidated sand deposits, is approximately 120km wide. Broadly, the upper 2,000 to 3,000m of sediments comprises deltaic deposits underlain by Cretaceous age Maconde Sandstone and marlstones, and the upper Cretaceous Pemba Formation Sandstone Member. The regional geology is illustrated in *Figure 8.2*.

Tectonic activity, especially faulting and other displacement over geological time, has created breaks in the continuity of the formations of various ages. Faults are typically oriented north to south and roughly parallel to the coast. These are mostly normal, east side down faults, and are interpreted as listric growth faults through the Tertiary sediments.

The Afungi Peninsula is located in the Rovuma Sedimentary Basin on the coastal plain and consists of undulating topography. The coastal plain was formed by sedimentation and erosion processes active throughout the Neogene geological period and more recent geologic history as extension from the east and uplift in the west contributed to formation of the coastal landforms. Within approximately 5km of the coast, elevations average 30m above sea level. Within 10 to 15km, elevations reach up to 100m. The stratigraphic development is related to the tectonic activity, including offshore rifting as well as uplift and faulting associated with the East Africa Rift System.

The upper 2,000 to 3,000m of sediments formed as an eastern thickening wedge of deltaic deposits—a deltaic progradation (Key et al., 2008). At great depth are the older, Cretaceous age Maconde Sandstone and marlstones, and the upper Cretaceous Pemba Formation Sandstone Member. These older formations are overlaid by fine textured marine sandstones (early Tertiary in age), which are in turn overlaid by the Mikindani Formation, a ferruginous sandstone and conglomerate, the predominant bedrock formation. It is exposed in places through the overlying Quaternary age unconsolidated sediments. Its thickness, according to literature, is variable: 30 to 675m.

However, AMA1 reportedly encountered a formation thickness of 1,100m.

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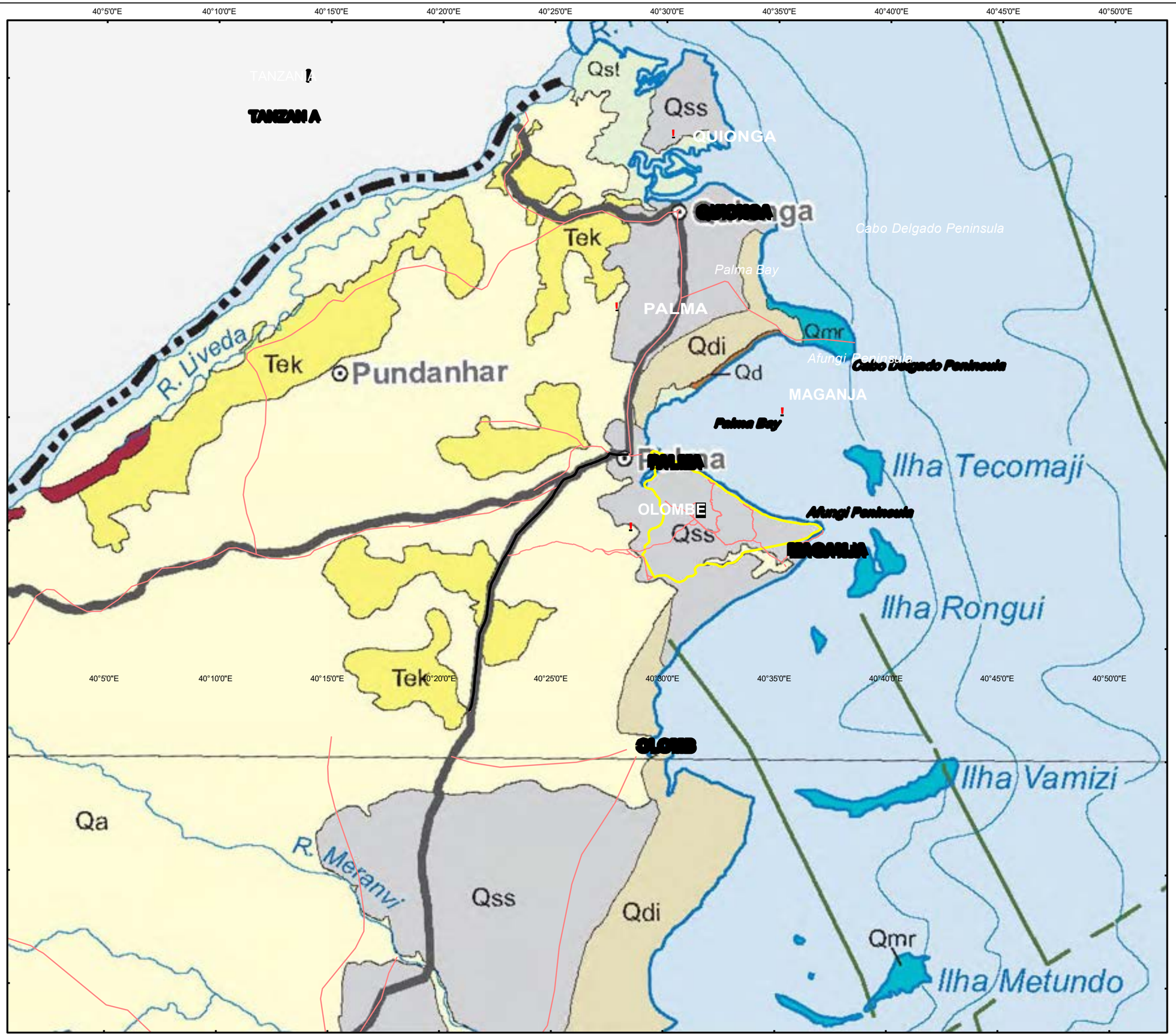

Legend

- Villages / Settlements
- Local Roads
- Afungi Project Site

Geology

- Meso-Cenozoic oceanic fault
- Meso-Cenozoic oceanic rift limit

- Qa - Alluvium, silt, gravel, debris, mud. Estruarine, tidal flat, back-barrier, interdune, mangrove swamps and salt marsh sediment
- Qd - Coastal dune and sand
- Qdi - Interior dune; aeolian sand Topuito Formation
- Qmr - Marine reef and bioclastic sediment
- Qss - Sand sheet with local gravel
- Qst - Fluvial marine mud
- Tek - Mikindani Formation

Project Area

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 8.2:
Geology of Northern Coastal Mozambique

CLIENT:

Anadarko
Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
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Projection: UTM Zone 37 S Datum: WGS84
Source: Worley Parsons, 2012
Inset Map: Esri Data & Maps

SIZE:
A3

10°30'0"S
10°35'0"S
10°40'0"S
10°45'0"S
10°50'0"S
10°55'0"S
11°0'0"S
11°5'0"S
11°10'0"S

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8.2.2 *Local Geology*

The Afungi Project Site is located on recent to Tertiary age units with the near-coast areas covered with recent (Quaternary) unconsolidated deposits that include dunes, low coastal deposits and stream sediment deposits, as well as reef and coral formations, lacustrine and tidal zone sediments and surface soils. These deposits are underlaid by the Mikindani Formation; a Miocene–Pliocene age fluvial sandstone and conglomerate formation. Beneath the western portion of the site, the predominately sandy sediments are underlaid by weathered, dark grey, very soft rock siltstone and mudstone at depths varying from approximately 23m to greater than 90m below existing ground level. These sedimentary rocks are probably the Mikindani Formation of Miocene age.

The Mikindani Formation lithology is divided into lower sandstone with basal conglomerate beds overlying an unconformity, and an upper thicker and generally sandier section. The thickness of the formation varies from 30 to 675m (Ferro & Bouman, 1987; Key et al., 2008). The sandstones are described as massive, red-brown and burrow-mottled. The ancient Royuma River Delta is thought to have deposited much of the Mikindani Formation.

The Afungi Project Site is underlaid by, in descending order, gravel to fine-grained size alluvium, Mikindani Formation sandstone and conglomerate, and deeper Tertiary sandstones and carbonates (AMEC, 2011). Sand dominates 70 percent of the Afungi Project Site and originated from marine alluvial deposits (Insitituto de Investigacao Agronomica de Mocambique, 1972).
A number of faults are present in the area and these are being studied further. These generally trend north-south, roughly parallel to the coast. Most of these are normal, north-striking, east dipping listric faults.

8.3 *SOILS AND LAND CAPABILITY*

A soils and land capability study was undertaken within the Afungi Project Site [(1)]. Due to constraints accessing some parts of the site at the time of the fieldwork (due to the risk of UXOs), the baseline surveys were largely restricted to the Onshore Project Footprint Area (ie surrounding areas that had not been declared clear of landmines were avoided). The results were extrapolated for the rest of the Afungi Project Site (Area 2 in *Figure 8.3*), based on specialist interpretation of satellite imagery. These areas are illustrated in *Figure 8.3*.

8.3.1 *Soils and Land Use*

Currently, the main land use within the Afungi Project Site is subsistence agriculture (including cassava, rice and coconut) and minimal livestock

(1) This study was undertaken by Digby Wells Environmental.

grazing. Small-scale farms or '*machambas*' (fragmented cultivated lands) are evident across the Afungi Project Site between open savannah woodland/bushland. Rice is cultivated in wetlands situated in lowlands along waterways. It is apparent that the local livelihood is dependent on the soil resource.

The soils in the Afungi Project Site comprise two soil units of significance:

- a large area comprising all land outside of the wetland zones (estuaries and marshes). This area comprises deep grey/white sands, referred to as sand units or S-Units; and
- areas representing the wetland zones, which include the estuaries, marshes and drainage course zones. These are referred to as wetland units or W-Units.

The distribution of these two soil units are illustrated in *Figure 8.4*.

40°30'0"E 40°32'0"E 40°34'0"E

AREA 1

AREA 2

Helipad

Pit1

Pit2

Legend

- Soil Sampling Points
- Soil Observations Points
- Local Roads
- Area 1
- Area 2
- Afungi Project Site

Project Area

Kenya, Tanzania, Congo (DRC), Angola, Zambia, Zimbabwe, Botswana, South Africa, Malawi, Mozambique, Seychelles, Comoros, Madagascar, Indian Ocean

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 8.3:
Soil Study and Survey Areas (including Observation and Sampling Points)

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 35 000

DRAWING: Soil Study and Survey Areas.mxd

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Projection: UTM Zone 37 S, Datum: WGS84 Source: Promap, 2012, Digby Wells, 2012 Inset Map: Esri Data & Maps	SIZE: A3

10°52'0"S

10°48'0"S

10°50'0"S

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10°52'0"S

10°48'0"S

10°50'0"S

Legend

- Villages / Settlements
- Local Roads
- Afungi Project Site
- W-Unit- Wetland Unit
- S-Unit- Sand unit

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 8.4:
Distribution of Soil Units

CLIENT:

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Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 50 000

DRAWING: Distribution of Soil Units.mxd

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Projection: UTM Zone 37 S, Datum: WGS84 Source: Digby Wells, 2012 Inset Map: Esri Data & Maps	SIZE: A3

10°52'0"S
10°46'0"S
10°48'0"S
10°50'0"S
40°30'0"E
40°32'0"E
40°34'0"E
40°36'0"E

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The Sand Unit (S-Unit)

The majority of the soils encountered outside of the wetland zones in the S-Unit comprise sand of the orthic phase, classified as a Namib soil type (Nb) [(1)]. Infrequent occurrences of the Longlands form were observed, which is typically associated with wetland soils [(2)].

The physical characteristics of the S-Unit conform to the following:

- topsoil and subsoil (horizons) for the investigated depth of 150cm;
- in most cases, both horizons comprised pure medium to coarse sand and thus were without structure and had a loose consistency;
- the more organic rich topsoil ranged from 10 to 20cm in depth;
- grey-whitish coloured subsoil (quartz grains) made up the rest of the depth;
- clay content in both layers was estimated to be lower than 10 percent [ie pure sand in classification terms (MacVicar et al., 1991)];
- the ever-present process of leaching drains the sand very easily, resulting in inherent low fertility;
- the profile properties provide an inherent extremely high erosion hazard, especially on increased gradients (such as stockpiles); and
- rates for permeability in sands are classed as very rapid. Percolation rates of over 15cm/h serve as a reference (Pitty, 1979); therefore, water-holding capacities will be low.

Given the characteristics described above, the sand cannot be regarded as a high-potential crop production medium. However, due to the sandy nature of the soils, the following risks and sensitivities may arise.

- Constituents transported by surface water could potentially infiltrate rapidly into the sand and pose a risk to underlying groundwater.
- Sand will be highly susceptible to erosion where exposed (site clearance, stockpiles).
- A decrease in the fertility status can be expected during disturbance of the upper layers of the soil profile in which topsoil formation occurs.

(1) Classified according to MacVicar et al., 1991.

(2) Classified according to MacVicar et al., 1991.

Figure 8.5 Typical Profiles of the S-Unit

Left: Point # 135 – a typical sand profile within the Afungi Project Site. Right: Point # 155A – sand profile on the coastline.

Source: Digby Wells, 2012.

The Wetland Soil Unit (W-Unit)

Wetlands can be defined as ecosystems that are transitional between terrestrial and aquatic systems, where the water table is usually at or near the surface, or where the land is periodically covered with shallow water, and where this land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil. (1)

A number of soils associated with wetlands were grouped to make the W-Unit. Wetness indicators are a main characteristic of all wetland soils, and are found in the soil in the form of grey colours, often in association with mottles or stains. The grey colouring and mottling are caused by a prolonged exposure to wet and dry phases and are induced by a fluctuating water table. The colour of the mottles can vary between yellow, orange, red and black, and combinations are commonly found.. Four main soil types were identified in the delineated wetlands and comprise the greatest percentage of the W- Unit, in accordance with *Soil Classification – A Taxonomic System for South Africa* (Department of Agricultural Development, 1991):

- Ka – Katspruit (wetland soil, permanent wet subsoil);
- Ch – Champagne (organic wetland soil);
- Kd – Kroonstad (wetland soil, permanent wet subsoil); and
- Lo – Longlands (seasonal wet subsoil).

The physical characteristics of these four soil types are summarised in *Table 8.1* and their related properties are outlined below:

(1) Definition from South Africa National Water Act, 1998.

- very dark or greyish top layer varying between 15 and 60cm in depth;
- the dark variations relate to a significant content (5 to 10 percent) of organic carbon. The high organic matter content is also responsible for a heavier soil texture;
- the subsoil comprises grey loamy to clayey layers, showing variations in clay content from 5 to 40 percent. However, variation per soil type is less;
- in some cases, a sandy layer separates the topsoil and clay (Kd and Lo forms);
- infiltration rates will vary from extremely rapid (sands) to very slow (clays); and
- water-holding capacities vary from 60mm/metre in the sandy top (A) and subsoils (B, E, C) to between 90 and 120mm/metre in the heavier textured layers (G).

Figure 8.6 Profiles of the W-Unit

Top left: Point # 196 – Ch or Ka soil type in the W-Unit (note the very dark top layer). Top right: Point # 1AF – Lo profile. Bottom left: Point # 346A – Ch profile (dark topsoil underlaid by sand). Bottom right: Point # 295A – profile in a mangrove area.

Source: Digby Wells, 2012.

Table 8.1 Characteristics of W-Unit Soils

Soil Type Code	% of Wetland Unit	Summarised Description of Soil Type	Depth Interval per Layer (cm)	Estimated Clay Content Range per Layer	Texture Class per Layer	Permeability of Profile
Ka	30	A two-layer soil profile typical of wetland zones. Grey top layers overlie grey mottled clayey bottom layers. Water tables are commonly found.	**A**: 0-10/20 **G**: 10/20-30/100	**A**: 5-40 G: 15-40	**A**: Sand to clay **G**: Sandy loam to loam to clay	Rapid (sand) to very slow (clay)
Ch	30	The soil profile occurs in parts of wetlands with abundant vegetative cover.. Very dark organic-rich top layers characterise the profile to depths beyond the usual 20/30cm and overlie sand to grey loamy bottom layers, occasionally dark blotched.	**O**: 0–20/60 **C**: 20/60–60/140	**O**: 10–35 **C**: 5–20	**O**: Silty loam to silty clay loam **C**: Sand to loam/silty loam	Moderate to rapid
Kd	20	A three-layer soil profile typical of wetlands. Beneath top sand, a leached sandy sub-layer overlies an orangey spotted and streaked bottom layer with significantly heavier texture.	**A**: 0–20/30 **E**: 20/30–30/75 **G**: 30/75–50/130	**A**: ≤5 **E**: ≤5 **G**: 15–35	**A**: Sand **E**: Sand **G**: Sandy loam to clay loam	Rapid (sand) to very slow (clay
Lo	15	A three-layer soil profile typical of wetlands and similar to the Kd for the first two layers, after which a somewhat heavier textured and mottled bottom layer follows.	**A**: 0–10/30 **E**: 10/30–30/120 **B**: 30/120–60/135	**A**: ≤5 **E**: ≤5 **B**: 5–20	**A**: Sand **E**: Sand **B**: Sand to sandy loam	Rapid

Source: Digby Wells, 2012.

The W-Units are regarded as highly sensitive due to their important functioning in the ecosystem, and for the following reasons:

- Wetlands play an important role in surface drainage and serve as a mechanism to recharge the groundwater system.
- Contamination of wetlands may lead to the transportation of potentially hazardous elements to the soil resource adjacent to and beneath them, posing potential risk to groundwater resources and nearby coastal waters.

8.3.2 Land Capability

A combination of terrain form, soil types, thickness and slope gradients in association with broad agricultural potential, define the land capability of an area (GDACE, 2008). Land capability can also be defined as an interpretive grouping of land units with similar potentials and continuing limitations or hazards. Land capability is a more general term than land suitability and is more conservation orientated. Land capability is also defined as the most intensive long-term sustainable use of land under rain-fed conditions. Land capability should aim to provide an objective basis for establishing post-use capability targets. Based on these definitions, two land capability classes were assigned for the Study Area (*Figure 8.7*):

- a combination of arable [1] (A)and grazing (G) capability ('A/G') for the S-Unit; and
- a wetland capability for the W-Unit.

Land Capability of the S-Unit

Where commercial cropping is practised, a grazing capability class would most probably be assigned to the Survey Area, due to factors such as low fertility and easily leachable status. The low fertility and ready leaching would require high management and cost inputs that would, in most cases, exclude it from a cropping production recommendation. In the Survey Area, the current land use is for food production exclusively. The land capacity of the S-Unit is considered to include a combination of grazing and arable capability.

Land Capability of the W-Unit

The wetland areas are defined in terms of the wetland delineation guidelines, which use hydrology, soil topography and vegetation criteria to define the limits of these areas. The zone is dominated by hydromorphic and organic soils and plant life that are associated with the wetland. Two of the four main soils found in the wetland zones are associated with permanent wetland zones (DWAF, 2003).

(1) Arable describes land that can be cultivated for growing crops.

The soils of the wetlands in the Survey Area are grey to black in the topsoil horizons. Transported clays, with pronounced mottling on gleyed backgrounds, characterise the subsoils. The soils occur within the zone of groundwater influence. The combination of soil types and hydromorphic vegetation was used to derive the wetland land capability classification for the W-Unit.

8.3.3 Soil – Chemical and Physical Properties

Table 8.3 contains the soil analytical results for the dominant soil types observed in the Study Area. The sampling locations are illustrated in *Figure 8.3*.

Organic carbon (C) in the topsoil ranges from 0.12 to 0.73 percent in the sandy topsoils. Generally soils with a C content of around 1 percent can be cultivated. Soil with a C content of less than 1 percent is considered to be low but expected for soil under tropical climatic conditions. The W-Unit soil, however, contains between 4.96 and 10.01 percent C. This is to be expected, because organic material cannot be oxidised easily under permanent waterlogged soil conditions and therefore accumulates in the topsoil.

The sodium (Na) content of the soil samples is generally high in relation to calcium (Ca), magnesium (Mg) and potassium (K). Na accumulates in soils because of the close proximity of the sea. The exchangeable sodium percentage (ESP column in *Table 8.2*) indicates the ratio of Na to the total Ca, Mg and K soil content. Generally, soil physical problems can be expected when the ESP exceeds five. Na is a large hydrated ion and causes clay dispersion if it is present in high concentrations on the soil clay exchange complex compared to other cations present [1]. Dispersion of clay particles will block soil pores, preventing rainwater infiltration. The clay content is, however, low and might not prevent the infiltration of rainwater.

Phosphorus (P) or fertility status, as outlined in *Table 8.2*, is low. P is an important macronutrient and the P content, with a low of 1 and a high of 5mg kg^{-1}, is considered very low and indicative of very poor P soil status. Generally, soil P content needs to be 20-30 mg kg^{-1} to sustain agricultural crops.

The K fertility status of the soils is low. K is also an important macronutrient needed for optimal crop production. Generally, the soil K content needs to be 200mg kg^{-1} to sustain agricultural crops.

The topsoil pH ranges from 4.6 to 6.3. This pH range is indicative of acidic soil conditions, not only in the topsoil but also in the subsoil. A liming programme would be needed to optimise soil fertility if gardening is considered. An optimal soil pH is considered to be pH 6.5.

1) A positively charged ion.

Legend

- Villages / Settlements
- Local Roads
- Afungi Project Site
- W: Wetland
- A/G: Arable / Grazing

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 8.7:
Land Capability

CLIENT:

Anadarko
Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
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10°52'0"S

10°46'0"S

10°48'0"S

10°50'0"S

Projection: UTM Zone 37 S, Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Digby Wells, 2012. Inset Map: Esri Data & Maps

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The soils in this area have a low cation exchange capacity (CEC). A low CEC reflects low soil clay and organic matter content because CEC is a property of both clay and organic material. The CEC ranges from 0.89 to 7.22cmol (+)kg^{-1} for the non-waterlogged topsoils. Low CEC implies low nutrient content, while the opposite is true for high CEC. The topsoil CEC of the waterlogged soil is 7.22 to 23.22cmol (+)kg^{-1}, indicating the build-up of organic matter in the topsoil due to the waterlogged conditions.

The size limits for sand, silt and clay used in the determination of soil texture classes are sand: 2.000 to 0.050mm, silt: 0.050 to 0.002mm and clay: < 0.002mm. The clay content range is from 1.9 to 6.5 percent in the topsoil, while the subsoil has similar clay content. The clay content of the two waterlogged topsoil samples is higher: 10.8 percent and 18.9 percent. Higher clay content is expected, because the position of the waterlogged soil in the landscape allows clay to accumulate over time.

Table 8.2 *Chemical and Physical Properties of the Dominant Soils Present*

Sample Point	ESP %	Org C %	CEC Cmol (+) kg^{-1}	K mg kg^{-1}	Ca mg kg^{-1}	Mg mg kg^{-1}	Na mg kg^{-1}	P (Bray1)mg kg^{-1}	pH (H_2O)	Sand %	Silt %	Clay %
AMA1 178A	56.34	0.73	3.34	120	94	135	433	1	4.6	90.1	3.4	6.5
AMA1 178E									4.7	96.8	1.2	2.0
AMA1 178G									4.8	94.5	1.2	4.3
AMA1 243A	32.49	0.26	0.89	17	289	45	66	5	5.4	97.0	1.1	1.9
AMA1 243C									5.7	97.0	1.1	1.9
AMA1 2601A	14.43	10.06	23.20	498	804	923	770	1	5.4	60.4	28.8	10.8
AMA1 2601G									5.9	77.6	6.0	16.4
AMA1 2601C									5.4	92.6	1.2	6.2
AMA1 61A	10.19	0.16	1.08	17	47	35	25	1	4.8	97.0	1.1	1.9
AMA1 61C									5.3	97.0	1.1	1.9
AMA1 293A	2.77	1.66	10.83	121	415	302	69	2	5.0	77.4	3.7	18.9
AMA1 333A	89.76	0.12	0.94	34	16	53	195	1	4.5	97.0	1.1	1.9
AMA1 333G									5.1	94.8	1.1	4.0
AMA1 295A	53.88	4.98	7.22	501	673	1,429	895	2	5.5	94.7	1.2	4.1
AMA1 295E									5.9	97.0	1.1	1.9
AMA1 94A	30.80	0.30	0.96	44	200	51	68	1	5.8	96.9	1.1	1.9
AMA1 94E									5.9	96.9	1.1	1.9
AMA1 94B									5.4	96.8	1.2	2.0
AMA1 13A	5.64	0.72	0.69	29	410	44	9	4	6.3	97.0	1.1	1.9
AMA1 13C2									6.6	97.0	1.1	1.9
AMA1 13C3									7.2	97.0	1.1	1.9
AMA1 343A	1.94	1.32	3.28	40	15	20	15	3	5.6	96.8	1.2	2.0
AMA1 343C									5.3	96.9	1.1	2.0
AMA1 302A	30.82	0.11	0.02	22	3	21	1	1	5.0	97.0	1.1	1.9
AMA1 302C									5.4	97.0	1.1	1.9
AMA1Helipad A	6.19	0.11	0.21	27	57	28	3	1	5.0	97.0	1.1	1.9
AMA1Helipad C									5.3	97.0	1.1	1.9

Source: Digby Wells, 2012.

8.3.4 Soil Erodibility

One of the key sensitivities of the soil in the Survey Area is the risk of erosion taking place where natural vegetative cover has been removed. Erodibility is defined as the vulnerability or susceptibility of a soil to erosion. It is a function of both the physical characteristics and the treatment of the soil. Both forms of erosion (wind and water) selectively carry off fine particles from the soil surface, and both are eliminated by mulching the soil or by providing an adequate plant cover. Wind erosion is very selective, carrying the finest particles, particularly organic matter (clay and loam), for many kilometres. Loamy sand, rich in particles between 10 and 100 microns in size, is the most vulnerable soil (Bagnold, 1937). More clayey soil is much stickier and better structured, and hence more resistant to wind erosion. Coarse sand is also more resistant, since the particles are too heavy to be removed by wind erosion. The less structure-improving matter a soil has on the surface (organic matter, iron and free aluminium, lime), the more susceptible it will be to erosion. Soil moisture increases the cohesion of sand and loam, temporarily preventing their erosion by wind.

Inferred erodibility for the soils of the Survey Area is illustrated in *Table 8.3*. It is evident that nearly all of the soils (top to bottom) observed are highly erodible. Where the soil will be disturbed by activities including site clearance, removal, stockpiling, infill, levelling and grading, erosion will need to be managed carefully.

Table 8.3 Erodibility of the Soils

Horizon per Soil	Soil Type	Texture	Structure	Organic Matter Content	Slope Gradient (%)	Erodibility
A (top)	Nb, Kd, Lo	Sand	Loose medium/ coarse single-grained	Low	0–2	High
A (top)	Ka	Sand to clay loam	Loose medium/ coarse-grained to coarse block	Low to moderate	0–2	Moderate to high
E (sub)	Kd, Lo	Sand	Loose medium/ coarse-grained	Very low	0–2	High
G (bottom)	Ka, Kd	Sandy loam to clay	Massive to coarse block	Very low	0–2	High
B (bottom)	Lo	Sand to sandy loam	Loose to massive	Very low	0–2	High
C (sub)	Nb	Sand	Loose medium/ coarse-grained	Very low	0–2	High
O (top)	Ch	Silty loam to silty clay loam	Massive to weak block	High	0–2	Low
C (sub)	Ch	Sand to loam	Loose single grains to massive	High	0–2	Low

Source: Digby Wells, 2012.

8.3.5 Agricultural Potential

Agricultural potential of the soils in the Survey Area is determined by a combination of soil depth, soil properties and climatic conditions. The dominating soil occurring in the Survey Area is deep sand, well drained and low in soil fertility. The average rainfall in the area is very high, and this specific climate and soil combination results in low arable agricultural potential due to low fertility, a situation common in the tropics of Africa.

8.4 GROUNDWATER

8.4.1 Context

A groundwater study was conducted to establish the baseline conditions of the Afungi Project Site. Secondary data, including groundwater well data from adjacent areas, was used to assist in characterising the baseline, while primary data was collected within the Survey Area between February and December 2012 (see methodlogy in *Annex C*).

8.4.2 Regional Hydrogeology

MacDonald and Davies (2000) report that aquifers in the younger littoral deposits of calcarenites and reef limestone are the most productive, and that the fractured or weakly cemented sandstones, such as those in the northern coastal Mozambique region, can provide higher aquifer yields and are suited to large-scale development. For example tertiary sandstone aquifers, such as in the Mikindani Formation, are capable of specific capacities ranging from 0.13 to 1.1m^3/hr/m.

Aquifers in the younger littoral carbonates potentially offer more production with specific capacities of 0.53 to 3.3m^3/hr/m. However, these shallower aquifers are typically more mineralizsed and (with Total Dissolved Solid (TDS) concentrations greater than 1,000mg/l) and are considered to be vulnerable to saline water intrusion which is reported to have occurred in some areas as a result of over-abstraction (Ferro and & Bouman, 1987; Steyl &and Dennis, 2009). The groundwater quality of deeper aquifers is reportedly good, with TDS concentrations below 300mg/l.

The Quaternary alluvium aquifer has, in places, been exploited for supplies in the coastal areas (Smedley, 2002), especially along the main rivers where the alluvial deposits are better developed. Further, sand and gravel aquifers along floodplains, particularly where annual flooding provides recharge, can contain significant amounts of groundwater (MacDonald and & Davies, 2000) and higher specific capacities can occur.

8.4.3 Local Hydrogeology

Groundwater Occurrences

The main aquifer in the study area is a primary intergranular delivering yields of between 0.5 and 10L/s. Aquifer testing of groundwater exploration boreholes indicated relatively high aquifer transmissivities (T) ranging from $2 \cdot 10^0$ to $2 \cdot 10^2 m^2/d$. Relatively shallow groundwater conditions occur beneath the Afungi Project Site with differences in water levels being apparent, which is attributed to the presence of locally developed lenses of silt and clay. Based on the available geological information, indications are that there is no ubiquitous confining layer separating a shallow aquifer from a deeper aquifer.

Groundwater Elevations and Flow Direction

Groundwater levels range from 0.5 to 69.4 metres below ground level (mbgl). Shallower water levels were measured close to Palma Bay in the east and in low lying areas. Available data indicates shallower groundwater levels at the end of the rainy season (April) than in the dry season with fluctuations in the order of up to a few metres.

The groundwater flow direction across Afungi Project Site is generally to the east and south-east in the general direction of the coast. However, this varies locally due to groundwater discharge into drainage features such as rivers and wetlands.

Groundwater Recharge

Stable isotope data provide evidence that the groundwater in the area is fed by rainwater recharge, and that there are no differences in recharge source across the area. Considering the local geology, hydrology and hydrogeology, it is assumed that rapid direct recharge of rainfall occurs, as evidenced from site rainfall data and groundwater levels. Further, indications are that the topographic high to the west of the Afungi Project site is an area of recharge.

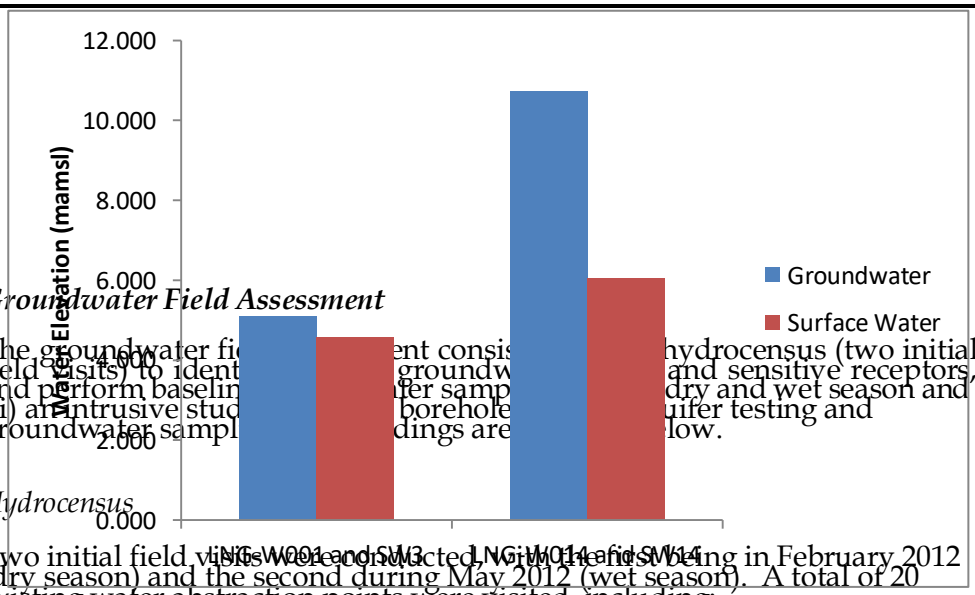
Ferro and Bouman (1987) described the aquifer recharge rates as being medium to high relative to other areas of Mozambique. Smedley (2002) assigned aquifer recharge rates of between 100 to 300mm/year for the region. This corresponds to a groundwater recharge rate of 9-26% of the mean annual precipitation at Palma of 1,165mm/year.

Surface Water – Groundwater Interaction

A comparison of water elevations in boreholes and surface water features indicates that the groundwater elevations are higher and that the surface water features are gaining systems, ie surface water features are receiving groundwater discharge (*Figure 8.8*). However, the spatial distribution of available data points with regards to surface water - groundwater interaction is limited, and hence the interaction between groundwater and the streams and wetlands remains poorly understood.

Based on field observations, it is currently assumed that groundwater discharges into streams and wetlands in areas close to the coast. It is also assumed that groundwater is in direct contact with the estuaries and the sea within Palma Bay.

Figure 8.8 ***Comparison of Groundwater and Surface Water Elevations***



8.4.4 Groundwater Field Assessment

The groundwater fi ent consis hydrocensus (two initial field visits) to ident groundw and sensitive receptors, and perform baselin fer samp dry and wet season and (ii) an intrusive stud borehole uifer testing and groundwater sampl dings are low.

Hydrocensus

Two initial field visits were conducted, with the first being in February 2012 (dry season) and the second during May 2012 (wet season). A total of 20 existing water abstraction points were visited, including:

- Four community supply boreholes equipped with handpumps;
- Seven shallow hand-dug wells close to streams for community use;
- Seven monitoring boreholes installed by AMA1 (piezometers installed in geotechnical boreholes);
- One borehole at the Palma site camp; and
- One *dambo* (wetland area).

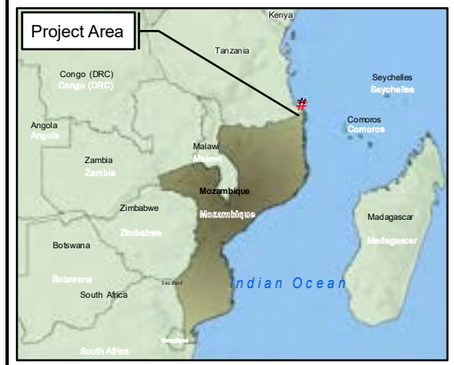
A description of the hydrocensus points is provided in *Table 8.4* and the locations of the hydrocensus points indicated in *Figure 8.9*.

Table 8.4 ***Location and Description of Hydrocensus Points***

Well No.	Description	Latitude	Longitude	Altitude (amsl)	Topographical Setting	Comment
HC1	Handpump	10.82264	40.52168	30m	Flat surface	Working handpump in middle of village
HC2	Handpump	10.82222	40.52192	31m	Flat surface	Non-working handpump in middle of village
HC3	Handpump	10.82161	40.52272	29m	Flat surface	Working handpump in middle of village
HC4	Well	10.81800	40.52734	14m	Along stream	Hand-dug well next to stream
HC5	Well	10.82238	40.53188	13m	Along stream	Hand-dug well next to stream
HC6	Well	10.82039	40.56497	11m	Along stream	Hand-dug well next to stream
HC7	Well	10.81828	40.56903	8m	Along stream	Hand-dug well next to stream/beach
HC8	Well	10.81344	40.54964	9m	Next to mangrove	Hand-dug well next to stream/mangrove
HC9	Well	10.81087	40.50038	19m	Along stream	Hand-dug well next to stream
HC10	Handpump	10.84521	40.47839	51m	On hill	Working handpump in middle of village
HC11	Well	10.84782	40.47372	31m	Along stream	Hand-dug well next to stream
AF06	Borehole	10.81806	40.54095	15m	Flat surface	Piezometer installed in geotechnical borehole
AF14	Borehole	10.80762	40.53704	14m	Flat surface	Piezometer installed in geotechnical borehole
AF17	Borehole	10.80532	40.54504	10m	Close to ocean	Piezometer installed in geotechnical borehole
AF18	Borehole	10.80769	40.54285	12m	Flat surface	Piezometer installed in geotechnical borehole
AF19	Borehole	10.81248	40.54038	15m	Flat surface	No sample due to obstruction in borehole
AF20	Borehole	10.83976	40.50328	36m	Flat surface	Piezometer installed in geotechnical borehole
AF21	Borehole	10.80037	40.51055	26m	Flat surface	No sample due to obstruction in borehole
Camp	Borehole	10.76145	40.47345	24m	On hill	Borehole supplying the Palma Camp
Dambo	Wetland	10.84061	40.46881	38m	On hill	*Dambo*

Legend

- Villages / Settlements
- Local Roads
- Afungi Project Site
- W: Wetland
- A/G: Arable / Grazing



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 8.7:
Land Capability

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 50 000

DRAWING: Land Capability.mxd

REV: A

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Impacto Projectos e Estudos Ambientais

ERM

10°52'0"S

10°46'0"S

10°48'0"S

10°50'0"S

T:\GIS Projec

Projection: UTM Zone 37 S, Datum: WGS84 Source: Bing Maps ©2010 Microsoft Corporation. Digby Wells, 2012. Inset Map: Esri Data & Maps	SIZE: A3

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10°48'0"S

10°50'0"S

Local communities use groundwater mainly for domestic purposes including drinking and, to a lesser extent, for livestock watering, irrigation and construction. The main source of water for communities and farmers in the area is from hand-dug wells, boreholes equipped with handpumps and surface water from several perennial streams that are present in the area. The following figures show common domestic-use well types.

Figure 8.10 ***Typical Community Borehole Equipped with Handpump (Senga Village)***

Source: ERM, 2012.

Figure 8.11 ***Typical Hand-dug Well Used for Community Water Supply***

Source: ERM, 2012.

Intrusive Investigation

Between August and September 2012, 14 boreholes were drilled under ERMs supervision to depths of between 35 and 90m. Five of these were drilled

specifically for environmental monitoring purposes, six to assess Project water supply (groundwater exploration boreholes), and three to serve as water supply boreholes for local communities. Blow yields of between 0.3 and 10L/s were obtained. Details of these boreholes are provided in *Table 8.5* and the location is indicated in *Figure 8.9*.

Aquifer testing was carried out on each of these boreholes to determine hydrogeological parameters including transmissivity and hydraulic conductivity, and to assess the capacity of the aquifer for water supply.

Groundwater samples were taken from these 14 boreholes and an additional four boreholes supplying the Projects camps in December 2012 during the dry season. This data was collected to supplement the baseline data and additional parameters were analysed to perform groundwater fingerprinting. Newly installed community boreholes LNG-W008 and LNG-W009 could not be sampled. LNG-W008 could not be sampled as the installed hand pump was broken and LNG-W009 did not contain sufficient water for sampling.

Table 8.5 Details of Boreholes Drilled between August and September 2012

BHID	Purpose	X (m)	Y (m)	Elevation (mamsl)	Depth of BH (m)	Blow Yield (L/s)
LNG-W001	Project Water Supply	667930	8804020	16.59	90	4
LNG-W002	Project Water Supply	668207	8803800	16.69	39	4
LNG-W003	Project Water Supply	663784	8799918	32.16	60	3
LNG-W004	Project Water Supply	664354	8800548	25.95	60	3
LNG-W005	Project Water Supply	665479	8800537	21.15	60	3
LNG-W006	Project Water Supply	665235	8800562	20.68	60	10
LNG-W007	Community Water Supply	648678*	8791683*	89*	84	1
LNG-W008	Community Water Supply	661173*	8810343*	29*	60	2
LNG-W009	Community Water Supply	632160*	8812730*	78*	85	0.3
LNG-W010	Environmental Monitoring	668864	8805421	4.94	50	3
LNG-W011	Environmental Monitoring	673967	8800273	4.63	45	3
LNG-W012	Environmental Monitoring	663491	8804139	10.39	37	3
LNG-W013	Environmental Monitoring	660837	8800409	20.99	35	6
LNG-W014	Environmental Monitoring	666381	8799042	13.08	40	6

Notes: Datum WGS84, Projection UTM 37L
*Co-ordinates and elevation recorded using a hand-held GPS
Mamsl Metres above mean sea level

8.4.5 Baseline Groundwater Quality

Groundwater samples were taken during three different sampling campaigns being (i) hydrocensus dry season (February 2012), (ii) hydrocensus wet season (May 2012) and (iii) intrusive investigation dry season (December 2012) as described in *Section 8.4.4*. Data gathered from the following boreholes has been used to describe the quality of the groundwater according to the following groupings:

- Community boreholes equipped with handpumps (HC1, HC3, HC10 and LNG-W007);
- Shallow hand-dug community wells (HC4 to HC9 and HC11);
- Project water supply exploration boreholes (LNG-W001 to LNG-W006);
- Camp water supply boreholes (Palma Camp 2 and 3, BGP Main and Bactec Camp 1);
- Environmental monitoring boreholes (LNG-W010 to LNG-W014); and
- Piezometers installed in geotechnical boreholes (AF06, AF14, AF17 to AF20).

Analytical results of groundwater samples were screened against the Mozambican Water Quality Standards for Human Consumption (Ministerial Diploma no. 180/2004, of 15 September) and the World Health Organisation Drinking Water Quality Guidelines (WHO, 2011). The specific water quality standards are presented in *Table 8.6* below.

Table 8.6 ***Drinking Water Standards***

onstituent	**Unit**	**WHO (2011)**	**Mozambican Guideline (Ministerial Decree no. 180/2004)**
Major Ions			
Calcium as Ca	mg/l		50
Magnesium as Mg	mg/l		50
Potassium as K	mg/l		
Sodium as Na	mg/l	200	200
Fluoride as F	mg/l	1.5	1.5
Sulphate as SO_4^2	mg/l	500	250
Chloride as Cl	mg/l	250	250
Nitrate as NO_3	mg/l	50	50
Nitrite as NO_2	mg/l	3	3
Ortho Phosphate as PO_4	mg/l		
Ammonium as NH_4	mg/l		1.5
Total Nitrogen as N	mg/l		
Total Alkalinity as $CaCO_3$	mg/l		
Total Hardness as $CaCO_3$	mg/l		500
Trace Elements (Metals)			
Aluminium as Al	µg/l	200	200
Antimony as Sb	µg/l	20	
Arsenic as As	µg/l	10	10
Barium as Ba	µg/l	700	700
Beryllium as Be	µg/l	12	
Bismuth as Bi	µg/l		
Boron as B	µg/l	2400	300
Cadmium as Cd	µg/l	3	3
Total Chromium as Cr	µg/l	50	50
Cobalt as Co	µg/l		
Copper as Cu	µg/l	2000	1000
Iron as Fe	µg/l	2000	300
Lead as Pb	µg/l	10	10
Lithium as Li	µg/l		
Manganese as Mn	µg/l	400	100
Mercury as Hg	µg/l	6	1
Molybdenum as Mo	µg/l	70	70
Nickel as Ni	µg/l	70	20
Selenium as Se	µg/l	40	10
Zinc as Zn	µg/l	3000	3000
Hydrocarbons			
Benzene	mg/l	0.01	
Toluene	mg/l	0.7	
Ethylbenzene	mg/l	0.3	
Xylenes	mg/l	0.5	
Naphthalene	mg/l		0.0001*

Community Boreholes Equipped with Handpumps

Community borehole HC3 complies with drinking water standards. HC1 and HC10 both exceeded standards for electrical conductivity (EC) and HC10 exceeded standards for Pb in one sampling round (dry season). The newly installed community water supply borehole at Moia, LNG-W007, exceeded the applicable standards for Pb and the measured pH was below the range recommended by the applied guidelines.

Shallow Hand-Dug Community Wells

Shallow hand-dug wells generally comply with applied standards with a few exceptions, these being HC5 (EC) and HC6 (Mn). Both exceedances were found in the dry season, however, HC5 was not sampled in the wet season.

Project Water Supply Exploration Boreholes

Each of the Project water supply exploration boreholes exceeds drinking water guidelines for a few constituents as follow: LNG-W001 (Na, Cl, Fe, Pb), LNG-W002 (Pb), LNG-W003 (pH), LNG-W004 (pH, Pb), LNG-W005 (Fe) and LNG-W006 (Fe).

Camp Water Supply Boreholes

In the camp water supply boreholes, the following screening levels are exceeded: BGP Main (pH), Palma Camp 2 (EC, Na, Cl, Pb), Palma Camp 3 (Ca, Na, Cl) and Bactec Camp 1 (Pb).

Environmental Monitoring Boreholes

LNG-W014 fully complies with the applied standards. Following exceedances were noted in the other environmental monitoring boreholes LNG-W010 (EC, Ca, Mg, Na, SO_4, Cl, B, Fe, Mn) and LNG-W011 (pH, Cl, Fe), LNG-W012 (Fe) and LNG-W013 (pH).

Piezometers Installed in Geotechnical Boreholes

AF18, AF19 and AF20 fully comply with applied standards. AF06 exceeded the WHO standard for Mn slightly in the wet season and AF14 exceeded Ca, Fe and Mn in the dry season.

Constituents of Concern – Drinking Water Quality

Sodium, chloride, calcium, sulphate, magnesium, iron and manganese are likely to affect the taste of the groundwater, while lead and boron present potential health risks. Boron was found above the levels outlined in *Table 8.6* at LNG-W010, which is located in close proximity to the coast at Palma Bay. As the groundwater from LNG-W010 will not be abstracted for potable purposes, lead is the sole constituent of concern. Lead was found in a number of boreholes at concentrations between 10.3 and 18.8ug/L, exceeding applicable drinking water standards (10.0ug/L). Affected boreholes include two community boreholes LNG-W007 and PIC10, two groundwater production boreholes (Palma Camp 2 and Bactec Camp) and three groundwater exploration boreholes (LNG-W001, LNG-W002 and LNG-W004). It is recommended that the lead concentrations that have been detected are confirmed in future groundwater sampling rounds and if found to persist, the effected groundwater should be treated to remove lead before used for human consumption.

8.4.6 Groundwater Fingerprinting

Ion Ratios

The cations observed are generally Na-dominated, while anions vary from alkalinity (carbonate (CO_3^{2-}) + bicarbonate (HCO_3^-)) to chloride dominated. Generally those samples which are alkalinity-dominated have lower salinity than the chloride dominated samples. The chloride-dominance appears to increase with borehole depth and is greater in boreholes closer to the ocean (ie LNG-W010). Following four geochemical signatures are apparent:

- Group 1: Na-alkalinity signature – LNG-W002, W005, W006 and W014 have salinities ranging from 10 – 22mS/m;
- Group 2: Na- Cl-alkalinity-SO_4 signature – LNG-W004, W012, W013, Bactec Camp 1 and BGP Main have higher salinities (23-67mS/m);
- Group 3: Na -Cl-alkalinity signature – LNG-W003 and W007. Salinities range from 70 – 81mS/m; and
- Group 4: Na-Cl-SO_4 signature – LNG-W001, W010, W011, Palma Camp 2 and Palma Camp 3 have higher salinities than the other samples (114-731mS/m). Most of these samples have a Na:Cl ratio similar to that of seawater, suggesting that the aquifer from which groundwater is being abstracted may be affected by saline intrusion.

There is no identifiable spatial pattern to the signatures, however Group 4 samples are generally deep wells located close to the sea. Group 3 and Group 2 water may represent a mixture between fresher recharge (Group 1) and deeper more saline water with a marine influence.

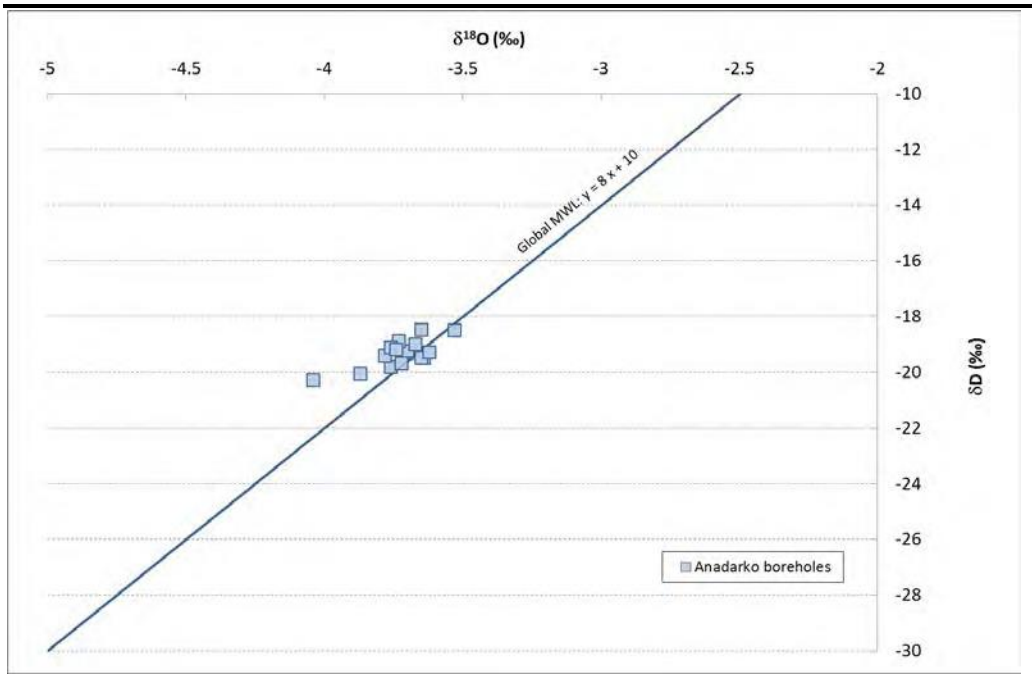
Stable Isotope Data

The stable isotope data are plotted on a meteoric water line (MWL) in *Figure 8.12*. Despite the physical distance between the samples, the results are

similar, within 1 ‰ of each other for δD and within 0.25‰ for $\delta^{18}O$. The samples plot near to the global meteoric water line, indicating recharge by rainwater and no evaporation.

This data provides evidence that the groundwater in the area is fed by rainwater recharge, and that there are no differences in recharge source across the area. The groundwater isotope ratios are more depleted than seawater, therefore no seawater intrusion is evident, and the observed marine influence may be due to salts present in the aquifer sediments related to the formation in a marine environment.

Figure 8.12 ***Stable Isotope Data from Boreholes Relative to the Global MWL***



8.4.7 Seasonal Variation in Water Quality

The natural variation of the water quality in the Afungi Project Site was studied based on two hydrocensus sampling rounds, one during the wet season and one during the dry season.

Representative radial diagrams of the groundwater chemistry for hand-dug wells and deeper boreholes (ie >40m deep) in both the dry season (February 2012) and the wet season (May 2012) are presented in *Figure 8.13* and *Figure 8.14*. These radial diagrams graphically present the relative hydrochemical composition of the groundwater, allowing for a visual comparison between different seasons.

The chemistry of groundwater in shallow hand-dug wells, as shown by HC7, changes significantly between the wet season and the dry season. In the dry season, the water is dominated by sodium (Na) and chloride (Cl), whereas in the wet season the water is dominated by Na, calcium (Ca) and bicarbonate

(HCO_3) (alkalinity). The seasonal change in shallow groundwater chemistry is attributed to direct and rapid rainfall recharge, and confirms that the shallow groundwater would be highly susceptible to any surface contamination.

The chemistry in HC3 is dominated by alkalinity, Cl and Na, and suggests that the aquifer from which groundwater is being abstracted is recharged during the wet season. The results of HC3 are in contrast to the groundwater from HC10, which has a geochemical signature that does not suggest frequent recharge, with little seasonal variation in water quality. The depths of these two handpump-equipped boreholes are unknown, and the potential exists for them to be abstracting groundwater from aquifers at different depths.

Figure 8.13 ***Radial Diagrams for Hand-dug and Handpump Wells***

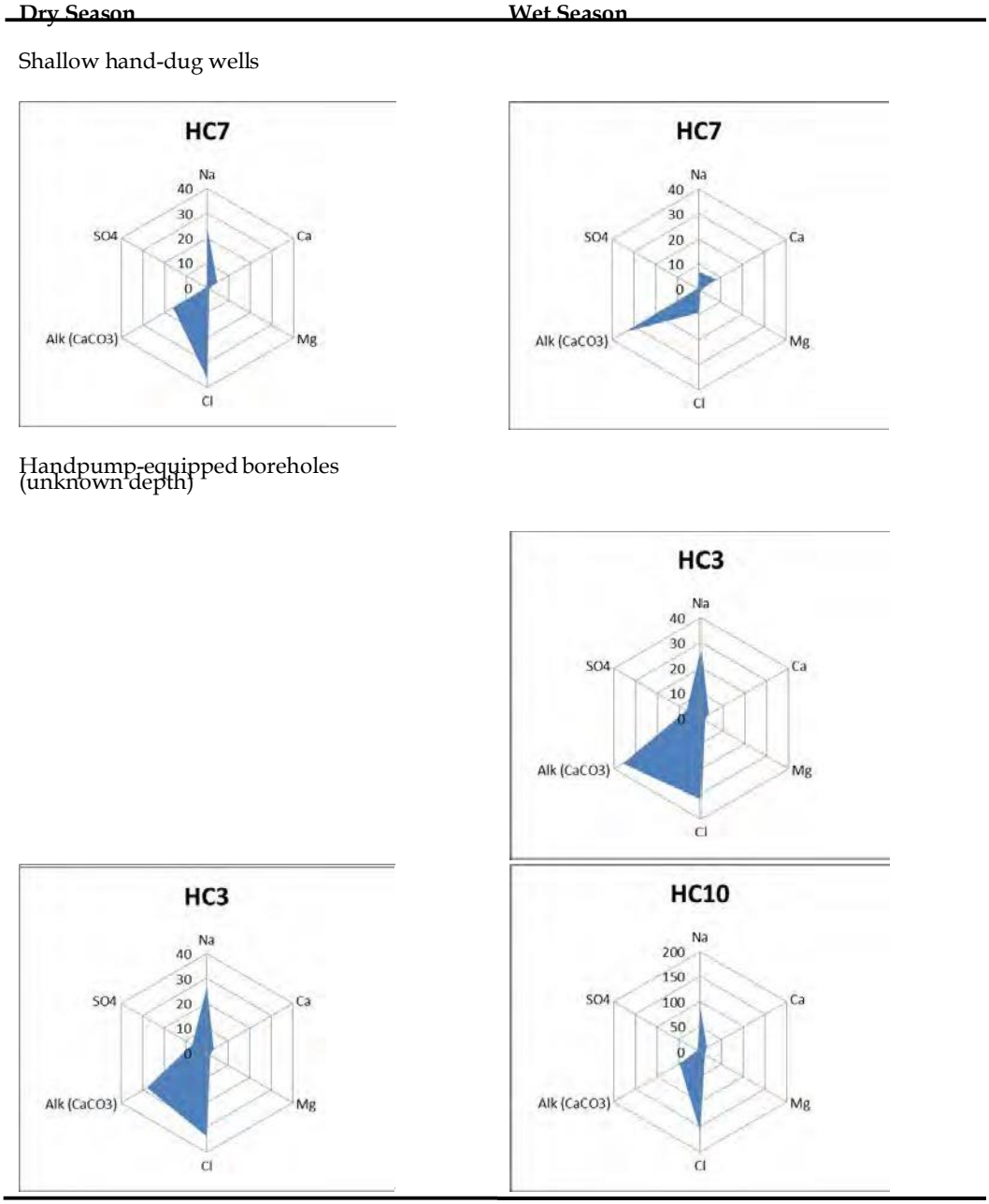
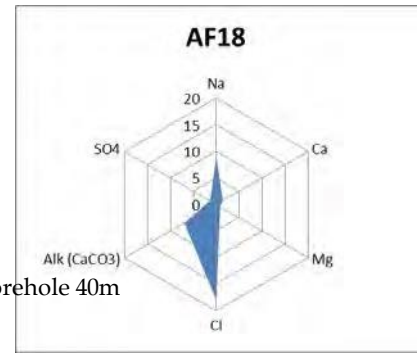
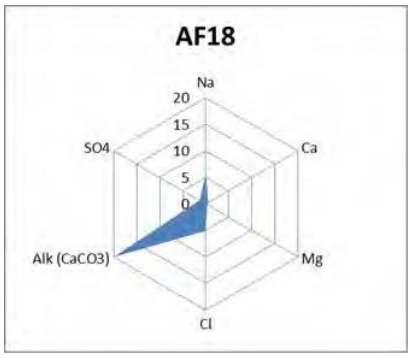
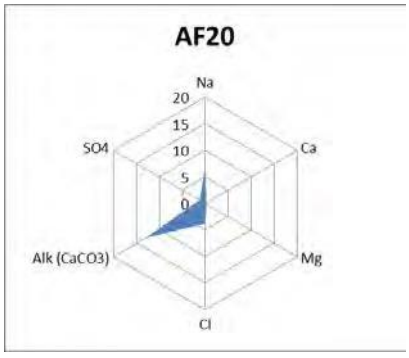
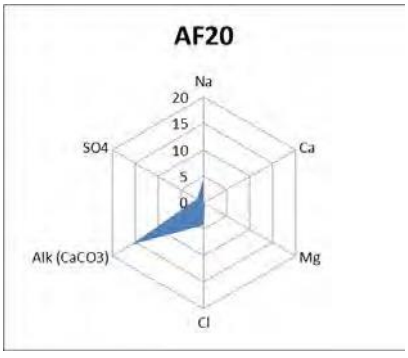
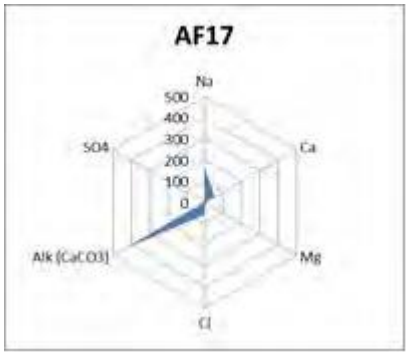
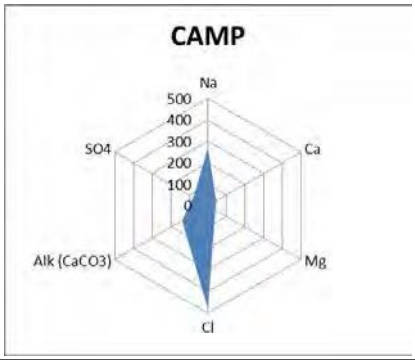
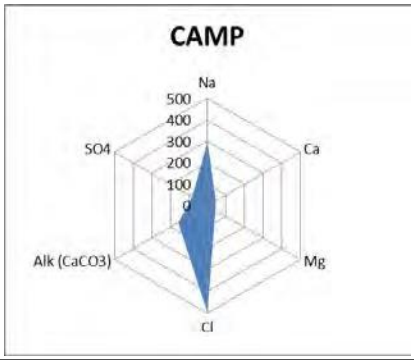


Figure 8.14 Radial Diagrams for Boreholes

Dry Season	Wet Season
Borehole 40m	
	
Borehole 40m	
	
Borehole 100m	
	
	

The geochemistry of the groundwater abstracted from the boreholes AF18 and AF20 confirms recharge of the aquifer at 40m below surface during the wet season, not unlike the pattern in the shallow hand-dug wells or the 100m deep borehole AF17.

8.5 HYDROLOGY

The objective of the hydrological baseline assessment is to assess the current surface water environment prior to development, to enable management steps to be put in place to maintain the integrity of surface water environments. To facilitate this, flowline and run-off models were developed (see *Annex C* for details on methodology).

8.5.1 Geographical Context

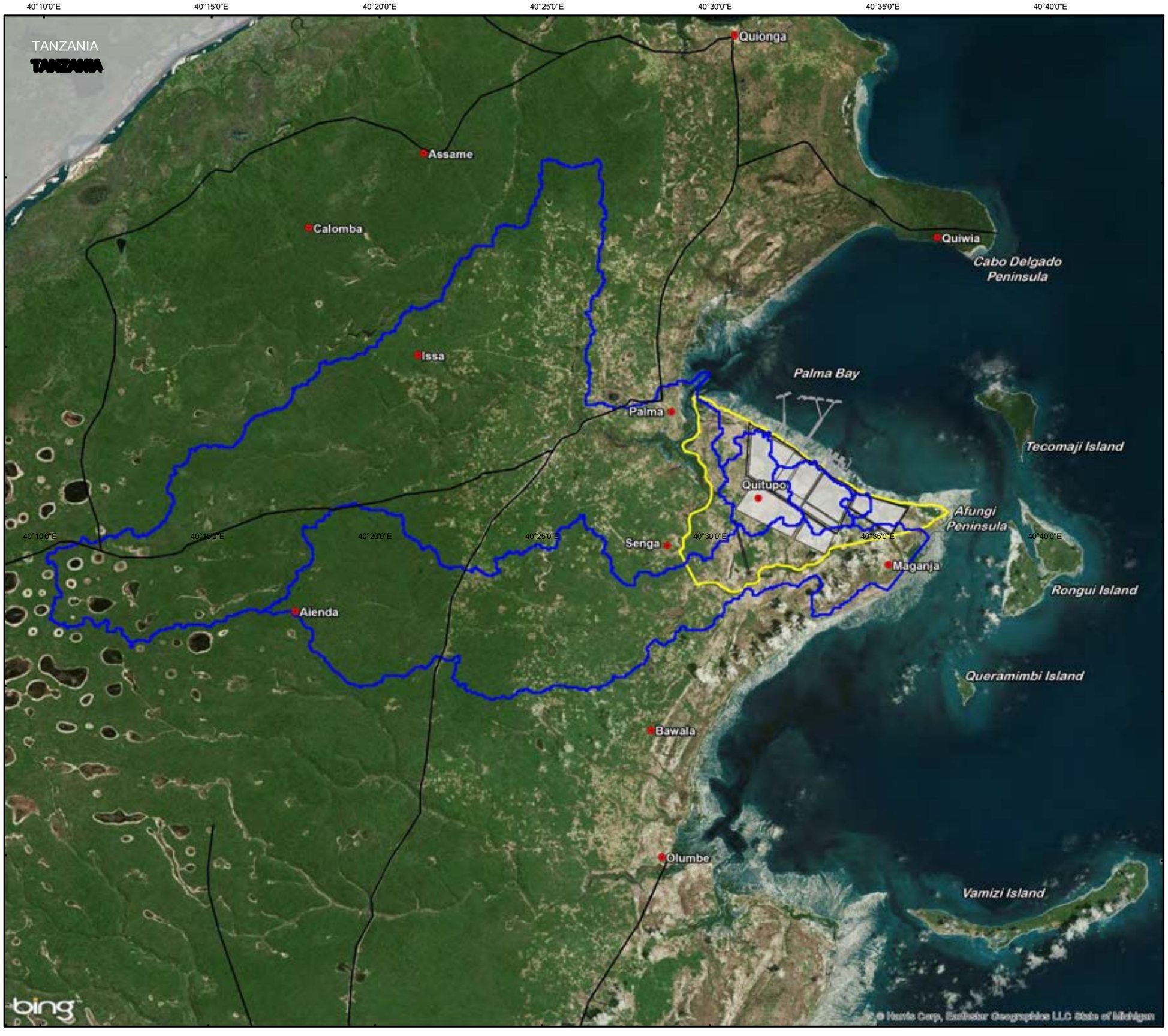
The hydrological baseline study was conducted within the Afungi Project Site and adjacent areas. Regional secondary data including climate, topographic, geologic and land cover/land-use data were assessed in characterising the baseline of the Study Area. Field observations were made within the Survey Area.

8.5.2 Regional Watershed Catchments

There are four main catchments in the vicinity of the Project Area, as illustrated in *Figure 8.15*:

- Catchment A (approximately 14km^2);
- Catchment B (approximately 10km^2);
- Catchment C (approximately 182km^2); and
- Catchment D (approximately 394km^2).

The catchment gradients are low, thus off-site flow rates can be expected to be low. It can be seen that the headwaters in the large catchments comprise pans or *dambos*, which do not have clearly defined stream channels due to the relatively flat topography on the coastal plain.



Legend

- Villages / Settlements
- Regional Roads
- Afungi Project Site
- Jetty
- Onshore Project Footprint
- Catchments

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 8.15:
Delineated Catchments in the Study Area

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: GM	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 180 000

DRAWING: Delineated_Catchments_in_the_Study_Area.mxd

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Impacto Projectos e Estudos Ambientais

ERM

11°50'S

10°40'0"S

10°45'0"S

10°50'0"S

10°55'0"S

11°00'S

Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
ERM, 2012. Inset Map: Esri Data & Maps

SIZE:
A3

T:\GIS Projects

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10°40'0"S

10°45'0"S

10°50'0"S

10°55'0"S

11°00'S

8.5.3 *Watershed Modelling Methodology Overview*

The methodology used in the analysis of the watershed entailed a review of available data sets and reports from the public domain, a site visit and computer modelling. Once the watercourse and catchment boundaries were estimated, the physical properties of the area (climatic conditions, topography, soil conditions, vegetation cover and land use) were compiled to estimate peak run-off rates and develop the hydrological baseline of the area. Other baseline studies discussed herein were leveraged in the development of this analysis. A detailed discussion of the methodology applied in the modelling of the watershed is provided in *Annex C*; an overview of these methods is provided below.

Delineation of Watercourses and Catchment Boundaries

The modelled drainage network and catchments were developed by applying Watershed Modeling System (WMS) software and NASA's Aster Global Digital Elevation Model (GDEM). The WMS provides typical hydrologic and hydraulic modelling, using models such as HEC-HMS and HEC-RAS. River/stream/drainage networks and catchment basins were mapped using Digital Elevation Model data.

Determination of Peak Rainfall Estimates

The determination of peak rainfall events for the respective return periods and peak flow rates for the drainage areas within the catchments was undertaken by the Rational Method and SCS Method.

Determination of Floodlines

The HEC-RAS model is designed to perform one-dimensional hydraulic calculations for natural and constructed channel networks, and was used to assess all major surface water systems within the Survey Area. The floodlines were calculated by performing a steady-state analysis.

8.5.4 *Floodline Analysis*

The aim of the floodline analysis was to assess the distance that water will flow along the bank from the stream channel during an extreme rainfall event. The floodline analysis was performed for the rivers/streams that flow through the Survey Area.

Catchment Delineation and Catchment Characteristics

Stream length and gradient are key factors in floodline analysis, and are important in estimating the time of concentration, which can be defined as the time it would take for water to flow from the furthest point of the catchment to reach the point of consideration.

Size of Catchment

The size of the catchment has an important influence on the rainfall–run-off relationship. The areas visited along the coast have been largely cleared of vegetation and converted to cropland. The soils for the smaller catchments within the Survey Area comprise deep grey/white sands and sandy soils. Thus, for this study, the relationship between rainfall intensity and infiltration rate of the soils is important.

Field observations indicate that the predominant vegetation comprises forests and grasslands, with closed-canopy forest/woodland present on slightly elevated areas, interspersed with open grassland/wetlands. These vegetation types, together with the small-gradient topography, play a major role in the flood hydrology. A key characteristic of the stream channels is that they are interspersed with open grasslands and wetlands, which attenuate much of the flow. Although a high-intensity storm may produce considerable overland run-off flow, when this reaches the stream channels flows will be slowed considerably. For the larger catchments, water storage capacity plays a major role in the flood hydrology.

Catchment Shape

The catchments for this study can generally be described as long and narrow, and can be expected to reduce peak flows due to:

- topographical factors allowing for a smaller slope over the catchment;
- storm intensity being reduced, as a storm will not fall on the entire catchment at the same time; and
- longer travel time (Tc) through the catchment allows for more flow attenuation.

Catchment Slope

The slope of the catchment is important in determining flood peaks. Steep slopes cause water to flow faster and to shorten the critical duration of a flood-causing storm, thus leading to the use of higher rainfall intensities. On steep slopes, the vegetation is generally less dense, soils are shallower and there are fewer depressions, which cause water to run off more rapidly. The result is that infiltration is reduced and flood peaks are consequently even higher. A summary of the catchment characteristics is presented in *Table 8.7*.

Table 8.7 Summary of the Catchment Characteristics

Catchment	Catchment Area (km^2)	Longest Watercourse (km)	Slope (m/m)	Time of Concentration* (hrs)
Catchment A	14	6	0.003	2.4
Catchment B	10	6	0.002	3
Catchment C	182	35	0.003	9.2
Catchment D	394	40	0.004	9.6

* Time of concentration is defined as the required time for a storm of uniform area and temporal distribution to contribute to the run-off from the catchment.

Flood Peaks and Volumes

The estimated peak discharges for the respective catchments is presented in *Table 8.8*. The Rational Method and the SCS Method were used to calculate the peak discharges.

Table 8.8 Estimated Peak Discharges for Catchments

Catchment	Tc (hr)	Peak Discharge (m^3/s)			
		Rational Method		SCS Method	
		5 year	10 year	50 year	100 year
Catchment A	2.4	44	60	43	55
Catchment B	2.9	27	36	30	38
Catchment C	9.2	171	231	180	235
Catchment D	9.6	294	399	282	368

The estimated flood volumes, calculated from the SCS Method, are presented in *Table 8.9*.

Table 8.9 Estimated Peak Volumes for Catchments

Catchment	Discharge Volume (m^3)	
	50 year	100 year
Catchment A	642,040	812,110
Catchment B	493,880	624,700
Catchment C	7,570,000	9,760,000
Catchment D	15,000,000	19,320,000

Existing Conditions Flood Extent

The approximate extent of inundation of the Afungi Project Site in the 100-year event was determined using a HEC-RAS hydraulic model, with the peak determined using the Rational Method and SCS Method. The HEC-RAS model for the Study Area included five rivers, with the peak flows input for the five reaches. The tailwater level of 1.8m was considered in the model, corresponding to Mean High Water Spring (MHWS).

The floodline analyses performed for the 1 in 100 year event is illustrated in *Figure 8.16* below. It is apparent that a large extent of the coastal area is located within a flood area and the extent of inundation in the 100-year event covers a significant proportion of the proposed Project Footprint Area.

Legend

- Villages / Settlements
- Local Roads
- Regional Roads
- Jetty
- Onshore Layout
- Afungi Project Site
- 1 in 100 Year Floodline

MAIN MAP SCALE:

0 1 2 3
Kilometers

TITLE:

Figure 8.16:
Delineated Floodlines for the
1 in 100 year Rainfall Event

CLIENT:

Anadarko Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: GM	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 70 000

DRAWING: Delineated_Floodlines.mxd

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10°54'0"S

10°48'0"S

10°46'0"S

10°44'0"S

10°50'0"S

10°52'0"S

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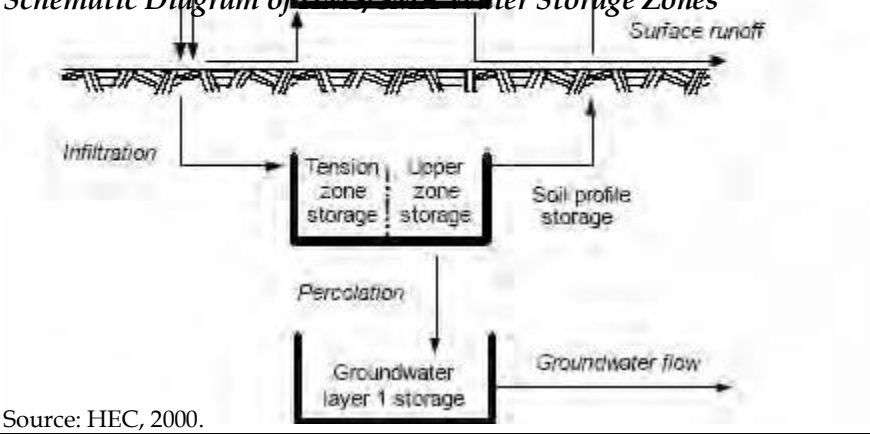
HEC-HMS was used to perform long-term rainfall run-off simulations for the respective catchments. This is a physically based distribution model, which can be used to simulate hydrological processes such as vertical soil moisture flow, evapotranspiration (ET), infiltration, overland flow, channel flow and groundwater flow within the catchments. HMS includes the Soil Moisture Accounting (SMA) which requires rainfall depths and evapotranspiration rates, as input to define the rainfall, run-off, storage and losses relationships.

Four water storage zones were simulated, as shown in *Figure 8.17* below. For the simulation of water movement through the various storage zones, the maximum capacity (maximum depth) of each storage zone, initial storage condition in terms of percentage of the filled portion of each zone, and the transfer rates, such as the maximum infiltration rate, are required.

Figure 8.17 ***Schematic Diagram of HMS/SMA Water Storage Zones***



Source: HEC, 2000.

The parameter estimates established in the model were determined from information sourced from the Rovuma River Basin [(1)] and rainfall data was extracted from the NOAA website [(2)]. The mean annual evaporation data used in the study was estimated at 1,400mm/yr. The Clark unit hydrograph technique was used to determine run-off. In this method, the process of translation and attenuation of excess rainfall dominate the movement of flow through the catchment.

(1) http://ruvumariver.org/

(2) http://www.noaa.gov/ Hourly data from the period 18 February 2000 to 29 June 2012 was used in developing this model.

8.5.5 Model Results

The catchment characteristics (size, shape, slope, soil composition and vegetation cover) as well as variables such as infiltration rate, soil depth, percolation rates and groundwater depth all have a significant influence on the modelled flow rates. At the beginning of a rainfall event, much of the rain is intercepted by the vegetation and subsequently by the high infiltration and percolation rates of the soils. However, heavy rainfall events will produce quick overland flow (run-off) if the storage capacity of the soil is overwhelmed by the magnitude of rainfall.

Base flow (as opposed to subsurface flow) is the main contributor to stream flow in the catchments. The model shows an annual average stream flow of approximately 20 percent of the rainfall, and indicates that the river flow rates will reach zero over extended periods with no or low rainfall.

There are currently no stream flow records within the Survey Area or from watercourses in close proximity. Therefore, the modelled flows could not be verified through cross-reference with existing or historical data. Stream flow measurement would need to be performed to definitively confirm these simulations.

8.5.6 Water Quality

Surface water sampling was conducted between 14 and 18 May 2012. The results are summarised in *Table 8.10* below and the sampling locations illustrated in *Figure 8.18*. Water quality results were compared to Mozambique and WHO standards. The water quality is generally good, with concentrations of TDS well within drinking water standards. Some parameters, such as iron (Fe) and aluminium (Al), marginally exceed the WHO recommended limits for acceptability of water ie taste, odour and appearance, but no health-based guidelines are exceeded. The exception is sample S6, collected from adjacent to the sea, which shows a distinct marine influence with elevated salt concentrations.

Table 8.10 ***Surface Water Quality Constituents Compared against Mozambique and WHO Potable Water Standards***

Constituent	Unit	Standards		Surface Water Sampling Location								
		Mozambique *	WHO (2011)	S1	S2	S3	S4	S5	S6	S7	S8	S9
pH – value at 25°C		6.5–8.5	6.5–8.5	6. 59	6. 80	6.91	6.43	6.65	7.28	6.67	6.45	6.59
Electrical conductivity at EC	mS/m	5–200	25	11.4	7.4	30.2	6.2	6.0	1027.6	75. 7	14.5	7.2
Total dissolved solids as TDS	mg/l	1000	ns	72.96	47.36	193.28	39.68	38.40	6576.64	484.48	92. 80	46.08
Total alkalinity as $CaCO_3$	mg/l	ns	ns	20	26	30	14	20	56	24	14	18
Suspended solids as SS	mg/l	ns	ns	<10	<10	<10	<10	<10	10	<10	<10	<10
Chlorides as Cl	mg/l	250	250	14.9	6.7	66.9	6.8	8.6	3333.6	15.5	9.9	13.2
Sulphate as SO_4	mg/l	400	500	2.48	0.76	8.42	<0.05	0.73	417.38	6.40	0.56	1.04
Nitrate NO_3 as N	mg/l	50	50	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2.0	0.4	<0.2
Calcium as Ca	mg/l	50	ns	2.7	2.6	5.3	1.4	1.1	73.3	2.3	0.8	1.0
Magnesium as Mg	mg/l	50	ns	32	175	8	84	5	<2	<2	66	<2
Sodium as Na	mg/l	200	200	9. 7	4.5	41.7	4.4	7.8	1907.0	11.8	6.5	9.6
Potassium as K	mg/l	ns	ns	2.1	2.7	2.3	0.3	1.8	71.6	1.8	0.5	1.2
Aluminium as Al	mg/l	0.2	0.2	<0.020	0.08	0.09	0.27	0. 31	<0.020	0.08	0.13	0.11
Iron as Fe	mg/l	0.3	0.3	0.1	1.9	0.2	1.1	0.2	0.1	0.1	0.1	0.2
Manganese as Mn	mg/l	0.1	0.05	0.03	0.18	0.01	0.08	0. 01	<0.002	<0.002	0.07	<0.002
Total chromium as Cr	mg/l	0.0.5	0.05	0.0057	0.0026	0.0025	0.0044	0.0140	0.0078	0.0043	<0.0015	<0.0015
Copper as Cu	mg/l	1	2	<0.007	0.014	<0.007	0.007	<0.007	<0.007	0.0034	<0.007	<0.007
Nickel as Ni	mg/l	0.02	0.02	<0.002	0.002	<0.002	0.003	<0.002	<0.002	0.002	<0.002	<0.002
Zinc as Zn	mg/l	3	3	0.01	0.05	0.02	0.02	0.01	<0.003	0.01	0. 01	0.01
Cobalt as Co	mg/l	ns	ns	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cadmium as Cd	mg/l	0.003	0.005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00 05	<0.0005	<0.0005
Lead as Pb	mg/l	ns	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0. 005	<0.005
Benzene	ug/1	ns	ns	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene	ug/1	ns	ns	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ethylbenzene	ug/1	ns	ns	<2	<2	<2	<2	<2	<2	<2	<2	<2
p/m-Xylene	ug/1	ns	ns	<3	<3	<3	<3	<3	<3	<3	<3	<3
o-Xylene	ug/1	ns	ns	<2	<2	<2	<2	<2	<2	<2	<2	<2
Naphthalene	ug/1	ns	ns	<2	<2	<2	<2	<2	<2	<2	<2	<2
Surrogate Recovery Toluene D8	%	ns	ns	105	103	102	104	104	104	104	102	104
Surrogate Recovery 4--Bromofluorobenzene	%	ns	ns	108	108	109	109	109	109	110	108	109

Notes: * Mozambican Water Quality Standards for Human Consumption (Ministerial Diploma no. 180/2004, of 15 September

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Legend

- Sampling Locations
- Villages / Settlements
- Regional Roads
- Local Roads
- Jetty
- Onshore Layout
- Afungi Project Site

MAIN MAP SCALE:

0 1 2 3
Kilometers

TITLE:

Figure 8.18:
Surface Water Quality Sampling Locations

CLIENT:

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DATE: Oct 2013	CHECKED: GM	PROJECT: 0133576
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DRAWING: Surface Water Quality Sampling Locations.mxd

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8.5.7 Conclusion

The Project is located in the drainage paths and low-lying areas within catchments A, B and D. During construction the sandy soils, which are highly susceptible to erosion, will be exposed. The Project Footprint Area falls inside the modelled flood zones of catchments A and B. Flooding in these areas could be managed by appropriate flood mitigation measures such as diversion channels to divert flows around and away from the site.

High-intensity rainfall events are experienced in the Study Area, but this will be tempered by the deep sandy soils which allow for high infiltration and permeability rates. These factors, combined with the slow velocity flows (due to the relatively flat topography) would reduce the flooding potential due to water infiltration. Therefore, high-intensity rainfall events would need to occur over a long period of time to allow for soil saturation before overland flow would likely occur.

Stream flow is highly variable and extremely large flow rates are experienced following high-magnitude rainfall events in the wet season. As base flow is the main contributor of stream flow in the catchments, indications are that significant quantities of water are temporarily stored in floodplains, resulting in shallow groundwater tables. It is recommended that continuous stream flow monitoring be undertaken to calibrate the model results against actual flow data, to further the understanding of the surface water environments.

8.6 SURFACE WATER ECOLOGY

8.6.1 Overview

The Afungi Peninsula is bordered by two major drainage basins: the Rovuma Drainage Basin, 35km to the north, and the Messalo Drainage Basin, approximately 90km to the south. Due to the low gradient of the peninsula, the fresh-water systems within the Afungi Project Site are largely interconnected wetland systems ending in estuaries connected to Palma Bay. There are no major rivers draining the immediate area. The rainfall in the area averages above 1,000mm/year; the highest flows are experienced in February to April, and the lowest flows in August. The local people use the estuaries and wetland systems for subsistence fishing, but not to a large extent.

8.6.2 Baseline Surveys and Catchments within Study Area

The Survey Area included 12 sampling sites, all wetlands, which are outlined in *Table 8.11*. Sampling was undertaken within the wetlands during low flow (14 to 17 October 2011 and 22 to 25 June 2012) and high flow (24 to 29

February 2012). Of the sampling sites, nine were fresh-water sites (lacustrine wetlands [1]) and three were estuaries.

Table 8.11 Selected Sampling Sites (Wetland and Estuarine)

Site Name	Description	Coordinates	
MOZ 1	Wetland	S 10°50′07.58″	E 40°33′21.57″
MOZ 2	Wetland	S 10°49′50.94″	E 40°31′50.89″
MOZ 3	Wetland	S 10°49′21.89″	E 40°31′55.34″
MOZ 4	Estuary	S 10°48′23.53″	E 40°33′09.69″
MOZ 5	Wetland	S 10°49′00.74″	E 40°31′36.83″
MOZ 6	Estuary	S 10°47′23.84″	E 40°31′35.83″
MOZ 7	Wetland	S 10°50′00.73″	E 40°30′20.72″
MOZ 8	Wetland	S 10°52′01.51″	E 40°29′27.94″
MOZ 9	Wetland	S 10°50′54.77″	E 40°33′16.08″
MOZ 10	Wetland	S 10°49′21.31	E″ 40°33′30.34″
MOZ 11	Wetland	S 10°48′20.53″	E 40°31′27.52″
MOZ 12	Estuary	S 10°49′15.53″	E 40°34′34.29″

Source: NSS, 2012.

Five major catchments have been identified within the Survey Area, as shown in *Figure 8.20*. *Table 8.12* describes the location of chosen sampling sites within each catchment. These wetlands are interconnected systems.

Table 8.12 Catchments and Wetlands within Survey Area

Catchment and Assessment Sites	Site Description
Catchment A	
MOZ 2	Upper catchment zone, close to the start of the permanent wetland
MOZ 3	Mid catchment zone
MOZ 5	Mid catchment zone
MOZ 6	Estuary
MOZ 11	Lower catchment zone with broad permanent wetland
Catchment B	
MOZ 1	Upper catchment, close to the start of the permanent wetland
MOZ 4	Estuary
MOZ 10	Lower catchment zone with broad permanent wetland
Catchment C	
MOZ 8	Upper catchment, close to the start of the permanent wetland
MOZ 9	Mid catchment zone
Catchment D	
MOZ 7	Upper catchment, close to the start of the permanent wetland
Catchment E	
MOZ 12	Estuary

Source: NSS, 2012.

(1) Lacustrine wetlands have permanent wet conditions and may include water bodies and shallow pans. The systems typically have plants growing in the water, although riparian zones or floodplain areas can become dryer during the dry season.

Within the 3,600ha Project Footprint Area, approximately 933ha of wetlands exist (see *Figure 8.20*). Of these wetlands, approximately 210ha are estuarine systems, 281ha are permanent fresh-water wetlands and 442ha are seasonal wetlands. A riparian buffer (indicated in red in *Figure 8.20*) that extends 150m [1] around all wetland systems expands this area to approximately 841ha. A discussion on these wetland systems is provided in the following sections.

(1) The term riparian buffer is used to describe lands adjacent to streams where vegetation is strongly influenced by the presence of water.

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Palma
Palma Bay
MOZ6
MOZ11
MOZ4
MOZ5
Quitupo
MOZ3
MOZ10
MOZ12
MOZ2
MOZ7
MOZ1
MOZ9
Senga
Maganja
MOZ8
bing

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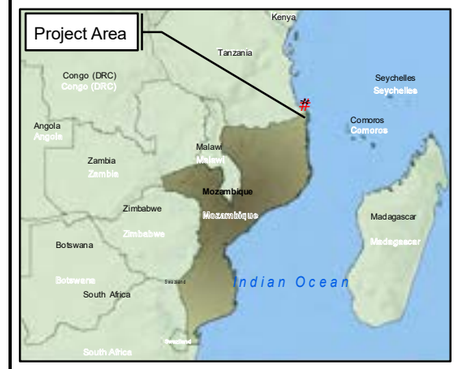
Legend

- Villages / Settlements
- Aquatic and Wetland Sites
- Local Roads
- Onshore Project Footprint
- Nearshore Components
- Afungi Project Site

Wetlands

- Estuary
- Permanent wetland
- Seasonal wetland
- Un-delineated wetland
- Wetland Buffer (150 m)



MAIN MAP SCALE:

0 1 2 4 Kilometres

TITLE:

Figure 8.19:
Surface Water Ecology Survey Area

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
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DRAWING: Surface Water Ecology Survey Area.mxd

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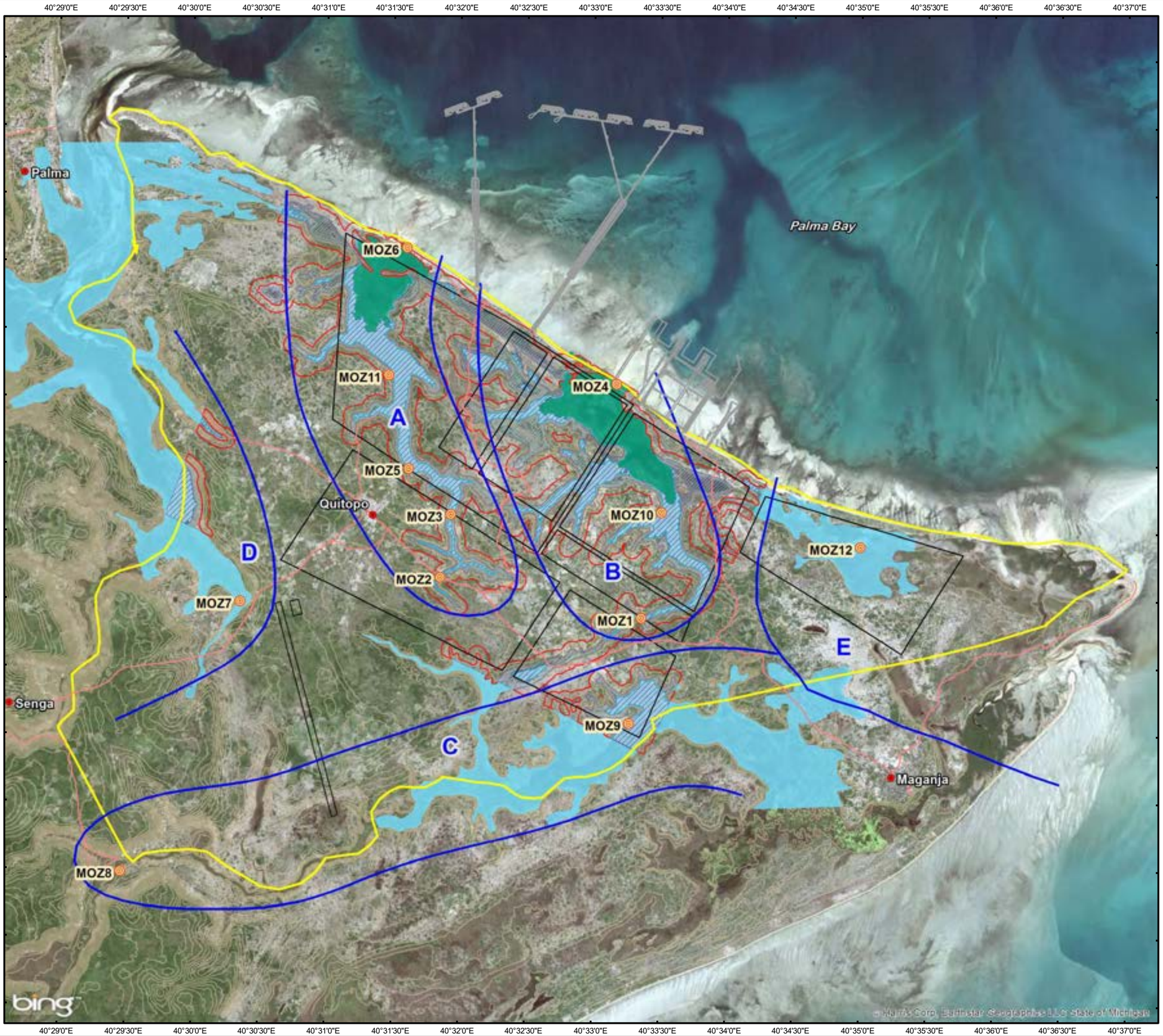

Legend

- Aquatic and Wetland Sites
- Villages / Settlements
- Local Roads
- Contours
- Nearshore Components
- Onshore Project Footprint
- Wetland Groups
- Afungi Project Site

Wetlands

- Estuary
- Permanent wetland
- Seasonal wetland
- Unspecified wetland
- Wetland Buffer (150 m)

Note:
Preliminary - to be updated with catchment E

MAIN MAP SCALE:

Metres

TITLE:

Figure 8.20:
Wetland Catchments

CLIENT:

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Moçambique Área 1, Lda

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DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
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DRAWING: Wetland Catchments.mxd

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8.6.3 Lacustrine Wetlands

In their natural state, the lacustrine wetlands in the Survey Area are considered unchannelled valley bottom wetlands [1], according to the classification of Kotze et al. (2007). Basic characteristics of a wetland change as each wetland progresses through its catchment, from the source towards the coastline, with four recognisable zones being present within the Survey Area.

- In the **upper catchment zone** close to the source, wetlands tend to be narrow and the extent of seasonal wetland far exceeds the extent of permanent wetland. Terrain tends to be varied and the riparian zones are not strictly confined to slopes adjacent to the wetland. Sites were selected where sufficient permanent water was present for aquatic surveys.

- In the **middle zone**, between the start of a wetland and its end at the coastline, wetlands tend to be clearly defined by steep and high slopes and with a moderately broad permanent wetland. The riparian vegetation tends to be well developed and largely restricted to the steep slopes.

- Towards the **lower end of the catchment**, wetlands tend to be dominated by extensive permanent wetlands, with well-defined slopes that demarcate the wetland edges. The height of these slopes tends to be less than in the mid catchment areas, and the area of seasonal wetland tends to be small.

- **Estuarine areas** are discussed in *Section 8.6.4*.

Sediment and Biotopes

In terms of the aquatic environment, the beds of the wetlands in the Survey Area are composed of fine sands and muds, rather than rocks and cobbles. The bottom consists of soft sediment and the major biotopes [2] observed in the Survey Area include:

- open water, inhabited by suspended planktonic forms and fish;
- shallow-edged, inhabited by benthic (bottom-dwelling) forms; and
- marginal, with roots and plants inhibited by other assemblages of invertebrates and fish.

Water Quality

The following physical variables were examined for the fresh water wetlands:

(1) These are valley bottom areas with no clearly defined stream channel, usually gently sloped and characterised by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs occur mainly from the channel entering the wetland, as well as from adjacent slopes.
(2) A biotope is a region that has a characteristic set of environmental conditions and, consequently, a particular type of fauna and flora.

- dissolved oxygen (DO);
- temperature;
- electrical conductivity (EC);
- TDS;
- salinity; and
- pH.

The mean values of the physical variables measured at wetland (not estuarine) sampling locations are shown in *Table 8.13* and discussed further below. These are compared against the Target Water Quality Range (TWQR), a management objective developed by the South African Department of Water Affairs and Forestry (DWAF, 1996) for South African aquatic ecosystems and used to specify the desired or ideal concentration range and/or water quality requirements for a particular constituent. Although there are some water quality standards in place in Mozambique, none are specifically related to the standards required for optimal ecosystem functioning (Mozambique Environmental quality regulations, 2004). Consequently, the South African guidelines were used to give an indication of ecosystem deterioration in the Survey Area, with the understanding that these are not absolute for Mozambique.

Table 8.13 ***Physical Water Quality Parameters of the Wetland Sampling Sites in Low Flow (LF) 2011, 2012 and High Flow (HF) 2012***

***In situ* variables**	**MOZ 1**		**MOZ 2**		**MOZ 3**		**MOZ 5**		**MOZ 7**	
TWQR*	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**
DO (mg/l) **>8.00**	2.93	5.05	10.91	5.19	8.66	5.05	1.28	1.75	6.19	3.39
DO (%) **80–100**	36.64	65.0	149.9	71.72	107.92	64.07	16.3	23.63	84.2	45.77
Temp (C) **N/A**	26.9	28.2	35.2	32.1	26.6	27.2	27.5	30.9	31.3	30.5
EC (mS/m) **70**	12.40	11.55	11.68	9.48	14.96	12.38	28.87	15.37	21.8	18.19
TDS (mg/l) **450**	62	58	58	47	75	62	144	77	109	91
Salinity **N/A**	0.06	0.06	0.05	0.04	0.07	0.06	0.14	0.07	0.10	0.08
pH **6–9**	5.8	5.9	6.6	5.6	6.3	6.3	6.2	6.0	5.8	5.7

***In situ* variables**	**MOZ 8**		**MOZ 9**		**MOZ 10**		**MOZ 11**	
TWQR	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**	**LF**	**HF**
DO (mg/l) **>8.00**	5.26	7.68	3.31	4.35	4.99	3.76	2.53	1.68
DO (%) **80–100**	64.07	99.51	41.80	58.29	62.88	50.77	32.02	21.88
Temp (C) **N/A**	25.3	28.2	27.3	30.0	27.2	30.3	27.3	28.3
EC (mS/m) **70**	14.17	67	22.78	217	19.30	254	19.40	103
TDS (mg/l) **450**	71	13.29	114	43.49	96	50.92	97	20.52
Salinity **N/A**	0.07	0.06	0.11	0.21	0.09	0.24	0.09	0.10
pH **6–9**	6.3	6.1	5.8	6.0	5.9	6.0	5.6	6.2

Key:

–: No data available; LF = low flow; HF = high flow.

*Red text delineates Target Water Quality Range (TWQR) (see methodology in *Annex C* for further information).

Constituents that did not meet the DWAF (1996) TWQR are highlighted in blue.

Source: NSS, 2012.

Dissolved Oxygen

Dissolved oxygen levels for water resources in naturally flowing systems should be between 8mg/l and 12mg/l (depending on temperature, TDS and height above sea level), and the percentage saturation should be between 80 and 120 percent (Dallas & Day, 2004). The oxygen values observed typically fell below the TWQR ranging from 1.28 to 6.19mg/l, with only two samples reaching levels within the suggested TWQR (at sites MOZ 2 and MOZ 3 Catchment A), as shown in *Table 8.13*. The wetlands in the Survey Area are naturally slow flowing and shallow, and therefore this guideline for oxygen levels is possibly unsuitable for such a system. Where levels fell within the TWQR (ie in Catchment A), it is likely that this was a result of higher levels of photosynthesis/ decomposition of aquatic plants and increased temperatures.

The oxygen levels fluctuated drastically between seasons and no real trends could be identified at any of the sites. This is expected in watercourses with such low levels and slow-flowing waters. Therefore, the risk of oxygen depletion impacts in these ecosystems is not considered high.

Temperature

The water temperatures within the Survey Area wetlands ranged from approximately 25 to 35°C, as shown in *Table 8.13*. The sites with the highest temperatures generally aligned with the sites with low oxygen levels. No seasonal changes were evident from the observed temperatures, probably due to the natural tropical nature of the ecoregion, where the mean air temperature does not fluctuate substantially.

Electrical Conductivity (EC)

EC is a measure of the ability of water to conduct an electrical current. The TWQR for EC is 0 to 70mS/m (DWAF, 1996a). The EC values obtained at the wetland sampling sites fell within these ranges, typically 9 to 28 (see *Table 8.13*). However, EC at sites MOZ 9, MOZ 10 and MOZ 11 were considerably higher, likely to be a result of marine water flowing into the fresh-water systems at these points. The higher EC values observed during low flow indicate a seasonal variance.

Total Dissolved Solids

TDS measures the total amount of soluble material in a water sample, and includes organic, inorganic, ionised and un-ionised material. The greatest mass of this material in natural waters comprises inorganic ions. The most

common of the cations are Na^+, K^+, Ca^{2+} and Mg^{2+} and the anions [(1)] are HCO_3 , CO_3^{2-}, Cl^- and SO_4^{2-}. Less common inorganic ions include nutrients such as NO_3 and PO_4^{2-}, various trace metals and inorganic material. The TDS values at the fresh-water sampling sites were low, which is considered good for such wetlands. Seasonal variance occurs as higher TDS concentrations were observed during the low flow period, especially at MOZ 5 (Catchment A), which had high concentrations of Na, Cl, K, Mg and SO_4 present.

Salinity

The salinity of the fresh-water sampling sites is tabulated in *Table 8.13*. The salinity values at the sites ranged from 0.04 to 0.24, and as expected were lower than those observed in marine water (32 to 36), indicating that the fresh-water sampling sites did contain mostly fresh water. No TWQR is available for salinity in inland waters.

pH

The pH values of the fresh-water sampling points are provided in *Table 8.13*. The TWQR for all aquatic ecosystems should be between the pH values of 6 and 9, which is typical of fresh-water habitats. However, pH should not vary from the range of the background pH for a specific site and time of day by >0.5 of a pH unit or by >5 percent, whichever estimate is the more conservative (DWAF, 1996). The pH recorded for most of the sites fell within the TWQR range, with the exception of sites MOZ 1, MOZ 2 and MOZ 7 at low flow 2011, and MOZ 9, MOZ 10 and MOZ 11 at high flow 2012. At these sites, the values observed are not of concern as they are not considered acidic.

Chemical Water Quality Parameters

The atmosphere, geological weathering, agriculture run-off, industrial effluents and acid mine drainage are the main sources of trace metals in water bodies (Dallas & Day, 2004). Almost all metals are toxic to aquatic organisms, and to humans at certain concentrations. Heavy metals, namely Cd, Cr, Cu, Pb, Fe, Hg, Mn and Zn (Roberts, 2001; Marchard, 2009) are the most toxic form of aquatic pollution (Laws, 2000).

As for physical constituents, chemical constituents were also compared against the TWQR and a few constituents were above the recommended target levels, including Al, Cu, Fe, Zn, Na, Cl, ammonium, sulphates, chemical oxygen demand (COD) and suspended solids (SS) at a number of the sampling sites [South African Water Quality Guidelines (SAWQG) for Aquatic Ecosystems (DWAF, 1996a) – see methodology in *Annex* C]. These concentrations were all considered to be relatively natural, apart from the nutrient and organic enrichment from the activities of the surrounding rural communities. In addition to this, all the sites had high levels of suspended solids. This was particularly evident in Catchment B at MOZ 1 and MOZ 10 in the high flow, where the levels were excessive – possibly related to increased sedimentation, likely to be from erosion and run-off from cultivated lands.

Levels of suspended solids were much reduced at MOZ 10 during the low

(1) A negatively charged ion.

flow, which could indicate temporal changes at this site. However, this occurrence could not be confirmed at MOZ 1, where the constituent was only measured during the high flow.

The site that was shown to have the highest contamination was MOZ 5 (Catchment A), but this was only the case during the low flow and it is suspected that there was a small source of marine water in the low flow as higher levels of Na, Cl, sulphates and other ions that are normally in abundance in saline water were observed. In the high flow, MOZ 10 (Catchment B) and MOZ 9 (Catchment C) water quality had a similar WQ trend, suggesting that these sites also have an influx of salts, possibly from Palma Bay.

Diatoms

Diatom communities are widely used indicators of biological integrity and physico-chemical conditions in aquatic ecosystems because of their high dispersal rates, rapid growth rate and direct response to environmental changes (Taylor, 2011; 2012). This study considered species composition and abundance, but also examined a range of diatom indices, which are good indicators of present ecological status in wetlands. The indices used in the assessment included the Specific Pollution Sensitivity Index (SPI) and the Biological Diatom Index (BDI), the percentage of pollution-tolerant valves (%PTV) and the number of deformed cells (see *Annex C* for details of the methodology used).

The diatoms flora encountered is a typical acidic water flora with a considerable percentage of tropical African endemic species. Assessment of the diatom populations in the samples indicated that there were very high abundances of certain species present. A summary of all diatom taxa that were present above 50 individuals per sample is shown in *Table 8.14*. The *Brachysira* genera tended to dominate in both seasons. This species is predominantly found in benthic slow-flowing habitats and is often found in high abundances in low conductivity and low pH wetland-type habitats, which dominated in the Survey Area.

Table 8.14 Diatom Genera and Species with Abundances of More Than 50

Site	Low Flow (2011/ 2012) Species Abundance	High Flow (2012) Species Abundance
MOZ 1	*Nitzschia* spp. (93)	
MOZ 2	*Brachysira vitrea* (182)	*Brachysira neoexilis* (85) *Frustulia* spp. (92)
MOZ 3	*Brachysira vitrea* (205)	*Brachysira* spp. (161) *Brachysira neoexilis* (65) *Eunotia* spp. (98) *Navicula heimansiodes* (122)
MOZ 5	Insufficient cells for count	None
MOZ 7	*Eolimna minima* (89) *Nitzschia pavuloides* (55)	*Eolimna minima* (69) *Achnanthidium exiguum* (64) *Eunotia* spp. (67) *Rhopalodia* spp. (61)
MOZ 8	*Eunotia* spp. (74)	*Brachysira neoexilis* (60)
MOZ 9	*Brachysira neoexilis* (142) *Eunotia* spp. (71)	*Brachysira* spp. (161) *Eunotia* spp. (60)
MOZ 10	*Brachysira neoexillis* (234) *Brachysira procera* (87)	*Brachysira* spp. (148) *Brachysira neoexilis* (85)
MOZ 11	None	*Brachysira* spp. (165)

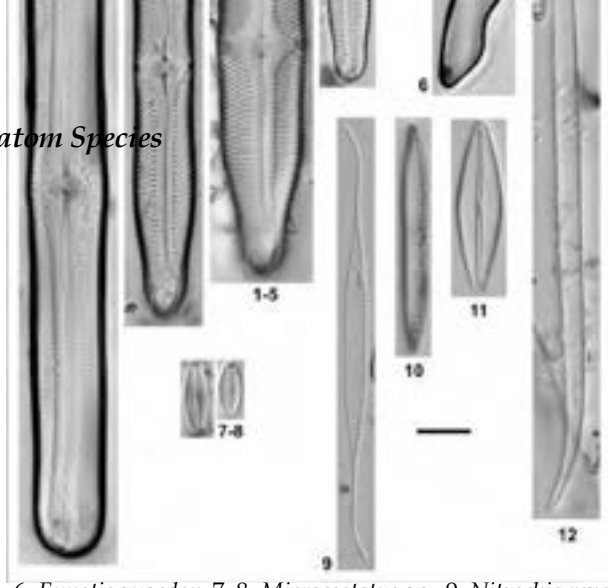
Source: NSS, 2012.

Some examples of diatoms observed in the fresh-water wetlands are shown in

Table 8.20.

Few deformed cells were observed and communities were typically indicative of good water quality, with the exceptions of MOZ 1, MOZ 5 and MOZ 7 in the upper and mid zones of the catchments. Diatoms at these sites showed a higher percentage of pollutant-tolerant valves. The diatom community at MOZ 5 showed the impact by pollutants during the high flow sampling. This coincided with the water quality results that showed higher levels of metals (Cu and Zn) and organic pollutants (NH_4 and COD). The reason for this was possibly due to the proximity of this site (600m) to Quitupo, the largest settlement on Afungi Peninsula. The human activities included farming (rice paddies), the washing of clothes and bathing in water from this system. This may have resulted in the increased levels of organic pollution observed at this site. During low flow, MOZ 5 had insufficient cells available for a meaningful count. This may be the result of high TDS levels and sedimentation at the site, because the sample contained mostly detrital material and sediment.

Figure 8.21 Fresh-water Diatom Species



1–5: *Pinnularia* spp.; 6: *Eunotia zygodon*; 7–8: *Microcostatus* sp.; 9: *Nitzschia reversa*; 10: *Hantzschia* sp.; 11: *Frustulia* sp.; 12: *Stenopterobia anceps*. Scale bar = 10 μm.
Source: NSS, 2012.

Similarly, the diatoms at MOZ 1 and MOZ 7 specifically showed a higher percentage of pollutant-tolerant valves. This predominantly consisted of a high diversity of various *Nitzschia* species, which typically indicates high levels of organic material and waste. Such organic levels were indeed present at all sites, and particularly evident at MOZ 1 in the high flow, where there were eight species of *Nitzschia* and an extremely high concentration of organic contamination. The cause for this influx of organic material could, however, not be determined with certainty at this site, as no major anthropogenic activities were identified.

Macro-invertebrates

The general diversity of macro-invertebrates was low. The only families with abundances over 100 were Gomphidae (MOZ 1), Hydracarina (MOZ 2) and Caenidae (MOZ 7), and only during the low flow assessment. This was due to seasonal differences at the different sampling sites, because the macro-invertebrates showed a decrease in abundances during high flow. A low EPT indicated that the community structures consisted of a low number of sensitive taxa, probably due to low habitat availability for these taxa (see methodology in *Annex C*). For example, the stone habitat was absent and therefore no stoneflies (Plecoptera) were present. Overall, all sites were affected by low oxygen, high temperatures, no slow-flow conditions, and lack

of biotope habitats (ie no stones). The water quality at the sites was considered good to high quality. However, Ca, Cu, Cl, Mg, Na, Zn, NH_4 and total hardness of the water at the sites (*Table 8.13*) could have affected and reduced the number of sensitive families present.

In general, the low abundance of present families indicated that even though most of the species that occur here were tolerant to the habitat and water quality conditions, only low numbers were naturally able to survive.

Ichthyofauna

No historical data is available for ichthyofauna in the Survey Area. The Rovuma River is one of the main rivers in the country in terms of flow, and runs along the border between Mozambique and Tanzania. It rises close to Niassa Lake and flows towards the Indian Ocean. This river is the closest large river to the Survey Area, but it does not flow into any of the aquatic systems sampled. The majority of species in the region [1] are considered of Least Concern (LC) or Data Deficient (DD) according to the IUCN, with the exceptions of *Barbus choloensis*, which is considered Vulnerable (VU), and *Oreochromis mossambicus*, which has been categorised as Near Threatened (NT). Of these two species, the former was not sampled. However, the absence within the sample set recorded for this Project does not necessarily indicate the absence of this species in the system. The latter species, *O. mossambicus*, was sampled at a few sites within the Survey Area. This species is threatened due to interbreeding with the invasive species *Oreochromis niloticus*. However, in this area the extent or presence of such interbreeding could not be identified in this study. In addition to *O. mossambicus*, eight fish species were sampled at the fresh-water sites and these are listed in *Table 8.15*.

Table 8.15 Fish Observed at Fresh-water Sampling Sites during Low Flow 2011 and 2012 and High Flow 2012

Common Name	Species	IUCN Status
Redspot barb	*Barbus kerstinii*	LC
Sharptooth catfish	*Clarias gariepinus*	LC
Annual killifish	*Nothobranchius hengstleri*	DD
Mozambique tilapia	*Oreochromis mossambicus*	T
Black tilapia	*Oreochromis placidus*	LC
Southern moothbrooder	*Pseudocrenilabrus philander*	LC
Dusky sleeper	*Eleotris fusca*	DD
Indo-Pacific tarpon	*Megalops cyprimoides*	DD
Commerson's glassy perchlet	*Ambassis ambissis*	DD

Key:

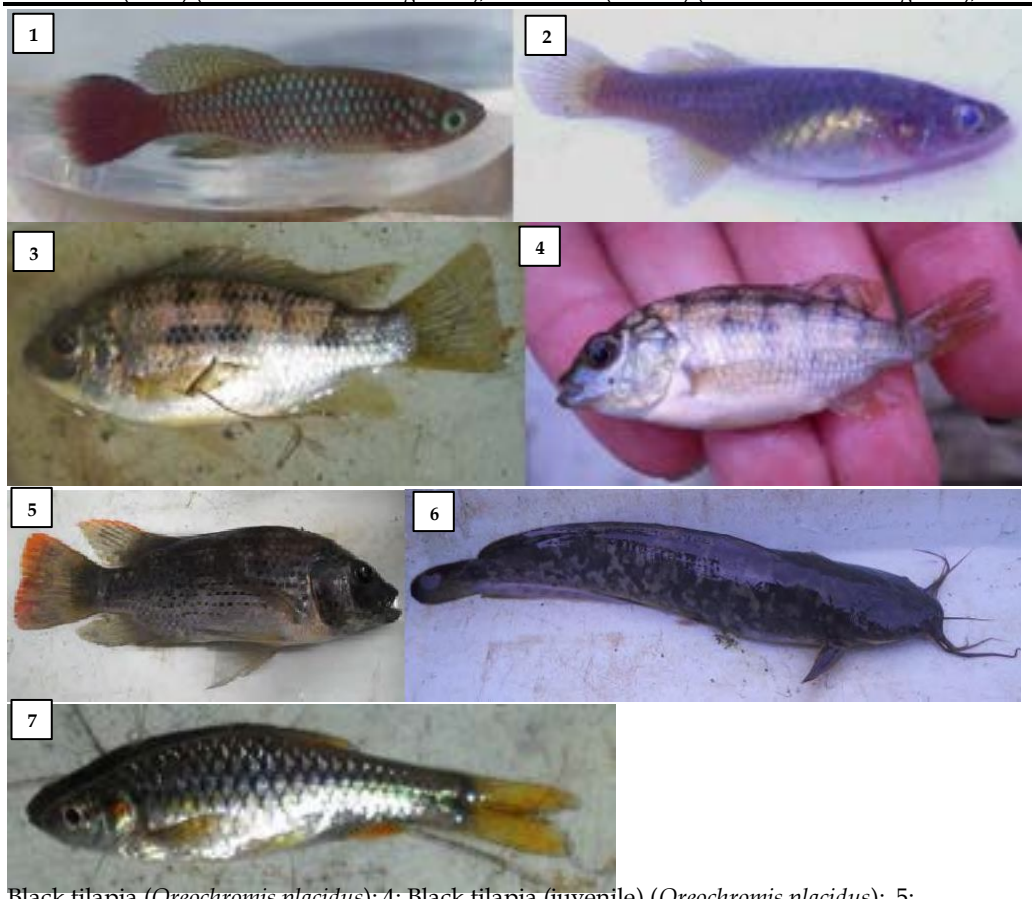
LC: Least Concern, T: Threatened, DD: Data Deficient, according to IUCN Red Data List, 2012.

Source: NSS, 2012.

(1) Based on the following sources: Livingstone (1859), who sampled fish in the lower reaches of the Rovuma River and deposited it to the British Museum of Natural History. Collections by South African Institute for Aquatic Biodiversity (SAIAB) have improved the knowledge of the fauna in the Rovuma River in the Niassa Reserve (Bills, 2004) and the wetlands of the Maputo Special Reserve (Bills, 2001).

For the Data Deficient species, it should be noted that species identified as being Data Deficient could have conservational importance and/or sensitivity to contaminants and should be considered during management decisions in the area. For instance, the presence of the species *N. hengstleri* might possibly be of importance, but this could not be established due to deficient data. This species was sampled at two catchments in the area, Catchments B and C. This was an interesting find, as currently this species is only known from its locality ie Nassoro Village, situated approximately 20km from Afungi Peninsula. Catchment B (at MOZ 1 and MOZ 10) and Catchment C (MOZ 8 and MOZ 9) are thus new localities for *N. hengstleri*.

Figure 8.22 ***Indigenous Fish Sampled during the High Flow and Low Flow Periods***



1: Killifish (male) (*Nothobranchius hengstleri*); 2: Killifish (female) (*Nothobranchius hengstleri*); 3: Black tilapia (*Oreochromis placidus*); 4: Black tilapia (juvenile) (*Oreochromis placidus*); 5: Mozambique tilapia (*Oreochromis mossambicus*); 6: Sharptooth catfish (*Clarius gariepinus*); 7: Redspot barb (*Barbus kerstenii*).

Source: NSS, 2012.

Overall, the species sampled during this study preferred wetland habitats. As such, the species present all generally had no major sensitivities to water quality, flows or habitat alterations (Skelton, 2001). At many of the sites, the fish abundances usually increased during the summer season, due to greater fish activity as a result of spawning. The presence of some fish species highlighted the connectivity between the fresh-water wetlands and the

estuaries. Two estuarine fish species, *M. cyprinoides* and *E. fusca*, were sampled at MOZ 5, a fresh-water site in Catchment A. This indicated that there was connectivity between the wetland and the estuarine site of Catchment A (MOZ 6). The presence of *M. cyprinoides, E. fusca* and another estuarine fish species, *A. ambassis*, at MOZ 11 (Catchment A) also indicated the connectivity with the estuary of Catchment B (MOZ 4).

Anthropogenic Influences

The majority of land alterations within the Survey Area were predominantly related to cultivation. Overall, the sites that were most severely altered by this were at MOZ 7 (Catchment D) and MOZ 8 (Catchment C), both are which were situated in close proximity to villages and could have been influenced by activities such as the the cultivation of alien plants, high algal content (due to nutrients from crop farming and the washing of clothes), organic enrichment (possibly from faecal matter), water abstraction and a change in hydrology due to artificially created channels. *Figure 8.23* shows some examples of existing anthropogenic alterations in the lacustrine wetlands.

Figure 8.23 Evidence of Anthropogenic Alteration at Wetland Sites

Top left: Artificial channel with raised banks for planting legumes at MOZ 7. Top right: Maize cultivation within wetland at MOZ 7. Bottom left: Cashew nut (*Anacardium occidentale*) and coconut (*Cocos nucifera*) trees planted in the upper zone at MOZ 3. Bottom right: Pond that developed as a result of a road crossing at MOZ 2.

Source: NSS, 2012.

Wetland Sensitivity

The wetland sites ranged from Sensitive to Highly Sensitive (as defined in *Annex C*). These are discussed further in *Section 8.6.6* by catchment.

8.6.4 Estuarine Wetlands

Overview

Along the coastline, approximately 20 estuaries occur within 100km of the Afungi Project Site, with varying catchment sizes feeding them. These estuaries include the large Rovuma estuary and the Palma estuary, which have the largest catchments in the area. The smallest estuaries are mainly areas created by tidal action on the beaches and the subsequent growth of mangroves. The numerous seagrass beds situated offshore also seem to play an important part in these estuaries, as decaying seagrass was evident in Catchments A and B (see *Figure 8.20*). This external input of nutrients and detritus is important in the cycling of nutrients within the ecosystems. The offshore marine environment plays a major part in the lives of the local people as fish are their major source of protein.

Estuarine systems have large variations in their abiotic and biotic characteristics. These variations are present within estuaries, as well as between different biogeographical regions. They can differ based on natural mean annual run-off, size, wave action at the mouth, biogeochemical characteristics of the adjacent marine environment and the catchment, and biotic composition. Thus, each estuary is unique and different from any other estuary (DWA, 2010).

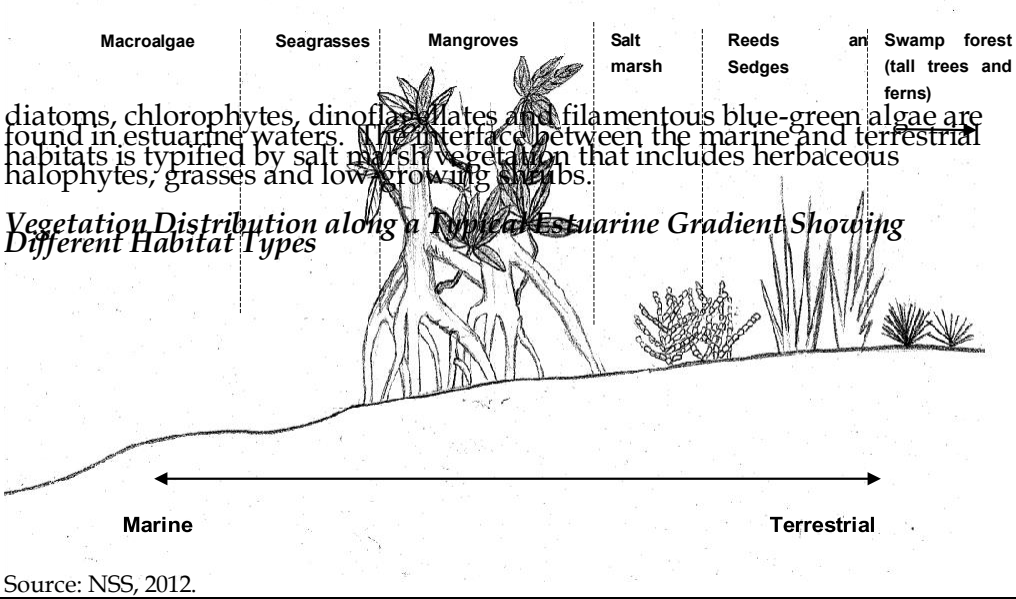
Estuaries are normally classified based on their size, saline intrusion and the duration of the connection with the ocean. The estuaries of Catchments A, B and E are small when compared to the Palma estuary. The duration of the connection of these estuaries with the sea in Palma Bay is unknown; however, the tidal flow significantly influences the area of the estuary, as the water level fluctuates by approximately 1m between high tide and low tide. The amount of fresh water flowing into the system seems to be low, especially in Catchment B.

Estuarine Vegetation

The zonation of vegetation in intertidal habitats (ie estuaries) is a universal phenomenon (Turpie et al., 2010). Estuarine habitats are characterised by common representative species that are adapted to specific physico-chemical conditions. Plants in the estuarine environment undergo osmotic stress due to evaporation and high sediment and surface water salinities from sea-water inflow, which influences distribution as seen in *Figure 8.24*. For instance, hypersaline tolerant seagrasses, such as *Ruppia* spp., and red and green microalgae, such as *Porphyra* spp. and *Ulva* spp., are likely to occur in areas where salinity is high (≥35ppt). Shallow pools provide a habitat for bacterial crusts and benthic algal mats. In addition to this, microalgae in the form of

diatoms, chlorophytes, dinoflagellates and filamentous blue-green algae are found in estuarine waters. The interface between the marine and terrestrial habitats is typified by salt marsh vegetation that includes herbaceous halophytes, grasses and low-growing shrubs.

Figure 8.24 ***Vegetation Distribution along a Typical Estuarine Gradient Showing Different Habitat Types***



Source: NSS, 2012.

The basic habitat types associated with the estuarine environment are listed in *Table 8.16*, in accordance with Turpie et al. (2010). Not all of these habitats may be represented in every estuary, as this is subject to a range of environmental factors.

Table 8.16 ***Flora Habitats associated with a Typical Estuarine Environments***

Habitat Type	Defining Features of a Habitat
Open surface water area	Habitat for phytoplankton
Intertidal sand and mudflats	Habitat for intertidal benthic microalgae
Submerged macrophyte beds	Eg *Zostera capensis* (eelgrass), *Ruppia cirrhosa, Potamogeton pectinatus*
Macroalgae	Distribution changes along a gradient from the sea landwards, eg *Ulva* spp., *Enteromorpha* spp., *Caulerpa filiformis*
Intertidal salt marsh	Halophytic species, often succulent, eg *Spartina maritima, Sarcocornia perennis, Triglochin* spp.
Supratidal salt marsh	Halophytic species tolerant of salt spray, which includes species such as *Sarcocornia pillansii, Sporobolus virginicus*
Reeds and sedges	*Phragmites australis, Schoenoplectus littoralis*
Mangroves	*Avicennia marina, Rhizophora mucronata, Bruguiera gymnorrhiza*
Swamp forest	Occurring on the landward side of the estuary, and includes species such as *Barringtonia racemosa, Hibiscus tiliaceus*

Classification adapted from Turpie et al.(2010) by NSS (2012).

Although the ecological significance of each of these estuarine habitats as a whole must not be overlooked, the mangroves within these habitats are of particular global importance. Mangroves are a unique forest type and are limited to the intertidal area of estuaries, lagoons and sheltered coastal zones. They act as nurseries for larval fish and certain fish are functionally dependent on them for survival. This unique forest type is a high priority for conservation, as natural expansion of populations is rarely ever documented (Spalding et al., 2010). Mangrove populations worldwide are declining at a rate of 0.86 percent per year (according to the most recent estimates), which is three to five times higher than the decline of other forest types (Spalding et al., 2010). While mangroves in Africa are generally not as diverse as in other regions in the world, the latest records (Spalding et al., 2010) show that Mozambique and Tanzania have the highest diversity in the African continent (excluding introduced species).

Both of the estuaries assessed for this study were identified as shallow-water saline systems with sandy substrates. Dense mats of decomposing organic matter were recorded at the south-eastern estuary site, MOZ 4 in particular. The description of the vegetation found at each estuary site is listed in the summary provided for each estuary sampled (see *Figure 8.36* and *Figure 8.38*). Overall, plant species diversity was low (which is not uncommon for saline systems) but mangrove diversity was considerably higher. The low diversity of submerged macrophytes may be attributable to low water levels, as submerged macrophytes require >1.5masl to develop (Van Niekerk et al., 2008).

Sediment

The grain size distribution within the estuaries (MOZ 4, MOZ 6 and MOZ 12) is dominated by medium and coarse sand, with very fine sand representing about 15 percent of the total sediment fractions. This is evident between the various sites sampled within the estuaries. The samples from the three estuarine sites indicate poorly sorted sediment (with the exception of MOZ 6b, which was classified as very poorly sorted), indicating that no severe impacts are present that have altered the physical properties of the sediment. The moisture content was found to be fairly low, at an average value of around 20 percent; this low percentage will have no significant impact on the ecosystems, but does influence the habitat character and the overall ecosystem composition. The organic content of the samples was classified as Low according to the USEPA (2001) for samples MOZ4a, MOZ4b and MOZ6a. It was evident during the sampling survey that organic content in the estuaries originates from upstream sources, local sources including mangroves and from the seagrass beds situated in the near shore.

A follow-up survey of the estuarine sites during June 2012 resulted in similar moisture content at the sites, while the additional sampling site MOZ 12 also indicated similar moisture content values. The organic content during the June survey was again Low to Very Low according to the USEPA (2001) scale,

reinforcing that organic material is not staying within the system but being transported to the sea.

Water Quality

The following physical variables were examined for the estuarine systems:

- DO;
- temperature;
- EC;
- TDS;
- salinity; and
- pH.

The mean values of the physical variables measured are shown in *Table 8.17* and are discussed further in the sections below. The constituents were compared to the SAWQG for Coastal Aquatic Ecosystems (DWAF, 1996c) to see if the values fell within the TWQR. When these values were not available, the results were compared to the USEPA (2009), United Nations Water Quality guidelines (UNWQG) and Australian and New Zealand guidelines (ANZECC, 2000a) to give an indication of ecosystem deterioration in the Survey Area, with the understanding that these are not absolute for Mozambique.

Table 8.17 Physical Water Quality Parameters of the Estuarine Sampling Sites in Low Flow 2011 and 2012 and High Flow 2012

In situ Variables	Range	MOZ 4			MOZ 6			MOZ 12
		LF 2011	HF 2012	LF 2012	LF 2011	HF 2012	LF 2012	LF 2012
DO (mg/l)	[A]>5 [B]6-14	*4.62*	*4.55*	5.85	*3.86*	*2.73*	5.94	5.80
DO (%)	[C]>80–90	*73.40*	*73.44*	*77.17*	*60.47*	*44.39*	*78.80*	*73.09*
Temp (°C)	[A] Must not exceed ambient temp by 1%	28.3	29.5	26.5	29.4	30.7	27.9	26.1
EC (mS/m)	–	5,793	5,566	1,834	5,008	5,215	1,293	790
TDS (mg/l)	–	28,96 6	27,829	9,171	25,040	26,074	6,468	3,951
Salinity	32–36	*38.53*	*36.78*	10.85	32.67	34.15	7.42	4.40
pH	[A]7.3–8.2 [B]6.5–8.5	7.7	7.5	7.1	7.4	6.9	6.6	6.6

Key:

–: No data available.

[A] Water Quality Guidelines for South African coastal marine waters (DWAF, 1996c).

[B] USEPA (2009) WQ guidelines.

[C] Western Australian WQ guidelines.

Constituents that did not meet the TWQR for saltwater are *italicised*.

Legend: LF: low flow; HF: high flow.

Source: NSS, 2012.

Dissolved Oxygen

Dissolved oxygen levels usually range from 6 to 14mg/l in saline water because it has limited solubility. However, DO values observed in the estuaries are considered to be low in comparison, ranging from 2.73 to 4.62mg/l, with higher levels observed at Catchment B. This is typical of mangrove waters. DO concentrations naturally vary over a 24-hour period as a result of tidal exchange. Under warmer conditions, water is more likely to become anoxic or hypoxic because of a decreased ability of water to hold DO and increased bacterial respiration. The water temperature at MOZ 4 (Catchment B) was 1°C lower than MOZ 6 (Catchment A) and this may explain the higher DO value recorded at Catchment B. In addition, there was a visible increase in DO values at the two sites during low flow 2012, which was probably influenced by the drop in temperature at these sites. A similar DO value was recorded at MOZ 12 during this time.

Temperature

Temperatures ranging between 28.3 °C (Catchment B) and 30.7°C (Catchment A) were observed at low flow in 2011 and 2012. Water temperatures observed during the high flow 2012 survey were higher compared to those observed during the low flow 2011 survey, as the measurements were taken in February, a hot summer month in comparison to October (spring). The temperatures dropped to 26.5 °C (MOZ 4) and 27.9 °C (MOZ 6) during June 2012 (winter), with MOZ 12 showing a similar temperature of 26.1 °C as the other estuarine sites during this time. Water temperature influences the density (densest at 4°C), conductivity and pH of these water columns.

Electrical Conductivity

The EC values of the estuarine sites are considered to be high, as a result of the high concentrations of cations (Ca^{2+}, Mg^{2+}, Na^{+}) and anions (Cl^{-} and SO_4^{2-}) at these sites. These concentrations are natural for saline systems. An evident decreased EC was noted during the low flow 2012 sampling, which was probably due to an influx of fresh water into these systems as a result of the heavy rains in the area before and during sampling.

Total Dissolved Solids

The TDS values observed at the estuarine sites are considered extremely high, probably due to the fact that the TDS were measured at the mouth of the mangroves at low tide, and reflect the high concentrations of cations (ie Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and anions (ie Cl^{-} and SO_4^{2-}) at these sites. However, these extremely high TDS values observed were also found in a similar study in the mangrove ecosystems in the south-east coast of India (Ramanathan et al., 1999).

The TDS values reduced considerably during the low flow 2012 sampling, which was probably caused by fresh-water floods entering these systems due to increased rainfall in the area. MOZ 12 had a similar TDS value as recorded from the other two estuaries during this time.

The estuarine systems were hypersaline and only dependent on tidal flow, with no fresh water flowing into these systems. The estuarine water can become denser than oceanic waters under these conditions, sinking and forming a high-saline bottom layer.

Salinity

Subtropical surface waters of the east coast of Africa are usually characterised by relatively high salinities (>35) caused by greater evaporation rates. The salinity at Catchment B was higher than at Catchment A, indicating that more saline water entered this system from Palma Bay. The limited fresh water draining from upstream wetlands did not reduce the salinity levels, as the levels were similar during both the low flow and high flow surveys. However, during low flow 2012, the salinity dropped as low as 11 (MOZ 4) and 7 (MOZ 6), which confirms the assumption that there was an influx of fresh water into these systems. A salinity value of 4, the lowest observed, was observed at MOZ 12.

pH

According to the international guidelines of the EPA, the pH for saline systems should range between 8.5 and 8.5. The pH values within the estuaries sampled range between 6.9 (MOZ 6 – Catchment A) and 7.7 (MOZ 4 – Catchment A), indicating alkaline brackish waters, probably due to dissolved calcium from shells and offshore coral influencing the estuaries.

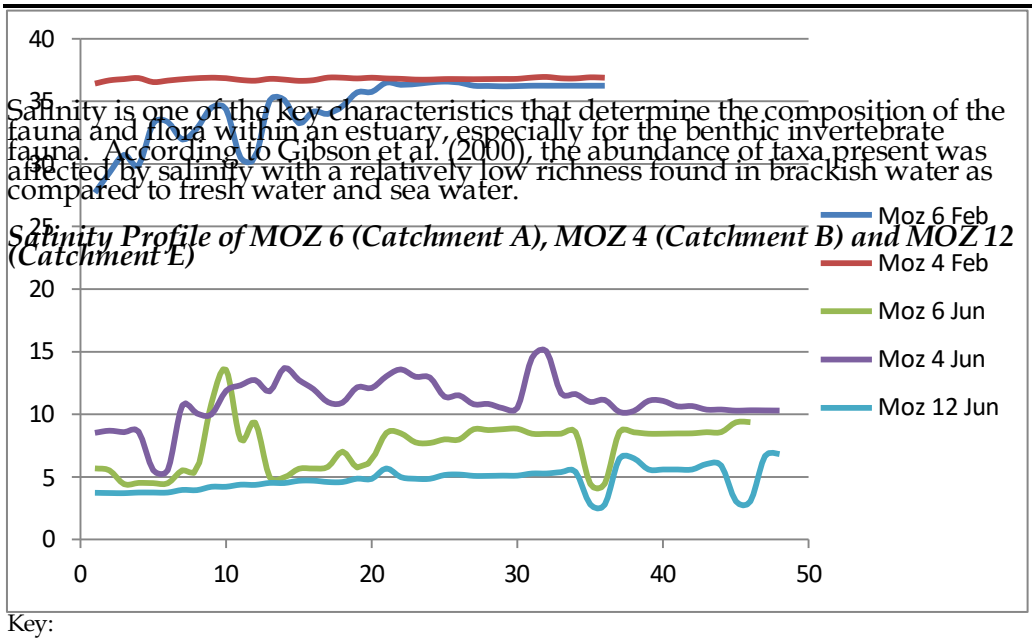
Water Quality Profiles

An important aspect of estuarine ecology is the gradient or profile of salinity within the estuary. Estuaries can be fresh-water dominated with a low level of sea water intrusion, or more marine dominated if the fresh-water inflow is limited. A salinity profile for each estuary is provided in *Figure 8.25* below.

No significant salinity profile was seen at site MOZ 4 (Catchment B) during the February 2012 survey, indicating that the fresh-water inflow to MOZ 4 was limited and the estuary was dominated by sea water. The salinity profile for the June 2012 survey indicated that no profile was evident from the head to the mouth of the estuary; however, the salinity was significantly lower than during February 2012. This trend was also observed at MOZ 6 (Catchment A) during the June 2012 survey, compared to the February 2012 survey. The slight salinity profile seen during February 2012 at MOZ 6 was still present during June 2012, even though it was less pronounced. These lower salinities will change during the high tide, as the tidal variation intrudes up to the head of both these estuaries. The salinity profile of MOZ 12 did indicate a salinity increase from the head to the mouth of the estuary. However, the salinity at MOZ 12 was lower than at MOZ 4 and MOZ 6, which possibly indicates a more significant fresh-water source.

Salinity is one of the key characteristics that determine the composition of the fauna and flora within an estuary, especially for the benthic invertebrate fauna. According to Gibson et al. (2000), the abundance of taxa present was affected by salinity with a relatively low richness found in brackish water as compared to fresh water and sea water.

Figure 8.25 ***Salinity Profile of MOZ 6 (Catchment A), MOZ 4 (Catchment B) and MOZ 12 (Catchment E)***



Key:
X-axis: 10m intervals from the estuary mouth to upper reaches of the estuary.
Y-axis: salinity (in PSU).

Source: NSS, 2012.

The pH within sites MOZ 6 and MOZ 4 follows a similar trend to that of salinity. At site MOZ 6 in February 2012, the pH was approximately 5 at the upper reaches of the estuary, increasing to 7.2 at the mouth of the estuary. This is due to the increased salts of the sea water increasing the pH. The pH profiles during June 2012 for both MOZ 4 and MOZ 6 indicated a lower pH, corresponding to the decreased in salts due to the increased fresh-water inflow. The pH of MOZ 12 was similar to the pH profile measured at MOZ 6.

The percentage oxygen saturation for MOZ 6 and MOZ 4, measured together with the pH and salinity, indicates a relatively low saturation percentage in the upper reaches compared to the mouth of the estuary. This could be due to the notably higher water volume within the upper reaches compared to the mouth. In addition, the cover of the mangroves was significantly higher within the upper reaches compared to the mouth, which could lead to a slightly lower photosynthetic rate.

Chemical Water Quality Parameters

The concentrations of nutrients, metals and salts at each of the sampling sites are listed in *Table 8.18*. The constituents analysed at each site were compared to the SAWQG for Coastal Aquatic Ecosystems (DWAF, 1996c) to see if the values fell within the TWQR. When these values were not available, the results were compared to other international guidelines. It was found that the concentrations of Ba, Cu, Ni, Pb, Zn and NO_3 exceeded the TWQR. Seasonal trends were observed, with the concentrations of Ni, Cu and NO_3 being higher during low flow 2011 and Pb higher during high flow 2012.

The water in the estuaries mostly consisted of sea water. It was not possible to determine the sources that lead to the high concentrations in the estuaries.

Table 8.18 Constituents Measured at Estuarine Sampling Sites during Low Flow 2011 and 2012 and High Flow 2012

Constituents	TWQR	MOZ 4			MOZ 6			MOZ 12
		Low Flow 2011	High Flow 2012	Low Flow 2012	Low Flow 2011	High Flow 2012	Low Flow 2012	Low Flow 2012
Metals								
Al (mg/l)	-	<0.006	<0.006	<0.006	<0.006	<0.006	0.016	0.027
Ag (mg/l)	0.005[a]	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
B (mg/l)	-	6.309	5.185	0.909	3.631	4.538	0.546	0.750
Ba (mg/l)	**0.001[b]**	<0.001	*0.032*	*0.017*	*0.031*	*0.030*	*0.013*	*0.219*
Be (mg/l)	-	<0.001	-	-	<0.001	-	-	-
Bi (mg/l)	-	<0.01	-	-	<0.01	-	-	-
Ca (mg/l)	-	495.189	449.892	71.582	277.677	400.853	43.566	52.559
Cd (mg/l)	0.004[a]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Co (mg/l)	-	<0.002	0.016	<0.002	<0.002	0.004	0.006	0.004
Cr (mg/l)	0.008[a]	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cu (mg/l)	**0.005[a]**	*1.284*	*0.268*	*0.034*	*1.225*	*0.256*	*0.030*	*0.032*
Fe (mg/l)	0.1[b]	<0.006	<0.006	<0.006	<0.006	<0.006	0.024	<0.006
Ga (mg/l)	-	0.066	-	-	0.055	-	-	-
Hg (mg/l)	0.0003[a]	-	<0.001	<0.001	-	<0.001	<0.001	-
Li (mg/l)	-	0.224	0.192	0.032	0.118	0.164	0.020	0.024
Mn (mg/l)	-	0.028	<0.001	<0.001	0.075	<0.001	<0.001	<0.001
Mo (mg/l)	-	-	0.143	0.045	-	0.141	0.041	0.036
Ni (mg/l)	**0.025[a]**	*0.245*	<0.003	<0.003	*0.285*	<0.003	<0.003	0.042
Pb (mg/l)	**0.012[a]**	*0.14*	*0.246*	0.010	*0.20*	*0.366*	*0.025*	*0.037*
Si (mg/l)	-	6.816	6.122	0.930	9.176	6.408	4.214	2.105
Sr (mg/l)	-	9.329	8.064	1.304	4.993	7.081	0.793	0.872
Rb (mg/l)	-	1.607	-	-	1.011	-	-	-
Te (mg/l)	-	<0.023	-	-	<0.023	-	-	-
Tl (mg/l)	-	<0.087	-	-	<0.087	-	-	-
V (mg/l)	-	1.437	-	-	1.066	-	-	-
Zn (mg/l)	**0.025[a]**	*0.111*	*0.132*	*0.067*	*0.105*	*0.087*	*0.032*	*0.108*
Ions								
Cl (mg/l)	-	19,857.7	18,498.3	2,992.5	11,505.6	16,393.0	2,992.5	2,891.7
F (mg/l)	5[a]	0.987	0.915	0.353	0.678	0.815	0.258	0.280
K (mg/l)	-	470.613	413.779	69.127	261.087	362.184	41.226	47.646
Mg (mg/l)	-	1,538.947	1,319.052	226.873	860.329	1,161.638	159.530	171.680
Na (mg/l)	-	10,632.45	10,512.76	1,865.21	6,970.54	9,488.98	1,662.03	1,530.80
Nutrients								
NO_3 (mg/l)	**0.01[b]**	*0.180*	<0.057	0.098	*0.215*	<0.057	0.168	0.069

Constituents	TWQR	MOZ 4			MOZ 6			MOZ 12
		Low Flow 2011	High Flow 2012	Low Flow 2012	Low Flow 2011	High Flow 2012	Low Flow 2012	Low Flow 2012
NH_4 (mg/l)	0.6[a]	0.515	0.560	<0.057	0.348	0.516	<0.057	<0.057
NO_2 (mg/l)	-	-	<0.005	<0.005	-	<0.005	<0.005	<0.005
PO_4 (mg/l)	<6.7[a]	<0.025	<0.025	<0.025	<0.025	0.055	<0.025	0.041
SO_4 (mg/l)	-	2,490.34	3,208.88	593.21	1,584.60	3,159.75	348.66	356.20
Total alkalinity (mg/l)	-	33.7	32.8	15.8	47.4	26.4	22.9	23.0
Total hardness (mg/l)	-	7,574	6,555	1113	4,236	5,785	766	838
Soap, grease and oil (SOG) mg/l	-	-	0.10	2.80	-	0.25	0.60	1.4
Organic enrichment								
COD (mg/l)	-	-	953.10	53.65	-	868.50	1,061.60	599.10
Chlorohpyll A	-	-	-	<0.01	-	-	<0.01	<0.01
Turbidity								
SS (mg/l)	-	-	323	70	-	276	54	38
Turbidity (NTU)	-	-	2.1	3.6	-	1.6	4.5	3.9

Key:

– = Not available.

a = South African Guidelines for Coastal Waters (DWAF, 1996c).

b = International Guidelines – USEPA (2009).

Constituents in coastal water exceeding the South African (DWAF, 1996c) and USEPA (2009) TWQR are *italicised*.

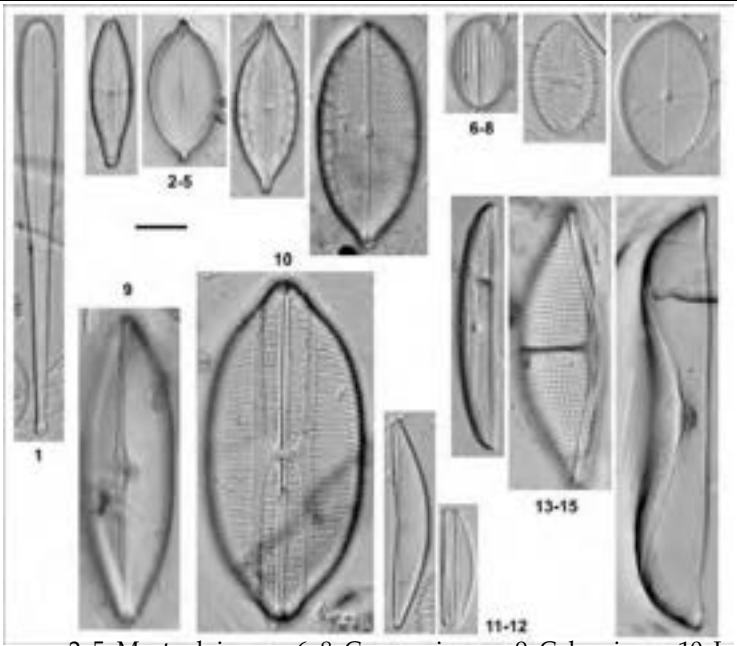
Source NSS, 2012.

Microalgae and Benthic Microalgae

Six different groups of microalgae were observed in the estuaries during the February 2012 survey: diatoms, chlorophyta, cynanophyta, crysophyta and dinoflagelletes. The most abundant taxa present are diatoms, followed by chlorophyta (green algae), in both the February and June surveys. A similar trend was seen for the benthic phytoplankton where the diatom group was the dominant taxa. Benthic microalgae and microalgae depend on fresh-water inflow to provide nutrients into the system and, as the fresh-water inflow is fairly low, their abundance are limited (Snow et al., 2000). No visible algal patches were seen to indicate significant amounts of nutrients within the system. Nutrients within the water samples were also found to be low and, as such, limiting the growth and abundance of microalgae and benthic microalgae.

The diatoms were dominated by a high abundance of *Gomphosphaenia* sp., *Amphora* sp., *Navicula* sp. and *Rhopalodia* sp. Twenty species were observed, all of which are considered to be naturally abundant in saline conditions. In terms of impacts, none could be identified with certainty, although no deformed cells were evident and the abundances tended to be natural, which suggested limited stress on diatom communities. Spatial analysis, however, did reveal that diatoms at MOZ 4 were composed of more tolerant species.

Figure 8.26 ***Brackish Water Diatom Species***



1: Licmorphora sp.; 2–5: Mastogloia spp.; 6–8: Cocconeis spp.; 9: Caloneis sp.; 10: Lyrella sp.; 11–12: Seminavis spp.; 13–15: Amphora spp. Scale bar = 10 µm.

Invertebrates

Research has shown that up to 200 species are able to occur in the benthic substrate in subtropical estuaries (NSS, 2012). Four species of micro-

invertebrates were observed in the estuaries of Catchment A and B (see *Table 8.19*).

Table 8.19 Micro-invertebrate Species Observed at Estuarine Sites

Order	Family	Species
Decapoda	Palaemonidae	*Macrobranchium equidens*
Phyllodocida	Nereididae	*Dendronereis arborifera*
Phyllodocida	Nereididae	Unidentified sp.
Tanaidacea	Apseudidae	*Apseudes digitalis*

Source: NSS, 2012.

The zooplankton sampling resulted in nine taxa being collected, of which eight were sampled at site MOZ 6 and six taxa sampled at site MOZ 4 during February 2012. The June 2012 sampling survey resulted in eight taxa overall, with seven taxa sampled at MOZ 6, six taxa at MOZ 4 and only five taxa sampled at the additional site MOZ 12. The benthic invertebrates results showed 17 different taxa were sampled at site MOZ 4 and 14 taxa at site MOZ 6 during February 2012. The total taxa diversity between the two estuaries counted as 24 taxa. The June 2012 survey yielded 18 different taxa at site MOZ 4, MOZ 6 and MOZ 12. However, the abundances of especially the Amphipoda taxa were significantly higher in June than during February 2012. The sampling at MOZ 12 yielded seven taxa, MOZ 4 yielded eight, and 16 taxa were sampled at MOZ 6.. Overall, the abundance of taxa was also the highest at MOZ 6. MOZ 6 also yielded one family that predominantly occur in fresh water ie Chironomidae.

A fairly diverse benthic invertebrate community supported by the poorly sorted sediment and the present organic content is present in the estuaries of the Survey Area. The important taxa group sampled in this assessment was the Decapoda. They are a very important part of the mangrove system, playing a key role in the cycling of nutrients in these systems, and were found to be the most abundant taxa at both estuary sites. These taxa were also evident throughout all the mudflats present in the upper reaches of the estuary systems. These areas possibly only receive water during flooding, and potentially at spring tide. The results also indicated no significant seasonal differences in diversity at MOZ 4 and MOZ 6, while the diversity at MOZ 12 was similar to the other sites. However, at MOZ 6 the abundances of zooplankton were significantly higher during the June 2012 survey. The abundance of zooplankton at site MOZ 12 was similar to MOZ 6, while at MOZ 4 a slightly decreased abundance as compared to MOZ 6 was seen. This is an indication of a functioning ecosystem, as the higher water levels in May and June 2012 have resulted in more nutrients being available for phytoplankton and, as such, the zooplankton community.

Ichthyofauna

The fish species sampled during the high flow and low flow surveys at the three estuary sites are presented in *Table 8.20*. A higher level of connectivity is

present within MOZ 6, as is evident by the sampling of *M. cyprinoides* at fresh-water MOZ 5, indicating the connectivity of the system. The dusky sleeper, *E. fusca*, was also sampled at MOZ 5, providing further evidence of connectivity as well as the importance of the estuary. The fish species sampled within the estuaries are not considered to be under any serious conservational threat according to the IUCN, with the exception of *O. mossambicus*, which is listed as Near Threatened as this species inbreeds with *O. niloticus*, a species quite common in parts of Africa. Some of the species observed, however, have not been evaluated by the IUCN and therefore no information about their status is available. *Chanos chanos* (milkfish) may be considered as potential conservation concern, as it is a commercially exploitable species. However, most of this species sampled in the estuaries were juveniles, which rely on mangrove systems as a nursery ground. They are particularly susceptible to impacts in the water and habitat through direct toxicity or via indirect mechanisms (eg increased susceptibility to predation).

Table 8.20 Fish Species Sampled at Estuary Sites

Common Name	Species Observed	Conservation Status*	Estuarine Use Functional Group
Mozambique tilapia	*Oreochromis mossambicus*	Near Threatened	FM
Halfbeak	*Hemiramphus far*	Not assessed	MMO
Round/Natal moony	*Monodactylus argenteus*	Not assessed	MM
White-spotted puffer	*Arothon hispidus*	Not assessed	MS
Mangrove red snapper	*Lutjanus argentimaculatus*	Not assessed	MMO
Great barracuda	*Sphyraena barracuda*	Not assessed	MMO
Milkfish	*Chanos chanos*	Not assessed	MMO
Dusky sleeper	*Eleotris fusca*	Least Concern	ER
African mudskipper	*Periophthalmus argentilineatus*	Not assessed	ER
Bentstick pipefish	*Trachyrhamphus bicoarctatus*	Not assessed	EM
Thornfish	*Terapon jarbua*	Least Concern	MM
Commerson's glassy perchlet	*Ambassis ambassis*	Least Concern	EM
Squaretail mullet	*Liza vagiensis*	Not assessed	MM
Mullet	*Liza dumerilii*	Not assessed	MM
Striped silver biddy	*Gerres methueni*	Not assessed	MMO
Cardinalfish	*Apogon* sp.	Not assessed	MS

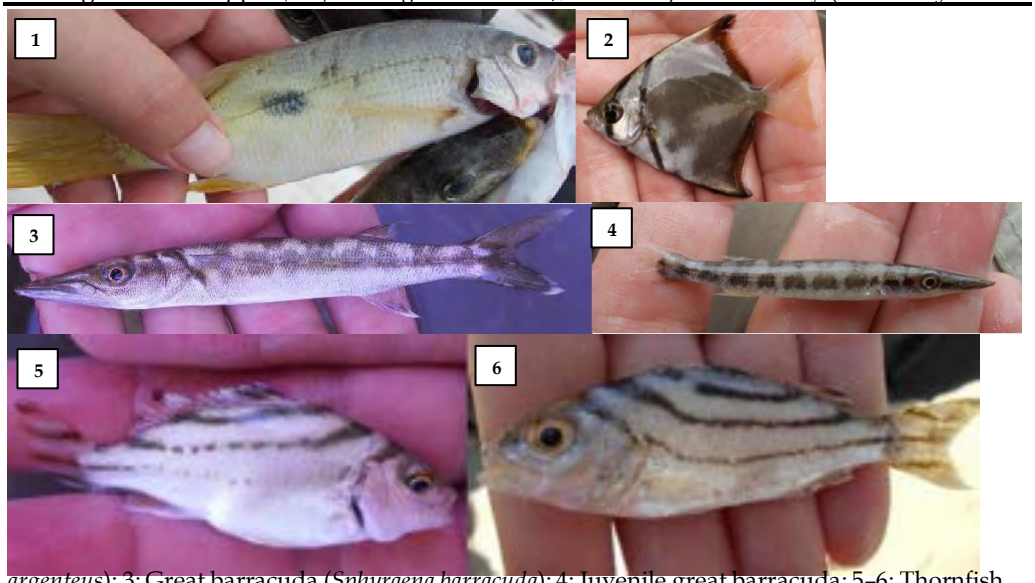
Key:
FM = Fresh-water migrants; MM/MMO = Marine migrants; MS = Marine straggles; ER/EM = Estuarine species. * The conservation status is based on the IUCN Red List of Threatened Species (2012).

Source: NSS, 2012.

As evident in *Table 8.20*, the dominant guild within the estuaries is the marine migrant, which indicates a dominance of species that spawn in the ocean but then enter estuaries in large numbers and specifically as juveniles. These species are often euryhaline (capable of tolerating a wide range of salt concentrations). Some marine migrants depend on estuaries to survive, and most of the species classified in this guild observed are opportunistic and are able to use the near shore marine environment as an alternative habitat if

estuarine conditions are not present (Elliot et al., 2007). Some examples of these species are shown in *Figure 8.27*.

Figure 8.27 Marine Fish Species Observed in the Estuaries Sampled



1: Mangrove red snapper *(Lutjanus argentimaculatus)*; 2: Round/Natal moony (*Monodactylus argenteus*); 3: Great barracuda (*Sphyraena barracuda*); 4: Juvenile great barracuda; 5–6: Thornfish (*Terapon jarbua*).

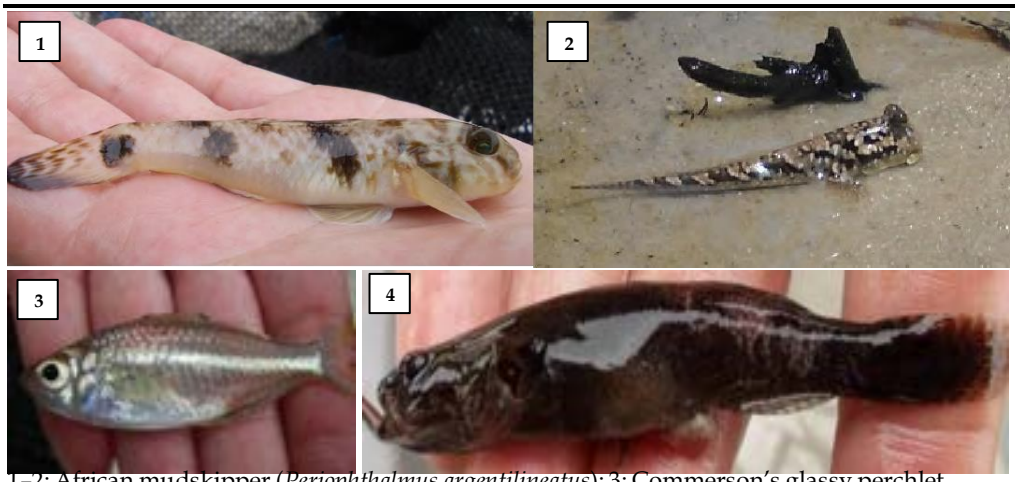
Source: NSS, 2012.

Estuarine residents were also present, and these species are capable of completing their full life cycle within the estuarine environment and are shown in *Figure 8.28*. Estuarine migrants can be species that have a larval stage of their life cycle that occurs outside of the estuary, or the species can be represented by a discreet marine population. Marine stragglers enter estuaries only in low numbers, occur only in the lower reaches of an estuary due to their limited tolerance to fresh water, and are mostly associated with the near shore marine environment (Elliot et al., 2007). Fresh-water migrant species frequent estuaries in moderate numbers and can occur beyond the oligohaline reaches of an estuary.

As shown in *Figure 8.28*, African mudskippers (*Periophthalmus argentilineatus*) were observed in the estuaries. These are restricted to the mangrove systems of East Africa. This fish species is amphibious and uniquely adapted to intertidal habitats – they can move in water as well as using their pectoral fins to walk on land. Other estuarine species observed are shown in *Figure 8.28*.

The fish communities present in Catchments A and B are diverse. The habitat conditions and fish observed indicate that numerous functions are provided for the fish community by these estuaries.

Figure 8.28 Estuarine Fish Species Observed in the Estuaries



1–2: African mudskipper (*Periophthalmus argentilineatus*); 3: Commerson's glassy perchlet (*Ambassis ambassis*); 4: Dusky sleeper (*Eleotris fusca*).

Source: NSS, 2012.

Avifauna

Birds make an important contribution to the recreational and aesthetic value of estuaries, as well as contributing to the maintenance of estuarine processes through predation and nutrient inputs (DWA, 2010). A number of species were observed within the estuarine habitats, including waders in the intertidal area; these are further detailed in *Section 8.9* of this chapter.

Estuarine Resources

The specific resources that are provided by estuaries are generally related to the provisioning fish (as bait and food) and shellfish resources that are important for recreational, subsistence and informal commercial purposes. Estuaries are also able to provide raw materials like reeds and sedges for crafts and fencing, while mangroves forests can provide material for building, firewood, timber and poles. The ecosystem services offered by estuaries differ between estuaries due to their catchment characteristics. The most important services of estuaries are their nursery functions and the export of sediment and nutrients needed for the marine environment (DWA, 2010). Estuaries serve as a nursery to many fish species that can then recruit into marine fisheries areas offshore (Lamberth & Turpie, 2003). These systems can also provide a refuge area for coastal species, as estuaries have sheltered habitats that are not generally present in the more exposed coastline. The habitats and biodiversity in estuaries can also provide cultural services in the form of recreation, education and research opportunities.

Estuarine Sensitivity

Based on present data, the quality of habitat, existing alterations (man-made) to the system and current land use in the Survey Area, these estuaries are

considered to be in a good condition. The estuaries are considered to be Highly Sensitive (as defined in *Annex C*). These are discussed further in *Section 8.6.6* by catchment.

Four species of frogs were recorded at both MOZ 4 and MOZ 12, including the following species of conservation concern: Parker's reed frog (*Hyperolius parkeri*) and African bullfrog (*Pyxicephalus edulis*) at MOZ 4 and shoring leaf-folding frog (*Afrixalus crotalus*) and Lindner's toad (*Mertensophryne lindneri*) at MOZ 12. Only two species of frog were observed at MOZ 6, within highly brackish areas of the estuaries. Lindner's toad is considered to be the species of highest conservation importance of all the amphibians detected during the surveys of the estuaries. It belongs to the group of habitat-specific toads known as woodland toads. Channing (2001) indicates that this species has been recorded only three times and is restricted to a small region near the Mozambique/Malawi border, but reports that the species has been known to occur within southern Tanzania as well. Although woodland toads, like other toads, are frogs of low wetland association, it is a highly conservation-important species (although only listed as Least Concern) based on its range restriction and decreasing global population trend (IUCN, 2012).

A variety of other faunal species use the mangroves, and evidence of some of those observed are illustrated in *Figure 8.29*.

Figure 8.29 ***Faunal Species Observed in the Mangroves***

Left: Fiddler crab (*Uca annulipes*). Right: Spoor of African clawless otter (*Aonyx capensis*).
Source: NSS, 2012.

The mangrove habitats provide an important buffering capacity between the marine and inland environment. Various marine fish depend on the estuaries as a nursery habitat for immature stages and a large number of bird species are also found to use these estuarine sites, as indicated in *Section 8.9*. The fish communities present in these estuary systems are diverse.

Anthropogenic Influences

Estuaries provide a habitat for important sources of food and building materials for local communities. Human activities such as the harvesting of

natural resources (wood, reeds, sedges, snails, fish and salt) are currently affecting the estuarine wetlands (MOZ 4 and MOZ 6). However, all of these impacts are minimal and are currently not having any noticeable effect on the system. Alien vegetation is also present, as evidenced by the cultivation of fruit trees such as coconuts and cashews. *Figure 8.30* shows some examples of existing anthropogenic impacts in the estuaries.

Figure 8.30 Evidence of Anthropogenic Alteration at the Estuarine Sites

Top left: Snail harvesting at MOZ 6. Top right: Extensive coconut plantation – MOZ 6. Bottom left: Evidence of wood harvesting at MOZ 4. Bottom right: Alien tree *Casuarina equisetifolia* – often associated with swamp forest vegetation of estuaries.

Source: NSS, 2012.

8.6.5 Catchment Characteristics

This section describes the characteristics of each of the five catchment areas (A, B, C, D and E) as listed in *Table 8.12*, to provide an overview of the sensitivities of each of the systems.

The present ecological status of the wetlands and estuaries has been determined by assessing water quality, diatoms, habitat, macro-invertebrates and fish community integrity based upon the following biotic scoring systems and indices: Index of Habitat Integrity (IHI), Macro-invertebrate Response Index (MIRAI), South African Scoring System, version 5 (SASS5) and Riparian Vegetation Response Assessment Index (VEGRAI). For further detail, see the surface water ecology methodology in *Annex C*. Ecological categories were used to define aquatic and riparian habitat integrity to determine the

ecological condition of a river or fresh-water system in terms of the deviation of biophysical components from the natural reference condition (Kleynhans & Louw, 2008), based on scores. The Present Ecological Status categories range over a continuum of levels of disturbance of the natural state of the ecosystem, from no disturbance or natural (Category A) to critically modified (Category F) and are represented by characteristic colours, defined by Kleynhans and Louw (2008) in *Table 8.21*. Aquatic and riparian habitat integrity has been calculated according to the methodology in *Annex C*.

In some cases, a particular entity may potentially have membership of two classes when there is uncertainty to which category a particular waterbody belongs, and this is reflected below where relevant.

Table 8.21 Present Ecological Status Codes and Descriptions

Category	IHI (%), MIRAI (%), SASS5, VEGRAI	Short Description	Long Description
A	90–100	Natural	Unmodified state with no impacts, conditions natural. (Scores between 87.4 and 92 = A/B)
B	80–89	Largely natural	Largely natural with few modifications. A small change in natural habitats and biota may have taken place, but the ecosystem functions are essentially unchanged. (Scores between 77.4 and 82 = B/C)
C	60–79	Moderately modified	Moderately modified – loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. (Scores between 57.4 and 62 = C/D)
D	40–59	Largely modified	Largely modified – a large loss of natural habitat, biota and basic ecosystem functions has occurred. (Scores between 37.4 and 42 = D/E)
E	20–39	Seriously modified	Seriously modified – the loss of natural habitat, biota and basic ecosystem functions are extensive. (Scores between 17.4 and 22 = E/F)
F	<20	Critically modified	Critically/extremely modified – modifications have reached a critical level and the system has been modified completely, with an almost complete loss of natural habitat and biota. In the worst instances, the basic ecosystem functions have been destroyed and the changes are irreversible.

Source: Modified from Kleynhans & Louw (2008); Kleynhans (1996, 1999) and Kleynhans et al. (2007).

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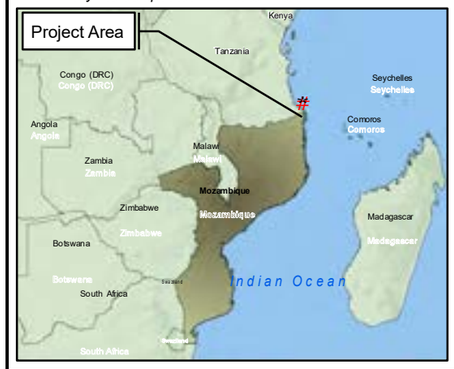
Legend

- Aquatic and Wetland Sites
- Villages / Settlements
- Local Roads
- Contours
- Nearshore Components
- Onshore Project Footprint
- Wetland Groups
- Afungi Project Site

Wetlands

- Estuary
- Permanent wetland
- Seasonal wetland
- Unspecified wetland
- Wetland Buffer (150 m)

Note:
Preliminary - to be updated with catchment E



MAIN MAP SCALE:

0 1 2 4 Kilometres

TITLE:

Figure 8.31: Wetland Catchments

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 50 000

DRAWING: Wetland Catchments.mxd

REV: A

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Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Natural Scientific Services CC, 2012
Inset Map: Esri Data & Maps

SIZE: A3

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Catchment A

Five sampling sites were selected in Catchment A and these are outlined in *Table 8.22*. Catchment A is an unchannelled valley bottom system, ending in a shallow-water estuary with a sandy substrate. The system is a slow-flowing deep wetland, and has artificial channels dug within the wetland to increase the flow for agricultural purposes.

Table 8.22 Sampling Sites within Catchment A

Catchment and Assessment Sites	Site Description
Catchment A	
MOZ 2	Upper catchment zone, close to the start of the permanent wetland
MOZ 3	Mid catchment zone
MOZ 5	Mid catchment zone
MOZ 6	Estuary
MOZ 11	Lower catchment zone with broad permanent wetland

Source: NSS, 2012.

The aquatic habitat integrity of the lacustrine areas of the catchment was Largely Natural with some anthropogenic influences, eg the artificial channels and high algal presence (although no visible algal patches were seen within the estuary site, as described in *Section 8.6.4*).

The overall riparian habitat integrity ranges from Moderately to Largely Modified, with the main anthropogenic influences identified on the upper and lower riparian zones of the catchment from the removal of natural vegetation for the planting of crops, fruit trees, exotic trees, etc. The integrity of the marginal zone was high and ranged from Natural to Largely Natural. The riparian habitat integrity of the estuarine sampling point (MOZ 6) within the catchment was Natural, with virtually no anthropogenic influences present and dominated by dense groves of mangrove trees.

The main ecosystem services supplied by the lacustrine wetlands include natural resource provision and the cultivation of foods. Similarly, the estuary at the mouth of the catchment provides natural resources used by the local people.

In terms of water quality, low oxygen levels, influenced by high temperatures and slightly high salts content, were observed at each of the lacustrine wetland sites within Catchment A (see *Section 8.6.3*). NH_4, COD, SS and Zn had concentrations exceeding TWQRs, within the lacustrine sites, with site MOZ 11 in the lower catchment zone also exceeding levels of Al and Fe. SS, Zn and Al are considered to be naturally occurring constituents within these systems. The higher levels of NH_4, COD and Fe could be attributed to sewage within the lacustrine wetland systems. The water quality results in the estuarine site indicate that the oxygen levels were low and the salinity high (see *Section 8.6.4*). A decrease in the salinity profile was observed at site MOZ

6, indicating that there was fresh-water inflow into the estuary. Within the estuary, the water quality showed exceeding concentration levels of Ba, Cu, Ni, Pb, Zn and NO_3, and because most of the water was sea water, the exact source of contamination could not be determined. Nutrient variables within the estuarine water samples were also found to be low and, as such, limit the growth and abundance of microalgae and benthic microalgae.

The MIRAI scores were Largely Natural to Moderately Modified and indicated that the macro-invertebrates within the lacustrine wetland are influenced by flow modification, habitat and water quality. Low numbers of sensitive families and a generally low family diversity indicated that only tolerant families could survive in these wetlands with limited flow and absence of the stone biotope. In addition to this, there were also high percentages of airbreathers, which were also indicative of slow-flowing habitats with a lack of sufficient oxygen levels, high temperatures and high water levels. Only one species of macro-invertebrate, identified to family level only, was sampled at the estuary site MOZ 6 (see *Section 8.6.4*). The most abundant benthic invertebrate taxa group sampled in the estuary site was the Decapoda, which play a very important role in the cycling of nutrients in the mangrove system. The zooplankton and benthic invertebrate sampling resulted in eight and 14 taxa sampled at site MOZ 6 respectively. The distribution and abundance of these species living in the benthic environment is dependent on the physical sediment composition. The fairly diverse benthic invertebrate community is supported by the poorly sorted sediment and the organic content present.

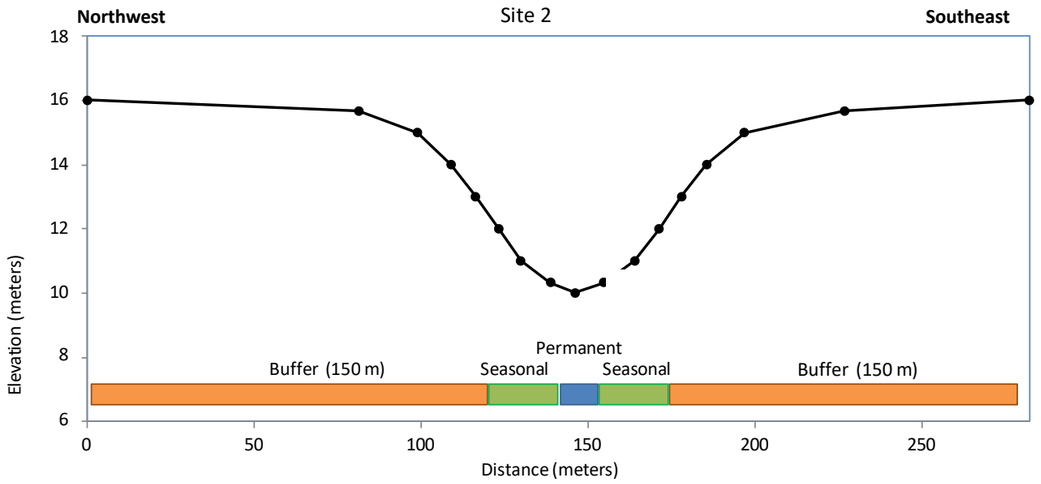
Fish species of note observed in the lacustrine wetlands of Catchment A including the data-deficient *Eleotris fusca* (MOZ 5), *Megalops cyprinoides* (MOZ 5) and *Ambasis ambassis* (MOZ 11). These data-deficient species are important to consider as they may have a conservational importance (see *Section 8.6.3*). The dominant fish guild in the estuary was the marine migrant guild, which indicates species that spawn in the ocean and then enter estuaries in large numbers, specifically as juveniles. The large number of juveniles indicated that the estuary is mostly used as a nursery ground. In terms of number of species, the estuary in Catchment A had a higher number of fish species and a higher abundance of species than the estuary in Catchment B (MOZ 4). This indicates that this estuary is more productive, potentially due to increased phosphates present in the system, the slightly larger size of the estuary and the catchment and connectivity of the estuary.

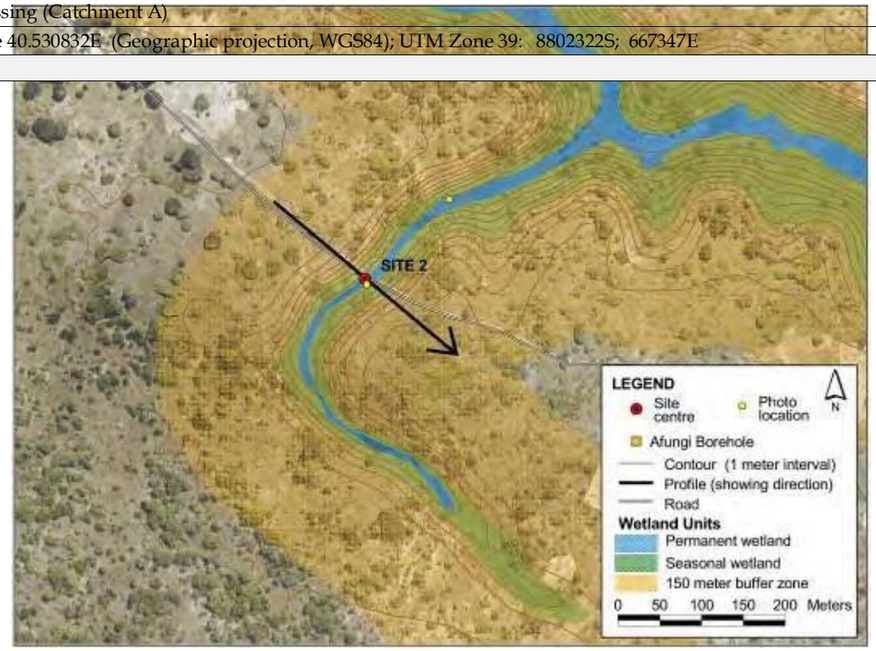
Figure 8.32 to *Figure 8.36* provide general information and detailed results for the high flow (October 2011) and low flow sampling assessments (February 2012) for each sampling site in Catchment A.

Figure 8.32 Sampling Site MOZ 2

Wetland Type	Unchannelled valley bottom wetland, but pooling has occurred due to a road crossing (Catchment A)
Location	In the proposed Project Footprint Area (24 masl). Latitude 10.830675S; Longitude 40.530832E (Geographic projection, WGS84); UTM Zone 39: 8802322S; 667347E

Wetland Layout





Source: Aerial image supplied by AMA1

General Site Description

This wetland is located towards the top of its catchment, and in the same wetland system as sites 3, 5 and 6. In its natural state, the wetland at this site would consist of a narrow unchannelled valley bottom, but has been altered into a dammed wetland at the site and channelled thereafter.

Photos

Low Flow 2011			High Flow 2012		
UPSTREAM	*DOWNSTREAM*	*CLOSE-UP*	*UPSTREAM*	*DOWNSTREAM*	*CLOSE-UP*

Riparian Zone Description

Marginal Zone (MZ)	The marginal zone was approximately 10m wide. There is a large pool of water up to 0.75m deep as a result of a flow obstruction created by building a road across the wetland. In its natural state, the zone was dominated by a diversity of ferns and sedges. A few naturally occurring woody species were present, up to a height of about 5m.
Lower Zone (LZ)	This zone covered an area with a topographical rise of approximately 7m above the marginal zone.
Upper Zone (UZ)	The upper zone was not readily distinguishable from the surrounding terrestrial vegetation, and much of the natural vegetation had been displaced by cultivation and planting of fruit and nut-bearing trees.

Vegetation

SPECIES	MZ	LZ	UZ	SPECIES	MZ	LZ	UZ
Ageratina adenophora *	x			*Hyphaene coriacea*		x	x
Acacia sp.		x		*Mangifera indica* *		x	x
Anacardium occidentale *			x	*Musa acuminata (hybrid)* *	x		
***Berlinia orientalis* (VU)**		x		*Nymphaea nouchali*	x		

Hyphaene coriacea – lala palm

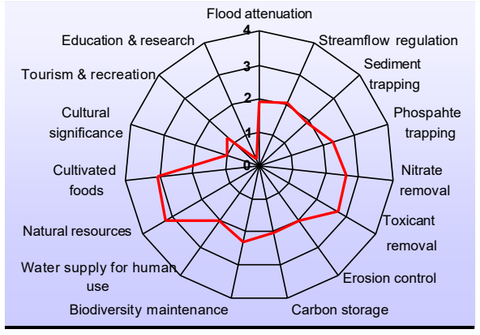
Xylotheca kraussiana

Crinum sp. – pyjama lily

Brachystegia spiciformis		x	x	*Ochna inermis*			x
Combretum apiculatum			x	*Ozoroa obovata*		x	
Combretum eleagnoides		x		*Parinari curatellifolia*		x	
Commelina sp.			x	*Strychnos pungens*			x
Crinum sp.			x	*Syzigium sp.*	x		
Cuscuta sp.	x			*Themeda triandra*		x	
Cyperus prolifer	x			*Uapaca* sp.	x		
Dichrostachys cinerea		x		*Vitex* sp.	x		
Ferns	x			*Xylotheca kraussiana*			x

Key: * denotes alien plant species; VU – Vulnerable as per IUCN Red List classification

Wetland Ecoservices



The ecoservices provided by MOZ 2 feature high levels of cultivated foods and natural resource provision to local communities. Toxicant removal and flood attenuation are moderately important services supplied by this part of the wetland.

Current Impacts

- Road crossing wetland, no culvert installed and causing obstructed flow
- Water extraction for drilling activities
- Litter
- Fish traps
- Water wells downstream
- Alien plants present

Aquatic Description

	Low Flow 2011	High Flow 2012
Water Surface Dimensions	Width: 10 m; Depth: 0.2–0.6m	Width: 10 m; Depth: 0.2–0.8m
Water Turbidity (Dallas 2005)	Clear	Opaque
Dominant Velocity-depth Classes	Slow deep	Slow deep
Water Quality Parameters	T(°C)=35.2; pH=6.6; EC(mS/m)=11.68; DO(mg/l)=10.19; DO(%)=146.9; TDS(mg/l)=58	T(°C)=32.1; pH=5.6; EC(mS/m)=9.48; DO(mg/l) = 5.19; DO(%)=71.72; TDS(mg/l)=47
Algae Presence	Abundant	Abundant
Dominant Biotope Diversity	Pool	Pool
Other Biota	Tadpoles and water birds	Frogs and terrapins
Highly Sensitive Taxa (Score 11–15)	None	None

Riparian Present Ecological State

ZONE	Overall	Marginal	Lower	Upper
VEGRAI %	65.3	87.5	57.5	51.0
Ecological Categories (EC)	C – moderately modified	A/B – natural– largely natural	C/D – moderately – largely modified	D – largely modified

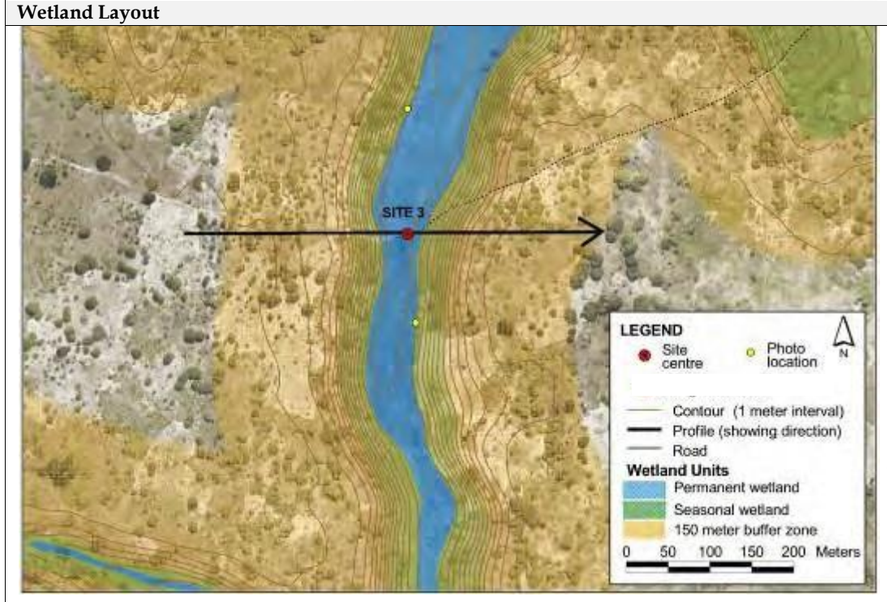
Aquatic Present Ecological State

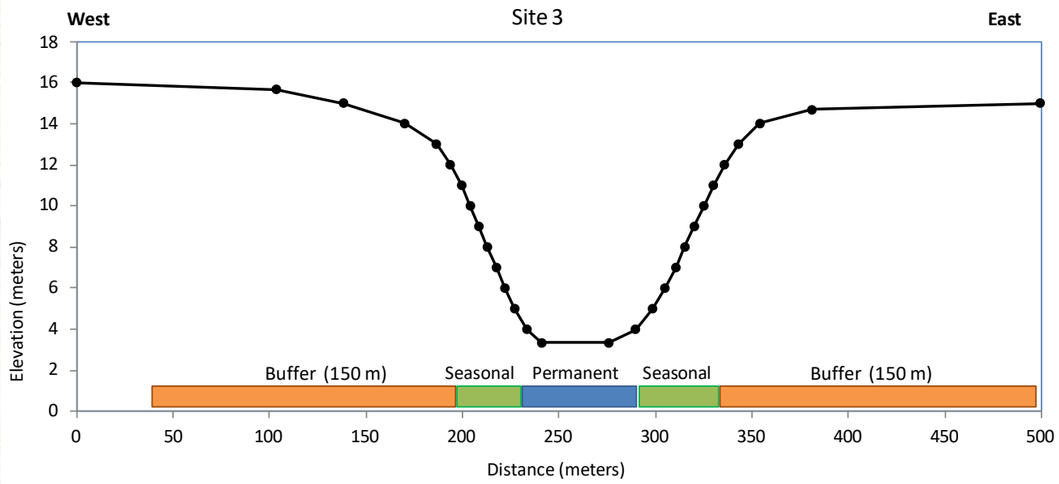
DATE	SAMPLERS	WQ	Diatoms			IHI	SASS 5 & ASPT	MIRAI	Fish
			SPI	BDI	%PTV				
14/10/2011	C. Renshaw A. Austin	√	17.4	20.0	2.5	86 (B)	77 and 3.9	82 (B)	√
24/02/2012	C. Renshaw W. Malherbe	√	18.9	20.0	1.3	80 (B)	68 and 4.5	66 (C)	√

Figure 8.33 Sampling Site MOZ 3

Wetland Type	Unchannelled valley bottom wetland (Catchment A)
Location	On the proposed main access road, upstream of Project Footprint Area (22 masl). Latitude 10.822934S; Longitude 40.532135E (Geographic projection, WGS84); UTM Zone 39: 8803178S; 667494E

Wetland Layout





Source: Aerial image supplied by Client

General Site Description

This site was located on the same wetland as sites 2 and 5, ultimately leading to the estuary that is described as Site 6. This site was accessed via a foot and bicycle path used by the local community, and some impacts caused by local communities were thus observed there. Various interesting plant species were identified at the site, despite the impacts occurring there. The only available water was in pools scattered through the system, with a very limited water flow. Lots of algae. Sulphuric smell within sediment.

Photos

Low Flow 2011			High Flow 2012		
UPSTREAM	*DOWNSTREAM*	*CLOSE-UP*	*UPSTREAM*	*DOWNSTREAM*	*CLOSE-UP*

Riparian Zone Description

Marginal Zone (MZ)	The marginal zone was moderately large with a width of approximately 40m. This zone consisted of an unchannelled system dominated by ferns and sedges. The centre of the marginal zone was significantly wetter and deeper than the outer edges. *Pandanus* and *Drosera* species (illustrated below) were unusual plants observed in this zone.
Lower Zone (LZ)	Large parts of the lower zone had been cleared of natural vegetation and planted with tree crops such as coconuts, cashew nuts and mangoes; however, patches of mature riparian vegetation dominated by large *Brachystegia spiciformis* trees still remained.
Upper Zone (UZ)	The upper zone closely resembled the surrounding terrestrial vegetation and had been heavily impacted by the planting of alien trees.

Vegetation

SPECIES	MZ	LZ	UZ	SPECIES	MZ	LZ	UZ
Ageratina adenophora *	x			*Hyphaene coriacea*		x	x
Anacardium occidentale *		x	x	*Mangifera indica* *		x	x
Andropogon gayanus		x	x	*Cyperus prolifer*	x		
Brachystegia spiciformis		x	x	*Nymphaea nouchali*	x		

Pandanus livingstonianus – screw pine

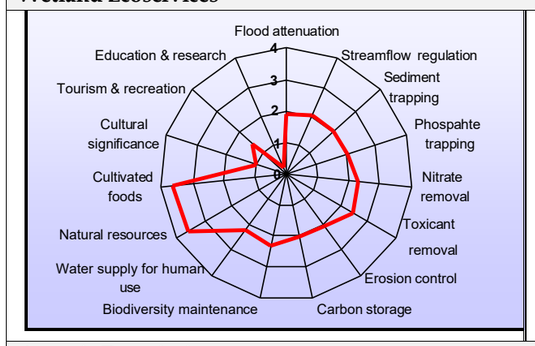
Drosera indica – sundew (insectivorous plant)

Ochna inermis – stunted plane

Chamaecrista sp.				*Ochna inermis*	x
Cocos nucifera *				*Pandanus livingstonianus*	x		
Crinum sp.		x		*Parinari curatellifolia*			x
Cuscuta sp.	x			*Pseudolachnostylis maprouneifolia*		x	
Drosera indica	x			*Cyperus* sp.	x		
Gardenia ternifolia		x	x	*Sclerocarrya birrea*		x	
Hibiscus sp. *(pink)*		x		*Strychnos* sp.			
Hibiscus sp. *(yellow)*		x		*Strychnos pungens*			x
Hypericum sp.	x			*Utricularia* sp. *(white)*			
Hyperthelia dissoluta			x				

Key: * denotes alien plant species; VU – Vulnerable as per IUCN Red List classification

Wetland Ecoservices



Important ecoservices supplied by MOZ 3 include provision of cultivated foods and natural resources to local communities. Capacity for removal of various toxicants is moderate.

Current Impacts

- Artificial channel created
- Former rice cultivation downstream
- A footpath through marginal zone continuing eastwards across wetland, causing pooling

Aquatic Description

	Low Flow 2011	High Flow 2012
Water Surface Dimensions	Width: 1–5 m; Depth: 0.2–0.6m	Width: 1–5 m; Depth: 0.2–0.8m
Water Turbidity (Dallas 2005)	Clear	Clear
Dominant Velocity-depth Classes	Slow deep	Slow shallow
Water Quality Parameters	T(°C)=26.6; pH=6.3; EC(mS/m)=14.96; DO(mg/l)=8.66; DO(%)=107.92; TDS(mg/l)=75	T(°C)=27.2; pH=6.3; EC(mS/m)=12.38; DO(mg/l)=5.05; DO(%) = 64.07; TDS(mg/l)=62
Algae Presence	Abundant	Abundant
Dominant Biotope Diversity	Pool	Pool
Other Biota	Tadpoles and frogs	Tadpoles and frogs
Highly Sensitive Taxa (Score 11–15)	None	None

Riparian Present Ecological State

ZONE	Overall	Marginal	Lower	Upper
VEGRAI %	58.0	85.3	47.5	41.3
Ecological Categories (EC)	**C/D – moderately – largely modified**	**B – largely natural**	**D – largely modified**	**D/E – largely modified** – seriously modified

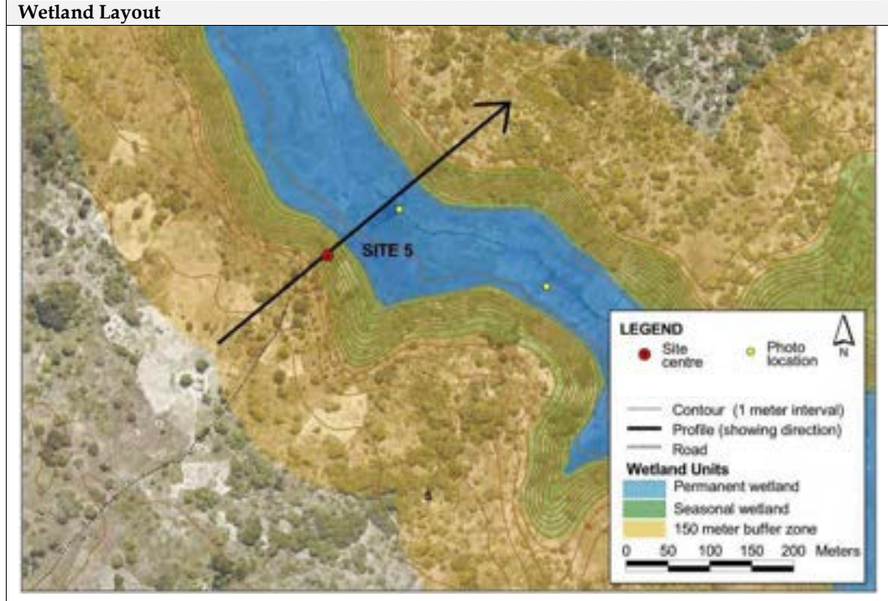
Aquatic Present Ecological State

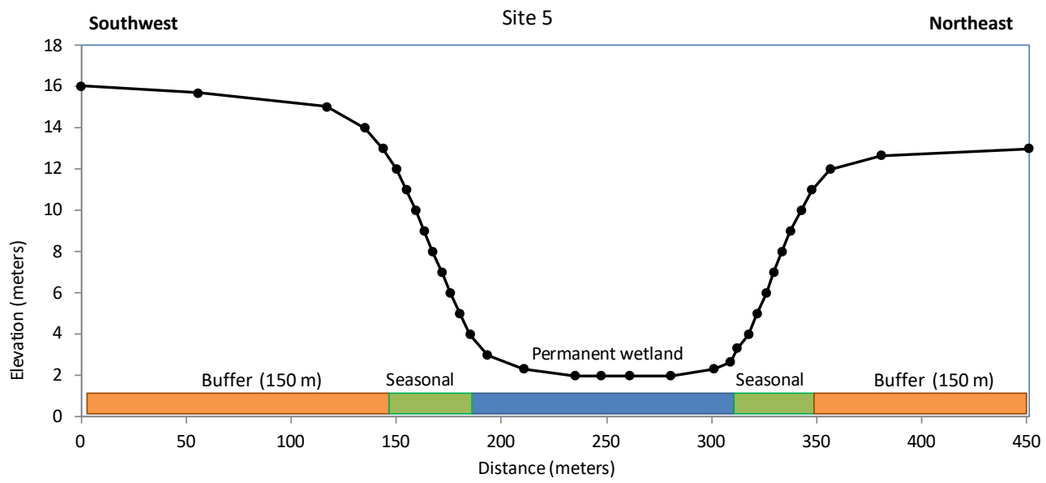
DATE	SAMPLERS	WQ	Diatoms			IHI	SASS 5 & ASPT	MIRAI	Fish
			SPI	BDI	%PTV				
15/10/2011	C. Renshaw A. Austin	√	**18.6**	**20.0**	**0.8**	**88 (B)**	**72 and 4.2**	**70 (C)**	√
25/02/2012	C. Renshaw W. Malherbe	√	**21.0**	**20.0**	**0.5**	**87 (B)**	**68 and 4.5**	**65 (C)**	√

Figure 8.34 Sampling Site MOZ 5

Wetland Type	Unchannelled valley bottom wetland that has been partially channelled artificially (Catchment A)
Location	Upstream from proposed Project Footprint Area. Latitude 10.817248S; Longitude 40.526839E (Geographic projection, WGS84); UTM Zone 39: 8803810S; 666918E

Wetland Layout





Source: Aerial image supplied by Client

General Site Description

This site consisted of a broad permanent wetland located close to the large Quitupo Village. A significant channel had been excavated in the centre of the wetland, but limited flow was apparent. Large pools of standing water dominated by water lilies were a prominent feature of the site.

Photos

Low Flow 2011			High Flow 2012		
UPSTREAM	*DOWNSTREAM*	*CLOSE-UP*	*UPSTREAM*	*DOWNSTREAM*	*CLOSE-UP*

Riparian Zone Description

Marginal Zone (MZ)	The marginal zone was over 100m wide and consisted mostly of a thick floating mat of ferns, sedges and *Juncus* reeds. Walking over the floating mat was treacherous, with the risk of breaking through into the unknown depths below. A number of specimens of a large *Eulophia* orchid were observed in this zone.
Lower Zone (LZ)	The lower zone was largely transformed by the planting of tree and herbaceous crops such as coconuts and cassava.
Upper Zone (UZ)	The upper zone was largely transformed through cultivation and, to a lesser extent, by human habitation.

Vegetation

SPECIES	MZ	LZ	UZ	SPECIES	MZ	LZ	UZ
Ageratina adenophora *	x			*Mangifera indica* *		x	x
Anacardium occidentale *		x	x	*Manihot esculenta* *		x	
Andropogon gayanus			x	*Cyperus prolifer*	x		
Berlinia orientalis (VU)			x	*Musa acuminata* (hybrid) *	x	x	
Brachystegia spiciformis		x	x				

Eulophia rosea

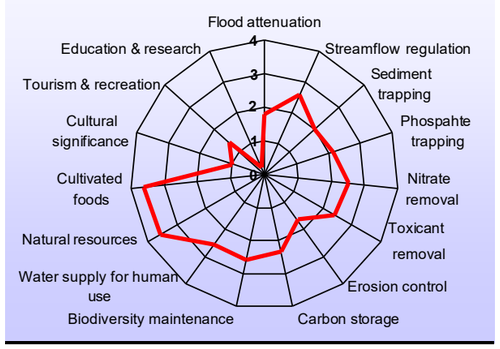
Nymphaea nouchali

Ferns

Cassia sp.		x		*Nymphaea nouchali*	x		
Cocos nucifera *		x		*Ochna inermis*			x
Combretum eleagnoides			x	*Panicum coloratum*			x
Eulophia rosea	x			*Parinari curatellifolia*		x	
Ferns	x			*Phoenix reclinata*	x	x	x
Gymnosporia sp.			x	*Pseudolachnostylis maprouneifolia*			x
Heteropogon contortus		x		*Psidium guajava* *	x		
Hibiscus sp. (yellow)		x		*Sclerocarrya birrea*			
Hyphaene coriacea		x		*Searsia* sp.			
Juncus sp.	x			*Strychnos pungens*		x	
Leersia hexandra	x			*Themeda triandra*		x	

Key: * denotes alien plant species; VU – Vulnerable as per IUCN Red List classification

Wetland Ecoservices



The ecoservices supplied by the wetland at MOZ 5 feature strongly in the provision of natural resources and cultivated foods. The water supply for human use and maintenance of biodiversity are also important, as is the capacity for removal of various toxicants.

Current Impacts

- Paths and channels bisecting wetland
- Alien plants present
- Algal growth
- Artificial channelisation present
- Evidence of rice cultivation

Aquatic Description

	Low Flow 2011	High Flow 2012
Water Surface Dimensions	Width: 10–20m; Depth: 0.1–1m	Width: 10–20m; Depth: 0.1–1m
Water Turbidity (Dallas 2005)	Discoloured	Discoloured
Dominant Velocity-depth Classes	Slow shallow	Slow shallow
Water Quality Parameters	T(°C)=27.5; pH=6.2; EC(mS/m)=28.86; DO(mg/l)=1.28; DO(%)=16.30; TDS(mg/l)=144	T(°C)=30.9; pH=6.0; EC(mS/m)=15.37; DO(mg/l)=1.75 ; DO(%)=23.63; TDS (mg/l)=77
Algae Presence	Common	Common
Dominant Biotope Diversity	Pool	Pool
Other Biota	Water birds and mongoose	Water birds, frogs and snails
Highly Sensitive Taxa (Score 11–15)	None	None

Riparian Present Ecological State

ZONE	Overall	Marginal	Lower	Upper
VEGRAI %	59.3	84.3	45.0	48.8
Ecological Categories (EC)	C/D – moderately – largely modified	B – largely natural	D – largely modified	D – largely modified

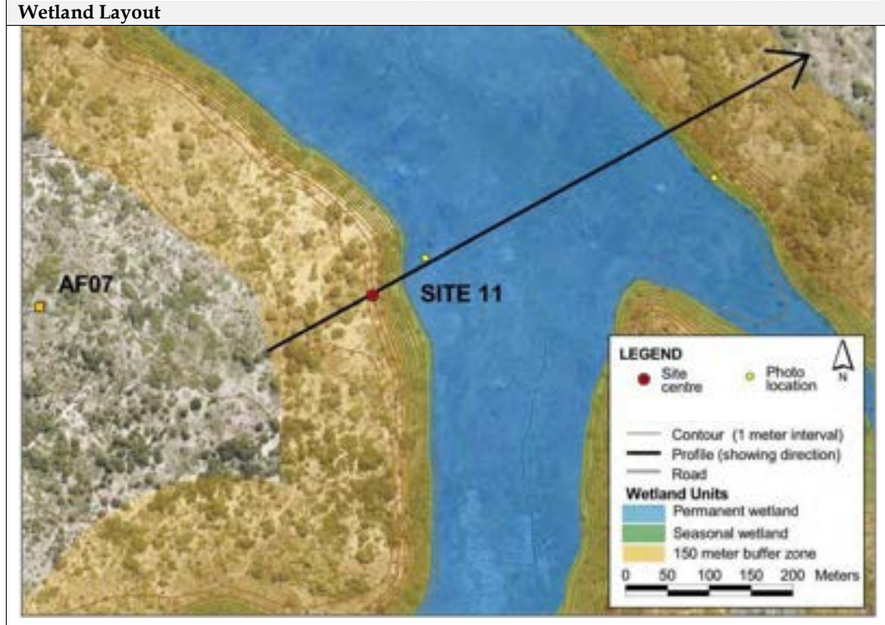
Aquatic Present Ecological State

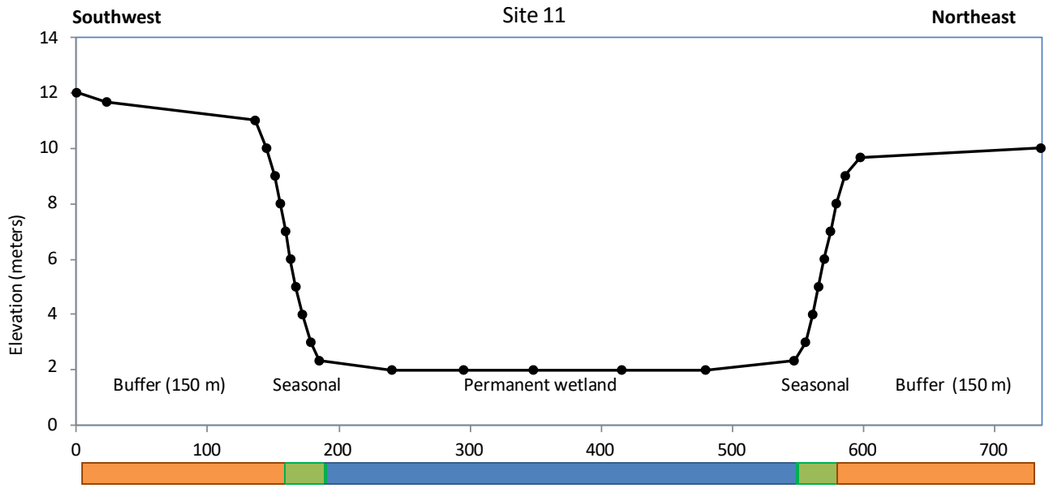
DATE	SAMPLERS	WQ	Diatoms			IHI	SASS 5 & ASPT	MIRAI	Fish
			SPI	BDI	%PTV				
16/10/2011	C. Renshaw A. Austin	√	Insufficient cells for count			94 (A)	101 and 4.2	87 (B)	√
25/02/2012	C. Renshaw W. Malherbe	√	15.5	17.7	21.3	88 (B)	79 and 4.9	66 (C)	√

Figure 8.35 Sampling Site MOZ 11

Wetland Type	Unchannelled valley bottom wetland in the lower catchment zone and in close proximity to the estuary (Catchment A)
Location	Downstream from the proposed Project Footprint Area (13 masl). Latitude 10.80576S; Longitude 40.52435E (Geographic projection, WGS84); UTM Zone 39: 8805081S; 666653E

Wetland Layout



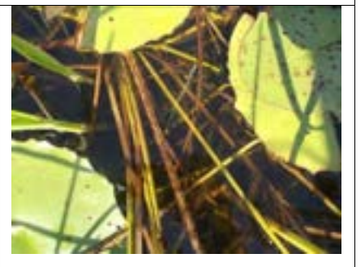


Source: Aerial image supplied by Client

General Site Description

This site is located towards the end of the fresh-water component of this wetland system and within sight of the coast, portrayed by a row of tall coconut palms on the north-western horizon. The woody riparian vegetation is well developed and with few anthropogenic disturbances.

Photos

High Flow 2012			Low Flow 2012		
UPSTREAM	*DOWNSTREAM*	*CLOSE-UP*	*UPSTREAM*	*UPSTREAM*	*UPSTREAM*
					

Riparian Zone Description

Marginal Zone (MZ)	The marginal zone consists of a broad stretch approximately 400m wide, with large volumes of water and dominated by sedges and other aquatic plants. The outer edges of the marginal zone support many grasses, and the small insectivorous *Drosera indica* was found there growing among a terrestrial *Utricularia* species.
Lower Zone (LZ)	The lower zone occurs on a steep slope of approximately 10m in height, and supports a varied amount of riparian vegetation. Some patches are sparse while other patches are tall and dense.
Upper Zone (UZ)	The upper zone merges gradually in the surrounding terrestrial vegetation, marked by numerous *Strychnos* shrubs and *Hyphaene* palms. Abandoned huts and many cashew-nut trees provide evidence of recent settlement in the area.

Vegetation

SPECIES	MZ	LZ	UZ	SPECIES	MZ	LZ	UZ
Afzelia quanzensis			x	Ferns	x		
Andropogon gayanus		x		*Gardenia ternifolia*			x
Aristida congesta			x	*Hyparrhenia tamba*			x
Berlinia orientalis (VU)		x	x	*Hyphaene coriacea*		x	x

Marginal zone where *Drosera indica* was found

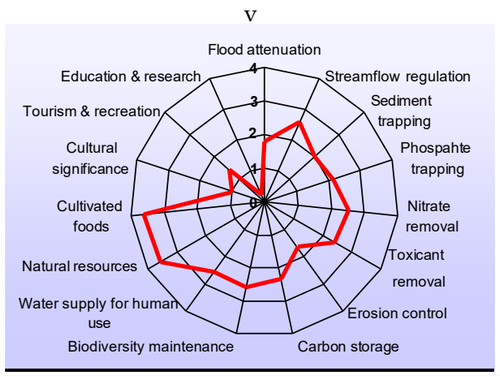
Brachystegia trees and *Hyphaene* palms in the riparian vegetation

Eulophia speciosa – terrestrial orchid

Brachystegia spiciformis		x		*Leersia hexandra*	x		
Chamaecrista sp.	x			*Melinis repens*			x
Cocos nucifera *			x	*Musa acuminata* (hybrid) *	x		
Cuscuta sp.	x			*Nymphaea nouchali*	x		
Cyperus dives	x			*Phoenix reclinata*	x	x	
Cyperus prolifer	x			*Strychnos spinosa*	x		
Digitaria eriantha			x	*Utricularia* sp. *(white)*	x		
Drosera indica	x			*Xylotheca kraussiana*			x
***Eulophia speciosa* (Decl)**		**x**		*Xyris capensis*	x		

Key: * denotes alien plant species; VU – Vulnerable as per IUCN Red List classification

Wetland Ecoservices



The ecoservices provided by the wetland at MQZ 11 rank high in natural resource provision, biodiversity maintenance and toxicant removal.

Current Impacts

- Passage through the wetland in the form of pedestrian and bicycle traffic
- Limited cultivation of fruit trees
- Limited vehicle passage has occurred

Aquatic Description

	High Flow 2012	Low Flow 2012
Water Surface Dimensions	Width: 0.5–3m; Depth: 0.1–0.5m	Width: 0.5–3m; Depth: 0.1–1m
Water Turbidity (Dallas 2005)	Discoloured	Discoloured
Dominant Velocity-depth Classes	Slow shallow	Slow shallow
Water Quality Parameters	T(°C)=28.3; pH=6.2; EC(mS/m)=20.52; DO(mg/l)=1.68; DO(%)=21.88; TDS(mg/l)=103	T(°C)=27.3; pH=5.6; EC(mS/m)=19.40; DO(mg/l)=2.53; DO(%)=32.02; TDS(mg/l)=97
Algae Presence	Common	Abundant
Dominant Biotope Diversity	Pool	Pool
Other Biota	Firefly larvae, tadpoles and frogs	Frogs, shrimps and prawns
Highly Sensitive Taxa (Score 11–15)	None	None

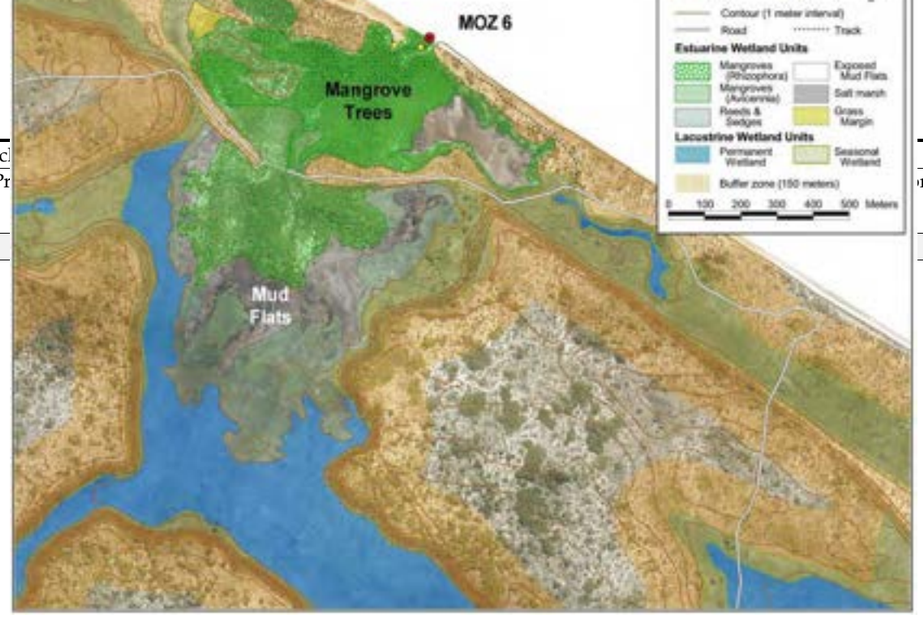
Riparian Present Ecological State

ZONE	Overall	Marginal	Lower	Upper
VEGRAI %	64.2	89.3	55.5	47.8
Ecological Categories (EC)	C – moderately modified	A/B – natural – largely natural	D – largely modified	D – largely modified

Aquatic Present Ecological State

DATE	SAMPLERS	WQ	Diatoms			IHI	SASS 5 & ASPT	MIRAI	Fish
			SPI	BDI	%PTV				
29/02/2012	C. Renshaw A. Austin W. Malherbe	√	18.7	20.0	0.3	88 (B)	57 and 4.4	61 (C)	√
22/06/2012	A. Austin W. Malherbe	√	15.8	20.0	2.0	89 (B)	136 and 5.4	78 (C)	√

Figure 8.36 Sampling Site MOZ 6



Source: Aerial image supplied by Client

Wetland Type	Saline estuarine wetland (Catch
Location	This site is in the proposed Pr…ngitude 40.526542E (Geographic projection, WGS84); UTM Zone 39: 8806815S; 666900E

Wetland Layout

General Site Description

This site consists of a lesser estuary in comparison to MOZ 4, covering approximately 65ha extending below the high tide level. It is connected to the ocean during high flow, where most of the water in the estuary originates. This estuary could, similarly, not be separated into different riparian zones and only one zone is therefore considered. Despite the smaller area, this estuary supported denser groves of mangrove trees than were seen at MOZ 4. Species composition was, however, similar. Limited tree cutting was observed. The fauna was impacted by local communities to a greater extent than the vegetation, with extensive harvesting of snails and fishing seen.

Photos

Low Flow 2011		High Flow 2012	
UPSTREAM	*ESTUARY MOUTH*	*UPSTREAM*	*ESTUARY MOUTH*

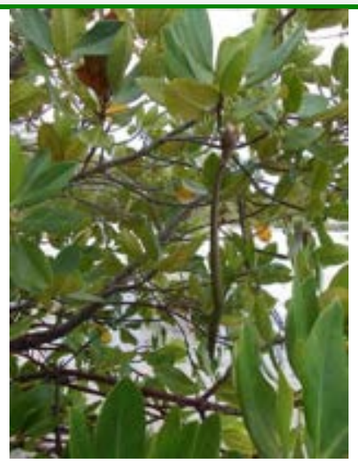
Estuarine Vegetation Description

Four of the main estuarine habitats were identified at MOZ 6: submerged macrophytes, mangroves, supratidal salt marsh and reeds and sedges. Seagrasses of the submerged macrophyte habitat were concentrated in the lower regions of the estuary, at the mouth, and extended outwards towards the subtidal zone. Mangroves dominated the largest proportion of the estuary, covering a total area of 38.38ha. This was comprised of 23.48ha of open *Avicennia marina* forest and 14.90ha of dense *Rhizophora mucronata* and *Ceriops tagal* forest. The average tree height was 6 to 8m and the canopy cover was approximately 80 percent. Adult, juvenile and seedling mangrove trees were recorded, and this is indicative of healthy population structure and recruitment. Significant adult die-off was observed in the open *Avicennia marina* habitat. The majority of the mangrove forest was comprised of *Rhizophora mucronata* interspersed with *Ceriops tagal*. Flowers and propagules were present on *Avicennia marina* and propagules on *Ceriops tagal* and *Rhizophora mucronata*. The supratidal salt marsh habitat was minimal in extent, with a small population of *Sarcocornia decumbens* (glasswort), which was replaced by sedges and grasses. Diversity in this habitat was low, owing to the stressful nature of the physical environment. Grasses and a sporadic distribution of mangrove fern (*Acrostichum aureum)* occurred at the transition between wetland and the forest/woodland.

Estuarine Vegetation

Xylocarpus granatum – cannonball mangrove

Sonneratia alba – mangrove apple



Ceriops tagal – Indian mangrove

SPECIES

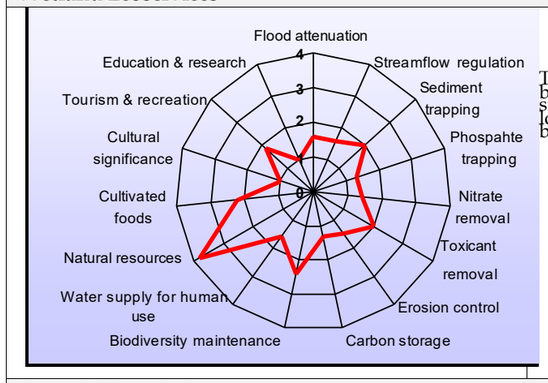
Avicennia marina	*Ceriops tagal*	*Elaphoglossum* sp.
Bruguiera gymnorrhiza	*Cocos nucifera* *	*Sonneratia alba*
Casuarina equisetifolia *	*Cynodon dactylon*	*Xylocarpus granatum*

Key: * denotes alien plant species

Main channel exiting the estuary

Rhizophora mucronata – mangrove trees

Wetland Ecoservices



The ecoservices supplied by MOZ 6 are similar to those supplied by MOZ 4, due to the similar conditions that prevail at both sites. The sites are important sources of natural resources to local communities, and important for the maintenance of biodiversity.

Current Impacts

- Alien plants introduced – coconut plantations and *Casuarina equ*isetifolia along beach. *C. equisetifolia* is often associated with swamp forests adjacent to estuaries
- Harvesting of mangroves for wood (outer edges of forests only)
- Snail harvesting by local community
- Foot and vehicle paths through the mangrove forests

Aquatic Description

	Low Flow June 2012	High Flow 2012
Water Surface Dimensions		Width: 1–10m; Depth: 0.1–1.2m
Water Turbidity (Dallas 2005)		Discoloured
Dominant Velocity-depth Classes		Slow deep
Water Quality Parameters	T(°C)=29.4; pH=7.4; EC(mS/m)=5008; DO(mg/l) = 3.86; DO(%)=60.47; TDS(mg/l)=25040; Salinity=32.67	T(°C)=30.7; pH=6.9; EC(mS/m)=5215; DO(mg/l) = 2.73; DO(%)=40.39; TDS(mg/l)=26074 Salinity=34.15
Dominant Biotope Diversity		Pool
Other Biota		Estuarine prawns

Riparian Present Ecological State			
Estuarine Health Index	97.5	Present Ecological Status	**A – natural**

Aquatic Present Ecological State

DATE	SAMPLERS	WQ	Diatoms			Invertebrates	Fish
			SPI	BDI	%PTV		
17/10/2011	C. Renshaw A. Austin	√	**9.3**	**10.8**	**13.5**	√	√
22/02/2012	W. Malherbe C. Renshaw A. Austin	√	**10.3**	**3.2**	**7.2**	√	√

Catchment B

Three sampling sites were considered in Catchment B, and these are outlined in *Table 8.23*. Catchment B is similar to catchment A; an unchannelled valley bottom system, ending in a shallow-water estuary system with a sandy substrate. Similarly, the system is a slow-flowing deep wetland, and has artificial channels dug within the wetland to increase the flow.

Table 8.23 Sampling Sites within Catchment B

Catchment and Assessment Sites	Site Description
Catchment B	
MOZ 1	Upper catchment, close to the start of the permanent wetland
MOZ 4	Estuary
MOZ 10	Lower catchment zone with broad permanent wetland

Source: NSS, 2012.

The aquatic habitat integrity of the lacustrine sampling sites within Catchment B is considered Natural, showing very limited effects of anthropogenic influence in comparison to the other catchments sampled. The overall riparian habitat integrity ranged from Largely Natural to Moderately Modified, with only limited removal of natural resources and cultivation of fruit trees. The riparian habitat integrity of the estuary was Natural, with virtually no anthropogenic impacts present and dense groves of mangrove trees. The main ecosystem services supplied by the lacustrine and estuarine wetlands in Catchment B included natural resource provision and the maintenance of biodiversity.

In terms of water quality, low oxygen levels, influenced by high temperatures and slightly high salts content (EC and TDS), were observed at all of the lacustrine wetland sites within Catchment B. NH_4, COD and SS had exceeding concentrations within the lacustrine sites. MOZ 10 (in the lower area of the catchment) also had exceeding levels of Al, Cu and Zn. SS, Zn and Al are considered to be naturally occurring constituents within these systems. The slightly elevated levels of Cu at site MOZ 10 may be due to infiltration of saline water.. The higher levels of NH_4 and COD could be attributed to sewage within the lacustrine wetland systems. The water quality results in the estuarine site indicated that the oxygen levels were low and salinity high. No significant salinity profile was seen at the estuary site MOZ 4, which indicates that the fresh-water inflow to MOZ 4 was limited and that the estuary is dominated by sea water. The water quality showed exceeding concentration levels of Ba, Cu, Ni, Pb, Zn and NO_3 in the estuary and, because most of the water was sea water, the exact source of contamination could not be determined.

The low EPT (*Ephemeroptera*, *Plecoptera* and *Trichoptera*) richness indicated that the macro-invertebrate community structures of the lacustrine wetland consisted of a low number of sensitive taxa, probably due to low habitat

availability for these taxa. The MIRAI scores for the wetlands were Largely Natural to Moderately Modified and indicated that the macro-invertebrates within Catchment B were influenced by flow modification, habitat and water quality. Three species of macro-invertebrate were sampled at the estuary. The important benthic invertebrate taxa group sampled in the estuary site was the Decapoda. They are a very important part of the mangrove system and were found to be the most abundant taxa at the estuary. The distribution and abundance of the zooplankton and benthic invertebrates living in the benthic environment are dependent on the physical sediment composition. The fairly diverse benthic invertebrate community is supported by the poorly sorted sediment and the organic content present.

Fish species of note observed in the lacustrine wetlands within Catchment B included the data-deficient killifish (found in MOZ 1 and 10). Previously, this species was discovered in only one other location worldwide, described in 2007 (see *Section 8.6.3*). Due to the lack of data, this species has not been assigned a conservation status by the IUCN. The dominant fish guild in the estuary was the marine migrant guild, which indicated species that spawn in the ocean and then enter estuaries in large numbers, specifically as juveniles. The large number of juveniles indicated that these estuaries are mostly used as nursery grounds.

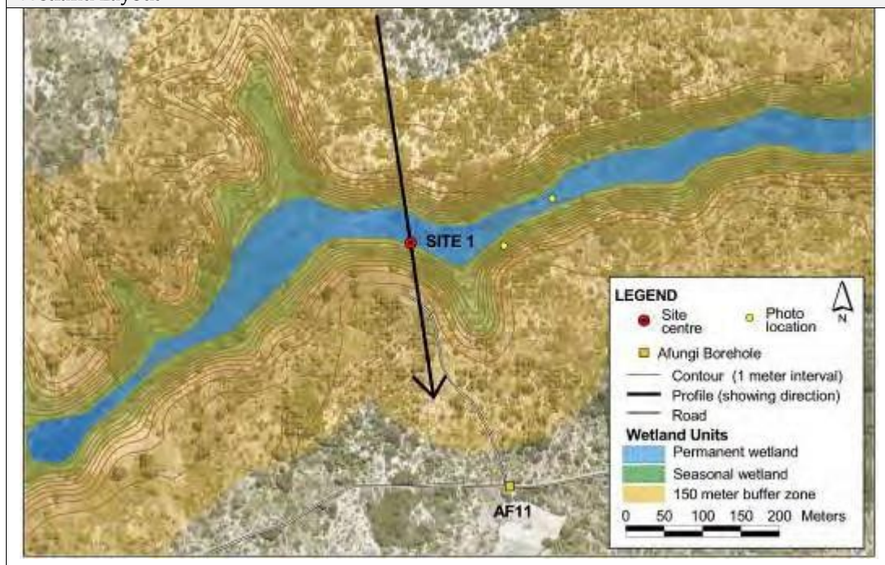
Catchment B is particularly sensitive, both in the upper and mid reaches of the catchment, due to the presence of threatened Red Data plant species – the *Platycoryne mediocris* orchid and *Berlinia orientalis* along the catchment.

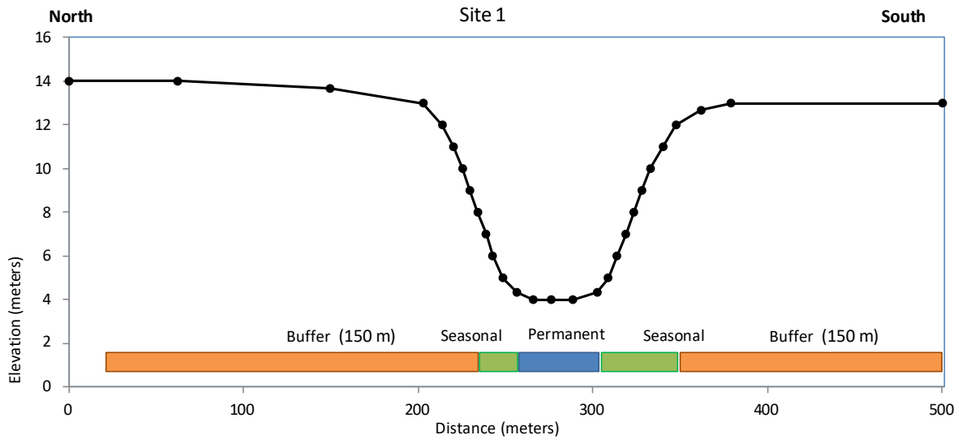
Figure 8.37 to *Figure 8.39* provide general information and detailed results for the high flow (October 2011) and low flow sampling assessments (February 2012) for each sampling site in Catchment B.

Figure 8.37 Sampling Site MOZ 1

Wetland Type	Unchannelled valley bottom wetland (Catchment B)
Location	In the proposed Project Footprint Area (21 masl). Latitude 10.83564S; Longitude 40.555946E (Geographic projection, WGS84); UTM Zone 39: 8801759 S; 670090 E

Wetland Layout





Source: Aerial image supplied by Client

General Site Description

A moderately broad unchannelled valley bottom with a perennial slow flow of slightly brackish water. The site was observed in a largely natural state with healthy vegetation cover in all riparian zones. The *Nothobranchius hengstleri* (killifish) caught suggests that the system may experience both dry and wet periods, but it is unlikely that these systems dry out completely. Limited impacts were observed, and this site was considered suitable as a reference for various other sites.

Photos

Low Flow 2011			High Flow 2012		
UPSTREAM	*DOWNSTREAM*	*CLOSE-UP*	*UPSTREAM*	*DOWNSTREAM*	*CLOSE-UP*

Riparian Zone Description	
Marginal Zone (MZ)	The marginal zone was approximately 40m wide at the site and permanently wet across its width. The vegetation was dominated by various sedge species and a few grasses, notably *Leersia hexandra*. This species appears to grow where former mounds had been created to place fish traps or for rice cultivation, and its presence could be the result of former disturbances.
Lower Zone (LZ)	The lower zone incorporated an approximately 8m topographical rise above the marginal zone. Riparian vegetation was sparse and discontinuous along the length of the zone, but reached a tree height of approximately 10m to 12m.
Upper Zone (UZ)	Very little riparian vegetation was present in the upper zone, and the zone could not be easily distinguished from adjacent terrestrial vegetation.

Vegetation

SPECIES	MZ	LZ	UZ	SPECIES	MZ	LZ	UZ
Musa acuminata (hybrid) *	x			*Hyphaene coriacea*		x	x
Berlinia orientalis (VU)		**x**	**x**	*Mangifera indica* *			x
Commelina sp.		x		*Cyperus prolifer*	x		
Nymphaea nouchali	x			*Parinari curatellifolia*			x

Brachystegia spiciformis

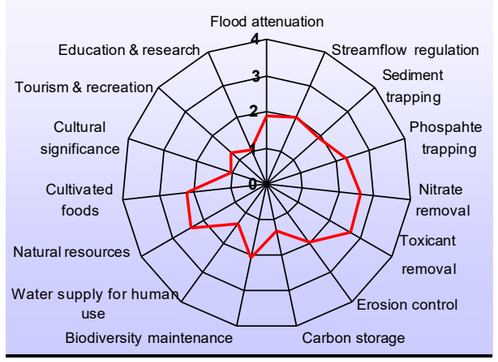
Berlinia orientalis **(VU)**

Utricularia sp.

Brachystegia spiciformis	x	x	*Phoenix reclinata*		x
Anacardium occidentale *	x	x	*Cyperus* sp.	x	
Commelina sp.	x	x	*Rauvolfia caffra*		x
Dichrostachys cinerea	x		Sensitive Ground Plant		x
Diplorhynchus condylocarpon		x	*Strychnos (tight)*		x
Gardenia ternifolia		x	*Strychnos pungens*		x
Hibiscus sp. *(yellow)*	x		*Utricularia* sp. *(yellow)*	x	
Hyparrhenia sp.		x	*Vitex* sp.	x	

Key: * denotes alien plant species; VU – Vulnerable as per IUCN Red List classification

Wetland Ecoservices



The ecoservices provided by MOZ 1 are generally low. The site provides few natural resources or cultivated foods to local communities, but provides for moderate levels of biodiversity maintenance, erosion control and removal of various toxicants.

Current Impacts

- Artificial channel created
- Evidence of past rice cultivation
- Algal growth
- Fishing traps in deeper sections of channel
- Few aliens plants present
- Water abstraction

Aquatic Description

	Low Flow 2011	High Flow 2012
Water Surface Dimensions	Width: 0.3–5m; Depth: 0.1–0.6 m	Width: 0.3–5m; Depth: 0.1–0.6 m
Water Turbidity (Dallas 2005)	Clear	Opaque
Dominant Velocity-depth Classes	Slow shallow	Slow shallow
Water Quality Parameters	T(°C)=26.9; pH=5.8; EC(mS/m)=12.40; DO(mg/l)=2.93; DO (%)=36.6; TDS(mg/l)=62	T(°C)=28.2; pH=5.9; EC(mS/m)=11.55; DO(mg/l)=5.05; DO(%)=65.0; TDS(mg/l)=58
Algae Presence	Abundant	Abundant
Dominant Biotope Diversity	Pools and run	Pools
Other Biota	Tadpoles, frogs, snails and birds	Tadpoles, frogs and snails
Highly Sensitive Taxa (Score 11–15)	Helodidae (Marsh beetles)	None

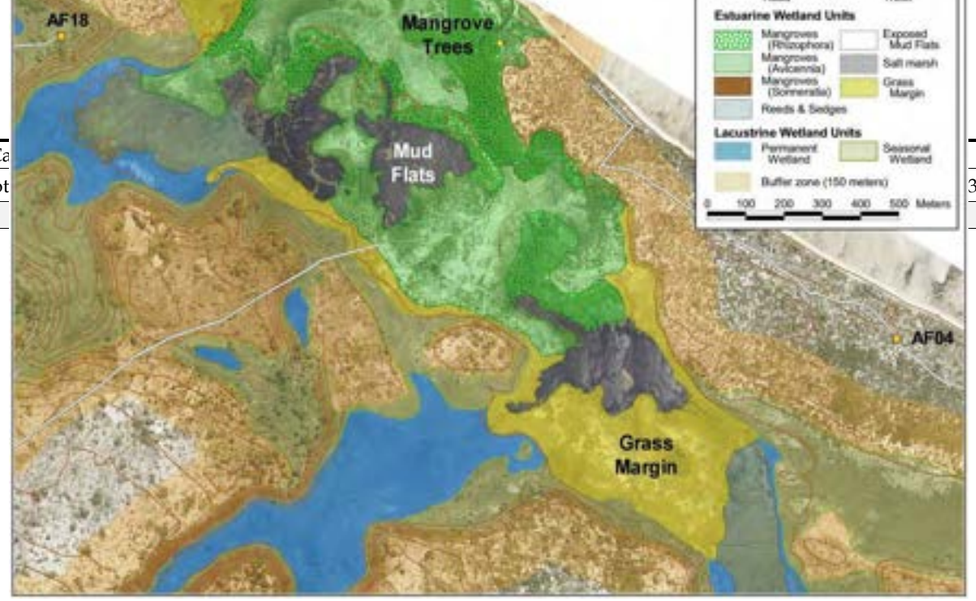
Riparian Present Ecological State

ZONE	Overall	Marginal	Lower	Upper
VEGRAI %	84.7	90.0	84.5	79.5
Ecological Categories (EC)	B – largely natural	A/B – natural – B – largely natural	B – largely natural	B/C B – largely natural – moderately modified

Aquatic Present Ecological State

DATE	SAMPLERS	WQ	Diatoms			IHI	SASS 5 & ASPT	MIRAI	Fish
			SPI	BDI	%PTV				
14/10/2011	C. Renshaw A. Austin	√	12.7	17.6	12.0	93 (A)	78 & 4.6	81 (B)	√
24/02/2012	C. Renshaw W. Malherbe	√	15.5	15.8	14.8	91 (A)	97 & 4.4	80 (B)	√

Figure 8.38 Sampling Site MOZ 4



Source: Aerial image supplied by Client

Wetland Type	Saline estuarine wetland (Ca
Location	In the proposed Project Foot 39: 8804955S; 669759E
Wetland Layout	

General Site Description

This site consists of a large estuary covering approximately 100ha and extending well below the high-tide level. Most of the water in this estuary originates from the ocean, to which it is connected during high flow. The wide flat estuary could not be separated into different riparian zones, and only one zone was therefore considered. Some parts of the estuary supported virtually impenetrable groves of mangroves, whereas other areas consisted of open mudflats or permanent pools of brackish water. Low faunal and floral species diversity was apparent, although a unique diversity of mangrove species was observed. Extensive die-off of trees was observed in the upper reaches of the estuary, but no evidence of tree cutting was observed in these areas and it is thus assumed to be a natural phenomenon.

Photos

Low Flow 2011		High Flow 2012	
UPSTREAM	*ESTUARY MOUTH*	*UPSTREAM*	*ESTUARY MOUTH*

Estuarine Vegetation Description

Two estuarine habitats were identified at MOZ 4: mangroves and reeds and sedges. In addition to this, a grass margin and a mudflat habitat was observed. Mangrove habitat dominated the site across length of the estuary and covered 59.66ha. This was mostly composed of open *Avicennia marina* habitat, covering 41.11ha, and dense *Rhizophora mucronata* and *Ceriops tagal* forest with some *Bruguiera gymnorrhiza*, covering 18.55ha. *Sonneratia alba* was found on small islands in the intertidal zone, covering only 0.90ha. Interspersed in the mangrove forest was some herbaceous cover of sea purslane (*Sesuvium portulacastrum*), a sprawling coastal succulent, and some grasses. The average mangrove tree height was 4 to 6 m and there was variable cover, ranging from 20 percent in areas of high adult mortality to 75 percent in dense patches of impenetrable forest of *Avicennia marina*. Tree mortality appeared to be related to natural causes. Significant recruitment of new individuals, with 60 percent of the population as seedlings was also recorded. Flowers were present on *Avicennia marina*, *Lumnitzera racemosa* and *Sonneratia alba*. Propagules were present on *Bruguiera gymnorrhiza*. An absence of halophytic succulents was noted

on the mud flats in the supratidal zone and this may be due to limited tidal inflow. The sedges were replaced by grasses, and there was an abundance of the golden leather fern (*Acrostichum aureum).*

Estuarine Vegetation

Avicennia marina – white mangrove

Acrostichum aureum – golden leather fern

Bruguiera gymnorrhiza – large-leaved mangrove

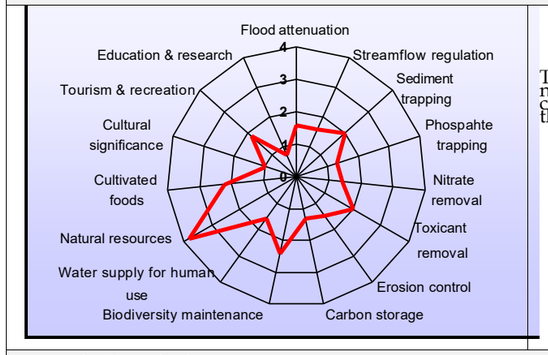
SPECIES		
Avicennia marina	*Ceriops tagal*	*Rhizophora mucronata*
Acrostichum aureum	*Cocos nucifera* *	*Sonneratia alba*
Bruguiera gymnorrhiza	*Crassula* sp.	
* *Casuarina equisetifolia*	*Cynodon dactylon*	

Key: * denotes alien plant species

Mangroves (*Rhizophora mucronata*) lining a channel

Mangrove trees (*Avicennia marina*) on the mudflats

Wetland Ecoservices



The saline estuary at MOZ 4 is important for the provision of natural resources such as snails, wood and fish to local communities. The estuary also provides an important site for the maintenance of unique biodiversity.

Current Impacts

- Track traversing upper reaches of mangroves lined with sandbags
- *Casuarina equisetifolia* found on the banks of the lower estuary. *C. equisetifolia* is often associated with swamp forests adjacent to estuaries
- Foot and vehicle paths through the mangrove forests
- Aliens plantations on outer edges
- Harvesting wood from mangroves
- Former salt harvesting in upper reaches
- Aquaculture

Aquatic Description

	Low Flow 2011	High Flow 2012
Water Surface Dimensions		Width: 1–10m; Depth: 0.1–1.2m
Water Turbidity (Dallas 2005)		Discoloured
Dominant Velocity-depth Classes		Slow deep
Water Quality Parameters	T(°C)=28.3; pH=7.7; EC(mS/m)=5793; DO(mg/l)=4.62; DO(%)=73.40; TDS (mg/l)=28966; Salinity=38.53	T(°C)=29.5; pH=7.5; EC(mS/m)=5566; DO(mg/l)=4.55; DO(%)=73.44; TDS (mg/l)=27829; Salinity=36.78
Dominant Biotope Diversity		Pool
Other Biota		Estuarine prawns

Riparian Present Ecological State

Estuarine Health Index	**97.5**	Present Ecological Status	**A– natural**

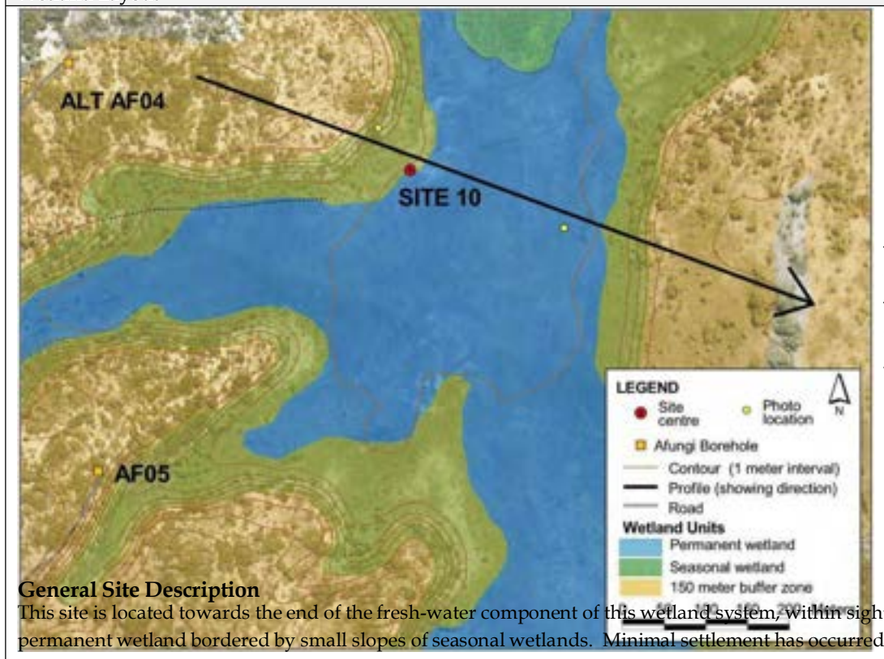
Aquatic Present Ecological State

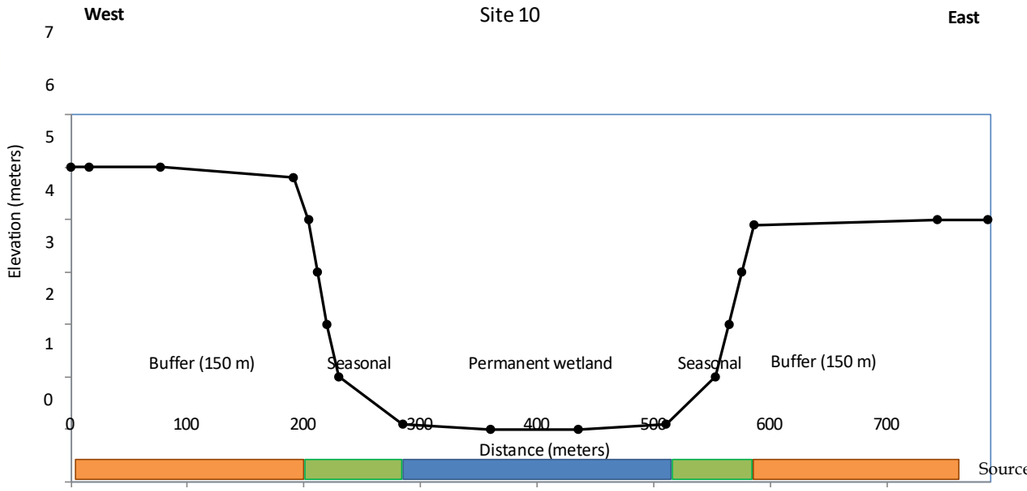
DATE	SAMPLERS	WQ	Diatoms			Invertebrates	Fish
			SPI	BDI	%PTV		
15/10/2011	C. Renshaw A. Austin	√	√	**9.6**	**3.5**	√	√
23/02/2012	W. Malherbe C. Renshaw A. Austin	√	√	**9.2**	**3.4**	√	√

Figure 8.39 Sampling Site MOZ 10

Wetland Type	Unchannelled valley bottom wetland in the lower catchment zone and in close proximity to the estuary (Catchment B)
Location	In the proposed Project Footprint Area (5 masl). Latitude 10.82262S; Longitude 40.55843E (Geographic projection, WGS84); UTM Zone 39: 8803198S; 670369E

Wetland Layout



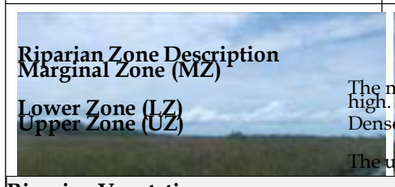
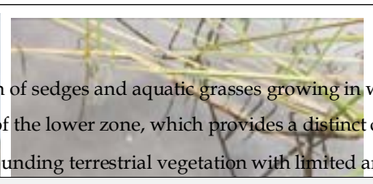
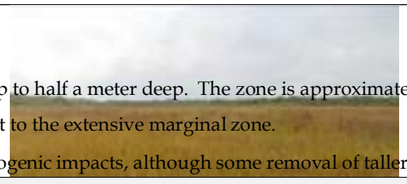
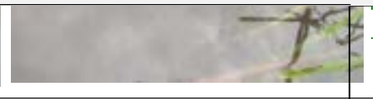
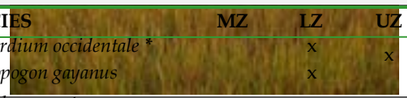


Source: Aerial image supplied by Client

General Site Description

This site is located towards the end of the fresh-water component of this wetland system, within sight of the estuary and tall coconut palms that line the coast. The wetland in this part is typical of the lower end of the catchments, with an extensive permanent wetland bordered by small slopes of seasonal wetlands. Minimal settlement has occurred in the vicinity, resulting in this area remaining in a relatively pristine state.

Photos

	High Flow 2012		Low Flow 2012	
UPSTREAM	*DOWNSTREAM*	*CLOSE-UP*	*UPSTREAM*	*DOWNSTREAM*
				
				

Riparian Zone Description

Marginal Zone (MZ)

The marginal zone consists of an extensive plain of sedges and aquatic grasses growing in water up to half a meter deep. The zone is approximately 250m wide and bordered by short but steep slopes up to 5m high.

Lower Zone (LZ)

Dense riparian vegetation grows on the slopes of the lower zone, which provides a distinct contrast to the extensive marginal zone.

Upper Zone (UZ)

The upper zone merges gradually into the surrounding terrestrial vegetation with limited anthropogenic impacts, although some removal of taller trees does appear to have occurred here.

Riparian Vegetation

SPECIES	MZ	LZ	UZ
Anacardium occidentale *		x	x
Andropogon gayanus		x	
Aristida congesta		x	
***Berlinia orientalis* (VU)**		**x**	**x**

SPECIES	MZ	LZ	UZ
Melinis repens			
Nymphaea nouchali	x	x	
Ochna inermis		x	x
Ozoroa obovata			x

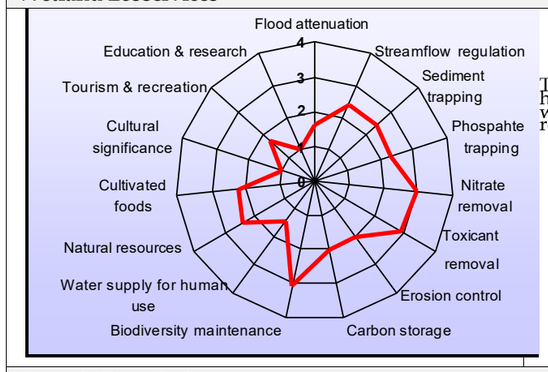
Utricularia vulgaris – aquatic bladderwort

Ozoroa obovata – resin tree

Brachystegia spiciformis		x	x	*Pandanus livingstonianus*		x	
Chloris gayana	x			*Perotis patens*			
Combretum eleagnoides	x			*Phoenix reclinata*	x	x	
Crinum sp.		x		***Platycoryne mediocris* (EN)**		**x**	x
Cyperus prolifer	x	x	x	*Pseudolachnostylis maprounelfolia*			
Digitaria eriantha			x	*Ctenium concinnum*			
Eleocharis sedge	x	x		*Striga* sp.			
Flueggea virosa				*Strychnos spinosa*		x	x
Hyparrhenia sp.			x	*Swartzia madagascariensis*		x	x
Hyparrhenia lamba				*Utricularia vulgaris*			
Hyphaene coriacea		x	x	*Vitex* sp.	x		
Juncus sp.	x				x		
				Xylotheca kraussiana			
						x	

Key: * denotes alien plant species; VU – Vulnerable as per IUCN Red List classification

Wetland Ecoservices



The lack of local communities living in the vicinity of MOZ 10 has a profound influence on the ecoservices supplied by the wetland. Biodiversity maintenance and various toxicant removals are the most important ecoservices provided there.

Current Impacts

- Limited removal of riparian vegetation
- Limited cultivation of fruit trees

Aquatic Description

	High Flow 2012	Low Flow 2012
Water Surface Dimensions	Width: 0.5–10m; Depth: 0.1–0.5m	Width: 0.5–10m; Depth: 0.1–0.5m
Water Turbidity (Dallas 2005)	Clear	Clear
Dominant Velocity-depth Classes	Slow shallow	Slow shallow
Water Quality Parameters	T(°C)=30.3; pH=6.0; EC(mS/m)=50.92; DO(mg/l)=3.76; DO(%)=50.77; TDS(mg/l)=254	T(°C)=27.2; pH=5.9; EC(mS/m)=19.30; DO(mg/l)=4.99; DO(%)=62.88; TDS(mg/l)=96
Algae Presence	Abundant	Abundant
Dominant Biotope Diversity	Pool	Pool
Other Biota	Water birds, frogs and killifish	Frogs and killifish
Highly Sensitive Taxa (Score 11–15)	None	None

Riparian Present Ecological State

ZONE	Overall	Marginal	Lower	Upper
VEGRAI %	77.6	88.3	77.8	66.7
Ecological Categories (EC)	B/C – largely natural – moderately modified	A/B – natural to B – largely natural	B/C – largely natural – moderately modified	C

Aquatic Present Ecological State

DATE	SAMPLERS	WQ	Diatoms			IHI	SASS 5 & ASPT	MIRAI	Fish
			SPI	BDI	%PTV				
28/02/2012	C. Renshaw A. Austin W. Malherbe	√	**17.9**	**20.0**	**2.5**	**92 (A)**	**74 and 4.4**	**72 (C)**	√
22/06/2012	A. Austin W. Malherbe	√	**18.5**	**20.0**	**2.3**	**93 (A)**	**81 and 4.5**	**75 (C)**	√

Catchment C

Three sampling sites were considered in Catchment C and these are outlined in *Table 8.24*. Catchment C is an unchannelled valley bottom system. The system is a slow-flowing deep wetland.

Table 8.24 Sampling Sites within Catchment C

Catchment and Assessment Sites	Site Description
Catchment C	
MOZ 8	Upper catchment, close to the start of the permanent wetland
MOZ 9	Mid catchment zone

Source: NSS, 2012.

The aquatic habitat integrity of the lacustrine wetlands within Catchment C are Natural, showing limited anthropogenic impacts. The overall riparian habitat integrity ranged from Moderately to Largely Modified, with the main impacts identified at site MOZ 8 in the upper section of the catchment. Cultivation within all of the riparian zones (marginal, lower and upper) takes place. There is extensive cultivation of cassava in the upper zone of site MOZ 9 with the marginal and lower zones relatively natural, comprising dense vegetation. The main ecosystem services supplied by the lacustrine wetlands in Catchment C include natural resource provision and the cultivation of foods.

In terms of water quality, low oxygen levels, influenced by high temperatures and slightly high salts content (EC and TDS), were observed at each of the lacustrine wetland sites, together with exceeding concentrations of NH_4, COD and SS.

The MIRAI scores were Moderately Modified and indicated that the macro-invertebrates within the lacustrine wetland are influenced by flow modification, habitat and water quality. Low numbers of sensitive families and a generally low family diversity indicated that only tolerant families could survive in these wetlands with limited flow and absence of the stone biotope. In addition to this, there were also high percentages of airbreathers, which are also indicative of slow-flowing habitats with a lack of sufficient oxygen levels, high temperatures and water levels.

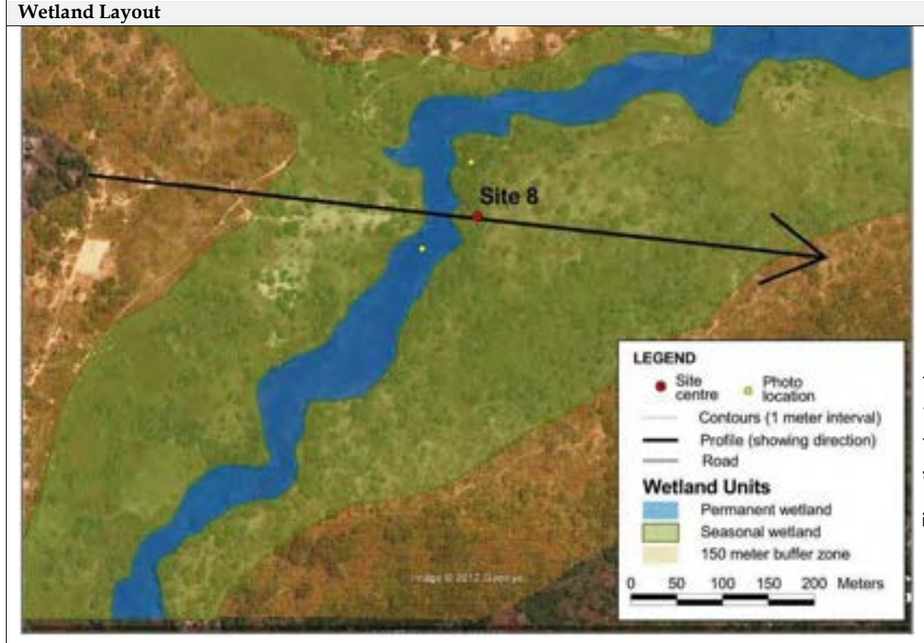
Fish species of note observed in the lacustrine wetlands within Catchment C included the data-deficient killifish (see *Section 8.6.4*).

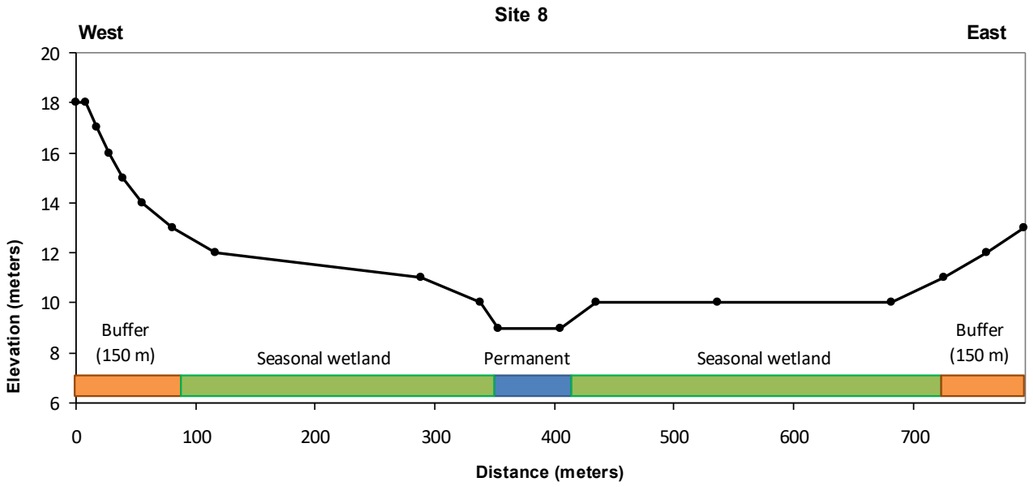
Figure 8.40 to *Figure 8.41* provide general information and detailed results for the high flow (October 2011) and low flow sampling assessments (February 2012) at each sampling site in Catchment C.

Figure 8.40 Sampling Site MOZ 8

Wetland Type	Unchannelled valley bottom wetland (Catchment C)
Location	Upstream from the proposed airstrip (12 masl). Latitude 10.86707S; Longitude 40.49108E (Geographic projection, WGS84); UTM Zone 39: 8798319S; 662981E

Wetland Layout





Source: Aerial image supplied by Client

General Site Description

The site forms part of a large wetland system draining eastwards in the direction of Maganja settlement, and is located at the start of the permanent wetland where a reliable source of water becomes available. The wetland at this point shows the typical characteristics of an upper catchment. A small village occurs in the vicinity of the site and numerous impacts associated with the settlement.

Photos

High Flow 2012			Low Flow 2012	
UPSTREAM	*DOWNSTREAM*	*CLOSE-UP*	*UPSTREAM*	*DOWNSTREAM*

Riparian Zone Description	
Marginal Zone (MZ)	The marginal zone at this site is narrow and not clearly distinguishable from the adjacent lower zone, partly due to the site being in the upper reaches of the catchment, and partly due to extensive cultivation of crops and fruit trees in the lower zone.
Lower Zone (LZ)	The lower zone differs between the north and south banks of this wetland. The north bank is settled and supports considerable amount of agriculture, while the south bank remains in a relatively pristine state with tall dense riparian vegetation in close proximity of a village. There must be reasons unknown to the assessment team for the protection of this area of riparian vegetation.
Upper Zone (UZ)	The upper zone exists on a gradual slope extending upwards from the lower zone, and no clear topographical definition between the two zones exists. The zones cannot thus be easily distinguished from one another on the ground.

Vegetation

Nymphoides indica – waterlily

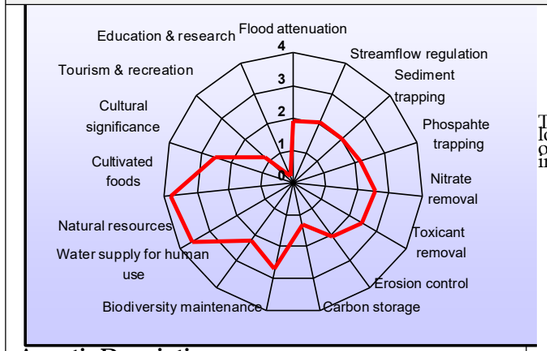
Acampe sp. – epiphytic orchid

Platycoryne mediocris – terrestrial orchid

SPECIES	MZ	LZ	UZ	SPECIES	MZ	LZ	UZ
Acampe sp.		x		*Nymphoides indica*			x
Anacardium occidentale *		x		*Ochna inermis*	x		
Ananas comosus		x		*Panicum coloratum*		x	
Chamaecrista sp.	x			*Panicum maximum*	x	x	
Cocos nucifera *		x	x	*Parinari curatellifolia*	x		
Crinum sp.	x			*Phoenix reclinata*		x	x
Cyperus dives	x			***Platycoryne mediocris* (EN)**		**x**	
Cyperus prolifer	x			*Psidium guajava* *		x	
Dactyloctenium aegyptium	x	x		*Ctenium concinnum*		x	
Ferns	x			*Strychnos* sp.	x		
Gardenia ternifolia			x	*Strychnos spinosa*	x		
Gladiolus sp.		x		*Syzigium* sp.			x
Imperata cylindrica		x		*Vangueria infausta*	x		
Mangifera indica *		x	x	*Xeromphis* sp.	x		
Nymphaea nouchali	x						

Key: * denotes alien plant species; VU – Vulnerable as per IUCN Red List classification

Wetland Ecoservices



The wetland at MQZ 8 provides important ecoservices to the local communities in the form of cultivated foods and provision of natural resources. Maintenance of biodiversity is of moderate importance there.

Current Impacts

- Cultivation within each of the riparian zones: rice, cassava and orchards including coconuts, mangoes, guavas
- High algae content due to nutrients from crops and washing
- Passage through the wetland
- Removal of natural vegetation
- Water abstraction
- Fishing

Aquatic Description	High Flow 2012	Low Flow 2012
Water Surface Dimensions	Width: 5–10m; Depth: 0.1–0.7m	Width: 5–10m; Depth: 0.1–0.8m
Water Turbidity (Dallas 2005)	Clear	Clear
Dominant Velocity-depth Classes	Slow shallow	Slow shallow
Water Quality Parameters	T(°C)=28.2; pH=6.1; EC(mS/m)=13.29; DO(mg/l)=7.68; DO(%)=99.51; TDS(mg/l)=67	T(°C)=25.3; pH=6.3; EC(mS/m)=14.17; DO(mg/l)=5.26; DO(%)=64.07; TDS(mg/l)=71
Algae Presence	Common	Abundant
Dominant Biotope Diversity	Pool	Pool
Other Biota	Water birds and frogs	Water birds and frogs
Highly Sensitive Taxa (Score 11–15)	None	Crambidae (Score=12)

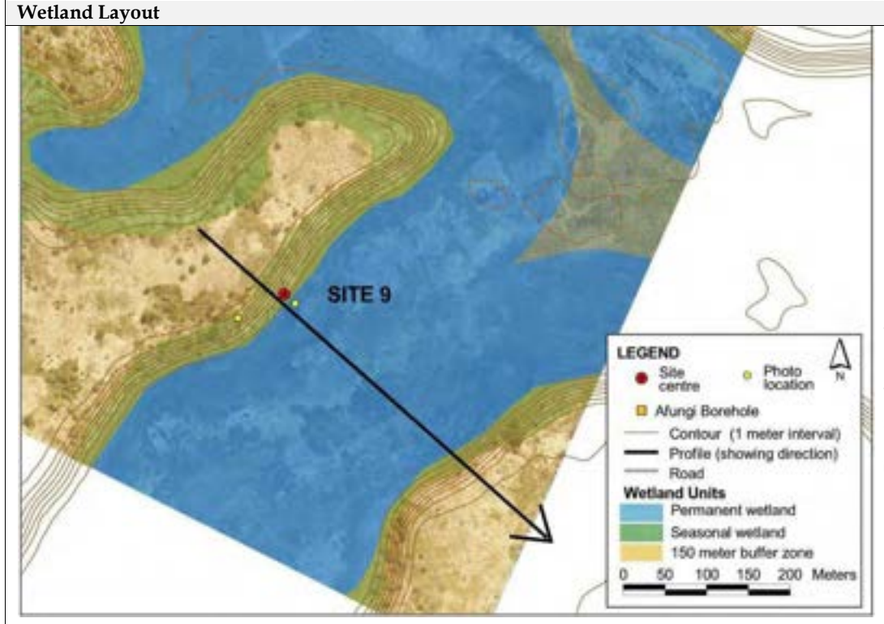
Riparian Present Ecological State				
ZONE	Overall	Marginal	Lower	Upper
VEGRAI %	54.5	78.3	46.8	38.5
Ecological Categories (EC)	D – largely modified	B/C – largely natural – moderately modified	D – largely modified	D/E – largely modified – seriously modified

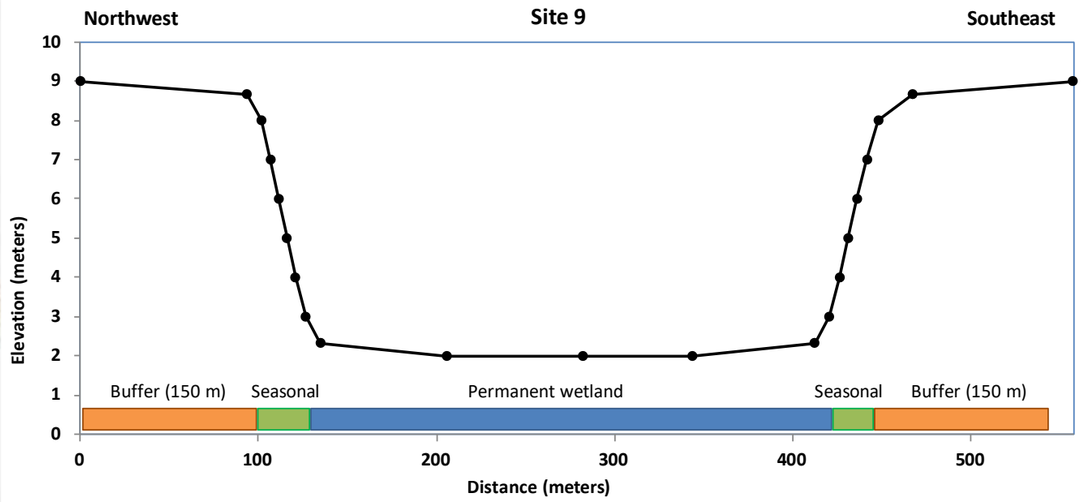
Aquatic Present Ecological State									
			Diatoms			IHI	SASS 5 & ASPT	MIRAI	Fish
DATE	SAMPLERS	WQ	SPI	BDI	%PTV				
27/02/2012	C. Renshaw	√	18.2	20.0	2.0	91 (A)	63 and 4.2	64 (C)	√
26/06/2012	A. Austin W. Malherbe								
	A. Austin W. Malherbe	√	17.3	19.2	1.0	90 (A)	78 and 5.5	67 (C)	√

Figure 8.41 Sampling Site MOZ 9

Wetland Type	Unchannelled valley bottom wetland (Catchment C)
Location	Upstream of the Project Footprint Area (9 masl). Latitude 10.8486S; Longitude 40.55446E (Geographic projection, WGS84); UTM Zone 39: 8800328S; 669921E

Wetland Layout





Source: Aerial image supplied by Client

General Site Description

This site is located on the same wetland system as Site 8, but shows many characteristics of a lower catchment zone, with an extensive permanent wetland zone bordered by a narrow seasonal zone supporting sparse woody riparian vegetation.

Extensive cassava plantations and settlement occur in the outer edges of the upper zone. The communities living here have no vehicle access and live in a somewhat isolated state, depending on agricultural and locally acquired natural resources.

Photos

High Flow 2012			Low Flow 2012	
UPSTREAM	*DOWNSTREAM*	*CLOSE-UP*	*UPSTREAM*	*DOWNSTREAM*

Riparian Zone Description	
Marginal Zone (MZ)	The marginal zone consists of a broad permanent wetland approximately 300m wide, with considerable water resources within.
Lower Zone (LZ)	The lower zone consists of sparse riparian vegetation growing on moderately tall steep slopes.
Upper Zone (UZ)	Extensive plantations of cassava and an associated settlement have been established within the outer edges of the upper seasonal wetland zone. Extensive removal of vegetation has occurred as a result of the settlement.

Vegetation

Chamaecrista sp.

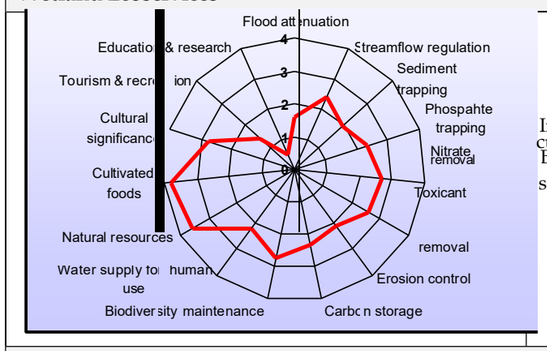
Gymnosporia sp.

Striga sp.

SPECIES	MZ	LZ	UZ	SPECIES	MZ	LZ	UZ
Anacardium occidentale *		x		*Leersia hexandra*	x		
Andropogon gayanus		x		*Manihot esculenta* *			x
***Berlinia orientalis* (VU)**		**x**		*Nymphaea nouchali*	x		
Brachystegia spiciformis		x		*Ochna inermis*		x	x
Chamaecrista sp.	x			*Ozoroa obovata*		x	
Cocos nucifera *			x	*Perotis patens*		x	x
Combretum eleagnoides		x		*Phoenix reclinata*	x	x	
Crinum sp.	x			*Striga* sp.		x	
Cynodon dactylon			x	*Strychnos* sp.		x	x
Cyperus prolifer	x			*Strychnos spinosa*			x
Dactyloctenium aegyptium		x		*Syzigium* sp.	x		
Gymnosporia sp.		x		*Themeda triandra*		x	
Hyphaene coriacea		x	x	*Vangueria infausta*		x	
Juncus sp.	x			*Vitex* sp.	x		

Key: * denotes alien plant species; VU – Vulnerable as per IUCN Red List classification

Wetland Ecoservices



Important ecoservices provided at MOZ 9 include provision of cultivated foods and natural resources to the local communities. Biodiversity maintenance, water supply and cultural significance rank as moderately important there.

Current Impacts

- Extensive cultivation of cassava in the upper zone
- Water abstraction
- Removal of riparian vegetation

Aquatic Description

	High Flow 2012	Low Flow 2012
Water Surface Dimensions	Width: 2–5m; Depth: 0.1–0.8m	Width: 2–5m; Depth: 0.1–0.8m
Water Turbidity (Dallas, 2005)	Clear	Clear
Dominant Velocity-depth Classes	Slow shallow and deep	Slow shallow and deep
Water Quality Parameters	T(°C)=30.0; pH=6.0; EC(mS/m)=43.49; DO(mg/l)=4.35; DO(%)=58.29; TDS(mg/l)=217	T(°C)=27.3; pH=5.8; EC(mS/m)=22.78; DO(mg/l)=3.31; DO(%)=41.80; TDS(mg/l)=114
Algae Presence	Common	Abundant
Dominant Biotope Diversity	Pool	Pool
Other Biota	Frogs and killifish	Frogs and killifish
Highly Sensitive Taxa (Score 11–15)	None	None

Riparian Present Ecological State

ZONE	Overall	Marginal	Lower	Upper
VEGRAI %	62.4	88.5	57.5	41.3
Ecological Categories (EC)	C – moderately modified	A/B – natural – largely natural	D – largely modified	D/E – largely modified – seriously modified

Aquatic Present Ecological State

DATE	SAMPLERS	WQ	Diatoms			IHI	SASS 5 & ASPT	MIRAI	Fish
			SPI	BDI	%PTV				
27/02/2012	C. Renshaw A. Austin W. Malherbe	√	**18.3**	**20.0**	**1.3**	**96 (A)**	**71 and 4.7**	**74 (C)**	√
23/06/2012	A. Austin W. Malherbe	√	**18.3**	**20.0**	**0.3**	**94 (A)**	**76 and 5.0**	**69 (C)**	√

Catchment D

Only one sampling site was considered in Catchment D: MOZ 7, located in the upper zone of the lacustrine wetland (see *Figure 8.20*). The wetland system is classified as an unchannelled valley bottom system that has been artificially channelled by local people for agriculture. The system is a slow-flowing shallow to deep wetland. This site is located in the upper reaches of a permanent tributary to a larger wetland system that drains into a large estuary at the edge of Palma town. The wetland takes on a seasonal appearance upstream of this site.

The aquatic habitat integrity of site is Natural to Largely Natural. The overall riparian habitat integrity is Largely Modified. The marginal zone consists of a broad wetland that has been channelled by the local communities. The wetland has been widely terraced to create dry ridges on which small herbaceous crops such as beans are cultivated. Much vegetation has been cleared from the lower zone for cultivation; however, some patches of natural vegetation remain. Most of the upper zone has been transformed for cultivation. Remnant large trees are common indicating the area must formerly have consisted on a tall thicket; however, little of that thicket now exists. The main ecosystem services supplied by the wetland in Catchment D include natural resource provision and the cultivation of foods.

In terms of water quality, low oxygen levels, influenced by high temperatures and slightly high salts content (EC and TDS), were observed at site MOZ 7, together with exceeding concentrations of NH_4, COD, SS and Zn (see *Section 8.6.4*). SS and Zn are considered to be a naturally occurring constituent within these systems, while the higher levels of NH_4 and COD could be attributed to sewage within the wetland system.

The diatoms at MOZ 7 specifically showed a higher percentage of pollutant-tolerant species, dominated by a high diversity of various *Nitzschia* species, which typically indicates high levels of organic material and waste. The macro-invertebrate community structures of the lacustrine wetlands consisted of a low number of sensitive taxa, probably due to low habitat availability for these taxa. The MIRAI scores were Moderately Modified, indicating that the macro-invertebrates within the lacustrine wetland were influenced by flow modification, habitat and water quality. Only tolerant families can survive in this wetland, and this is likely a result of the limited flow and absence of the stone biotope. In addition, a high percentage of airbreathers observed is indicative of slow-flowing habitats with a lack of sufficient oxygen levels, high temperatures and water levels.

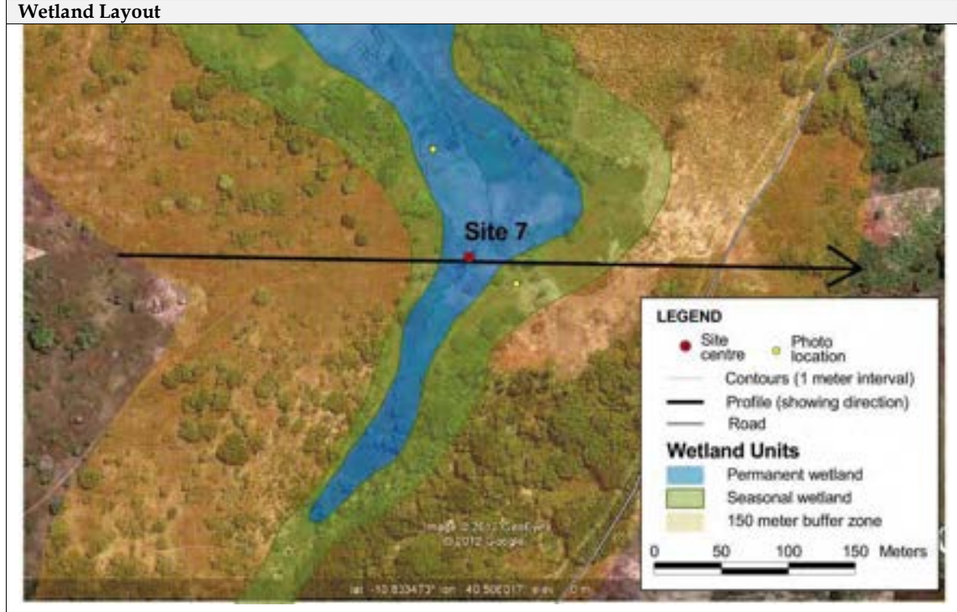
No fish species of high conservational importance were observed at site MOZ 7. However, it must be noted that *Barbus choloensis*, a vulnerable species, is expected to occur within the catchment.

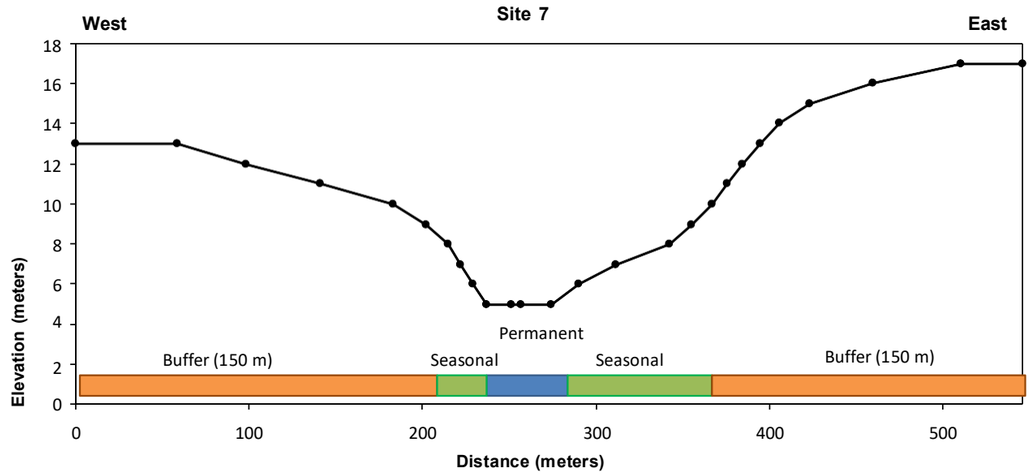
Figure 8.42 provides general information and detailed results for the high flow (October 2011) and low flow sampling assessments (February 2012) at each sampling site in Catchment D.

Figure 8.42 Sampling Site MOZ 7

Wetland Type	Unchannelled valley bottom wetland that has been artificially channelled (Catchment D)
Location	Upstream from proposed airstrip (15 masl). Latitude 10.83272S; Longitude 40.505436E (Geographic projection, WGS84), UTM Zone 39: 8802110S; 664569E

Wetland Layout



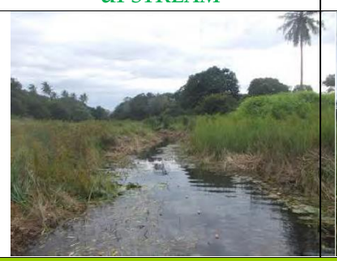


Source: Aerial image supplied by Client

General Site Description

This site is located in the upper reaches of a tributary to a larger wetland system that drains into a large estuary at the edge of Palma town. This site is located at the upper edge of the permanent wetland, which is slow flowing. The wetland takes on a seasonal appearance shortly upstream of this site.

Photos

Low Flow 2011			High Flow 2012		
UPSTREAM	*DOWNSTREAM*	*CLOSE-UP*	*UPSTREAM*	*DOWNSTREAM*	*CLOSE-UP*
					

Riparian Zone Description

Marginal Zone (MZ)	The marginal zone consists of a broad wetland that has been channelled by the local communities. The wetland has been widely terraced to create dry ridges on which small herbaceous crops such as beans are cultivated.
Lower Zone (LZ)	Much vegetation has been cleared from the lower zone for cultivation; however, some patches of natural vegetation remain. A large thicket that overlaps into the upper zone was seen a short distance upstream of the site.
Upper Zone (UZ)	Most of the upper zone has been transformed for cultivation. Skeletons of large trees remain and the area must formerly have consisted on a tall thicket; however, little of that thicket now remains.

Vegetation

SPECIES	MZ	LZ	UZ	SPECIES	MZ	LZ	UZ
Acacia sp.		x		*Mangifera indica* *		x	
Adansonia digitata		x	x	*Manihot esculenta* *			x
Anacardium occidentale *		x		*Cyperus prolifer*	x		

Ficus sur – broom cluster fig

Lycopodium sp.

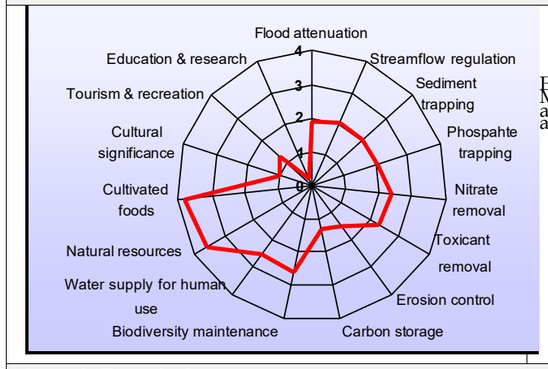
Cyperus dives

***Berlinia orientalis* (VU)**		x	x
Beans *	x		
Brachystegia spiciformis		x	
Cassia sp.		x	
Cocos nucifera *		x	
Cuscuta sp.	x		
Cyperus esculentis	x		
Ferns	x		
Ficus sur		x	
Flueggea virosa			x
Hyparrhenia tamba		x	
Hyphaene coriacea			x
Kigelia africana		x	x
Leersia hexandra	x		
Lycopodium	x		

Musa acuminata *	x		
Nymphaea nauchali			
Ochna inermis	x		
Panicum maximum			
Parinari curatellifolia			x
Phoenix reclinata			
Pseudolachnostylis maprouneifolia		x	
Strychnos pungens			x
Trema orientalis			
Trichilia emetica		x	x
Typha capensis			
Utricularia sp. (yellow flower)			x
Vitex sp.		x	
Xylotheca kraussiana			x
		x	
	x		
	x		
		x	

Key: * denotes alien plant species; VU – Vulnerable as per IUCN Red List classification

Wetland Ecoservices



Ecoservices supplied by MOZ 7 are similar to those supplied by MOZ 5. These rank high on the provision of natural resources and cultivated foods to local communities. Water provision is an important service, as is the maintenance of biodiversity.

Current Impacts

- Alien trees cultivated and displacing natural vegetation
- Artificial channel created
- High algae content due to nutrients from crops and washing in the wetland
- Bank erosion
- Presence of solid waste
- Limited maize cultivation in marginal zone
- Evidence of tillage within marginal to lower zone for legume cultivation
- Water abstraction
- Washing of clothes
- Fish 'air sucking' from lack of sufficient oxygen levels

Aquatic Description

	Low Flow 2011	High Flow 2012
Water Surface Dimensions	Width: 0.5–3m; Depth: 0.1–0.4m	Width: 1–3m; Depth: 0.1–0.8m
Water Turbidity (Dallas, 2005)	Clear	Discoloured
Dominant Velocity-depth Classes	Slow deep	Slow shallow
Water Quality Parameters	T(°C)=31.3; pH=5.8; EC(mS/m)=21.80; DO(mg/l)=6.19; DO(%)=84.20; TDS(mg/l)=109	T(°C)=30.5; pH=5.7; EC(mS/m)=18.19; DO(mg/l)=3.39; DO(%)=45.77; TDS(mg/l)=91
Algae Presence	Abundant	Abundant
Dominant Biotope Diversity	Pool	Pool
Other Biota	None	Frogs and terrapin
Highly Sensitive Taxa (Score 11–15)	None	None

Riparian Present Ecological State

ZONE	Overall	Marginal	Lower	Upper
VEGRAI %	53.3	77.4	45.0	37.5
Ecological Categories (EC)	**D – largely modified**	**B/C –** Largely natural – moderately modified	**D – largely modified**	**D/E – largely modified – seriously modified**

Aquatic Present Ecological State

DATE	SAMPLERS	WQ	Diatoms			IHI	SASS 5 & ASPT	MIRAI	Fish
			SPI	BDI	%PTV				
17/10/2011	C. Renshaw A. Austin	√	**9.3**	**10.8**	**13.5**	**90 (A)**	**75 and 3.9**	**76 (C)**	√
28/02/2012	C. Renshaw W. Malherbe	√	**13.7**	**12.8**	**10.7**	**81 (B)**	**58 and 3.8**	**60 (C)**	√

Catchment E

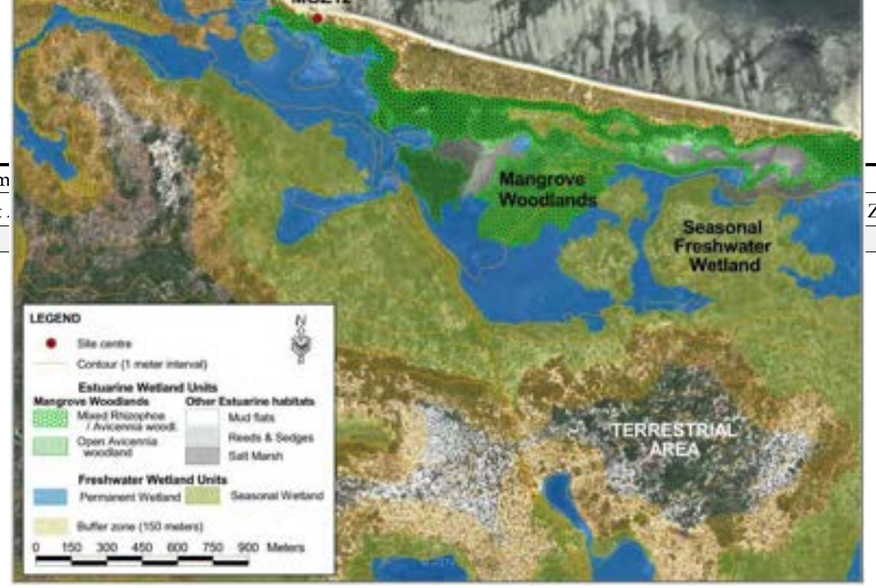
Only one sampling site was considered in Catchment E: MOZ 12, located in an estuary (see *Figure 8.20*). This was sampled in the June 2012 low flow assessment. The estuary is a shallow-water saline system with a sandy substrate. The habitat in Catchment E ranges from shoreline to extensive mangrove systems and large salty mudflats, dominated by halophytic plants, to more fresh-water marshlands punctuated by islands of coastal dry forest, which provides an important habitat to a wide diversity of faunal species.

The salinity profile of MOZ 12 indicates a salinity increase from the head to the mouth of the estuary. However, the salinity at MOZ 12 was lower than at in the other estuaries sampled, which possibly indicates a more significant fresh-water source. The water quality results showed exceeding concentration levels of Ba, Cu, Pb, and Zn, and because most of the water was sea water, the exact source of contamination could not be determined. Nutrient variables within the estuarine water samples were also found to be low and, as such, limit the growth and abundance of microalgae and benthic microalgae.

Eight fish species were identified during the June 2012 survey, with the dominant guilds being estuarine migrants and estuarine residents. A total of four frog species were identified in June 2012, which is a good result granted its estuarine nature. Two species of conservation concern, namely the snoring leaf-folding frog and Lindner's toad, were recorded. The latter is considered to be restricted in its geographic extent (see *Section 8.6.4*).

Catchment E is considered to be a Highly Sensitive environment, based on the low levels of anthropogenic influence within this large and diverse system. Salt harvesting is evident, but is on a small scale and restricted to a patch in the eastern interior. A small isolated fishing village is located within the extreme north-eastern corner of the system (outside of the Onshore Project Footprint Area) but its effects on the ecosystem appear to be small, with footpaths and bicycle tracks traversing the estuary.

Figure 8.43 Sampling Site MOZ 12



Source: Aerial image supplied by Client

Wetland Type	Saline estuarine wetland (Catchm
Location	In the proposed Project Footprint . Zone 39: 8802850S; 672772E.

Wetland Layout

General Site Description

The salinity profile reveals that there is a source of fresh-water inflow into the site; however, the source is deceiving when onsite. The estuary is very shallow and narrow. A slight ridge of sand on the western side approximately 2m high retains the estuary to its current location, preventing a westward spread along the coast. There was a clear lack of herbaceous vegetation within the main part of the estuary, due to the high salt content and fluctuation in salinity. Extensive die-off of mangrove trees was observed, as in other estuarine sites, and is thought to be the result of salinity fluctuations, which may be a natural phenomenon. Limited evidence of tree cutting was observed, but was not the cause of the significant die-back of trees.

Photos

Low Flow 2012		High Flow 2012	
UPSTREAM	*ESTUARY MOUTH*		

Estuarine Vegetation Description

The vegetation in and around this estuary was not assessed in detail. The extent of the estuary and the species composition towards the outer peripheries requires further investigation. The estuary mouth was dominated by *Rhizophora mucronata* trees, while the mudflats deeper within the estuary were dominated by *Avicennia marina* shrubs.

Estuarine Vegetation

SPECIES		
Avicennia marina	*Cocos nucifera* *	*Cynodon dactylon*
* *Casuarina equisetifolia*	*Crassula* sp.	*Rhizophora mucronata*

Key: * denotes alien plant species

Wetland Ecoservices	Current Impacts
Important site for provision of natural resources for the local community.	• The Marampa village nearby resulted in a considerably higher human presence at this site than other estuarine sites assessed • Foot and bicycle traffic between Marampa and Maganja villages

Aquatic Description	
	Low Flow 2012
Water Surface Dimensions	Width: 1–5m; Depth: 0.1–0.6m
Water Turbidity (Dallas 2005)	Discoloured
Dominant Velocity-depth Classes	Slow shallow
Water Quality Parameters	T(°C)=29.4; pH=7.4; EC(mS/m)=5008; DO(mg/l) = 3.86; DO(%)=60.47; TDS(mg/l)=25040; Salinity=32.67
Dominant Biotope Diversity	Pool
Other Biota	Fiddler crabs

Aquatic Present Ecological State

DATE	SAMPLERS	WQ	Diatoms			Invertebrates	Fish
			SPI	BDI	%PTV		
23/06/2012	W. Malherbe A. Austin	√	√	**9.2**	0.5	√	√

8.6.6 Sensitivity of Catchments

The wetland sites ranged from sensitive to highly sensitive (as defined in *Annex C*). These are discussed further in *Section 8.6.5* by catchment. For the Onshore Project Footprint Area, the wetlands [1] in Catchments A, B and E are relevant. The wetlands in Catchment A were found to be more disturbed by human activities (settlements, cultivation and tree felling in the riparian zones) than at Catchment B and Catchment E. It appears that Catchment A has been subject to human activities and modification for a greater period of time than wetlands in Catchment B. This notwithstanding, the estuary of Catchment A has a higher abundance and diversity of estuarine fish species than Catchment B. Catchment A also has high habitat diversity (estuaries, broad lower catchment, narrow upper catchment, permanent wetland, seasonal wetlands and riparian zones).

Catchment B, like Catchment A, has high habitat diversity (estuaries, broad lower catchment, narrow upper catchment, permanent wetlands, seasonal wetlands and riparian zones). However, unlike Catchment A, Catchment B has a greater degree of connectivity with natural habitats than Catchments C and E. This connectivity promotes more robust floral and faunal populations and higher terrestrial faunal diversity (in particular the larger species). Threatened Red Data plant species, *Platycoryne mediocris* orchid and *Berlinia orientalis* tree (see Vegetation Baseline, *Section 8.7* for more detail) were more widespread and abundant in Catchment B than at either Catchment A or Catchment E. The possible new skink species was only observed in Catchment B, despite similar searches in Catchment A [2]. The data-deficient killifish was identified in only two locations: Catchment B and two in Catchment C. They were not found in Catchment A, despite extensive sampling (habitats at Catchment E are not suitable for the killifish). Moreover, the wetlands in Catchment B had a higher abundance and diversity of frog species than in Catchment A [3]. In terms of human disturbance, the wetlands and their buffer zones in Catchment B have been less modified than in Catchment A.

Catchment E has a low level of human disturbance (low levels of salt harvesting). There isn t an upstream fresh-water inflow, which has resulted in limited wetland habitat diversity being present. However, Catchment E wetland habitats are connected to those in Catchments B and C. As indicated earlier, this connectivity supports robust wetland floral and faunal populations and terrestrial faunal diversity.

(1) Includes fresh-water wetlands, estuaries and associated riparian zones and buffers.

(2) The skink species was only found in natural habitat, undisturbed by human activity. This may explain why it was not found in Catchment A.

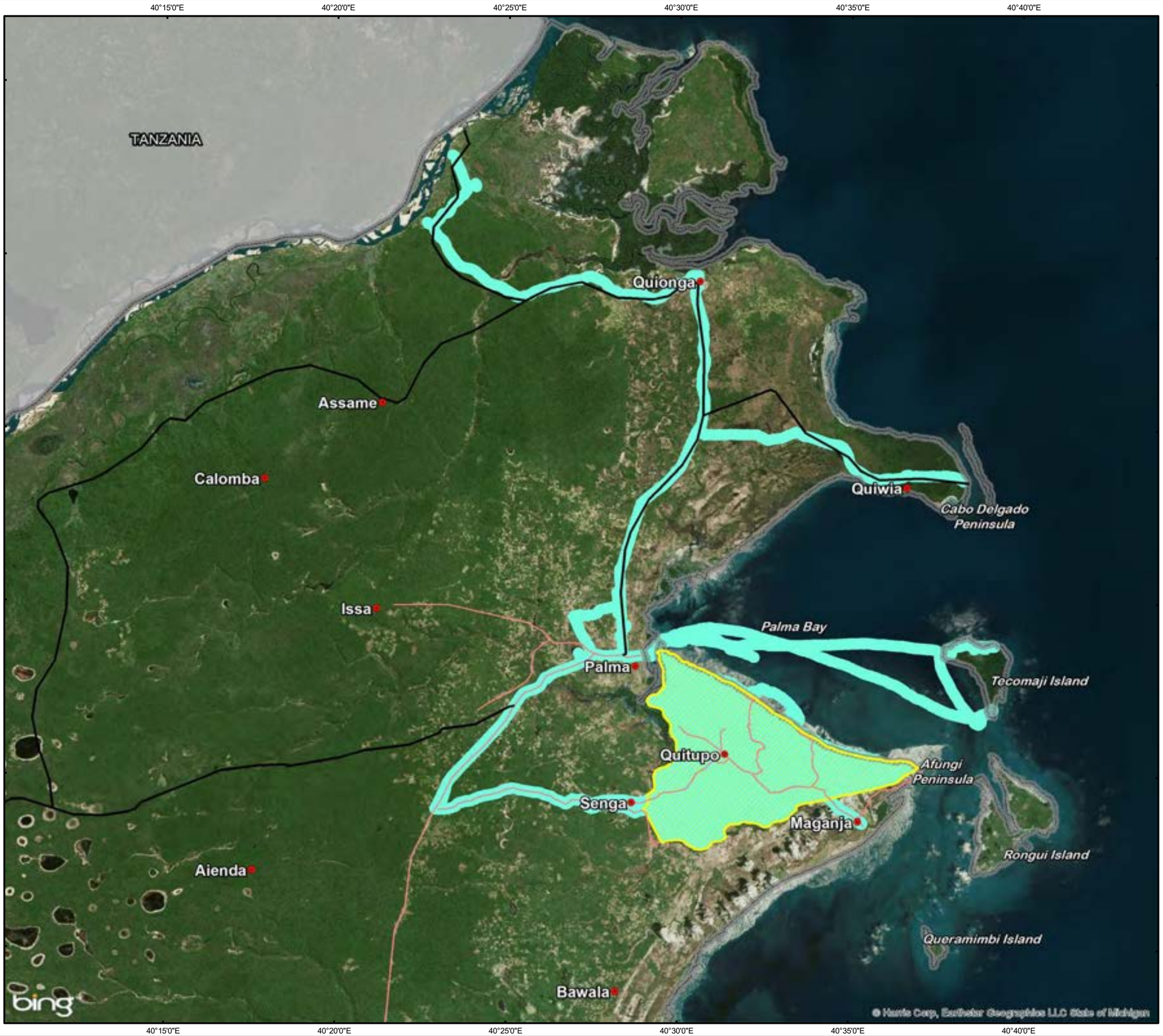
(3) It should be noted that while a high number and diversity of frog species were noted in Catchment E, night-time surveys were not allowed in this catchment for safety reasons. Thus, it is not possible to draw a direct comparison to Catchment B. However, given the low levels of human disturbance in Catchment E, it is likely that Catchment E has a similar abundance and diversity of frog species as Catchment B.

In light of the above, wetlands in Catchments B and E are considered to be highly sensitive, while wetlands in Catchment A are considered to be sensitive.

8.7 VEGETATION

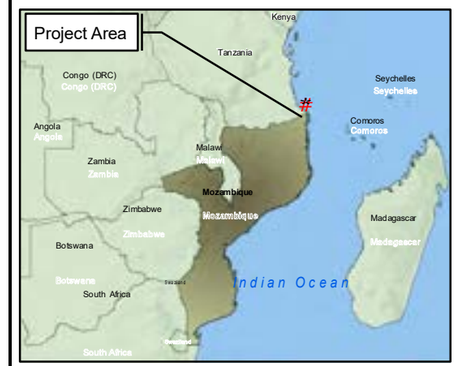
8.7.1 Geographical Context

The vegetation and flora study was conducted over an extensive area, including the Afungi Project Site and main travel arteries to and from Cabo Delgado and the Rovuma River. The Survey Area incorporates the Afungi Project Site and its immediate surroundings. Transects and site-specific surveys were conducted to record changes in vegetation composition and habitat diversity attributed to environmental gradients. The transects highlighted areas of unique composition, where site-specific vegetation surveys were conducted to identify more subtle nuances in plant community development. The Study Area was evaluated to better understand the extent of existing anthropological impacts; this was used for comparative analysis in understanding ecosystem functionality. More intensive surveys were conducted in the Survey Area to develop the vegetation and flora baseline of the Afungi Project Site. *Figure 8.44* shows the extent of the Survey Area and the surrounding Study Area.



Legend

- Villages / Settlements
- Local Roads
- Regional Roads
- Afungi Project Site
- Study Area
- Survey Area
- Mozambique Borders



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 8.44:
Vegetation Study and Survey Areas

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 195 000

DRAWING: Vegetation Study and Survey Areas.mxd

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Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Enviro-Insight, 2012.
Inset Map: Esri Data & Maps

SIZE: A3

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8.7.2 *Mozambique Regional Vegetation Context*

A limited amount of publically available data exists on the composition of the vegetation in Cabo Delgado Province. Vegetation classification done by Wild and Barbosa (1967) suggests that the Survey Area can be divided into two vegetation types: Coastal Thickets and Savannah Woodland. Coastal Thickets (and forest) are found on littoral dunes and occur as a narrow band along the eastern boundary of the Afungi Project Site, with *Mimusops caffra* as the characteristic plant species. The western half of the Survey Area, with Quitupo as the epicentre, is classified as Woodland and Savannah Woodland, characterised by the presence of *Berlinia* and *Brachystegia* species.

However, ground-truthing within the Afungi Project Site shows that Wild and Barbosa's classifications were generalised and are not considered to be representative of the vegetation present. The coastal thickets found on the littoral dunes are highly fragmented and segregated by mangrove swamps. Furthermore, *Mimusops caffra* is not considered a character species of this area. Although *Berlinia* and *Brachystegia* are considered characteristic of savannah woodland areas, the vegetation structure varies from open grassland, to grassland with thickets, to savannah and woodland. The most recent land-use and land-cover maps of the Survey Area indicate that the vegetation is degraded due to historic land-use and agricultural practices. Therefore, the species composition and structure of the area has been modified.

8.7.3 *Vegetation Context of Cabo Delgado Province*

An intensive vegetation survey conducted by Timberlake et al. (2010) culminated in the publication of *Coastal Dry Forests in Cabo Delgado Province, Northern Mozambique – Botany and Vegetation*. These East African coastal forests have a high level of endemism and, despite their relatively small area, are now considered an important and distinct ecoregion. It is estimated that only 10 percent of East Africa's coastal forest is intact, remaining under constant threat due to expanding rural and agricultural settlements and increased pressure on the natural resources available. Despite this vegetation type's highly fragmented nature, a chain of natural forest relics are found within the secondary savannah woodland. However, low-altitude Moist forest, Miombo woodlands, mangroves and vegetation associated with watercourses and rivers are excluded from the defined coastal cry forests. The Survey Area is thus located outside the vulnerable coastal dry forest.

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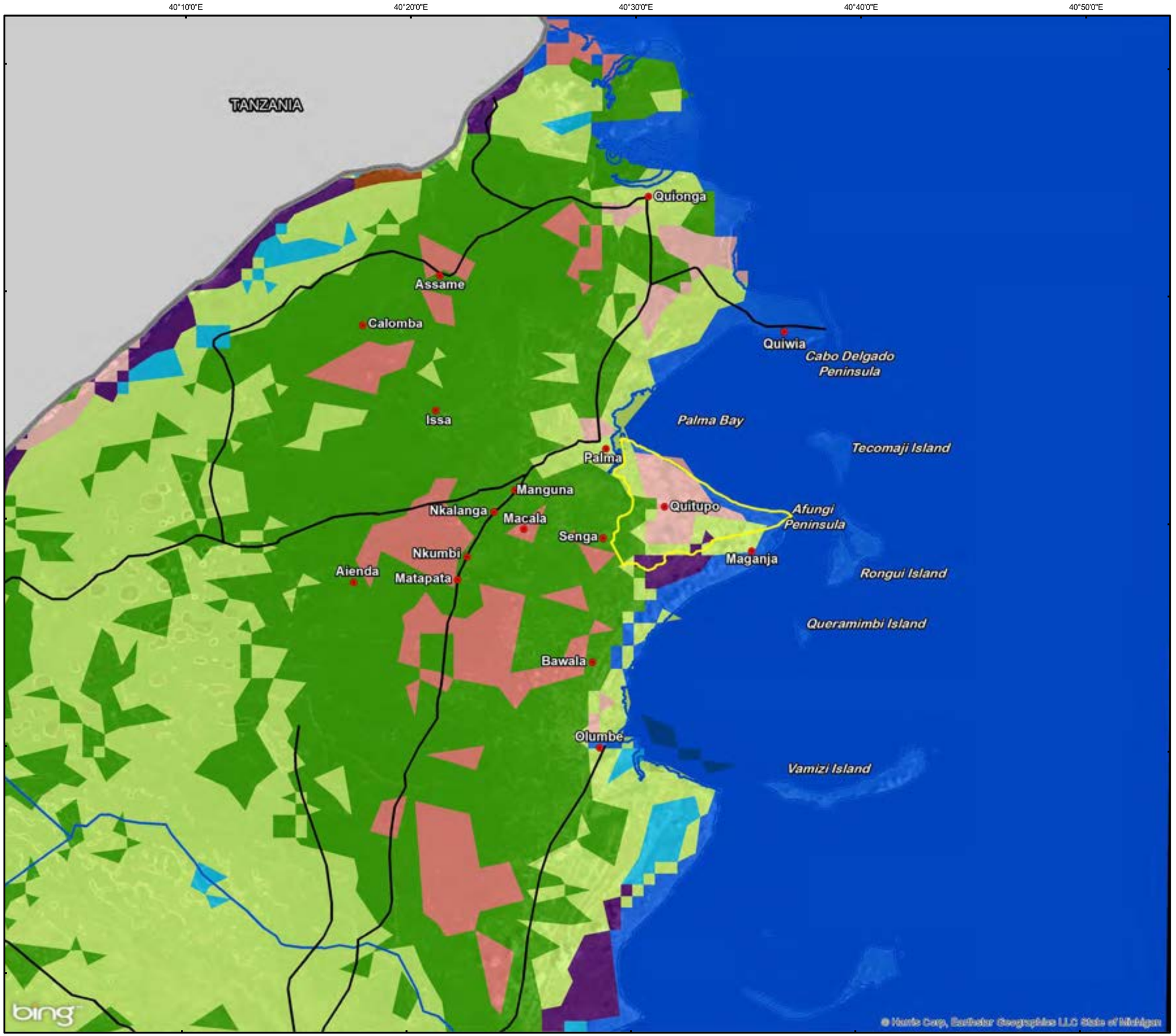

Legend

- Villages / Settlements
- Regional Roads
- Boundary with Tanzania
- Afungi Project Site

Land Cover

- 1 Tree Cover, broadleaved, evergreen
- 2 Tree Cover, broadleaved, deciduous, closed
- 3 Tree Cover, broadleaved, deciduous, open
- 8 Tree Cover, regularly flooded, saline water
- 9 Mosaic: Tree Cover/Other natural vegetation
- 12 Shrub Cover, closed-open, deciduous
- 13 Herbaceous Cover, closed-open
- 14 Sparse herbaceous or sparse shrub cover
- 15 Regularly flooded shrub and/or herbaceous cover
- 16 Cultivated and managed areas
- 17 Mosaid: Cropland / Tree Cover / Other natural vegetation
- 19 Bare Areas
- 22 Artificial surfaces and associated areas
- 20 Water Bodies

MAIN MAP SCALE :

Kilometers

TITLE:

Figure 8.45: National land cover data (30 arc seconds resolution) shown at regional scale (courtesy Global Land Cover 2000)

CLIENT:

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DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 300 000

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Projection: UTM Zone 37 S, Datum: WGS84 Source: Global Land Cover, 2000 and Enviro-Insight, 2012.	SIZE: A3

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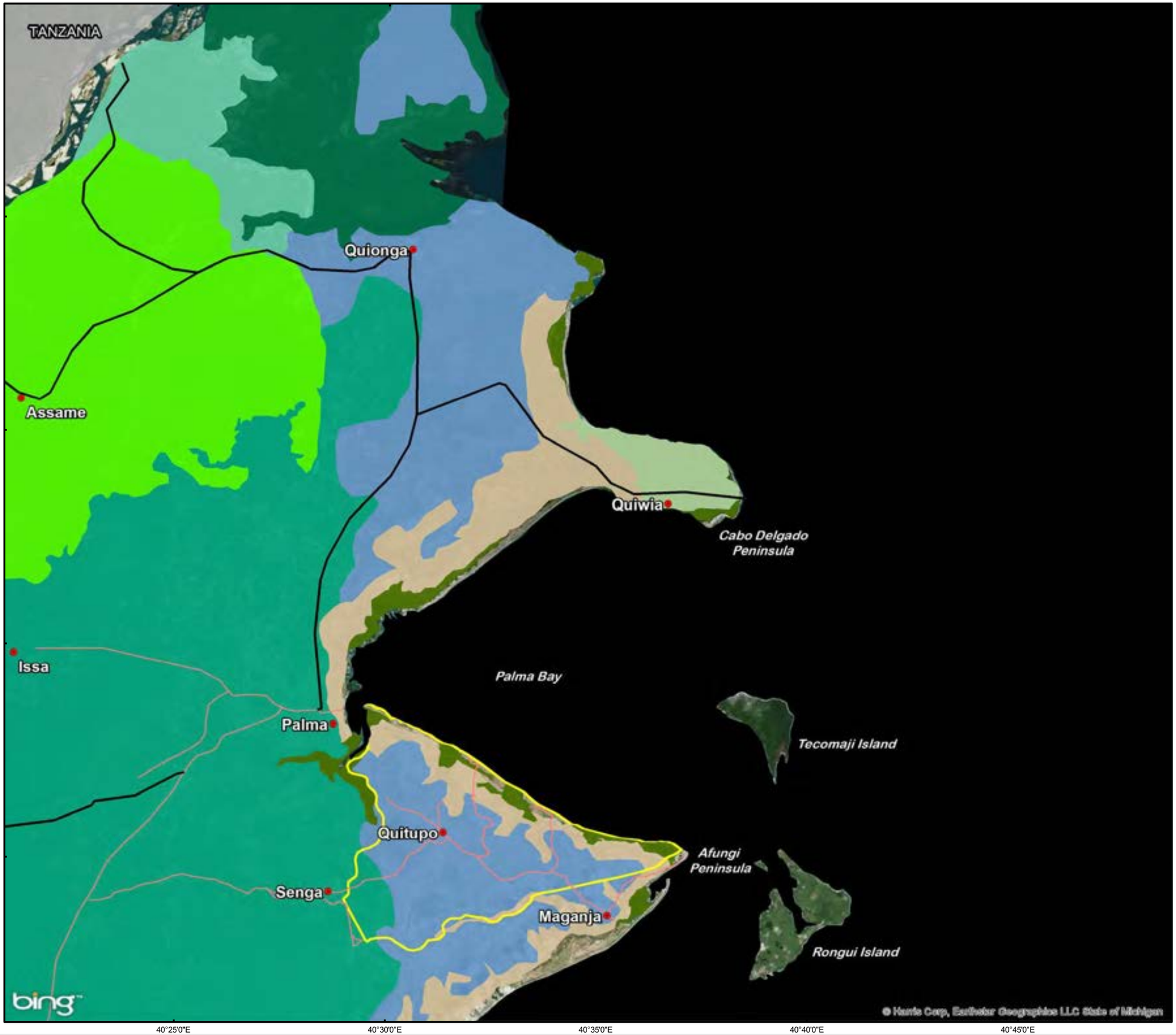

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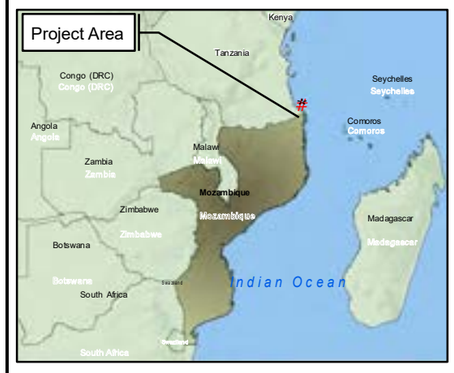
Legend

- Villages / Settlements
- Regional Roads
- Local Roads
- Afungi Project Site

Vegetation Units

- Coastal river delta with mangroves
- Coral rag forest
- Dense forest
- Inland dense woodland with miombo
- Mangrove
- Near coastal open savanna-wetland mosaic
- Riverine savanna-wetland mosaic
- Sandy coastal open woodland



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 8.46:
Regional structural Vegetation Units derived from remote sensing imagery and ground truthing

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DRAWING: Regional structural Vegetation Units.mxd

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	Projection: UTM Zone 37 S Datum: WGS84 Source: Bing Maps ©2010 Microsoft Corporation. Enviro-Insight, 2012 Inset Map: Esri Data & Maps	SIZE: A3

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8.7.4 Vegetation Context of the Survey Area

The Survey Area comprises a diversity of habitats and vegetation types. This system is driven by a moisture regime dependent on subsurface water flow from higher elevations, through a network of wetlands, *'dambos'* [1] and mangroves eventually to reach the sea. The spatial arrangement of different vegetation communities is clearly dependent upon the availability of the subsurface water flow. Along this flow gradient, seven distinctly different Vegetation Units have been identified and are discussed below.

Rural villages and smaller household settlements are found scattered throughout the Survey Area. However, indications are that these settlements are not static and that many households move to a new area if agricultural soils become nutrient-depleted or when natural resources become difficult to obtain. Much of the vegetation in the Survey Area has been transformed or modified by local agricultural practices, as indicated by the structural analysis of the vegetation and comparison of plant species composition and diversity. Although species composition has been maintained in some of the identified Vegetation Units, the structure and density varies tremendously within each. This variation can be attributed to the clearing of vegetation for cultivation, and slash-and-burn agricultural practices frequently implemented. However, recovery of degraded environments is also evident, as many damaged trees such as the msasa (*Brachystegia spiciformis*) regenerate readily.

Analysing the data collected in the Survey Area identified the presence of approximately 250 different plant species, predominantly trees and shrubs. The probability of more species occurring in the Survey Area is high, considering the rapid phenological adaptations of plants to changing climatic conditions. Since much of the plant identification is based on fertile material such as flowers and seeds or fruits present during the survey periods, some plant species would have escaped positive identification[2]. Not all species were used in the classification of Vegetation Units, as some of the species were inconsistently distributed. Despite the fact that the greater part of the area is considered to be duneveld, seven major Vegetation Units were identified.

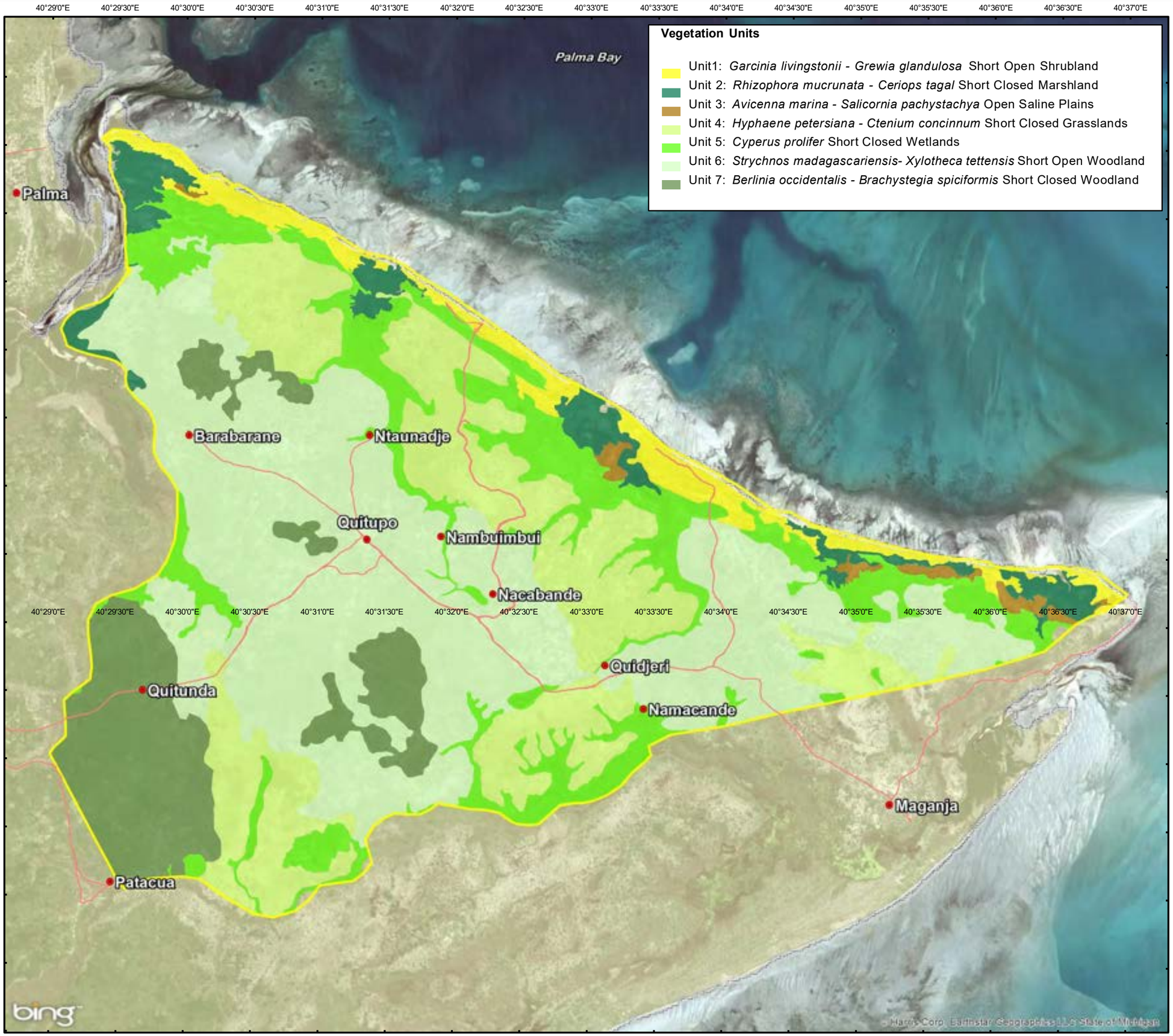
These are defined as:

- **Vegetation Unit 1**: The *Garcinia livingstonii – Grewia glandulosa* Short Open Shrubland;
- **Vegetation Unit 2**: The *Rhizophora mucrunata – Ceriops tagal* Short Closed Marshland;
- **Vegetation Unit 3**: The *Avicenna marina – Salicornia pachystachya* Open Saline Plains;
- **Vegetation Unit 4**: The *Hyphaene petersiana – Ctenium concinnum* Short Closed Grasslands;

(1) Dambos are depressions within wetland systems where water levels are not dependent on surface rainfall run-off, but rather on water welling up from below. Dambos are also found at higher elevations outside wetland systems and are presumably fed from arterial springs, and retain water for longer periods during the dry season.
(2) Note:tThe presence of threatened Red Data plant species, *Platycoryne mediocris* orchid and *Berlinia orientalis* were observed by the Surface Water Ecology specialist team but were not observed during the vegetation baseline fieldwork.

- **Vegetation Unit 5**: The *Cyperus prolifer* Short Closed Wetlands;
- **Vegetation Unit 6**: The *Strychnos madagascariensis*– *Xylotheca tettensis* Short Open Woodland; and
- **Vegetation Unit 7**: The *Berlinia occidentalis* – *Brachystegia spiciformis* Short Closed Woodland.

The location of the seven Vegetation Units is shown in *Figure 8.47*.
Description of the Vegetation Units includes common names, followed by the scientific name in italics. However, considering the vast number of taxa, many plant species have no common names, necessitating the use of scientific names only in these instances.

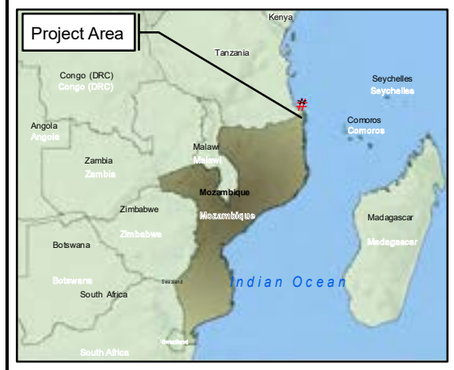


Vegetation Units

- Unit1: *Garcinia livingstonii - Grewia glandulosa* Short Open Shrubland
- Unit 2: *Rhizophora mucrunata - Ceriops tagal* Short Closed Marshland
- Unit 3: *Avicenna marina - Salicornia pachystachya* Open Saline Plains
- Unit 4: *Hyphaene petersiana - Ctenium concinnum* Short Closed Grasslands
- Unit 5: *Cyperus prolifer* Short Closed Wetlands
- Unit 6: *Strychnos madagascariensis- Xylotheca tettensis* Short Open Woodland
- Unit 7: *Berlinia occidentalis - Brachystegia spiciformis* Short Closed Woodland

Legend

- ! Villages / Settlements
- Local Roads
- Afungi Project Site
- Mozambique Borders



MAIN MAP SCALE:

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TITLE:

Figure 8.47
Vegetation Units within the Afungi Project Site

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 50 000

DRAWING: egetation Units within the Afungi Project Site.mxd

REV: A

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10°53'0"S

Projection: UTM Zone 37 S Datum: WGS84 Source: Bing Maps ©2010 Microsoft Corporation. Enviro-Insight, 2012 Inset Map: Esri Data & Maps	SIZE: A3	T:\GIS Projects

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8.7.5 *Vegetation Units within the Afungi Project Site*

The seven Vegetation Units identified are discussed below.

Vegetation Unit 1: The Garcinia livingstonii – Grewia glandulosa Short Open Shrubland

This is a relatively narrow Vegetation Unit found along the Afungi Project Site coastline (*Figure 8.47*, above). It forms a fragmented mosaic with Vegetation Units 2 and 3 and is dominated by mangrove species and exposed saline estuaries. The geomorphology is relatively flat and the substrate is dominated by shifting dunes and sandy soils. This area is a more arid than the surrounding areas; this is likely due to exposure to oceanic influences such as dramatic tidal fluctuations, high humidity and the presence of salt spray (see *Figure 8.48* below).

Figure 8.48 ***Short Shrubland Structure of Vegetation Unit 1***

Source: Enviro-Insight (December, 2011).

The dominant feature along the coastline is the presence of the white mangrove (*Avicenna marina*) and the mangrove apple (*Sonneratia alba*) growing in the oceanic tidal zone, but also found as scattered individuals on the narrow stretch of white sand stretching the length of the beachfront. The most visual features found in this littoral zone are the tall coconut palms (*Cocos nucifera*), horsetail tree (*Casuarina cunninghamiana*), an abundance of raisin bush (*Grewia glandulosa*), the dune morning glory (*Ipomoea pes-caprae*), bush tick-berry (*Chrysanthemoides monilifera*) and small bush violet (*Barleria repens*). The vegetation quickly gives rise to other trees and shrubs that form a short, open shrubland with an abundance of white thorn (*Acacia seyal*), needle bush (*Azima tertacantha*), coast bone apple (*Catunaregam spinosum*), forest corkwood (*Commiphora woodii*), dune myrtle (*Eugenia capensis*), rubber euphorbia

(*Euphorbia tirucalli*), African mangosteen (*Garcinia livingstonei*), copalwood (*Guibourtia schliebenii*), common spike-thorn (*Gymnosporia buxifolia*), climbing turkey-berry (*Keetia gueinzii*), Zulu milkberry (*Manilkara concolor*), cork bush (*Mundulea sericea*), glossy currant (*Searcia lucida*), white milkwood (*Sideroxylon inerme*), green monkey orange (*Strychnos spinosa*), climbing tarenna (*Tarenna junodii*), lagoon tulip tree (*Thespesia populnea*) and chocolate berry (*Vitex payos*).

The herbaceous layer is poorly represented with large open sandy patches interspersed with forbs such as spiderling (*Boerhavia diffusa*), *Centimopsis gracilenta*, fishbone dwarf cassia (*Chamaecrista mimosoides*), sand crown-berry (*Crossopteryx febrifuga*), *Cyperus crassipes*, *Dicerocaryum zanguebaricum*, *Indigofera eriocarpa* and devil's thorn (*Tribulus terrestris*).

Vegetation Unit 2: The Rhizophora mucronata – Ceriops tagal Short Closed Marshland

This is a highly fragmented Vegetation Unit found along the coastline, where water flowing from drainage lines throughout the Survey Area dissipates into the ocean. Due to erosive water action and oceanic tidal influences, these give rise to estuaries dominated by mangrove species. This fresh and saline water interaction forms a mosaic with Vegetation Unit 3, where fresh water from higher altitudes is prevalent during oceanic low tide, but inundated by sea water during high or spring tides. The geomorphology is relatively flat and the substrate dominated by high salinity, sandy soils. The zone is permanently wet, either due to fresh / brackish water outflow (during low tide) or inundated with sea water during high or spring tides (see *Figure 8.49*).

Figure 8.49 *Mangrove Vegetation from Vegetation Unit 2*

Source: Enviro-Insight (March 2012).

The vegetation is dominated by relatively short mangroves, less than 5m in height. Although black mangrove (*Bruguieria gymnorrhiza*) generally dominates on the seaward side, larger white mangroves were found in the littoral zone. The most dominant mangroves on the landward side are the red mangrove (*Rhizophora mucronata*) and the Indian mangrove (*Ceriops tagal*). The red mangrove is especially prevalent along the river embankment, forming a dense, almost impenetrable stand of old and young germinating mangrove trees. Scattered individuals of the mahogany mangrove (*Xylocarpus moluscensis*) also occur. Moving deeper inland, the white mangrove and Tonga mangrove (*Lumnitzera racemosa)* become more dominant.

No herbaceous plant species occur within this Vegetation Unit.

Vegetation Unit 3: The Avicenna marina – Salicornia pachystachya Open Saline Plains

This Vegetation Unit is associated with the areas located inland of Vegetation Unit 2 and forms an integral part of the *Rhizophora mucrunata – Ceriops tagal* Short Closed Marshland ecosystem. This system is dependent on an influx of fresh water from higher altitudes and sea water from the ocean during high or spring tides. Seasonal rainfall also effects ecosystem functionality, and this Vegetation Unit becomes inundated during the rainfall season. Due to its location in the landscape, minerals are constantly supplemented from higher elevations due to substurface water flow. This Vegetation Unit also forms part of the wetland ecosystem. The soils are sandy with a high salinity and play an important role in salt harvesting by local communities (see *Figure 8.50*).

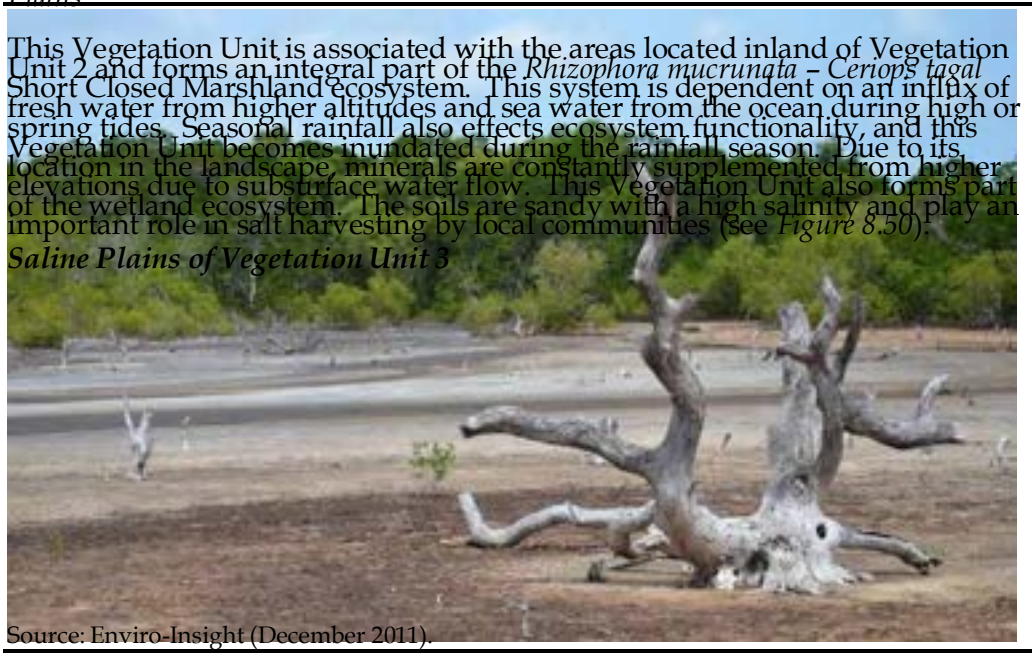


Figure 8.50 ***Saline Plains of Vegetation Unit 3***

Source: Enviro-Insight (December 2011).

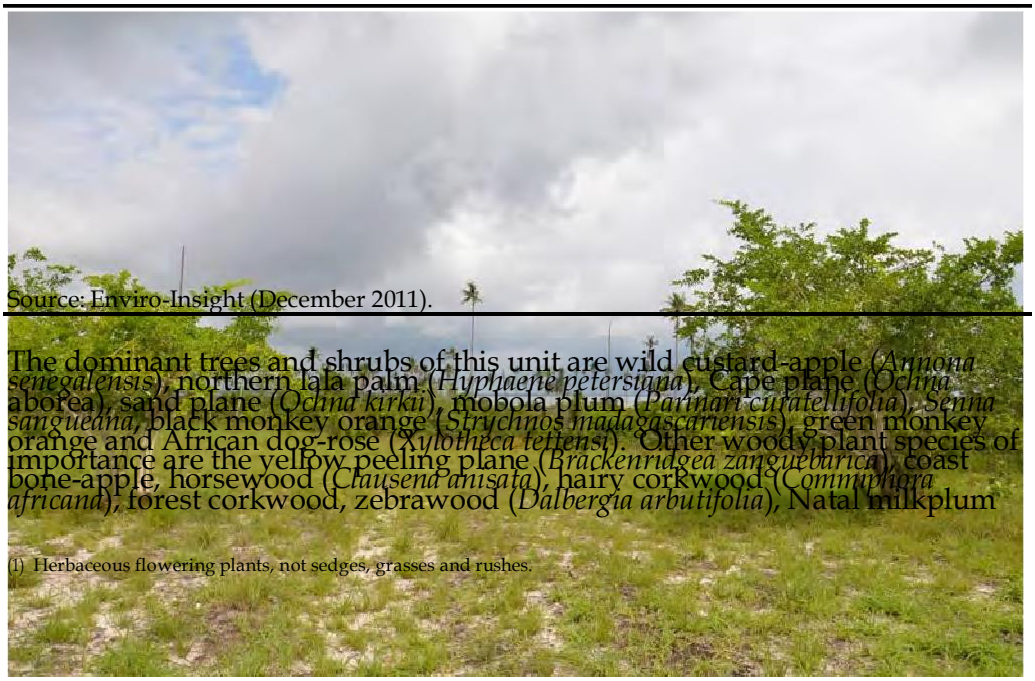
The area is characterised by large open sandy areas, usually with water accumulation in depressions to form shallow open water bodies. Vegetation

is limited to white mangroves and scattered individuals of Indian and Tonga mangroves. Although grass species such as couch grass (*Cynodon dactylon*) and sedges occur along the periphery of these water bodies, the only forb [1] of prominence is glasswort (*Salicornia pachystachya*), which is adapted to the high salinity.

Vegetation Unit 4: The Hyphaene petersiana – Ctenium concinnum Short Closed Grasslands

This Vegetation Unit is found as a fragmented mosaic, inland of the primary dune vegetation identified in Vegetation Unit 1. Characteristic are the exposed sandy patches with a sparse herbaceous canopy cover and scattered individuals of plant species reminiscent of the diversity also found in Vegetation Unit 1. The terrain is relatively flat, dominated by sandy soils much like beach sand, and a relatively poor canopy cover. Disturbance is evident and attributed to historic land-use practices and agriculture. Water percolation is good, but water retention is very poor (see *Figure 8.51*).

Figure 8.51 ***Grassland Structure of Vegetation Unit 4***



Source: Enviro-Insight (December 2011).

The dominant trees and shrubs of this unit are wild custard-apple (*Annona senegalensis*), northern lala palm (*Hyphaene petersiana*), Cape plane (*Ochna arborea*), sand plane (*Ochna kirkii*), mobola plum (*Parinari curatellifolia*), *Senna sangueana*, black monkey orange (*Strychnos madagascariensis*), green monkey orange and African dog-rose (*Xylotheca tettensis*). Other woody plant species of importance are the yellow peeling plane (*Brackenridgea zanguebarica*), coast bone-apple, horsewood (*Clausena anisata*), hairy corkwood (*Commiphora africana*), forest corkwood, zebrawood (*Dalbergia arbutifolia*), Natal milkplum

(1) Herbaceous flowering plants, not sedges, grasses and rushes.

(*Englerophytum natalense*), Natal guarri (*Euclea natalensis*), wild gardenia (*Gardenia ternifolia*), red-heart tree (*Hymenocardia ulmoides*), sand nightstar (*Leptactina delagoensis*), *Maprounea africana*, kooboo berry (*Mystroxylon aethiopicum*), snake bean (*Swartzia madagascariensis*), chocolate berry and sourplum (*Ximenia caffra*).

The dominant grass species is sickle grass (*Ctenium concinnum*) with hairy blue grass (*Andropogon chinensis*) being subdominant. Other grasses encountered in a forb-dominated herbaceous layer are Natal red top (*Melinis repens*), white buffalo grass (*Panicum coloratum*), cat s tail (*Perotis patens*) and giant spear grass (*Trachypogon spicatus*).

The dominant forbs present are *Indigofera eriocarpa*, *Indigofera schimperi*, miniature morning glory (*Merremia tridentata*), *Oldenlandia herbacea*, *Rhynchosia minima*, spiky mother-in-law s tongue (*Sansevieria canaliculata*), wing-seeded sesame (*Sesamum alatum*), witchweed (*Striga junodii*), narrow-leaved wild sweetpea (*Vigna vexillata*) and two species of mistletoe (*Tapinanthus kraussianus* and *Tapinanthus natalitius*).

Vegetation Unit 5: The Cyperus prolifer – Short Closed Wetlands

This Vegetation Unit includes both seasonal wetlands and permanently wet *dambos*, as the two are considered to be inherently linked in ecosystem functionality. Furthermore, the apparent seasonal drying of the wetlands is only superficial as subsurface water flow continues unabated to feed fresh water through Vegetation Units 2 and 3, before flowing into the sea. The soil is considered alluvial in origin, with illuviation of minerals from higher elevations. Due to the relatively high nutrient content and moisture regime within the wetland system, rice is cultivated by local communities living in the Survey Area. Approximately 10 percent of this Vegetation Unit has been modified by agriculture (see example in *Figure 8.52*).

Figure 8.52 ***Wetlands of Vegetation Unit 5***

Source: Enviro-Insight (December 2011).

Tree and shrub species are relatively scarce, with only scattered individuals of octopus cabbage tree (*Cussonia aborea*), orange bird berry (*Heslundia opposita*), northern lala palm, giant sensitive plant (*Mimosa pigra*), woodland umdoni (*Syzygium guineense*), narrow-leaved mahobohobo (*Uapaca nitida*) and black plum (*Vitex doniana*) along the periphery.

The grass layer is dominated by hairy blue grass, snowflake grass (*Andropogon eucomus*), swamp grass (*Diplacne fusca*), cottonwool grass (*Imperata cylindrica*) and Guinea grass (*Panicum maximum*).

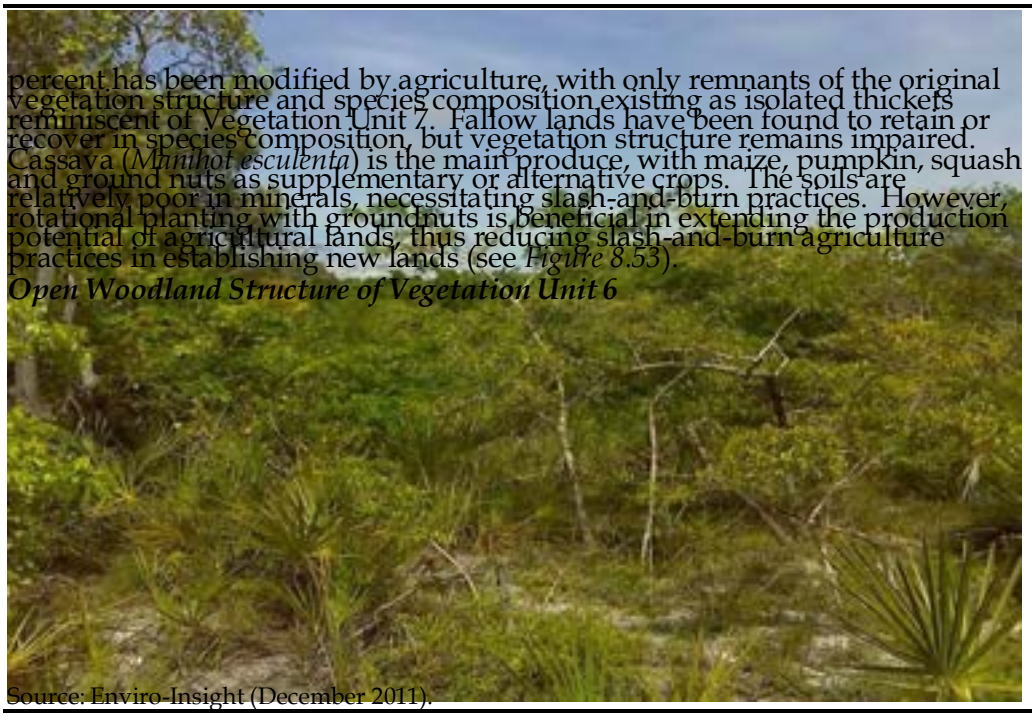
The dominant forbs are *Asystasia gangetica*, common sedge (*Bulbostylis burchellii*), blue commelina (*Commelina erecta*), Moore's crinum (*Crinum moorei*), doll's powderpuff (*Cyanotis speciosa*), *Cyperus crassipes*, winged sedge (*Cyperus denudatus*), *Cyperus exaltatus*, white sedge (*Cyperus hemisphaericus*), white-flowered sedge (*Cyperus obtusiflorus*), dwarf papyrus (*Cyperus prolifer*), purple nutsedge (*Cyperus rotundus*), *Cyperus vestitus*, *Dissotus debilis*, dwarf dissotis (*Dissotis phaeotricha*), sundew (*Drosera* sp.), *Eulophia livingstoneana*, *Eulophia seleensis*, *Eulophia speciosa*, water ipomoea (*Ipomoea aquatica*), *Juncus rigidus*, *Mariscus solidus*, blue waterlily (*Nymphaea nouchali*), knotweed (*Persicaria madagascariensis*), *Platycoryne buchanniana*, *Pycreus polystachyos* and common xyris (*Xyris capensis*).

Vegetation Unit 6: The Strychnos madagascariensis – Xylotheca tettensis Short Open Woodland

This Vegetation Unit is dominant throughout the Afungi Project Site, and typically very disturbed due to agricultural practices. Approximately 70

percent has been modified by agriculture, with only remnants of the original vegetation structure and species composition existing as isolated thickets reminiscent of Vegetation Unit 7. Fallow lands have been found to retain or recover in species composition, but vegetation structure remains impaired. Cassava (*Manihot esculenta*) is the main produce, with maize, pumpkin, squash and ground nuts as supplementary or alternative crops. The soils are relatively poor in minerals, necessitating slash-and-burn practices. However, rotational planting with groundnuts is beneficial in extending the production potential of agricultural lands, thus reducing slash-and-burn agriculture practices in establishing new lands (see *Figure 8.53*).

Figure 8.53 ***Open Woodland Structure of Vegetation Unit 6***



Source: Enviro-Insight (December 2011).

The dominant tree species are cashew nut (*Anacardium occidentale*), mango (*Mangifera indica*), Cape plane, plane tree (*Ochna mossambicensis*), Natal plane (*Ochna natalitia*), mobola plum, *Senna sangueana*, black monkey orange, green monkey orange and African dog-rose. Other trees encountered are baobab (*Adansonia digitata*), bitter false-thorn (*Albizia amara*), *Berlinia orientalis*, msasa, yellow peeling plane, coast bone-apple, four-leaved bushwillow (*Combretum tadenogonium*), sand crown-berry, marula (*Sclerocarya birrea* subsp. *caffra*), zebra wood, wild pear (*Dombeya kirkii*), Kei-apple (*Dovyalis hispidula*), common saffron (*Elaeodendron croceum*), Natal guarri, African mangosteen, white cross-berry (*Grewia pachycalyx*), munondo (*Julbernardia globiflora*), sausage tree (*Kigelia africana*), forest milkberry (*Manilkara discolor*), *Maprounea africana*, broad-leaved resin tree (*Ozoroa obovata*), kudu-berry (*Pseudolachnostylis maprouneifolia*), African star-chestnut (*Sterculia africana*), woodland umdoni, pigeonwood (*Trema orientalis*), jackal coffee (*Tricalysia coriacea*), narrow-leaved mahobohobo, lesser mahobohobo (*Uapaca sansibarica*), wild medlar (*Vangueria infausta*), plum finger-leaf (*Vitex ferruginea*) and sourplum.

The dominant grass species are finger grass (*Digitaria eirantha*), Natal red top, yellow thatching grass (*Hyperthelia dissoluta*), white buffalo grass, Guinea grass, cat's tail, red grass (*Themeda triandra*), giant spear grass and couch grass.

Forbs are found in strong association with *Agelanthus zizyphifolius*, Madeira vine (*Anredera cordifolia*), broom asparagus (*Asparagus virgatus*), sorel (*Biophytum umbraculum*), common sedge,, fishbone dwarf cassia, Ecklon's blue commelina (*Commelina ecklioniana*), blue commelina and commelina zambesiaca, Moore's crinum, wild grape (*Cyphostemma cirrhosum*) and *Cyphostemma natalitium*, *Drimiopsis burkei*, flame lily (*Gloriosa superba*), common dwarf wild hibiscus (*Hibiscus aethiopicus*), prickly tree hibiscus (*Hibiscus diversifolius*) and *Hibiscus surattensis*, small pink ipomoea (*Ipomoea magnusiana*), African cucumber (*Momordica trifoliolata*), *Psorospermum febrifugum*, forest burr (*Pupalia lappacea*), *Rhynchosia caribaea*, fire-ball lily (*Scadoxus multiflorus*), thorny rope (*Smilax anceps*) and mistletoe (*Tapinanthus natalitius*). The thorny rope and prickly tree hibiscus are most prevalent in cultivated areas.

Vegetation Unit 7: The Berlinia occidentalis – Brachystegia spiciformis Short Closed Woodland

This Vegetation Unit is predominantly found as isolated patches within Vegetation Unit 6, with the largest remaining vestige found below the Senga pass to the west of the Afungi Project Site. Although this area remained relatively unaffected by agricultural activities, newly opened areas cleared for cultivation are evident. All other Unit areas are highly fragmented and sparsely distributed. The soils are humic in nature, but nutrients are rapidly leached when the existing canopy cover is destroyed. Due to the closed nature of the canopy cover, the herbaceous layer is poorly developed with almost no grass species present (see *Figure 8.54*). This Vegetation Unit shows habitat features with high potential in feeding, breeding, nesting and resting requirements for all wildlife. The structure is well developed and evidence of resource use by the local population is less in this vegetation structure than in many of the others identified.

Figure 8.54 ***Closed Woodland Structure of Vegetation Unit 7***

Source: Enviro-Insight (December 2011).

The dominant and characteristic tree species are *Berlinia orientalis*, msasa and munondo. Other trees found in profusion are pod mahogany (*Afzelia quanzensis*), coffee neat's foot (*Bauhinia petersiana*), sand ivory (*Berchemia discolor*), horsewood, flame creeper (*Combretum paniculatum*), large-fruited bushwillow (*Combretum zeyheri*), hairy corkwood, forest corkwood, zebrawood, zebra wood flat-bean (*Dalbergia melanoxylon*), Kei-apple, false gardenia (*Heinsia crinita*), red-heart tree, *Hypericanthus* sp., false marula (*Lannea schweinfurthii*), dwaba-berry (*Monanthotaxis caffra*), mobola plum, black bird-berry (*Psychotria capensis*), marula, glossy currant, *Senna sanguenea*, black monkey orange and green monkey orange, climbing tarenna, narrow-leaved mahobohobo and lesser mahobohobo, white ironwood (*Vepris lanceolata*), chocolate berry and wing bean (*Xeroderris stuhlmannii*).

The grass layer is poorly developed within the thicket, with yellow thatching grass dominating the more exposed areas. Other grasses encountered are hairy blue grass, white buffalo grass and Guinea grass.

Dominant shrubs and creepers are brooms and brushes (*Acalypha villicaulis*), the orchid (*Acampe pachyglossa*), blue aneilema (*Aneilema dregeanum*), broom asparagus, sorel, Ecklon's blue commelina, Moore's crinum, dodder (*Cuscuta campestris*), wild grape, *Cyphostemma natalitium* and hairy grape bush (*Cyphostemma woodii*), *Dalechampia capensis*, wild yam (*Dioscorea sansibarensis*), *Dorstenia psilurus*, sea-bean (*Entada wahlbergii*), flame lily, *Plectranthus gracillimus*, bushman's grape (*Rhoicissus tridentata*), mother-in-law's tongue (*Sanseviera hyacinthoides*), fire-ball lily, thorny rope and *Trianolepis africana*.

8.7.6 Analysis of Flora

Threatened and Endangered Flora Analysis

No Red Data plant species (above Least Concern category according to IUCN, 2012) were recorded within the seven Vegetation Units. Although no Red Data flora species were encountered, suitable habitat is present. A number of locally protected plant species such as baobab, white mangroves, black mangrove, Indian mangrove, Longa mangrove, red mangrove and star-apple mangrove occur in the Afungi Project Site (see *Annex G* for a complete list). These plant species strongly contribute to habitat diversity by extending feeding, breeding, nesting and resting attributes to wildlife.

The presence of various orchids in the Vegetation Unit 5 (*Eulophia livingstoneana*, *Eulophia seleensis*, *Eulophia speciosa* and *Platycoryne buchananiana*) in conjunction with observations by the Surface Water Ecology specialist team of the Red Data orchid species *Platycoryne mediocris,* indicates the potential for many more orchid species to be present. The occurrence of Red Data species cannot be resolved without further surveys during periods when the various inflorescence stages in potential orchids are most prevalent. Therefore, it is reasonable to assume that species of Red Data orchids may be present in the Survey Area.

Alien Flora Analysis

The alien plant species present in the Survey Area include cashew nut, coconut palm, mango and guava (*Psidium guajava*). These tree species occur throughout the Survey Area – at villages, old settlements/households and newly settled areas. These settlement areas with associated agricultural practices are dominated by pioneer and undesirable/invasive plant species such as devil's weed (*Datura stramonium*) and castor oil bush (*Ricinus communis*). Horsetail tree and sisal (*Agave sisalana*), both found in Vegetation Unit 1, are known invasive species, and active intervention may be required if control is desired.

Floristic Sensitivity Analysis

A sensitivity analysis was performed for all seven Vegetation Units identified in the Afungi Project Site. Evaluations of sensitive flora were developed, based on:

- attributes such as plant species diversity and fragmentation;
- presence or absence of undesirable or invasive flora species; and
- presence or absence of Red Data plant species.

The following factors, with the criteria used for classification, were considered important in determining the floristic sensitivity of each area:

- habitat availability, status and suitability for the presence of Red Data plant species;

- landscape or habitat sensitivity;
- current floristic status;
- floristic diversity; and
- ecological performance/fragmentation.

High sensitivity values indicate areas that are considered natural, relatively unaffected by human influences or generally managed in an ecologically sustainable manner. Low sensitivity values indicate areas of poor ecological status or importance in terms of floristic attributes, including areas that have been negatively affected by human impacts or poor management. A summary is provided in *Table 8.25* below, and further detail has been included in *Annex C* (Baseline Methodology).

Table 8.25 Floristic Sensitivity Analysis for Each Vegetation Unit

Vegetation Unit	Floristic Sensitivity Status	Rationale
1	Moderate	Habitat modification and the highly fragmented nature of this Vegetation Unit
2	Very High	Highly specialised ecosystem functionality and contribution in maintaining other ecosystems
3	Moderate	Presence of mangrove species and its importance in maintaining ecosystem functionality of Vegetation Unit 2
4	Low	Poor species diversity and limited habitat potential
5	Very High	High ecological functioning and influence in ecosystem functionality of various other Vegetation Units. Furthermore, the potential for the presence of Red Data species is high
6	Moderate	Habitat modification and the highly fragmented nature of this Vegetation Unit
7	High	Suitable Red Data habitat potentially available in this Vegetation Unit

Source: Enviro-Insight, 2012.

As *Figure 8.55* below illustrates, the floristic sensitivity of most of the interior of the Survey Area is mostly considered Moderate. However, areas of greater sensitivity are interspersed throughout and concentrated near the coastal areas.

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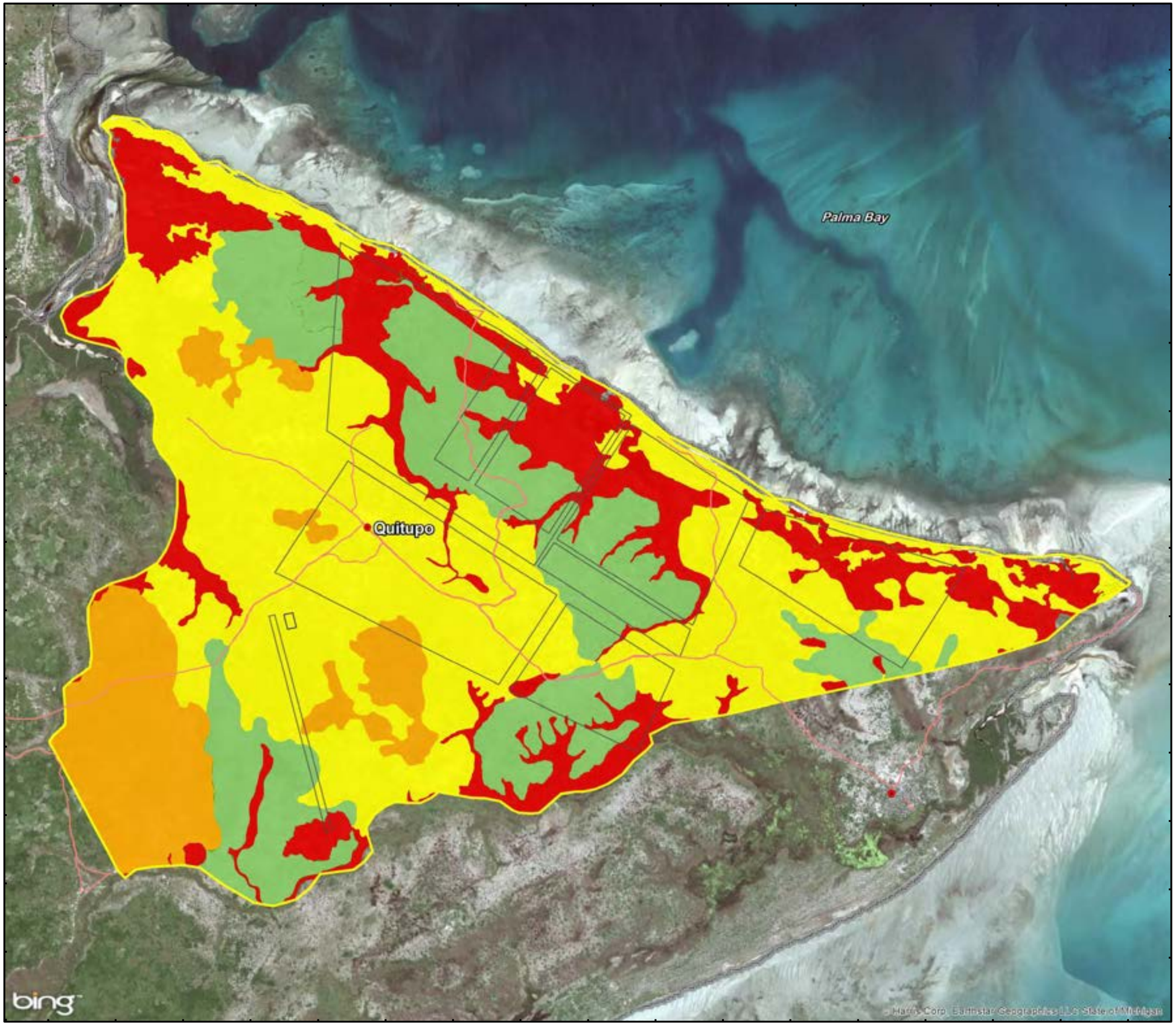

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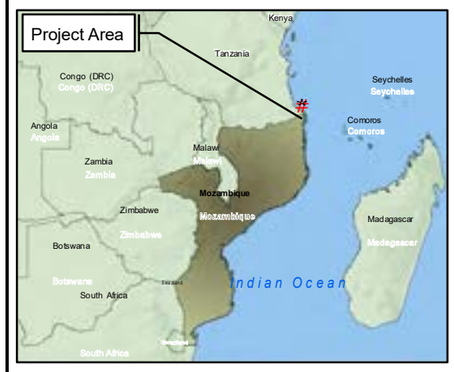
Legend

- Villages / Settlements
- Local Roads
- Onshore Project Footprint
- Afungi Project Site
- Mozambique Borders

Vegetation Sensitivity

- Very Low Sensitivity
- Low Sensitivity
- Moderate Sensitivity
- High Sensitivity
- Very High Sensitivity



MAIN MAP SCALE:

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Figure 8.55:
Red Data Flora Sensitivity Analysis

CLIENT:

Anadarko Moçambique Área 1, Lda

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DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 50 000

DRAWING: Red Data Flora Sensitivity Analysis.mxd

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8.8 HERPETOFAUNA

8.8.1 Geographical Context

The herpetofauna study was conducted within the general vicinity of the Afungi Project Site, including the main travel corridors to Cabo Delgado and the Rovuma River, as well as Tecomaji Island. The Survey Area consists of the Afungi Project Site and its immediate surroundings; this includes Tecomaji Island and the access roads between the Palma Camp and the Afungi Project Site. Sightings of herpetofauna outside of the Afungi Project Site were recorded to better understand the regional context; however, active sampling and trapping were performed in the Survey Area only. Field surveys were conducted to establish the baseline conditions as they relate to the herpetofauna on site. A map of the Study Area and Survey Area is presented in *Figure 8.56*.

8.8.2 Mozambique Regional Herpetofauna Context

Mozambique's vast north/south extent provides a large number of different habitat types, resulting in a large diversity of herpetofauna within the country. While there are no formal publications that deal explicitly with this topic, reputable sources indicate that 215 reptile (Utez et al., 2011) and 69 amphibian species (Amphibiaweb, 2012) are expected to occur in Mozambique. This is likely an underestimation of the actual diversity, due to under-sampling in many of the remote areas of Mozambique; especially in the northern areas of Cabo Delgado Province. The *National Report on Implementation of the Convention on Biological Diversity in Mozambique* (MICOA, 2009) lists only 167 reptile species and indicates that the number of amphibian species is unknown. This document further indicates that threats to herpetofauna include collection for food, skin and medicinal purposes, the pet trade and habitat destruction.

8.8.3 Cabo Delgado Province Herpetofauna Context

Published secondary data related to the existing land cover and vegetation maps do not provide a sufficient level of detail and, in some instances, appear inaccurate when compared to field evaluations. Therefore a map of the structural vegetation and land cover was created from the available remote sensing imagery and an understanding of the vegetation from field observations. Input from the botanical specialists was also leveraged in the development of these maps.

From a herpetological perspective, the landscape classification is similar to the Vegetation Units discussed in the Vegetation and Flora Baseline (*Section 8.7*). However, this representation (*Figure 8.57*) provides the general landscape types necessary to inform the herpetological field studies, so the nomenclature differs slightly.

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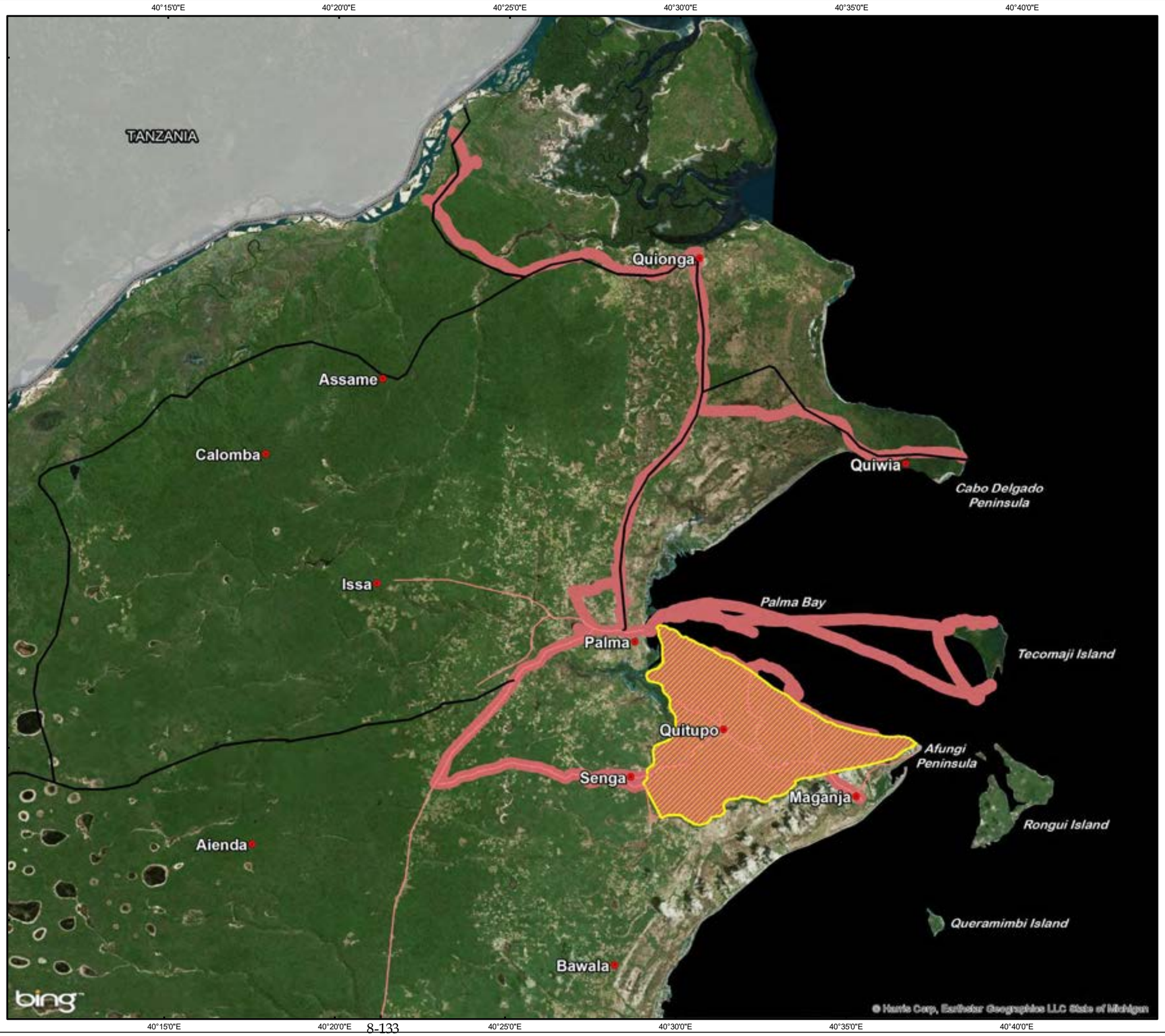
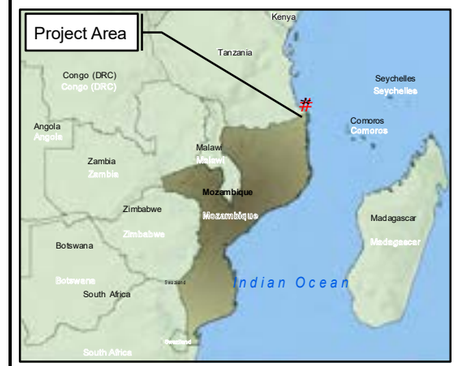


Legend

- Villages / Settlements
- Regional Roads
- Local Roads
- Afungi Project Site
- Study Area
- Survey Area



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 8.56:
Herpetological Study and Survey Areas

CLIENT:

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DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
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Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Enviro-Insight, 2012
Inset Map: Esri Data & Maps

SIZE:
A3

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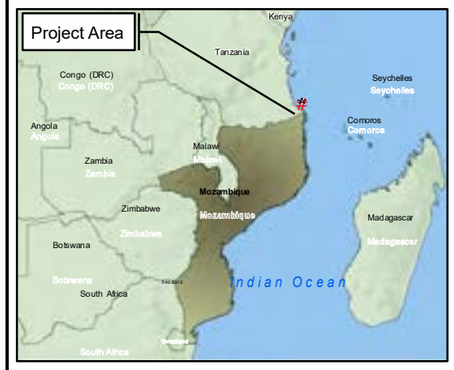
Legend

- Villages / Settlements
- Local Roads
- Afungi Project Site
- Mozambique Borders

Landscape Classification

- Coastal Sandy Scrub
- Contiguous Trees
- Fresh Wetland
- Mixed Woodland Savanna & Agriculture
- Saline Wetlands, Mangroves & Beaches



MAIN MAP SCALE:

0 1 2 4 6 8 10 12 14 16 18 20 Kilometres

TITLE:

Figure 8.57:
Structural Landscape Classification of Afungi Project Site

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DRAWING:
Structural Landscape Classification of the Afungi Project Site.mxd

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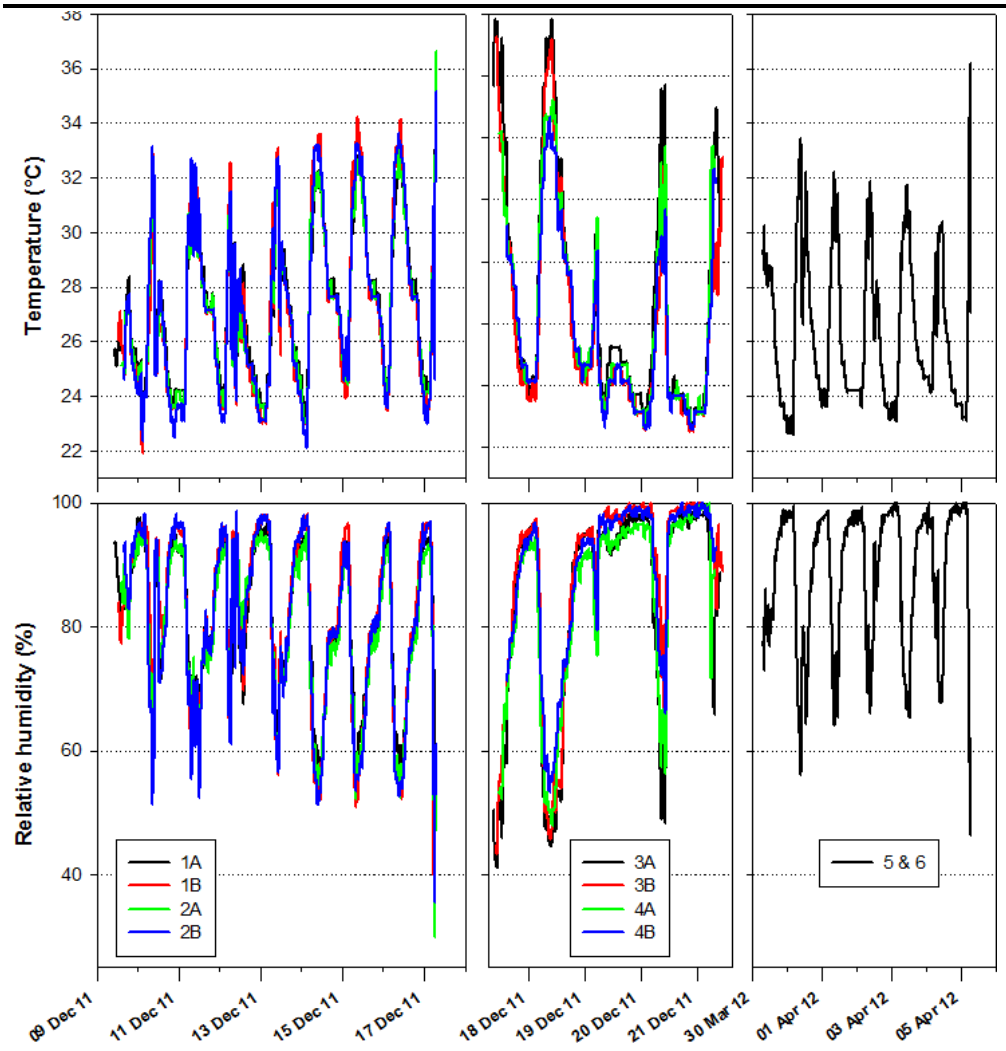
8.8.4 *Herpetological Fauna Results*

Several survey methods were applied to study the herpetological fauna within the Survey Area; these are described in *Annex C* (Baseline Methodology). This section presents an overview of the field observations and the data obtained.

Ideal climatic conditions were experienced throughout the herpetofauna field surveys conducted in December and March/ April (*Figure 8.58*). The warm and very humid conditions resulted in very good trapping success, and 487 individuals (representing 35 species) were captured.

Figure 8.58 ***Temperature and Humidity during the Herpetological Survey***



Source: Enviro-Insight, 2012.

Ten trapping arrays were deployed during the herpetofauna surveys, and their locations are provided in *Table 8.26*. An attempt was made to undertake a spatially representative trapping effort to cover the various habitat types within the Survey Area. An overview of these trap locations and active searching routes are provided in *Figure 8.59*.

Table 8.26 ***Drift Fence Funnel Trap Array Locations and Descriptions***

Trap Site	Coordinates and Altitude	Habitat Description	Aerial Photo	Photo 1	Photo 2
1A	S: 10°50'8.21" E: 40°33'25.36" Alt: 17m	Dense closed woodland vegetation with tall trees bordering a large wetland Trap location within Vegetation Unit 5			
1B	S: 10°50'9.63" E: 40°33'27.34" Alt: 17m	Ecotone of dense closed woodland vegetation and open grassy woodland Trap location within Vegetation Unit 6			
2A	S: 10°49'55.47" E: 40°33'54.82" Alt: 23m	Dense forest with tall trees and closed canopy; heavy leaf litter on floor Trap location within Vegetation Unit 6			
2B	S: 10°49'54.47" E: 40°34'3.09" Alt: 23m	Open grassy woodland and mixed woodland mosaic Trap location within Vegetation Unit 6			
3A	S: 10°47'56.68" E: 40°30'36.16" Alt: 19m	Near coastal open grassy woodland with adjacent palm plantations Trap location within Vegetation Unit 4			
3B	S: 10°48'0.95" E: 40°30'35.35" Alt: 27m	Thick stand of low-growing trees with closed canopy and heavy leaf litter on floor Trap location within Vegetation Unit 7			
4A	S: 10°49'39.26" E: 40°32'46.92" Alt: 32m	Open grassy woodland with few trees/bushes near a small drainage line Trap location within Vegetation Unit 4			

4B	S: 10°49'36.20" E: 40°32'45.66" Alt: 33m	Dense forested patch within open grassy woodland Trap location within Vegetation Unit 4			
5	S: 10°50'32.31" E: 40°30'43.51" Alt: 25m	Mixed woodland mosaic with tall grass stands; cashew and mango trees present Trap location within Vegetation Unit 6			
6	S: 10°49'37.26" E: 40°34'11.67" Alt: 19m	Near coastal sandy grassy woodland with patchy forested stands Trap location within Vegetation Unit 6			

40°28'30"E 40°29'0"E 40°29'30"E 40°30'0"E 40°30'30"E 40°31'0"E 40°31'30"E 40°32'0"E 40°32'30"E 40°33'0"E 40°33'30"E 40°34'0"E 40°34'30"E 40°35'0"E 40°35'30"E 40°36'0"E 40°36'30"E 40°37'0"E

Palma Bay

Palma

3A
3B

ADA7

ADA5

ADA6

Quitupo

4B
4A

6

2

ADA4
2B

1A
ADA1
2A

ADA3
1B
ADA2

5

Senga

1

Maganja

bing

Harris Corp, Earthstar Geographics LLC State of Michigan

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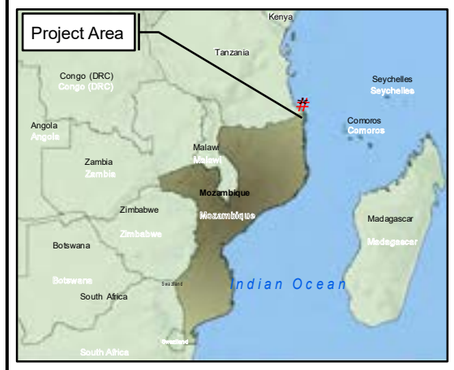
Legend

- Villages / Settlements
- Active Sample Sites
- Major Frogging Sites
- Reptile Trap Arrays
- Local Roads
- Afungi Project Site



MAIN MAP SCALE:

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TITLE:

Figure 8.59:
Herpetofauna Trapping and Active Searching Sites

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Traps were usually placed on the ecotones of two or more distinct habitat types to maximise the species diversity of trapped individuals. For example, one of the drift fence arms of Array 1B extended into the sandy open grassland, while the remaining two arms extended into the forested patch and the mixed habitat. *Figure 8.60* below illustrates a typical drift fence location spanning various habitat types.

Figure 8.60 ***Typical Herpetofauna Trapping Array***

Source: Enviro-Insight, 2012.

Observations from the trapping and active searching methodologies resulted in a total of 769 individual reptiles and amphibians being documented within the Survey Area (representing 72 species in total). *Table 8.27* illustrates these field observations. A selection of the reptiles and amphibians photographed during the surveys are shown in *Figure 8.61* and *Figure 8.62* respectively.

Table 8.27 ***Herpetofauna Field Survey Results***

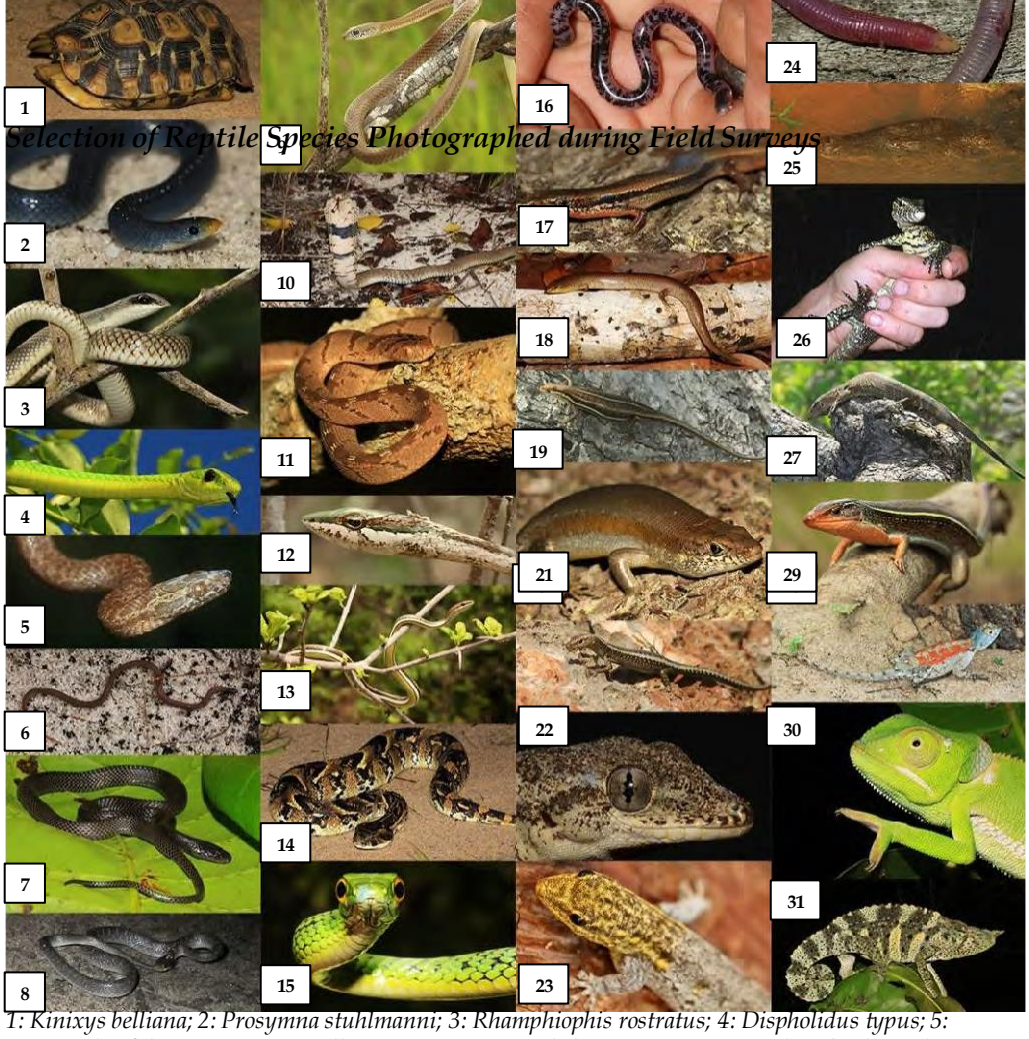
	Funnel Trap		Active Search		Total Species Observed	Total Species Expected	% Observed
	Individuals	Species	Individuals	Species			
Reptile	85	19	153	28	36	112	32
Amphibian*	402	16	128*	34	36	49	74
Totals	487	35	281*	62	72	161	

Key:

* This represents the minimum total, as chorusing frogs were not counted.

Source: Enviro-Insight, 2012.

Figure 8.61 ***Selection of Reptile Species Photographed during Field Surveys***



1: Kinixys belliana; 2: Prosymna stuhlmanni; 3: Rhamphiophis rostratus; 4: Dispholidus typus; 5: Lamprophis fuliginosus; 6: Aparallactus capensis; 7: Mehelya nyassae; 8: Crotaphopeltis hotamboeia; 9: Psammophis mossambicus; 10: Naja mossambica; 11: Dasypeltis medici; 12: Thelotornis mossambicanus; 13: Psammophis orientalis; 14: Bitis arietans; 15: Philothamnus punctatus; 16: Rinotyphlops mucroso; 17: Panaspis wahlbergii; 18: Lygosoma afrum; 19: Mabuya varia; 20: Mabuya maculilabris; 21: Cryptoblepharus boutonii; 22: Hemidactylus platycephalus; 23: Lygodactylus luteopicturatus; 24: Unidentified amphisbaenian; 25: Crocodylus niloticus; 26: Varanus niloticus; 27: Varanus albigularis; 28: Gerrhosaurus nigrolineatus; 29: Agama mossambica; 30: Chamaeleo dilepis; 31: Chamaeleo melleri.

Source: Enviro-Insight, 2012.

Figure 8.62 *Selection of Amphibian Species Photographed during Field Surveys*

1: Bufo lindneri; 2: Bufo taitanus; 3: Bufo maculatus; 4: Chiromantis xerampelina; 5: Hildebrandtia ornata; 6: Pyxicephalus edulis; 7: Arthroleptis stenodactylus; 8: Leptopelis broadleyi; 9: Phrynomantis bifasciatus; 10: Kassina maculata; 11: Kassina senegalensis; 12: Hylarana galamensis; 13: Hyperolius tuberilinguis; 14: Hyperolius argus; 15: Hyperolius acuticeps; 16: Afrixalus fornasini; 17: Afrixalus delicatus; 18: Xenopus muelleri; 19: Hemisus marmoratus; 20: Ptychadena oxyrhynchus; 21: Ptychadena taenioscelis; 22: Ptychadena guibea; 23: Breviceps mossambicus; 24: Phrynobatrachus natalensis; 25: Phrynobatrachus mababiensis.

Source: Enviro-Insight, 2012.

8.8.5 Herpetofauna Species of Conservation Concern

The southern African python (*Python natalensis*) is currently not listed by the IUCN, and the South African Reptile Conservation Assessment (SARCA, 2012) lists the southern African python as 'Not Evaluated'. However, the southern African python was listed in the South African Red Data book (Branch, 1998) as vulnerable, and the Mozambique Forestry and Wildlife Law Regulation (Decree No. 12/2002) lists the *'Python or Boa Constrictor'* as protected. Since the boa constrictor does not occur in Africa, it is assumed that this is in reference to the southern African python. This species was not directly observed during field surveys; however, the local interviewees were unanimous in their agreement that pythons are often found within the Survey

Area. In South Africa, the National Environmental Management: Biodiversity Act No. 10 of 2004 (NEMBA) lists the southern African python as a protected species. It is therefore prudent to treat this snake as a vulnerable species, despite its lack of current IUCN status in Mozambique. Apart from the southern African python, no other herpetofauna species of conservation concern are expected to occur within the Afungi Project Site.

8.8.6 Possible Novel Species

During the December 2011 survey, four individuals of a fossorial legless skink were found that do not appear to be known to science. These small legless skinks belong to either the *Acontias* or *Typhlosaurus* genus, as there is some disagreement about the recent taxonomical revision based on the phylogenetic relationship of this Acontinae subfamily (Lamb et al., 2010).

Given the characteristics observed and the fact that these skinks have very limited dispersal capabilities, it is very likely that this is either a novel species or at least a subspecies. Further studies would be necessary to understand the population density and/or distribution of this skink.

Three of the individuals were found within 2m of each other on the banks of the fresh-water wetland near trap Array 1A, and the other individual was found in the dense wooded patch around Array 4B (see *Figure 8.59* above). As a precautionary measure, it is suggested that the preliminary protection of this skink can be achieved by the protection of the wetlands and the contiguous tree habitat types, which are classified as sensitive (see habitat and sensitivity map discussion below).

The unidentified amphisbaenian (*Figure 8.62*, #24) must still be fully identified before any strong statement can be made about its relative significance. The fact that it is not identifiable from the high-resolution photography obtained suggests that it may either be a novel species or a different form of an existing species. A specimen that was injured during the construction of a trap array was collected and preserved to aid with the identification, using museum reference material and possibly the help of a specialist.

It is not possible to know or predict the conservation status of the possible new fossorial skink species and the unidentified amphisbaenian. The precautionary approach is to assume that they are rare and require special consideration during Project development.

8.8.7 Herpetofauna Habitat Sensitivity

It is difficult to assign herpetofauna communities accurately to a structural habitat type unless extensive long-term surveying has taken place. However, the data collected during the surveys does allow for certain generalisations to be made. These are discussed based on the structural landscape classification provided in *Section 8.6.5* and shown previously in *Figure 8.57*.

Each of the habitat types was assigned a sensitivity rating, as evaluated from a herpetofauna perspective. The sensitivity rating of each of these habitat types was based on the importance of the ecosystem function, ie the evaluated herpetofauna species diversity, abundance and relative importance (conservation status). The landscape type and its resilience to disturbance were also evaluated, as well as the connectivity between other landscape types of similar sensitivity. High connectivity was seen to increase the sensitivity rating, because completely isolated/fragmented areas of a high sensitivity provide less useful ecological function than connected areas.

Six sensitivity categories were defined. These are presented in *Figure 8.63*

below:

1. **Very High:** limited landscape type essential for the functioning of the herpetofauna community and at high risk from disturbance.

2. **High:** very important for the functioning of the herpetofauna community and at risk from disturbance.

3. **Medium;** this landscape type is useful for functioning of the herpetofauna community and can be at risk from extensive disturbance. Some disturbance has already taken place.

4. **Low–Medium:** not essential for the functioning of the herpetofauna community, but provides habitat for many common species. At low risk from disturbance that has already taken place over long periods of time.

5. **Low:** not essential for the functioning of the herpetofauna community, because few species occur here. Herpetofauna in this landscape therefore not at great risk from disturbance.

6. **Negligible:** because almost no herpetofauna exist here, disturbance of this landscape type is unlikely to have a direct influence on the herpetofauna community.

For example, the sensitivity category of Very High would be afforded to landscape types that meet the following criteria:

- provides an essential lower trophic-level tier (low in the food web) on which many other trophic levels (predators) are dependent;
- provides additional ecological services (such as breeding, shelter and foraging habitat);
- provides for a great diversity and density of herpetofauna;
- consists of a relatively small total area of occurrence and a low resilience to impacts (high susceptibility);

- exhibits good connectivity to other landscape types of high sensitivity; and
- consists of areas in which species of conservation concern are likely to occur.

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Palma

Palma Bay

Quitupo

Maganja

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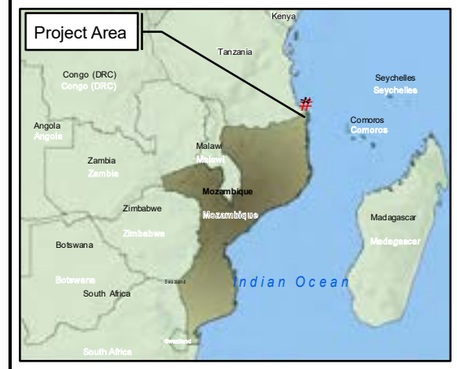
Legend

- Villages / Settlements
- Local Roads
- Onshore Project Footprint
- Afungi Project Site

Herpetofauna Sensitivity

- Negligible
- Low
- Low-Medium
- Medium
- High
- Very High



MAIN MAP SCALE:

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TITLE:

Figure 8.63:
Herpetofauna Sensitivity Map

CLIENT:

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8.8.8 Habitat Types within the Survey Area and their Sensitivity

Short Closed Wetlands – Vegetation Unit 5

The key drivers of the herpetofauna community are the fresh-water wetland systems. These systems provide active breeding opportunities for amphibians for more than half the year. However, amphibians had already bred during the first visit in October 2011 and most of the same species were still breeding (calling and mating) in April 2012. It is likely that this breeding activity occurs for most of the year, and some species may even breed continually throughout the year. With such a long breeding season and such ideal conditions for breeding (shallow warm slow-moving water that is heavily vegetated), it is not surprising that many vertebrate predators rely on the extensive amphibian population as a source of food.

The densely vegetated nature of the fresh-water wetlands and woodland vegetation of the wetland banks of Vegetation Unit 5 provide an ideal corridor for the natural migration and dispersal of herpetofauna. The dense closed woodland along the wetland banks is almost all that remains intact after many years of bush-clearing for agricultural practices; agricultural fields cannot be made on the sloped banks of the wetland as they will erode. The importance of such corridors is highlighted, as it is only through migration and dispersion that populations can exchange gene alleles and avoid homozygosis (inbreeding). The recolonisation of areas that have suffered localised population collapses (from hunting, fire and flooding) can take place more easily through established dispersal corridors such as these productive wetlands. Fragmentation of the landscape through agriculture and/or development can therefore be mitigated by maintaining these dispersal/migration corridors.

Although rain occurs frequently at certain times of the year, there are very few ponds/puddles that remain for any length of time. This is mostly due to the sandy nature of the soil and the absence of clay. Consequently, nearly all available surface fresh water in the area is restricted to the wetlands. This dependable source of fresh water attracts a variety of animals, at least periodically, throughout the year. Reptile species reliant on surface water, such as the crocodile and southern African python, are typically restricted to fresh-water wetlands except during migration.

It bears note that very few small mammals were trapped/observed during these surveys. It is strongly suspected that the high density and diversity of mammalian meso-predators (see *Section 8.10,* Mammals baseline) is explained directly by the availability of amphibian prey (or availability of other amphibian-reliant prey such as birds, snakes and lizards). This is supported by the fact that very few snake species were observed that do not eat amphibians rather there were specialist feeders such as centipede-eaters and egg-eaters. If the amphibian community does indeed serve as one of the major contributors to the lower trophic levels of the food web as is suggested, then the maintenance of this community is essential for the continued existence of

the vertebrate communities reliant on this trophic level. If maintenance of the amphibian community relies upon the maintenance of the fresh-water wetland habitat, then the maintenance of the majority of the vertebrate community will therefore also rely upon the maintenance of the fresh-water wetland habitat.

Finally, all of the terrestrial reptile or amphibian species (including the possible new fossorial skink and the unidentified amphisbaenian) found within the Survey Area can be expected to occur in Vegetation Unit 5. This observation, in conjunction with the three points discussed above, makes these fresh-water wetlands of integral importance to the continued functionality of the herpetofauna community and all other vertebrate communities that rely on the herpetofauna assemblages. The wetlands are therefore afforded the highest possible sensitivity category: Very High.

Short Closed Woodland – Vegetation Unit 7

This landscape type was most likely the dominant structural landscape type during historical times. Land alterations such as bush-clearing for agricultural purposes, fires and tree felling (for both timber and fuel) have reduced the area occupied by contiguous stands of trees to a few remnant patches. The selective avoidance of felling useful fruit or nut trees, notably cashew and mango trees, has resulted in dense stands of these exotic trees with few naturally occurring species in-between. Therefore, Short Closed Woodlands are not necessarily of great botanical importance, but do provide a significant structural habitat type for herpetofauna.

Trees contribute to herpetofauna refugia in the following ways:

- the spaces under exfoliating tree bark is occupied by numerous species (eg geckos, lizards, frogs and small snakes);
- hollow branches or tree holes provide refuge for larger-bodied reptiles (eg monitor lizards, agamas and snakes);
- arboreal species shelter in dense patches of leaves (eg chameleons);
- leaf litter under dense stands of trees provides shelter and a foraging habitat for numerous fossorial reptiles (eg snake-eyed skinks and worm-lizards) and amphibian species (eg rain frogs);
- detritus tree material attracts insects and other invertebrates, providing a valuable foraging habitat and shelter for a multitude of herpetofauna species; and
- herpetofauna are prone to overheating and rely on extensive well-shaded areas for effective thermoregulation while inactive and taking shelter.

Trees provide a food source for many herbivorous animals, large stands of trees are particularly valuable to such herbivores as food is easily accumulated. The presence of many different prey species attracts a variety of herpetofauna predators that use these dense stands of trees as foraging sites.

Finally, the fact that only a few large stands of this landscape type still remain intact, in conjunction with the refugia and foraging potential discussed above, results in a habitat sensitivity classification of either High or Medium. The ultimate classification is dependent on the connectivity of this habitat with other sensitive habitats; greater connectivity results in a higher sensitivity (*Figure 8.63*).

Short Closed Grasslands and Short Open Woodland – Vegetation Units 4 and 6

Short closed grasslands and short open woodland interspersed with agriculture are the dominant landscape types within the Survey Area. A large proportion of this area has been used for agriculture repeatedly over many years, resulting in a mosaic of regrowth (from past agricultural disturbances) interspersed with natural stands of trees and grass and current agricultural fields. While the clearing of vegetation initially impacts heavily on the herpetofauna community, the surrounding patches of natural and semi-natural vegetation allow for the continued presence of many herpetofauna species. Certain species fond of open areas such as the plated lizards (*Gerrhosaurus* spp.) are benefited by such agricultural practices; hunting for insects is performed in the agricultural fields and refuge is taken in the dense bush adjacent to the fields. Other species such as the dwarf geckos (*Lygodactylus* spp.) also benefit from the creation of agricultural fields because trees are felled at approximately 1.5m above the ground, which provides good refugia when the bark starts to exfoliate.

Nevertheless, all of the species found in Vegetation Units 4 and 6 are relatively common and are also found in the more sensitive landscape types. A sensitivity classification of Low–Medium was therefore given to this landscape type, except for the south-eastern portion near the village of Maganja. This area is surrounded by sensitive habitat types and therefore has its sensitivity rating elevated to Medium (*Figure 8.63*).

Short Open Scrubland – Vegetation Unit 1

Very few herpetofauna species were observed in this landscape type, mostly because of the close proximity to the ocean. Most terrestrial reptiles (with a few exceptions) are not tolerant of the salty conditions associated with open vegetation near ocean beaches. Amphibians are especially intolerant of saline conditions, and very few species are found here.

The entire coastal sandy scrub habitat is considered to be of Low sensitivity, regardless of its proximity to other sensitive habitat types, because this landscape type has low value to herpetofauna even for dispersal purposes (*Figure 8.63*).

Beaches, Short Closed Marshland and Open Saline Plains – Vegetation Units 2 and 3

As mentioned above, few herpetofauna species are tolerant of saline conditions. Only a single reptile species, the yellow-headed dwarf gecko (*Lygodactylus luteopicturatus*), was found in the mangrove stands. It is possible that a few other arboreal species may be found in this habitat. In Nigeria (West Africa), numerous reptile species are found in mangroves (Luiselli & Accani, 2002) but evidence of the importance of mangroves for East African species is lacking (Nagelkerken et al., 2008). As expected, no amphibians were found in the saline wetlands. The sandy ocean beaches represent a dry and salty environment that does not favour East African herpetofauna.

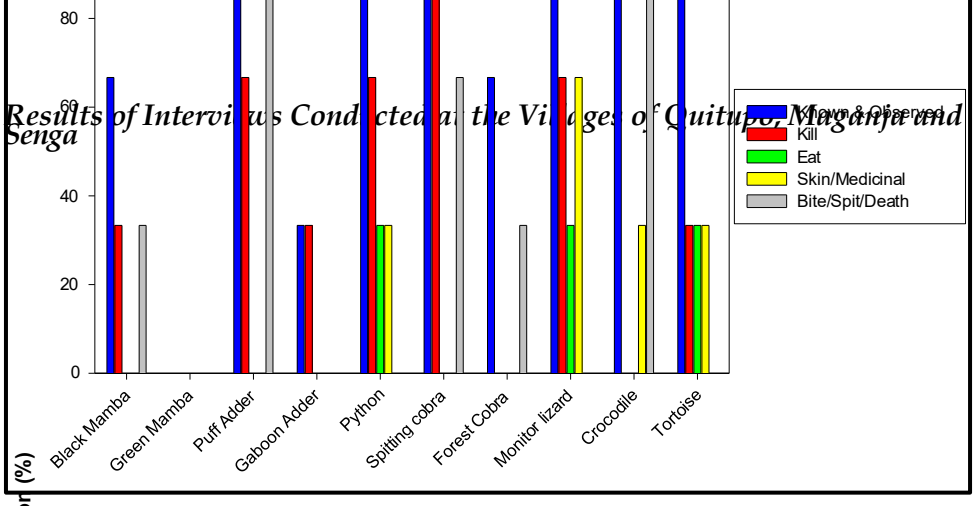
Despite the obvious unique botanical characteristics of the mangroves and the unique food web of the saline wetlands and mangroves, this landscape type cannot be afforded a herpetofauna sensitivity classification other than Negligible (*Figure 8.63*).

8.8.9 Herpetofauna Health and Safety Concerns

Several potentially dangerous herpetofauna were encountered during the surveys, and venomous snakes were also encountered within the confines of the Palma Camp. The potential health and safety risks associated are highlighted below.

Informal interviews with the communities of Quitupo, Maganja and Senga were undertaken with the village elders and their trusted companions; questions were asked with the aid of an interpreter. The results of the interviews are summarised in *Figure 8.64*.

Figure 8.64 Results of Interviews Conducted at the Villages of Quitupo, Maganja and Senga



Note:
The Bite/Spit/Death column represents the pooled results of individuals with knowledge of someone being bitten, spat in the eyes, or killed by a particular reptile.

Source: Enviro-Insight, 2012.

The primary outcomes from these interviews are:

- Villagers are at risk from potentially dangerous reptiles:
  - seven cases of crocodile bites have occurred since 2010 (no deaths but amputations required, all occurring in or near fresh-water wetlands);
  - five deaths from black mamba bites have occurred since 2005; and
  - two puff adder bite cases occurred (dates uncertain) with no fatalities.
- The Christian village of Senga differs markedly from the Muslim villages of Quitupo and Maganja in that they use some reptiles as a food source (Muslims from these two villages do not eat terrestrial reptiles).
- The use and killing of reptiles does not appear to occur at an intensity that is likely to affect the local reptile population. This is predominantly because the villagers are very fearful of most large snakes and crocodiles and lack the necessary means to kill them safely.
- The villagers consider all green arboreal snakes to be the same species, especially the boomslang (male), green mamba and the non-venomous speckled green snakes. For this reason, it is unclear if the identification of a green mamba during the field surveys was accurate.

From the interview data obtained and from encountering potentially dangerous reptiles during the surveys, it is clear that there is a potential health and safety risk associated with Project staff and contractors interacting with reptiles in the field. The *National Census of Wildlife* (Agreco, 2008) documents reports that crocodiles in Mozambique account for more human deaths than that from all mammals combined (elephants, lions, etc). In fact, for deaths where the responsible animal was reported (204), crocodiles accounted for 134 (66 percent) of these deaths. Similarly, for injuries that did not result in death (82), crocodiles were responsible for 36 (44 percent). Only three individual crocodiles were encountered during the surveys, but they nonetheless need to be considered to represent a potential safety risk.

8.9 AVIFAUNA

8.9.1 Geographical Context

An avian study was conducted within the general vicinity of the Afungi Project Site, including the main travel corridors to Cabo Delgado and the Rovuma River as well as Palma Bay and Tecomaji Island. Qualitative surveys (direct observations and habitat interpretation) were used to better understand the avian context of the broader region. The resulting data was used to emphasise the importance between bird assemblages in the local context (Survey Area) with the region (Study Area). The Study Area was evaluated to establish a comparative analysis between the Afungi Project Site and the surrounding region, while more intensive surveys were conducted in the Survey Area to establish the baseline conditions as they relate to the avifauna on site. Avian surveys and data collection (quantified bird point counts) were undertaken within the Afungi Project Site and the immediately adjacent intertidal habitat. *Figure 8.65* shows a map of the Survey and Study Areas.

8.9.2 Mozambique Regional Avifauna Context

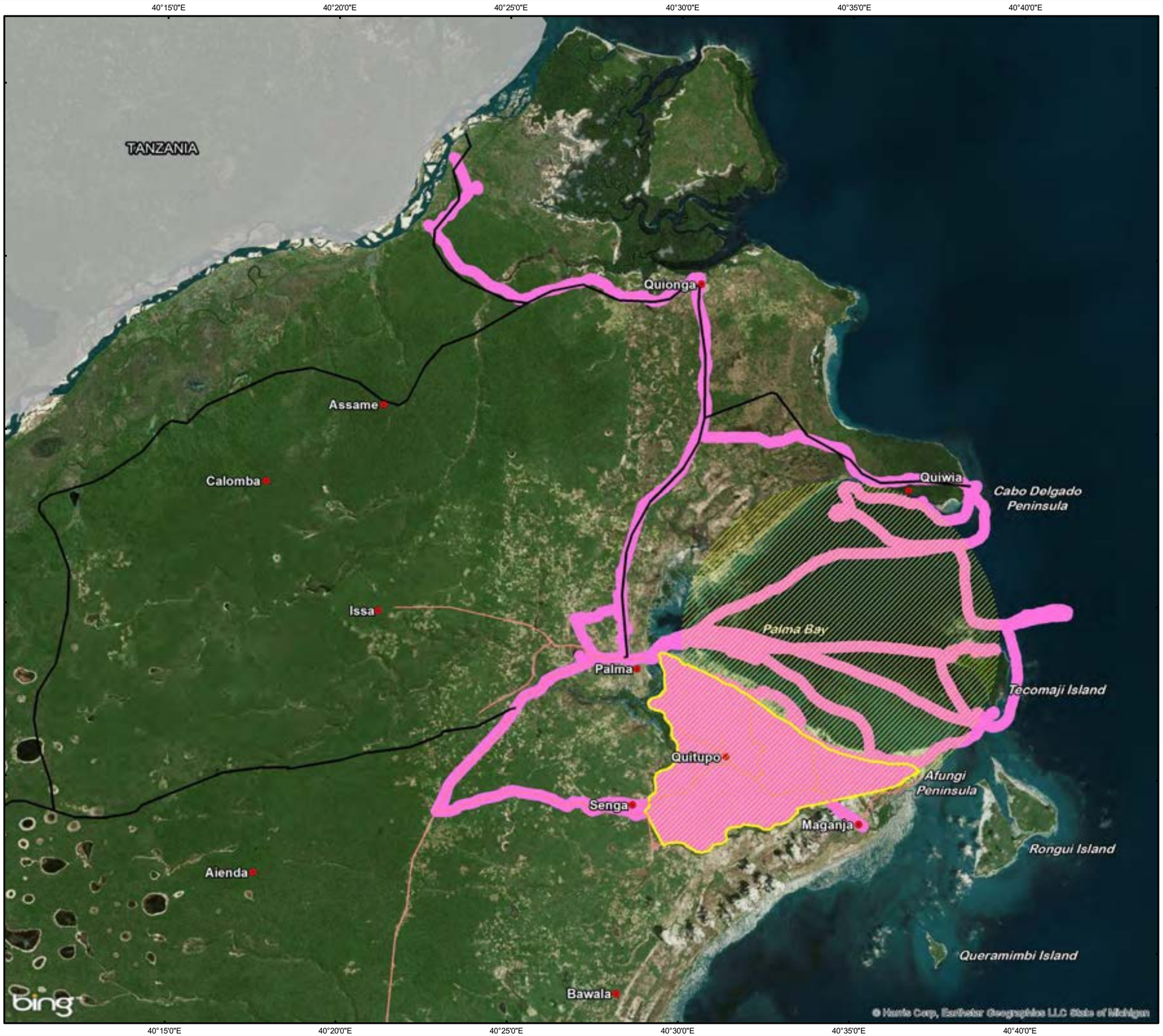
Mozambique is largely unexplored in terms of its avifaunal diversity although it is well received internationally as a fascinating and very rewarding birding destination (Cohen et al., 2006). The country holds more than 730 bird species, of which approximately 530 species are breeding within its boundaries (Parker, 2001; Lepage, 2012). It has long been recognised as an area of great avifaunal interest, supporting high bird diversities (Parker, 2001; MICOA, 2009).

However, being a vast country, it is surprising that Mozambique has only one true endemic bird species, namely the Namuli apalis (*Apalis lynesi*), which only occurs in northern Mozambique on Mount Namuli (Parker, 2001; Sinclair & Ryan, 2010).

From a conservation perspective, Mozambique sustains a number of range-restricted species, in particular forest birds. Many of these species are near-endemic to the country and are confined to four Endemic Bird Areas, which are shared with neighbouring countries such as Zimbabwe, Malawi and South Africa. Two of these areas are located in mountainous terrain (eg the Eastern Zimbabwe Mountains and the Tanzania–Malawi Mountains) while another two are restricted to an extension of the South African forests and the coastal plain south of Maputo. The Afungi Project Site does not overlap with any of these geographical areas.

Typical examples of taxa restricted to the coastal plain south of Maputo are the Rudd's apalis (*Apalis ruddi*), Neergaard's sunbird (*Cinnyris neergaardi*), pink-throated twinspot (*Hypargos margaritatus*) and lemon-breasted canary (*Serinus citrinipectus*) (all known as Maputaland endemics in South Africa). A typical example of taxa restricted to the Eastern Zimbabwean highlands is the Swynnerton's robin (*Swynnertonia swynnertoni*). And lastly, taxa restricted to the Tanzanian–Malawi Mountains include the Thyolo alethe (*Alethe choloensis*), dapple-throat (*Modulatrix orotruthus*) and long-billed forest warbler (*Artisornis moreaui*).

Furthermore, the country holds a number of biome-restricted species, of which 30 species have Afro-temperate (highland) affinities, 25 species are restricted to the East African coastal littoral and another 26 species are restricted to the Zambezian woodlands (Parker, 2001). Species with Zambezian affinities are restricted to one of Africa's most extensive biomes, which is well represented in Mozambique by mopane (*Colophospermum mopane*) and *Brachystegia* woodland.



Legend

- Villages / Settlements
- Local Roads
- Regional Roads
- Afungi Project Site
- Survey Area
- Study Area

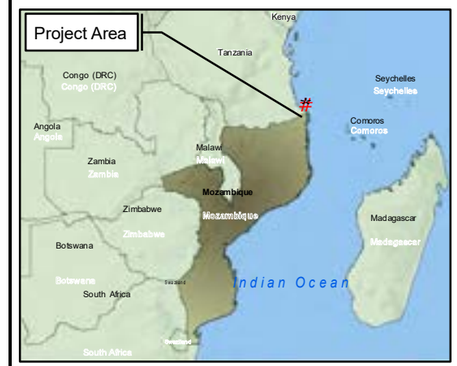


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Figure 8.65:
Avian Study and Survey Areas

CLIENT:

Anadarko Moçambique Área 1, Lda

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DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 195 000

DRAWING: Avian Study and Survey Areas.mxd

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Impacto Projectos e Estudos Ambientais

ERM

Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Enviro-Insight, 2012
Inset Map: Esri Data & Maps

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Mozambique recently gained favour with avian tourists for its avifaunal diversity, especially after the disclosure of its climax lowland forests and *Brachystegia* woodlands north of the Save River. This richness in species has contributed to an increased influx of ornithologists and citizen scientists to the region, mainly with the intention of investigating the avian tourism potential of the area.

From an avifaunal perspective, certain parts of Mozambique have become well-known birding destinations for many sought-after species, of which some are threatened and restricted in range. These include the African pitta (*Pitta angolensis*), green-headed oriole (*Oriolus chlorocephalus*), white-chested alethe (*Pseudoalethe fuelleborni*), East Coast akalat (*Sheppardia gunningi*) and Mascarene martin (*Phedina borbonica*).

8.9.3 Cabo Delgado Province Avifauna Context

The avifauna of Cabo Delgado Province is poorly known but is believed to be an important wintering area for water birds and particularly waders, as evidenced by the large concentrations of crab plover (*Dromas ardeola*), greater sand plover (*Charadrius leschenaultii*) and other Palaearctic scolopacid waders.

The area is generally located on low-lying plains and consists of coastal woodland, of which large parts are modified by crop cultivation. There are also numerous rivers and streams that flow eastwards to the Indian Ocean and terminate in extensive mangrove forests. However, the province holds many biome-restricted species that are confined to the coastal plain.

There are no Important Bird Areas (IBAs) (1) in Cabo Delgado Province. The nearest IBAs are located in Tanzania on the opposite side of the Rovuma River, namely:

- Mnazi Bay (TZ028, located approximately 45km north of the Afungi Project Site); and
- Mtwara and Newala district coastal forests (TZ052 and TZ053, located approximately 40km north-west of the Afungi Project Site) (Baker & Baker, 2001).

The nearest Mozambican IBA (known as Netia) to the Afungi Project Site is located in Nampula Province, approximately 440km south of the Afungi Project Site.

8.9.4 Avian Habitat Types Identified in the Survey Area

The following text provides an overview of the avifaunal habitat types associated with Vegetation Units present within the Survey Area. Avian community types are discussed in *Section 8.9.6*

(1) As defined by Bird Watch International.

Short Closed Woodland – Vegetation Unit 7

This habitat is scattered in the Survey Area and consists as closed woodland and forest remnants surrounded by open woodland and cultivated land (mainly used for the production of cassava). It is more prominent on the northern section of the Survey Area, where it tends to be better defined and less disturbed. Typical canopy include *Berlinia orientalis*, mobola plum and msasa (*Figure 8.66*), although some areas were also dominated by alien species such as cashew nut trees and mango trees. However, intact examples of mature woodland persist outside the Survey Area boundary and can be viewed either en route to the Afungi Project Site or north of Palma towards the Rovuma River.

The presence of lianas (mainly thorny rope) and a well-developed layer of leaf litter are characteristic of the closed woodlands and provide a very specific habitat for bird species with elusive and unobtrusive behavioural traits.

Figure 8.66 ***Floristic Structure of Short Closed Woodland***

Source: Enviro-Insight, December 2011.

Short Closed Grassland and Short Open Woodland – Vegetation Units 4 and 6

This woodland type is structurally similar to savannah grassland and is shaped by long-term anthropogenic disturbances that range from firewood collection to frequent burning regimes. It is widespread in the Survey Area and characterised by a short to medium woody cover with a well-defined graminoid layer. Typical woody species include the black monkey orange,

African mangosteen, *Xylotheca tettensis* and northern lala palm. It is often regarded as a secondary variant of mature *Berlinia orientalis* woodland.

Figure 8.67 ***Floristic Structure of Short Closed Grassland and Short Open Woodland***

Source: Enviro-Insight, December 2011 (top images) and March 2012 (bottom images).

Short Open Shrubland – Vegetation Unit 1

This habitat type is restricted to the coastal littoral zone and consists of a species-rich floristic composition of short dense thicket (mainly milkwood members of the Sapotaceae) and coconut palms (*Figure 8.68*). As with most of the vegetation communities in the Survey Area, the composition and structure is also a function of human-induced activities.

An important ecological function of this habitat type, although artificial, is the roosting and nesting habitat provided by the senescent palm trees for a large variety of hole-nesting bird species (eg woodpeckers, parrots, rollers, starlings and barbets). It is also the only area within the Survey Area that provided a habitat for the collared palm-thrush (*Cichladusa arquata*) and the biome-restricted Dickinson's kestrel (*Falco dickinsoni*).

Figure 8.68 ***Anthropogenic-modified Coastal Thicket (with Coconut Palms)***

Source: Enviro-Insight, December 2011 (top images) and April 2012 (bottom images).

Short Closed Wetlands – Vegetation Unit 5

The fresh-water wetlands are represented by landscape features of linear configuration and include a number of drainage lines and seasonally inundated grassy *dambos* (or vleis) that are part of five major wetland systems within the Study Area (*Figure 8.69*). These systems are confined to the bottom valleys of ancient dune typologies that are responsible for a rather complex and localised catchment area. The vegetation cover is characterised by obligate and facultative wetland species, depending on the surface water retention ability of the wetland. Dominant species include dwarf papyrus, *Leersia hexandra, Panicum repens, Typha capensis, Nymphaea nuchalis, Diascia* spp. and *Desmodium* spp. The edges of the wetlands are invariably occupied by swamp forest elements such as *Voacanga thouarsii* and *Syzygium cordatum*.

Small inundated pools contained within this habitat type are an important non-breeding foraging habitat for the endangered Madagascar pond heron (*Ardeola idae*), while also sustaining large numbers of ralfids (rails and flufftails) and ploceid weavers and widowbirds (*Euplectes* spp.) during the austral summer.

Figure 8.69 Diversity of Fresh-water Wetlands and Dambos within the Survey Area

Source: Enviro-Insight, April 2012 (top left image) and October/December 2012 (remaining images).

Open Saline Plains – Vegetation Unit 3

This habitat type is ecotonal and constitutes the transition between the inland fresh-water wetlands and the mangrove forests (*Figure 8.70*). It is therefore periodically inundated by surface water with a high salinity due to tidal fluctuation. A typical woody layer is near-absent while the vegetation cover is predominantly composed of dwarf halophytes (eg glasswort) and short white mangroves.

This habitat is an important foraging area for Palaearctic wader taxa, storks and the Vulnerable wattled crane (*Grus carunculatus*).

Figure 8.70 Typical Estuarine Salt Marsh Conditions within the Survey Area

Source: Enviro-Insight, December 2011 (top and bottom left images) and March 2012 (bottom right).

Short Closed Marshland – Vegetation Unit 2

These forests are species-poor and comprise of monospecific stands of vegetation with highly specialised plant species that are adapted to survive the high salinity of the surface water and associated anoxic conditions (*Figure 8.71*). The mangrove forests are restricted to estuaries along the coastline of the Afungi Project Site, and occur between mean sea level and the high-water spring tide level. It is dominated by white mangrove and red mangrove species, although part of its composition is made up of *Bruguiera gymnorrhiza*, Indian mangrove, Tonga mangrove and star-apple mangrove.

The mangrove forests are equally poor in avifaunal species, although they are an essential foraging habitat for sunbird taxa and the mangrove kingfisher (*Halcyon senegaloides*). The latter is common in the mangroves during the austral winter.

Figure 8.71 Mangrove Forests Compositions Observed within the Study Area

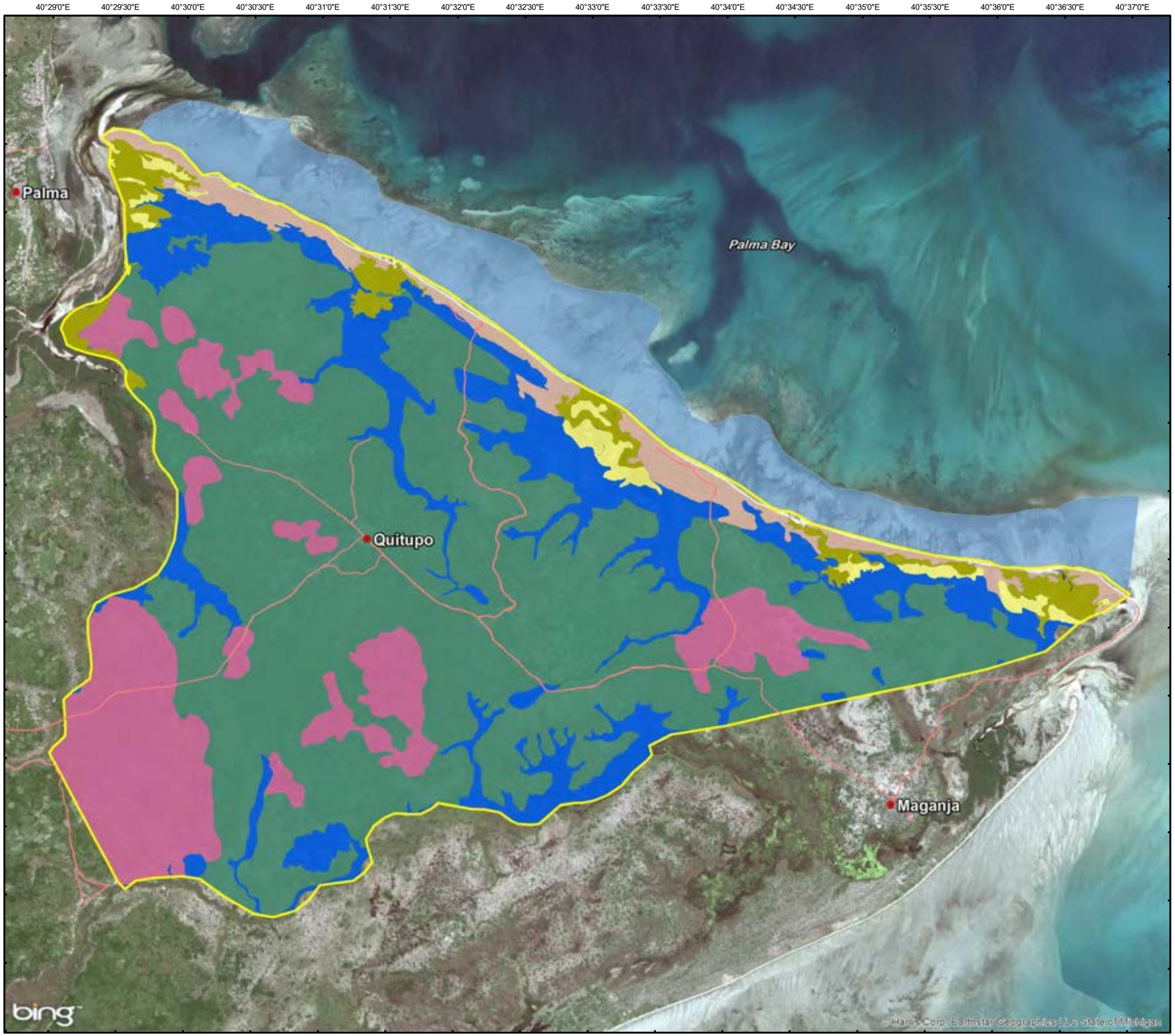
Source: Enviro-Insight, October 2011 (top left image) and April/March 2011 (top right and bottom images).

Habitat Types Associated with Intertidal Beaches and Mudflats

This habitat type is confined to the intertidal zone of sandy coastal sediments that are inundated during high tide but exposed during low tide (*Figure 8.72*). This habitat type is a critical important foraging area for large concentrations of shorebirds, especially Palaearctic waders, the crab plover and the dimorphic egret (*Egretta dimorpha*).

Figure 8.72 ***Extensive Intertidal Beaches Evident during Low Tide***

Source: Enviro-Insight, April 2012 (top images) and October 2011 (bottom images).



Legend

- Villages / Settlements
- Local Roads
- Afungi Project Site

Avifauna Sensitivity

- Open mixed woodland
- Modified palm savanna and coastal thicket
- Closed Berlinia orientalis woodland and forest
- Freshwater wetlands and dambos
- Estuarine salt marsh
- Mangrove forest
- Avifauna Intertidal Zone

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Figure 8.73:
Avifaunal Habitat Types within the Survey Area

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Anadarko Moçambique Área 1, Lda

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DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 50 000

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Avifaunal Habitat Types within the Survey Area.mxd

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Projection: UTM Zone 37 S Datum: WGS84
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Inset Map: Esri Data & Maps

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8.9.5 *Avifaunal Richness and Composition*

Field Observations

The field survey observations recorded 323 bird species within the Survey Area (*Figure 8.65*), which equates to 44 percent of the approximate 736 species listed for Mozambique (according to Lepage, 2012**).**

It was evident during the survey that the avifauna is poorly documented with many species previously unknown or anecdotal to the area, especially when their current distribution patterns are compared to Sinclair and Ryan (2010). Examples of these species include the palm-nut vulture (*Gypohierax angolensis*), red-chested flufftail (*Sarothrura rufa*), wattled crane, lesser jacana (*Microparra capensis)*, silvery-cheeked hornbill (*Bycanistes brevis*), two species of *Acrocephalus* warblers, pale flycatcher (*Bradornis pallidus*), blue-mantled crested flycatcher (*Trochocercus cyanomelas*), variable sunbird (*Cinnyris venustus*), southern brown-throated weaver (*Ploceus xanthopterus*), southern red bishop (*Euplectes orix*), brimstone canary (*Crithagra sulphurata*) and Reichard's seed-eater (*Crithagra reichardi*).. This illustrates the lack of ornithological knowledge and need for more intensive avifaunal surveys and exploration in northern Mozambique.

Of more importance is the discovery of two taxa that have not been previously recorded in Mozambique. These taxa include the *reichnowi* race of the short-tailed batis (*Batis* sp. nr. *B. mixta*) and the eastern black-headed batis (*Batis minor*) (Fjeldsa et al., 2006). In addition, the surveys also confirmed the presence of the vulnerable wattled crane, which was until recently only known from historical records along the Royuma River (personal communication, Mr Richard Beilfuss of the International Crane Foundation). The confirmation of this species in the Survey Area and the Rovuma River delta highlights the possibility of a breeding population that could represent formerly displaced birds from Tanzania.

Table 8.28 provides a summary of the total number of species, threatened (and Near Threatened) species, endemics and biome-restricted species observed in the Survey Area when compared to the entire avifauna of Mozambique.

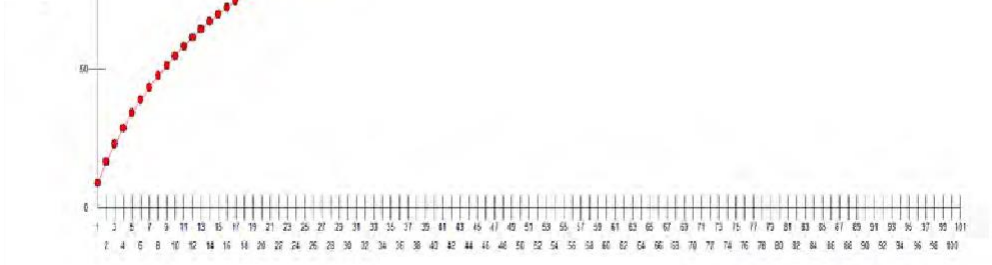
Table 8.28 Avian Species of Concern within the Survey Area

	Number of Species Observed	**Number of Species Recorded in Mozambique**	**Percent**
Total number of species	323	736	43.8
Number of globally threatened/Near Threatened species (IUCN, 2011)	11	48	22.9
Number of locally threatened species (Parker, 2005)	3	22	13.6
Number of restricted-range species pertaining to Endemic Bird Areas (Parker, 2001)	0	15	0
Number of East African near-endemic species shared with adjacent Tanzania	9	25	36
Number of species restricted to the East African Coast biome (Parker, 2001)	13	25	52
Number of species restricted to the Zambezian biome (Parker, 2001)	5	26	19.2

Source: Enviro-Insight, 2012.

As shown in *Figure 8.74*, the observed number of species is within the limit (the curve is approaching saturation) of the number of species expected to occur, and provides a realistic indication of the thoroughness and general coverage of the Survey Area during the survey period.

Figure 8.74 Species Accumulation Curve (Based on 101 Sample Point Count)



Source: Enviro-Insight, 2012.

An analysis (1) based on bird data generated from the 101 point counts showed that the sombre greenbul (*Andropadus importunus*) followed by the dark-capped bulbul (*Pycnonotus tricolor*) were the most prominent species in the Survey Area. Other noteworthy species include the collared sunbird (*Hedydipna collaris*), black-backed puffback (*Dryoscopus cubla*), Cape turtle dove (*Streptopelia capicola*) and green-backed camaroptera (*Camaroptera brachyura*) (*Table 8.29*). These species are widespread and are numerically abundant in

(1) The analysis uses abundance values (absolute counts) and their distribution (the distribution of observations) to estimate the percentage contribution of each species' average abundance value in the Survey Area, as well as its fidelity (represented by the consistency of its occurrence across the point counts) based on the similarities between samples (using calculated similarity coefficients). Therefore, species with high average abundance values and high consistency values across all point counts will achieve higher contributions, and are thus prominent or typical species in the area.

habitat types of both open woodland (dark-capped bulbul and Cape turtle dove) and dense woodland (sombre greenbul and collared sunbird) structure. They are the most dominant species in the Survey Area and are common in the woodlands of the East African coast.

Table 8.29 also shows the dominance of shorebird species recorded during the austral summer period. These include high numbers of crab plover, dimorphic egret and Palaearctic waders. More frequently observed wading birds include the greater sand plover (*Charadrius leschenaultii*), common whimbrel (*Numenius phaeopus*), white-fronted plover (*Charadrius marginatus*), grey plover (*Pluvialis squatarola*), common ringed plover (*Charadrius hiaticula*), sanderling (*Calidris alba*) and terek sandpiper (*Xenus cinereus*).

Table 8.29 Prominent Bird Species Observed within the Survey Area

Species	Av. Abundance	Consistency	% Contribution
Sombre greenbul	0.86	2.79	20.66
Dark-capped bulbul	0.76	1.69	12.47
Collared sunbird	0.5	1.23	9.07
Black-backed puffback	0.54	0.79	5.86
Cape turtle dove	0.31	0.56	4.16
Green-backed camaroptera	0.24	0.54	3.96
Tawny-flanked prinia	0.38	0.4	2.95
Emerald-spotted wood dove	0.28	0.39	2.9
Zitting cisticola	0.25	0.35	2.58
Crab plover	4.74	0.31	2.32
Yellow-rumped tinkerbird	0.19	0.31	2.26
Scarlet-chested sunbird	0.3	0.31	2.26
Palaearctic wader complex	5.77	0.27	2.03
Tropical boubou	0.28	0.27	2.02
Purple-banded sunbird	0.23	0.2	1.45
Yellow-breasted apalis	0.25	0.16	1.22
African paradise flycatcher	0.18	0.16	1.16
Yellow-throated longclaw	0.17	0.15	1.11
Yellow-bellied greenbul	0.17	0.14	1.05
Dimorphic egret	0.28	0.14	1

Source: Enviro-Insight, 2012.

Table 8.30 lists the species with the lowest recorded abundance values in the Survey Area. Many of these species were only recorded once during the point count surveys. However, the majority are believed to be widespread in the Survey Area, but always occur in low densities.

Table 8.30 Avian Species within the Survey Area with Low Abundance Values*

Species	Average Abundance
African pygmy kingfisher	0.01
Black crake	0.01
Black cuckoo	0.01
Black sparrowhawk	0.01
Black-eared seed-eater	0.01
Blue-mantled flycatcher	0.01
Broad-tailed paradise whydah	0.01
Species	**Average Abundance**
Common sandpiper	0.01
Common squacco heron	0.01
Diderick cuckoo	0.01
European golden oriole	0.01
Hadeda ibis	0.01
Lesser moorhen	0.01
Little egret	0.01
Lizard buzzard	0.01
Madagascar pond heron	0.01
Marsh warbler	0.01
Orange-winged pytilia	0.01
Red-backed shrike	0.01
Tambourine dove	0.01

Three-banded plover	0.01
Woodland kingfisher	0.01
Woolly-necked stork	0.01
Yellow-throated petronia	0.01

Key:

* Average abundance of less than 0.02 (n=101).

Source: Enviro-Insight, 2012.

A significant proportion of the low abundant species include medium-sized *Accipitrine* taxa (sparrowhawks and goshawks) and water birds (eg rallids). These species are probably overlooked due to their elusive behaviour. They are often difficult to detect in the dense structure of habitat in which they occur. The remaining species occur naturally at low densities.

8.9.6 Avian Associations and Community Structure

A total of 157 (1) species/taxa and 2,963 individuals representing three dissimilar avifaunal communities were recorded from the 101 point counts conducted:

Community 1 – Associated with Intertidal Beaches

Community 1 represents a community restricted to the intertidal beaches. It is characterised by large concentrations of plovers, waders and terns, accompanied by the crab plover and dimorphic egret. Other noteworthy species include the hamerkop (*Scopus umbretta*), African sacred ibis (*Threskiornis aethiopicus*), African openbill (*Anastomus lamelligerus*) and woolly-necked stork (*Ciconia episcopus*). However, these taxa occur in lower densities. The western reef heron (*Egretta gularis*) is an uncommon resident and only recorded occasionally.

(1) Herewith referring to those species observed during the point counts (excluding those noted during random transect walks).

Community 2 – Associated with Coastal Woodland and Azonal Habitat

Community 2 represents a diverse community denoted by four discrete associations confined to coastal woodland and its associated azonal habitat.

Community 2A – Associated with Saline Wetland Habitat

This community is confined to salt marshes and shares part of its composition with Community 1. It is typified by waders and birds that show high affinities for inland bodies of water.

Indicator species for this community include Kittlitz's plover (*Charadrius pecuarius*), wood sandpiper (*Tringa glareola*), little stint (*Calidris minuta*), ruff (*Philomachus pugnax*), marsh sandpiper (*Tringa stagnatilis*) and black-winged stilt (*Himantopus himantopus*).

The wattled crane and saddle-billed stork (*Ephippiorhynchus senegalensis*) occur in low densities.

Community 2B – Associated with Fresh-water Wetland Habitat

This community is confined to fresh-water *dambos* and drainage lines. The dense grassy cover of the fresh-water wetlands are inhabited by a bird composition that is atypical to Community 1 and Community 2A. The only similarity between this community and Community 2A occurs at the family level (herons, storks), where the different taxa show similar morphologies and function. The rallids (rails, crakes and flufftails) are unique to this community.

Indicator species for this community include cryptic taxa such as the zitting cisticola (*Cisticola juncidis*), croaking cisticola (*C. natalensis*), Zanzibar red bishop (*Euplectes nigroventris*), common waxbill (*Estrilda astrild*) and the yellow-throated longclaw (*Macronyx croceus*).

Species unique to this community include rallids and gamebirds; such as the red-chested flufftail (*Sarothrura rufa*), African rail (*Rallus caerulescens*), African crake (*Crecopsis egregia*) and blue quail (*Coturnix adansonii*). The Madagascar pond heron (*Ardeola idae*) and black coucal (*Centropus grillii*) occur in low densities.

Community 2C – Associated with Open Woodland Habitat

This community is largely sedentary on the open woodland and savannah grassland habitat types. It is a species-rich community consisting of so-called bushveld or savannah taxa. A definitive feature of this community is the formation of multispecies flocks (or bird parties), whereby different foraging species join the flock as it advances through the woodland canopy.

Indicator species for this community include the tawny-flanked prinia (*Prinia subflava*), flappet lark (*Mirafra rufocinnamomea*), fork-tailed drongo (*Dicrurus*

adsimilis), pale batis (*Batis soror*), black-crowned tchagra (*Tchagra senegalus*), red-faced crombec (*Sylvietta whytii*) and white-browed scrub robin (*Cossypha heuglini*).

The majority of species pertaining to this community are regionally widespread in sub-Saharan Africa.

Community 2D – Associated with Closed Woodland and Forest Habitat

This community is confined to the closed-canopy *Berlinia orientalis* woodland, the forest fragments and bush clumps. A character shared among most species pertaining to this community is their liquid, complex vocalisations and the tendency to forage in the lower strata or among the leaf litter.

Indicator species for this community include the yellow-rumped tinkerbird (*Pogoniulus bilineatus*), eastern nicator (*Nicator gularis*), red-capped robin-chat (*Cossypha natalensis*), bearded scrub robin (*Cercotrichas quadrivirgata*), square-tailed drongo (*Dicrurus ludwigii*), black-throated wattle-eye (*Platysteira peltata*) and African broadbill (*Smithornis capensis*).

Fischer's greenbul (*Phyllastrephus fischeri*), barred long-tailed cuckoo (*Cercococcyx montanus*), narina trogon (*Apaloderma narina*) and the short-tailed batis (*Batis* sp. nr. *B. mixta reichnowi*) also occur in low densities.

Community 2E – Associated with Closed and Open Woodland Habitat

This community consists of unspecialised and generalist species that are present in open as well as closed-canopy woodland. However, the difference is that the distribution of the abundance values of these species varies depending on the floristic structure of the woodland. For example, the sombre greenbul is commonly encountered in open and closed woodland, but is more common in closed-canopy vegetation. The taxa pertaining to this community are collectively known as edge species, and will often use modified habitats such as agricultural areas for foraging.

Typical species with high abundance values in structurally open woodland are the Cape turtle dove, dark-capped bulbul, emerald-spotted wood dove (*Turtur chalcospilos*), brown-crowned tchagra (*Tchagra australis*), scarlet-chested sunbird (*Chalcomitra senegalensis*) and brown-headed parrot (*Poicephalus cryptoxanthus*).

Typical species with high abundance in structurally closed-canopy woodland include the black-backed puffback, collared sunbird, purple-banded sunbird (*Cinnyris bifasciatus*), African paradise flycatcher (*Terpsiphone viridis*) and green-backed camaroptera.

The cluster analysis also shows that modified palm savannah and coastal thickets are prevalent in Community 2E. Hole-nesting species will

temporarily vacate their preferred habitat to use dead palm trees for breeding or roosting purposes.

From the analysis it is also evident that the mangrove forests are occupied by an undifferentiated bird community, even though this habitat type is floristically well defined. However, the mangroves do hold significant numbers of sunbirds, with five different species co-occurring (eg purple-banded, grey, olive, scarlet-chested and collared sunbirds). The sunbirds are the main pollinators of some of the mangrove species.

Community 3 – Seabird Populations

The inshore seabird population within the Study Area was found to be severely species-poor and comprised mainly of marine tern species. The dominant terns include the swift tern (*Sterna bergii*), lesser crested tern (*Sterna bengalensis*), little tern (*Sterna albifrons*) and the common tern (*Sterna hirundo*). The Caspian tern (*Sterna caspia*) occurs in low densities.

An adult male greater frigatebird (*Fregata minor*) and a juvenile red-footed booby (*Sula sula*) sighted near Cabo Delgado Peninsula were regarded as vagrant individuals. These individuals were probably stray birds from the Aldabra Atoll breeding colonies (approximately 640km north-east of the Afungi Project Site).

8.9.7 Species of Conservation Concern

Important Habitat

The intertidal zone provides habitat for at least 22 wading bird species, of which 13 are Palaearctic migrants and five are *Sterna* (tern) species.

During the survey, a total of 1,651 birds were counted on 38ha of coastline of the Afungi Project Site. This indicates that the coastline supports approximately 44 birds/ha during the austral summer (December). *Table 8.31* shows that the intertidal zone supports a high number of shorebirds (with up to 32 percent of the global crab plover population appearing in winter within the Survey Area). Field observations also indicate that the exposed coral at Cabo Delgado (across Palma Bay from the Survey Area) is an important high-tide roosting site for these bird species.

One of the wader species present along the coastline of the Survey Area is the Eurasian curlew (*Numenitus arquata*). It is classified as Near Threatened (IUCN, 2012), owing to a moderately rapid decline at several key breeding populations in the northern hemisphere. Its non-breeding habitat is threatened by disturbances of its intertidal foraging habitat and the development of infrastructure on high-tide roosting areas.

Table 8.31 ***Density Estimates of Waders and Terns within the Coastline of the Survey Area****

Taxon Group	Number of Individuals (on 38ha)	Density (birds/ha)
Crab plover	479	12.7
Palaearctic wader complex	794	21.1
Dimorphic egret	28	0.7
Various tern species	116	3.1

Key:

*Estimates obtained during December, 2011.

Source: Enviro Insight, 2012.

Globally Threatened Species

Four globally Threatened and seven Near Threatened bird species were recorded within the Study Area (IUCN, 2010). Of these, five species were observed within the Survey Area (*Table 8.32*) and images of these are provided in *Figure 8.75*. Of these five species, the Madagascar pond heron, wattled crane and the southern banded snake-eagle are likely to be susceptible to habitat changes brought on by development; due to high habitat fidelity (wattled crane and Madagascar pond heron) and limited closed woodland habitat (southern banded snake-eagle). The remaining species (those confirmed in the Survey Area) occupy large home ranges and occur over large areas of similar habitat. These species are therefore at a lower risk.

Table 8.32 ***Global Conservation Status of Avian Species within the Survey Area***

Species	Common Name	Conservation Status*	Status within the Study Area	Occurrence within Survey Area
Anthreptes reichenowi	Plain-backed sunbird	Near Threatened	Uncommon, only recorded from mature woodland	Not recorded, status uncertain, probably absent
Ardeola idae	Madagascar pond heron	Endangered	Fairly common non-breeding (austral winter) visitor from Madagascar	Confirmed from selective pools within fresh-water wetlands
Bucorvus cafer	Southern ground hornbill	Vulnerable	Uncommon resident north of Afungi, close proximity to Tanzanian border	Not recorded, likely to be absent
Circaetus fasciolatus	Southern banded snake-eagle	Near Threatened	Common resident north of Palma	Uncommon resident on Afungi (1-2 pairs)
Falco concolor	Sooty falcon	Near Threatened	Uncommon non-breeding (austral summer) visitor	Rare
Glareola ocularis	Madagascar pratincole	Vulnerable	Status uncertain – observed overhead from open grassy areas; roosting and foraging areas unknown	Not recorded

Grus carunculatus	Wattled crane	Vulnerable	Uncommon and possible breeding resident in the Rovuma Delta	Confirmed from the salt marsh habitat and wetlands dominated by short Cyperaceae
Numenius arquata	Eurasian curlew	Near Threatened	Common non-breeding visitor along the coastline	Common on the sandy beaches
Polemaetus bellicosus	Martial eagle	Near Threatened	Uncommon foraging visitor (probably from nearby reserves or game management areas)	Not recorded
Rynchops flavirostris	African skimmer	Near Threatened	Common along the Rovuma River	Unlikely to occur within the Survey Area
Terathopius ecaudatus	Bateleur	Near Threatened	Common foraging visitor (probably breeds in nearby reserves or game management areas)	Common foraging visitor

Key:

* The conservation status is based on the IUCN Red List of Threatened Species (2011).

Figure 8.75 ***Bird Species of Global Conservation Interest***

Left: Wattled crane – Vulnerable. Centre: Southern banded snake-eagle – Near Threatened. Right: Madagascar pond heron – Endangered.

Source: Enviro-Insight, 2012.

Biome and Range – Restricted Species

The Afungi Project Site provides habitat for five bird species with Zambezian affinities and 13 with affinities to the East African coastal woodlands (Parker, 2001). The majority of these species are widespread and common in the region, as shown in *Table 8.33*.

Table 8.33 ***Biome Restricted Species***

Scientific Name	Common Name	Biome Type	Habitat	Status within Study Area
Falco dickinsoni	Dickinson's kestrel	Zambezian	Palm savanna	Rare, although breeding in Survey Area
Circaetus fasciolatus	Southern banded snake-eagle	East African Coast	Dense *Berlinia orientalis* woodland – limited by large trees used during hunting	Common resident north of Palma
Poicephalus cryptoxanthus	Brown-hooded parrot	East African Coast	Open woodland with fruit trees	Common in palm savanna (breed in dead palms)
Halcyon senegaloides	Mangrove kingfisher	East African Coast	Mangrove forest and adjacent dense woodland	Common summer visitor
Lybius melanopterus	Brown-breasted barbet	East African Coast	Most habitat types and mangrove trees with mistletoes	Common breeding resident
Phyllastrephus fischeri	Fischer's greenbul	East African Coast	Closed *Berlinia orientalis* woodland/forest	Uncommon breeding resident – common in mature woodland and thicket within the northern part of the Study Area
Telophorus quadricolor	Gorgeous bush shrike	East African Coast	Mainly coastal thicket, also dense woodland	Common breeding resident

Prionops scopifrons	Chestnut-fronted helmet-shrike	East African Coast	Mature broad-leaved woodland and *Berlinia* forest	Common in mature forests adjacent to the Afungi Project Site – absent in the Survey Area
Batis soror	Pale batis	East African Coast	All woodland habitat types	Vary common breeding resident
Anthreptes reichenowi	Plain-backed sunbird	East African Coast	Mature woodland	Probably absent in the Survey Area – only observed within the northern Study Area
Cinnyris veroxii	Grey sunbird	East African Coast	Closed woodland and mangrove forest	Common breeding resident
Pyrenestes minor	Lesser seedcracker	East African Coast	Mature woodland and adjacent *dambos*	Uncommon breeding resident
Euplectes nigroventris	Zanzibar red bishop	East African Coast	Wetlands	Common breeding resident
Lamprotornis corruscus	Black-bellied starling	East African Coast	Closed woodland	Uncommon breeding resident
Turdus libonyana	Kurrichane thrush	Zambezian	Dense woodland	Common breeding resident
Calamonastes stierlingi	Stierling's barred warbler	Zambezian	Open woodland	Uncommon breeding resident
Cinnyris talatala	White-bellied sunbird	Zambezian	Varied	Common breeding resident
Vidua obtusa	Broad-tailed paradise whydah	Zambezian	Broad-leaved woodland	Common breeding resident

Source: Parker, 2001.

Figure 8.76 Biome Restricted Avian Species Observed within the Survey Area

Top left: Chestnut-fronted helmet-shrike. Top right: Mangrove kingfisher. Bottom left: Brown-breasted barbet. Bottom right: Brown-headed parrot.

Source: Enviro-Insight, October 2011–April 2012.

Locally Threatened Species

These are species that do not meet the IUCN criteria but are listed by Parker (2005) since their numbers are declining in Mozambique. Three species occur in the Afungi Project Site:

- Locust finch (*Paludipasser locustella*): a cryptic species that is highly unpredictable and irregular in occurrence. It is rare in northern Mozambique, and the observations from the Study Area stem from nomadic individuals. It was observed on the Rovuma floodplain, although it can occur on the inundated or moist grassland areas within the Survey Area. It is threatened by wetland disturbances.

- Blue quail: a common species in moist grassland bordering *dambos* and fresh-water wetlands. It is nomadic and can be absent during unfavourable conditions (eg dry years). It is threatened by wetland disturbances.

- Red-headed quelea (*Quelea erythrops*): a fairly common resident and nomad within the Survey Area. It was frequently observed in small groups from dense grassy fresh-water wetlands, especially during the dry season. It is threatened by wetland disturbances and the cage-bird trade.

Apart from the abovementioned species, the following species is worthy of discussion and is likely to occur in the Survey Area:

- African pitta (*Pitta angolensis*): an elusive, intra-African breeding migrant restricted to dense thickets and forested habitat types. It is likely to be a passage migrant to the Study Area. The patches of well-developed *Berlinia orientalis* woodland on the northern part of the Survey Area provide a suitable habitat for this species. It is threatened by deforestation and fragmentation.

Important Non-threatened Species

The following species are worthy of discussion since the Survey Area supports either significant numbers of these species or provides a migration corridor for species on their passage between breeding and non-breeding habitats:

- Crab plover; this species is currently listed as Least Concern since the global population appears to be stable (IUCN, 2012). It is a non-breeding visitor to the east coast of Africa, with the bulk of the population wintering along the Kenyan, Tanzanian and Mozambican coastline (Hockey, 2005; Hockey & Aspinall, 1996).

- Instantaneous counts of non-breeding individuals along the coastline of the Survey Area (479 individuals from 12 counts equalling 12.71birds/ha) suggest that approximately 32.6 percent of the entire global population (estimated at 50,000 individuals by Hockey & Aspinall, 1996; Rose & Scott, 1997) winter on the coastline of the Survey Area (as counted in December 2011). It is interesting to note that Hockey and Aspinall (1996) estimate the Mozambican population to be 500 individuals, while 30ha of suitable habitat in the Survey Area sustains 479 individuals.

- Mangrove kingfisher: this species is currently listed as Least Concern, even though the population trend appears to be declining. This decline is not believed to be sufficiently rapid to approach the vulnerable threshold (IUCN, 2012); however, it is listed as vulnerable in South Africa (Barnes, 2000). It is a local migrant that breeds during the austral summer in coastal woodlands and spend the austral winter in mangrove forests (Turpie, 2005).

- The mangrove kingfisher is fairly common within the Survey Area, and the high number of observations during the late summer season highlights the importance of the mangrove forests during local migration.

8.9.8 Avifauna Sensitive Habitat

The avifaunal sensitivity of any piece of land is based on its inherent ecosystem service (eg wetlands) and overall preservation of biodiversity. In addition, the sensitivity of any piece of land is a key consideration when identifying impacts; this is discussed in the Avian Impact Assessment in *Section 12.11*.

Ecological Function

The extent to which a site is ecologically connected to its surrounding areas is an important determinant of its sensitivity. Systems with a high degree of landscape connectivity or with extensive drainage systems between them are perceived to be more sensitive and will be those contributing to important avifaunal flyways or overall preservation of bird diversity.

Avifaunal Importance

Avifaunal importance relates to species diversity, endemism (unique species or unique processes) and the presence of topographical features or primary habitat units with the intrinsic ability to sustain conservation-important species.

Sensitivity Scale

- **High**: High sensitivity ecosystems either have a low inherent resistance or low resilience towards disturbance factors, or are highly dynamic systems considered being important for the maintenance of ecosystem integrity (eg pans, salt marsh habitat).. Most of these systems represent ecosystems with high connectivity with important bird flight paths or high bird diversities, while providing suitable habitats for a number of threatened or rare species.

- **Medium**: Medium sensitivity ecosystems are slightly modified systems that occur along gradients of disturbances from low to medium intensity. They have some degree of connectivity with other ecological systems or ecosystems with intermediate levels of species diversity, and may include potential ephemeral habitats for threatened species.

- **Low**: Low sensitivity ecosystems include areas of disturbed/transformed systems with little ecological function. They are generally very poor in species diversity or feature a dominant composition of unspecialised and widespread species.

High Sensitivity Avifaunal Habitat Types

The following habitat types are of High avifaunal importance/High ecological function (see sensitivity map, *Figure 8.77*):

Estuarine Salt Marshes and Fresh-water Wetlands

The salt marsh and fresh-water wetland habitat types represent High sensitivity as they provide critically important avifaunal habitats due to their unique composition of bird species. Both habitat types are spatially limited and restricted. The characteristics of the wetlands and their value towards bird conservation can be summarised as follows:

- Fresh-water wetlands show a linear configuration, which functions as important dispersal corridors for a variety of bird species. These linear networks maintain a high connectivity with other habitat types within the Survey Area and facilitate the movement of bird species between the different habitat types.
- Fresh-water wetlands sustain habitat-specific bird compositions that are regionally unique.
- Fresh-water wetlands and salt marshes sustain additional micro-habitat types (eg open pools, *Cyperus* stands, mudflats) which, in turn, elevate avifaunal species richness. More importantly, these micro-habitat types are colonised by a variety of species, often aquatic-associated species of different guilds (eg fish-eating species, wading birds and waders) that are absent from the adjacent woodlands.
- Fresh-water wetlands and salt marsh vegetation provide habitats for two globally threatened species: the Madagascar pond heron and wattled crane.

Large Intact Forest/Closed Woodland Remnants

These habitat units are considered as High sensitivity due to their distinct floristic structure, patchy occurrence and dense midstrata and understorey. These areas are preferred by elusive bird taxa, many being uncommon and thinly distributed in sub-Saharan Africa. They play an important role as stepping stones for intra-African migrants that disperse along the East African coast. They also provide habitats for Near Threatened species such as the southern banded snake-eagle and a high diversity of East Coast biome-restricted species.

Medium–High Sensitivity Avifaunal Habitat Types

The following habitat types are of Medium–High avifaunal importance.

Intertidal Zone and Mangrove Forests

The intertidal zone and mangrove forests are widespread beyond the borders of the Survey Area. However, both units are important since they support large numbers of migratory bird species during certain times of the year.

The intertidal zone is an important wintering habitat for large numbers of Palaearctic waders, including a significant proportion of the global crab plover population, which winters within the Survey Area.

The mangroves assist bird migration and experience influxes of tropical species during certain times of the year (eg mangrove kingfisher). The upper reaches are also ecologically well connected with fresh-water wetlands.

Medium Sensitivity Avifaunal Habitat Types

The following habitat types are of Medium avifaunal importance.

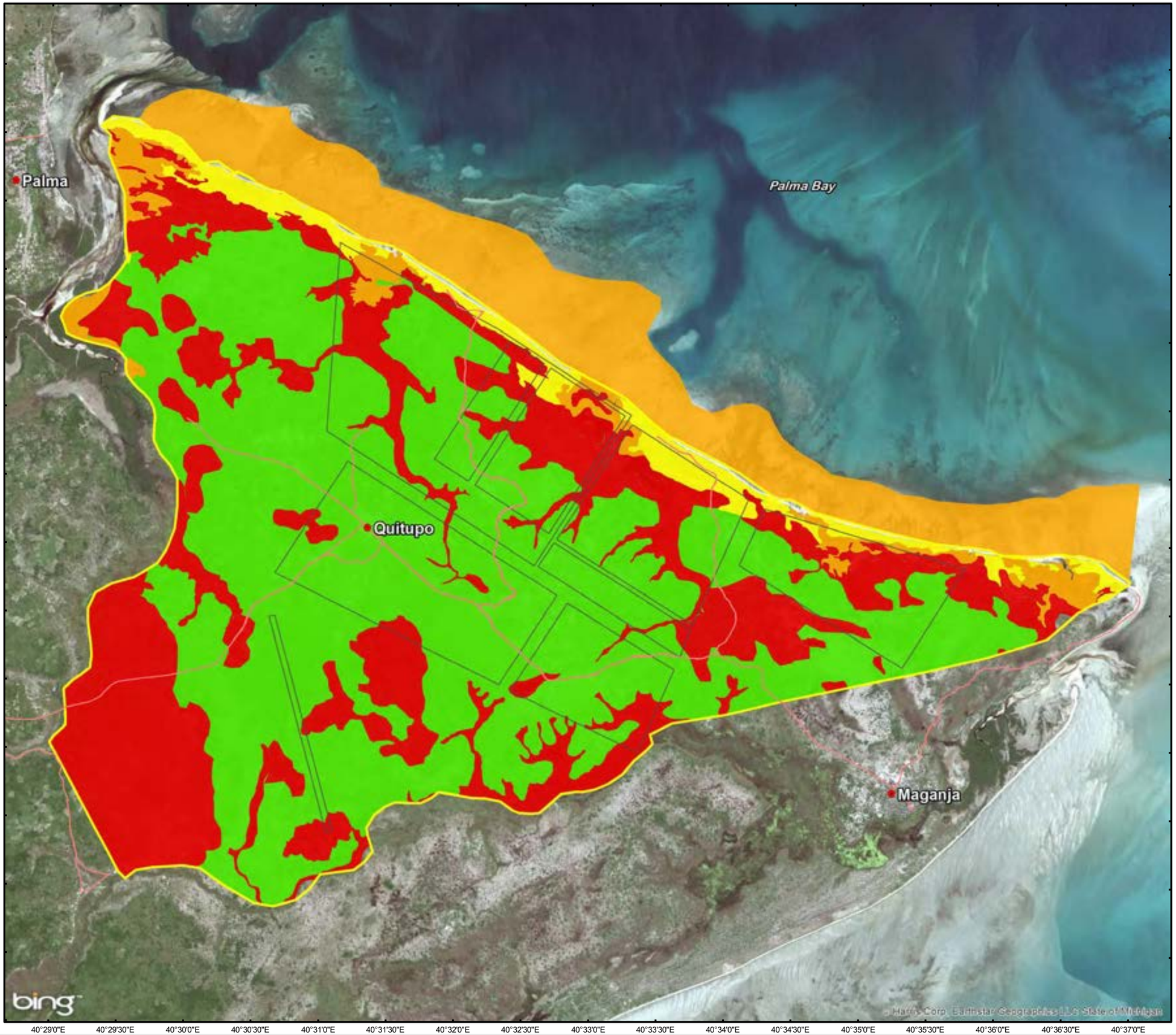
Modified Palm Savannah and Coastal Thicket

These habitat types are slightly modified and present a high density of palm trees. The palm trees (when dead) provide a seasonal breeding and roosting habitat for cavity-roosting/breeding bird taxa – a guild composition that is often severely constrained by the patchy distribution of suitable nesting/roosting space.

Low Sensitivity Avifaunal Habitat Types

Open Woodland

This is the dominant habitat type within the Survey Area, due to large areas having been converted for agriculture. This habitat type is mainly colonised by widespread species and is considered of Low sensitivity.



Legend

- Villages / Settlements
- Local Roads
- Onshore Project Footprint
- Afungi Project Site

Avifauna Sensitivity

- Low
- Medium
- Medium-High
- High

MAIN MAP SCALE:

0 1 2 4 Kilometers

TITLE:

Figure 8.77:
Sensitivity Map Illustrating the Important Avifaunal Habitat

CLIENT:

Anadarko Moçambique Área 1, Lda

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DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 50 000

DRAWING:
Sensitivity Map Illustrating the Important Avifaunal Habitat.mxd

REV: A

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240 Main Road
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Cape Town, SOUTH AFRICA
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Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Enviro-Insight, 2012
Inset Map: Esri Data & Maps

SIZE: A3

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8.10 MAMMALS

8.10.1 Geographical Context

The mammalian study was conducted within the general vicinity of the Afungi Project Site and main travel corridors to Cabo Delgado Peninsula and the Rovuma River. The Study Area was evaluated to establish a regional context for many of the mammalian taxa, as numerous mammalian species are migratory. The Study Area was investigated by means of qualitative survey methods (direct observations and habitat interpretation) and the resulting data was used to emphasise the importance of the mammalian assemblages in the local context (Survey Area) within the region (Study Area). The Survey Area incorporates the Afungi Project Site and its immediate surroundings, and represents the focus area of the mammalian baseline study. In this area, all mammalian survey methods were employed (interviews, spoor tracking, camera traps, Sherman traps, predator call-ups, direct observations, night drives, habitat and GIS analysis). *Figure 8.78* shows the Survey Area and Study Area for the mammalian study.

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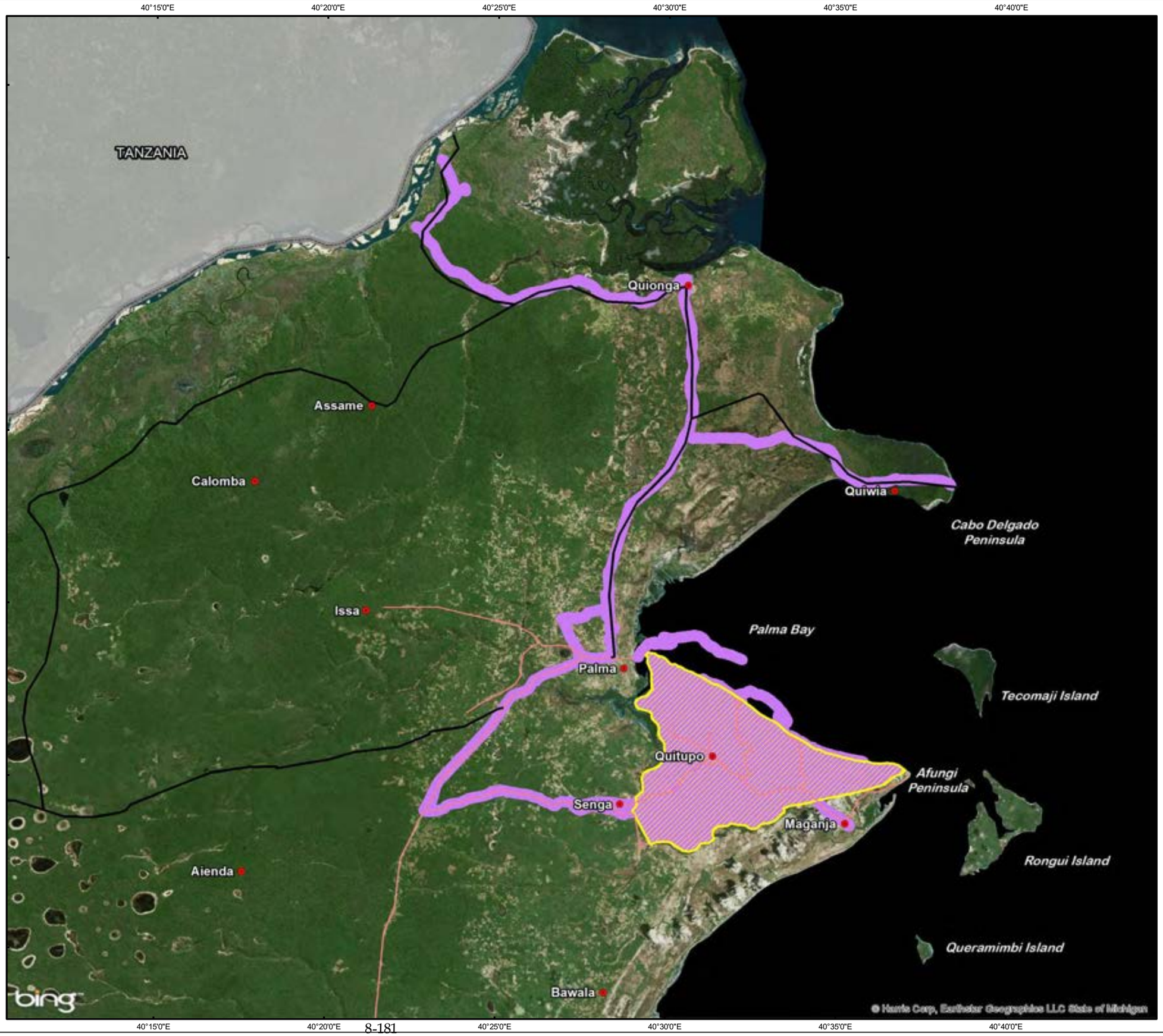
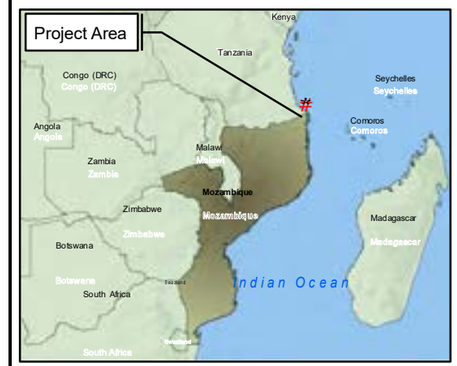


Legend

- Villages / Settlements
- Local Roads
- Regional Roads
- Afungi Project Site
- Study Area
- Survey Area



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 8.78:
Mammalian Study and Survey Areas

CLIENT:

Anadarko
Moçambique Área 1, Lda

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DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 195 000

DRAWING: Mammalian Study and Survey Areas.mxd

REV: A

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Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Enviro-Insight, 2012
Inset Map: Esri Data & Maps

SIZE: A3

8.10.2 Mozambique Regional Mammalian Fauna

Although Mozambique has a relatively rich diversity of mammalian fauna, much of the intact populations are largely confined to conservation areas (Mozambique Council for Environmental Affairs, 2009). However, the wilderness areas in the western and northern areas of Cabo Delgado Province are known to support large viable mammalian populations, notably of larger mammals, including various Red Data species. Major threats to mammal biodiversity in the region include subsistence hunting and habitat destruction resulting from slash-and-burn agriculture practices, livestock overgrazing and informal settlement sprawl. Such impacts are common to southern African systems that do not afford the protection of recognised national parks.

With regard to larger mammals, many of the threatened species in Mozambique are either hunted for subsistence use, are susceptible to habitat loss or are key factors in human/ wildlife conflict. Subsistence use and habitat degradation are similarly key factors affecting the population dynamics of Red Data small mammals in the region.

Mozambique has 232 recorded species of mammal (MICOA, 2009). However, many factors contribute to the difficulty in accurately predicting local assemblages of mammal species. Mozambique is a very large country with highly variable population densities and localised environmental pressures. Therefore, the habitat integrity of a given area and subsequent mammalian diversity needs to be assessed on a site-specific basis. Mammal lists, both Red Data and otherwise, were obtained through the IUCN Red List (2012), Skinner and Chimimba (2007) and MICOA (2009) to provide a predictive focal point for the survey. Thus, the population dynamics of the Survey Area could be compared with the literature and the presence of predicted Red Data species could be evaluated.

8.10.3 Cabo Delgado Province Mammalian Fauna

Unlike many areas within Mozambique, Cabo Delgado Province exhibits comparatively broad mammalian density and diversity. The Study Area exhibits strong linkage to many important conservation areas, including the Niassa Conservation Area and Quirimbas National Park, which provide migration corridors for mammals [Ntumi, Ferreira & Van Aarde (2009), Timberlake et al. (2010) and Agreco (2008) National Census of Wildlife]. These areas play significant roles in the national conservation of Red Data mammalian species.

8.10.4 Primary Mammalian Fauna Groups

In total, 40 mammal species were recorded during three survey periods. The winter (dry season) survey yielded 34 species, with the same number of species recorded for the summer (wet season) surveys. There were only three species from each season that were not recorded in the other survey period, showing a pattern of very low seasonal differentiation, which is discussed

below. The full list of mammal species and their Red Data/protected status is shown in *Table 8.34*.

Table 8.34 Mammals Observed within the Survey Area

Common Name	Scientific Name	IUCN Status
PRIMATES		
Greater galago	*Otolemur crassicaudatus*	LC
Grant's African galago	*Galago granti*	LC
Vervet monkey	*Cercopithicus pygerythrus*	LC
Baboon	*Papio cynocephalus*	LC
CARNIVORA		
African civet	*Civettictis civetta*	LC
African clawless otter	*Aonynx capensis*	LC
African lion	*Panthera leo*	VU
Honey badger	*Mellivora capensis*	LC
Large-spotted genet	*Genetta maculata*	LC
Large-grey mongoose	*Herpestes ichneumon*	LC
Leopard	*Panthera pardus*	NT
Marsh mongoose	*Atilax paludinosus*	LC
Serval	*Lepttailurus serval*	LC
Side-striped jackal	*Canis adustas*	LC
Slender mongoose	*Galerella sanguinea*	LC
Spotted hyaena	*Crocuta crocuta*	CD
RODENTIA		
Bushveld gerbil	*Tatera leucogaster*	LC
Gambian giant rat	*Cricetomys gambianus*	LC
Multimammate mouse	*Mastomys* spp.	LC
Pygmy mouse	*Mus minutoides*	LC
Doormouse	*Graphiurus* spp.	LC
Red bush squirrel	*Paraxerus palliatus*	LC
Red veld rat	*Aethomys*	LC
Striped bush squirrel	*Funisciurus flavivittis*	LC
Spiny mouse	*Acomys spinnosimus*	LC
Tree squirrel	*Paraxerus cepapi*	LC
Water rat	*Dasymys incomptus*	LC
RUMENANTIA		
Bushbuck	*Tragalephus scriptus*	LC
Common duiker	*Sylvicapra grimmea*	LC
Impala	*Aepyceros melampus*	LC
Warthog	*Phacochoerus africanus*	LC
Waterbuck	*Kobus ellipsiprymnus*	LC
WHIPPOMORPHA		
Hippopotamus	*Hippopotamus amphibius*	VU
LAGOMORPHA		
Scrub hare	*Lepus saxitillis*	LC
PROBOSCIDEA		
African elephant	*Loxodonta africana*	VU
MACROSCELIDIDAE		
Four-toed elephant shrew	*Petrodromus tetradactyla*	LC
EULIPOTYPHLA		
Musk shrew	*Cocidura* spp.	LC/DD
Unknown shrew	*Crocidura* spp.	DD
Total number	**38**	

Key:
CR: Critically Endangered, EN: Endangered, VU: Vulnerable, NT: Near Threatened, LC: Least Concern and DD: Data Deficient, according to IUCN Red Data List, 2012.

Due to the inherently large variations in the mammalian taxa, each group must be assessed separately in the context of Survey Area. Mammalian groups are defined and discussed below.

Herbivores

Very Large Herbivores: Elephant and Hippopotamus

Very large herbivores found in the region include the African elephant (*Loxodonta africana*) and hippopotamus (*Hippopotamus amphibious*). Although additional information on these species is provided in the Threatened and Endangered Mammal Species section, a brief summary is provided here.

African Elephant

The African elephant is the largest terrestrial mammal species on earth, with females weighing up to 3,500kg and males weighing up to 6,000kg. Herd dynamics vary geographically (differences being due to forage availability, hunting pressure, local climate and terrain) but in the Study Area, medium-size herds (10 to 15 individuals) as well as pairs (males) are commonplace; this information was acquired from local communities as well as direct observation. Throughout their range in sub-Saharan Africa, elephants are subjected to pressure from poaching (for both ivory and meat), sanctioned exterminations (agricultural and human conflict) and habitat reduction. The Study Area as a whole may represent an important migratory link between the Niassa reserve and habitats to the south.

Hippopotamus

The hippopotamus is a very large herbivorous species that can weigh up to 3,000kg (very large males). The species is highly social, existing in pods of up to 100, although within the region, the numbers of a given herd would seldom exceed 20. Displaced individuals, mostly males, will often migrate to other suitable areas seeking new habitats and herds. Although primarily aquatic, hippos will walk in excess of 20km at night in search of foraging grounds. The hippopotamus is listed as a vulnerable species in Mozambique due to unsustainable pressures from both local communities and authorities. Historically, the species is responsible for many human fatalities as well as agricultural conflicts. Within the Study Area, the Rovuma River provides a habitat for most of the hippopotamus in the area. However, some individuals are known to migrate temporarily into the Afungi Project Site in search of new habitats. This area is not considered to be a stronghold for the species in the Study Area or region.

Large Herbivores

Large herbivores found in the region include impala (*Aepyceros melampus*), kudu (*Tragalephus strepticeros*), warthog (*Phacochoerus africanus*) and sable antelope (*Hippotragus niger*), which have been recorded by Timberlake et al. (2010). Due to constant subsistence use as well as some small-scale habitat clearing, very few large herbivores remain within the Survey Area or the peninstula as a whole. Regionally, most of the large herbivore activity is

located to the north on Cabo Delgado Peninsula, near the Rovuma River or inland to the west of the Study Area. The western interior regions of Cabo Delgado Peninsula and the Rovuma River all show large tracts of intact habitat and lower human densities. However, bushbuck (*Tragalephus scriptus*), a large/medium-sized ungulate, were sighted frequently throughout the Survey Area. The reason for this could be the refuge provided by the dense habitats.

Small Herbivores

Small herbivores occur throughout the Survey Area and were sighted frequently, albeit in relatively low densities. Grey duikers (*Sylvicapra grimmea*) and suni (*Neotragus moschatus*) were sighted on numerous occasions during all the survey periods, with frequent records of spoor and scat. As a taxonomic group, small ungulates are far more resilient than their larger counterparts, primarily due to their ability to take refuge in a wider range of habitats and their lower densities. Small herbivores are often among the last of the mammalian taxa to be eliminated in heavily disturbed or heavily used areas.

However, these species are targeted by local communities as a food source.

Carnivores

Large Carnivores

Larger carnivores exhibit a strong presence throughout the region, including within the Survey Area. Relevant species include spotted hyena (*Crocuta crocuta*), African lion (*Panthera leo*), leopard (*Panthera pardus*) and African wild dog (*Lycaon pictus*), which has been recorded in the region by Timberlake et al. (2009). There is likely an inadequate supply of food to support viable populations of lions and wild dogs within the Survey Area. However, leopards have a highly variable diet and spotted hyenas are opportunistic predators; both species were recorded on numerous occasions within the Survey Area and throughout the region. Reports from the towns of Maganja and Senga indicate lions are periodically present, but not resident to the Survey Area; these incursions are at best sporadic. On a regional scale, lions were recorded on Cabo Delgado Peninsula and are said to infiltrate the area regularly. This has been witnessed by local communities as well as Project staff. From a health and safety perspective, the lions in the region occasionally resort to man-eating, as was the case in 2008/2009 when two lions killed 28 people over a period of 12 months.

Meso-carnivores

This taxonomic group was observed to be by far the most numerous within both the region and the Survey Area. Relevant species include honey badger (*Mellivora capensis*), side-striped jackal (*Canis adustas*), African clawless otter (*Aonynx capensis*), serval (*Leptailurus serval*), water mongoose (*Atilax paludinosus*), large grey mongoose (*Herpestes ichneumon*) and African civet (*Civettictis civetta*). This strong presence could be explained by a number of factors. First, the African dog (*Canis africanus*) is uncommon in the area. This species severely depletes prey supplies throughout Mozambique and serves as an apex predator throughout most of the central and southern parts of the

country. Second and most important, the food supply (especially within the feeding spectrum of meso-carnivores) is still highly functional. Wetland areas exhibit an extremely high density of amphibians, the mangrove areas show massive densities of large crabs, all of which are preyed upon by the above-mentioned species. Finally, meso-carnivores often react positively to the presence of humans (in the absence of large densities of African dogs) and will readily forage on anthropogenic food sources. Side-striped jackals, servals, water mongooses and African civets were all seen frequently in dens or foraging next to human settlements both in the region and within the Survey Area.

Small Carnivores

Small carnivores include species of mongoose, the genet (*Genetta* spp.), polecat (*Ictonyx striatus*) and African weasel (*Poecilogale albinucha*) (Mozambique protected species). Of these species, slender mongooses (*Galerella sanguinea*) and spotted genets were seen frequently throughout the region and within the Survey Area. These species are usually highly resilient and respond positively to human presence, as they readily use anthropogenic food sources or feed on the rodents that are attracted to human settlements. These species are not dependent on specific habitat requirements; therefore, most habitat types are suitable to meet the ecological requirements of these species. Dietary requirements are equally broad, which increases the adaptability of the group and therefore the overall resilience.

Primates

Species from this taxonomic group include the vervet monkey (*Cercopithecus aethiops pygerythrus*), yellow baboon (*Papio cynocephalus*), thick-tailed bushbaby (*Otolemur crassicaudatus*) and Grant's galago (*Galago granti*). These species of primates were frequently sighted, both within the Survey Area and the region as a whole. The Sykes' monkey (*Cercopithecus albogularis*) was expected in the region but was not recorded. By Mozambican standards, the diurnal primate species observed were extremely confident in their behaviour, showing strong interest in humans and human settlement. Nocturnal primates such as thick-tailed bushbabies and Grant's galagos were fairly abundant, probably due to the lack of means for the local inhabitants to harvest them (ie no torches). The regional landscape-level likelihood of occurrence for primates was not mapped, due to the complete broad-spectrum habitat usage of the group.

Small Mammals

Species from these taxa include mammal species below 1kg in weight. This includes most species of rodent, lagomorph, sengi and shrew. The Survey Area exhibited a low abundance and density of small mammals, which only showed significant presence within close proximity to wetland areas. The reasons for this are conjecture, although some assumptions can be made, which include:

- poorly developed basal layer in much of the study area, providing poor refugia and forage;
- relatively low diversity of small mammal habitats throughout the site;
- suboptimal and homogeneous dominant substrate; and
- rich density of meso-predators.

8.10.5 Species of Conservation Concern

Globally Threatened Species

Confusion still persists regarding which is the most appropriate information source to use when discussing species of conservation concern. The most common method is to examine lists generated by Mozambican conservation authorities as well as the list of IUCN globally threatened and regionally threatened species. In addition, the Convention for the Trade in Endangered Species (CITES) can be consulted regarding the use and exploitation of mammalian species. By examining all available sources of information, a list of relevant threatened species for a particular area can be finalised. The combined list of IUCN global and Mozambican threatened species, their Red Data status and site-specific information, as well as the probability of occurrence in the Survey Area, is shown in *Table 8.35*. In addition, species protected by the Mozambican Ministry of Agriculture and Rural Development Regulation of Forestry and Wildlife (2002) must be considered.

Table 8.35 Probability of Occurrence of Red Data Mammals in the Study Area

Common Name	Scientific Name	IUCN[1]	Likelihood[2]	Site-specific Information
Globally Threatened Species in the Region				
CARNIVORA				
African wild dog	*Lycaon pictus*	EN	Moderate	Confirmed north on Cabo Delgado Peninsula and the Rovuma River
Brown hyena	*Parahyaena brunnea*	NT	Nil	Not within known distribution
Cheetah	*Acionynx jubatus*	VU	Low	Suboptimal habitat
Leopard	*Panthera pardus*	NT	Confirmed	Confirmed in Palma and in the Afungi Study Area
Lion	*Panthera leo*	VU	Medium	Confirmed on Cabo Delgado Peninsula
PROBOSCIDEA				
Elephant	*Loxodonta africana*	NT	Confirmed	Confirmed in areas adjacent to and south of the Rovuma River
PERRISIDACTYLA				
White rhinoceros	*Ceratotherium simum*	NT	Nil	Locally extinct
Black rhinoceros	*Diceros bicornis*	CR	Nil	Regional stronghold several hundred kilometres to the west
WHIPPOMORPHA				
Common Name	**Scientific Name**	**IUCN[1]**	**Likelihood[2]**	**Site-specific Information**
Hippopotamus	*Hippopotamus amphibius*	VU	Confirmed	Confirmed in the Survey Area although considered to be vagrant. Common in the Rovuma River and within inland wetlands
RODENTIA				
Vincent's bush squirrel	*Paraxerus vincenti*	EN	Low	Not within known distribution
Checkered sengi	*Rhynchocyon cirnei*	NT	Low	Not within known distribution
Delectable soft-furred mouse	*Praomys delectorum*	NT	Low	Not within known distribution
Malawi galago	*Galagoides nyasae*	DD	Low	Not within known distribution
Dusky elephant shrew	*Elephantulus fuscus*	DD	Medium	May occur in region

Arend's golden mole	*Carpitalpa arendsi*	VU	Low	Not within known distribution
PHOLIDOTA				
Pangolin	*Manis temminckii*	NT	Medium	Consistently confirmed by local communities as a utilisable species
RUMENANTIA				
Giraffe	*Giraffe camelopardalis*	LC	Nil	Locally extinct
Mountain reedbuck	*Redunca fulvorufula*	LC	Nil	Not within known distribution
Roan antelope	*Hippotragus equinus*	LC	Medium	Unlikely to occur in area due to sustained hunting pressure
Sitatunga	*Tragalephus speki*	NT	Nil	Unlikely to occur in area due to sustained hunting pressure
Tsessebe	*Damaliscus lunatus*	LC	Low	Unsuitable habitat

Key:
CR: Critically Endangered, EN: Endangered, VU: Vulnerable, NT: Near Threatened, LC: Least Concern and DD: Data Deficient, according to IUCN Red Data List, 2012.
Low: infrequent incursions are possible, but overall unlikely to occur within the Survey Area.
Medium: regular periodic incursions into the Survey Area, although non-resident.
High: resident in the Survey Area on a permanent to semi-permanent basis.
Confirmed: observed in the Survey Area (includes observation of tracks).
Nil: no chance of occurring within the Survey Area due to inadequate habitat or the area being outside of all known distributions.

The landscape scale of the Red Data potential of the overall Study Area is illustrated in *Figure 8.79*. This map shows the likelihood of occurrence for sensitive Red Data species, based on the following factors:

- known distribution of Red Data species in the region;
- habitat potential (ecological requirements); and
- connectivity to surrounding wilderness and conservation zones.

Four of the recorded mammal species are listed as IUCN Red Data in Mozambique (namely African lion, African elephant, hippopotamus and leopard), and nine species are listed as protected by the Mozambican Forestry Act of 1999/2002 (African civet, African clawless otter, large grey mongoose, marsh mongoose, slender mongoose, large-spotted genet, honey badger,

serval and side-striped jackal). Only the leopard can be considered to be a permanent resident of the Afungi Project Site. The other species, although resident in the region, will at most make periodic incursions to the Afungi Peninsula. Of the Mozambican protected species, most have been addressed in detail in the above section, describing the prevailing mammalian assemblages in the region.

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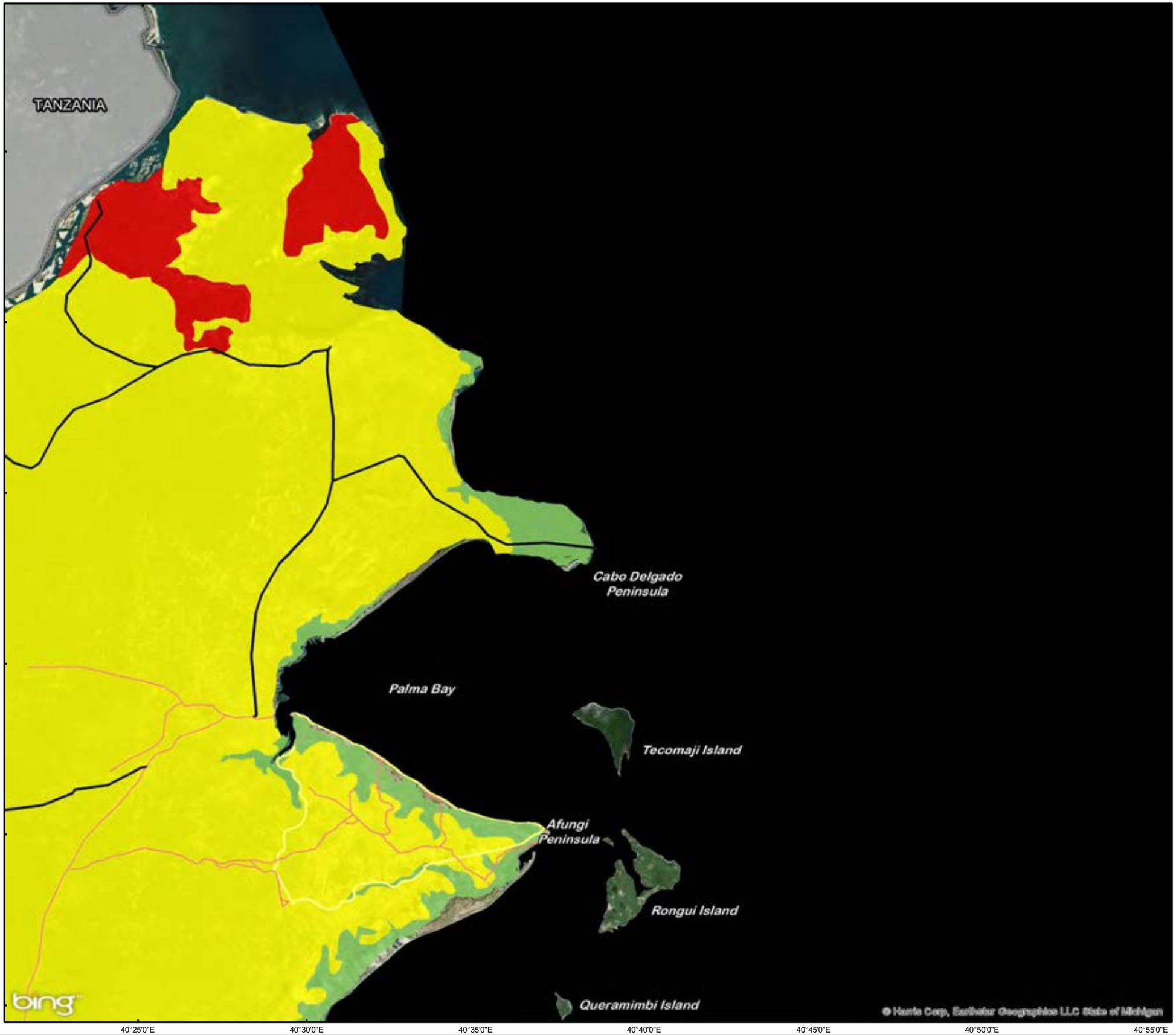


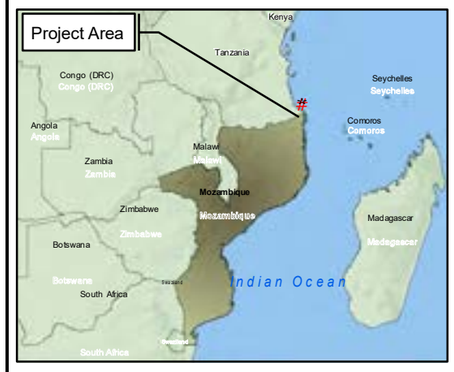
40°25'0"E 40°30'0"E 40°35'0"E 40°40'0"E 40°45'0"E 40°50'0"E 40°55'0"E

Legend

- Regional Roads
- Local Roads
- Afungi Project Site

Likelihood of Occurrence

- Low-Medium
- Medium
- High



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 8.79
Regional Likelihood of Occurrence for Combined Red-Data Species

CLIENT:

Anadarko Moçambique Área 1, Lda

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 160 000

DRAWING: Regional Likelihood of Occurrence for Combined Red-Data Species.mxd

REV: A

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Inset Map: Esri Data & Maps

SIZE: A3

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8.10.6 Mammalian Sensitivity

Regional Mammalian Sensitivity

On a regional landscape scale, Afungi Peninsula as a whole exhibits Low and Medium–High sensitivity (*Figure 8.80* below). There are a number of key reasons for this. From a geographical perspective, a peninsula is bordered by ocean on three sides, thus reducing its capacity as a migratory pathway. This creates a form of island scenario (from a migratory point of view), isolating the area from migratory corridors. Areas to the north, such as the Rovuma delta and areas inland, form valuable components of historical migratory routes to areas such as the Niassa Conservation Area (Anderson & Pariela, 2005). The prevailing habitat of Afungi Peninsula is predominated by relatively non-sensitive habitat types and is lacking very large tracts of the more sensitive Vegetation Units, such as primary wetlands leading into grassland *dambos* and forests. Although these units are present, they are not as prevalent as in the areas further north. Finally, Afungi Peninsula shows a much stronger degree of transformation from human land use than other areas in the region.

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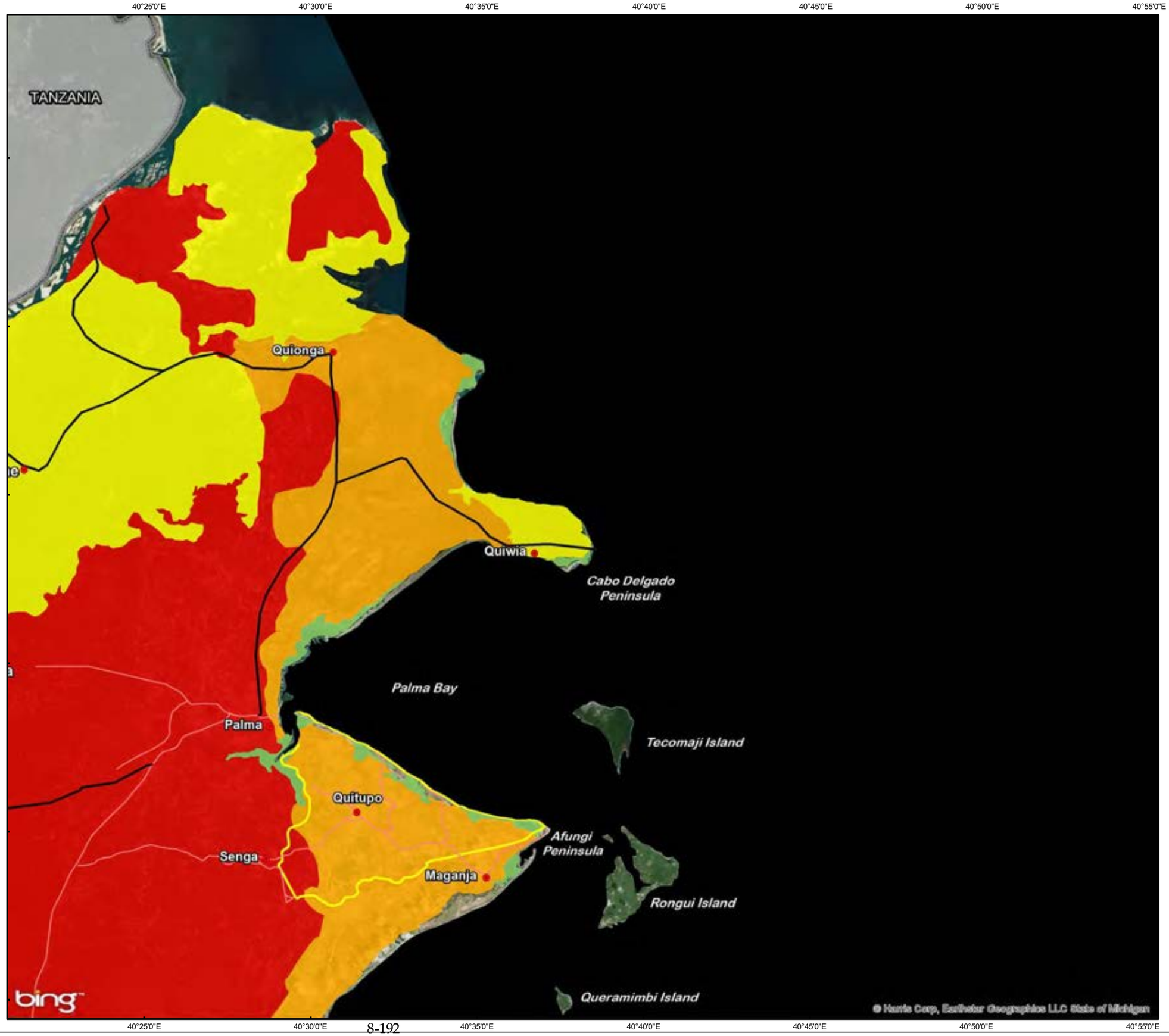
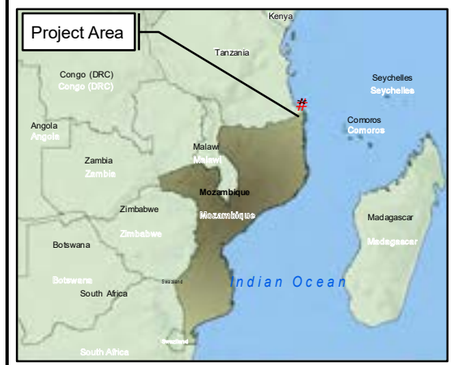


Legend

- Villages / Settlements
- Local Roads
- Regional Roads
- Afungi Project Site

Regional Mammal Sensitivity

- Low
- Low-Medium
- Medium-High
- High



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 8.80
Regional Mammalian Sensitivity

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 200 000

DRAWING: Regional Mammalian Sensitivity.mxd

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Projection: UTM Zone 37 S Datum: WGS84
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Inset Map: Esri Data & Maps

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Relationship between Vegetation Units and Mammalian Sensitivity

As noted in *Section 8.7*, the Afungi Project Site contains seven Vegetation Units. *Table 8.36* provides an overview of how the various mammalian species use these Vegetation Units, and the accompanying text provides additional details.

Table 8.36 Description of the Vegetation Units in a Mammalian Context

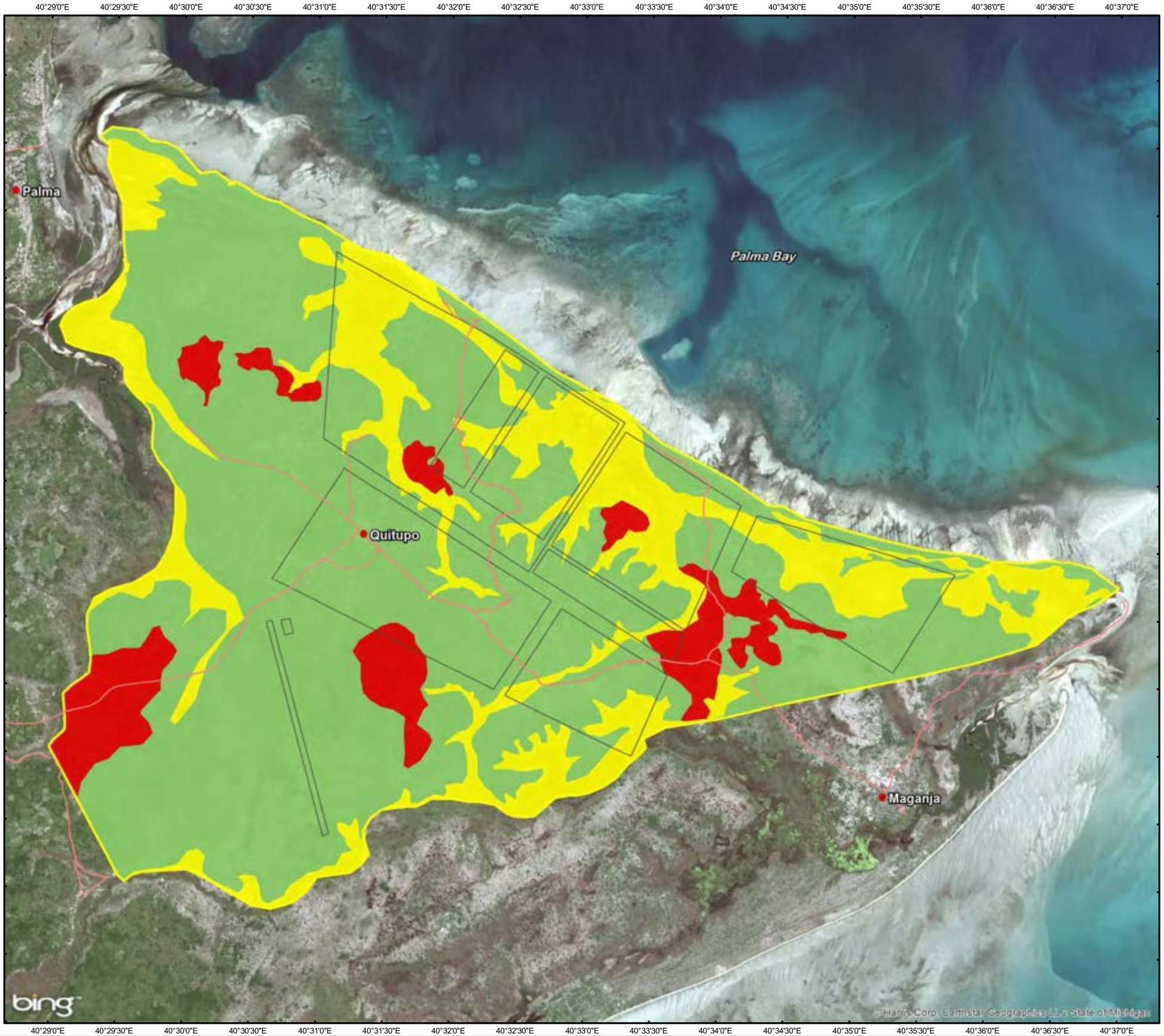
Vegetation Unit	Sensitivity	Remarks
1	**Low**	This habitat is represented by a thin littoral zone lining the coastline of the Survey Area. The primary structure is an artificial vegetation assemblage, due to the cultivation of coconut palms in the region. Mammal species sampled include small carnivores (most likely scavenging fish, crustaceans or anthropogenic food sources) and diurnal primates. Due to a lack of available forage, poor refugia potential and high human habitation, this habitat type is considered to be of Low mammalian sensitivity.
2	**Medium**	The mangrove stands in the study site are characterised by variable structure, zero basal herbaceous layer and high salinity substrates. These ecological conditions basically eliminate grazing potential for any ungulates, as well as small mammals. However, there exists an extremely productive macro-invertebrate density (crabs), which gives rise to very frequent foraging incursions from meso-predators such as jackal, serval, water mongoose, otter, civet and genet. Therefore, this habitat type is considered to be of Medium mammalian sensitivity.
3	**Medium**	This ecotone (1) is characterised by high salinity substrate as well as areas of tidal flats and open woody (mangrove) stands. It shows almost non-existent refuge or grazing potential and therefore eliminates the potential of most mammalian species to persist on a permanent basis. The area is, however, a prime habitat for macro-invertebrates (crabs), which provide forage potential for meso carnivores and small carnivores such as African clawless otter, genet, mongooses, jackals, servals and civet. Being an important ecotone, the overall mammalian sensitivity is Medium.
4 & 6	**Medium**	Vegetation Units 4 and 6 have been discussed together, due to their similarities and relevant cross-applicability to mammalian fauna. The short closed grasslands and short open woodlands form a type of a mosaic that feed into each other extensively. This vegetation type is structurally referred to as mixed open woodlands and/or short closed grassland, which often occurs as a dominant mosaic within the Survey Area. It makes up the bulk of what may commonly be referred to as dominant duneveld. Although it is one of the most widespread of the habitat types, these units are not highly sensitive from a mammalian perspective, due to the relatively sterile sandy substrate, variable slash-and-burn agricultural regimes and variable basal layers. Therefore, this habitat type is considered to be Medium mammalian sensitivity.
5	**High**	These areas are characterised by permanent, semi-permanent or seasonally inundated grassy wetlands, giving way to swampy forested islands. These marshy areas show grazing potential for small and larger ungulates as well as the strong meso-predator assemblage found within the area, which most likely frequents the area due to the extremely high density of prey populations

(1) An ecotone is a transition zone between two habitats.

Vegetation Unit	Sensitivity	Remarks
		(amphibians, rodents and reptiles). Especially where the *dambos* lead into permanent wetlands and associated closed forests, the overall mammal sensitivity of this habitat type is considered to be High.
7	**Medium to High**	This is a fragmented habitat that structurally resembles closed or semi-closed woodland. Although highly fragmented within the Survey Area, the vegetation type is prevalent in and around the Palma region and near the Rovuma River. Although this habitat provides refugia for many of the taxonomic groups, including meso and small carnivores, small ungulates and arboreal primates, the forage potential is generally low. The mammalian sensitivity of this habitat varies between Medium (fragmented secondary regrowth) and High, depending on the complexity of the vegetation and the proximity to permanent wetlands.

Mammalian Sensitivity within the Survey Area

The majority of the Afungi Project Site is of Medium and Low mammalian sensitivity, due to the overwhelming presence of Medium and Low sensitivity mammalian habitat types. Areas of Low sensitivity include the mangrove regions and the wetland *dambos*, which showed forage potential for many of the prevalent mammalian taxonomic groups. However, a single group (meso-predators) use these areas and therefore, the habitat is not considered sensitive. The intact closed woodland habitats occurring to the west of the Project Footprint Area and the permanent wetlands and drainage areas interspersed throughout are considered of High sensitivity. Both these areas are characterised by habitat integrity as well as structural diversity. The primary woodlands are interspersed by low hills and ecotonal forest woodlands, whilst the wetlands often lead into canopy forest and/or grassy *dambos* and provide corridor linkages throughout the area. These areas are illustrated in red in *Figure 8.81* below.

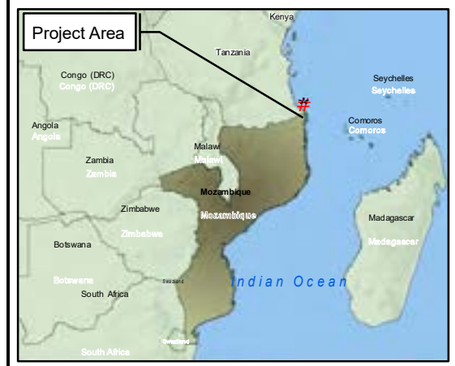


Legend

- Villages / Settlements
- Local Roads
- Onshore Project Footprint
- Afungi Project Site

Mammal Sensitivity

- Low
- Med
- High



MAIN MAP SCALE:

0 1 2 Kilometres

TITLE:

Figure 8.81:
Mammal Sensitivity within the Afungi Project Site

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
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DRAWING: Mammal Sensitivity within the Afungi Project Site.mxd

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10°53'0"S

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Local Knowledge and Interviews

The following summary information was obtained from the interviews from the towns of Quitupo, Senga and Maganja and a number of smaller communities and hunters throughout the Study Area and Survey Area. Due to the descriptive nature of the answers, it is not possible to represent the data graphically.

- Extensive subsistence use of mammals by local communities takes place throughout the Survey Area, the Afungi Peninsula and the region as a whole.

- Although some incursions by larger ungulate species do take place south of the Rovuma River, most mammal species found or actively hunted in the Survey Area are small mammals (rodents, shrews), meso-sized species (mongooses, genets, rabbits), arboreal species (bushbabies, squirrels, tree rats) or small antelope [primarily duiker (*Sylvicapra grimmea)* and suni (*Neotragus moschatus*)].

- Larger antelope species, primarily bushbuck and greater kudu, impala, roan antelope (*Hippotragus equines*) and sable antelope (*Hippotragus niger*), are primarily located within and north of Cabo Delgado Peninsula, as well as in the western corridors towards Niassa Province.

- All antelope species are coveted as a source of food within the Survey Area. Hunting methods primarily involve the use of snares and, in some cases, bows and arrows. In corroboration with the baseline data, the local inhabitants state that few larger antelope exist within the actual Survey Area, with larger species being found to the north and west.

- The Red Data species most often seen is the African elephant, which are prominent north of Cabo Delgado Peninsula. Hippopotamus show a permanent presence in the Rovuma River and the larger wetlands to the west and south-west of the Survey Area.

- Hippopotamus are seen as a threat to crops and human lives. However, hippopotamus rarely make incursions into the Survey Area.

- Large carnivores are often seen within the region and within the Survey Area. Red Data species such as leopard (IUCN Near Threatened) and lion (IUCN Vulnerable) are infrequently encountered within the Survey Area, but more often encountered within Cabo Delgado Peninsula and the areas surrounding the Rovuma River. Lions in the Palma area have historically preyed on both humans and livestock, and the attitude towards lions is overwhelmingly negative. However, due to the large presence of tsetse fly in the area, livestock losses due to carnivores are not considered to be a primary concern. The most common large carnivore in the area is the spotted hyena, which is said to rely on anthropogenic food sources (such as livestock and human refuse).

- All the local communities interviewed use small mammals as a staple food source. Methods of acquisition vary slightly between communities, but encompass burning of the basal layer to isolate mice and burrows, which are dug out of burrow systems.

- Significant conflict exists between local communities and elephants. Elephants often raid croplands, although this was mostly confined to the areas immediately adjacent to or within Cabo Delgado Peninsula and the Rovuma River area. Six out of 16 (38 percent) of the interview events were aware that the unauthorised killing of problem elephants was illegal. In recent memory, no human has been killed by elephants throughout the region, despite numerous crop-raiding events. The National Wildlife Census (2008) corroborates these findings, showing the Study Area to be in the highest density zone in terms of elephant crop raids, yet showing zero fatalities from elephants throughout the survey period.

- The pangolin (*Manis temminckii*) is seldom seen by most of the communities on Afungi Peninsula. As with most of Mozambique, the animal itself is one of superstition. Only one of the communities actively seeks out the animal for traditional medicine. One the communities (Maganja) reveres the pangolin as its totem animal and it is forbidden by the local chief to harm the animal. Hunters from the community capture individual animals, but do not kill or consume them. Rather, any captured animals are sequestered for a period of time and are involved in prayer rituals before being released. However, all other communities and individuals interviewed kill and consume the pangolin and consider it to be a delicacy. Pangolins are not traded to market in larger towns for currency. The fact that pangolins are a protected species is not known by local communities.

A high level of confidence can be placed in these interview results, for several reasons:

- Species identifications were facilitated using relevant field guides. Interview subjects were asked to give the local name and well as to provide any additional information (habitat, behaviour, vocalisations), to the satisfaction of the specialist.

- Although only 16 sets of interviews were conducted, answers usually resulted from the general consensus of many members of the community, facilitated by elders and hunters (mostly males). The women in the village offered useful information on crop raiding by elephants and hippopotamuses.

- Finally, interview subjects were mainly restricted to males in the community, preferably hunters, elders or members who spend much time in the Study Area (women tending crops) and had the relevant knowledge to assist in the process.

8.10.7 Health and Safety Analysis

There are a number of mammalian species in the Afungi Project Site that can potentially be of considerable danger to humans, and pose a health and safety risk to the Project. This analysis [1] is based on the number of observations of dangerous mammals (or signs of dangerous mammals) onsite, as well as:

- suitable habitat conditions for potentially dangerous species;
- further analysis of results from local interviews; and
- analysis of historical human/wildlife conflict data.

The potentially dangerous species and the risk associated with each of three distinct areas are shown in *Table 8.37*.

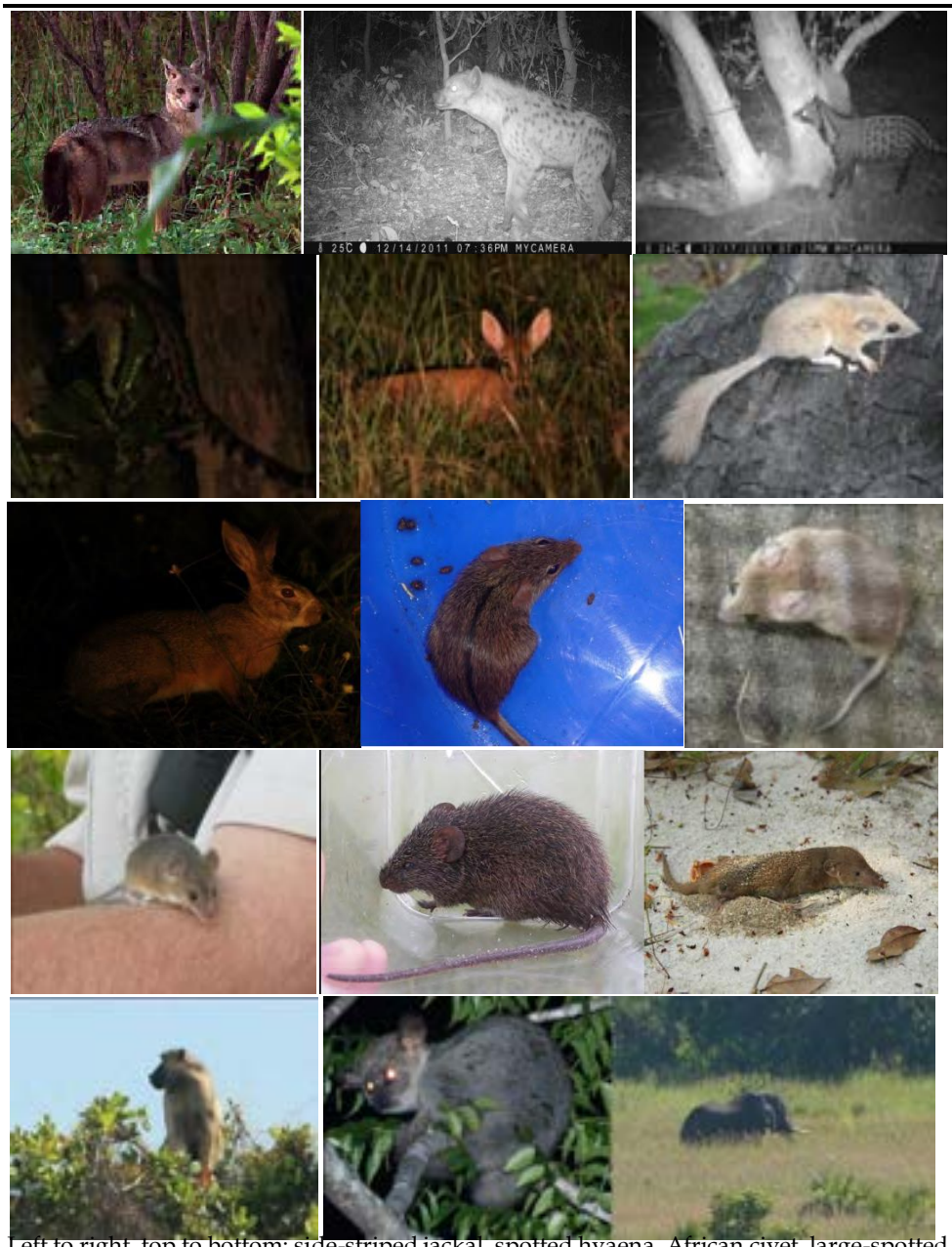
Table 8.37 Health and Safety Analysis for Potentially Dangerous Mammals

Species	Afungi Project Site	Cabo Delgado Peninsula	Rovuma District
African elephant	Low	Medium	High
Lion	Low	Medium	High
Leopard	Low	Low	Low
Spotted hyena	Low	Low	Low
Hippopotamus	Low	Low	High

Source: Enviro-Insight, 2012.

(1) Methodology for analysis is described in *Annex C*.

Figure 8.82 A Selection of Mammal Photographs Taken during the Field Surveys



Left to right, top to bottom: side-striped jackal, spotted hyaena, African civet, large-spotted genet, common duiker, dormouse, scrub hare, single-striped mouse, fat mouse, pygmy mouse, water rat, musk shrew, yellow baboon, thick-tailed bushbaby, African elephant.

Source: Enviro-Insight, 2011 and 2012.

8.11 SUMMARY OF KEY ONSHORE ENVIRONMENTAL SENSITIVITIES

The following section provides an overview of the primary sensitivities associated with each of the specialist disciplines and baseline studies described in this chapter. This section provides a short summary of the main issues to take cognisance of when assessing potential impacts or developing mitigation measures. The sensitivity maps provided in *Sections 8.6* to *8.10* have been overlaid in *Figure 8.83* to highlight these overlapping habitat sensitivities.

665000 670000 675000

8810000 8805000 8800000

Palma Bay

PROCESSING UTILITIES AREA

TRAINS 1 & 2

TRAINS 3 & 4

TRAINS 5 & 6

CONSTRUCTION LAYDOWN/ STAGING AREA

OPERATIONS HOUSING AREA

PIPELINE INLET GAS AREA

OPERATIONS SUPPORT AREA

CONSTRUCTION SUPPORT FACILITY AREA

AIR STRIP PASSENGER TERMINAL

AIR STRIP

Quitupo

Maganja

bing

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Legend

- Villages / Settlements
- Local Roads
- Nearshore Components
- Onshore Layout
- Airstrip
- Afungi Project Site

Sensitivity Rating

- Very High
- High
- Medium-High
- Med
- Low
- 150m Buffer

MAIN MAP SCALE:

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Figure 8.83: Key Onshore Environmental Sensitivities

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8.11.1 Sensitive Habitat Types

Flora

Three of the Vegetation Units fall within the High to Very High sensitivity category: Vegetation Unit 2 – Short Closed Marshland (Very High), Vegetation Unit 5 – Short Closed Wetlands (Very High) and Vegetation Unit 7 – Short Closed Woodland (High). These Vegetation Units support the ecological functions of the animal communities discussed below.

Herpetofauna

Fresh-water wetland systems are classified as High sensitivity areas for herpetofauna as they serve as active breeding grounds for more than half the year. In turn, vertebrate predators rely on the extensive amphibian population as a source of food. The fresh-water wetlands are therefore a fundamental part of the herpetofauna community and all other vertebrate communities that rely on the herpetofauna assemblages. Several large reptile species, including the Vulnerable southern African python, exist in the fresh-water wetland systems. Additionally, a potentially new species of fossorial legless skink was discovered in these areas.

Contiguous trees are classified as Medium–High sensitivity as they provide a significant structural habitat for herpetofauna. In addition to the value this habitat provides to herpetofauna, predators use the thick stands of trees as foraging sites. Leaves and hollow logs act as refuge and shelter, and detritus tree material attracts insects and other invertebrates as valuable food sources. Only a few large stands of this landscape type still remain intact and, in conjunction with the refugia and foraging potential, increases the sensitivity classification of this area.

Avifauna

High sensitivity avian habitat types include the estuarine salt marshes and fresh-water wetlands of Vegetation Units 3 and 5, as well as the large intact forest/closed woodlands of Vegetation Unit 7. Medium–High sensitivity avifaunal habitat types include the mangrove forests associated with Vegetation Unit 2 and the intertidal zone. All these areas play an importance ecological function for resident and transient avian species within the Afungi Project Site.

The estuarine salt marshes and fresh-water wetland networks connect other habitat types within the Afungi Project Site and support the movement of bird species between habitats. They sustain habitat conditions and micro-habitat types that contribute to the diverse avifauna found in these areas, including for two globally threatened species: the Madagascar pond heron and wattled crane. Large intact forest/closed woodlands are considered High sensitivity as they play a role for intra-African migratory birds that disperse along the East African coast. They also provide habitats for several Near Threatened species. The intertidal zone and mangrove forests support large numbers of

migratory bird species, serve as a winter habitat and are ecologically connected to fresh-water wetland networks, which gives them a Medium–High sensitivity rating.

Mammals

The Afungi Project Site as a whole exhibits Low to Medium mammalian sensitivity; however, the fresh-water wetlands associated with Vegetation Unit 5 exhibit a High mammalian sensitivity. These areas provide forage for grazing mammals and meso-predators reliant on the density of prey populations (amphibians, rodents and reptiles). The sensitivity of the closed woodlands of Vegetation Unit 7 varies between High and Medium; this sensitivity is dependent on the complexity of the vegetation and the proximity to permanent wetlands. This habitat provides refugia for many taxonomic groups (meso and small carnivores, small ungulates and arboreal primates).

However, the forage potential is generally low.

8.11.2 Integrated Onshore Sensitivities

The various habitat types present within the Afungi Project Site are ecologically linked and are largely dependent on the surface-water flow regime. A commonality among the faunal groups discussed above is a high degree of reliance on Vegetation Units 5 and 7.

The short closed wetland areas associated with Vegetation Unit 5 are an integral component of the overall biodiversity of the Afungi Project Site. All fauna groups are reliant on the attributes these fresh-water wetlands provide (ie habitats for feeding, breeding, nesting, migration and refugia). Furthermore, amphibians (primarily frogs) occupy the base of the food chain for a majority of the species in the area. As the amphibian life cycle is tied to these wetland areas, it stands to reason that the overall well-being of the vertebrate community will therefore also rely upon the maintenance of the fresh-water wetland habitat.

The short closed woodlands of Vegetation Unit 7 provide another key habitat type used by all the faunal groups within the Afungi Project Site. However, the sensitivity of these areas is largely dependent on the size of the area, degree of fragmentation, and connectivity to other sensitive habitat types. Short closed woodlands occurring in the riparian areas adjacent to wetlands and large contiguous woodland areas provide more value to the faunal communities than do smaller or isolated woodland areas.

Certain species are reliant on sensitive habitat types provided by other Vegetation Units. As an example, the mangroves found in Vegetation Unit 2 are an essential foraging habitat for the sunbird taxa and the mangrove kingfisher. However, all fauna groups are reliant on the wetlands and woodlands of Vegetation Units 5 and 7. Therefore, these are considered the most sensitive habitat types within the Afungi Project Site.

Chapter 9

Socio-economic and Community Health Baseline

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9 SOCIO-ECONOMIC AND COMMUNITY HEALTH BASELINE

9.1 INTRODUCTION

This chapter outlines the socio-economic and health baseline of areas (both onshore and offshore) potentially affected by the Project. The chapter is structured into a number of sections, as follows:

- *Sections 9.2* and *9.3* provide a summary of the baseline and sources of information used to compile the baseline, respectively.
- *Section 9.4* defines the Project Area of Influence, providing both an overview of the geographic characteristics as well as the respective administrative divisions and governance structures.
- *Sections 9.5* to *9.7* provide an overview of Cabo Delgado Province (an important part of the Area of Indirect Influence (1)) and aims to set the broader social, health and economic context in which the Project will be located.
- *Sections 9.8* to *9.14* provide a description of the social, health and economic characteristics of the Area of Direct Influence, which includes Palma District and the Afungi Project Site and Surrounds (including Senga and Maganja).
- *Section 9.15* provides a description of the cultural and religious profile of the Afungi Project Site and Surrounds (including Senga and Maganja).
- *Section 9.16* provides an overview of perceptions and expectations about the Project.
- *Section 9.17* provides an understanding of the shipping movements and types of vessels used within the Study Area.
- *Section 9.18* details the archaeology and cultural heritage baseline of the Afungi Project Site, based on both primary and secondary data.

9.2 SUMMARY

Palma District is located in the north-east of Cabo Delgado Province. *Figure 9.1* and *Figure 9.2* below show Cabo Delgado Province and the Palma District.

(1) Although the Area of Indirect of Influence has a broader scope to the regional (southern and eastern Africa) and national level (Mozambique), the focus of this report will be the Province of Cabo Delgado.

Legend

- District Centre
- Capital City of Cabo Delgado

Roads

- Primary
- Secondary

- Afungi Project Site
- Boundary with Tanzania

Province

- Cabo Delgado
- Niassa
- Nampula

- District Boundary

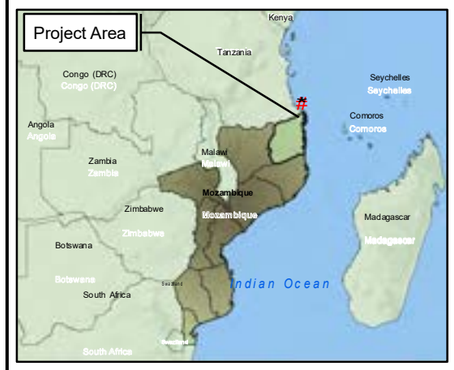

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Figure 9.1: Cabo Delgado Province and Administrative Division

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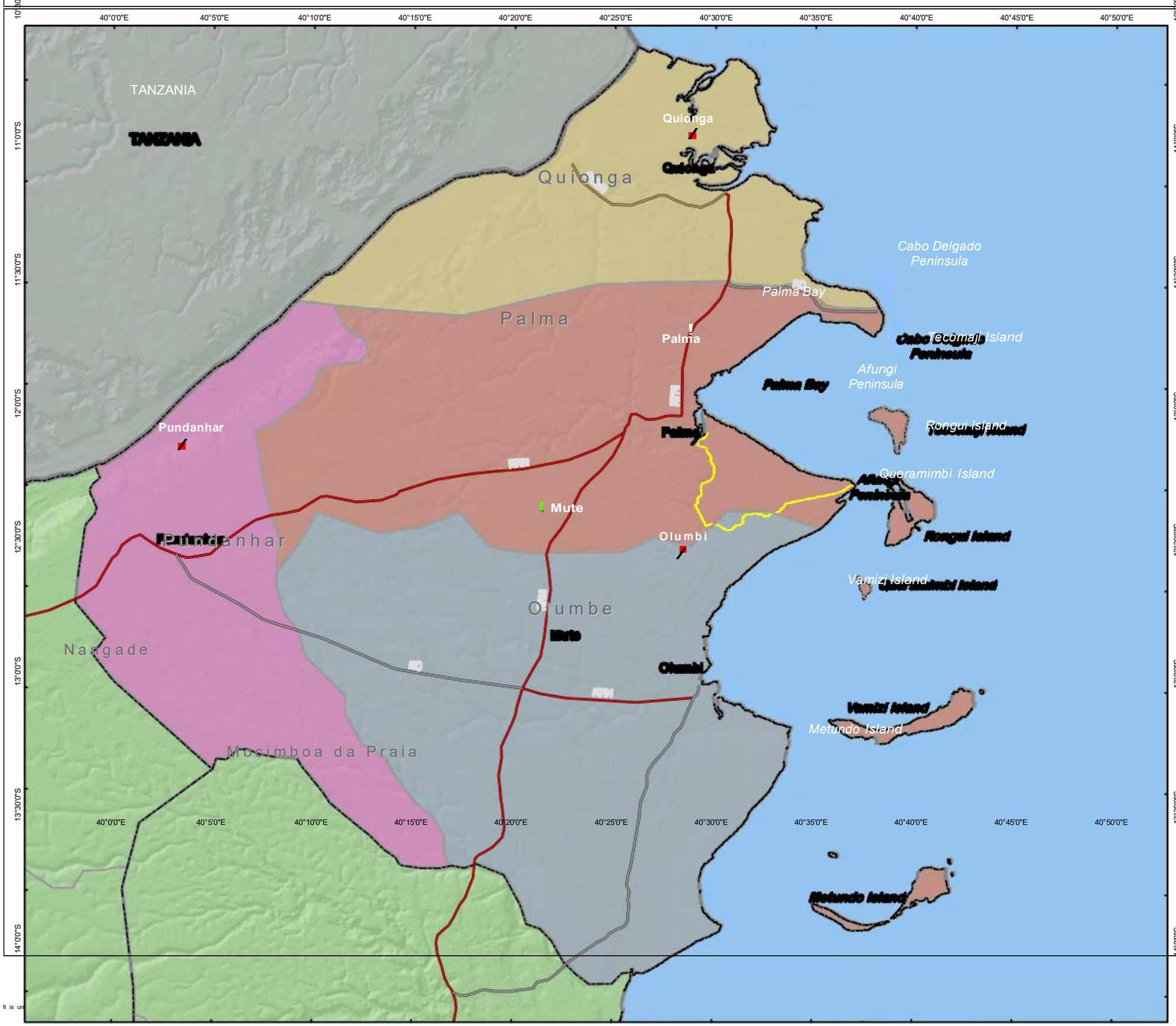

Legend

- District Centre
- Locality Centre
- Administrative Post Centre

Roads

- Tertiary
- Local
- Non Classified

- Afungi Project Site

Province

- Cabo Delgado

- District Boundary

Administrative Post

- Olumbe
- Palma
- Pundanhar
- Quionga

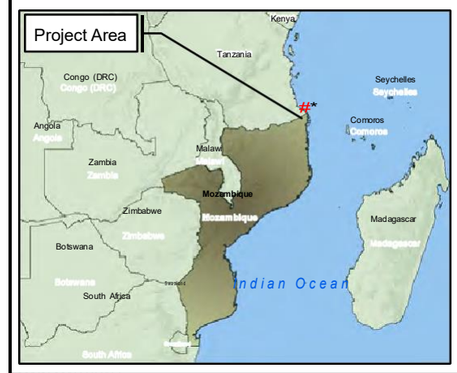

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Figure 9.2:
Palma District, Administrative Posts and Localities

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Anadarko Moçambique Área 1, Lda

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Palma District comprises four Administrative Posts, six Localities and several villages. The Afungi Project Site is located in the Palma Administrative Post and in the Locality of Mute, south-east of Palma town, as shown in *Figure 9.2* and described in *Section 9.9.2*. In 2012, the population in the Mute Locality was an estimated 16,473 (*Table 9.19*) and accounts for 32 percent of the Palma District population. Within the Afungi Project Site, the population is estimated at approximately 2,700, accounting for 5.3 percent of the Palma District population (*Table 9.20*).

9.2.1 Education and Employment

In 2007, the level of education in Cabo Delgado was very low, as 81.3 percent of the economically active population (15 years or older) did not complete any level of education. This was a small improvement compared to 1997, when 86.5 percent had not completed any level of education [Mozambican National Institute of Statistics (INE), 2007d]. As in Cabo Delgado Province, the level of education is quite low in Palma District, with 88 percent of the economically active population having no level of education (INE, 2007d). In the Afungi Project Site and Surrounds (including Senga and Maganja), illiteracy is high, especially among women (92 percent).

Low levels of educational attainment can be attributed to the lack of education facilities and an inefficient education system in the District. Challenges faced by the education system in the District include a small number of schools; a limited number of teachers, classrooms and materials such as desks and books; lack of EP2 (Second Level of Primary Education) and higher-level schools; long travel distances to schools (for both teachers and students); high dropout rate due to food security issues (this forces young people to engage in household farming activities during some periods of the year, eg harvesting); and a high dropout rate among young females that may be influenced by early marriages and teenage pregnancy.

In Cabo Delgado Province and Palma District, formal employment is scarce and mostly provided by the State (public officials of local administration, teachers and health professionals). The private sector is almost non-existent, and salaried employment is limited to tourism operators, some small private operators working in commerce and fisheries, temporary employment opportunities associated with recent hydrocarbon exploration projects, and road construction and maintenance contracts. Thus, the population is largely self-employed [(1)] (85 percent in Cabo Delgado and 87 percent in Palma District), the great majority in agriculture and fisheries, and therefore highly dependent on natural resources for their livelihoods and income earning. Moreover, there is very limited experience and awareness of formal employment procedures and expectations.

(1) Self-employment is an occupational category recognised by the INE to classify people who work on their own (for themselves). This includes formal or informal employment and trade, including surplus from subsistence agriculture and fisheries. The term self-employed is used throughout this report.

Waged employment is not common, and is only reported by approximately 4 percent of the heads of households in the Afungi Project Site and Surroundings (including Senga and Maganja). This is due, among other factors, to lack of investment in employment-generating activities, limited capacity building of human resources due to high-level illiteracy and lack of trained people, and lack of developed infrastructures such as roads, energy and water supply.

9.2.2 Livelihoods (Agriculture, Fishing and Tourism)

Most of the agricultural activities are of a small scale and, in general, agricultural productivity is low. In the Afungi Project Site and Surrounds (including Senga and Maganja), subsistence farming is the primary activity for 50 percent of the heads of households, followed by fishing, which is carried out by about 24 percent of heads of households. Agriculture is practised in highland and lowland areas. Highland areas are usually located in the grasslands and adjacent to riverbanks, or in the high/plateau areas with sandy soils. These areas are usually utilised for crop farming such as cassava, sorghum, maize and peanuts, as well as trees such as cashew, mango and coconut. Lowland areas are located in the floodplain areas where the most productive soils are found. These are usually used to produce rice, sweet potatoes, bananas and sugar cane.

Tourism and fisheries are also contributors to the provincial economy. This is attributed to Cabo Delgado being a coastal province with numerous islands located along the coast, which have proved to be a base for the establishment of fishing centres and the development of fishing activity. They are also the main attraction for international tourists, and tourism brings in the most revenue. The District has the potential to develop tourism activities, due to its diversity of marine, coastal and game resources. Industrial tuna fishing occurs in the Exclusive Economic Zone (EEZ) close to the territorial waters of Palma District. Industrial and semi-industrial fisheries by Mozambican operators occur far south of Cabo Delgado Province.

In Palma District, some 21 percent of women are artisanal subsistence fishers, indicating that they already play an important role in ensuring food security for families, as well as generating income. Artisanal fishing is practised by the communities along the coast and along inland waterways, where catches are used for consumption as well as for sale. This constitutes the second-most important activity in terms of food security and income for the domestic economy in the Afungi Project Site and Surroundings (including Senga and Maganja), and is the occupational activity of 24.3 percent of heads of households. For a small percentage of residents, fishing is a source of seasonal employment. During fishing season people fish, and during the off season people grow crops.

9.2.3 *Transport*

The sea not only supports fishing activities but provides a network for the transportation of goods and services along the Mozambican coastline and to Tanzania. This is, in part, due to the general limited development of transportation infrastructure and services in northern Cabo Delgado and the Palma District. There are a limited number of boats operating in the area and, in terms of transportation, local people tend to walk instead of utilising sea-based transport, as it is expensive. Palma Bay experiences little activity in terms of shipping and navigation activities, with mostly fishing vessels (artisanal), local transport boats (small conventional and artisanal boats) and some recreational navigation (small recreational boats) using the bay. Transit shipping routes in the Mozambique Channel pass between 15 and 25 nautical miles offshore.

The road network infrastructure in the District is poor and not well developed, covering approximately 256km. It consists of tertiary roads, feeder roads and non-classified segments. However, District authorities have implemented road construction and maintenance projects that include repairing and paving some roads.

9.2.4 *Health*

A vast majority of the households in Palma District rely on unprotected water sources like open wells (60.1 percent); surface water like rivers, lakes and lagoons (7.2 percent); and other unspecified sources (1.6 percent), according to Census 2007 results (INE, 2007). This reliance on unsafe water sources poses a variety of health risks (eg diarrhoea and cholera) for the local population.

There are limited health facilities in the District, with a high number of people in all Administrative Posts living more than 8km from a health facility. The lack of public transport and poor road infrastructure exacerbate the situation. For instance, the nearest hospital is the Rural Hospital of Mocímboa da Praia, located 80km from Palma town, to which patients from Palma requiring major surgery or more specialised medical assistance are referred.

Access to health services is also poor in the Afungi Project Site and Surroundings (including Senga and Maganja). With the exception of the Maganja health facility, all healthcare facilities are located some walking distance away in the Administrative Post centres. However, vaccination services are available for children through First Responders or APEs (Elementary Polyvalent Agents).

9.2.5 *Sanitation, Waste and Power*

The lack of sanitation facilities is a significant problem facing the communities in Palma District, including in the Afungi Project Site and Surrounds (including Senga and Maganja). Some 81 percent of the population in the Afungi Project Site and Surrounds (including Senga and Maganja) do not have

access to adequate latrines. This poses significant health problems for people, as urinating and defecating in the bush may affect water sources.

There are no formal waste disposal systems or sites in the District, and most people burn or dispose of waste outside their houses or on unoccupied land.

Firewood is used as the main energy source for cooking, followed by palm leaves and coconut fibre. Households mainly use petroleum products and battery-operated flashlights/lamps for lighting.

9.2.6 Heritage and Culture

A notable cultural ceremony in the Afungi Project Site and Surrounds are the initiation rites (for girls and boys) that mark the entry of children into adulthood. These initiation rites are conducted from December to January. Male children are taken to specific locations (usually near a river or lagoon) where they are taught for approximately one month about the activities that await them in their adult lives. Girls are initiated at home. Areas where these ceremonies are undertaken are important to the community, and are used for many generations.

Sacred sites include cemeteries, churches and mosques (where different types of worship services are conducted), as well as sites where initiation rites are performed. Ten archaeological sites were recorded in the area of Afungi Peninsula, as well as one abandoned sacred place and several burial sites. Most of these sites have been affected by extensive cultivation, and those closer to the coast have been influenced by sea erosion. The archaeological finds included beads, shells (including pearl oysters), fish bones and potsherds.

9.3 SOURCES OF INFORMATION

9.3.1 Literature Sources

The information provided in this baseline chapter has been gathered from a wide range of sources. It draws upon a review and analysis of existing information, including data collected for EIAs from the exploration phase of the Project (2008) and from other available sources, including statistical reports and data from the main sectors (tourism, fishing, agriculture) of the Province of Cabo Delgado and the District of Palma. These are referenced where applicable throughout the text.

9.3.2 Baseline Surveys

Location-specific information and data for the area is sparse and, therefore, intensive primary data was also collected through household questionnaires, focus group discussions (FGDs) and interviews for this baseline. The Household Survey findings are described throughout this chapter. The

survey methodologies applied by the socio-economic specialists are presented in *Annex C* and baseline support material are presented in *Annex G*

9.4 SOCIO-ECONOMIC STUDY AREA

9.4.1 Area of Influence

The area of influence is based on the Project's potential direct and indirect impacts associated with the social, health, economic and cultural components that describe the social baseline on which the Project is to be implemented.

Two areas of influence have been defined:

- the Area of Indirect Influence; and
- the Area of Direct Influence.

These are further described in the following subsections.

Area of Indirect Influence

From a socio-economic perspective, the Area of Indirect Influence (AII) is broadly defined as the Province of Cabo Delgado (*Figure 9.1*) and, to some extent to Mozambique as a whole, when the economic benefits are considered. As noted previously in *Chapters 1* and *5*, this is due to the socio-economic effects that the Project may have in terms of potential synergies between the Project, public and private sectors on local, regional and national levels, as well as the macro-economic effects on exports, balance of payments and Gross Domestic Product (GDP).

Area of Direct Influence

As described in *Chapter 4*, the main components of the Project are grouped together and discussed as Onshore, Near Shore and Offshore components of the overall Project. The scope of the socio-economic baseline includes physical, social and economic infrastructure, social networks and access to services and economic activities (eg agriculture, fishing, near shore transportation of products and people, collection of natural resources, and other activities carried out by the residents in the Study Area). The scope used to determine the Area of Direct Influence (ADI) are outlined below:

- the large portion of the population residing in the Afungi Project Site, practising subsistence agriculture within its boundaries; and the many households residing outside the Afungi Project Site (within Palma District ie from Palma town, as well as Senga and Maganja villages) also engaged in agricultural activities within the Site;
- the population of Palma town and other villages and areas adjacent to the Afungi Project Site, using the coast and the near shore areas within the

Afungi Project Site for fishing and other activities (ie both primary and secondary livelihood activities);

- the population of Palma town and fishing centres located in Palma District, to the north and south of the Afungi Project Site, also using coastal waters adjacent to the Site for fishing and the transportation of passengers and merchandise along the coast; and

- the broader social considerations, such as access to employment, absorption of local labour, in-migration and settlement by people in search of employment, and increased dynamics of the local economy among others, will have direct effects on the Palma District, recognising that there will be population movements and activities in the surrounding towns and villages and along the Project's primary access routes.

Using the criteria outlined above, the ADI can be described as including:

- Palma District;
- Palma-Sede Administrative Post and Mute Locality; and
- Afungi Project Site.

As stated above and in the methodology, the Household Survey assessed the Afungi Project Site and two main villages located in the vicinity of the Site, namely Senga and Maganja. For the purpose of presenting the Household Survey results, this is described as Afungi Project Site and Surrounds (including Senga and Maganja).

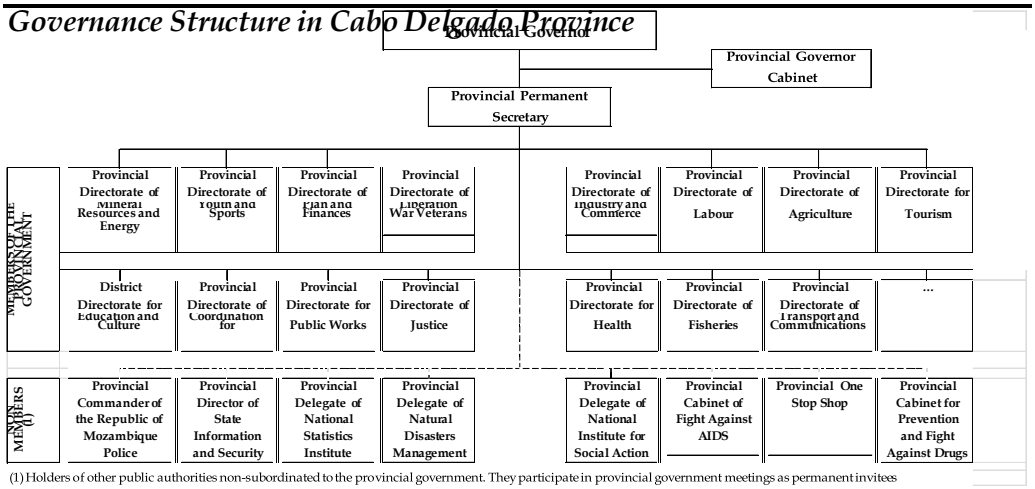
9.5 CABO DELGADO PROVINCE: ADMINISTRATIVE AND POLITICAL OVERVIEW

Cabo Delgado Province is located in northern Mozambique, bordered by Tanzania to the north (by the Rovuma River), Niassa Province to the west, Nampula Province to the south and the Indian Ocean to the east, as shown in *Figure 9.1*.

Cabo Delgado Province is subdivided into 15 districts, with Palma District being the most relevant to this Project, as this is where the Project is to be located. *Figure 9.1* shows the location of Palma District in relation to Cabo Delgado Province.

The governance structure in Cabo Delgado Province (*Figure 9.3*) follows a hierarchical organisational structure headed by a political figure, the Provincial Governor, who is appointed by the President of Mozambique. The Governor's Office is aided by a Permanent Secretary. Several sector institutions, such as environment, agriculture, fisheries, tourism, health, education, mineral resources and energy, to name those most relevant to this study, are represented at a provincial level by Provincial Directorates headed by the respective Provincial Director, which provide the necessary technical support to the Governor's Office.

Figure 9.3 *Governance Structure in Cabo Delgado Province*



(1) Holders of other public authorities non-subordinated to the provincial government. They participate in provincial government meetings as permanent invitees

Source: Impacto, 2012.

9.6 CABO DELGADO PROVINCE: SOCIO-DEMOGRAPHIC INDICATORS

9.6.1 Population Distribution

Based on a projected annual growth rate of 2 percent, the population of Cabo Delgado Province in 2012 was estimated to be 1,797,335, representing 6.5 percent of the population of Mozambique (*Table 9.1*). With a growth rate of 1.9 percent, Cabo Delgado has the second-lowest growth rate in the country after Gaza and Inhambane provinces, which have a growth rate of 1.7 percent per annum (INE, 2010b). The low population growth rate in the province is primarily attributed to four factors:

- low birth rate (41 born/1,000 people);
- high infant mortality (88 deaths/1,000 people);
- gross mortality rate (16 deaths/1,000 people); and
- low life expectancy, equivalent to 49 years old.

Table 9.1 *Population of Cabo Delgado Province (1997–2012)*

Year	Provincial Population	Percentage of National Population	Growth Rate per annum	Men %	Women %	Urban %	Rural %
1997	1,380,202	8.6	1.9	48.4	51.6	16.8	83.2
2007	1,634,162	7.9	1.9	48.4	51.6	20.8	79.2
2012*	1,797,335	6.5	1.9	48.4	51.6	22.9	77.1

Key:

* The 2012 figures represent a forecast based on the projected growth rate of 2%.

Source: INE, 2010b.

9.6.2 *Employment*

Nearly 88 percent of the economically active population of the province is engaged in agriculture, forestry, fishing and extractive activities (*Table 9.2*), while 9 percent work in the tertiary sector (ie trading and finances, administrative services) and 3 percent are engaged in secondary sector activities (industry) (INE, 2010b).

The majority of Mozambique's rural inhabitants are self-employed [1]. Waged employment occupies only a small part of the economically active population. In Cabo Delgado Province, 85 percent of the population are self-employed, followed by non-remunerated household workers (9 percent) [2]. Less than 5 percent of the population are employed in the public and private sectors.

Table 9.2 ***Economically Active Population (15 Years and Older) in Cabo Delgado Province by Sector and Employer, 2007***

	Total Residents	Sector of Activity (%)	State Employee	Private Company Employee	Self-employed Worker	Non-remunerated Family Worker	Other Dependent Worker
Total residents	664,742		16,288	14,323	563,609	59,523	10,999
Employment position (%)		100.0	2.5	2.2	84.8	9.0	1.7
Agriculture, forestry, fishing and extractive	581,447	87.5	1,064	2,604	517,903	55,563	4,313
Industry and energy	14,337	2.2	557	2,415	10,091	651	623
Construction	6,790	1.0	613	2,253	3,243	248	433
Transport and communications	2,589	0.4	582	1,219	590	45	153
Services	57,987	8.7	13,340	5,742	30,893	2,632	5,380
Unknown	1,592	0.2	132	90	889	384	97

Source: INE, 2010b.

9.6.3 *Education*

The education sector in Mozambique comprises four main subsystems (general, technical and professional, training of teachers and education of adults) and four main levels (primary, basic, intermediate and higher education).

General education constitutes the backbone of the education system, with the primary level divided in two degrees (EP1 and EP2) and the secondary level also subdivided in two cycles (ESG1 and ESG2), as shown in *Table 9.3*.

(1) See *Section* 9.2.1 for the definition of self-employment.

(2) Non-remunerated household workers is a category used by the INE to categorise people aged 15 or older who work for an household without receiving remuneration, eg farming and domestic activities. Generally, they live as a member of the household, receiving food and board. In some cases, they are indirect relatives (nephews or nieces, for example) who live under the protection of the household.

In 2007, there were 1,064 schools in Cabo Delgado Province, of which:

- 78 percent offered the First Degree of Primary Education (EP1);
- 18.7 percent offered the Second Degree of Primary Education (EP2);
- 2.6 percent offered the First Cycle of Secondary Education (ESG1); and
- 0.7 percent offered the Second Cycle of Secondary Education (ESG2).

In Cabo Delgado Province, the illiteracy level was 66.6 percent in 2007, the highest in the country, where the average was 50.3 percent (INE, 2010b) [(1)]. *Table 9.3* compares the level of education completed by the population aged 15 years and older in 1997 and 2007 (INE, 2010d). Among the adult population, 81.3 percent had not completed any level of educational attainment, 10.9 percent completed EP1 and 2.53 percent completed EP2. The proportion of people who completed ESG1 and ESG2 was 3.3 percent and 1.28 percent respectively in 2007 (INE, 2010d).

The determinants that have contributed to these low levels of educational attainment include insufficient education facilities for the population, limited schools offering all levels of primary and secondary education, and insufficient education sector budgets to provide resources such as well-trained teachers. These determinants have led to a high number of people entering adulthood either without attending school, not finishing at least the first level of education (primary school) or not completing higher levels of education.

Table 9.3 ***Levels of Education Completed by the Population of Cabo Delgado Province (15 Years and Older)***

Completed Level of Education	1997 Census		2007 Census	
	Inhabitants	%	Inhabitants	%
Total	742,163	100.00	667,488	100.00
No level	642,180	86.53	542,516	81.28
Literacy (read and write in one language)	1,555	0.21	2,119	0.32
EP1	65,612	8.84	72,757	10.90
EP2	22,866	3.08	16,888	2.53
ESG1	5,759	0.78	22,004	3.30
ESG2	1,622	0.22	8,540	1.28
Elementary Technical Education (ETE)	144	0.02	81	0.01
Basic Technical Education (ETB)	484	0.07	679	0.10
Intermediate Technical Education (ETM)	426	0.,06	535	0.08
Teacher training	708	0.10	897	0.13
Higher education	212	0.03	672	0.10
Unknown	595	0.08	2,762	0.43

Source: INE, 2010b.

(1) The illiteracy level refers to the percentage of the population within the group of 15 years of age or older who do not know how to read and write in any language.

9.6.4 Road Infrastructure

The road network across the province is relatively poor. Of the total roads, 15 percent are classified as primary and 14 percent as secondary roads, while the majority (57 percent) are classified as tertiary roads and the remainder are feeder roads. *Figure 9.4* below and *Table 1.3* in *Annex G* show the road network in Cabo Delgado Province, according to the official road classification. The two primary roads linking the province with the remainder of the country are the N1 and N14.

The N1 links Cabo Delgado Province with the southern and central parts of the country and also connects the province with Nampula Province (cities of Nacala and Nampula) via the Erati and Nacaroa districts. The N14 links Cabo Delgado Province to Niassa Province. It intersects with the N1 at Mieze, then continues to link the Marrupa and Majune districts in Niassa Province.

The main secondary road in Cabo Delgado Province is the N380, which extends some 259km. Some sections of the road are paved, whereas other sections are unpaved and in a poor condition. The road links the city of Pemba with the north and north-western districts in the province, and terminates in Mocímboa da Praia.

The main tertiary road is the R762, which extends some 291km. It is a compacted-earth road that runs in a northerly direction along the coast to Palma, and passes through Mocímboa da Praia. This road, along with the R775 and R1260 [1], is currently [2] being paved between Mocímboa da Praia and the Tanzania border in Namoto. Linking with the N380, these roads connect the provinces in the north, south and centre of the country, as well as extend to Tanzania.

9.6.5 Water Supply

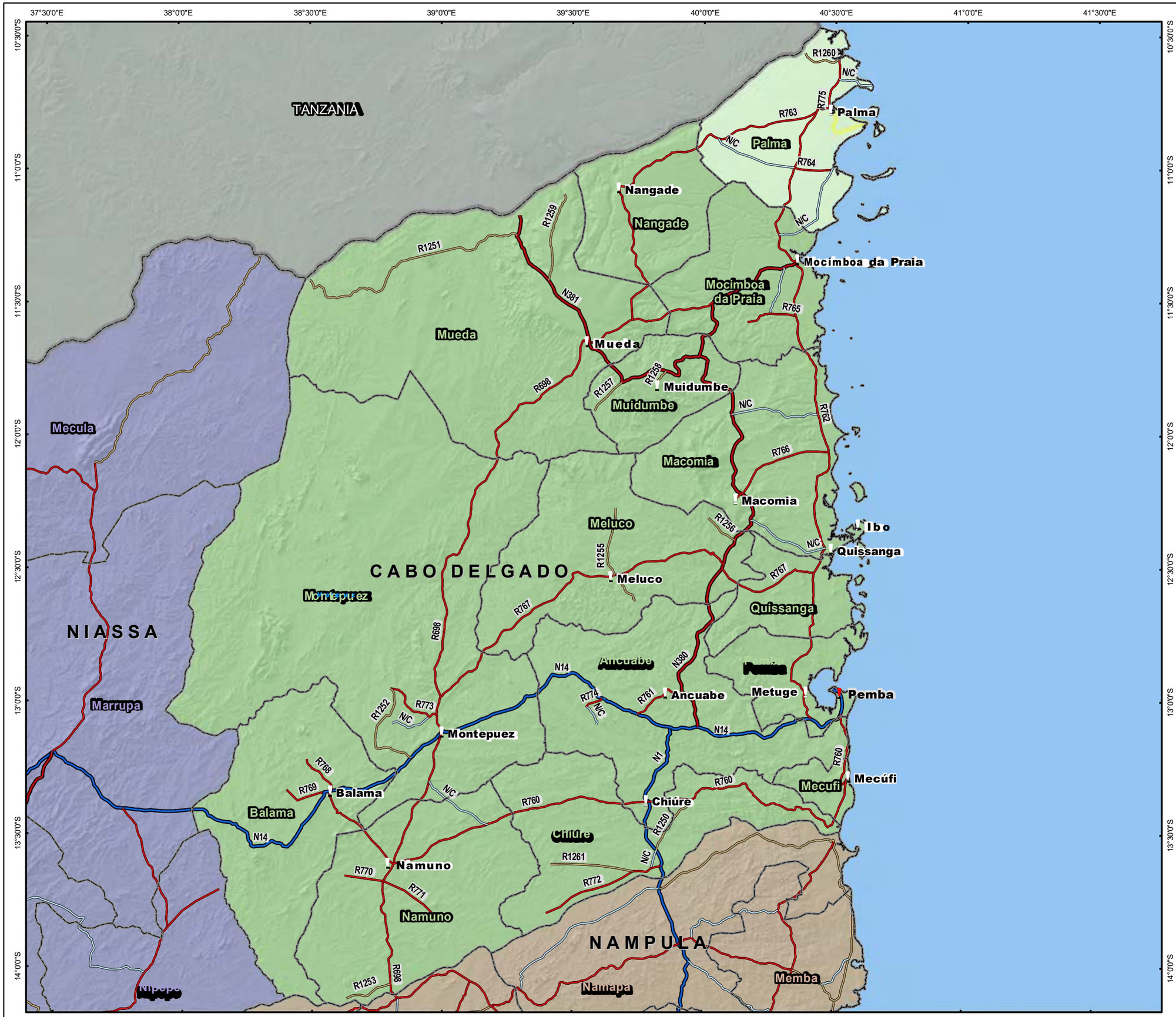
There are three main types of water supply in Cabo Delgado Province. In the urban areas, water is mainly supplied by FIPAG (the Water Supply Investment and Asset Fund) via a centralised/piped water supply system that sources water from boreholes nearly 40km from Pemba (Pemba Metuge District). In the District and some Administrative Post centres, water is sourced from small piped systems managed by the District Administration or private operators. Water from these small piped systems is abstracted from varying sources, including boreholes and surface waters. In rural areas (most villages), water is sourced from springs, wells and boreholes (with handpumps), and these are managed by the local communities that, according to the Water Law, must organise themselves in Water Committees and Maintenance and Repair Groups. In 2010, approximately 13 percent of

(1) The R762, R775 and R1260 connect Mocímboa da Praia with Palma, Palma with Quionga, and Quionga with Namoto (on the Rovuma River border established with Tanzania) respectively.

(2) February 2013.

boreholes with handpumps in the province were not operational (Government of the Province of Cabo Delgado, 2010a) [1].

(1) Boreholes with handpumps are generally non-operational due to breakdowns of the pumps, lack of water because of defects in construction or an insufficient water table or low quality of the water (brackish water).



Legend

- District Centre
- Capital City of Cabo Delgado

Roads

- Primary
- Secondary
- Tertiary
- Local
- Non Classified

- Afungi Project Site
- Boundary with Tanzania

Province

- Cabo Delgado
- Niassa
- Nampula

- District Boundary
- Palma District

MAIN MAP SCALE:

0 20 40 60 80

Kilometers

TITLE:

Figure 9.4:
Road Network in Cabo Delgado Province

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 1 500 000

DRAWING: Road Network in Cabo Delgado Province.mxd

REV: A

ERM
Great Westerford Building
240 Main Road
Rondebosch, 7725
Cape Town, SOUTH AFRICA
Tel: +27 21 681 5400
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Impacto Projectos e Estudos Ambientais

ERM

Projection: UTM Zone 37 S Datum: WGS84
Source: DIVA-GIS, Impacto, 2012.
Inset Map: Esri Data & Maps

SIZE: A3

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9.6.6 *Poverty Levels*

Table 9.4 shows the results of the poverty assessments of Cabo Delgado Province over three periods, extending from 1996 to 2009. The assessments are based on consumption and expenditure patterns for a basic basket of food items (Mozambican Ministry of Planning and Development, 2010). In the period 2002 to 2003, the province had the third-highest levels of poverty in the country (63.2 percent). Inhambane Province and Maputo Province had the highest (80.7 percent) and second-highest (69.3 percent) poverty levels countrywide.

Poverty levels in Cabo Delgado Province decreased to 37.4 percent in the period 2008 to 2009. This was lower than the national average (54.7 percent) and the average level for northern Mozambique (46.5 percent) for the same period. The 25.8 percent decrease in provincial poverty levels can, in part, be attributed to a better 2008–2009 agriculture campaign aimed at improving household consumption patterns, as well as improvements in access to public services and infrastructures – especially transportation infrastructure, which increased access to trading networks (1).

Table 9.4 Poverty Levels in Cabo Delgado Province, Northern Mozambique and the Country

Location	Poverty Levels (%)		
	1996–1997	**2002–2003**	**2008–2009**
Cabo Delgado Province	57.4	63.2	37.4
Northern Mozambique	66.3	55.3	46.5
National	69.4	54.1	54.7

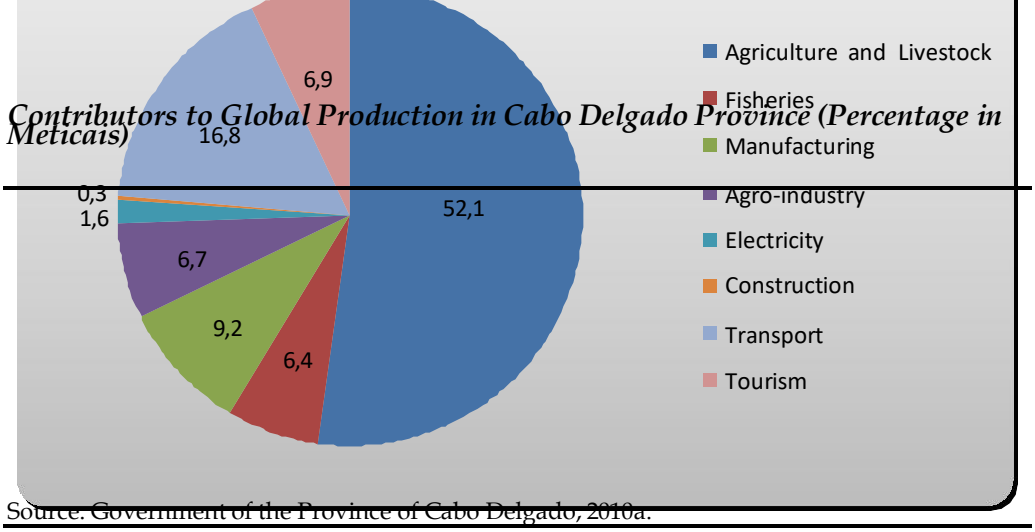
Source: Mozambican Ministry of Planning and Development, 2010.

9.7 *CABO DELGADO PROVINCE: ECONOMIC ACTIVITIES*

A range of economic activities are undertaken in Cabo Delgado Province, with agriculture (52 percent), transportation (16.8 percent) and the manufacturing industry (9.2 percent) sectors being the dominant contributors (Government of the Province of Cabo Delgado, 2010a). *Figure 9.5* below and *Table 1.2* in *Annex G* provide an overview of the economic sectors and their contribution to the province's global production in 2010. Each activity is described further below.

(1) The report titled *Poverty and Well-being in Mozambique: Third National Evaluation* does not analyse in detail the factors that influenced the decrease of poverty at provincial level.

Figure 9.5 ***Contributors to Global Production in Cabo Delgado Province (Percentage in Meticais)***



Source: Government of the Province of Cabo Delgado, 2010a.

9.7.1 *Agriculture*

The economy of Cabo Delgado Province is dominated by subsistence agriculture. Agricultural activities comprise crop and livestock farming, and most farming activities are undertaken for subsistence purposes. The main food crops grown are maize, sorghum, rice, pearl millet, beans, groundnuts, cassava and sweet potato. Households only sell produce at the local markets when there is a surplus. Cash crops include cashew, sesame and cotton (see *Table 9.5*). Cotton production has, however, declined in the past years due to decreasing prices in the international markets. In the coastal areas, coconut is grown for household consumption and for sale on the local and regional market (Government of the Province of Cabo Delgado, 2010a). Most farming is undertaken by households using slash-and-burn practice in a rain-fed regime. The majority of farmers use manual labour as there are no irrigation systems to water the crops.

Table 9.5 ***Agricultural Production in Cabo Delgado Province, 2010***

Crops	Cultivated Area in 2010 (ha)	Production (t)
Food Crops		
Maize	260,959	369,199
Sorghum	129,487	109,307
Rice	67,869	80,428
Pearl millet	9,169	6,418
Beans	112,399	141,588
Groundnuts	77,795	63,705
Cassava	326,432	1,281,316
Sweet potato	11,061	24,752
Horticultural products	6,820	6,584
Cash Crops		
Crops	**Cultivated Area in 2010 (ha)**	**Production (t)**
Cashew	1,305,385*	10,846**
Cotton	35,589	16,453
Sesame	35,019	18,895

Source: Government of the Province of Cabo Delgado, 2010a.

9.7.2 *Transport*

The provincial transportation sector is primarily driven by Pemba port and airport operations, including the transport of cargo and passengers by several medium and small private operators within the province. From a regional perspective, the transportation sector involves linkages mainly with the northern provinces of Nampula and Niassa as well as the Tanzanian border, utilising the natural border provided by the Rovuma River.

The port facilities in Pemba are one of the main points of entry for merchandise in the province and the main point of exports, although some cargo is taken to the province or exported via the port of Nacala in Nampula Province, south of Cabo Delgado. Domestic and international passengers (mostly tourists) arrive daily at Pemba International Airport.

The port and airport are also important logistics points for vessels and aircrafts supporting petroleum and hydrocarbon development activities. The importance of the transport sector in the province's economy (the second-largest contributor) is influenced by the petroleum and hydrocarbon development activities undertaken by international companies operating in

Cabo Delgado Province. This is further discussed in *Section 9.7.7*.

9.7.3 Manufacturing Industry

The manufacturing sector in Cabo Delgado Province is underdeveloped and concentrated in the city of Pemba and the Montepuez and Mueda districts, which together account for 58 percent of all manufacturing ventures in the province. The majority of manufacturing industries are small-scale operations intended for domestic markets. Industries include maize processing, salt production, bread-making and furniture manufacturing. Industries that are export-oriented include the processing of cashew nuts and cotton (see *Table 9.8*).

In 2007/2008, several industrial enterprises discontinued their activities; in particular, the marble factory of Montepuez, along with some industrial units oriented for the production of furniture, processing of juices and dry fruit, and the processing of cashew, textiles and sisal [1] (Government of the Province of Cabo Delgado, 2010c).

(1) The main factors that negatively influence the development of industry in Cabo Delgado Province are the lack of skilled labour, a not-enabling business environment for private operators, lack of supply of goods and associated services and the malfunction of infrastructure, such as the port, and water and energy distribution (Government of the Province of Cabo Delgado, 2010c).

Table 9.6 Industrial Production in Cabo Delgado Province, 2010

Product	Unit	Production
Corn flour	Tonnes	251,752
Salt	Tonnes	13,150
Bread	MZN	72,530,000
Cashew nuts	Tonnes	332
Furniture	MZN	10,250

Key:

MZN: New Mozambican Metical.

Source: Government of the Province of Cabo Delgado, 2010b.

9.7.4 Trade and Exports

Trade in Cabo Delgado Province is not well developed. In 2010, there were 1,466 urban shops and 292 wholesalers, primarily located in Pemba, in the three other municipalities of Montepuez, Mueda and Mocímboa da Praia and in the District centres. In the rural areas, trade and commerce is supported by 960 rural shops and 4,269 rural informal traders and street vendors (Government of the Province of Cabo Delgado, 2010c).

The province is one of Mozambique's main exporters of cotton (raw and seed) and timber (logs and milled timber). In 2009, timber and cotton seed exports yielded 599,722,724 New Mozambican Metical (MZN) (Government of the Province of Cabo Delgado, 2010a). In 2010, the value of the provincial exports increased by 18 percent to 710,829,756 MZN, due to exports of raw cotton and timber. *Table 9.7* shows the volumes of products exported in 2009.

Table 9.7 Provincial Exports in Cabo Delgado Province, 2009

Product	Unit	Quantity Exported
Timber (sawed wood)	m^3	32,908
Timber (wood in logs)	m^3	5,742
Precious stones	kg	17.73
Sea cucumbers	Tonnes	11.88
Cotton seed	Tonnes	10,425
Raw cotton	Tonnes	7,437
Shells (1)	Tonnes	36
Cashew nuts	Tonnes	5.5
Lobster	Tonnes	2

Source: Government of the Province of Cabo Delgado, 2010b.

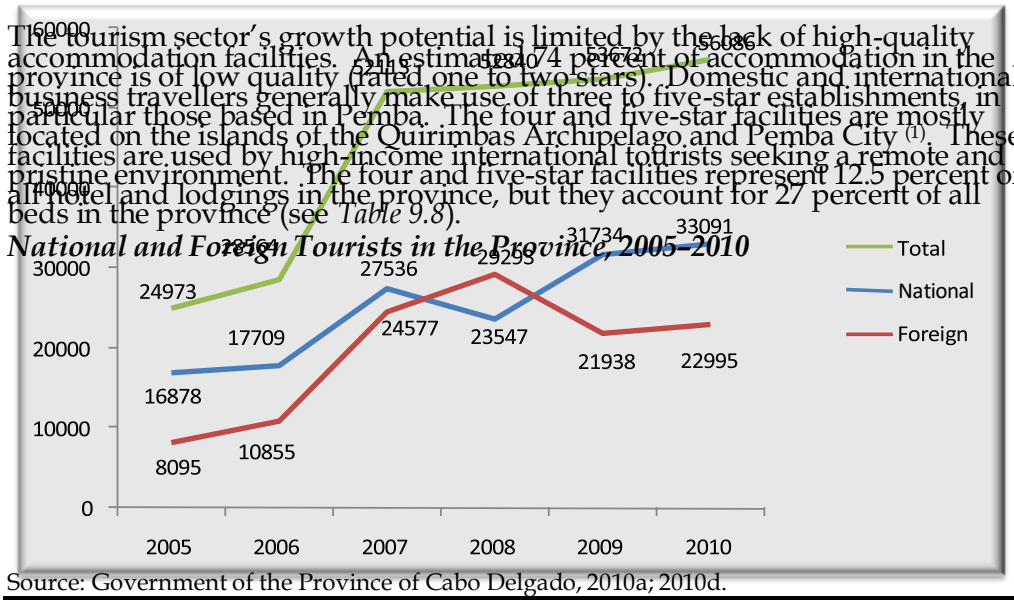
(1) Some shells exported are for ornamental objects, and others as raw material for the construction and garment-related industries.

9.7.5 *Tourism*

Tourism is an important contributor to the provincial economy and has potential for expansion. In 2010, this sector contributed 7 percent to the provincial economy, as well as generating 10 percent in tax revenue. Between 2005 and 2010, the number of national and foreign guests in local hotels and guest houses grew by 125 percent (from 24,973 guests in 2005 to 56,086 guests in 2010) (Government of the Province of Cabo Delgado, 2010a; 2010d). *Figure 9.6* shows that the number of national tourists dropped between 2007 and 2008, but has experienced steady growth until 2010. The number of foreign tourists grew by 269 percent between 2006 and 2008, but decreased between 2008 and 2009 due to the global financial crisis. The sector started showing signs of recovery again in 2010, as shown in *Figure 9.6*.

The tourism sector's growth potential is limited by the lack of high-quality accommodation facilities. An estimated 74 percent of accommodation in the province is of low quality (rated one to two stars). Domestic and international business travellers generally make use of three to five-star establishments, in particular those based in Pemba. The four and five-star facilities are mostly located on the islands of the Quirimbas Archipelago and Pemba City [1]. These facilities are used by high-income international tourists seeking a remote and pristine environment. The four and five-star facilities represent 12.5 percent of all hotel and lodgings in the province, but they account for 27 percent of all beds in the province (see *Table 9.8*).

Figure 9.6 ***National and Foreign Tourists in the Province, 2005–2010***



Source: Government of the Province of Cabo Delgado, 2010a; 2010d.

(1) Out of the nine tourist establishments in the province classified with four and five stars, two are in the city of Pemba and seven in the Quirimbas Archipelago (two in Palma District).

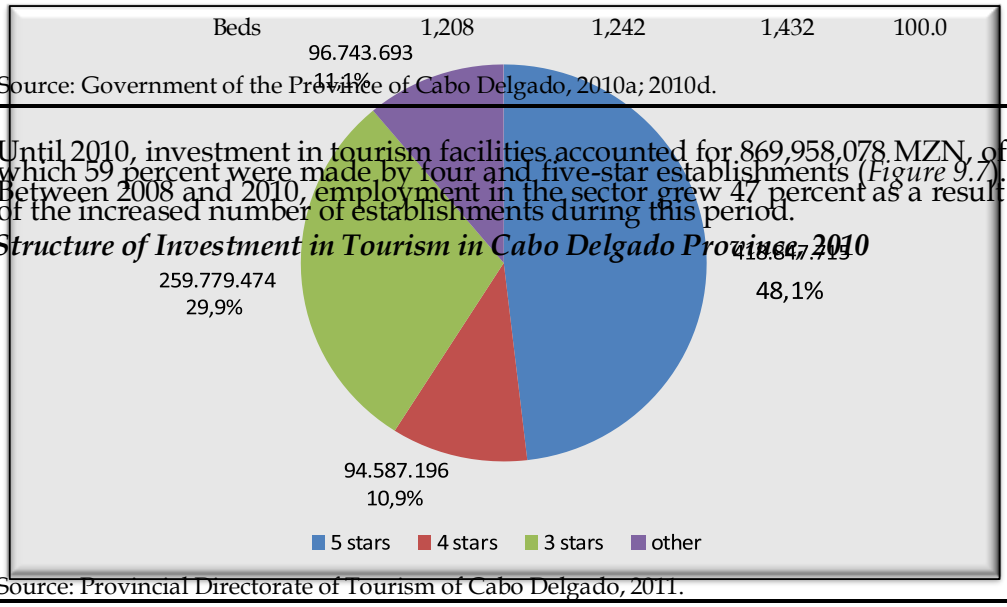
Table 9.8 ***Tourism Accommodation in Cabo Delgado Province, 2008–2010***

Classification	Establishments/ Beds	2008	2009	2010	
				No.	%
Five stars	Establishments	2	2	4	5.6
	Beds	234	234	288	20.1
Four stars	Establishments	4	4	5	6.9
	Beds	74	74	97	6.8
Three stars	Establishments	8	9	10	13.9
	Beds	298	304	338	23.6
Less than three stars	Establishments	47	51	53	73.6
	Beds	602	630	709	49.5
Total	Establishments	61	66	72	100.0
	Beds	1,208	1,242	1,432	100.0

Source: Government of the Province of Cabo Delgado, 2010a; 2010d.

Until 2010, investment in tourism facilities accounted for 869,958,078 MZN, of which 59 percent were made by four and five-star establishments (*Figure 9.7*). Between 2008 and 2010, employment in the sector grew 47 percent as a result of the increased number of establishments during this period.

Figure 9.7 ***Structure of Investment in Tourism in Cabo Delgado Province, 2010***



Source: Provincial Directorate of Tourism of Cabo Delgado, 2011.

In order to grow the tourism sector further, the Government developed the Strategic Plan for Tourism Development in Mozambique (2004–2013). The aim of the plan is to prioritise tourism activities, define products and markets, identify Priority Areas for Tourism Investment (PATIs) and evaluate the tourism resource base and the potential role of conservation for tourism. In Cabo Delgado Province, two PATIs were identified:

- PATI Type A/B of Pemba–Quirimbas; and
- PATI Type B of the Northern Coast of Cabo Delgado [1].

These areas are illustrated in *Figure 9.8*. The Northern Coast of Cabo Delgado PATI includes the Palma District, and has the following key interests that can be developed into tourist attractions:

- culture (art and crafts, dance and other cultural expressions);
- ecology (fauna, flora and forest diversity);
- landscape beauty [Rovuma Bay, Quionga lighthouse, Palma Bay, islands (see *Section 9.3*, Footnote 3), lagoons of Nangade and Lidede, and lowland areas of Palma District];
- water sports (recreational fishing and diving); and
- land-based sports (photo safaris, hunting, fresh-water fishing and canoeing).

(1) The Strategic Plan for Tourism Development in Mozambique (2004-2013) defines PATI A/B as *"destinations with a limited level of tourism development"* and PATI B as *"destinations with a high tourist potential, although undeveloped"*.

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TANZANIA

CABO DELGADO

NIASSA

NAMPULA

Palma

Nangade

Mueda

Muidumbe

Macomia

Ibo

Quissanga

Meluco

Ancuabe

Metuge

Pemba

Mocímboa da Praia

Montepuez

Balama

Chiúre

Namuno

Mecúfi

Legend

- District Centre

Roads

- Primary
- Secondary
- Tertiary

- Afungi Project Site
- Boundary with Tanzania

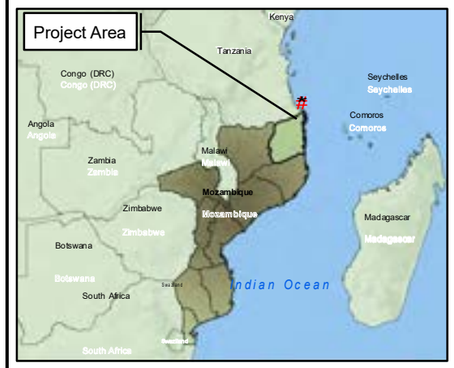
Province

- Cabo Delgado
- Niassa
- Nampula

- District Boundary
- Palma District

- Quirimbas National Park

- Provincial Government Plan - 2009 - 2013
- Priority Areas for Tourism Investment 2004 - 2013 Plan
- Priority Areas for Tourism Investment - Arco Norte Project - 2006 - 2010



MAIN MAP SCALE:

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Figure 9.8:
Priority Areas for Tourism Investment in Cabo Delgado Province

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
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DRAWING: Priority Areas for Tourism.mxd

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Projection: UTM Zone 37 S Datum: WGS84
Source: DIVA-GIS. Impacto, 2012.
Inset Map: Esri Data & Maps

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9.7.6 *Fisheries*

Small-scale Fisheries

Small-scale fisheries is the only subsector of fisheries industry activities contributing to the economy of the province. Other fisheries subsectors are active south of the province and, in terms of commercial activities, industrial tuna fishing takes place beyond 12 nautical miles with no direct contributions to the provincial economy [1].

Small-scale fisheries and fishing industry-related activities are an important part of the provincial population's livelihood activities, especially for those living on the coastal areas – even though its contribution to the provincial economy is low at 6.4 percent. The majority of small-scale fisheries participants are artisanal subsistence fishermen who fish for household consumption (thereby playing an important role in food security for those involved) and sell the surplus locally. Only a small number of artisanal fishermen are more market-oriented, using more appropriate boats, technology and labour.

As shown in *Table 9.9*, small-scale fisheries involve 32,392 fishers, with a gender breakdown of 76 percent male and 24 percent female participants (National Survey of Small-Scale Fisheries, 2007). Of the artisanal fishers, 44 percent fish use boats, 29 percent fish without boats, 22 percent are collectors (eg of shellfish) and five percent are diverse [2]. As previously mentioned, most of the small-scale fishing is undertaken for the purpose of household consumption, and surplus is usually sold to neighbours and at local markets. Some of the major challenges facing artisanal fishers seeking to be more market-oriented are a poor road network for marketing the fish, and a lack of refrigeration for the transportation of fresh produce. Accordingly, most fish is dried or smoked as a means of preservation.

The traded fish catches recorded in 2010 were 2,598t – a growth of 17 percent compared with 2009 (see *Table 9.10*) (Portal of the Government of Cabo Delgado a/b/d). According to the Fisheries Research Institute [3], catches in Cabo Delgado have grown from 11,558t in 2009 to 18,059t in 2011, partially because two additional fishing gears [4] were monitored in 2011. Thus, catch levels by artisanal fishers that use fishing gear in the province seem to be relatively stable during this period, despite more steady growth in the use of beach seine nets (from 5,909t in 2009 to 7,033t in 2011) and surface gill nets (from 2,582t in 2009 to 3,586t in 2011). Statistically, handline fishing remains the fishing gear with a higher fish effort and lower catch rate (13kg/ day),

(1) *Section G2* of *Annex G* provides an overview of the legal framework and government legal approach and strategy for the fisheries sector, focusing specifically on the Small-Scale Fisheries Subsector.
(2) These are the four main categories of fishermen identified by the Small-Scale Fisheries Subsector (National Survey of Artisanal Fisheries, 2007).
(3) The Fisheries Research Institute (IIP) is the national institution responsible for estimating catches, fish effort and capture rates for each fishing gear.

(4) Fishing gear refers to the fishing equipment used (eg seine net, handline).

while encircling gill nets/surrounding pursing nets present a higher catch rate (144kg/day).

Table 9.9 Number of Small-scale Fishers in Cabo Delgado Province

	Men	Women	Men/Women
Total	**24,609**	**7,783**	**32,392**
Fishers with boats	**14,209**	**52**	**14,261**
Permanent	12,666	34	12,700
Occasional	1,543	18	1,561
Fishers without boats	**5,660**	**3,801**	**9,461**
Handline	2,479	16	2,495
Harpoon	1,796	1,082	2,878
Quinias/double stick net (1)	725	2,232	2,957
Gamboas/barrier (2)	470	448	918
Chicocota/stow net (3)	26	23	49
Tarrafa/handcast	164		164
Divers	**1,404**	**6**	**1,410**
Collectors	**3,336**	**3,924**	**7,260**

Source: National Survey of Small-Scale Fisheries, 2007.

Legend:
(1) Small-size net pushed by two persons.
(2) Vertical barrier fixed in the intertidal zone.
(3) Conic net/trap fixed in areas with current.

Table 9.10 Volume of Fish Sold Commercially in Cabo Delgado Province (2008–2010)

	2008 (t)	2009 (t)	2010 (t)
Total	**1,646**	**2,219**	**2,598**
Fish	1,124	1,452	1,507
Shrimp	87	111	131
Lobster	84	142	153
Crab	18	19	26
Sea cucumber	48	83	99
Oyster		79	91
Octopus and squid	195	219	425
Other	91	113	166

Source: Portal of the Government of Cabo Delgado a/b/d.

Industrial and Semi-industrial Fisheries

Cabo Delgado Province and the area where the Project is undertaking its activities in Area 1 and Area 4 has no nationally registered industrial and semi-industrial fishing activities. Nationally, industrial and semi-industrial fishers focus on shallow-water shrimp, deepwater shrimp and line fishing. These types of fishing are mainly confined to the south of latitude 16°S, more than 440km from the southern limit of Area 1 and Area 4.

According to a report from the fisheries sector (Fenessy et al., 2011), in 2010 there were two industrial and 27 semi-industrial line fishing vessels targeting demersal fish (bottom fish) along the Mozambican coast. All these were national vessels, which reported a total catch of 626t in 2010. The catch comprised of slinger (*Chrysoblephus puniceus*), the seabreams (*Polysteganus coeruleopunctatus*, *Cheimerius nufar*), king mackerel (*Scomberomorus commerson*), groupers (*Epinephelus* sp. and others) and grunters (*Pomadasys kaakan*), among other demersal and pelagic fish species. The industrial and semi-industrial sector supplies both the domestic and southern African (mainly South African) markets. These fishers are based mainly in southern Mozambique, a considerable distance from Cabo Delgado Province and Palma District. However, some of these fishers occasionally operate in Area 1 or adjacent to it (in areas such as Beira and Quelimane, and occasionally Angoche in Nampula Province). In addition, there may be some sporadic line fishing north of latitude 16°S, but this is normally limited to water depths of 25 to 200m (Almeida, 2005; Impacto, 2008).

Commercial Tuna Fisheries

The Indian Ocean accounts for 24% of the annual production of tuna in the world, and is considered as the second most important fishing zone worldwide, after west and central Pacific Ocean (ADNAP, 2013). The western region of the Indian Ocean (including Mozambique) is responsible for approximately 80% of all tuna catches in the Indian Ocean (ADNAP, 2013).

The Indian Ocean Tuna Commission (IOTC) [(1)] is an intergovernmental organisation created within the context of Article XIV of the Food and Agriculture Organisation constitution, of which Mozambique has recently become a member. Its mandate consists of managing tuna population units and others of the tuna family *(Thunnidae)* of the Indian Ocean and adjacent zones (Impacto, 2009). There are over 8,000 tuna fishing boats authorized and registered under IOTC (ADNAP, 2013).

Industrial tuna fishing is permitted along the coast east of Cabo Delgado where Area 1 is located, under the framework of the fisheries partnership agreement between the European Union (EU) and the Republic of Mozambique. Under the agreement, 75 EU vessels are allowed to fish off the coast of Mozambique within the EEZ but beyond the 12 nautical mile limit (approximately 21.6km) (*Figure 9.9*). This commercial activity has little impact on the Cabo Delgado economy, as the licences are issued by the Ministry of Fisheries at central government level and the catches remain offshore. The countries covered under the terms of the protocol include Spain, Portugal, France, Italy and Greece, and the main species caught by the EU vessels is tuna. The agreement sets a quota for catches by EU boats of 10,000t of fish per

(1) Contracting parties to the IOTC: European Union, Australia, China, Comoros, Eritrea, Philippines, France(*), India, Iran, Japan, Madagascar, Malaysia, Mauritius, Oman, Pakistan, Kenya, United Kingdom(*), Republic of Korea, Seychelles, Sri Lanka, Sudan, Thailand and Vanuatu.

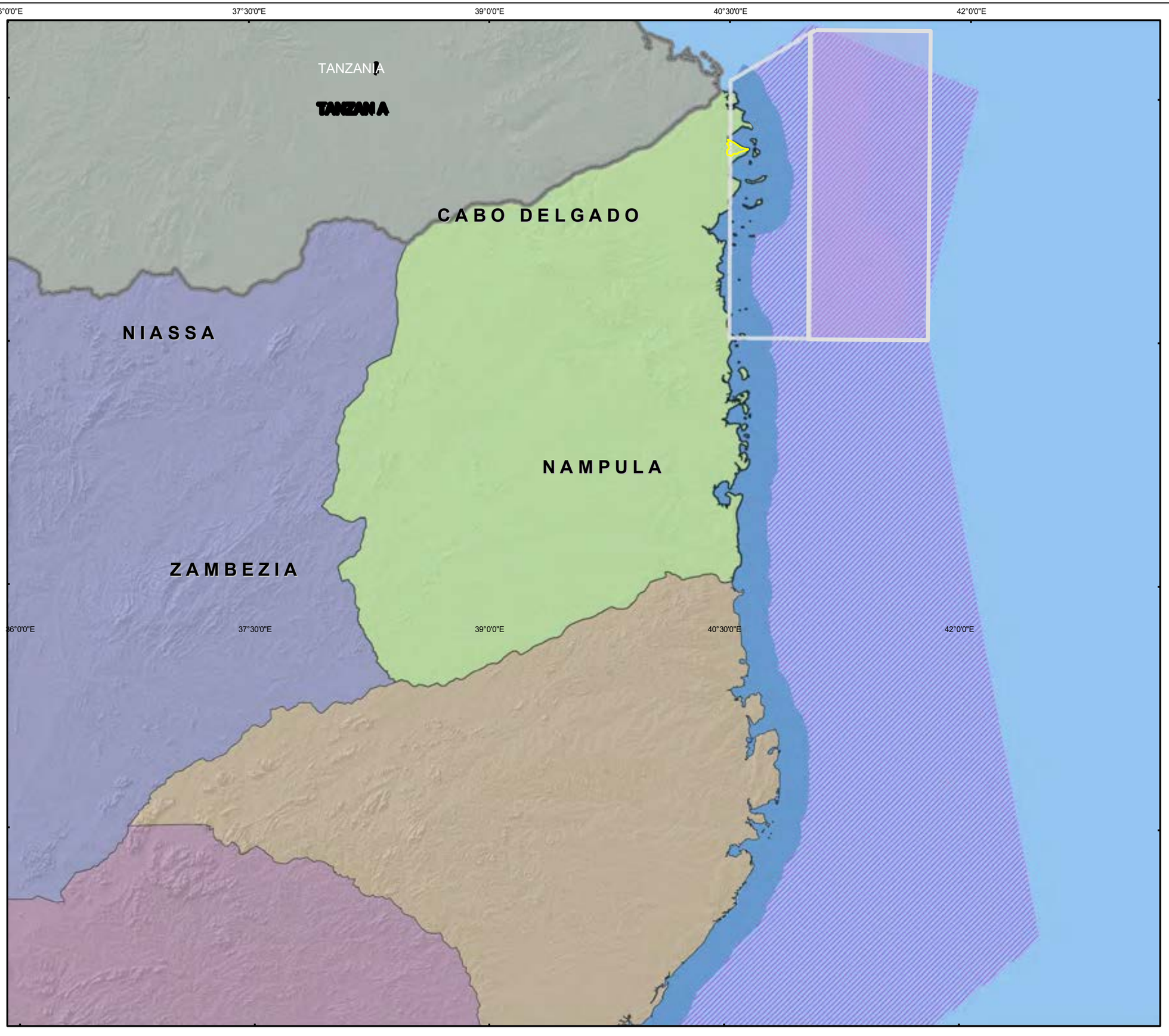
(*) Representing their overseas territories that exist in the region.

annum. Additionally, two other contracts have been signed with tuna associations from Europe and Japan, benefiting 50 vessels (ADNAP, 2013). Commercial fishing therefore takes place under this agreement within the eastern portion of the Area 1. Historically, however, commercial fishing efforts in Area 1 are low compared to the fishing activities in deeper waters further east (Impacto, 2010). Half of the EU fleet comprises longliners and the other half are purse-seiners. Logbook data provided by the EU fleet to the Fisheries Administration of Mozambique show that vessels operate in Mozambique's EEZ four months per year on average. During the remainder of the year, vessels operating in the EEZ are from countries in the West Indian Ocean region, including Mauritius, Madagascar, Seychelles and Comoros. This is due to the fact that tuna is a migratory fish species and fleets pursue

stocks through several EEZs.

In 2012, the Mozambican government granted tuna fishing rights in the 12 miles of its territorial waters and the 200 miles of its exclusive economic zone to the Oceanfresh Seafood Division, a subsidiary of British group Lonrho. The concession has been granted for a period of five years, during which Oceanfresh Seafood Division is authorised to catch 12,000 tons of tuna per year.

According to a report (Impacto, 2008), when the vessels are present in the EEZ, their location depends on the position of the concentrations of target species. This is influenced primarily by the location and abundance of food resources such as small pelagic fish, cephalopods and pelagic crustaceans (Potier et al., 2004). In Mozambique, there is evidence to suggest that the location and abundance of target food resources changes dramatically from year to year. *Figure 9.10* shows the distribution of fishing by the tuna fleet in the Mozambique EEZ, including areas adjacent to Area's 1 and 4.



Legend

- Afungi Project Site
- Boundary with Tanzania

Province

- Cabo Delgado
- Niassa
- Nampula
- Zambezia

- Area 1
- Area 4

- Permitted Fishing Areas for EU Vessels
- Exclusion Zone

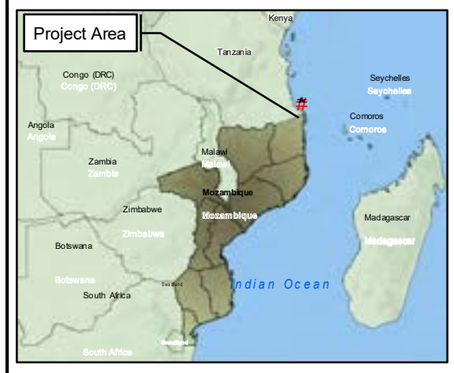


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Figure 9.9:
Industrial Fishery Zone where EU have rights to fish in Mozambique

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 2 500 000

DRAWING: European Union's Industrial Fishery Zone.mxd

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TANZANIA

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ROVUMA ONSHORE
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AREA 1
(AMA1)

AREA 4
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CABO DELGADO

ROVUMA ONSHORE
(AMA1)
AREA 1
(AMA1)
AREA 4
(Eni)

Legend

- Artisanal Fishing Grounds
- Tuna Fishing Grounds (industrial purse-seiners and longliners)
- Concession Areas
- Afungi Project Site
- Boundary with Tanzania

Province

- Cabo Delgado

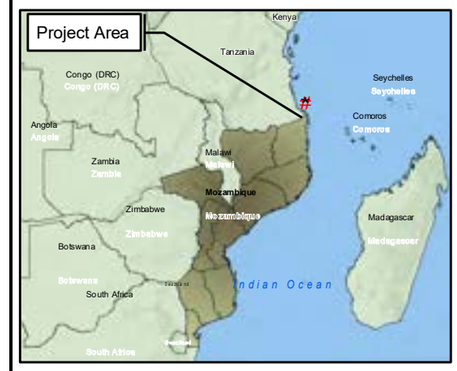

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Figure 9.10:
Distribution of Tuna Fishing Vessels in relation to the Project Area

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 800 000

DRAWING: Distribution of Tuna Fishing Vessels.mxd

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Projection: UTM Zone 37 S Datum: WGS84
Source: DIV-GIS. Impacto, 2012.
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Catches in 2009 and 2010 were estimated at 3,000t per year (*Table 9.11*), which represents a decrease of 54 percent in comparison to 2008 catches (6,549t). The bulk of the tuna catch (60 to 80 percent) comprises yellow fin (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*), similar to global statistics. The remainder of the catch includes other tuna species, shark and marlin. All tuna caught in Mozambican waters is sent to export markets through transhipment operations carried out at sea or in ports of the Seychelles and Mauritius, and therefore do not enter Mozambique.

Table 9.11 Tuna Catch Estimates for the International Fleet Operating in Mozambique in 2009 and 2010

Species	Catch 2009 (t)	2009 (%)	Catch 2010 (t)	2010 (%)
Albacore	100.4	3	86	3
Bigeye	168.8	5	134	5
Yellowfin	805.4	26	1,024	35
Skipjack	1,844.1	60	764	26
Others	168.3	5	933	32
Total	3,087.0	100	2,941	100

Source: Compiled from National Fisheries Administration database (ADNAP).

Other Industrial Fisheries

Deepwater shrimp fisheries are located approximately 600km from Area 1and Area 4, in the Sofala Bank, which begins on the coast near Angoche in Nampula Province, and extends to the Save River south of the city of Beira, on the border between Sofala and Inhambane provinces. These fishers catch between 800 and 1,000t of shrimp per annum, while the shallow-water shrimp fishers catch an average of 5,000 to 8,000t per annum.

At the moment, there is no tuna processing industry in the country and all benefits only come from fishing licenses taxes. Recognizing the importance of tuna fishing for Mozambique and aiming at maximizing the benefits for the country, the Council of Ministers approved The *Plano Estratégico de Desenvolvimento da Pescaria de Atum em Mocambique* (PEDPA) (Strategic Development Plan for Tuna Fisheries), on July 2013 in their 22nd Ordinary Session (See *Annex G, Section G1.3*). Some of the key actions of this strategic plan include:

For the small-scale fisheries:

- Directing semi-industrial and artisanal fisheries to the catching of tuna and similar species.
- Establishment of fishing gear appropriate for tuna.
- Promotion of the consumption of fresh tuna and its by-catch.
- Development of tuna storage and processing infrastructures.

For industrial fisheries:

- Establishment of a local industry to process tuna, in the main ports of Mozambique (such as Nacala for the purse seiners and Maputo for the longliners), which would also contribute with taxes from exportation.
- Promotion of the use of local ports for transhipment and off-load , using part of the catch for local consumption.
- Promotion of the consumption of fresh tuna and its by-catch.
- Promotion of a national industrial tuna fleet or international fleet based in Mozambique.
- Make it compulsory to off-load part of the tuna by-catch in the national ports.

9.7.7 Exploration and Production of Hydrocarbons

Between 2005 and 2006, the Government of Mozambique started creating concession blocks for onshore and offshore hydrocarbon exploration in the Bacia do Rovuma (Rovuma Bay). Since then, several international companies have conducted seismic surveys in many of the blocks (see *Figure 9.11*), which have identified significant natural gas reserves.

To date, the positive effects of hydrocarbon exploration and production in the country, on the economy, have been mostly observed at a central government level where applications for permitting for various activities and for payments are directed. *Table 9.12* below summarises the types of fees required by companies undertaking reconnaissance and exploration activities in the minerals, petroleum and natural gas sectors in different development phases of a project. These include the breakdown of licence fees, production fees (royalties) and other taxations (EITI – the Extractive Industry Transparency Initiative, 2008).

Table 9.12 Relevant Taxes and Fees Required for Mineral and Hydrocarbon Exploration and Production Company Activities to the Government of Mozambique

Payments	Mineral Sector	Oil and Gas Sector
Licence fee	Reconnaissance Prospecting and surveying Mining concession Mining certificate	Reconnaissance Exploration Oil and gas pipelines
Surface tax	Depending on area	N/A
Royalty	3–10%	Gas: 6% Oil: 10%
Taxation on profit (IRPC)	-	32%
Taxation on contracted labour (IRPS)	Variable	Variable
Dividends	If government is a shareholder	If government is a shareholder

Source: EITI, 2008.

Table 9.13 below presents the contribution of large-scale mineral, petroleum and hydrocarbon development projects to the total revenue in Mozambique. Between 2008 and 2011, the revenue generated from exploration and other resource development-related activities increased from 2,144.3 to 2,803.3 million MZN (Bank of Mozambique, 2009; 2010; 2011). Most important to note is that contribution of the oil and gas sector within the megaprotects contribution has increased substantially, from 8.2 percent in 2008 to nearly 30 percent in 2011.

Table 9.13 Contribution of Megaprojects to National Revenue 2008–2011

	2008		2009		2010		2011	
	Million MZN	%	**Million MZN**	%	**Million MZN**	%	**Million MZN**	%
Energy production	455.4	21.2	786.0	50.5	1,374.5	45.4	778.4	27.8
Oil and gas exploration	176.6	8.2	133.6	8.6	833.8	27.6	836.1	29.8
Mineral resources exploration	965.2	45.0	233.7	15.0	341.4	11.3	746.1	26.6
Other	547.2	25.5	404.5	26.0	476.4	15.7	442.7	15.8
Total megaprojects	**2,144.3**		**1,557.8**		**3,026.1**		**2,803.3**	
Total country	**39,190.1**		**47,565.0**		**63,566.1**		**81,119.2**	
Megaprojects contribution (%)	**5.5**		**3.3**		**4.8**		**3.5**	

Source: Bank of Mozambique.

This data is not separated according to the relevant contributors (eg licences, royalties, taxation) through all period reported, or to the revenue distribution that took place at provincial government level.

At provincial level, the effects are felt in some sectors providing services to ongoing petroleum and hydrocarbon exploration activities, such as the port and airport of Pemba, cargo transporters, wholesaler suppliers (food, fuel and other) and tourism operators (accommodation and restaurants) (1).

According to the International Monetary Fund (IMF), the contribution of the megaprojects to the growth of the national added value (2) between 2003 and 2010 was 4 percentage points (IMF, 2011). It is estimated that between 2013 and 2015, the growth will range from 8 to 11 percent, a 3 percent increase due to megaprojects (3).

At a District level, the positive effects of hydrocarbon and petroleum exploration and development activities occur primarily through the procurement of local goods and services in both the Palma District and the northern Cabo Delgado region. Employment opportunities to date have

(1) In its 2010 annual report, the Government of Cabo Delgado identifies a growth of 253% in the movement of ships in the Port of Pemba, due to oil and gas activities (Portal of the Government of Cabo Delgado).
(2) National added value is defined as the difference between the gross product of a sector of activity and the cost of its intermediate factors.
(3) Megaprojects considered by IMF analysis were the production and distribution of electricity, aluminum production, natural gas extraction, coal extraction, and other mining projects.

largely been focused on unskilled casual labour for onshore exploration activities and some activities supporting Afungi Project Site activities. The Project has been careful to ensure that employment opportunities have specifically targeted men and women from communities directly impacted by Project activities.

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TANZANIA

Palma

! Nangade

Nangade

Palma

Mocímboa da Praia

! Mocímboa da Praia

ROVUMA ONSHORE (AMA1)

AREA 1 (AMA1)

AREA 4 (Eni)

Mueda

! Mueda

ROVUMA ONSHORE (AMA1)

Muidumbe

! Muidumbe

Macomia

! Macomia

! Ibo

! Quissanga

CABO DELGADO

! Meluco

AREA 2 (Statoil)

AREA 5 (Statoil)

NIASSA

Ancuabe

! Ancuabe

Metuge

! Pemba

! Montepuez

! Balama

! Chiure

AREA 3 (Petronas)

AREA 6 (Petronas)

! Namuno

NAMPULA

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Legend

- District Centre
- Capital City of Cabo Delgado
- Seismic Line

Roads

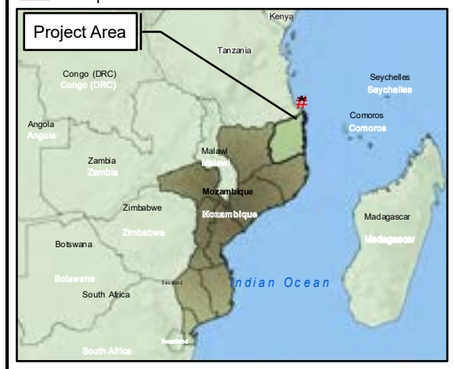
- Primary
- Secondary
- Tertiary
- Local
- Non Classified

- Concession Areas
- Afungi Project Site
- Boundary with Tanzania

- District Boundary
- Palma District

Province

- Cabo Delgado
- Nassa
- Nampula



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 9.11:
Blocks in Rovuma Basin established for Hydrocarbon Exploration & Production

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 1 500 000

DRAWING: Blocks in Rovuma Bay.mxd

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T:\GIS Projects\

Projection: UTM Zone 37 S Datum: WGS84 Source: DIVA-GIS. Impacto, 2012. Inset Map: Esri Data & Maps	SIZE: A3

14°0'0"S 10°30'0"S 11°0'0"S 11°30'0"S 12°0'0"S 12°30'0"S 13°0'0"S 13°30'0"S

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14°0'0"S 10°30'0"S 11°0'0"S 11°30'0"S 12°0'0"S 12°30'0"S 13°0'0"S 13°30'0"S

9.8 PALMA DISTRICT POLITICAL AND ADMINISTRATIVE ORGANISATION

9.8.1 Palma District

Mozambique is politically and administratively divided in 11 provinces, and each province into districts. The Government of Mozambique follows this geographical division with a central government based in Maputo comprising different sector ministries, as well as a provincial government based in each province capital, which also comprises different sector provincial directorates.

Palma District is located in the north-east of Cabo Delgado Province, as shown in *Figure 9.1*. The District is bordered by the Rovuma River to the north (which also forms the border with Tanzania), Nangade District to the west, Mocímboa da Praia District to the south, and the Indian Ocean to the east.

Palma District is comprised of four Administrative Posts, six Localities and several villages, as outlined in *Table 9.14* and illustrated in *Figure 9.2*. The Afungi Project Site falls within the Palma Administrative Post and Mute Locality (1). The District's administrative area extends to the nine islands (2) off the coast of the District, each of them belonging to an Administrative Post (depending the island's geographical position).

Table 9.14 District of Palma Administrative Posts and Localities

Administrative Posts	Localities
Palma	Palma-Sede, Mute
Olumbe	Olumbe-Sede, Quissengue
Pundanhar	Nhica do Rovuma
Quionga	Quirinde

The Palma District's present political and administrative structure is a result of the decentralisation process started by the Government of Mozambique in 2000, which reorganised the State at local level (3) and began the integration of community authorities in the local political organisation. *Annex G* provides some historical context and background information about this political and administrative organisation; in particular, the community organisation and the legal framework.

Figure 9.12 illustrates the political and administrative organisation structure of Palma District, considering the levels of the territory (from the District down to the village level) and the different structures and representatives involved

(1) The mapped boundaries of the Administrative Posts of Palma and Olumbe do not match the actual boundaries. The database used for preparing maps comes from an official source (CENACARTA) but, in the case of these two Administrative Posts, there are discrepancies when compared to the actual boundaries, as observed during the Social Assessment and confirmed by District authorities. There are no signs that these discrepancies correspond to disputes between the two Administrative Posts.
(2) Four are considered to be 'big islands' (Tecomaji, Rongui, Vamizi and Metundo), and five are 'small islands' (Quifuqui, Queramimbi, Quissingula, Vumba and Suavo).
(3) Law No. 8/2003 of the Local State Bodies – LOLE, Decree No. 11/2005, Regulation of the LOLE, and Decree No. 11/2012, which revises Law No. 8/2003 dated 19 May. Also note that except for the Mayors of the Municipalities, who are elected, the other bodies of local government are appointed in accordance with the rules of the State apparatus.

in district-level government administration (government/state bodies/community and consultative authorities) (1).

Figure 9.12 ***Political and Administrative Organisation of Palma District***

Level of Territory	Government	State Apparatus	Community Authority	Civil Society Community Management	Consulting Structure
District	Administrator Permanent Secretary District Services Directors	Administrator Office District Secretariat District Services			District Consulting Council
Administrative Post	Chief of Administrative Post	Administrative Secretariat		Local Forums	Administrative Post Consulting Council
Locality	Chief of the Locality	Administrative Secretariat		Community Comitees	
Village	Chief of Village	Administrative Council	Village Leader (3rd level); Assistant to Village Leader Chiefs of Zones	Comunity Comittees	

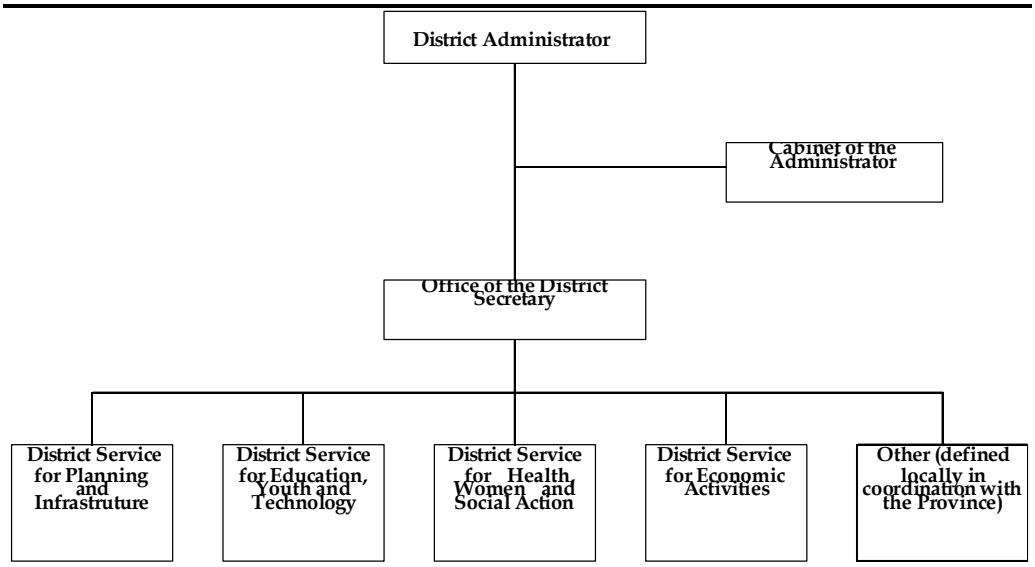
Source: Impacto, 2012.

The District is headed by the District Administrator and supported by a Permanent Secretary and Directors of the District Services (*Figure 9.13*). The minimum number of directors assisting the District Administrator is four, including the Director of Planning and Infrastructure; Director of Economic Activities; Director of Education, Youth and Technology; and Director of Health, Women and Social Affairs. The organisation structure of the services that compose the District's administrative system is illustrated in *Table 1.4* in *Annex G.*

Until the publication of the Decree No. 11/2012, formal state authority at district level ended at the locality level, but it has since been extended to the village level through the appointment of Village Chiefs by the District Administrator. Mute Locality is currently managed by the Locality President, a position that existed prior to the approval of Decree No. 8/2003 and Decree No. 11/2005. Some of these positions are considered to be political and, therefore, there is a strong link (formal but not defined in legal terms) between the party in power and the four levels of local state government.

(1) Blank cells in the community authority structure mean that they apply in the case of Palma District, while in the case of the consulting structure they are not foreseen.

Figure 9.13 Structure of Governance in Palma District



Source: Impacto, 2012 (based on Decree No. 6/2006 approved by the Council of Ministers).

Below the district government level, formal governing structures comprise, in hierarchical order, Chiefs of Administrative Posts, Chiefs of Localities and Chiefs of Villages, each of which supersedes the administrative levels below them, as shown in *Figure 9.12*.

9.8.2 *The Afungi Project Site and Surrounds (including Senga and Maganja)*

At the time of the baseline surveys, there was no state authority based in the villages within the Afungi Project Site and Surrounds. Community authorities were represented by a Village Leader and assistant, as observed in Quitupo, Senga and Maganja villages. Each of these villages has some scattered settlements headed by a Chief of Zone, who reports to the related Village Leader.

9.9 *PALMA DISTRICT AND AFUNGI PROJECT SITE: SOCIO-DEMOGRAPHIC INDICATORS OF THE AREA OF DIRECT INFLUENCE*

9.9.1 *Demographic Profile*

Palma District

With a surface area of 3,576km^2 and a population density of 13.5 inhabitants/km^2, Palma District had a population of 48,318 inhabitants in 2007, representing 3 percent of the total population of Cabo Delgado Province. *Table 9.15* provides an overview of social indicators for Palma District. The most recent census data available is from the 2007 Census, published in 2010 by the INE.

Table 9.15 Socio-demographic Indicators of Palma District in 2007

	Palma District (%)	Cabo Delgado Province (%)
Number of persons per household	3.71	4.1
Women	50.1	51.6
Urban population	0.0	20.8
Rural population	100	77.6
Demographic density	13.5	19.4
Population growth 1997–2007	1.37	1.9
People aged 15+ not completing any education level	88.13	81.28
With electricity	0.6	3.3
Piped water	0.2	5.0
With a borehole, well or pump	27.6	24.8
With a septic tank with improved latrine	1.2	3.05

Source: Government of the Province of Cabo Delgado, 2010e.

In Palma District in 2007, women accounted for 50.1 percent of the population (INE, 2010e). The District is rural; the villages are small and subject to an insignificant degree of urbanisation, the only exception being Palma town, the District centre that in the past years has experienced some growth in the upper town along the national road [1]. The average number of people per household was 3.71, which was lower than the average size of households throughout the province. This difference may be related to the rural character of the District; in rural areas, early marriage is common causing people to leave home at a young age [2] (*Sections 9.2.1* and *9.13.1* present more discussions on this matter).

Afungi Project Area and Surrounds (Including Senga and Maganja)

Based on the Household Survey undertaken in January 2012 as part of the Social Assessment, the average household size in the Afungi Project Site and Surrounds (including Senga and Maganja) is 4.1 persons. There are more women than men in the area (52.2 percent and 47.8 percent respectively). Wives are typically an average of 10 years younger than their husbands, reflecting early marriages among women. Approximately 91 percent of households have a male head of household, and only 9 percent have a female head of household. This is a low level of female representation when compared to the provincial level, where a female head of household accounts for 29 percent of households.

Table 9.16 presents a summary of some demographic indicators considered for the Afungi Project Site and Surrounds (including Senga and Maganja) and compares them with Palma District data from the 1997 Census.

(1) Nevertheless, in the 2007 Census, the INE considered Palma town as rural and classified the District as 100 percent rural.
(2) Throughout the fieldwork conducted in November 2011 and January 2012, the socio-economic team noted a number of initiation rites of young females, which mark their passage into adulthood.

Table 9.16 Socio-demographic Indicators of Surveyed Households in the Afungi Project Site and Surrounds (Including Senga and Maganja)

Indicator	Afungi Project Site and Surrounds (2012 Household Survey)	Palma District (1997 Census)
Average number of people in the household	4.14	3.71
Average number of men	1.98	1.85
Average number of women	2.16	1.86
Women (%)	52.20	49.90
Rural population (%)	100.00	100.00
Demographic density	38.30	13.50
Average age of head of household	47	-
Average age of wives	37	-
With electricity (%)		
With piped water (%)	0.00	0.00
With borehole, well or pump (%)	62.10	27.60
With septic tank with improved latrine (%)	0.00	3.05

Source: Impacto, 2012; INE (Palma District Census Data), 2010.

The population of the Afungi Project Site and Surrounds (including Senga and Maganja) is relatively young, with 39 percent of the population being under the age of 14 years. The remainder of the population (15+ years of age) accounts for 61 percent (*Figure 1.1* in *Annex G*).

9.9.2 Population Distribution

Palma District

The population of the District tends to be concentrated in the coastal areas (*Table 9.17* and *Figure 9.14*). Palma and Olumbe (south of Palma town), located on the coast, are the most populated Administrative Posts: 54 percent of the District population is located in Palma Administrative Post, with Olumbe the second-most populated at 26 percent.

In 2007, the Administrative Post of Palma had a higher population density than the District, with 28.6 residents/km^2 versus 13.51 residents/km^2 in the District in 2007, followed by Quionga with 10.4 residents/km^2, and Olumbe with 10 residents/km^2. The inland Administrative Post of Pundanhar had the lowest population density (4.2 residents/km^2) within Palma District. The larger concentrations of people occur in Palma town and the villages of Olumbe, Maganja, Quiwia and Quionga.

Table 9.17 Population Density by Administrative Post (2007)

District/ Administrative Post	Total Population	Surface Area (km²)	Population Density
District	48,318	3,576	13.5
Palma	26,073	921.6	28.6
Olumbe	12,549	1,251.3	10.0
Pundanhar	3,349	795.9	4.2
Quionga	6,347	609.3	10.4

Source: INE, 2010f.

The population of Palma District grew by 1.37 percent per year between 1997 and 2007, as shown in *Table 9.18*. This is lower than the 1.9 percent reported for the province. The growth rate of Cabo Delgado Province is impacted by the growth rates of urban areas, such as the City of Pemba and other municipalities within the province. According to the forecasts for 2012, the population is 41,438 inhabitants, corresponding to a growth of 1.26 percent between 2007 and 2012 – a slight decrease compared with the preceding period (INE, 2009g; 2010h) (1).

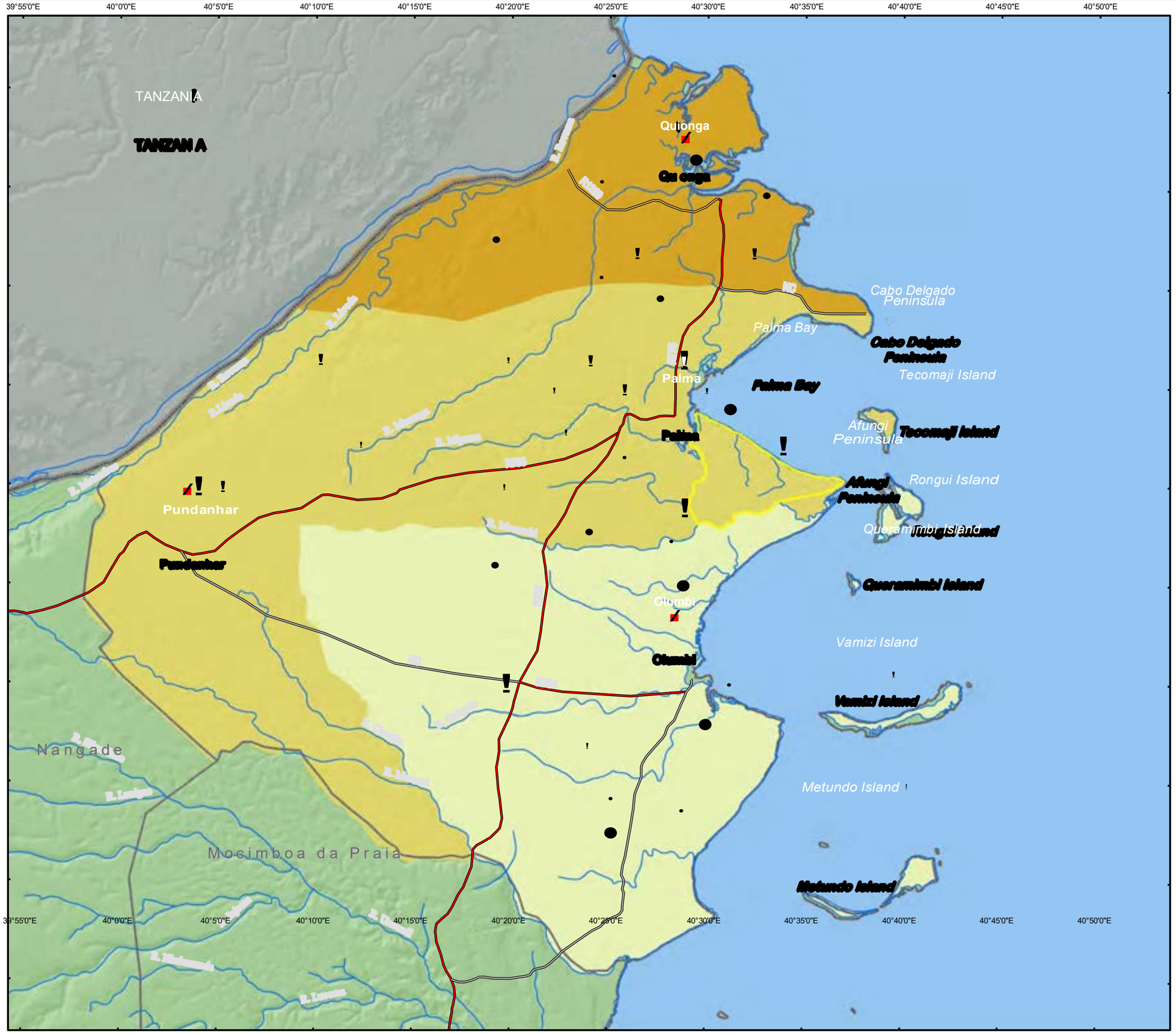
As illustrated in *Table 9.18*, population growth fluctuated in the Administrative Posts and in the respective Localities between 1997 and 2007 (2). In the Administrative Posts of Palma and Pundanhar, the growth was above the provincial average, at a rate of 2.4 and 3 percent respectively. For the Mute Locality, population growth was higher, at 3.5 percent. In the Administrative Posts of Olumbe and Quionga, growth was below average and even negative in the case of Olumbe (-0.4 percent). In the Locality of Quissengue, there was negative growth of 2.1 percent.

(1) The INE only provided the rate of growth projected for the period 2007 to 2012 for the District level. The population numbers projected for the year 2012 by Administrative Post and town were calculated by applying, in a linear manner, the rate of growth of 1.26 percent projected by the INE for the District.
(2) The existing information does not allow any analysis of the reasons explaining the variations between the Administrative Posts and towns. There are several factors that could explain the different growth rates.

Table 9.18 Population of Palma District (1997–2012)

Administrative Post	Locality	1997 Census			2007 Census				2012 Projection			
		Total	Men	Woman	Total	Men	Women	Growth Rate	Total	Men	Women	Growth Rate
Palma	Palma-Sede	13,131	6,635	6,496	15,673	7,664	8,009	1,8	16,685	8,308	8,377	
	Mute	7,395	3,651	3,744	10,400	5,133	5,267	3,5	11,072	5,513	5,558	
	Total PA	20,526	10,286	10,240	26,073	12,797	13,276	2,4	27,757	13,822	13,935	
Olumbe	Olumbe-Sede	7,315	3,543	3,772	7,598	3,691	3,907	0,4	8,089	4,028	4,061	
	Quissengue	6,140	3,259	2,881	4,951	2,784	2,167	-2,1	5,271	2,625	2,646	
	Total PA	13,455	6,802	6,653	12,549	6,475	6,074	-0,7	13,359	6,652	6,707	
Pundanhar	Nhica do Rovuma	2,489	1,277	1,212	3,349	1,631	1,718	3,0	3,565	1,775	1,790	
	Total PA	2,489	1,277	1,212	3,349	1,631	1,718	3,0	3,565	1,775	1,790	
Quionga	Quirinde	5,712	2,860	2,852	6,347	3,192	3,155	1,1	6,757	3,365	3,392	
	Total PA	5,712	2,860	2,852	6,347	3,192	3,155	1,1	6,757	3,365	3,392	
DISTRICT TOTAL		**42.182**	**21.225**	**20,957**	**48,318**	**24,095**	**24,223**	**1,37**	**51,438**	**25,614**	**25,824**	**1,26**

Source: INE, 2009g; 2010h.



Legend

- District Centre
- Administrative Post Centre
- Rivers

Roads

- Tertiary
- Local
- Non Classified

- Afungi Project Site
- Boundary with Tanzania
- District Boundary

Province

- Cabo Delgado

Population Density

- < 500
- 501 - 1000
- 1000 - 5000

Population Density (Hab/km^2)

- 1 - 2
- 3 - 4
- 5 - 11

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 9.14:
Population Distribution in Palma District

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 330 000

DRAWING: Population Distribution in Palma District.mxd

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Locality of Mute

The Afungi Project Site is located in Palma Administrative Post in the Locality of Mute [1], south-east of Palma town (*Figure 9.2*). Mute Locality is composed of several villages, most of which are located along the R762 road (running from Mocímboa da Praia to Palma town). Other villages are located along the non-classified road, starting at the intersection of the R762 road and running in an easterly direction towards the village of Maganja, located on the coast, south-east of the Afungi Project Site (*Figure 9.15*).

Figure 9.2 shows the more important villages that are part of Mute Locality, although physical boundaries are not already mapped, as explained.

According to local authorities, in 2012 the population [2] of Mute Locality was approximately 16,473, representing roughly 32 percent of the District, as shown in *Table 9.19* below.

Mute Locality has the second-highest population in the District after the Palma-Sede Locality. The high growth of the population is attributed to migrants who started to settle in the Locality in the period 1997 to 2007, and continued thereafter. According to the local authorities, this in-migration is due to the agricultural and fishing potential in the area [3]. At the time of the field baseline surveys, there were seven production zones (agricultural areas) that were home to a population of 3,447 people, including both permanent and seasonal residents (see *Table 9.19*).

Table 9.19 Population of Mute Locality

Mute Locality	**Census 1997**				**Mute Locality 2012**				**Main Languages Spoken**
	Total	**Men**	**Women**	**Households**	**Total**	**Men**	**Women**	**Households**	
Total	**6,906**	**3,405**	**3,501**	**1,847**	**16,473**	**7,937**	**6,536**	**4,607**	
Mute-Sede	927	453	474	240	3,681	1,597	2,084	657	Chimakonde
Quitupo	1,770	882	888	473	1,510	791	719	891	Makue, Kimwani
Senga	460	237	223	119	360	170	190	210	Chimakonde
Maganja	1,442	677	765	388	1,900	1,066	834	526	Kimwani, Makue
Macala	435	224	211	115	213	109	104		Makue
Muangaza	554	269	285	143	660	340	320	350	Chimakonde
Manguna	673	334	339	182	3,625	1,725	1,900	725	Makue
Matapata	355	191	164	102	945	470	475	144	Makonde
Nkalanga	290	138	152	85	132	60	72	77	Makue
Settlements in agriculture areas (production areas)					**3,447**	**1,609**	**1,838**	**974**	

(1) The administrative boundaries of Mute Locality (or any other Localities in the country) have not been mapped.

(2) For the purpose of this report, data provided by local authorities are used as they provide disaggregated data. However, it should be noted that the data are based on best estimates.

(3) Note that even people resident in villages and settlements relatively far from the coast (sometime up to 10km) can go to the coast to fish and come back after some time. This was evident during interviews held in Mute Locality, Quitupo and Senga.

Mute Locality	Census 1997				Mute Locality 2012				Main Languages Spoken
	Total	Men	Women	Households	Total	Men	Women	Households	
Total	**6,906**	**3,405**	**3,501**	**1,847**	**16,473**	**7,937**	**6,536**	**4,607**	
Zambia					35	16	19	19	No information
Nguco					1,420	700	720	172	No information
Nacache					42	21	21	20	Chimakonde
Namalala 2					400	190	210	237	Chimakonde
Patacua					223	111	112	70	Makue
Mapalangan ha					185	80	105	105	Chimakonde
Nkumbi					1,142	491	651	351	Chimakonde

Source: Data gathered at Mute Locality, as the 2007 Census does not have village level population data.

The Afungi Project Site and Surrounds

The Afungi Project Site is geographically located on the Afungi Peninsula and covers an area of 7,000ha. *Figure 9.15* shows the Afungi Project Site and Surrounds, which includes three villages – Quitupo within the Afungi Project Site, and Senga and Maganja in close proximity to the Afungi Project Site (at distances of 0.88 and 1.88km respectively) – included in the Household Survey carried out for the socio-economic baseline (see *Section 9.4.1*).

There are other smaller settlements, generally considered as belonging to the main villages, which were consulted and included during the village mapping and Household Survey activities (see *Figure 9.15*). These settlements or areas comprise:

- **small scattered settlements located near agricultural areas** (1 where some households live on a permanent and/or a seasonal basis. Most of them are located around Quitupo Village, occupying highland areas located near lowland areas;
- **coastal settlements with fishing centres** (located on the coast), such as Milamba 1 and N'semo/Quibuidju. In these settlements, some households reside on a permanent basis, engaging in agriculture and other activities such as informal trade and handicraft production, in some cases combining these activities with fishing. These settlements also happen to include a fishing centre (with permanent and seasonal fishermen and fish traders); and
- **fishing centres,** such as Milamba 2 and Ngodje. These specific fishing centres are mainly settlements of fishers, where fishers and fish traders live on a permanent or seasonal basis.

(1) As stated previously when describing the Mute Locality, those settlements are locally called production zones.

Table 9.20 below shows the main settlements and population distribution within the Afungi Project Site boundaries in 2012, estimated at 2,733 individuals who make up 743 households [1] - that is an estimated 38.3 persons/km^2 representing 5.3 percent of Palma District.

The population residing in the fishing centre of Ngodje, in the settlement with a fishing centre of Milamba and in the settlements near agricultural areas (production zones) belong administratively to the Village of Quitupo, while the population in the settlement with a fishing centre of N´semo/Quibundju and Patacua (production zone) are accounted for separately.

Table 9.20 Population Distribution in the Afungi Project Site

Residential Zone	No. of Permanent Residents	No. of Households
Village of Quitupo and scattered settlements (production zones)	1,022	273
Settlement with fishing centre of Milamba	488	130
Scattered settlement of Patacua (production zone)	223	70
Settlement with fishing centre of N´semo	1,000	269
Total	2,733	743

Source: Impacto, 2012, from village leaders.

(1) The number of households was recalculated using the average number of households observed in Quitupo, according to Census 1997 data, as the figure presented by the Mute Locality authorities for the number of households did not seem consistent. However, when cross-checking figures from Mute Locality with those provided by Quitupo Leaders, the number of total inhabitants matched the number provided by the Quitupo Village Leader.

40°30'0"E

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Porto de Palma

Palma

Ngodje

Ngodje

Palma Bay

Barabarane

Ntaunadje

Milamba 2

Milamba1

Quitupo

Nambuimbui

Nsemo/Kibundju

Nacabande

Nfunzi

Afungi Peninsula

Quidjeri

Quitunda

Nsenga

Namacande

Maganja

Patacua

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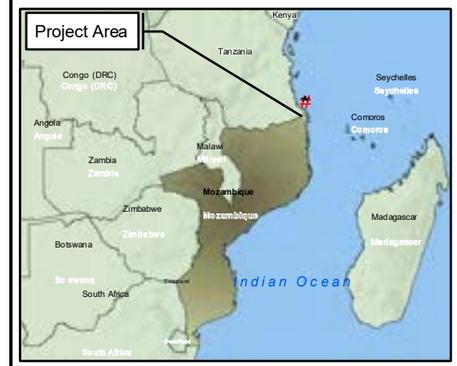
40°30'0"E

40°35'0"E

Legend

- Villages
- Settlement (production zone)
- Settlement with Fishing Centre
- Fishing Centre
- Local Roads
- Regional Roads
- Afungi Project Site



MAIN MAP SCALE:

Kilometers

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Figure 9.15:
Settlements in the Afungi Project Site and Surrounds (including Senga and Maganja)

CLIENT:

Anadarko
Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 52 000

DRAWING: Settlements in the Afungi Project Site and Surrounds.mxd

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9.9.3 Ethnolinguistic Groups

Palma District

Current INE/Census, Provincial or District-level data was unable to provide details on the languages spoken across the Palma District. However, the Social Assessment was able to identify the main languages spoken in villages that form part of Mute Locality (see *Table 9.21* above), and include Kiswahili, Kimwani, Cimakwe and Shimakonde [1].

Afungi Project Site and Surrounds (Including Senga and Maganja)

During the Household Surveys, ethnolinguistics in the Afungi Project Site and Surrounds were analysed based on the main languages spoken by heads of the household, and are presented in *Table 9.21*. The most dominant languages spoken are Cimakwé (54.3 percent), followed by Kimwani (20 percent) and Shimakonde (12.9 percent). A small portion of the population speaks Kiswahili (7.1 percent) and Emakhua (4.3 percent).

Table 9.21 Native Language of the Heads of Surveyed Households

Native Language	Quitupo (%)	Quitupo Settlements (Production Zones) (%)	Coastal Zone (%)	Senga (%)	Maganja (%)	Total (%)
Kiswahili	5.8	25.0	-	-	10.0	7.1
Kimwani	3.8	25.0	4.5	5.0	66.7	20.0
Cimakwé	86.5	37.5	86.4	10.0	13.3	54.3
Shimakonde	1.9	-		85.0	-	12.9
Emakhua	1.9	6.3	9.1	-	6.7	4.3
Other	-	6.3	-	-	3.3	1.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Impacto, 2012.

Each of the villages and settlements in the area can be characterised by their various ethnolinguistic groups, and are described below.

- **Quitupo Village and the Coastal Zone**: Cimakwé is the most dominant language (87 percent), followed by Kiswahili (5.8 percent) and Kimwani (3.8 percent). In the Coastal Zone approximately 9 percent of the households speak Emakhua, due to the migration of people into the area (permanently and seasonally).
- **In Quitupo Settlements (production zones):** 37.5 percent of the heads of households speak Cimakwé, but there are other groups found in large numbers, such as the Kiswahili and Kimwani (25 percent each).

(1) Note that the spelling of the name of the ethnic group and the language spoken is slightly different. Generally, the name of the language holds a prefix that corresponds to the article 'the' ('ki' for 'mwani' or 'ci' for 'makwé', for example).

- **Senga Village**: the dominant language is Shimakonde (85 percent), followed by the Cimakwe (10 percent) and Kimwani (5 percent). This indicates in-migration of the Makonde group to the coast from the Mueda highlands, where this group is predominant [1].

- **Maganja Village**: the dominant language is Kimwani (66.7 percent), followed by Cimakwe (13 percent) and Kiswahili (10 percent). The latter are migrants from the northern coastal parts of Cabo Delgado Province (Palma and Mocimboa da Praia districts).

9.9.4 Migration Patterns

Palma District

There is no available documented data regarding migration patterns of the population within the District in terms of domestic and cross-border migration. The differential in growth between Administrative Posts and Localities between 1997 and 2007 discussed previously (*Section 9.8.2*) suggests movements of population within the District and with neighbouring districts.

There are historical and economic links between Palma District (and other northern districts of Cabo Delgado) and Tanzania, north of the Rovuma River. These links can be seen through some Tanzanian traders established in Palma town and the flow of traders and goods between the two borders, using the road from the Namoto Border Post and the sea between the northern districts of Cabo Delgado and Tanzania.

However, the District also serves as an entry point for immigrants, specifically for people entering the country via the Namoto Border Post, near the Rovuma River bordering with Tanzania. Once in Mozambique, immigrants destined for Mozambique typically stay in Cabo Delgado Province or travel to Nampula and Zambézia provinces, where they participate in artisanal mining, or undertake onward travel to South Africa in search of work. There is evidence of irregular trade of goods and circulation of people by land and by sea, as not all movement is made through the Namoto Border Post and main roads, or from boat landings in or near Palma town, respectively.

The Rovuma River is the physical border between Mozambique and Tanzania, and the Namoto Border Post provides the only customs and immigration services in Palma District where authorities can control and document the migration of people and transportation goods [2].

(1) The Makonde group has a history of migration to the coast, both in past centuries and recent migrations, after independence. However, this Social Assessment did not study the migrations of the Makonde group. In the concrete case of Senga, results from the Household Survey and discussions from the focus group indicated that most of its inhabitants arrived after independence (1975) to work in the 'cooperatives of production' that the socialist-oriented Mozambican Government constituted in the Ngodje palm tree plantations abandoned by Portuguese owners, while a smaller group came after the peace agreement in 1992.
(2) The Unity Bridge, located in the north of Mueda District, is another point of entry from Tanzania, using the road network of Mueda District and giving access to the central region of Cabo Delgado Province and to some areas of Niassa Province.

Between the end of 2010 and July 2011, there was an unusual wave of political asylum seekers (approximately 18,000 individuals) who entered the Palma District. The asylum seekers originated from Ethiopia, Somalia, the Democratic Republic of the Congo and Burundi. In response, the central government (specifically the Ministry of Foreign Affairs) established an office in the Palma District to attend to and process these cases and forward them to the Refugee Centre of Marretane in Nampula Province [1]. Information obtained from the Mozambican National Institute for the Support of Refugees (INAR) in Palma showed that, in most of the cases, the motivation for immigration to the region was economic and was only in some cases political asylum.

Afungi Project Site and Surrounds (Including Senga and Maganja)

Table 9.22 summarises the approximate duration the surveyed households have lived in the Afungi Project Site and Surrounds, showing that the majority are native to the area (approximately 60 percent) or long-term migrants (13.6 percent) who settled in the area over 20 years ago (between 1975 and 1992). The remaining 25 percent are more recent migrants who settled in the Afungi Project Site and Surrounds after the Peace Agreement in 1992.

The Household Survey revealed that there are some differences within the areas surveyed. The higher proportion of households that are native and long-term migrants to the area reside mainly in the villages of Quitupo and Maganja (82.7 and 90 percent respectively). The higher proportion of more recent migrants was observed in areas around Quitupo Village and in the Coastal Zone (41 percent and 50 percent respectively), identifying that these people moved into the specific area after the 1992 Peace Agreement. In Senga Village, 60 percent of the residents have lived in the area for more than 20 years, while the remaining 40 percent settled in the village after the 1992 Peace Agreement.

Of those who migrated to the area, nearly 53 percent of households originated from other areas of Palma District [2], while 15 percent came from other districts within the province. The proportion of surveyed households that are seasonal migrants was relatively small at 4.3 percent, most of whom came from Palma town.

(1) The Mozambican National Institute for the Support of Refugees (INAR), under the supervision of the Mozambican Ministry of Foreign Affairs.
(2) Of this 53 percent, approximately 28 percent came from Palma, 18 percent from other zones/villages of the Palma Administrative Post, and 7 percent from another Administrative Post in the Palma District.

Table 9.22 Duration Surveyed Households have Lived in the Afungi Project Site and Surrounds

	Quitupo (%)	Quitupo Settlements (Production Zones) (%)	Coastal Zone (%)	Senga (%)	Maganja (%)	Total (%)
Always lived there	71.2	37.5	40.9	50.0	73.3	60.0
From independence to the war (1975–1980)	9.6	12.5	-	10.0	10.0	8.6
During the war (1980–1992)	1.9	-	9.1	10.0	6.7	5.0
After the Peace Agreement (1992–2011)	17.3	50.0	40.9	30.0	10.0	25.0
Unknown	-	-	9.1	-	-	1.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Impacto, 2012.

9.10 PALMA DISTRICT AND AFUNGI PROJECT SITE AND SURROUNDS: USE OF NATURAL RESOURCES

9.10.1 Use of Natural Resources in the Afungi Project Site and Surrounds (Including Senga and Maganja)

Forest Resources

The villagers communally use forested areas, and *Table 9.23* shows the type of timber and non-timber forest products collected including firewood, wild fruits and medicinal plants. Hunting is also widely practised by the communities in these areas (97.9 percent) [1]. The main forest resources supporting communities and their livelihoods are further discussed below.

Table 9.23 Availability and Use of Natural Resources by the Surveyed Households

	Availability (%)	% who collect	% who consume	% who sell
Grass for roofing	99.3	25.9	78.6	2.4
Coconut or palm tree leaves for the construction of houses	100	96.4	87.6	20.9
Grass/reeds to produce mats, baskets (crafts)	96.7	59.6	77.4	26.2
Coconut or palm tree leaves to produce mats, baskets (crafts)	99.3	87.1	84.7	26.6
Poles for the construction of houses	98.6	97.8	89.6	12.7
Tree trunks (kiaat tree, panga-panga)	59.3	6.0	50	-
Trees to produce charcoal	97.1	7.4	64.3	28.6

(1) These questions were constructed to understand if the resource is available and if the household collects or uses this same resource. Those who consume and/or sell are subgroups of those responding 'yes' to collection or use of the resource.

	Availability (%)	% who collect	% who consume	% who sell
Trees to produce firewood	98.6	94.9	87.8	13.1
Medicinal plants	97.9	73.0	89.3	13.7
Trees to host bees	82.1	30.4	89.7	15.4
Hunting animals	97.9	35.0	90.6	34.6
Fish	99.3	93,5	92,2	59,7

Source: Impacto, 2012.

Coconut, palm tree leaves and grasses are used for the construction of housing structures and for making mats and baskets. Coconut, palm tree leaves and grasses are collected by 96.4 percent of the surveyed households for use in housing construction and, to a lesser extent, for crafts. Although widely available, grasses for thatching are used for roofing by only 25.9 percent of the surveyed households, and by 59.6 percent of the households for crafts. Most households prefer to use palm/coconut leaves for roofing material, as it is more traditional.

Forest wood is used by approximately 94.9 percent of the households for firewood and by 97.8 percent of households for housing construction/framing. The majority of households use firewood for fuel as their main source of energy, specifically for cooking purposes. The majority of the wood collected is used by the collectors themselves, while 13.1 percent surveyed sell firewood for income.

Of the wood collected for construction, 89.6 percent is used by the collectors themselves and 10.4 percent sold. Firewood and timber for construction are generally sold in the fishing centres to migrant fishermen or fish traders, who are dedicated full time to their fishing activities and unable to gather the resources themselves, sold to wood traders, or transported by sea or foot to sell in marketplaces such as Palma town, where there is demand.

Medicinal plants are collected by approximately 73 percent of the surveyed households. Of this group, 89.3 percent collect these plants for their own use and 13.7 percent sell the plants to others.

The **production of charcoal** is not commonly practised in the area, and only 7.4 percent of the surveyed households reported that they use forest wood for the production of charcoal.

Hunting is undertaken, mainly for subsistence purposes, by 90 percent of the surveyed households, of which 34.6 percent reportedly sell the meat. Hunting is undertaken using traditional traps, and the most commonly hunted animals in the forest areas are gazelle and the helmeted guinea fowl.

Water

Households use surface water and groundwater for drinking and other domestic uses (this will be further addressed in *Section 9.13.3*). There is no known collection of rainwater for drinking, using systems such as cisterns. Use of surface water to irrigate farming plots is limited to some cases of manual watering by households growing vegetables in lowland areas.

Other Areas of Collective Use

Grazing fields, lakes, rivers and lagoons are communally shared resources. Livestock keeping is uncommon in the area; keeping cattle is rare due to the high incidence of tsetse fly. As such, grazing areas are hardly used, even though they are available. Many households will, however, keep chickens and goats.

Fisheries

Fish was also reported by 99.3 percent of households as a natural resource that was widely available. Of those who use fish, 92.2 percent do so for household consumption and 59.7 percent sell fish (small-scale fisheries in Palma District and Afungi Project Site and Surrounds will be addressed in *Section 9.14.3*).

9.11 PALMA DISTRICT AND AFUNGI PROJECT SITE AND SURROUNDS: LAND USE AND OCCUPATION PATTERNS

9.11.1 Existing and Applications for DUATs in Palma District

Land permits issued (or with applications pending) in the Palma District include land use activities such as game farms, forest concessions, agricultural land, campsites, residential and tourism areas. *Table 9.24* and *Figure 9.18* provide a summary of the status of current and pending DUATs in Palma District (Provincial Services of Geography and Land Registry [1], 2011) [2]. Game farms and reserves, as well as forest concessions, represent the majority of the areas already with a DUAT or in the process of obtaining a permit.

Table 9.24 DUAT Applications and Permits by Activity, 2011

DUATs in 2011	DUAT Area (ha)	No.
Forestry Concessions	**35,799**	**1**
DUATs Issued	**57,301**	**17**
Tourism (different classes)	7	
Agriculture	1	
Game farms	3	
Residential/other purposes	2	
Construction contractors' campsites	4	

(1) Serviços Provinciais de Geografia e Cadastro.

(2) In Palma District, land use assessment resumed to the occupation of land through DUATs already issued or required to the relevant authorities (provincial or central, according to the area required, to have an understanding of the other major development in initiatives using large areas in the district.

DUATs in 2011	DUAT Area (ha)	No.
DUATs Applied for /Planned Areas	**83,426**	**9**
Game farms	8	
Industry (LNG Project)	1	

Source: Provincial Services of Geography and Land Registry, 2011.

9.11.2 Afungi Project Site (1)

The areas closely related to land use and occupation patterns in the area are based on settlements and livelihood activities, and include settlement areas (2 percent), highland agriculture areas (7 percent) and coconut plantations (2 percent).

The land use and occupation in the Afungi Project Site by its inhabitants is briefly described below, and illustrated in *Figure 9.19*. Most inhabitants of the Afungi Project Site are permanent residents, but there are also cases of seasonal residents coming from Palma town and neighbouring villages (see *Section 9.9.4* and *Table 9.22*).

Settlement Areas

Settlement areas occupy only 2 percent of land in the Afungi Project Site (137ha) and correspond to areas occupied by the concentrated settlements of Quitupo Village, Milamba 2 and N´semo, as well as scattered and low-populated settlements such as the production zones and fishing centre of Ngodje.

Highland Agricultural Areas

Highland agricultural areas account for 7 percent of the Afungi Project Site (478ha). These areas are located in the grassland zones, usually adjacent to riverbanks in the high/plateau areas, where sandy soils are dominant. These areas are usually used for crop farming (cassava, sorghum, maize, beans and peanuts, as well as cashew trees, mango trees and coconut trees), as shown in *Figure 9.16*. Quitupo Village and the scattered settlements surrounding Quitupo (production zones) are located in these highland areas. These farming areas are critical for the villagers' livelihoods of subsistence-based agriculture and income generation, when surplus can be traded.

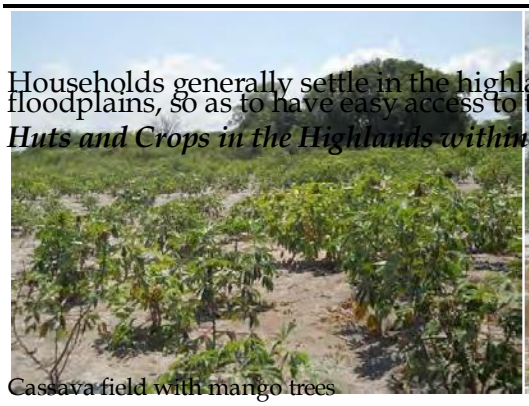
Lowland Farming Areas

Lowland farming areas are located in the floodplain areas – mosaics that occupy approximately 15 percent of the Afungi Project Site. These areas have the most productive soils and are mainly used to grow food crops such as rice, sweet potatoes, bananas and sugar cane (*Figure 9.17*). Rice is an important food crop for the local population, and income when surplus is sold.

(1) In this particular case of assessing the land use, only the Afungi Project Site was considered.

Households generally settle in the highland areas located close to the floodplains, so as to have easy access to the rich agricultural lowland areas.

Figure 9.16 ***Huts and Crops in the Highlands within the Afungi Project Site***



Cassava field with mango trees

Cassava field with farm huts

Figure 9.17

Lowlands with rice, banana and sugar cane crops

Rice field in the lowlands

Source: Impacto, 2012.

Coconut Plantations

Coconut plantations occupy 2 percent of the Afungi Project Site, and include coconut plantation areas and settled coconut plantation areas, each occupying 1 percent of the Site as described below.

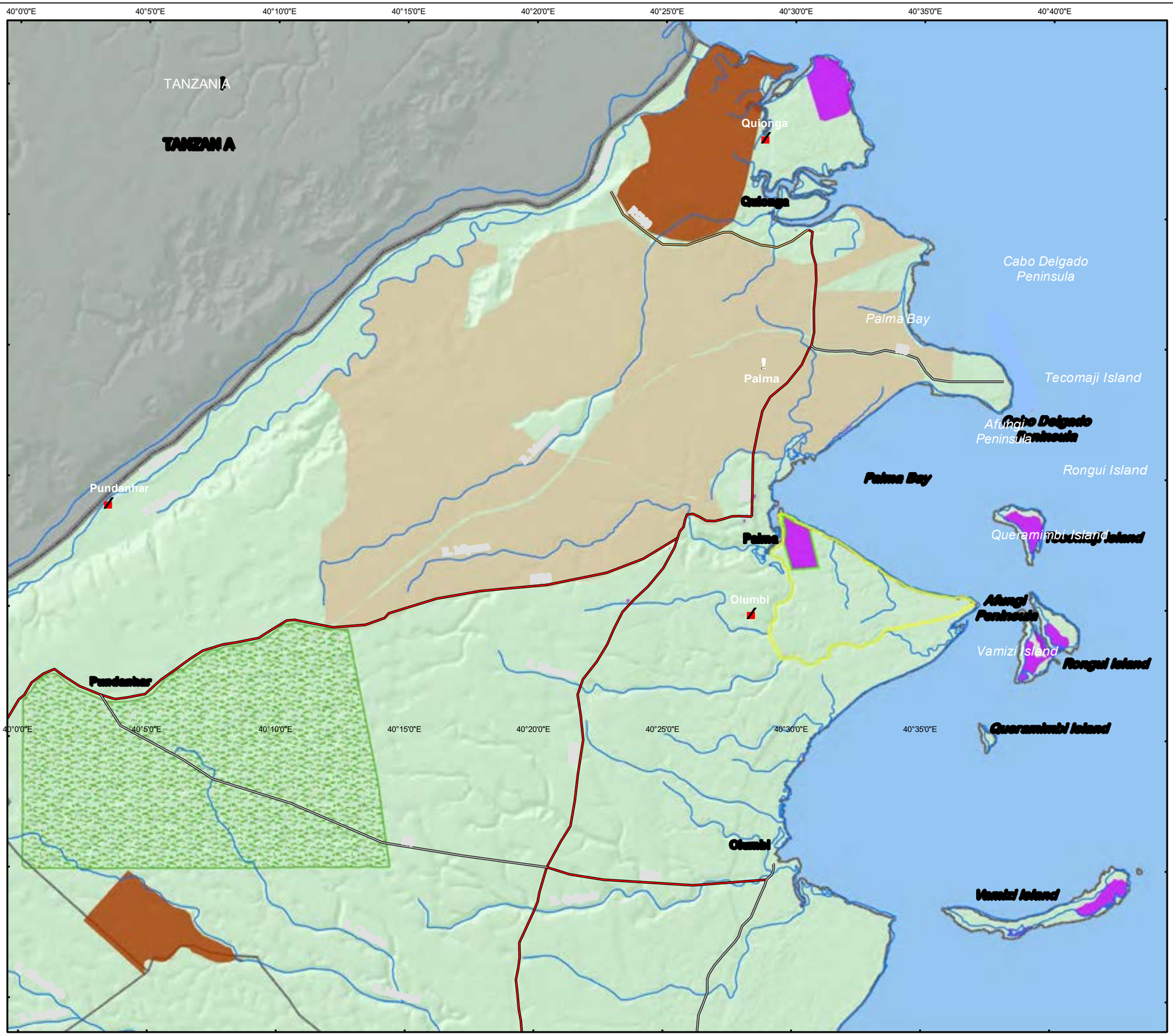
- The **coconut plantation areas** are sparsely or not populated, and mostly located along the coast of Ngodje. They consist of deteriorated or semi-abandoned coconut trees owned by the State [1] and other small landowners. There are also coconut plantations located in small patches near residential areas such as the Quitupo and Quitupo Settlements (production zones).

- **Settled coconut plantation areas** consist of coconut plantations also located along the coast. In the north-west part of Ngodje Zone, the coconut plantations belong to a private operator under a DUAT. While in the Milamba (1 and 2) and N´semo Zones, the coconut plantations belong to local residents. Other coconut plantation areas are located in small patches dispersed within the territory of the Afungi Project Site, generally near residential areas.

DUAT Area Assigned to a Private Operator

In the north-west of the Afungi Project Site, there is an area of approximately 667ha that belongs to a company called Kilaguni Lda, which was bought for tourism development (see *Figure 9.18*). The area is not developed and has a small number of huts on the coast that were intended for tourism occupation, a conventional house on the sea shore near Ngodje, and a plantation of deteriorated and semi-abandoned coconut trees with some settlements, also along the coast of Ngodje [2].

(1) According to information collected from the District Administration and during the Social Assessment, the Ngodje palm plantations originated from palm trees planted during colonial times, were abandoned after Mozambique became independent, and have since become the property of the State. Parts of these palm plantations were ceded to private operators.
(2) The consultant was informed that this private operator has some guards residing along the coast to control the coconut tree plantations.



Legend

- District Centre
- Administrative Post Centre
- Rivers

Roads

- Tertiary
- Local
- Non Classified

- Afungi Project Site
- Existing DUAT Area, not held by AMA1

- District Boundary

Area with DUATs

- Tourism
- Game Reserve

Requested Areas

- Game Farm
- Forest Concessions

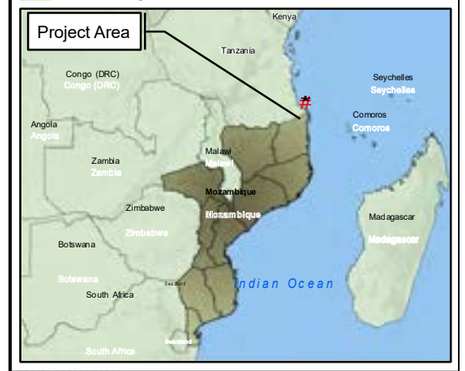


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Figure 9.18:
Existing and Requested DUATs (2011)

CLIENT:

Anadarko Moçambique Área 1, Lda

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DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 260 000

DRAWING: Existing and Requested DUATs (2011).mxd

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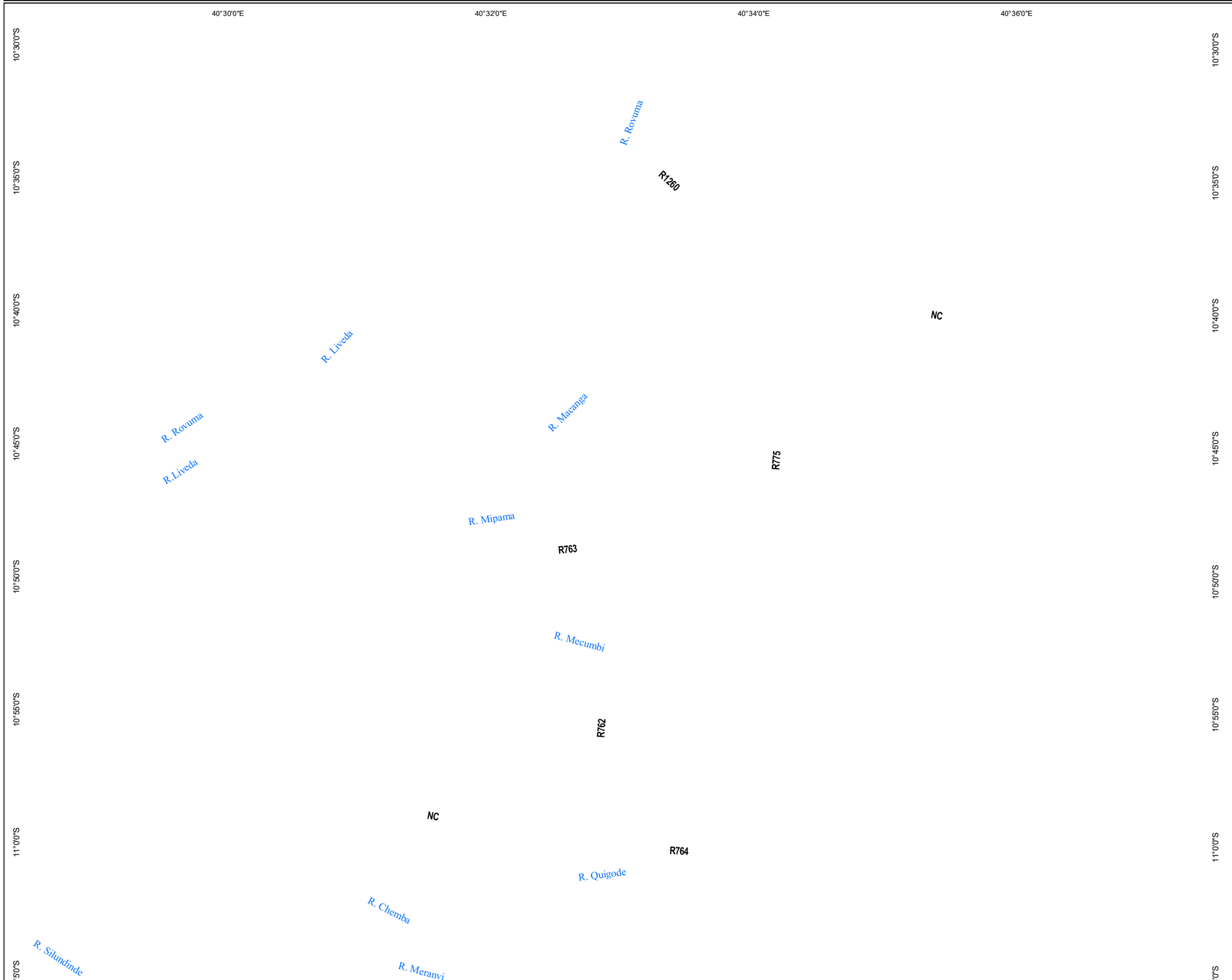
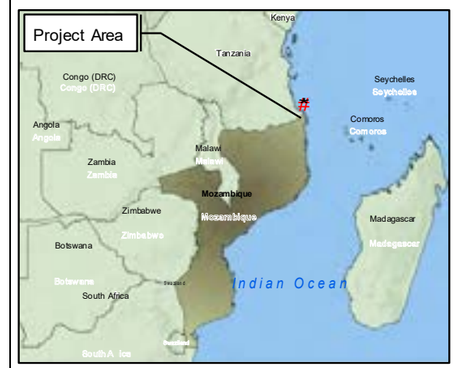


Legend

- Administrative Post Centre
- Villages
- Settlement (production zone)
- Settlement with Fishing Centre
- Fishing Centre
- Local Roads
- Afungi Project Site

Land Cover and Land Use

- Farming Areas
- Coconut Plantation
- Coconut Plantation with Human Occupation
- Human Occupation
- Mosaic of Floodplain and Farming Areas
- Salt Pans



MAIN MAP SCALE:

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Figure 9.19:
Land use in Afungi Project Site

CLIENT: Anadarko Moçambique Área 1, Lda / eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 52 000

DRAWING: Land use in the DUAT Area.mxd

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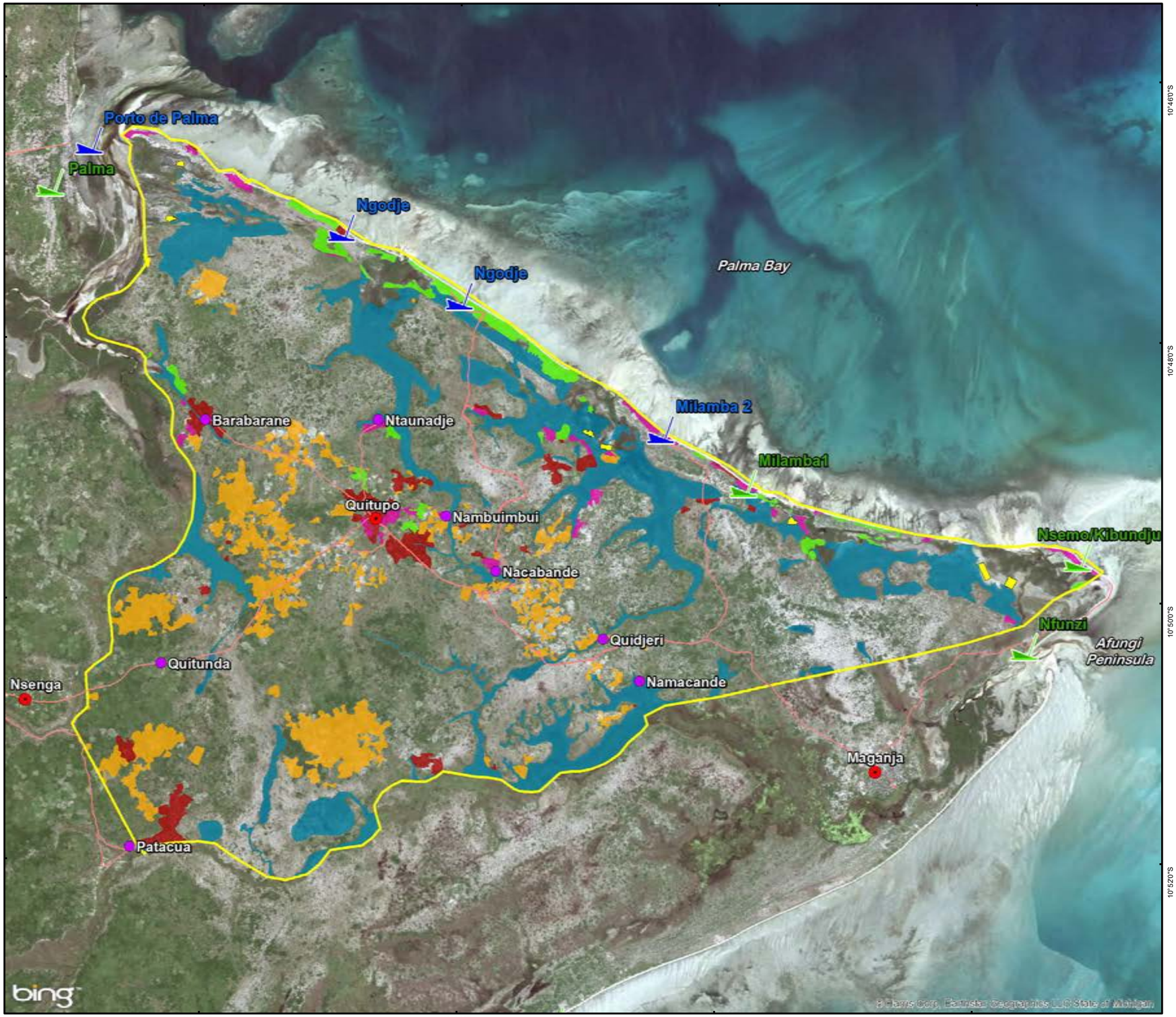

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9.11.3 Land Tenure

Based on the 2011 Household Survey done as part of the Social Assessment (140 households surveyed in November 2011), the majority of land occupied by households in the Afungi Project Site and Surrounds (including Senga and Maganja) was acquired through occupation (about 42 percent) or inheritance (about 31 percent) [1](*Table 9.25*). Only 1.4 percent mentioned that the land was assigned to them by the Government, and 12 percent reportedly acquired the land through the community authority [2]. The latter probably corresponds to households that have come from other areas of the District, or from outside the District.

Table 9.25 Access to Agricultural Land by Surveyed Households

	Plot 1 (%)	Plot 2 (%)	Plot 3 (%)
Assigned by the community authority	12.1	1.4	0.7
Assigned by the Government	1.4	0.7	-
Rented/borrowed	4.3	2.9	1.4
Occupation	42.1	23.6	7.1
Inheritance	30.7	20.7	2.6
Purchase/other type of acquisition	7.8	5.7	2.1

Source: Impacto, 2012.

In FGDs, villagers reported that in-migrants usually acquired land in the area through community channels. A new person to the area will request land from the Community Leader who, in turn, identifies available/unoccupied land. Before land is assigned, the Leader calls a meeting with all the residents of the village to present the person to the community. The individual has to produce documents regarding his origin (a letter from the local state or community authority from where he/she comes is generally well accepted). If the majority of the residents approve the person, the leader will then make land available to that person. Local Leaders suggest that this process eliminates conflict related to land, as all residents are made aware of the new person moving into the area and the land that the person is to be allocated.

All residents (new and old) enjoy the same rights to village land.

According to the Household Survey, people are allowed to lease land to others, and at least 4.3 percent of the households interviewed reported that they were using leased/ borrowed land. This is, however, a new trend, and it is believed that it is not controlled by the authorities or local Leaders.

(1) According to Land Law No. 19/97, local community members hold right s over land based in customary norms and practices, or through good faith occupation for more than 10 years. This right does not need to be documented through a land title. Inheritance and occupation of land result in land rights not needing permits or assignments by authorities.
(2) The Social Assessment identified the Village Leader, the Village Leaders Assistant and Chiefs of Zones as the relevant community authorities. However, community organisation has to be deeper assessed.

9.12 PALMA DISTRICT: NON-GOVERNMENTAL ORGANISATIONS AND DONORS

The main donors involved in funding activities in Palma District are the United States Agency for International Development (USAID), the Centre for Disease Control and Prevention (US Government), the Millennium Challenge Account (MCA) [1] and the Spanish Cooperation. The activities are implemented directly by the Government, non-governmental organisations (NGOs) or private companies involved in development.

At the time of this assessment, four implementing agencies were identified as relevant and active organisations operating in Palma District, and are described below (*Table 1.5* in *Annex G* provides more information about these organisations).

The Elizabeth Glaser Paediatric AIDS Foundation (EGPAF) is an NGO dedicated to preventing paediatric HIV infection and eliminating paediatric AIDS through research, advocacy and prevention, care and treatment programmes. In 2004, the EGPAF initiated activities in Mozambique with a prevention of mother-to-child transmission (PMTCT) programme in Nampula and Gaza provinces. EGPAF now works in four provinces, supporting the Ministry of Health to strengthen the implementation of PMTCT services at 254 sites across the country, as well as HIV care and treatment services at 67 sites. The EGPAF's work includes:

- increasing and expanding access to HIV-related services;
- strengthening existing PMTCT and HIV care and treatment services;
- improving the capacity of governmental departments;
- increasing the capacity of health facilities and communities to respond to the needs of people living with HIV;
- contributing to the development and implementation of national policies and guidelines; and
- improving monitoring and evaluation systems.

The Provincial Directorate of Health and the District Service for Health, Women and Social Affairs are the EGPAF's partners at provincial and district level respectively. The main assistance provided to Palma District is technical assistance, the training of District personnel and health professionals and the funding of related activities.

Food for the Hungry (FH) is an international humanitarian organisation with a focus on ending world hunger. Its Multi Year Assistance Program is funded by USAID and operates in Sofala and Cabo Delgado provinces, in areas of

(1) The MCA is an entity with the Millenium Challenge Corporation that is legally registered to operate in Mozambique.

intervention that include nutrition and health, water and sanitation, and food security. FH has a head office in Pemba and a District office in Palma. Its activities in Palma District are focused on three main lines of action:

- capacity building in the community through working with community leaders;
- agriculture, with the goals of guaranteeing food security and promoting cash crops, connecting farmers with the market. FH also promotes the creation of savings groups comprising 15 to 20 persons, and provides technical assistance to these groups with a view to their consolidation; and
- health and nutrition, with the main target group being pregnant women and children less than five years of age. In this line of work, the organisation also promotes access to drinking water and basic sanitation in the communities where it operates, assisting the communities to improve their access to safe water through the construction and management of new water sources.

Joint Aid Management (JAM) performs relief and sustainable development work throughout Africa. Its programmes, which are based on a Complete Community Development Approach (CCDA), include nutritional school feeding and interventions; orphan and vulnerable child care; water and sanitation; and food development, which includes agricultural development and the production of food.

Cowater International is a Canadian international consulting company working in Mozambique in development activities, mostly in the northern provinces of Nampula, Cabo Delgado and Niassa, and in the water sector.

In Palma District, JAM and Cowater operate in communities, contracted by FH and MCA as implementing consultants organising communities for the receipt and management of water sources, within the scope of the implementation of the Política Nacional de Águas (Mozambican National Water Policy) (1). Their work includes the preparation of communities for the opening of water boreholes and the installation of manual pumps. FH and MCA provide a substantial part of the funds for purchasing equipment, hiring the contractor and consultant support (JAM and Cowater). As beneficiaries, the communities themselves also contribute funding and their time to support these initiatives. Cowater and JAM facilitate all community organisation work, train the Water Committee (comprising 12 community members), and create conditions for the contractor to train the maintenance and repair group.

(1) Generally, the intervention of donors in the water sector is providing funds for communities that don't have access to safe water and are willing to organise themselves and contribute to have a water source. The repair of broken pumps is generally the responsibility of the community and of the local government, using funds raised by the community and Government budget.

9.13 PALMA DISTRICT AND AFUNGI PROJECT SITE SOCIAL SERVICES

9.13.1 Education Profile and Network

Palma District

In 2007, the level of educational attainment was quite low amongst the population of Palma District, with 88 percent of the population not completing any level of education. This is 7 percent higher than that of Cabo Delgado Province (at 81 percent) as a whole (see *Table 1.6* in *Annex G*). The percentage of those who complete EP2, ESG1 and Basic Technical Education (BTE) is also very low in the District (2.4 percent, 1.2 percent and 0.04 percent respectively). This is attributed to a lack of available schools teaching these levels and a limited numbers of teachers (INE, 1997d).

Table 9.26 shows that, in 2012, there were a high number of students attending EP1 (90 percent), compared with EP2 (6 percent) and ESG (4 percent) schooling levels, showing a large discrepancy between the two levels and that a large number students do not enter the second degree of primary education and therefore do not finish the Primary Education Level (EP1 + EP2) (1).

In Palma town, the First Cycle ESG School doesn't have proper facilities and is working inside the EP2 facilities. There are more males than females enrolled in all schooling levels, as well as a high number of male teachers compared to female teachers. In addition, there is a high attrition in female attendance between EP1 and EP2 (from 43 to 31 percent), which is attributed to early marriages (2) (a local custom that is deeply rooted among the residents of the District and in the Afungi Project Site and Surrounds, in particular). The education curriculum in schools is delivered in Portuguese (3).

Table 9.26 Schools in Palma District (2012)

Location	No. of Schools	No. of Students	No. of Teachers					
	Traditional Construction	Conventional Construction	Male	Female	Total	Male	Female	Total
EPI PRIMARY EDUCATION FIRST DEGREE								
Locality Palma Capital	7	4	2.289	1.770	4.061	41	30	71
Mute Locality	7	2	1.510	1.113	2.623	32	9	41
Olumbe AP	7	2	1.697	1.343	3.040	28	6	34
Pundanhar AP	3	1	498	409	907	13	1	14
Quionga AP	4	2	995	666	1.661	18	2	20
Total EP1	28	11	6.989	5.303	12.292	132	48	180
EP2 PRIMARY SECOND DEGREE								
Locality Palma Capital	0	2	315	162	477	15	3	18
Mute Locality	0	2	59	22	81	7	0	7
Olumbe AP	2	1	144	41	185	8	0	8

(1) The reasons for this discrepancy are complex and inter-related. Any intervention to develop education in the District needs to understand these factors in order to design a systemic approach and a consistent and long-term action plan.
(2) Young girls are expected to get married immediately after reaching puberty.

(3) According to the District education authorities, there is no bilingual education in primary schools in the Palma District.

Location	No. of Schools	No. of Students	No. of Teachers					
	Traditional Construction	Conventional Construction	Male	Female	Total	Male	Female	Total
Pundanhar AP	1	1	61	38	99	7	0	7
Quionga AP		1	30	12	42	4	0	4
Total EP2	3	7	609	275	884	41	3	44
GENERAL SECONDARY EDUCATION FIRST CYCLE								
Locality Palma Capital			400	180	580	18	1	19
Total ESG1			400	180	580	18	1	19
Total of District	**31**	**18**	**7.998**	**5.758**	**13.756**	**191**	**52**	**243**

Key:

A.P. = Administrative Post.

Source: Palma District Services of Education, Youth and Technology, 2012.

Afungi Project Site and Surrounds (Including Senga and Maganja)

Literacy levels in the Afungi Project Site and Surrounds are generally very low (see *Table 9.27*). Women, in particular, have very low levels of education, and 92 percent are illiterate. Adult Literacy and Education (ALE) programmes are aimed at people who are not of school age, and these are available throughout the country. In the Afungi Project Site and Surrounds, however, only one village (Senga) still has an ALE programme. In Quitupo and Maganja villages, the programmes have been discontinued due to a lack of available teachers. Some of those who attended the ALE classes have dropped out, due to subsistence activities such as farming that seasonally takes priority during the preparation of land or harvesting.

Table 9.27 Education Level of the Head of the Surveyed Household and Spouse

Education Level	Head of Household (1) (%)	Spouse or Wife of Head of Household (2) (%)
Illiterate	58.6	92.1
Basic level reading and/or writing	30.7	4.7
Primary school level 1	7.1	0.8
Primary school level 2	2.2	-
Middle school	0.7	-
Does not know/did not respond	0.7	2.4
Total	100.0	100.0

Note:

(1) 140 heads of households were surveyed.

(2) 127 wives of heads of households were surveyed.

Source: Impacto, 2012.

School Network and Access

There are three schools in the Afungi Project Area and Surrounds, two of which are EP1 level facilities (Senga and Quitupo) and one is an EP2 level facility (Maganja), as shown in *Table 9.28*. Since Maganja Village and Palma

town are relatively far from the villages of Quitupo and Senga and other settlements in the Afungi Project Site and Surrounds, many children who reside in these areas only complete EP1 level education and do not continue on to EP2, to complete a full primary school education.

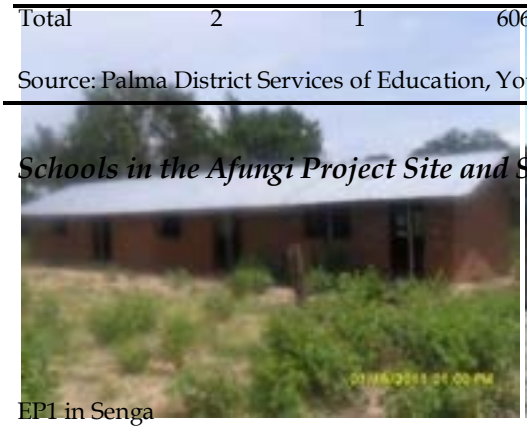
The schools in the area are usually constructed from locally sourced materials such as mud bricks, poles and fronds, with the exception of Maganja School, which was built of modern materials (blocks, corrugated iron, etc). Schools are often built and maintained by the communities (see *Figure 9.20*). In some communities, there are no classrooms, and learning occurs outdoors under trees (such as the case in N´semo, a settlement with fishing centre that is part of Maganja Village) and Quitupo.

Table 9.28 ***School Facilities in the Afungi Project Site and Surrounds***

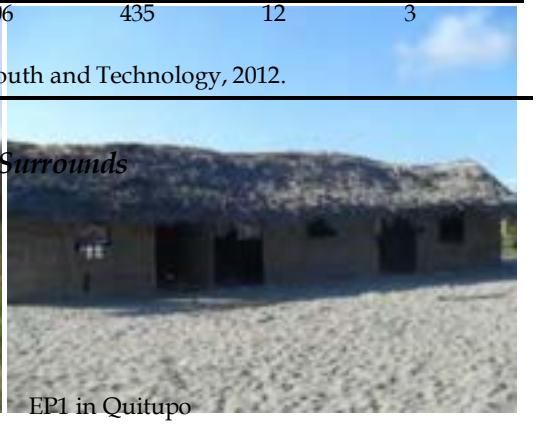
Village	Type		No. of Students		No. of Teachers	
	EP1	EP2	Men	Women	Men	Women
Quitupo	1	-	205	123	3	1
Senga	1	-	110	94	3	1
Maganja	-	1	291	218	6	1
Total	2	1	606	435	12	3

Source: Palma District Services of Education, Youth and Technology, 2012.

Figure 9.20 ***Schools in the Afungi Project Site and Surrounds***



EP1 in Senga



EP1 in Quitupo

First classroom, N´semo

Source: Impacto, 2012.

Second classroom, N´semo

EP1 room in Senga

Challenges facing the education system in the Afungi Project Site and Surrounds include:

- a lack of teachers;
- a lack of materials as well as desks, books, classrooms and school uniforms;
- a lack of EP2 level schools;
- the long travel distances to the nearest school (*Table 9.29*);
- high dropout rates due to food security issues (children are expected to assist with the harvest); and
- high dropout rates among young girls, due to early marriage and teenage pregnancy.

Table 9.29 ***Average Travel Time to Schools by Surveyed Household Members***

	Average Travel Time Required (Minutes/One Way)		
	EP1	**EPC**	**ESG**
Quitupo	6	87	87
Quitupo Settlements (production zones)	27	40	40
Coastal Zone	81	141	151
Senga	8	82	82
Maganja	24	21	187

Source: Impacto: 2012

9.13.2 Health Profile and Network

Palma District

The provincial health data for Cabo Delgado Province generally reports indicators that are well below the national averages. The provincial morbidity and mortality rates are higher than national rates, with the last reported provincial under-five mortality rate and infant mortality rates reported in 2003, at 241 and 178 per 1,000 live births respectively (World Bank, 2003).

The main notified diseases and the trend between 2010 and 2011 with the morbidity profile, number of deaths, incidence rate and mortality rate is summarised in *Table 9.30*. This highlights the burden of disease from malaria, and also notes that this has fallen by nearly 21 percent from the 2010 figures. It is noted that the health baseline presented in this chapter has limitations, due to the nature of data management and the health-seeking behaviours of the community.

Table 9.30 Main Illnesses Reported in Palma District, 2008–2011

Diseases	Notified Cases			Notified Deaths			Incidence Rate (%)		Mortality Rate (%)	
	2011	2010	Change (%)	2011	2010	Change (%)	2011	2010	2011	2010
Measles	4	3	33.3	0	0	0	0.01	0.01	0	0
Neonatal tetanus	0	0	0.0	0	0	0	0.00	0.00	0	0
Pertussis	0	0	0.0	0	0	0	0.00	0.00	0	0
Malaria	10,622	13,418	-20.8	18	18	0	20.15	26.03	0.2	0.1
Acute flaccid paralysis	3	1	200	0	0	0	0.01	0.00	0	0
Animal bite	1	0	0.0	0	0	0	0.00	0.00	0	0
Diarrhoea	1,214	1,509	-19.5	1	3	-66.7	2.30	2.93	0.1	0.2
Dysentery	406	444	-8.6	0	0	0	0.77	0.86	0	0
Cholera	0	0	0.0	0	0	0	0.00	0.00	0	0
Plague	0	0	0.0	0	0	0	0.00	0.00	0	0
Meningitis	0	0	0.0	0	0	0	0.00	0.00	0	0

Source: Austral COWI, 2012.

This remainder of this section provides the health baseline for the Project Area [1]. To align with the IFC performance standards, the methodology outlined in the Good Practice Notes for Health Impact Assessment (HIA) from the IFC was followed. The IFC methodology uses 13 environmental health areas (EHAs) to support the systematic analysis of health considerations. The set of EHAs provides a linkage between Project-related activities and potential positive or negative community-level impacts.

Stakeholders Opinions and Comments

Various stakeholders (ranging from national, provincial and district representatives of MISAU to members of the Afungi communities) were consulted during the completion of the health baseline. Stakeholder opinion and comments related to any development are vitally important, as people who have experience/insight in the area often understand the context and particular health challenges better. They will understand vulnerabilities of the communities and the ability of the communities and authorities to deal with any changes in the area, as well as the ability to cope with potential health impacts.

The comments and concerns of key stakeholders who were consulted as part of the health data collection exercise are summarised in *Table 9.35*.

(1) The health baseline study forms part of a Rapid Health Impact Assessment (RHIA) undertaken for the EIA Report. The baseline is required as part of the RHIA to identify and estimate the lasting or significant changes of different actions on the health status of a defined population, thereby assisting the Project in understanding the existing health needs of the community and considering the future consequences of different Project options on human health.

Environmental Health Areas

The baseline health description will be further summarised based on an EHA framework. This EHA framework covers a broad view of environmental health and encompasses a wide spectrum of health determinants, including social and institutional issues. The 13 EHAs and their specific area of focus are detailed in *Table 9.31* below. These baseline health descriptions are discussed for each relevant EHA, and include a summary description of the prevailing health conditions in the Study Area and the institutional capacity of the local authorities and the communities to manage or adjust to any potential health impacts or changes in the area that may affect health.

Table 9.31 Environmental Health Areas (EHAs)

	EHAs
1	Communicable diseases linked to overcrowding and poor environmental/socio-economic conditions
2	Vector-related diseases
3	Soil, water, hygiene and waste-related diseases
4	HIV/AIDS and sexually transmitted infections (STIs)
5	Food and nutrition-related issues
6	Non-communicable diseases
7	Accidents and injuries
8	Veterinary medicine and zoonotic diseases
9	Environmental health determinants/exposure to hazardous materials
10	Social determinants of health
11	Cultural health practices
12	Healthcare services and infrastructure
13	Health programmes and systems

EHA #1: Communicable Diseases Linked to Overcrowding and Poor Environmental/Socio-economic Conditions

Housing is rudimentary in the Study Area, with natural materials used for construction. Overcrowding did not appear to occur. Cooking was mainly performed in separate structures outdoors, but as biomass fuels were generally used, there is the possibility of exposure to poor air quality that can increase the risk of respiratory disease. Electricity is not available.

Community Health Needs/Vulnerabilities

- Tuberculosis (TB) is one of the leading causes of morbidity and mortality in Mozambique. This burden is increasing as a result of the co-morbid link with HIV/AIDS.
- At the local level, TB case detection was limited due to poor health-seeking behaviour and limited access to health services. Awareness and knowledge related to TB was also limited.
- Acute respiratory diseases are ranked as the third leading health challenge in the province, and the high rates of morbidity are compounded by co-

morbid factors such as anaemia, diarrhoea, malaria and chronic malnutrition.

- As the rural communities are relatively isolated, they can be considered vulnerable to influenza outbreaks.

Institutional Capacity

There is no data on standard TB indicators and, with the poor access to healthcare and limited health-seeking behaviour, it is challenging to understand what the burden of disease related to TB actually is.

- Treatment success rates are likely to be good, as there is a functional Directly Observed Treatment Short Course (DOTS) programme. However, access may limit follow-up, and the community health agents (CHA) programmes are not strong.

- With regards to ARI, the diagnostic capabilities in Palma District are limited with no radiological service, limited laboratory services and no nucleic acid amplification.

- There is a functional Routine Health Information Management System (RHMIS) in the District, but this is limited by the lack of diagnostics and skilled staff. Monitoring of specific health indicators is thus limited.

- There is minimal institutional capacity to manage any large-scale influx into the area.

EHA #2: Vector-related Diseases

Community Health Needs/Vulnerabilities

- There is no verifiable data on the burden of disease from malaria in the Project area but, due to recent interventions, there is an indication that malaria transmission is reducing. The lack of reliable diagnostics means that malaria is often overdiagnosed (Palma District Health Profile, 2011).

- Studies at the national level have estimated an annual incidence of malaria at 50 to 100 cases/1,000 population. In the 2007 MIS study, 71 percent of children aged six to 59 months tested positive on malaria rapid diagnostic tests (RDT) and 36.5 percent on slides (National Malaria Control Programme, 2007).

- Diagnosis is made by RDT and microscopy in Palma, but there is a reliance on RDT in the rural health centres. Stockouts of both RDTs and medication were reported to occur commonly in the rural areas.

- Knowledge related to malaria and prevention activities was limited, with a national study highlighting that only 28 percent of respondents reporting that mosquito nets offer some protection against malaria. This was

supported in the FGDs conducted in the Study Area. Control measures are limited in the Study Area. Insecticide-treated nets (ITN) have been distributed through the District, but utilisation is reported to be poor, which is related to the poor knowledge in the communities. In the FGDs, most households admitted to owning ITNs and children generally slept under them.

- There is a risk that dengue fever and chikungunya fever may occur along the coastal areas, especially where there are ports served by ships from regional and especially international destinations. The environment is suitable for the transmission of arboviral infections, and the vector is likely to be widely distributed.

- Lymphatic filariasis (LF) is an important local vector-borne disease that is subject to an eradication campaign. Human African trypanosomiasis (HAT) has not been reported locally, despite the reported presence in the disease vector (tsetse fly).

Institutional Capacity

- There is a functional National Malaria Control Programme (NMCP), but there is limited capacity to extend all elements of the programme to the rural areas in the far north of the country.

- There is also limited ability to understand malaria's true burden of disease due to the erratic supply chain, inability to report cases accurately, poor access to health services and the communities health-seeking behaviour. The same applies to arboviral diseases, LF and HAT.

- The ability to monitor changes effectively in malaria transmission and prevalence at the local level is also limited, due to inadequate surveillance mechanisms.

- The existing environmental health challenges may worsen if there are large-scale developments with resultant unplanned developments, resulting in an increased risk of transmission of malaria.

EHA #3: Soil, Water, Hygiene and Waste-related Diseases

Community Health Needs/Vulnerabilities

- Access to improved water sources is a major national challenge. Only 36 percent of the population of Cabo Delgado Province have access to these improved sources (UNICEF, 2010).

- Access to water was a major issue in the Study Area. In general, the community makes use of unprotected wells and streams as the required payment for water from protected standpipes prohibits their use. The 2007 Census reported that the majority of the households in the District

are supplied by unimproved water sources (68.8 percent), while the socio-economic baseline reported that 58 percent of the communities sampled obtained their water from protected sources (Impacto, 2012). Sanitation services were practically non-existent, with most communities practising open defecation in the sea or bush. There was a challenge to constrict latrines, due to the sandy soil and high water table. Latrines were generally only used for urination.

- Diarrhoeal diseases are the second-most common cause of morbidity in Palma District. The District had cholera outbreaks in 2009 and 2010.
- Skin (jiggers or tungiasis and fungal infections) and eye infections (conjunctivitis) related to poor hygiene are reported to be common.
- Soil-transmitted helminths (STHs) are common and, while there are quarterly school-based programmes to reduce the burden of disease, it was reported that roundworm and hookworm were especially common. Based on models, it is anticipated that the prevalence of STHs is over 50 percent in the District (Augusto et al., 2009).
- Symptoms suggestive of urogenital schistosomiasis were reported to be common, from men interviewed in the Study Area. The health authorities reported that they have no accurate data, but that they are more common around Pundahar and localised wetlands. Based on models, it is anticipated that the prevalence of urogenital schistosomiasis was between 50 and 100 percent in the District (Augusto et al., 2009).
- There is limited local knowledge regarding basic sanitation and hygiene practices.

Institutional Capacity

- There is minimal institutional capacity to provide basic services. The local District authorities may find it difficult to plan or support any increased demand on the required infrastructure or services.
- Outbreak response would require external support as diagnostics, human resources and logistical capacity are limited. The health services in the District have limited capacity to support information, education and communication (IEC) programmes that promote water use, hygiene and sanitation programmes.

EHA #4: HIV/AIDS and Sexually Transmitted Infections

Community Health Needs/Vulnerabilities

- In 2009, the estimated national prevalence of HIV/ AIDS and sexually transmitted infections in women and men was 13.1 percent and 9.2 percent respectively. The prevalence in Cabo Delgado was 9.5 percent and 9.2

percent in women and men respectively (INE, Ministério da Saúde and MEASURE DHS+/ORC Macro, 2009). The highest prevalence was in the age group from 20 to 24 years of age, with a significant gender difference that ranges from 1.2 to 4.2 percent in males and 5.9 to 11.1 percent in females (USAID, 2010; UNAIDS and WHO, 2008).

- The prevalence of HIV in Palma District is not known but, using statistics from the health centres, this was estimated at 3 percent based on provider initiated counselling and testing (PICT) in 2011. It is, however, likely to be closer to 9 percent, based on provincial statistics. As part of the fight against HIV/AIDS, the Government and NGOs have increased their awareness-raising campaigns, HIV testing and distribution of condoms.

- The uptake of HIV testing in antenatal care (ANC) is very good, as it is more or less mandatory. While the prevalence in this group was not known, it can potentially be used as a very good indicator for the current HIV prevalence. However, the uptake is limited by stockouts of HIV RDT and limited access to health services, limiting attendance of ANC.

- STIs are reported to be common and increasing in the Study Area.

- Polygamy and infidelity is common, and complex sexual networks occur in the area. It is not uncommon for a man to have four wives.

- It was reported that the general community has poor knowledge on HIV/STI transmission and prevention practices, and thus behaviours are poor. This was confirmed in the FGDs. This is related to limited access to information on health-related topics, and poor education.

- Teenage pregnancy is a significant social and health issue, with a reported increasing trend. There is an associated increase in STIs/HIV in this young age group, with alcohol abuse being a major cause of high-risk sexual activity.

- Condom usage is reported to be low, despite general availability. This has a cultural/ religious basis and relates back to limited consistent knowledge.

- Commercial sex workers (CSW) were reported to occue in the area according to both the FGDs, Key informant interviews (KIIs) with health authorities and discussions with local bar owners. It was reported that these women are generally outsiders.

- Although it was not possible to determine the incidence of HIV/AIDS in the Afungi Project Site, an attempt was made to assess the levels of knowledge and awareness in that regard through the Household Survey. The majority of households in the Afungi Project Site and Surrounds (approximately 95.5 percent) indicated that they had heard of HIV/AIDS. *Table 9.32* provides a summary of the sources of information about the

disease reported by surveyed households. A large portion of the population had heard of HIV/AIDS via radio (85.7 percent), friends (28.6 percent) or at a health facility (25 percent) (see *Table 9.32*).

Table 9.32 Source of Information about HIV/AIDS According to Surveyed Households

Sources of Information	%
Radio	85.7
Friends	28.6
Neighbours	9.3
Household	3.6
Community activists	3.6
At the Health Post/Centre	25.0
Meetings the Government had with the population	11.4
Other	3.6

Source: Impacto, 2012

Institutional Capacity

- There is limited coverage of antiretroviral treatment (ART) in the District, with access to healthcare and adherence to medications being major challenges.
- The District health service has a limited ability to extend outreach services to the general community, due to a lack of capacity and NGO programmes in the area.

The surveillance of HIV and STI prevalence in the District health statistics is limited, although there is the opportunity to use ANC data to monitor trends in HIV and STI (syphilis as an indicator) in the area.

EHA #5: Food and Nutrition-related Issues

Community Health Needs/Vulnerabilities

- Chronic malnutrition was cited as a significant concern among the provincial health programme managers. Acute malnutrition is not a major issue, and is often associated with underlying health conditions (such as HIV).
- A recent study (2011) found that 53 percent of children were moderately stunted (an indicator of chronic malnutrition) and 26.7 percent severely stunted (INE, Ministério da Saúde, and MDI International, 2012).
- Low birthweight associated with poor maternal nutrition, micronutrient deficiencies (anaemia) and infectious diseases such as malaria and HIV was noted. Low birthweight babies have a higher potential to die, as infants and their long-term cognitive development is markedly reduced.

- Anaemia is a major issue that is also a co-morbid factor in other communicable disease profiles. At a provincial level, 76 percent of children under five years were found to be anaemic, with 5.5 percent reported as having severe anaemia (INE, Ministério da Saúde, and MDI International, 2012).

Institutional Capacity

- The District health authorities have the ability to track trends in acute malnutrition, and could respond to nutritional emergencies with external support.

- There is no effective nutritional surveillance programme to determine the needs of the community. Thus, there are inadequate proactive nutritional support programmes at schools or linked to IEC interventions during ANC.

EHA #6: Non-communicable Diseases

Community Health Needs/Vulnerabilities

- Hypertension was reported to be common in Palma District. It was not easy to manage the disease due to the follow-up requirements, but adherence to treatment is reportedly good in those who do follow up.

- Diabetes is not reported as common, but the health centre in Palma has just received equipment and consumables to support the diagnosis of diabetes, so the case notifications may increase in time.

- Cancers are rare in the District, and are usually detected at a late stage. There is poor awareness and knowledge related to non-communicable diseases (NCDs) in the communities in the Study Area.

Institutional Capacity

- The health services in the Study Area are mainly focused on communicable disease management due to the local burden of disease, so NCDs are, in general, not addressed proactively.

- The health services have a limited ability to manage with an increased burden of disease from different NCDs due to a lack of human resources, diagnostics and inadequate supply chain of medications.

EHA #7: Accidents and Injuries

Community Health Needs/Vulnerabilities

- Road traffic accidents (RTAs) associated with speeding and alcohol misuse are the most common form of injury in the area. The roads in the area are

poor and this generally limits overspeeding, but poor driving techniques and unroadworthy vehicles add to the risk. There are no effective speed controls and active policing is limited to the main towns, due to resource constraints.

- The main road north of Palma to Quionga and Tanzania is the road where most accidents occur. Pedestrian vehicle accidents are also reported. The community, and especially children, have a low awareness of road safety. Off these main roads, RTAs are rare, due to the low volumes of traffic.

- Gender-based domestic violence (GBDV) is reported in the area and, based on information from the FGDs, it is tolerated and even accepted, especially in the rural areas. The root cause appears to be related to alcohol. The health services reported that it was rare for cases of GBDV to be reported to the health centres, either highlighting the stigma of GBDV, or that these incidents do not result in serious injuries.

- Assault and other forms of non-accidental injury were not common. Rape was reported to be extremely rare.

Institutional Capacity

- There is minimal capacity in the local health centres to manage trauma cases effectively. There is no effective pre-hospital ambulance system that responds to incidents, and the capacity of the health centres is limited by a lack of availability of skilled staff, diagnostic equipment and surgical capacity. Thus, the current healthcare system cannot cope with any increase in accidents or injuries.

Policing and related law enforcement is limited in the District, because of a lack of capacity and equipment and no proactive policing.

EHA #8: Veterinary Medicine and Zoonotic Diseases

Community Health Needs/Vulnerabilities

- Zoonotic diseases are poorly recognised and described in the Study Area, due to the limited local veterinary public health services available.
- No cases of rabies were reported from the KIIs.

Institutional Capacity

- There is limited institutional capacity from both the public health and veterinary health perspective to manage zoonotic diseases.

EHA #9: Environmental Health Determinants/Exposure to Hazardous Materials

Community Health Needs/Vulnerabilities

- There is no domestic refuse removal system and, thus, litter is common in most areas, concurring with the socio-economic baseline that the majority of the community are not managing household garbage appropriately (Impacto, 2012). However, the respondents in Quitupo reported that their village was clean, as people bury or burn their waste.

- There is no major industry in the area that created any potential source of pollution. Subsequently, there is minimal exposure to hazardous materials other than the garbage that the community themselves leave in the environment.

- Other than dust from wind, air quality is good and noise pollution is limited to general community noise.

Institutional Capacity

- There is limited environmental health capacity in the local District authority to monitor or support effective environmental controls.

- There is no formal landfill site in the District.

EHA #10: Social Determinants of Health

Community Health Needs/Vulnerabilities

- Mental health is a major consideration, as it relates to the community's perception of well-being and sense of place. This is difficult to document at baseline, as no detailed studies have been performed.

- It is reported that communities live in harmony and that they assist each other as required. The exception was Bairro Moa, where there was a sense of community discord and quarrels were common. There was also discontent with some local tribal authorities, which affected community cohesion.

- Life was described as challenging due to multiple factors, including alcohol abuse. Palm wine is the most common form of alcoholic beverage consumed locally.

- There are no studies on local alcohol or substance abuse, but a national study has found that 28.9 percent of women and 57.7 percent of men consume alcohol regularly, with the prevalence of drinking increasing with age and education in women and with income in men (INE, Ministério da Saúde, and MDI International, 2012). The number of bars in Palma-Sede is increasing, and it is significant that refrigerated bottled beer is now freely available.

- Substance abuse is limited to marijuana abuse, which is reported to be common. Suicide and depression were not reported at all from FGDs or KIIs with the local health authorities.

- Education is a major limitation in the area and, in the FGDs, all women reported a general low level of education. This was evaluated in the socio-economic baseline, where it was reported that 92 percent of women in the households were illiterate (Impacto, 2012).

- Health-seeking behaviour is reported to be poor. There is no evidence on the causes, but access to healthcare and a cultural preference for traditional medicine are likely factors.

Institutional Capacity

- There is minimal local capacity to cope with the potential social ills related to the potential rapid development of settlements in the Study Area.

EHA #11– Cultural Health Practices

Community Health Needs/Vulnerabilities

- Traditional healers (TH) play an important role in healthcare and the treatment of certain problems. Village-level health staff report significant use of traditional healers as well, which often results in the delay of care.

- In the FGDs, it was reported that the use of traditional medicine was common. There are many healers in the communities.

- The women reported generally using health centres in the first instance, and then TH. Perceptions that many health conditions are related to witchcraft or other forms of supernatural influence are common.

Institutional Capacity

- Gaps exist in understanding specific traditional medicine practices in the Study Area.

EHA #12: Healthcare Services and Infrastructure

There are six medical facilities in Palma District, including one Rural Health Centre (Type I), four Rural Health Centres (Type II) and one Health Post. The distribution of these facilities is outlined in *Table 9.33* and *Figure 9.21*.. The Health Centre of Palma is the only facility with inpatient beds (for children and adults) and services available, such as minor medical procedures and dentistry. All other facilities (with the exception of Maganja Health Centre) are located in the Administrative Post centres and provide outpatient services, have maternity wards and provide mother-child services and vaccinations.

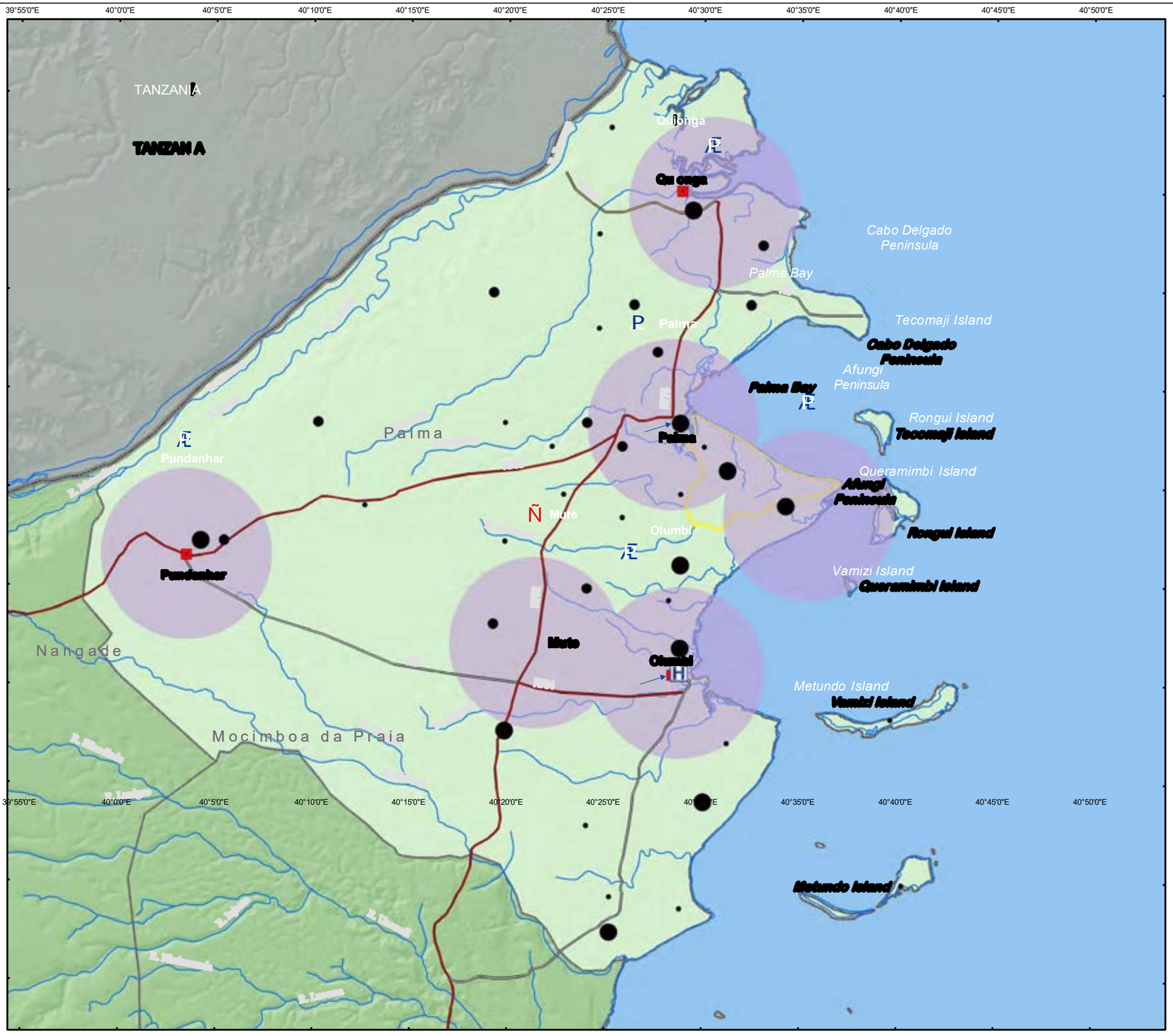
Mute Health Post is located in the Locality centre (see *Table 9.33*).

In each Administrative Post, there are many people living more than 8km away from a healthcare facility, and access is further complicated by a lack of public transport and poor road infrastructure (see *Figure* 9.27). The nearest hospital to the population residing in Palma District is the District Hospital of Mocímboa da Praia, located 80km from Palma town, to which patients from the area of Palma requiring major surgery or more specialised medical assistance are referred.

Table 9.33 Health Facilities in Palma District

Name of Centre	Location	Classification	Maternity Ward (No. Beds)	Inpatient Unit (No. Beds)	Consultations		Minor Surgery	X-ray Room
					Outpatient	Dentistry		
Olumbe Health Centre	Administrative Post of Olumbe Headquarters	Rural Type II	9	X	√	X	X	X
Quionga Health Centre	Administrative Post of Quionga Headquarters	Rural Type II	4	X	√	X	X	X
Mute Health Post	Locality of Mute Headquarters	Health Post	X	X	√	X	X	X
Pundanhar Health Centre	Administrative Post of Pundanhar Headquarters	Rural Type II	3	X	√	X	X	X
Palma Health Centre	Palma Town	Rural Type I	16	38	√	√	√	X
Maganja Health Centre	Maganja Village Locality of Mute	Rural Type II	4	X	√	X	X	X

Source: Palma District Services of Health, Women and Social Action, 2012.



Legend

- District Centre
- Administrative Post Centre
- Rivers

Roads

- Tertiary
- Local
- Non Classified
- Afungi Project Site
- Boundary with Tanzania

Province

- Cabo Delgado
- District Boundary
- Palma District

Health Centre

- Health Post
- Rural - Type I
- Rural - Type II
- Coverage Area - 8km

Population Density

- < 500
- 501 - 1000
- 1000 - 5000

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 9.21:
Distribution of Health Facilities in Palma District (2011)

CLIENT:

Anadarko
Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 330 000

DRAWING: Distribution of Health facilities in Palma District 2011.mxd

REV: A

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Source: DIVA-GIS. Impacto, 2012.
Inset Map: Esri Data & Maps

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R764
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R. Royuma
R. Lucuma
R. Livecda
R. Mipanta
R. Macuaga
R. Mecumbi
R. Quiuigoue
R. Chemba
R. Meranvi
R. Lunigue
R. Silundinde
R. Mecumbue
R. Livecda
R. Royuma
R. Ihjonta

Access to health services in the Afungi Project Site and Surrounds is very poor since (with the exception of Maganja Health Centre) all healthcare facilities are located at Administrative Post centres. There are volunteer health workers in the communities, referred to as First Responders/APEs who receive support from the Department of Health.

Community Health Needs/Vulnerabilities

- The capacity and quality of healthcare services is limited in the Study Area, with the highest level of healthcare being a District health centre (level 1). This building has recently been refurbished, and the level of care appears adequate for the intended scope of service. Access from rural areas is limited, due to poor roads and lack of a public transport system. The referral system to Mocimboa da Praia is lengthy, as there is only one ambulance in the entire District.
- The supply chain for the District health centres, and specifically the rural centres, is erratic, with frequent stockouts reported by healthcare workers.
- Medical waste management is poor, and there is a challenge with water supply, which influences infection control capacity.
- No healthcare facilities are available on the Afungi Peninsula, with the exception of Maganja, although nearly 33 percent of those interviewed in Maganja referred to Palma town as the location of first choice for hospital services. In the other areas, most of the population referred to the Palma Health Centre as the one they use, with the exception of 18 percent of the residents of Quitupo, the production zones and the Coastal Zone inhabitants, who make use of the healthcare facility in Maganja (see *Table 9.34* below).

Table 9.34 Location of Health Facilities Used by the Surveyed Households

District	Quitupo	Quitupo Settlements (Production Zones)	Coastal Zone	Senga	Maganja
Health Post/Centre with Outpatient Services Only (%)					
In the village or neighbourhood	-	-	4.5	25	100
Neighbouring village	18.8	18.8	45.5	-	-
Palma town	75	75	45.5	75	-
Another Administrative Post in the District	6.3	6.3	4.5	-	-
Total	100	100	100	100	100
Health Centre with Maternity Clinic and Hospitalisation Facilities (%)					
In the village or neighbourhood	-		-	-	66.7
Neighbouring village	-		18.2	-	-
Palma town	100		81.8	100	33.3
Another Administrative Post in the District	-		-	-	-
Total	100	0	100	100	100
District	**Quitupo**	**Quitupo Settlements (Production Zones)**	**Coastal Zone**	**Senga**	**Maganja**

Source: Impacto, 2012.

The healthcare facilities used by surveyed households are outlined below.

- The Maganja Health Centre is used by the majority of pregnant women in the village of Maganja (93 percent), since it has a maternity clinic.
- According to the social survey, a significant proportion of pregnant women prefer Palma Health Centre as their first choice for perinatal care – Quitupo production zones (88 percent), Quitupo (48 percent), Coastal Zone (59 percent) and Senga (35 percent) – despite the distance of the latter three.
- The First Responder/APE working in the village of Senga is the first point of call for 30 percent of households looking for healthcare for pregnant women, indicating their value in the community.

- For children above the age of five years and adults, the Maganja Health Centre is the first choice for residents of the village of Maganja. Likewise, the Palma Health Centre was the first choice for the residents of Quitupo (54 percent), Quitupo production zones (88 percent), Coastal Zone (36 percent) and Senga (40 percent).

Institutional Capacity

- The health infrastructure network is limited as buildings, equipment and staff appear to be inadequate to serve the healthcare needs of the population.
- There is no ability (in staff, infrastructure and/or supply chain) to cope with a sudden increase in population. This includes emergency services.

EHA #13: Health Programmes and Systems

Community Health Needs/Vulnerabilities

- Although there is extensive NGO activity in Cabo Delgado, there is limited health-related NGO activity in Palma District, with no health interventions reaching the Project area.

Institutional Capacity

- The RHMIS appears to be functional in the District, but it is limited by:

- poor health seeking behaviour (HSB) in the community;
- limited skilled staff;
- limited diagnostic aids; and
- limited recording and reporting.

- The institutional capacity limits the accuracy of reporting and the ability to use the RHMIS as an accurate health monitoring system.

- National disease control programmes (TB, malaria) are inadequately implemented in the District due to a lack of funding, logistics and human resources capacity.

Community Profiling

Potentially Affected Communities

To identify and quantify potential health impacts, an accurate population profile is required. Besides a demographic profile of the at-risk population and the identification of the most vulnerable groups, it is crucial to understand how the Project's activities are likely to impact at both the household and community level.

For the purposes of this baseline, the population who may be affected by the Project are divided into similar exposure groups, or potentially affected communities (PACs). The following seven PACs have been defined:

- Palma District Study Area:
  - PAC 1: Palma-Sede and its different *bairros* (neighbourhoods),
  - PAC 2: populations in the Afungi Project Site who may be potentially resettled,
  - PAC 3: coastal fishing settlements located in the Afungi Project Site and settlements designated as production zones, which may be resettled due to the Project's activities. These are recognised as different to PAC2, due to their use as fishing centres,
  - PAC 4: Senga. This community is located just outside the Afungi Project Site and may be impacted through altered access and influx,
  - PAC 5: Maganja. This community is located just outside the Afungi Project Site and may be impacted through altered access, and
  - PAC 6: communities in the broader Study Area (potential indirect impacts) – Olumbe, Quionga, Mondlane and Mute; and

- Transportation routes:
  - PAC 7: transportation routes and other linear features.

It is recognised that these PACs are a working model, which may evolve and change as the Project progresses, as they may be influenced by various social and biophysical factors. *Figure 9.22* and *Figure 9.23* consider the rough spatial arrangement of the different PACs, as listed above in the broader District and area of Afungi Peninsula.

Vulnerable or Indigenous Groups

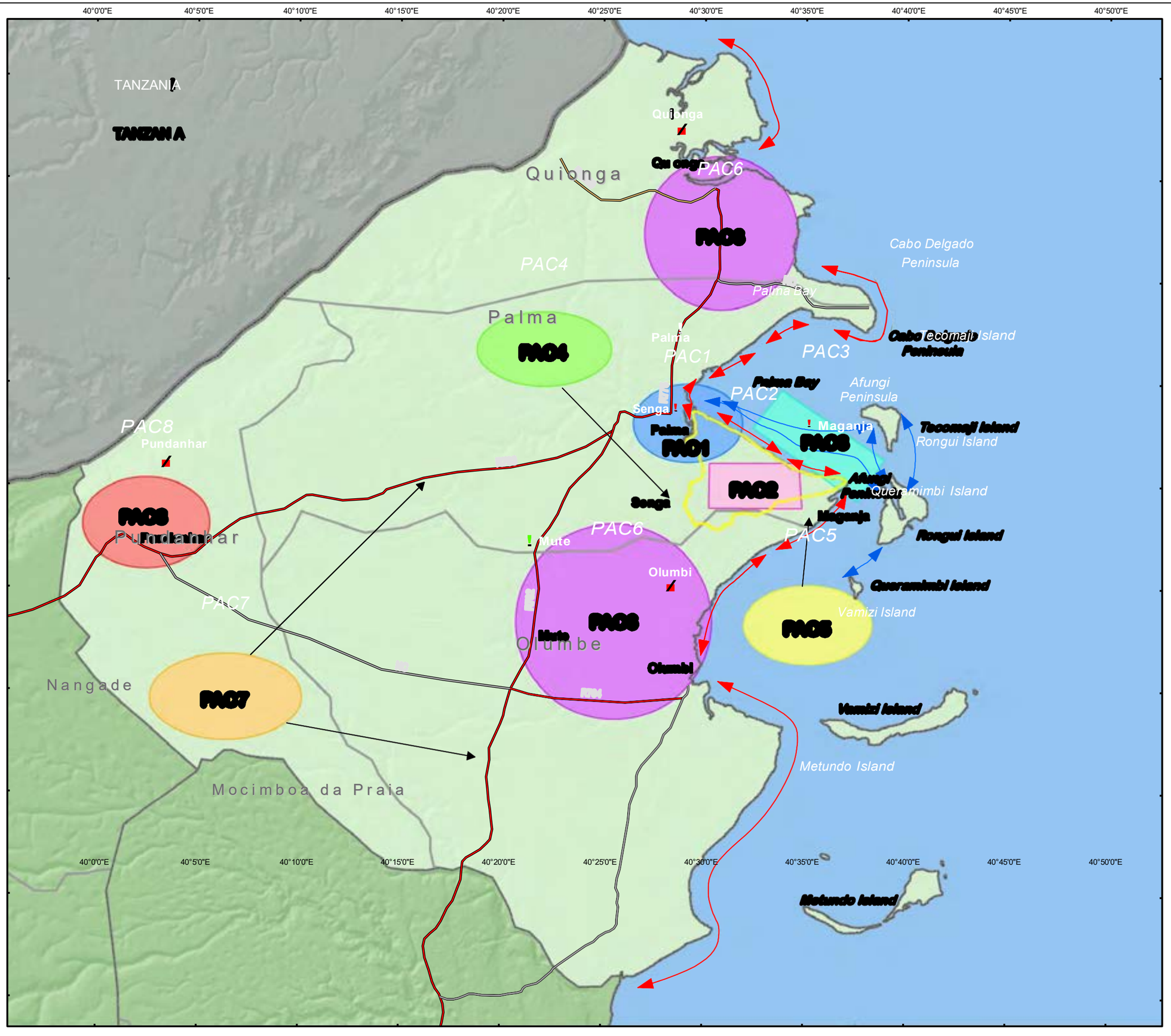
Women, young girls, disabled people and the elderly are seen as particularly vulnerable groups in the local setting. Access to and ownership of land also plays a role. There are no self-identifying marginalised ethnic or religious groups in the Study Area. It is anticipated that the social and economic studies that are underway will describe vulnerable and marginalised groups further.

Table 9.35 Stakeholder Comments or Health Concerns in Potentially Affected Communities

Variables	Health Outcomes/ Determinants	Potential Causes or Contributing Factors
What are the main health challenges in the community?	**Malaria** This is the biggest recognised public health challenge and accounts for around eight out of every 10 children's consultations and half of all consultations in adults in the health centres.	• Breakdown in the supply chain for diagnostic and treatment drugs and supplies is a contributing factor for all health issues. • Limited capacity to diagnose and treat malaria effectively at the village level. • Lack of ability to roll out the full malaria control policy effectively in remote rural areas. However, in spite of limitations, malaria is reducing at the local level. • Poor environmental health conditions in communities promote mosquito breeding and disease transmission. • Poor knowledge in disease prevention and poor health-seeking behaviour increases morbidity and mortality.
	Diarrhoea and associated water and sanitation-related diseases	• These diseases are associated with malnutrition, poor sanitation, poor hygiene and water quality/quantity. • There is a lack of access to potable water and effective sanitation services in most communities. Most communities do not have latrines. The sandy soil in the community and high water table limits the ability to construct even basic pit latrines. • Unprotected wells or surface sources are used for drinking water. This is especially a challenge when the households reside in the fishing areas or production zones. • Cholera outbreaks have occurred in previous years (2009, 2010), which highlights the susceptibility of the communities to outbreaks of severe diarrhoeal disease, linked to poor sanitation. • Urogenital schistosomiasis was raised as a concern, especially in the communities on Afungi Peninsula. The wetland areas in the Study Area are likely high-risk zones where disease transmission may occur. This water-contact disease again highlights the potential poor water use and sanitation practices in the area. • There is limited local knowledge regarding disease prevention, and hygiene practices are inadequate. • Eye and skin diseases are common, and are again linked to poor hygiene practices.
	Increasing rates of STIs and	• Commercial sex work is increasing, especially in Palma. There is currently no real link of

Variables	Health Outcomes/ Determinants	Potential Causes or Contributing Factors
	HIV/AIDS	commercial sex work to Project activities. • There are a number of new bars and guesthouses developing in Palma. The CSWs are increasingly using these as bases to attract clients. • Polygamy and infidelity are reported to be common in the local communities, and complex sexual networks occur. • STIs are reported to be common. However, sexual contact tracing is poor in patients diagnosed with STIs. Use of traditional medicine limits health-seeking behaviour for STIs. • Teenage pregnancy is a major social and health issue, and an increasing trend. There is also an associated increase in STIs/HIV in this young age group. • There is limited local awareness and knowledge related to practices and behaviours to reduce high-risk sexual contact. • Women and young girls are particularly vulnerable to high-risk sexual practices due to local cultural influences, and they have limited negotiating ability for safe sex practices. • Condom availability, knowledge and use is limited, due to a lack of education and cultural/religious preferences.
Stakeholder comments on potential negative impacts of the Project on the community		• Increase in malaria from outsiders moving in – sleeping outside at night while looking for living space, increase in breeding sites, limited local capacity to diagnose and treat an upsurge in cases. • An increase of malaria in the workforce, especially in night-shift workers, may give rise to a larger circulating reservoir of the disease with increased local transmission. • Increases in STIs and HIV/AIDS from an influx of people to the area, movement of CSWs from other geographic locations where there may be higher rates of STIs and HIV, which may promote increased local transmission. • Increases in teenage pregnancy. • Increased water shortages as a result of increased competition. • Increased diarrhoeal diseases from the influx of people into villages, adding to the prevailing poor sanitation situation. This has the potential to increase the risk for epidemics of cholera and dysentery. • Increases in food shortages and malnutrition due to the displacement of people, and also rising costs in the area.

Variables	Health Outcomes/ Determinants	Potential Causes or Contributing Factors
		• The potential for resettlement is unknown at present, but was a highlighted concern due to altered access.
Stakeholder comments on potential positive impacts of the Project on the community		• Improvements in local income. • Enhanced business opportunities. • Potential improvements in health systems and capacity through Project support due to Project impact.



Legend

- Villages
- District Centre
- Locality Centre
- Administrative Post Centre

Roads

- Tertiary
- Local
- Non Classified

- Afungi Project Site

Province

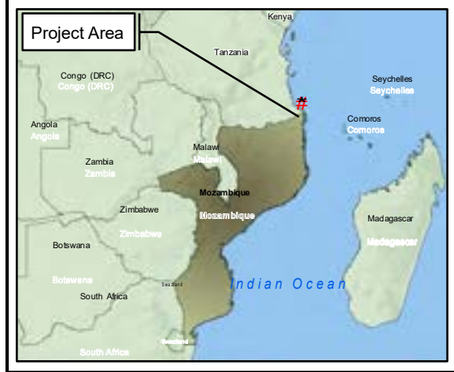
- Cabo Delgado

- District Boundary
- Palma District

- Administrative Post Boundary

Main Marine Access Routes

- Route for Tourism Operators
- Transportation of passenger and goods



MAIN MAP SCALE:

Kilometers

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Figure 9.22:
Potentially Affected Communities (PAC) in Palma District

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 330 000

DRAWING: Potentially Affected Communities in Palma District.mxd

REV: A

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Source: DIVA-GIS. Impacto, 2012.
Inset Map: Esri Data & Maps

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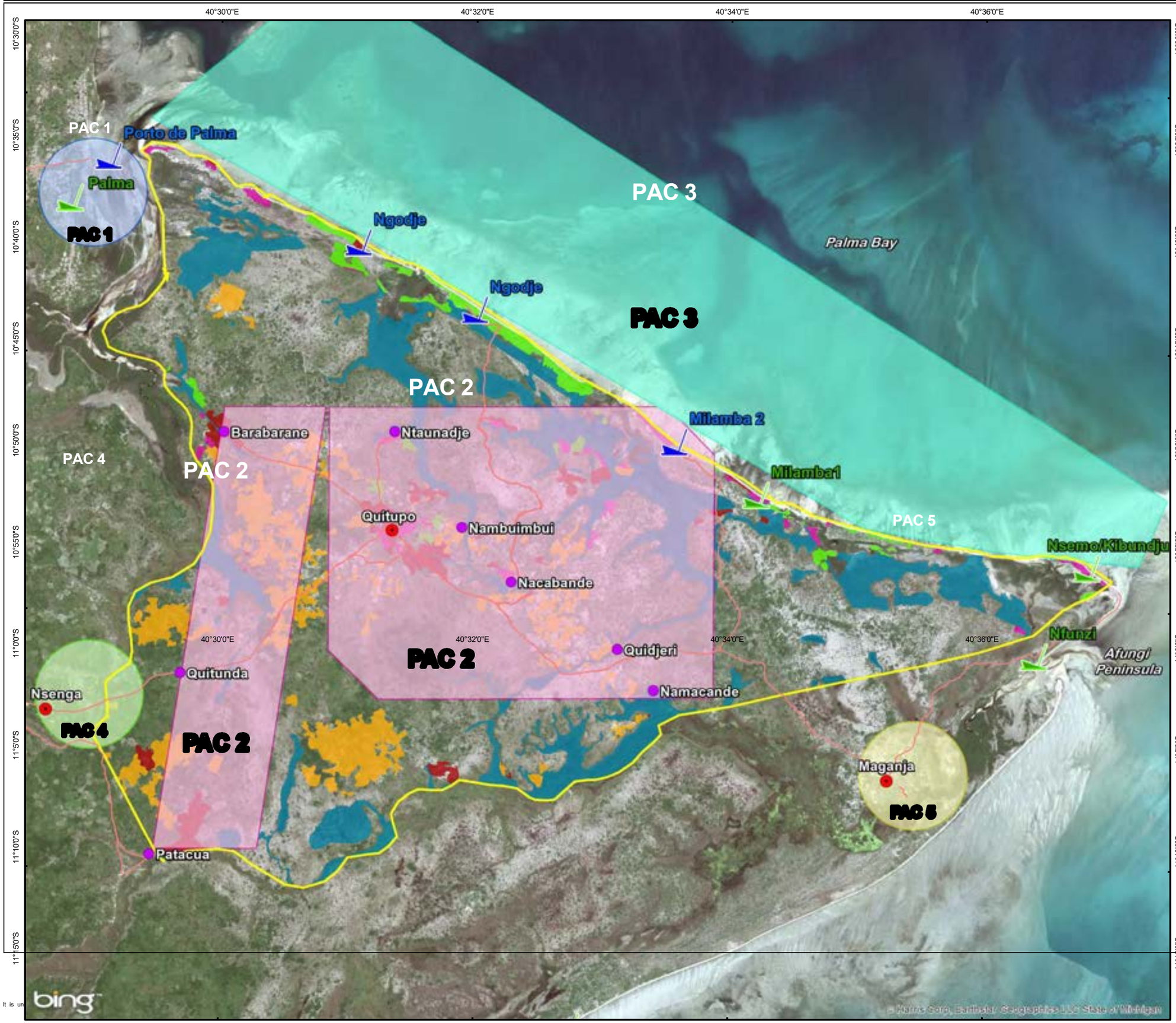
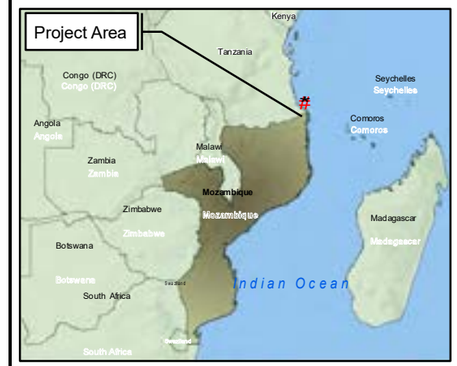


Legend

- Administrative Post Centre
- Villages
- Settlement (production zone)
- Settlement with Fishing Centre
- Fishing Centre
- Local Roads
- Afungi Project Site

Land Cover and Land Use

- Farming Areas
- Coconut Plantation
- Coconut Plantation with Human Occupation
- Human Occupation
- Mosaic of Floodplain and Farming Areas



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 9.23:
Potentially Affected Commmunities (PAC) in Afungi Peninsula

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 52 000

DRAWING:
Potentially affected communities on Afungi peninsula.mxd

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Source: Bing Maps ©2010 Microsoft Corporation.
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9.13.3 Water Supply and Sanitation

Palma District

Palma District has a small water supply system located in Palma town. This is supplemented by a number of other sources such as open wells, rivers, creeks, boreholes with handpumps and other surface water sources such as rivers, streams, lakes, lagoons and pans. The 2007 Census showed that the vast majority of households in the District rely on unprotected water sources such as open wells (60.1 percent); rivers, lakes and lagoons (7.2 percent); and other unspecified sources (1.6 percent). The proportion of households relying on protected water sources is 31.2 percent, out of which 27.6 percent utilise covered wells, 3.4 percent utilise boreholes with a handpump and 0.2 percent depend on water from the main water system in the town. *Table 9.36* shows the sources of water available in the District in 2011 and outlines the availability of these sources.

Table 9.36 Sources of Water in the District by Administrative Post, 2011

Location	Wells		Boreholes with Handpumps		Total		
	Op	Not Op	Op	Not Op	Op	Not Op	Total
Palma District	26	9	53	17	79	26	105
AP Palma Centre	9	5	30	10	39	15	54
AP Olumbe	6	3	17	05	23	8	31
AP Quionga	9	1	2	0	11	1	12
AP Pundanhar	2	0	4	2	6	2	8

Key:
Op: Operational.
Not Op: Non-operational.
AP: Administrative Post.

Source: Palma District Services for Planning and Infrastructures, 2011.

The authorities in Palma District have been actively working with the Spanish Cooperation and the Millennium Challenge Corporation as donors of the water sector, and with FH, JAM and Cowater as implementing organisations, to provide communities with protected water sources. This is achieved through the construction of boreholes with handpumps (1).

Basic sanitation in Palma District is a challenge, as 79 percent of the households reportedly have no access to sanitation facilities. Most of these households use the bush and beaches for sanitation purposes. Even so, of those who own a sanitation facility, only a few had a safe facility (0.3 percent

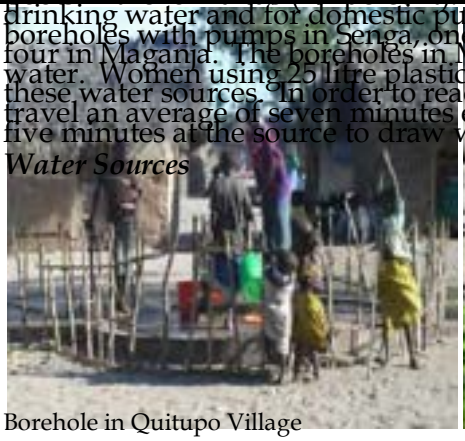
(1) The National Water Policy (PNA) determines that the source of water must be applied for by the community, which must organise itself to contribute part of the costs and select the group who is going to ensure community management of the source, as well as its maintenance and repair.

who use improved/pit latrine), while 19.7 percent of the District's households had a traditional latrine, which is an unsafe sanitation facility [1] (INE, 2010e).

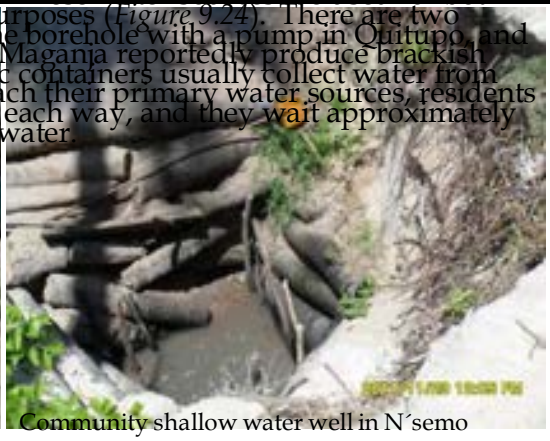
Afungi Project Site and Surrounds (Including Senga and Maganja)

There is no formal water system in the Afungi Project Site and Surrounds, and households use various water sources including wells with handpumps (45 percent), open wells (25 percent), community boreholes (17.1 percent) and pools in the lowlands (7.1 percent). These water sources are used for both drinking water and for domestic purposes (*Figure* 9.24). There are two boreholes with pumps in Senga, one borehole with a pump in Quitupo, and four in Maganja. The boreholes in Maganja reportedly produce brackish water. Women using 25 litre plastic containers usually collect water from these water sources. In order to reach their primary water sources, residents travel an average of seven minutes each way, and they wait approximately five minutes at the source to draw water.

Figure 9.24 ***Water Sources***



Borehole in Quitupo Village



Community shallow water well in N´semo

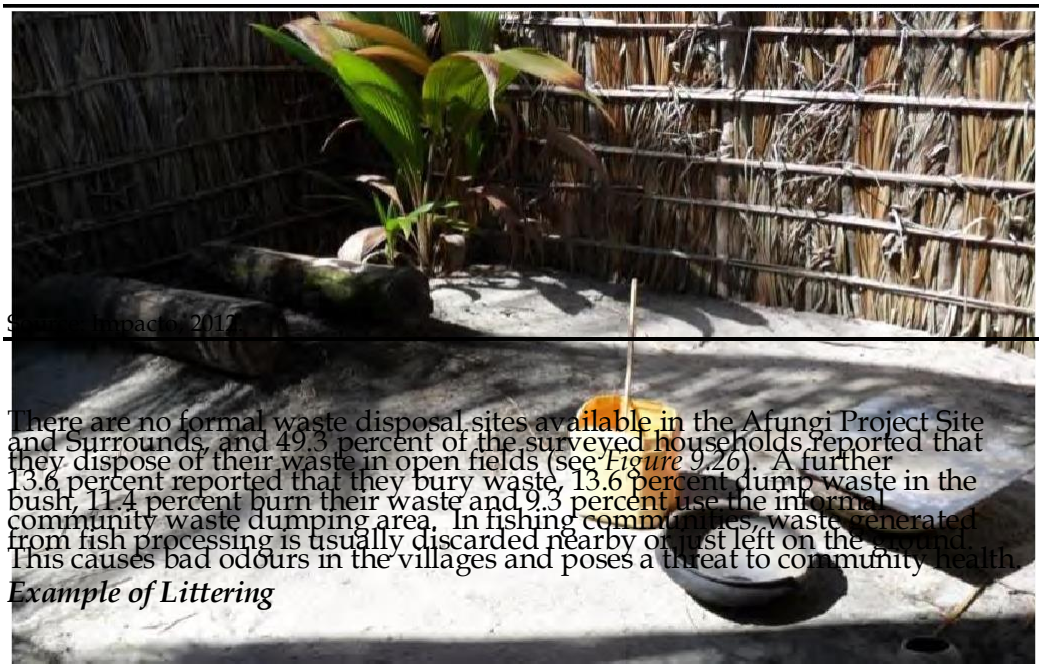
Source: Impacto, 2012.

Sanitary facilities (improved latrines and safe sanitary facilities) are insufficient and almost non-existent in the surveyed households. Approximately 81 percent of the households do not have sanitation facilities and instead use the bush, while 10 percent have traditional pit latrines and 8.6 percent use the beaches. Field observations noted that many households have bathrooms, as shown in *Figure* 9.25. These are built using palm or coconut tree leaves, but are only used for bathing purposes.

As opposed to access to safe water, access to sanitation and good waste disposal practices are not a priority identified by households to improve their welfare and health status. This highlights the importance of raising awareness of household hygiene knowledge, practices and behaviours.

(1) A traditional latrine consists of an open pit closed with some sticks, while an improved latrine consists of a pit covered by a slab with a cover that can be manually removed and closed.

Figure 9.25 ***Local Traditional Bathroom***



Source: Impacto, 2012.

There are no formal waste disposal sites available in the Afungi Project Site and Surrounds, and 49.3 percent of the surveyed households reported that they dispose of their waste in open fields (see *Figure 9.26*). A further 13.6 percent reported that they bury waste, 13.6 percent dump waste in the bush, 11.4 percent burn their waste and 9.3 percent use the informal community waste dumping area. In fishing communities, waste generated from fish processing is usually discarded nearby or just left on the ground. This causes bad odours in the villages and poses a threat to community health

Figure 9.26 ***Example of Littering***

Source: Impacto, 2012.

9.13.4 Electricity and Main Energy Sources

Palma District

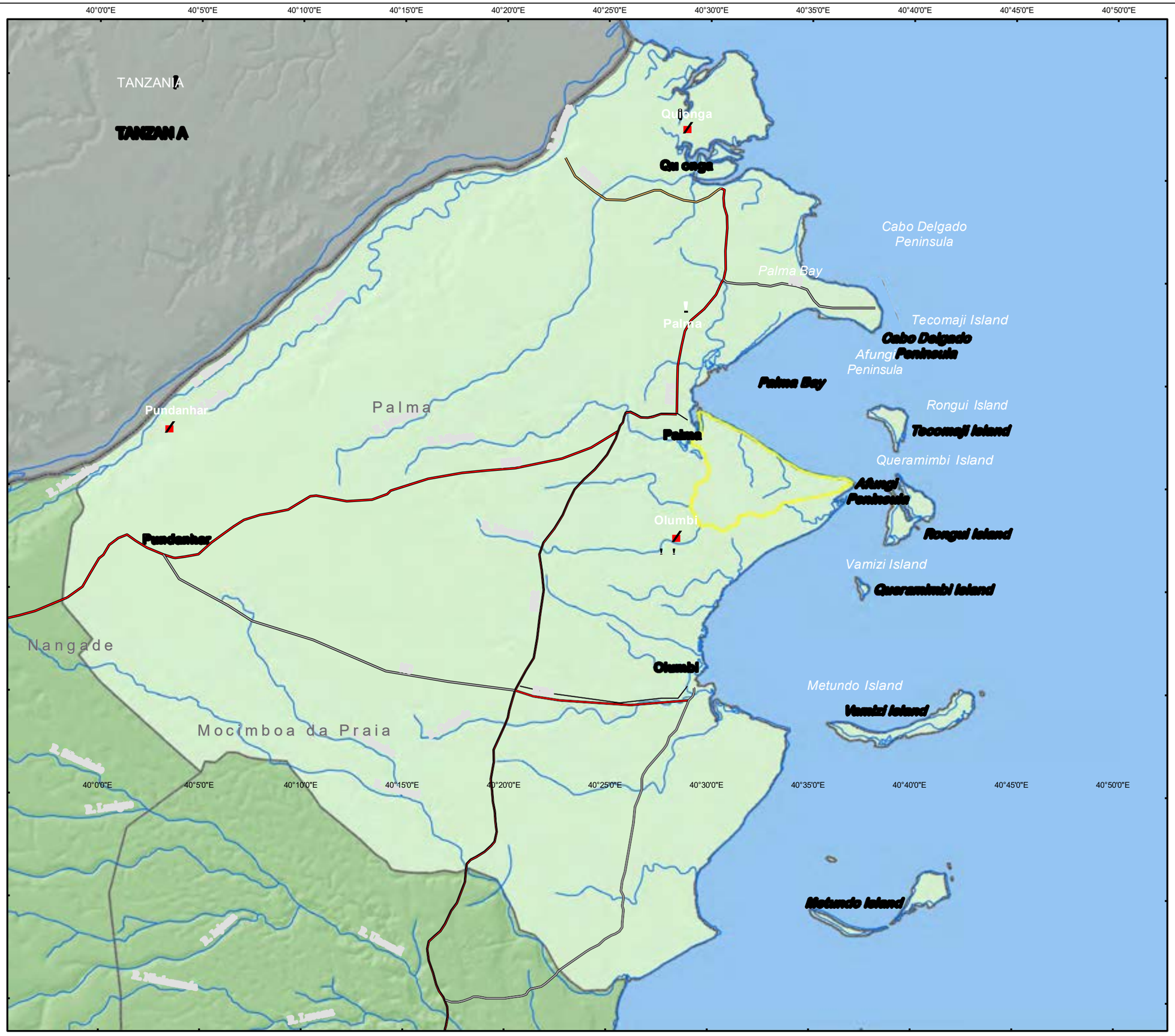
Palma District receives electricity from the national grid via a 33KV line that extends from the Auasse substation in the District of Mocímboa. However, as shown in *Figure 9.27*, only Palma town, Olumbe Administrative Post Centre and some villages located along the power line corridor have access to electricity. There was a plan for the network to be extended to the coastal village of Maganja, as well as to the village centre of Pundanhar, but this project was never completed. According to the 2007 Census, less than 1 percent of households in the District use electricity as their main source of lighting (INE, 2010e).

The majority of the households rely on sources of energy other than electricity, including petroleum, paraffin or kerosene (73 percent); firewood (25 percent); candles or batteries (1 percent); and generators, gas and solar panels (less than 1 percent).

Afungi Project Site and Surrounds (Including Senga and Maganja)

There is no electricity in the Afungi Project Site and Surrounds and, according to the authorities, there are no plans to connect the areas in and around the Site to the national electric grid. Surveyed households mainly use wood fuel for cooking (99.3 percent), which women gather in the surrounding forest areas, while 0.7 percent use coconut palm fronds. For lighting purposes, households mainly use petroleum products (47.9 percent) and battery-operated flashlights/lamps (44.3 percent). Individual solar panels are used in some stores and even in a few residences; however, this source of energy is primarily used to power televisions [1].

(1) An entrance fee is charged and this is another income-generating activity for some individuals.



Legend

- District Centre
- Administrative Post Centre
- Rivers

Roads

- Tertiary
- Local
- Non Classified

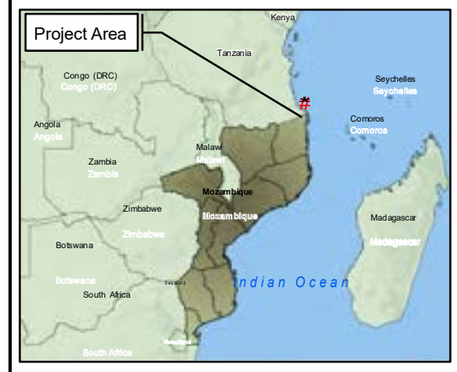
- Afungi Project Site
- Boundary with Tanzania

Province

- Cabo Delgado

- District Boundary
- Palma District

- Power Transmission Line (33kV)



MAIN MAP SCALE:

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Figure 9.27:
Electricity Distribution in Palma District

CLIENT:

Anadarko
Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 330 000

DRAWING: Electricity Distribution in the District.mxd

REV: A

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Impacto
Projectos e Estudos Ambientais

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Projection: UTM Zone 37 S Datum: WGS84 Source: DIVA-GIS. Impacto, 2012. Inset Map: Esri Data & Maps	SIZE: A3

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R. Lucoma
R. Kovuma
R1260
R775
R763
R. Mecumbi
R762
R764
R. Mipama
R. Mecumbue
R. Lunigue
R. Silundimde
R. Chemba
R. Meranvi
R. Quigode
R. Livecda
R. Mavanga
R. Kovuma
R. Livecda
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9.13.5 Roads, Transport and Communications Network

Road Network

The road network of Palma District covers approximately 256km in total, and is poorly developed and in bad condition. It consists of tertiary roads, feeder roads and non-classified roads (typically unpaved) (*Figure 9.29*). The tertiary road network connects Palma with the neighbouring districts, the City of Pemba and the other provinces within the country.. There is limited connection between Palma town and other centres in the Administrative Post.

The main roads in the District are:

- R762, connecting Pemba to Palma and continuing to Quionga via the R775 (22km);
- R763, which starts at the intersection with the R698 that comes from Mueda to Nangade (Imbuo) and then runs towards Pundanhar and Palma (160km); and
- R764, which starts at the intersection with the R762 in Palma and runs to Olumbe (15.7km).

Other important roads in the District comprise the following feeder and non-classified roads, which are also of poor quality:

- R1260, which connects Quionga to Namoto and the Rovuma River at the border with Tanzania;
- a non-classified road starting at the intersection with R775, which connects Palma to Quirinde; and
- a non-classified road starting at the intersection with R762, which connects Palma with the villages of Senga, Quitupo, and Maganja.

The improvement of the road network in the District is ongoing and focused on repairing and paving the roads linking Mocimboa da Praia with Palma (R762), Palma with Quionga (R775) and Quionga with Namoto on the Tanzanian border [1] (R1260), and will certainly enhance the movement of people and goods between the two countries. In addition eni is investigating upgrading the road between Pemba and Mocimboa da Praia.

Sea Transportation

As previously mentioned, the road network in Afungi Project Site and Surrounds is of poor quality and, as such, there is a general lack of public

[1] The contractor is ZAGOPE, a Brazilian company that will construct a 230km paved road from scratch between Mueda Town (in Moeda District) and the border with Tanzania in Namoto, north of Palma Town. The road is financed by the Portuguese Government (85%) and the Government of Mozambique (15%), and is planned to be concluded in March 2014.

transportation services in the area. As a result, some local people make use of boats to transport goods and people along the coastline and to and from Tanzania. Due to the high costs (about 50 MZN per passenger), only a small percentage of people (6 percent) make use of the boats for transportation. *Figure 9.29* shows the primary boat transportation routes along the coast of Palma District, and *Figure 9.28* below illustrates some examples of goods and modes of transport used.

Figure 9.28 Sea Transportation of Goods and People

Transporting stakes on the Ngodje coast

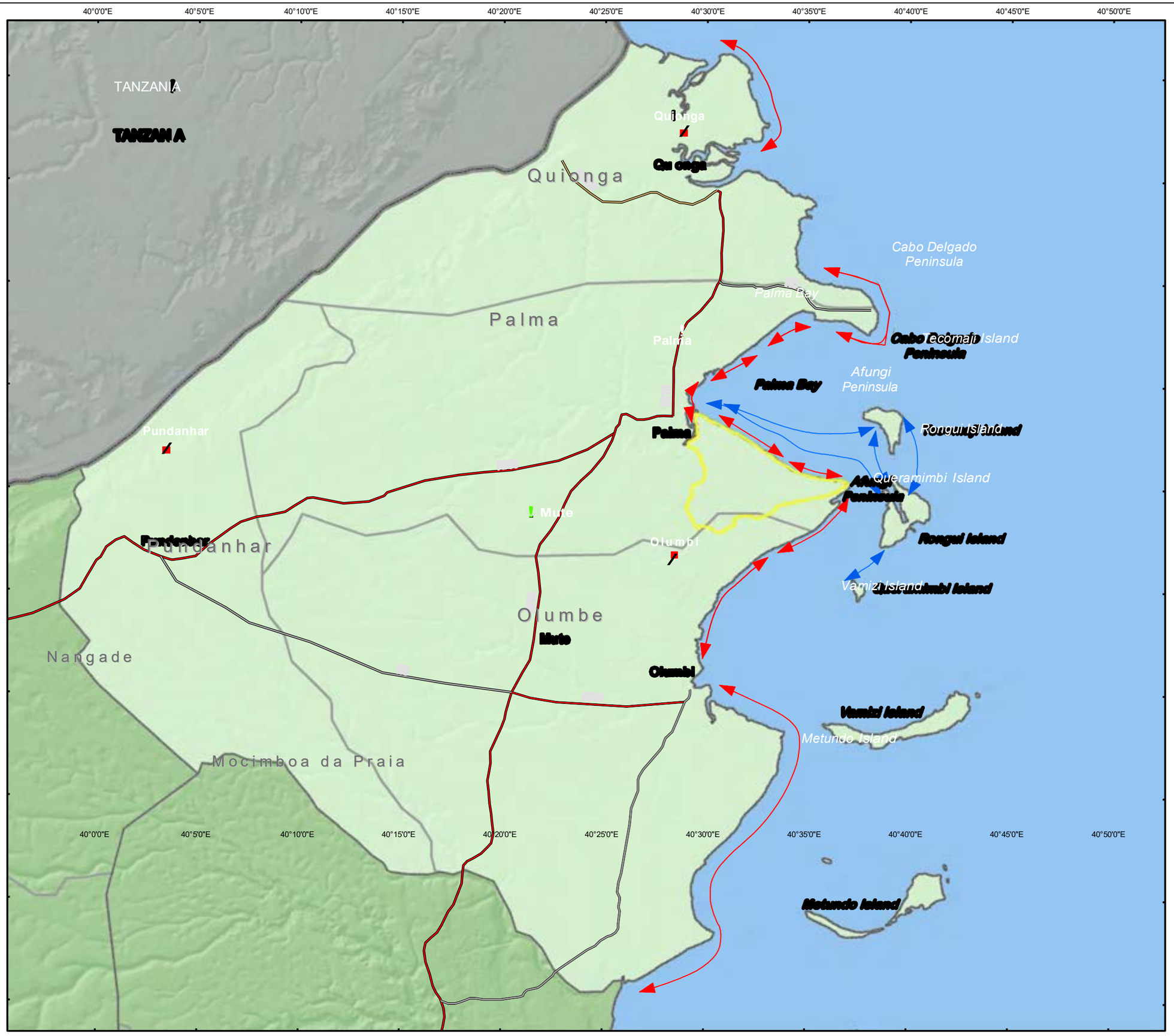
Transportation of farm products to a vessel in the N'gala Fishing Centre

Transport vessel property of a transporter resident in Milamba 2

Vessel transporting construction materials along the coast between Olumbe and Maganja

Woman transporting goods to a boat in Milamba 2, and a boat transporting people near the coast of Ngodje

Source: Impacto, 2012.



Legend

- District Centre
- Locality Centre
- Administrative Post Centre

Roads

- Tertiary
- Local
- Non Classified

- Afungi Project Site

Province

- Cabo Delgado

- District Boundary
- Palma District

- Administrative Post Boundary

Main Marine Access Routes

- Route for Tourism Operators
- Transportation of passenger and goods

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 9.29
Transport Routes in Palma District

CLIENT:

Anadarko
Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 330 000

DRAWING: Transport Routes in Palma District.mxd

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Projection: UTM Zone 37 S Datum: WGS84 Source: DIVA-GIS. Impacto, 2012. Inset Map: Esri Data & Maps	SIZE: A3

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Transportation

The main means of transport used in Palma District are semi-public minibuses and pickups owned by private operators, and boats [1] [2]. In 2011, the District had seven private transport services, covering the three following road routes:

- Mocímboa da Praia – Palma – Namoto;
- Olumbe – Mocímboa da Praia; and
- Palma town (District Centre) – Pundanhar–Nangade (a neighbouring district).

Given the poor road network and infrastructure, especially for the communities living along the coast, an alternative mode of transportation of people and goods is by sea, along the coast between the districts of Palma and Mocímboa da Praia, Nacala (in Nampula Province) and to Tanzania to the north (*Figure 9.29*). Boats are the main vessels used for sea transportation and, in 2011, there were 15 licensed boats operating along the coast (12 without outboard motors and three with outboard motors). There are also unlicensed boats operating along the coast. There is no further information available to enable a more detailed description of the local transportation baseline.

Communication Network

There are three mobile communication networks operating in Palma District: Mcel, Vodacom and Movitel [3]. Mcel and Vodacom are accessible in a radius of approximately 15km within Palma town and its surrounds. Movitel coverage is expanded to Mute Locality, Quionga and Pundanhar Administrative Posts. No land-based telephone network exists within the District.

9.14 PALMA DISTRICT AND AFUNGI PROJECT SITE ECONOMIC ACTIVITIES AND LIVELIHOODS

9.14.1 Employment Status of the Population

Palma District

The current level of economic development remains very low, the survival strategies of the population are primarily subsistence-based, and the local economic market is underdeveloped and served by small informal operators.

Table 9.37 summarises the economically active population by employment position and economic sector of activity. Nearly 86.5 percent of the

(1) Interview with District Service for Planning and Infrastructure, January 2012.

(2) Interview with District Service for Planning and Infrastructure, January 2012.

(3) As of February 2013.

economically active population of Palma District work in the primary sector, ie in agriculture, forestry, fishing and extractive activities, while the tertiary sector accounts for 9.3 percent, which includes those involved in commerce, finance and administrative services. Similar to the province, the secondary sector is not well developed in the District (INE, 2010c).

The majority of the population (87.1 percent) are self-employed workers (meaning people who work independently, rather than being formally employed, or working with other people) and non-remunerated household workers (8.6 percent) [1]. The proportion of the population employed in the public and private sector is small, corresponding to 1.6 and 1.3 percent respectively.

The majority of those working in the primary sector are self-employed or non-remunerated household workers, representing 89.6 percent (18,899 out of 21,099 inhabitants) and 8.5 percent (1,786 out of 21,099 inhabitants) of the sector respectively, and this includes the vast majority of subsistence farmers and fishers of Palma District [2]. The majority of those who work in the tertiary sector are also self-employed andinvolved in informal business. These account for 68 percent of the sector (1,554 out of 2,273 inhabitants).

Formal employment is scarce and is mostly provided by the State (roles include public officials of local administration, teachers and health professionals) and the private sector. Waged employment provided by the private sector is limited to those employed by tourism operators and those who gain temporary work offered by ongoing developments.

Table 9.37 Economically Active Population (15 Years or Older) in Palma by Sector and Employer, 2007

	Total Residents	% Sector of Activity	State Employee	Private Company Employee	Self-employed Worker	Non-remunerated Household Worker
Total residents	24,353		399	327	21,203	2,084
% Employment position		100.0	1.5	1.3	87.1	8.6
Agriculture, forestry, fishing and extractive	21,099	86.6	50	151	18,899	1,786
Industry and energy	479	2.0	10	12	432	16
Construction	179	0.7	17	82	70	6
Transport and communications	73	0.3	11	17	42	
Services	2,273	9.3	306	60	1,554	260
Unknown	250	1.0	5	5	215	16

Source: INE, 2010c.

[1] Non-remunerated household workers is a category used by the INE to capture people aged 15 or older who work for a household without remuneration, in most cases in farming and domestic activities. Generally, they live as a member of the household, sleeping and eating under the household's responsibility. In some cases, they are indirect relatives (nephews or nieces, for example) who live under the protection of the household.

(2) The INE data does not allow a more detailed breakdown to determine the number of fishers.

Palma District has a number of economic development opportunities given its available natural resources such as land, forests, wildlife, mineral and fishing resources, as well as beaches and islands surrounded by coral reefs. The potential of these resources remains underdeveloped, and the current patterns of development have not led to substantial improvements in living conditions in the District. Other potential development projects offering potential economic opportunities to offer are still in an early phase, eg exploration for hydrocarbons and various tourism projects.

Afungi Project Site and Surrounds (Including Senga and Maganja)

The Afungi Project Site and Surrounds have typically rural characteristics, and economic activities are essentially within the primary sector (eg agriculture and fishing). Livestock rearing (mainly goats and poultry) is practised on a small scale, and is an activity that families conduct mostly by habit and tradition.

Due to the lack of formal employment opportunities at a local level, men of working age often migrate to the main villages and nearest towns to seek paid temporary work. Informal commerce is also observed in the area, providing cash income to some households.

Table 9.38 contains a summary of the main occupational activities of the heads of households and their wives, confirming that agriculture and fishing are the dominant work activities.

Table 9.38 Main Occupations by the Head and Wife of Surveyed Households

Main Occupations	**Head of Household (%) (1)**	**Wife of Head of Household (%) (2)**
Works for others	4.3	0.8
Self-employed/small industry	4.3	0.8
Self-employed/preparation of food, drink	2.1	0.8
Self-employed/construction materials	4.3	3.1
Self-employed/commerce	8.6	0.8
Agriculture	50.0	85.0
Fishing using boat/net	21.4	2.4
Fishing without boat/net	2.9	2.4
Employed fisherman (paid in cash/in kind)	-	0.8
Other	2.1	0.8
Does not know/Did not answer	-	2.4
Total	100.0	100.0

Note:

(1) 140 heads of households were surveyed.

(2) 127 wives of heads of households were surveyed.

Source: Impacto, 2012

Some key observations are outlined below:

- Subsistence farming is the primary activity for 50 percent of the heads of households, followed by fishing, which is undertaken by about 24 percent of heads of households.
- The type of agriculture practised is subsistence farming, and there is no commercial farming taking place (1).
- Approximately 21 percent of fishermen use boats and/or nets.
- Self-employment activities as a whole are practised by approximately 19 percent of the heads of households, and these consist primarily of informal commerce activities.
- Waged work is not very common, and is only reported by approximately 4 percent of the heads of households.
- Approximately 85 percent of women are involved in subsistence agriculture. In some instances, wives are involved in fishing and self-employment activities, as reported by approximately 5 percent of the wives.

The primary occupations of heads of households in each of the settlement areas can be summarised as follows (see *Annex G, Table 1.7*):

- Most of the surveyed households are involved in agriculture, primarily in areas such as Senga (95 percent), Quitupo Settlements (production zones) (68.8 percent) and Quitupo (50 percent). An exception to this is the Coastal Zone, where the two most significant activities are fishing and commerce, in which approximately 32 and 23 percent of the households respectively are involved.
- Fishing is also an activity undertaken by households living in the interior zones, such as Quitupo Settlements (production zones), where approximately 25 percent and 19 percent respectively of the heads of households fish as their primary activity.
- Fishing activities are also closely related with the tradition of certain ethnolinguistic groups (ie the Makwé and Mwani). In Senga, where the population is primarily Makonde, none of the heads of households reported fishing to be their primary activity.

The following subsections provide a detailed description of the most important economic activities within the Afungi Project Site and Surrounds (including Senga and Maganja).

(1) The analysis of household income, included later in this report, will validate this affirmation.

9.14.2 *Agricultural Production and Services*

Palma District

Although fishing represents an important income-generating activity for the inhabitants of Palma District, in particular for those residing close to the coast, agriculture continues to be the one activity that involves the majority of the population. Most agricultural activities are of a small scale and are undertaken for subsistence purposes, which is also consistent with trends in the province. Surplus production is sold. Some households are engaged in the production of cash crops such as coconuts, cashews and, more recently, sesame seeds.

The most commonly grown crops are maize, cassava, peanuts and beans, and these are cultivated in the highlands, although soils within the highlands are typically sandy and have low productivity. Rice, sweet potatoes and horticultural products are cultivated in the lowland areas, generally located along the drainage lines and alluvial plains of rivers and streams, where soils are typically rich in nutrients.

Land is cultivated in a rain-fed regime over two seasons; the first season begins from October to November to prepare the plots for food crops as maize, rice and beans, and the second from March to April to prepare for sweet potato and vegetables. Manual watering is practiced on horticultural products cultivated on lowlands. Women are most active in crop farming and generally tend to their crops on a daily basis.

In accordance with the District's 2011 Economic and Social Plan Annual Balance, the 2010–2011 agricultural campaign aimed to cultivate a total of 44,129ha across the District, of which 40,919ha were planned for food crops and 3,210ha for sesame, as shown in *Table 9.39* (Government of Palma District, 2012).

Cassava is the main crop cultivated, occupying the largest area and having the highest volume of production. Rice is the second-most commonly cultivated crop. Out of an anticipated production of 165,847t of crops for the 2010–2011 campaign, the District ended with a total production of 167,232t.

Table 9.39 Agricultural and Cultivated Areas in Palma District (2010–2011)

Crops	Planned Area (ha)	Prepared Area (ha)	Sowed Area (ha)	Anticipated Production (t)	Production Achieved (t)	Average Production (t/ha)
Maize	7,702	7,714	7,714	13,864	13,885	1.8
Rice	8,238	8,254	8,254	14,828	14,857	2
Sorghum	3,910	3,905	3,905	2,737	2,734	1
Beans	3,035	3,029	3,029	2,074	2,090	2
Groundnuts	2,093	2,094	2,094	1,256	1,256	1
Cassava	15,734	16,275	16,275	128,872	130,200	8
Vegetables	39	44	44	156	176	4
Sesame	3,210	3,150	3,150	1,284	1,260	0
Crops	**Planned Area (ha)**	**Prepared Area (ha)**	**Sowed Area (ha)**	**Anticipated Production (t)**	**Production Achieved (t)**	**Average Production (t/ha)**
Sweet potatoes	168	172	172	764	774	5
Total	44,129	44,595	44,595	165,847	167,232	

Source: Government and Palma District Service of Economic Activity, 2012.

The agricultural extension services network is small for the number of households residing in the District, with only four technical stuff available, of whom two are public officials and two are from FH, assisted by 19 farmers working as extension monitors.

In general, agricultural productivity levels are low [(1)], and the District government and its partners (eg FH) are engaging in activities to foster production, productivity and the diversification of crops. These activities include the distribution of seeds (such as maize, rice, cowpea/nhemba bean, peanut and sesame), the distribution of cashew tree seedlings and the spraying of cashew trees, and the promotion of linkages between farmers and the market.

Afungi Project Site and Surrounds (Including Senga and Maganja)

Agricultural activities are the primary livelihood source for households in the area, and rudimentary farming practices such as slash-and-burn agriculture

are still widely practised.

Agricultural Calendar and Division of Labour

Most farming is subsistence in nature and is undertaken by all members of the household (including children). Field tilling and preparation are normally the male's responsibility; however, planting is performed by both men and women in November–December during a season with normal rains (if the rains are delayed, planting may also be delayed to January–February). Women are responsible for the weeding and cultivation of crops, and men provide support during the final harvest period. Weeding occurs between January and April, also depending on the timing of the rains. Harvesting takes place from May to August (see *Table 9.40*).

Table 9.40 ***Agricultural Calendar***

Activity	N	D	J	F	M	A	M	J	J	A	S	O
Field tilling/preparation												
Planting												
Crop cultivation/weeding												
Harvesting												

(1) The main reasons for low productivity in subsistence agriculture in Mozambique are a result of the labour and technology used (manual labour and slash-and-burn practice), deficient storage of harvests, low quality of goods such as seeds, fertilisers and insecticides, and insufficient extension services.

Activity	N	D	J	F	M	A	M	J	J	A	S	O

Source: Impacto, 2012.

Number of Plots per Household

All of the surveyed households have at least one plot of land for farming, with the exception of two households that depended on other activities for subsistence. Analysis indicated that almost half of the surveyed households depend on only one available plot:

- 44.3 percent of the households have one farming plot. In Quitupo, this proportion in much higher, with 87.5 percent of households having one plot;
- 34.3 percent of the households have two plots. In Senga, the proportion is higher, at 45 percent;
- 14.3 percent of the households have three plots. In Senga, the proportion is higher, at 25 percent, and
- 5 percent of the surveyed households have four plots.

Location of Farming Plots

Farming predominantly occurs in the highlands, especially for crops that are rain-fed; those that require more water or humidity are grown in the lowlands. In general, the lowland areas consist of river and stream corridors, where nutrient-rich alluvial plains are formed. The highland areas are generally sandy with lower productivity. The two most important staple food crops, cassavas and rice, are grown in the highlands and lowlands respectively. The other crops produced are peanuts, sweet potatoes, sorghum, maize, beans and vegetables.

Of the households that own two plots (Plot One and Plot Two), more than 60 percent of these are located in the highland areas, and approximately 30 percent in the lowland areas.

In Quitupo and Senga, a greater proportion of Plot One and Plot Two are located in the highland areas, with approximately 79 and 74 percent respectively in Quitupo, and approximately 85 and 71 percent respectively in Senga. This is related to the fact that there is a greater availability of highland plots, which have already been cleared or which could be cleared, in those areas.

In the Quitupo Settlements (production zones) and in the Coastal Zone, where more lowland plots are available and where these are located closer to the settlements, the proportion of Plot One and Plot Two located in the lowland areas is slightly higher. Thus, in the Quitupo production zones, 56 percent of Plot One are located in the lowlands, and 60 and 77 percent of Plot One and Two in the Coastal Zone.

During FGDs, the participants indicated that although the lowland areas are more productive than the highland areas, the latter are more important because they guarantee crops (mainly cassava) for the families for long periods during the year.

Average Size of Farming Plots

Table 9.41 below shows the average usable area owned by each of the households for farming, based on the areas where they live. On average, the surveyed households have 2.4ha of land for farming, and this average is higher in the Coastal Zone and the areas around Quitupo, where the plot sizes average 2.8 and 2.6ha respectively.

Table 9.41 Average Crop Sizes by Area of Residence, in the Afungi Project Site and Surrounds (in Hectares)

	Quitupo	Quitupo Settlements (Production Zones)	Coastal Zone [3]	Senga	Maganja	Total
Average area owned	2.4	2.6	2.8	2.2	2.0	2.4

Source: Impacto, 2012.

Access to Agriculture Extension Services

The agricultural extension services in the Afungi Project Site and Surrounds are weak. No direct and continuous agricultural extension service programmes are provided by the District Services for Economic Activities (DEAS), with the exception of some support provided to cashew nut producers. None of the villages in the Afungi Project Site and Surrounds are involved with the work undertaken by FH.

The availability of seeds and crop-spraying services for cashew plantations in the Afungi Project Site and Surrounds are primarily limited to Palma town. The vast majority of the surveyed households reported that to access these services they must travel to Palma, with some exceptions related to availability of crop-spraying services for cashew trees in Quitupo and Senga (see *Table 9.42*).

Table 9.42 Location of the Seed Supply and Spraying Services as Reported by Surveyed Households

Location	Quitupo	Quitupo Settlements (Production Zones)	Coastal Zone	Senga	Maganja
Seed Supplier (% of Household)					
In the village	22.1	-	4.5	-	3.3
Palma	78.8	93.8	90.9	100.0	96.7
Nearby village	-	6.3	4.5	-	-
Other AP	-	-	-	-	-
Location	**Quitupo**	**Quitupo Settlements (Production Zones)**	**Coastal Zone**	**Senga**	**Maganja**
Other district	-	-	-	-	-
Spraying (% of Household)					
In the village	63.5	-	9.1	25	3.3
Palma	36.5	75.0	72.7	55.0	63.3
Nearby Village	-	25.0	18.2	20.0	33.3
Other AP	-	-	-	-	-
Other District	-	-	-	-	-

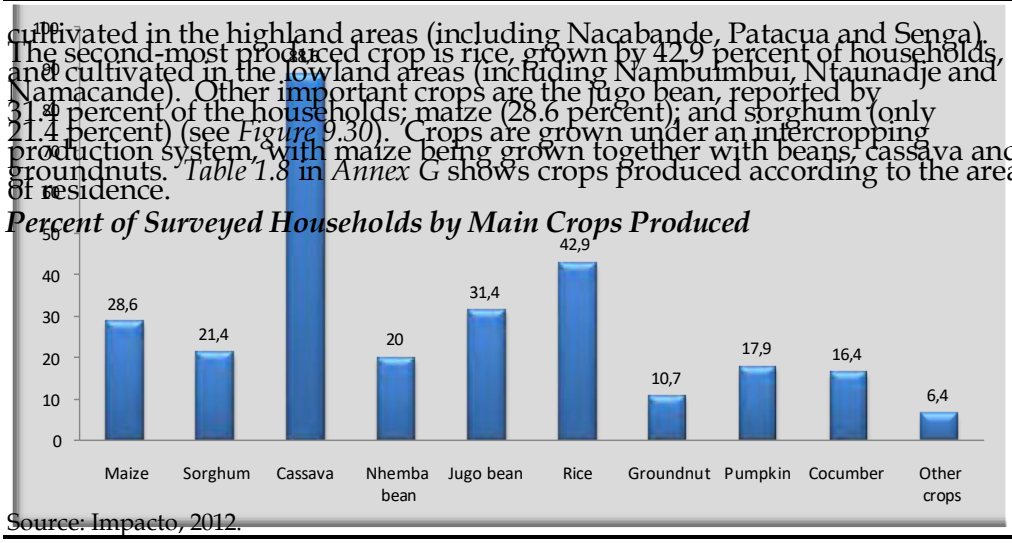
Source: Impacto, 2012.

Main Crops and the Sale of Crop Produce

Cassava is the primary crop, grown by 88.6 percent of households, and is

cultivated in the highland areas (including Nacabande, Patacua and Senga). The second-most produced crop is rice, grown by 42.9 percent of households, and cultivated in the lowland areas (including Nambuimbui, Ntaunadje and Namacande). Other important crops are the jugo bean, reported by 31.4 percent of the households; maize (28.6 percent); and sorghum (only 21.4 percent) (see *Figure 9.30*). Crops are grown under an intercropping production system, with maize being grown together with beans, cassava and groundnuts. *Table 1.8* in *Annex G* shows crops produced according to the area of residence.

Figure 9.30 ***Percent of Surveyed Households by Main Crops Produced***



Source: Impacto, 2012.

Although found in the Afungi Project Site and Surrounds, vegetables are not widely cultivated. For example, pumpkin and cucumber are reported as being produced by 17.9 percent and 16.4 percent of households respectively, while onion, tomato and lettuce were referred to by only 2 percent. Pumpkin and cucumber are cultivated without an irrigation system, during the coolest

part of the year, and are grown together with other crops such as cassava or maize.

Table 9.43 shows that in the 2010–2011 agriculture season, the sale of cassava, maize, sorghum and rice was practised by few households, since these crops are important to the households food security. For instance, being the most important crop in the diet of local households, cassava is cultivated by most households (88.6 percent), but is the least sold product (13.6 percent of households). In comparison, groundnuts were produced by only 10.7 percent of the households, but this crop is sold by a relatively high proportion of households that grow it (46.7 percent) [1]. *Table 1.9* in *Annex G* shows the marketing of crops produced by surveyed households according to their residence area.

Table 9.43 Crops and Annual Income Generated from their Sale, as Reported by Surveyed Households

	Maize	Sorghum	Cassava	Nhemba Bean	Jugo Bean	Rice	Groundnuts
Households producing the crop (%)	28.6	21.4	88.6	20.0	31.4	42.9	10.7
Households marketing the crop (%)	35.9	30.0	13.6	35.7	40.0	25.0	46.7
Average annual income (2010–2011) (MZN)	1,546	2,706	1,907	1,380	1,792	2,176	1,643

Source: Impacto, 2012.

Income generated by the sale of agricultural produce is very low, with the average annual income varying between 1,000 and 3,000 MZN. Agricultural products are sold locally to consumers or transported by the household by foot or boat to Palma town, to be sold to Palma-based traders. Typically, the income obtained from the sale of agricultural products is used to purchase basic household items and clothing.

The reasons for the sale of agricultural products not being significant are:

- underdeveloped markets;
- low crop yield resulting in low surplus to sell;
- lack of transportation services (poor roads and limited transportation); and
- lack of marketing agents to buy surplus production.

Fruit Trees and the Sale of Fruit Tree Produce

(1) Some households that have not produced this crop may have sold produce stocked from a previous agricultural campaign.

Table 9.44 below outlines statistis around the ownership and sale of fruit trees or produce in the area in the 2010–2011 agriculture season. All surveyed households have at least one type of fruit tree.. The most common trees grown include cashew, mango and coconut trees, which are owned by approximately 64, 45 and 46 percent of households respectively. Banana, papaya and citrus are owned by fewer households. (*Table 1.10* presented in *Annex G* disaggregates this data by area.)

In general, households own an average of seven mango trees, 94 cashew trees and 59 coconut trees. In Quitupo Village, the average number of cashew trees (83) per household is lower than in the Coastal Zone and in the Quitupo Settlements (production zones), where the households own an average of 171 and 123 cashew trees respectively. Coconut palm trees are mainly found along the Coastal Zone, where approximately 45.5 percent of the households report that they own an average of 196 coconut trees, and in the Quitupo Settlements (production zones), where 56 percent report that they own an average of 76 coconut trees.

Coconut and cashew were the two most significant fruit trees in terms of sales in the 2010–2011 agriculture season (coconut trees also provide leaves that are used for roofing houses, shading crops and producing handicrafts). Coconut trees contribute the most to income, although more households own cashew trees:

- Of the 63.6 percent households that have cashew trees, 18 percent sell their produce and 2.2 percent process/prepare their fruit, resulting in an average annual income of approximately 2,751 MZN.
- Of the 46.4 percent of households owning coconut trees, approximately 51 percent and 5 percent respectively reported to sell or process coconuts, obtaining an average income of approximately 3,032 MZN in the previous 12-month period.

Table 9.44 Ownership of Fruit Trees and the Sale of Fruit

	Banana	**Cashew**	**Papaya**	**Mango**	**Coconut**
Households owning (%)	12.1	63.6	10.7	45.0	46.4
Average number of trees per household	31	94	25	7	59
Households selling (%)	29.4	18.0	20.0	25.4	50.8
Households processing (%)	0	2.2	0	0	4.6
Average annual income (2010–2011) (MZN)	625	2,751	240	900	3,032

Source: Impacto, 2012.

Table 1.11 in *Annex G* resumes sale of fruit and the income reported by households in the 2010–2011 agriculture season, according to their area of

residence. In all each area, sales of coconut provide more income to households resident in those areas:

- The proportion of households selling cashews is higher in the Coastal Zone (30 percent) and in Quitupo (24.4 percent), providing an income of 2,433 and 2,771 MZN respectively.
- In the Coastal Zone, Maganja and Senga, more than 60 percent of the households sell coconuts, resulting in an income of 5,821 MZN (Coastal Zone), 2,100 MZN (Maganja) and 2,233 MZN (Senga).
- Note that in Senga, 60 percent of households report processing and selling *sura* (palm wine), an appreciated traditional alcoholic drink made of coconut or palm tree sap.

Keeping of Livestock

As previously stated, the keeping of livestock is not widely practised in the area. There are no cattle in the area, due to the high prevalence of tsetse fly. Livestock that is kept is used for subsistence purposes and culled for special occasions. The most common livestock are goats, chickens and ducks. *Table 9.45* summarises the ownership of animals for the surveyed households, as well as income generated by those who sold in the past 12 months.

Table 9.45 Keeping of Livestock and Income from its Sale for the Surveyed Households

	Households that Own Livestock (%)	Average No. of Animals	Households that Sold Livestock (%)	Average Income over the Past 12 Months (MZN)
Goats	16.4	9.3	34.8	3,781
Chickens	36.4	8.8	35.3	900
Ducks	2.9	6.0	25.0	1,000

Source: Impacto, 2012.

The selling and consumption of livestock is not common among the households, and only occurs in situations of extreme necessity or when money is needed to purchase other products or services. The prices of goats, chickens and ducks vary between 1,000 to 1,500 MZN, 100 to 150 MZN, and 200 to 250 MZN respectively. There are no markets in the Afungi Project Site and Surrounds where animals are sold, and sellers must wait for buyers to come to the area from different parts of the District or from Tanzania.

9.14.3 Small-scale Fisheries

Palma District

In *Section 9.7.6*, small-scale fisheries were identified as the only important fisheries subsector in Cabo Delgado. In Palma District and the Afungi Project Site and Surrounds, small-scale fishing is an important activity undertaken by

a large number of artisanal fishers for subsistence and income generation, therefore with a strong influence on their livelihoods.

For some, small-scale fishing is commonly practised in addition to agricultural activities (farming, planting of cashew and coconut trees). They are generally fishers without boats, divers and gatherers who fish mostly for home consumption and sell a small part of their catch locally. For others, fishing is their primary activity and although they may partake in agricultural activities. These are generally fishers using boats, and who consume part of and sell a large proportion of their catch. Only a small group can be regarded as small-scale commercial fishers. *Figure 9.32* shows the location of fishing centres in the District.

A number of fishing centres once existed on the islands of Tecomaji, Rongui and Queramimbi. These fishers were relocated to the mainland due to the construction of tourism facilities on these islands (of four fishing centres that existed on Vamizi Island, two still remain; on Metundo Island, only one of the previous two fishing centres remains [1]).

Palma District has a total of 7,447 fishers, representing 23 percent of the total 32,392 fishers in the province (Mozambican Ministry of Fishing, 2008c). *Table 9.46* shows the type and number of fishers in Palma District, in comparison to those in the province. The fishing methods that are most commonly practised are handlines (505), gill nets (164) [2] and seine nets (94). Women represent 21 percent of all the fishers, which clearly indicates that they play an important role in ensuring food security, as well as generating income. Out of 1,558 women who are artisanal fishers in Palma, 53 percent are collectors and 30 percent fish with double stick nets (*quinias*).

Compared with the province, Palma has a higher proportion of fishers with vessels, and some 44 percent of the fishers within the District own a vessel. Furthermore, out of 1,410 divers in the province, 53 percent are concentrated in Palma, highlighting the importance of diving in the District.

The majority of fishers without boats usually operate in areas close to their homes eg next to estuaries, and over coral reefs and sandbanks. They are subsistence fishers and use barriers/traps, double stick nets, handlines and harpoons. Harpoon and handline fishers fish along the shoreline in waters between 0.5 and 1m deep. Most subsistence handline fishers are young people. Collectors mainly operate individually during the low water spring tides. Some of them collect predominantly crabs, while others collect sea cucumbers and oysters as well as bait organisms such as bloodworm. The sea cucumber and oyster collectors sell their harvest mainly at local markets.

(1) During the socio-economic study, the consultant was able to verify that in the fishing centre of N´semo/Quibundje, fishers primarily comprise those who were transferred onshore from the islands.

(2) The enumerators assigned encircling gill nets and surrounding pursing to the same category during the census.

Table 9.46 Number of Small-scale Fishers in the Palma District and Cabo Delgado Province

	Number of Fishers District of Palma			Number of Fishers Cabo Delgado
	Men	**Women**	**Men/Women**	**Men/Women**
Total	5,890	1,558	7,447	32,392
Fishers with boats	2,578	0	2,557	14,261
Permanent	2,363	0	2,362	12,700
Occasional	215	0	215	1,561
Fishers without boats	1,387	717	2,104	9,461
Handline	433	0	433	2,495
Harpoon	491	202	693	2,878
Quimas/double stick net (1)	236	463	699	3,957
Quimas/barrier (2)	127	52	179	413

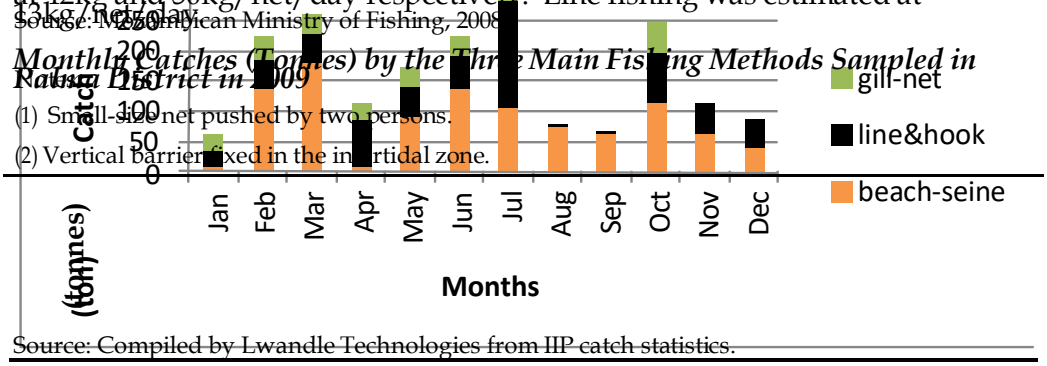
Source: Mozambican Ministry of Fishing, 2008.

(1) Small-size net pushed by two persons.

(2) Vertical barrier fixed in the intertidal zone.

Catch data from beach seine, drifting and set/anchored net and line fishing for 2009 are summarised in *Figure 9.31* and *Table 1.3* in *Annex G*. According to the National Fisheries Research Institute (IIP), the catches vary seasonally, but average landings per month were near 200t and the annual catch was estimated at 2,011t that year. There was a sharp decrease in 2010 to 1,306t and recovery to 1,939t in 2011, a figure near the 2009 catches. In 2011, monthly catches from Palma District were dominated by the beach seine, which yields around 87kg/ day/net, followed by drifting and set/anchored gill nets at 42kg and 50kg/net/day respectively. Line fishing was estimated at 13kg /net/day.

Figure 9.31 Monthly Catches (Tonnes) by the Three Main Fishing Methods Sampled in Palma District in 2009



Source: Compiled by Lwandle Technologies from IIP catch statistics.

Afungi Project Site and Surrounds (Including Senga and Maganja)

Small-scale fishing is practised by the communities along the coast and along inland waterways, where catches are used for consumption as well as for sale. This constitutes the second-most important activity in terms of food security and income for the domestic economy in the Afungi Project Site and Surrounds, and is the occupation of 24.3 percent of heads of surveyed households (*Table 9.38*).

According to the Strategic Plan for the Artisanal Fisheries Sub-sector (PESPA) 2007 (1), small-scale fishing may be subdivided into subsistence fishing and commercial artisanal fishing, and a distinction is made between fishers who only produce for home consumption and those who produce for consumption as well as for sale.

In general, the majority of households in the Afungi Project Site and Surrounds are involved in subsistence fishing oriented towards home consumption, with commercial fishing being largely undeveloped. Only a small group of fishermen approach small-scale fishing with a more commercial strategy.

During the survey, three fishing areas were identified within the area where this natural resource is available. These are:

- intertidal zones, which are widely used by gatherers to collect invertebrates (bivalves, crustaceans and gastropods) (see *Figure 9.35*);
- fishing areas located between the coast, the islands and areas around the islands, generally in areas up to 50m depth; and
- fishing areas located in deeper waters east of the islands; these waters are referred to by the fishermen as the 'high sea'.

Those intertidal and fishing areas up to 50m depth are frequented by fishermen residing in the Afungi Project Site, including the Palma Fishing Centre and the fishing centres in the Olumbe Administrative Post, although the offshore zone is only used by fishermen with motorised boats(2).

Main Types of Fishing Settlements

There are two settlements with fishing centres in the Afungi Project Site and Surrounds (*Figure 9.33*), namely Milamba 1 and N'Semo/Kibundjo and two fishing centres in Milamba 2 and Ngodje. The Funzi Fishing Centre is located just a few hundred meters outside the Afungi Project Site. There are approximately six fishing settlements to the south of Afungi Peninsula, along

(1) See *Annex G* for further information.

(2) At Palma Fishing Centre, only a very limited number of fishermen have motorised boats.

the coastline from Maganja to Olumbe, most of which are included in the Locality of Mute.

Milamba 1 and N´semo/Kibumdju are settlements with fishing centres [1] that are inhabited by a mixture of fishermen who reside there with their families, seasonal and permanent fishermen without their families, seasonal and permanent fish traders, and residents involved in other activities such as agriculture, coconut palm cultivation and commerce.

Other fishing centres (which are not necessarily population settlements) have permanent residents (fishermen, fish sellers, salaried fishing workers, etc) and some seasonal migrants from the interior of Palma District, and even from other provinces [2]. These people live there during periods of the year when fishing is favourable, and are commonly known as *vientes*, (loosely translated as 'outsiders'). These people include fishermen, waged fishing workers and fish sellers who remain in such fishing centres between August and October, before the beginning of the agricultural planting season. There are a number of fishermen, fish sellers and salaried workers who arrived as migrants and established residence in the fishing centres, marrying local women, thus establishing permanent residency in the fishing centre for periods of more than two or three years.

Other fishermen normally come and go daily or remain in the fishing centres for several days, and these are generally individuals who reside in settlements and villages located closest to the coast, such as Palma, Quitupo and various scattered settlements (production zones) located in the Afungi Project Site. For example, the Ngodje Fishing Centre only has four resident families, and the remaining fishermen and sellers stay for between one week and one month for the specific purpose of fishing, drying fish, selling their production or buying products. These people normally return to their own areas after these activities are completed.

The N´semo/Kibundjo Fishing Centre is the centre with the highest number of residents in the area, and hosts a large number of *vientes* from various points in the District and even from other provinces, mostly from the Nacala District in Nampula Province. The majority of the residents are individuals who previously lived on the islands of Tecomaji, Queramimbi and Rongui, and who subsequently were relocated due to the construction of resorts on those islands.

Table 9.47 shows the distribution of fishermen in the fishing centres located within the Afungi Project Site boundaries, with an approximate total of 757 permanent and temporary fishermen, corresponding to approximately 10 percent of the total number of fishermen in Palma District. The seasonal fishermen represent approximately one third of the total.

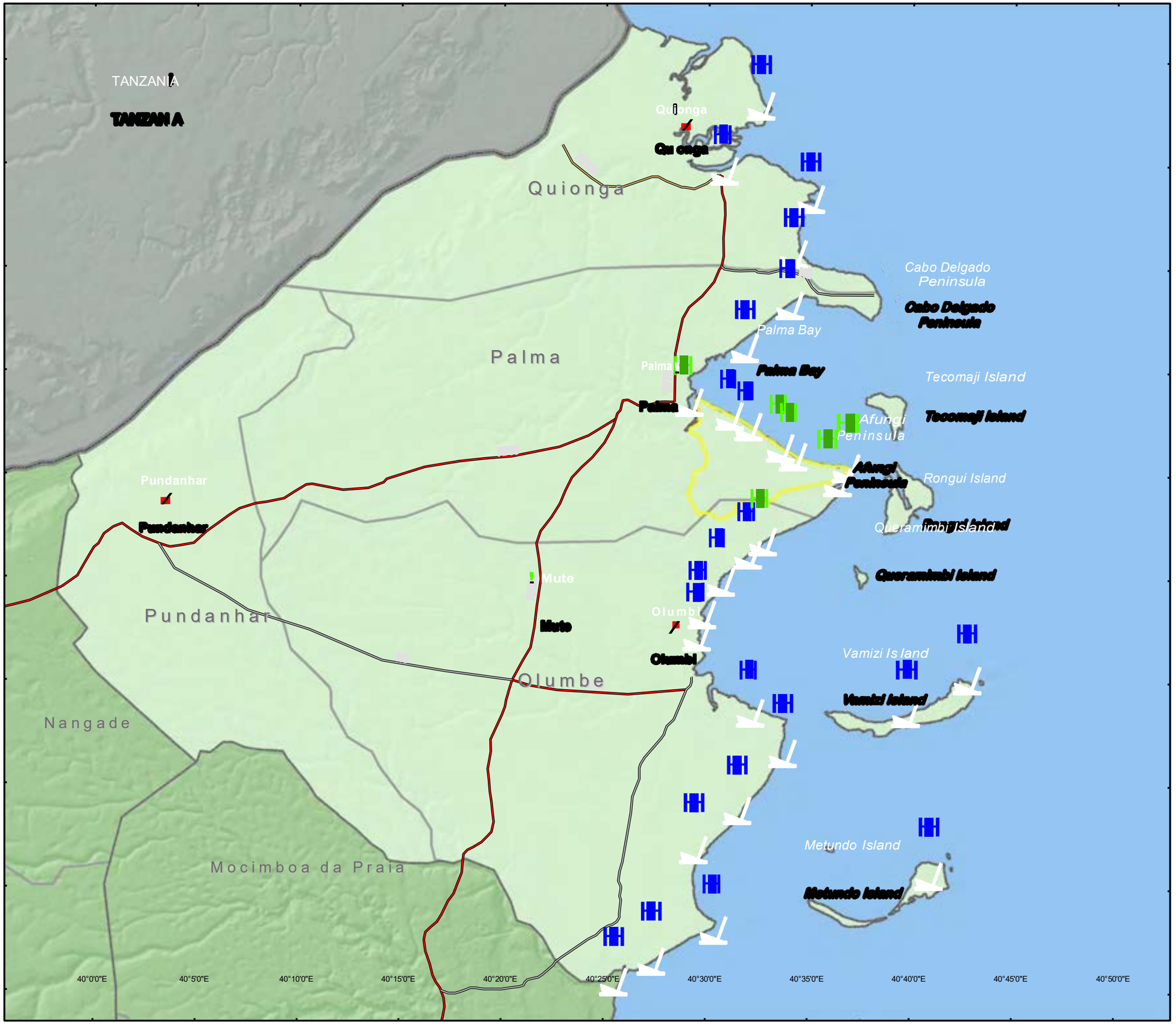
(1) Due to this distinction, the consultant differentiated between settlements with centres and fishing centres respectively, as outlined in *Section XX*.

(2) In the fishing centres visited, it was noted that there are many migrants from the Nacala District, Nampula Province.

Table 9.47 Number of Fishermen in the Fishing Centres of the Afungi Project Site

Fishing Centre	Permanent	Seasonal	Total
Ngodje	45	20	65
Milamba 1 and 2	192	80	272
N´semo/Kibundjo	270	150	420
Total	507	250	757

Source: Impacto, 2012.



Legend

- District Centre
- Locality Centre
- Administrative Post Centre
- Fishing Centre
- Settlement with Fishing Centre

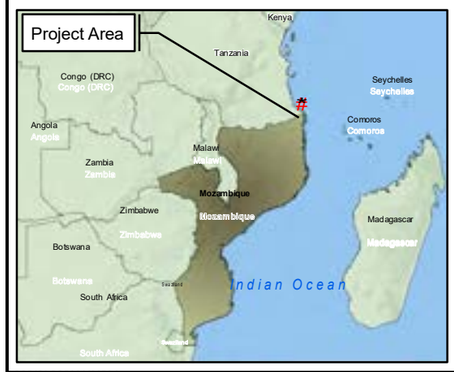
Roads

- Tertiary
- Local
- Non Classified

- Afungi Project Site
- District Boundary
- Administrative Post Boundary
- Palma District

Province

- Cabo Delgado



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 9.32: Fishing Centres in Palma District

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 330 000

DRAWING: Fishing Centres in the District.mxd

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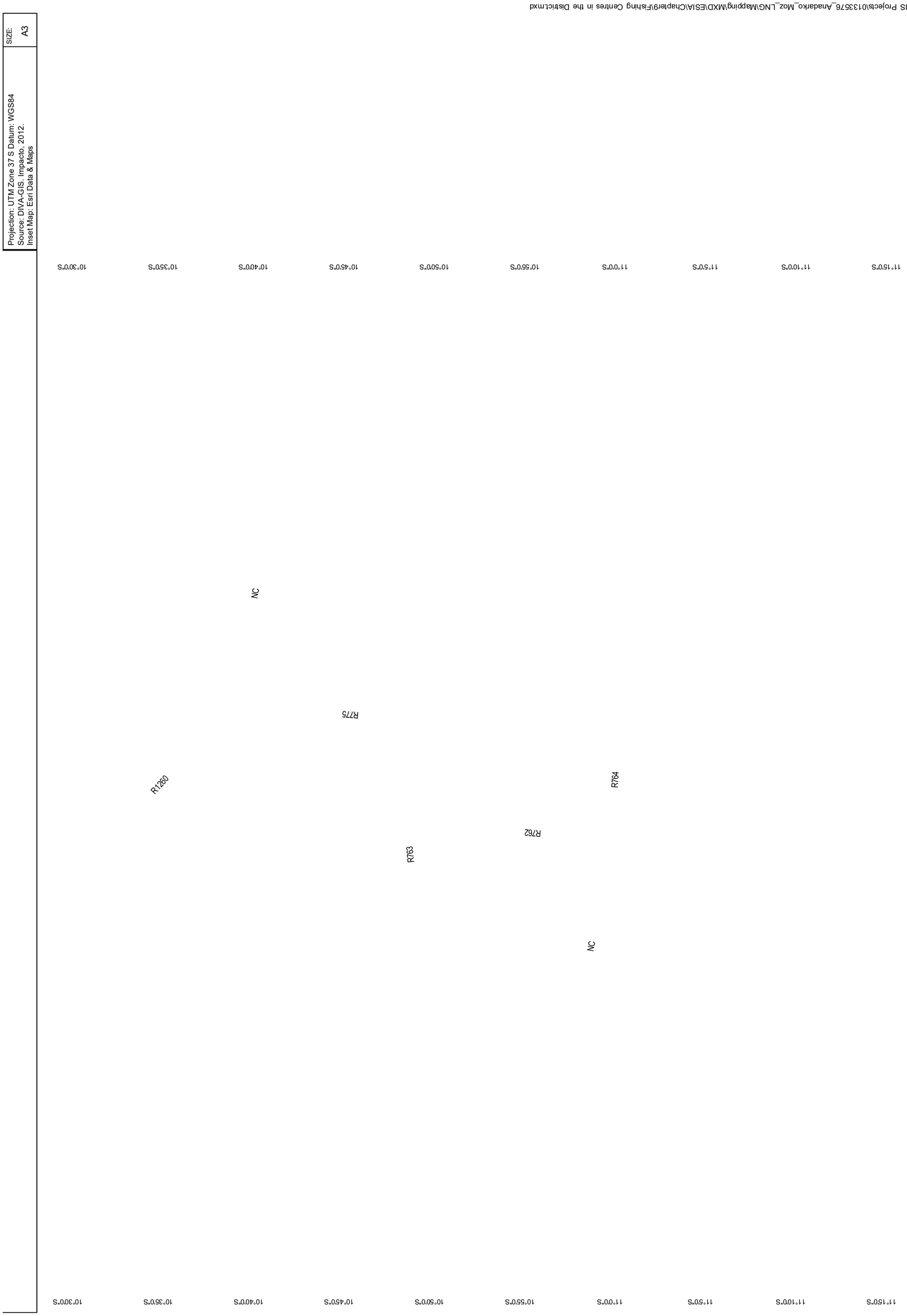

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Cabo Delgado Peninsula
Palma Bay
Porto de Palma
Palma
Ngodje
Ngodje
Tecomaji Island
Milamba 2
Milamba1
Manguna
Quitupo
Nkalanga
Macala
Nsenga
Nsemo/Kibundju
Afungi Peninsula
Nfunzi
Maganja
Nkumbi
Matapata
Rongui Island
Maganja Velha
Ngala
Nsenga
Queramimbi Island
Mbawala
Nanhela
Maganja Velha
Mute
Nongue
Ngala
Olumbi
R764
Vamizi Island
Nanhe a
Nongue
Olumbi
N14

Legend

- Villages
- Locality Centre
- Administrative Post Centre
- Settlement with Fishing Centre
- Fishing Centre
- Local Roads
- Regional Roads
- Afungi Project Site

Project Area

Kenya, Tanzania, Congo (DRC), Angola, Zambia, Malawi, Zimbabwe, Mozambique, Botswana, South Africa, Seychelles, Comoros, Madagascar, Indian Ocean

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 9.33:
Fishing Centres in the
Afungi Project Site and Surrounds

CLIENT: Anadarko Moçambique Área 1, Lda

DATE: Aug 2012	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 160 000

DRAWING: Fishing Centres in the Afungi Project Site and Surrounds.mxd

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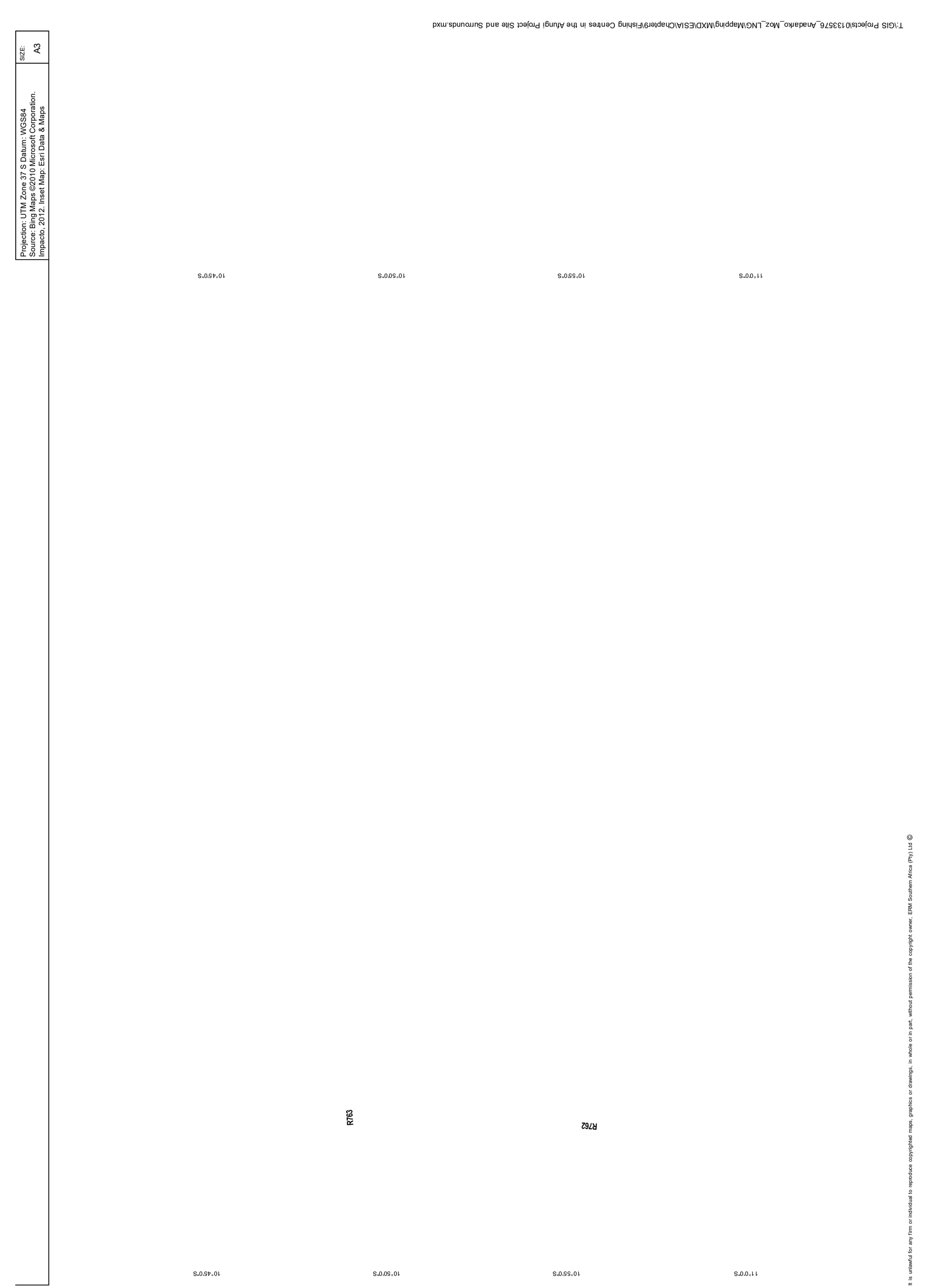

Projection: UTM Zone 37 S Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Impacto, 2012. Inset Map: Esri Data & Maps

SIZE: A3

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Types of Fishermen and Fishing Techniques

During the Social Assessment, 29 interviews were conducted with fishermen and fish sellers in the fishing centres in the Afungi Project Site and southern surrounds. Some households interviewed in the Household Survey reported fishing as their primary or secondary activity.

The interviews identified the following types of fishermen in the area: fishermen with boats, fishing boat workers, divers and gatherers. The types of boats most commonly used by the fishermen are canoes, flat-bottom boats and skiffs.

- Canoes are generally made from carved tree trunks and can carry between one and four people; however, it is quite common that canoes are designed to carry not more than two people. These are the common type of boats that are used for fishing between the coast of the Afungi Project Site and the islands. They are generally used by fishermen using handlines, or by divers.

- The most common types of boats are dhows or '*chuabos*'. Generally these are sailing vessels, but some *chuabos* may have outboard motors. Depending on the size and type of construction methods used, these boats have capacity for between four and 50 people.

- Fibreglass skiffs with outboard motors are few in number, and are only seen around the Palma Fishing Centre within the area.

The canoes used by fishermen are built locally by the fishermen themselves, in some cases with the help of the IDPPE programme, which provides training to fishermen and boat builders.

Most of the fishermen interviewed reported that the canoes, launches and skiffs are their own property. Some larger boats and skiffs were purchased through financing provided by lines of credit offered to fishermen under a programme financed by the Small Industry Development Fund and by the IDPPE, managed by GAPI and AMODER. In many cases, these larger boats are leased and/or shared.

Based on the interviews, the fishermen in the fishing areas use different fishing methods, as shown on *Table 9.48*.

Table 9.48 Types of Fishing Gears in the Afungi Project Site and Surrounds

Fishing Gear/Method	Species Caught	Characteristics
Gill nets (drifting)	Grouper, turtle, shark, parrotfish, crevalle jack (*Xareu*)	This type of fishing is done with a sailboat or motorboat, with the net being launched in two sections by six to 10 fishermen. The net remains in the sea overnight or for one or two weeks. In the first case, the fishermen gather the net and the fish a few hours afterwards or the next day. In the second case, the fishermen check and remove the fish over a period of a few days. First-grade fish is selected.
Pursing net	Rocktish, mackerel, sardine, redfish	This type of fishing requires a motorboat and a 1½ inch net. It is conducted during the night with the assistance of lanterns/flashlights (as light sources), catching schools of fish.
Seine net	Rocktish, peixe cozinheiro, ladrão, grouper, buju, nacassumbe, piri-piri, mambuaissui, gombezi, sala	This type of fishing occurs in areas near the shore or other shallow areas, where the net can be dragged to the beach or through shallow water. A midsize boat is used for this type of fishing, with between 10 and 14 fishermen who pull the net from the sea to the shore (or through the water).
Handline	Grouper, marlin, famache, tuna, sailfish, rockfish, sole, squid, rays	Handline fishing is undertaken in shallow waters with transportation via canoe. Fish are caught with a fishing line and hook.
Collectors	Bivalves, gastropods and crustaceans such as oysters, cutanda, small fish, macaza	This work is conducted primarily by women, in the tidal areas. Some catch/harvest seafood in up to knee-deep water, while others travel to the islands in canoes to dive for shellfish.
Divers	Grouper, rocktish, octopus, squid	Divers descend to a depth of up to 15m, without diving equipment. Fishermen swim or travel in canoes to the dive site.

Source: Impacto, 2012, from interviews with fishermen at the fishing centres, January 2012.

On average, seine netting takes place in waters between 5 and 7m deep, while the maximum depth for pursing nets is around 100m (depending on the size of the net).. Handline fishers fish in waters with a maximum depth of 200m. Divers typically dive to 15m and seldom exceed 30m (only a few very skilled divers are capable of diving to 30m depths).

The findings from the interviews show that there are a number of types and combinations of fishing methods practised, based on factors such as: ownership/use of a boat, type of fishing method, fish sale method (fresh, dry, smoked) and the position of the fisherman in the work process (self-employed or owner/salaried worker). In summary, the following types of fishermen were identified in the Afungi Project Site and Surrounds (Palma and southern surrounds):

- commercial artisanal fishermen, who fish using a large gill net. Small percentages of these fishermen are organised into associations, and most

reside in Palma town. They have skiffs with outboard motors (or sails, in some cases) and they fish using a cast net. They hire fishermen and pay them in cash or in kind, and sell fresh fish. They also dry the fish and sell it to marketers;

- subsistence artisanal fishermen using line fishing, who own their own canoes with capacity for between one and four individuals. They go out to fish alone or with other fishermen. In general, they do not hire workers. They share a boat and the produce, although the owner of the boat keeps an equal or higher percentage of the catch. A portion of the fish is sold fresh. They do not dry the fish, but sell it to small marketers in the fishing centres, who then dry and sell the fish;

- subsistence artisanal fishermen, who fish using a line and who are not the owners of the boat they use generally under a system of division of catches. Each fisherman sells part of the catch fresh, with the rest sold to local merchants who dry and sell the fish;

- Fishermen using pursing nets/*kavogo*, seine nets or gill nets, who are owners of boats with sails and a capacity for between four and 50 fishermen. The most common boats used are those with a capacity for 20 individuals. The specific characteristics of this category are:

    - subsistence artisanal fishermen who are owners of small vessels (with capacity of between two and four people). They share the boat and the catch with their fellow fishermen crew. Some of the catch is sold fresh and some sold to local marketers, who then dry and sell the fish, and

    - artisanal fishermen who are more market-oriented, and are owners of larger boats with a capacity of between six and 50 people. In general, they use salaried workers, who are paid in cash and/or in kind. The owner sells both fresh and dry fish, and sells fish to marketers in the fishing centres or external marketers with whom he already has a supply agreement;

- subsistence artisanal fishermen, who fish using pursing nets/*kavogo*, seine nets or gill nets, who are not boat owners. They share the boat and the catch with the owner. Most of the catch is sold to marketers, who dry and sell the fish; and

- salaried fishermen, who work on boats owned by fishermen with skiffs with outboard motors or sailboats with capacity for six to 50 individuals and who fish with gill nets, pursing nets or seine nets. They are paid in cash or in kind. Fishermen who catch and dry fish generally receive a portion of the fresh catch after the fishing trip, and another part after the sale of the dry fish.

Figure 9.34 and *Figure 9.35* illustrate the various fishing activities and methods.

Figure 9.34 ***Fishing Vessels and Activities***

Boat building in N´semo

Fish drying in Milamba 2

Pursing nets in the Ngodje Fishing Centre

Salaried fishermen at the N´semo Fishing Centre

Source: Impacto, 2012.

Figure 9.35 Fishing Activities in the Afungi Project Site and Surrounds

Bivalves and gastropods collected by collectors

Bivalves and gastropods processed as construction material

Source: Impacto, 2012.

Fishing Areas

During the socio-economic baseline fieldwork, a number of fishing areas located primarily in the Afungi Project Site and Surrounds were visited, during which 18 main areas were identified, as shown in *Figure 9.36*. These areas are generally used by fishermen from all fishing centres in the Afungi Project Site and Surrounds without distinction in terms of areas, since each fishing area has an abundance of certain species, which could be related to the existence of rock or coral formations, seaweed beds, depth (offshore/shallow coastal areas) and other factors. Thus, the areas are selected based on the type of species the fishermen catch.

During interviews and conversations with fishermen, some areas were reported to be good for fishing, especially those locations around the islands where it is possible to find a number of different species. However, in the past for a period of time, the population was prohibited from fishing in many of these areas. Even though no boundaries were established, fishing has been forbidden around Tecomaji Island and the Quimesse Fishing Area in Rongui Island, which have been granted for use by tourism operators.

Furthermore, as previously mentioned, fishermen who resided on Tecomaji Island were relocated from that area to the N´semo Fishing Centre. This has impacted the dynamics of their activities, since their previous location was in a strategic area in terms of access to fishing resources.

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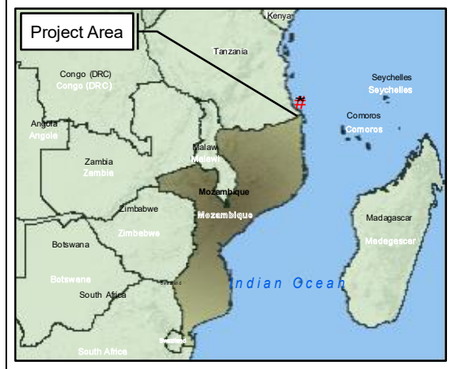
Cabo Delgado Peninsula
Palma Bay
Mitende
Tchotchobue
Mitalala
Ngodge mar
Boia
Parassi
Palma
Npuri
Mitupa
Quitunga
Alue
Nzungumuno
Tecomaji Island
Quilola
Nalungo
Manguna
Nkalanga
Macala
Quelimane
Nsenga
Afungi Peninsula
Mitundo
Nkumbi
Matapata
Rongui Island
Kassovo
Queramimbi Island
Quifichoni
Lebanon
Mute
Mussululo
Nguzi
Olumbi
R764
Vamizi Island

Legend

- Villages
- Locality Centre
- Administrative Post Centre
- Settlement with Fishing Centre
- Fishing Areas
- Fishing Centre
- Local Roads
- Regional Roads
- Afungi Project Site



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Kilometers

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Figure 9.36:
Fishing Areas Used by Fishermen of the Afungi Project Site and Surrounds

CLIENT: Anadarko Moçambique Área 1, Lda

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DRAWING: Fishing Areas Used by Fishermen.mxd

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Projection: UTM Zone 37 S Datum: WGS84 Source: Bing Maps ©2010 Microsoft Corporation. Impacto, 2012. Inset Map: Esri Data & Maps	SIZE: A3

10°45'0"S

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10°55'0"S

11°0'0"S

R763

R762

10°45'0"S

10°50'0"S

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Marketing Routes for Fishing Produce

The selling of fish produced in the fishing centres of the Afungi Project Site and Surrounds is primarily conducted via sea transportation in canoes or boats owned or leased by the fishermen to the port of Palma town, where there is a large centre for this purpose. The fishing centres located south of the village of Maganja market the fish using the Olumbe/Mocímboa da Praia route or the Palma route.

From Palma, Olumbe or Mocímboa da Praia, the fish is transported overland to various destinations in the interior of the District and province (such as Pundanhar, Mocímboa da Praia, Mueda and Nangade, among others), to other provinces (such as Nampula and Niassa) or even to other countries (such as Tanzania). There are Tanzanian traders travelling by boat to Palma or directly to the fishing centres to buy fresh and dried fish, as well as gastropods and molluscs processed by collectors, using contacts and networks already established between the Tanzanian traders and traders or fishermen established in Palma town or in the fishing centres.

In the fishing centres of the Afungi Project Site and Surrounds, fishing products are not always transported by sea. Sometimes, the merchandise is transported on foot to the Palma fishing centres and, in such instances, the owners of the merchandise hire carriers, who may even transport the products on their heads, and are paid approximately 50 MZN for each 50kg sack.

Table 9.49 summarises the cost of transporting merchandise and passengers by sea between the fishing centres in the Afungi Project Site and Surrounds, in Palma, and ground transportation between Palma and the main destinations reported.

Table 9.49 Cost of Maritime/Ground Transportation of Goods and People

	100kg Sack/Boat (MZN)	**Passenger/Boat (MZN)**	**50kg Sack/Car (MZN)**	**Passenger/Car (MZN)**
Ngodje–Palma	50	50	Non-existent	Non-existent
Milamba–Palma	100	100	Non-existent	Non-existent
N´Semo–Palma	200	175	Non-existent	50
N´Semo–MDP*	175	150	Non-existent	Non-existent
Palma–MDP*	-	-	65	100
MDP*–Nacala	-	-	350	600
N´semo–Nacala	-	200	Non-existent	Non-existent
Palma–Nangade	-	-	150	250
Nangade–Mueda	-	-	75	100
Palma–Tanzania	500	250	500	500

Key:

* MDP: Mocímboa da Praia.

Source: Impacto, 2012, from interviews with fishermen at the fishing centres, January 2012.

Contribution of Fishing to the Local Economy

Although largely viewed as an isolated economy, small-scale fishing interacts with a number of other activities from different sectors, as well as within its own chain of value, as outlined below.

- A large percentage of households undertake fishing in conjunction with other activities such as subsistence farming, coconut palm and cashew cultivation (part is used for sale), or production of handicrafts (for sale).
- Owners of boats lease their vessels for fishing or the transporting of goods.
- Support activities, such as supplies, boat building and repair- of these, the boat-building industry is the most important in the fishing centres of Afungi Project Site and Surrounds, in other villages and Palma town. According to the IDPPE (2004), there were 82 boat builders in Palma, based in fishing villages that are equipped with the infrastructure for boat building. There are no community-based suppliers of fishing equipment in the towns and villages sourrounding the Afungi Project Site (including Palma) or within the site itself, although it may be sold in local informal markets. The main sources of equipment are located in Pemba, Nacala, Nampula and Maputo, and even as far as Tanzania and Malawi [1].
- Other activities such as fish drying and marketing- in 2008, there were 212 processers in Palma District (out of 1,102 in Cabo Delgado Province) and 203 traders (out of 1,905 in Cabo Delgado Province). Sun or salt-dried and smoked fish increases the shelf life of fish products, eg salt-dried fish can last up to five months, making it more marketable and thus sold in different parts of the District, neighbouring districts and provinces.
- Wage labour was also observed in the area. Some fishermen work on vessels owned or operated by other individuals in exchange for a salary. For example, subsistence fishermen may be recruited by commercial artisanal fishermen as part-time labourers.

Changes in this interdependent system, caused by factors such as droughts, floods, pests, interruption in land and sea transportation of people and goods, and loss of access to the coast and fishing areas, could negatively impact livelihoods in the area and activities conducted by households. These include subsistence and commercial small-scale fishing and agriculture, or the informal marketing of products transported via land or sea, to mention only a few of the most important examples.

(1) No specific places were mentioned in these two countries as being used to purchase fish equipment.

9.14.4 Tourism

Palma District

Most of the existing tourism establishments in the District are based on marine, coastal and game resources. The Palma District has had limited investment in tourism infrastructure to date, with the exception being the established resorts on the islands eg Vamizi Island, and those currently under construction.

In line with the Strategic Plan for Tourism Development in Mozambique (2004–2013) and the Provincial proposal for Tourism Development (Provincial Tourism Directorate, 2008), the sector considered to have the most development potential is leisure tourism, based on sea activities and game farms. The Strategic Plan defined almost the entire Palma District as an area for multiple activities such as hunting and photographic safaris. Three coastal areas were defined for tourism based on beach and sea activities (Quirinde–Mbwizi, Quiwia and Lalane).(1). The sea-based operators along the coast and the islands depend on the pristine sea, corals, beaches and the vast variety of fish for their activities. Activities offered by these operators include scuba diving and snorkelling, sport fishing and recreational boat trips.

Table 9.50 shows some of the hotel establishments in Palma District, their ratings, location, capacity and respective volume of investments.

Table 9.50 Hotel Establishments in Palma District

Designation	Location	No. of Rooms	No. of Beds	Type	Category/ Ratings	Investment Value	No. of Workers	Notes
Hotel Palma	Palma Capital	6	13	Boarding house	Sole	150,000 MZN	3	
Casa Malope	Palma Sede	4	4	Guest-house	Sole	Not available	6	
Pensao Maganja	Palma Sede	10	11	Boarding house	One star	Not available	5	
Pensao Wivo	Palma Sede	7	7	Boarding house	One star	80,000 MZN	6	
Vamizi Island Lodge	Ilha Vamizi	12	32	Lodge	Five star	134,400,000 MZN	58	
Verde Mar	Ilha Metunge	10	20	Lodge	Five star	19,200,000 MZN	39	
Tecomaji	Ilha Tecomaji			Lodge		10,000,000 USD		Con
Quera-mimbi	Queramin mb			Lodge		Not available		Con
Tambuzi	Ilha Tambuzi			Lodge		150,000 USD		Con
Vumba	Ilha Vumba			Lodge		300,000 USD		Con

(1) See *Figure 9.18* showing existing and requested DUATs in Palma District for coastal tourism, game reserves and game farms.

Designation	Location	No. of Rooms	No. of Beds	Type	Category/ Ratings	Investment Value	No. of Workers	Notes

Key:

Con: in construction phase.

Source: Impacto, 2012.

9.14.5 Trade

Palma District

The trade network in Palma District consists mostly of small-scale informal traders, categorised by the industry and commerce sector as 'rural commercial activity'. The network comprises 157 commercial establishments (eg shops, stands and bars) (District Annual Balance of Economic and Social Plan, 2011). In addition, the District government has recently licensed 20 additional commercial and industrial establishments.

In Palma town, although informal, trade seems to be dynamic, with some established Tanzanian traders running their shops with goods brought from across the border, and other traders with supplies from Pemba and Nampula. Across the District, this rural commercial activity is limited and concentrated in the Administrative Posts and Locality centres and generally yet to be developed.

Afungi Project Site and Surrounds (Including Senga and Maganja)

The Afungi Project Site and Surrounds is characterised by a weak commercial network, both formal and informal. In Maganja Village and N´semo settlement, there is a market area with some informal commercial establishments (*Figure 9.37*), while in the villages of Senga and Quitupo there are only a few isolated establishments.

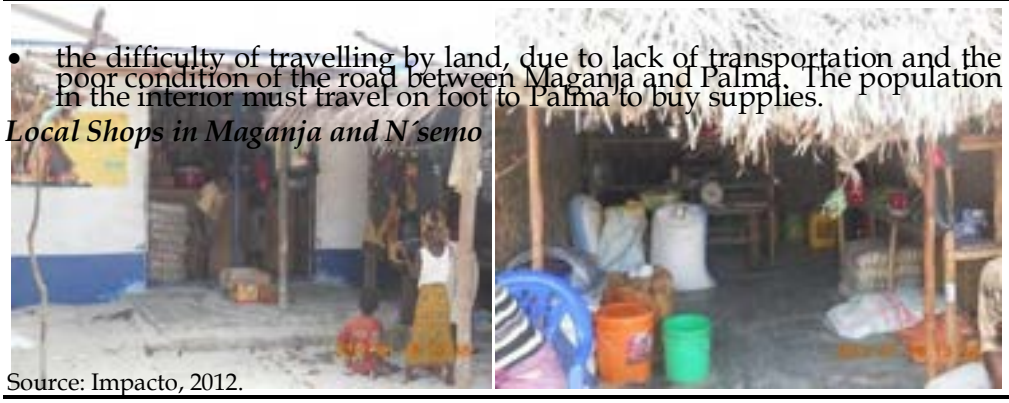
The existence of a more dynamic market in Maganja and N´semo is due to the fact that these settlements are located in a coastal zone, which is a stopping point for sea routes used to transport merchandise and passengers to this area from the northern and southern coasts of Cabo Delgado Province.

The primary factors contributing to these areas being stopping points on merchandise transportation routes are:

- the geographic location of Maganja and N´semo to the extreme east of the Afungi Peninsula;
- the large number of permanent and seasonal individuals and fishermen who reside in the village of Maganja and in the settlements with fishing centres of Nfunzi and N´semo; and

- the difficulty of travelling by land, due to lack of transportation and the poor condition of the road between Maganja and Palma. The population in the interior must travel on foot to Palma to buy supplies.

Figure 9.37 ***Local Shops in Maganja and N´semo***



Source: Impacto, 2012.

Approximately 70.7 percent of surveyed households mentioned that there are informal stands in their areas. However, only small and urgent purchases are made at these stands. The vast majority of the population (more than 90 percent) travel to Palma to purchase products for consumption and resale. Thus, the population of the Afungi Project Site and Surrounds is heavily dependent on Palma.

The majority of the surveyed households travel an average of 124 minutes on foot, or in boats, to buy food and other products [(1)]. *Table 9.51* provides information by zone and by time travelled by households to reach a location where there is a mill, a shop, an informal stand or a store buying farm products.

Table 9.51 ***Travel Time (in Minutes) to the Nearest Markets***

Zone/Village…	Coastal Zone	Maganja	Quitupo	Quitupo Settlements (Production Zones)	Senga
To a mill	151	193	95	270	99
To a shop	159	168	92	100	106
To an informal stand	65	12	9.0	42	25
To a store buying farm products	156	183	97	33	86

Source: Impacto, 2012.

(1) The Social Assessment did not address the frequency of travelling. However, field observations are that most of the households do not do it more than twice a month.

Only in the case of the villages of Quitupo, Maganja and Senga are there nearby informal stands, since the households in those areas reported that they spend between 9 and 25 minutes travelling to those establishments. Residents of other areas are required to travel for much longer.

All other types of commercial establishments are much further, and households reported spending between 1.5 and 4.5 hours travelling to those establishments:

- Almost all of the households are dependent on Palma, and travel long distances to process farm products at a mill.
- The same scenario (dependency) occurs with stores that sell basic products and buy agricultural products, as nearly all households report that they travel to Palma and spend between 1.5 and 3 hours travelling.

9.14.6 *Income-generating Activities in Afungi Project Site and Surrounds (Including Senga and Maganja)*

Income-generating Activities

The sale and processing of often-surplus farm produce, fruit, fish and, when necessary, livestock, are the basis upon which income for communities in the Afungi Project Site and Surrounds is derived.

Table 9.52 below presents the range of activities performed by the surveyed households and the average income obtained in each, by households involved over a 12 month period prior to the survey. With the exception of informal commerce and the sale of fresh fish, income reported in the same 12 month period from other activities is still very low.

Table 9.52 Income-generating Activities Reported by Surveyed Households

Income-generating Activities Performed	Households Involved (%)	Average Income Last 12 Months (MZN)
Sidewalk or street sales/informal commerce	9.3	16,545
Sale of fresh fish	29.3	11,523
Sale of food products	4.3	6,033
Specialised work (carpenters, stonemasons, painters)	2.9	5,300
Sale of farm products	40.7	3,402
Production and sale of traditional drinks	10.0	3,303
Sale of coconuts	25.0	3,220
Sale of cashews	12.1	2,820
Sale of dry/smoked fish	12.1	2,702
Sale of animals	12.9	2,166
Sale of medicinal plants	2.1	1,283
Sale of wood/fenceposts/thatch	6.4	1,180
Temporary work for others (neighbouring farms)	2.9	887
Sale of handicrafts (woven products, hats)	12.9	695
Income-generating Activities Performed	**Households Involved (%)**	**Average Income Last 12 Months (MZN)**
Income from permanent work (government, private)	4.3	-

Source: Impacto, 2012.

The sale of farm products, coconut and fresh fish are income-generating activities practised by a large number of households (41, 29 and 25 percent respectively). Other than these activities, the most important sources of income are the sale of animals and handicrafts (13 percent each), the sale of cashews (12 percent) and the sale of dried or smoked fish (12 percent).

Commerce in the area is undertaken through informal stands or street selling. Despite several households selling their own produce, only 9.3 percent of the households are involved in commercial activities that comprise buying and selling products.

A significant percentage of the surveyed households in the Afungi Project Site

and Surrounds sell farm products (40.7 percent). However, the average income over the previous 12-month period was approximately 3,402 MZN, highlighting the weak development of the local market (see *Table 9.52*).

Fish is sold fresh, dried or smoked. The sale of fresh fish is a significant activity in which 29.3 percent of the surveyed households participated, providing an average income of approximately 11,523 MZN over the previous 12-month period. Some 12.1 percent of the households engaged in the sale of dry/smoked fish, resulting in an average income of 2,702 MZN during the same period.

Although only 9.3 percent of the surveyed households are involved in informal commerce, it is a significant source of income, and provided an average annual income of 16,545 MZN. The items are sold at small stands constructed with traditional materials (bamboo and mud huts covered with thatch). The products sold are basic commodities such as sugar, salt, oil, soap and rice, which have been obtained through trade or purchased from Mocímboa da Praia and carried back to the community for sale locally.

Nearly 13 and 12 percent of households participated in the sale of livestock and cashew nuts respectively, resulting in an average income of 2,166 MZN and 2,820 MZN respectively. Specialised work is only undertaken by 2.9 percent of the households, resulting in an average income of approximately 5,300 MZN.. When production is low, some people secure temporary work on farms, in carpentry shops or sawmills owned by others, in exchange for money or agricultural products. Approximately 2.9 percent of households engaged in this type of temporary work, which contributed to an average income of 887 MZN.

Although 12.9 percent of households produce and sell handicraft products, this activity does not contribute greatly to household income. During FGDs, women stated that the sale of handicrafts (such as weaving) is not profitable, since there are no buyers for their products – and when woven items are completed, they wait a long time until buyers appear from Palma or other locations.

FGDs confirmed the existence of a women's association in Senga (the only such association in the area), which contributes to a savings fund. This fund has increased the savings of the participating women, so that they can later invest in their businesses.

Annual Income of Households

Households residing in the Afungi Project Site and Surrounds conduct a number of different income-producing activities as part of their survival strategies. In order to provide a more comprehensive analysis of the pooled income, the households were classified into four income groups, as shown in *Table 9.53*.

Table 9.53 Household Income Groups and Average Annual Income Reported by Surveyed Households

Income Group (in MZN)	%	Average Income per Group During the Past 12 Months (MZN)
150–1,549	25.0	956
1,600–4,300	25.0	3,112
4,400–9,000	21.8	6,373
+10,000	28.2	30,207
The whole sample	100.0	10,931
Don't know/Did not answer	11.4	-

Source: Impacto, 2012.

The average annual income reported by the surveyed households is 10,931 MZN, corresponding to a theoretical monthly income of approximately 911 MZN. A more comprehensive analysis of income shows that:

- half the sample reported an income that did not exceed 3,112 MZN in one year;
- 25 percent of the surveyed households have an average annual income of approximately 956 MZN, and a further 25 percent reported an average annual income of approximately 3,112 MZN;
- 21.8 percent reported an average income of approximately 6,372 MZN; and

- 28.2 percent of those surveyed had an average income of approximately 30,206 MZN (1,140 USD) in the previous 12-month period.

Table 9.54 shows the area of residence by income group for the Afungi Project Site and Surrounds.

Table 9.54 Area of Residence by Income Group in the Afungi Project Site and Surrounds

Income Group (in MZN)	Number of Surveyed Households by Area of Residence				
	Quitupo (N=48)	Quitupo Settlements (Production Zones) (N=12)	Coastal Zone (N=20)	Senga (N=18)	Maganja (N=26)
150–1,549	7	6	7	6	5
1,600–4,300	13	2	3	6	7
4,400–9,000	12	2	4	3	6
+10,000	16	2	6	3	

Key:

N: Total sample size.

Source: Impacto, 2012.

The following conclusions are drawn from *Table 9.55* above**.**

- In the Quitupo Settlements (production zones) and Senga, more households belong to the lowest income groups (below annual income of 4,300 MZN). This is due to the majority of households being engaged in subsistence farming as their primary activity.
- In Quitupo and Maganja, more than half the households belong to the two highest income groups. Their annual incomes range between 4,400 and above 10,000 MZN. This could be due to these households participating in activities such as fishing and informal commerce in addition to crop farming.
- In the Coastal Zone, half the households have incomes below 4,300 MZN. More than a third of the households (seven households) have very low income (between 150 and 1,549 MZN), while nearly one third (six households) have an income in excess of 10,000 MZN.

Table 9.55 shows the income groups based on the main occupation of the heads of the households.

Table 9.55 Income Groups Based on the Occupation of Surveyed Households

Main Occupation of the Heads of the Households	% of the Income Groups (MZN)			
	150–1,549	1,600–4,300	4,400–9,000	+10,000
Working for others	-	-	7.4	2.9
Self-employed/small industry	3.2	-	11.1	2.9
Self-employed/food preparation	-	-	7.4	2.9
Self-employed/construction materials	12.9	3.2	-	-
Self-employed/commerce	6.5	6.5	3.7	20.0
Farmer	58.1	64.5	55.6	25.7
Fisherman with boat/net	9.7	22.6	14.8	40.0
Fisherman without boat/net	3.2	3.2	-	5.7
Other	6.5	-	-	-
Total	100.0	100.0	100.0	100.0

The following conclusions may be drawn from *Table 9.55*.

In the two lowest income groups (150–1,549 MZN and 1,600–4,300 MZN), further analysis has determined that:

- a large percentage of the heads of households are farmers (58.1 and 64.5 percent of the two income groups respectively), indicating that these households practise subsistence farming largely for the purpose of food security; and
- in the case of households dedicated to fishing (representing 13 and 26 percent of the two income groups respectively), artisanal fishermen perform essentially subsistence-level fishing, also for the purpose of ensuring food security.

In the two highest income groups (4,400–9,000 MZN and +10,000 MZN), further analysis has determined that:

- approximately 56 and 26 percent of heads of households in each of the higher income groups respectively are farmers. These are households that, in addition to subsistence farming, are able to market extra agricultural production and/or own cashew trees and/or coconut trees and sell cashews or coconuts;
- approximately 15 and 46 percent of the households of each of the higher income groups respectively are market-oriented artisanal fishers, selling part of their production on the local market or to buyers at the fishing centres, thus obtaining relatively higher income; and
- nearly 19 percent of the heads of households from the higher income group of 4,400–9,000 MZN participate in informal small industry activities or food preparation, while 20 percent of those in the highest income group (+10,000 MZN) participate in informal commerce.

9.14.7 *Aquaculture*

No aquaculture projects have been identified within Palma Bay during fieldwork. However, areas in Palma Bay have been considered as having the potential for aquaculture and seaweed production based on criteria such as water depth, waves, currents, turbidity, etc. Approximately 7,079ha have been identified as having the potential for aquaculture in cages and 3,375ha with potential for seaweed production (INAQUA, 2011). These areas have since been declared as Marine Reserves by Decree no. 71/2011 of 30 December [1]. In terms of aquaculture in cages, Pemba Bay has the most potential, where 10,673.50ha have been declared as Marine Reserves for that purpose. With regards to seaweed, Palma was considered as having the most potential, followed by Macomia and Mecúfi Districts (INAQUA, 2011). Management of these marine reserves is the responsibility of the Ministry of Fisheries.

9.14.8 *Salt pans*

There are scattered salt pans (*Salinas*) distributed in the coastal areas of the Palma District. Crude salt is harvested from these pans primarily during summer when the temperatures are high. They are located relatively close to the shore line (less than 2km). On the Afungi Project Site, 1.5ha of land have been identified as being used for salt production in artisanal salt pans located close to Milamba II and to N´semo (*Figure 9.19*). Salt from these artisanal salt pans is used mostly for consumption and to sell in local markets. During the socio-economic fieldwork, it was indicated that the Afungi salt pans had not been operational for some time and didn´t "employ" many people. This was confirmed by MICOA (pers comm, 2013) who indicated that the local authorities did not consider the Afungi salt pans as being economically important in terms of the number of people involved in the activity.

9.15 *AFUNGI PROJECT SITE AND SURROUNDS (INCLUDING SENGA AND MAGANJA) CULTURAL AND RELIGIOUS PROFILE*

9.15.1 *Cultural and Religious Ceremonies*

The Afungi Project Site and Surrounds has a diverse ethnolinguistic composition, comprising of the Mwani, Makonde, Makwé and Makhua ethnic groups.

According to data from Census 1997 and Census 2007, more than half of the population of Cabo Delgado Province is of the Islamic faith (54.5 percent in 1997 and 53.8 percent in 2007). This proportion is higher in the coastal districts of northern Mozambique and Cabo Delgado that have been historically influenced by Islam [2].

(1) Marine reserve is defined by the Decree as an area for the development of marine aquaculture.

(2) Data from religions is not disaggregated to the District level in the national Census database.

According to field observation and data from the national census at provincial level, it can be assumed that the majority of the population in the Afungi Project Site and Surrounds are of the Islamic faith. In Senga, there are also followers of the Christian religion (Catholic), represented by the Makonde group. Places of worship found within the settlements include churches and mosques, reflecting the two primary religions practised in the area.

Animism and ancestor worship are not practised, because the residents believe in divine sovereignty to the extent that prayer meetings for rain and successful agricultural campaigns are conducted in churches or mosques. Such ceremonies are generally led by the Sheikh, in the case of Islam, or other religious leaders.

In addition to ceremonies and prayers for rain and successful agricultural campaigns, other ceremonies conducted include the *Ziharat*, *Maulide* and initiation rites. The *Ziharat* is performed to remember loved ones/ancestors, while the *Maulide* is a celebration with prayers for peace and prosperity and thankfulness to God (Allah) for granted favours.

Initiation rites ceremonies mark the entry of children into adulthood, and occur frequently in the area (*Figure 9.38*). Normally, male children are taken to specific locations (usually near a river or lagoon), where they are taught for approximately one month about the main activities that await them in their adult lives. Traditional subjects addressed during these initiation rites including matters related to sexuality, survival systems and rules of social conduct, as well as the ancient traditions (manifested through specific dances).

For young girls, the initiation rites normally occur in their homes, where girls are instructed in activities that await them in their adult lives, including aspects related to sexuality. During this time, girls are also taken to specific places in the forest, where they remain for a period of time performing dances and participating in other traditional initiation rite customs.

In general, the initiation rites are conducted from December to January, which coincides with the school holiday period, preventing conflicts with school attendance.

Figure 9.38 ***Men's Initiation Rites, Quitupo Village***

Source: Impacto, 2012.

Traditional and religious weddings are also conducted and locally referred to as *Chuo* and *Chitamo*. Normally, young girls marry between the ages of 12 and 15 years, after they have reached maturity that is marked by completion of the initiation rites. Boys normally marry between the ages of 15 to 18 when they feel capable or responsible enough to support a family, and after they have completed their initiation rites.

Selection of a wife is autonomous and is based solely on whether or not the young man is economically independent. However, young men and young women sometimes seek advice from their parents or maternal aunts or uncles during spouse selection, and this is also the case in the event of divorce.

During commemorative ceremonies, weddings and festive occasions in the community, different dances are performed, the most common of which include: *Nkala* (danced by men and women), *Tsihacubatula* (men, women and young people), *Manico* (men), *Chinguengue* (men women and young people), *Ndalandala* (girls), *Wave* (women) and *Zikirhi* (women).

Although ancestor worship is not practised in the communities, all focus groups mentioned that, before initiating a project, the proponent will inform the religious leaders, Sheikh and community leaders of their intentions so that ceremonies can be organised to bless the project.

9.15.2 *Sacred and Historical Sites*

The ancestor worship traditions (through *Ziharat* and *Maulide*) and ceremonial initiation rites take place at specific sacred sites.

Burial in cemeteries is a practice for both Islam and Christianity. Thus, cemeteries are found in areas near settlements. The information obtained from the Household Survey indicates that approximately 45 percent of the households have deceased buried in community cemeteries. The remainder reported burial in family cemeteries near their homes (37.9 percent) or far from their homes (15 percent). Community cemeteries are more frequent in villages where people are concentrated (Quitupo, Senga, Maganja), while family cemeteries are more common in scattered settlements such as the production zones and the Coastal Zone. The information collected during the FGDs confirms the survey data (*Table 9.56*) (1).

Table 9.56 Location of the Burial Sites in Afungi Project Site and Surrounds

	Total (%)	Coastal Zone (%)	Maganja (%)	Quitupo (%)	Quitupo Settlements (Production Zones) (%)	Senga (%)
Family cemetery close to the house	37.9	63.6	26.7	21.2	93.8	25.0
Family cemetery far from the house	15.0	22.7	16.7	19.2	6.2	-
Community cemetery	45.0	-	56.7	59.6	-	75.0
Other	2.1	13.6	-	-	-	-
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Impacto, 2012.

Churches, mosques and sites where initiation rites are performed are considered sacred sites.

9.16 *AFUNGI PROJECT SITE AND SURROUNDS (INCLUDING SENGA AND MAGANJA): EXPECTATIONS REGARDING THE PROJECT*

This section presents the perceptions of benefits and disadvantages of the Project, identified during the Household Survey (*Table 9.57*).

(1) This information will be a base to mapping all the family and community cemeteries during the Resettlement Action Plan.

Table 9.57 Perceived Advantages and Disadvantages of the Project by Surveyed Households

Advantages	Households (%)	Disadvantages	Households (%)
Social benefits (more schools, health centres, waterpumps)	65.0	Increase in AIDS cases	30.0
Access to employment	57.9	Prostitution	27.1
Road construction and maintenance	39.3	Entrance of outside individuals	26.4
People will open businesses in the zone	18.6	Criminality	25.7
Collective transportation on the highways coming into and leaving the zone	17.1	Loss of farmlands	22.9
Facilities for transporting products to sell in other areas	13.6	Prohibitions on fishing	17.9
Sale of farm products to the Project	7.1	Loss of producing trees (cashew, coconut, mango)	15.7
Arrival of buyers for farm products	5.0	Loss of houses and buildings	10.7
Other	11.4	Other	4.3

Source: Impacto, 2012.

In general, a higher proportion of the surveyed population identified the benefits rather than disadvantages or detrimental aspects of the Project.

The communities in the area hope that the Project will respect local habits and customs. They have requested that before beginning any activities, the developer should identify local leaders to engage and discuss the plans, and engage local communities in the Project. This will assist in preventing conflicts between the communities and the Project.

9.16.1 Perceived Advantages of the Project

The results of the Social Assessment show that local communities welcome the Project, since it is believed that it will drive development of the directly impacted communities in Palma District. Feedback from communities regarding the Project is indicated below.

- Approximately 65 percent of the surveyed households believe that the Project will provide social benefits such as an increase in infrastructure, for example (schools, waterpumps and hospitals).

  During FGDs in the villages of Senga and Quitupo, participants mentioned that they believe the Project will contribute to the construction of infrastructure such as mosques and maternity clinics or 'mothers' waiting houses' (1). According to participants, midwives endure great

(1) Houses near health units where mothers-to-be wait until delivery.

difficulties travelling to the homes of women in labour, due to the lack of transport.

- Fully 57.9 percent of the surveyed households believe that the Project will provide employment, thus contributing to an increase in household income.
- Some 39.3 percent of the households assume that construction of the Project will create conditions for the construction and maintenance of new roads, which will benefit surrounding communities.
- Other perceived advantages include the expansion of the electricity network (11.4 percent of households), expansion of the commercial network (18.6 percent), improvement of the transportation network as a result of construction of new roads (17.1 percent), and facilities for transporting products to be sold in other zones (13.6 percent).

9.16.2 Perceived Disadvantages

The identified disadvantages that could result from the development of the Project are summarised below.

- Approximately 30 percent of the surveyed households mentioned the potential increase in cases of HIV that could result from increased prostitution.
- Some 26.4 percent of surveyed households believe that the arrival of outside individuals (in-migrants) could increase, due to increased expectations for work and the establishment of camps for the Project.
- Some 25.7 percent of surveyed households believe that increases in levels of criminal behaviour could occur in the Afungi Project Site and Surrounds and in adjacent areas.
- The loss of farmland and producing trees (cashew, coconut and mango) was mentioned as a perceived disadvantage:
    - In Milamba, for example, it was mentioned that residents could lose their farming plots, houses and coconut tree plantations and be moved to another location.
    - The FGDs in Milamba and Maganja proposed that, in the case of damage to farmland or producing trees, the proponents should discuss or negotiate directly with the affected parties.
- The loss of houses and buildings was mentioned by only 10.7 percent of surveyed households as a disadvantage:

- During FGDs in Quitupo, the participants stated that they will suspend the construction of new houses, due to the rumours circulating that they may be resettled.

- Disruption to small-scale fishing was also mentioned as a potential disadvantage of the Project. Approximately 18 percent of surveyed households believe that they could be prohibited from fishing. This issue was also mentioned during the FGDs in Maganja.

9.16.3 Preferences if Resettlement were to Occur

When asked about possible resettlement, more than half of the surveyed families indicated that they would prefer to reside close to the location where they currently live (61.4 percent). Of the total households surveyed, 76.4 percent indicated a preference to reside in a concentrated village (or compound) and 71.4 percent preferred an area structured or organised as a village or settlement (*Table 9.58*).

Table 9.58 Resettlement Preferences of the Surveyed Households in the Afungi Project Site and Surrounds

	Total Households in the Sample (%)	Coastal Zone (%)	Maganja (%)	Quitupo (%)	Quitupo Settlements (Production Zones) (%)	Senga (%)
Preferred Location as Compared to the Location Where They Currently Reside						
Nearby	61.4	45.5	76.7	69.2	31.3	60.0
Far away	27.9	54.5	13.3	19.2	50.0	25.0
No preference	10.7	-	10.0	11.5	18.7	15.0
Type of Village						
Concentrated village	76.4	72.7	80.0	80.8	62.5	75.0
Scattered village	9.3	9.1	6.7	7.7	31.3	-
As isolated household	5.0	-	-	11.5	6.3	-
No preference	9.3	18.2	13.3	-	-	25.0
Formally Organised Settlement						
Yes	71.4	81.8	70.0	61.5	81.3	80.0
No	5.0	-	6.7	5.8	12.5	-
No preference	23.6	18.2	23.3	32.7	6.3	20.0

Source: Impacto, 2012.

With regard to the preferred resettlement location, a significant difference is noted between those who live in villages and those who are dispersed throughout the Coastal Zone or in the Quitupo Settlements (production zones), with a higher proportion of those who live in villages preferring to live near the village where they currently live.

- Approximately 77, 69 and 60 percent respectively of the residents of Maganja, Quitupo and Senga would prefer to live close to where they currently reside.

- Approximately 50 and 55 percent respectively of those who reside in the Quitupo production zones and in the Coastal Zone prefer to reside away from the location where they currently reside.

Independent of the place of residence, if resettlement occurs, the results indicate that approximately two thirds or more of the households in all communities have expressed that they would prefer to live in a concentrated and formally organised village.

This desire was confirmed during the FGDs, where participants mentioned the following:

- In concentrated and organised settlements, they would have access to better social conditions that they currently do not have, such as social infrastructure (water, electricity, schools, hospitals and mosques).

- If they are resettled, they expect that the activities they currently practise and the characteristics of the soil in the new locations will be taken into consideration.

  For example, the participants in Quitupo and Senga stated that their lands are productive, and they therefore hope that the population will not lose their lands. If they are transferred to another location, they prefer a location with good land for farming, since their base of sustenance is agriculture.

- The participants in Maganja and the Coastal Zone stated that they are not in favour of resettlement. However, if it is unavoidable, they would prefer to be transferred to another location with the same conditions in terms of marine resources.

When asked about being host communities, all respondents noted that:

- if they are required to receive people from other areas impacted by the Project, they expect that the incoming residents will respect their way of life; and

- during the phase when land is given out for farm plots or residences, the process should be clear to prevent any conflicts.

9.17 SHIPPING AND NAVIGATION

For the Shipping and Navigation Study, the Study Area is defined as Area 1 and the vicinity of the Mamba Gas Field in Area 4.

9.17.1 Background

The Mozambique Channel is situated in the Indian Ocean, between the latitudes 10°S and 25°S, with a length of approximately 1,000 nautical miles (1,600km), a width that varies between 250 and 600 nautical miles (400 to 950km), a minimum width of approximately 287.5 nautical miles (460km) between Angoche (in Mozambique) and TambohorYear (in Madagascar), an average depth of around 3,897m and a maximum depth of 7,455m (Java Atoll) (1).

The Mozambique Channel is a preferential navigation route for the maritime links between the USA, the Persian Gulf, Asia and southern and East Africa, and hosts a variety of ships including oil tankers, container ships, general cargo ships and cruise liners, among other types. Furthermore, the Mozambique Channel is a route for regional cabotage (2) in southern and East Africa, as well as for Mozambique domestic cabotage (3).

The Mozambique Channel became an established commercial navigation route when Arab traders used the channel in their commercial voyages to the southern and East Africa region, long before the arrival of Vasco da Gama in Mozambique (in the 15th century) on his discovery of the maritime route to India.

Despite it being a historically busy navigation route, the channel does not have an officially and formally established Traffic Separation Scheme (4). Instead, navigation is based on customary traffic lanes (5), even though the International Maritime Organisation (IMO) has put in place criteria and guidelines for the establishment of a Traffic Separation Scheme. Such a scheme is incorporated in Chapter V, Regulation 8, of the IMO International Convention on Safety of Life at Sea (SOLAS 74), related to the Organisation of Maritime Traffic (6).

Global economic growth and the increase in maritime trade has led to an increase in maritime traffic in the Mozambique Channel, peaking at the same time as the oil industry in the Persian Gulf. As such, the Mozambique Channel became the preferred route for oil tankers travelling from the Persian Gulf to the US, and East and southern Africa. Commercial fishing activity also

(1) Marine Highway Project preliminary study report, 1998.

(2) Transport in coastal waters.

(3) Transport between two points within a country.

(4) Navigation Lanes formally established in busy traffic areas or busy port entrance channels.

(5) Informal Navigation Lanes used in busy traffic areas/busy port entrance channels.

(6) IMO Convention SOLAS 74, consolidated Edition of 1997.

contributes to traffic in the Mozambique Channel, especially tuna fishing vessels (see *Section 9.7.6*).

Since the 1960s, considerable portions of the western parts of the Mozambique Channel have been subject to scientific expeditions related to oil exploration seismic surveys.. These surveys fall within the jurisdictional waters of South Africa, Mozambique, Tanzania and Kenya.

9.17.2 Recent Developments

A Marine Highway Project has been designed for the Mozambique Channel through funding by the World Bank Global Environment Facility (GEF). The main objective of this project is to implement a platform for the prevention of marine oil pollution. It also includes the management of maritime traffic by establishing a Traffic Separation Scheme, bearing in mind that preventing accidents is an important aspect of preventing oil pollution. .The Marine Highway Project has the following participating and beneficiary countries: South Africa, Comoros, Madagascar, Mauritius, Mozambique, Kenya, Seychelles, Somalia and Tanzania. South Africa is the funding signatory on behalf of the group of participating and beneficiary countries. The implementation of the project is under the responsibility of the South African Maritime Authority (SAMSA) in partnership with the Indian Ocean Commission (IOC), under the supervision of a Steering Committee composed of representatives of the participating and beneficiary countries. All preparatory work has been concluded and the Funding Agreement was signed in September 2007 (1).

During the last years, marine traffic in Cabo Delgado Province also includes the movement of several vessels involved in seismic and drilling activities for hydrocarbon exploration in the Rovuma Basin area of northern Mozambique (2).

9.17.3 Ports and Shipping Movement in and around Area 1 and the Mamba Gas Field

There are two ports within Cabo Delgado Province, namely Mocímboa da Praia and Pemba. The port of Mocímboa da Praia has a small quay, whereas the Port of Pemba is a conventional deepwater port with associated equipment and infrastructure.

The commercial traffic volumes to and from these ports has been decreasing over the last few years. According to the registry of the Administração Marítima (Maritime Authority) in Pemba, very few commercial ships called at the Port of Pemba in 2010. Between 2007 and 2009, the average number of calls per year at the Port of Pemba was around 82 commercial ships per year. In 2010, this dropped to 39, including both long course and cabotage traffic

(1) World Bank Report on the project. The status of this project is unclear.

(2) INP – National Petroleum Institute, Mozambique.

(*Table 9.59*). However, due to the intensive hydrocarbon exploration activity in the Rovuma Basin, 171 vessels involved in hydrocarbon exploration called at the Port of Pemba during the same period.

A similar pattern was observed in 2011. During this period, only 38 commercial ships called at the Port of Pemba, compared with 215 vessels involved in hydrocarbon exploration.

Table 9.59 Movement of Ships at the Port of Pemba in 2010 and 2011

Year	2010	2011
Number of commercial ships	39	38
Number of survey ships	172	215
Total number of ships	211	253

Source: Maritime Administration – Pemba/CFM Office Pemba Branch.

Between 2008 and 2010, the Port of Mocímboa da Praia was called on by just a single ship carrying a containerised cargo (mainly timber). According to the Maritime Authority representative in Mocímboa da Praia, only four commercial ships called at the port in 2011.

There is no registry of conventional ships arriving in Palma Bay; however, it appears that only local small transport and fishing crafts use Palma Bay. In addition, some small recreational boats engaged in tourism (used support to diving and sightseeing activities) have been observed cruising the Study Area.

9.17.4 Types of Vessels

The shipping activity in and around Area 1 and Area 4 in the Rovuma Basin comprises mostly small-scale traffic, some maritime traffic transiting the Mozambique Channel, vessels engaged in hydrocarbon exploration and scientific research, tourism cruise ships, tourism small boats, and some medium-size local and regional cabotage vessels – primarily traffic travelling from Mocímboa da Praia to the Port of Pemba, as shown in *Figure 9.39*.

39°0'0"E 39°30'0"E 40°0'0"E 40°30'0"E 41°0'0"E 41°30'0"E 42°0'0"E 42°30'0"E

Mombasa
Mtwara
Dar es Salaam
TANZANIA
Palma
Comoros
Mocìmboa da Praia
CABO DELGADO
Pemba

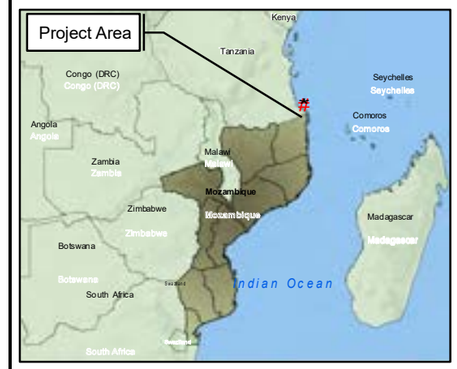
39°0'0"E 39°30'0"E 40°0'0"E 40°30'0"E 41°0'0"E 41°30'0"E 42°0'0"E 42°30'0"E

Legend

- Capital City of Cabo Delgado
- Town
- Afungi Project Site
- Boundary with Tanzania
- Cabo Delgado Province
- Quirimbas National Park
- Area 1
- Area 4

Cabotage Routes

- Domestic Cabotage
- Regional Cabotage: Comoros
- Regional Cabotage: Tanzania and Kenya
- Informal Traffic: Mozambique-Comoros



MAIN MAP SCALE:

Kilometers

TITLE:

Figure 9.39:
National and Regional Cabotage Routes

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Anadarko Moçambique Área 1, Lda

eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 1 450 000

DRAWING: National and Regional Cabotage Routes in Area 1.mxd

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Projection: UTM Zone 37 S Datum: WGS84 Source: DIVA-GIS. Impacto, 2012. Inset Map: Esri Data & Maps	SIZE: A3

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10°00'S

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11°30'S

12°00'S

12°30'S

The informal traffic (red line in *Figure 9.39*) indicates local transport routes by artisanal boats used by the population, from the mainland to the Comoros islands and vice versa.

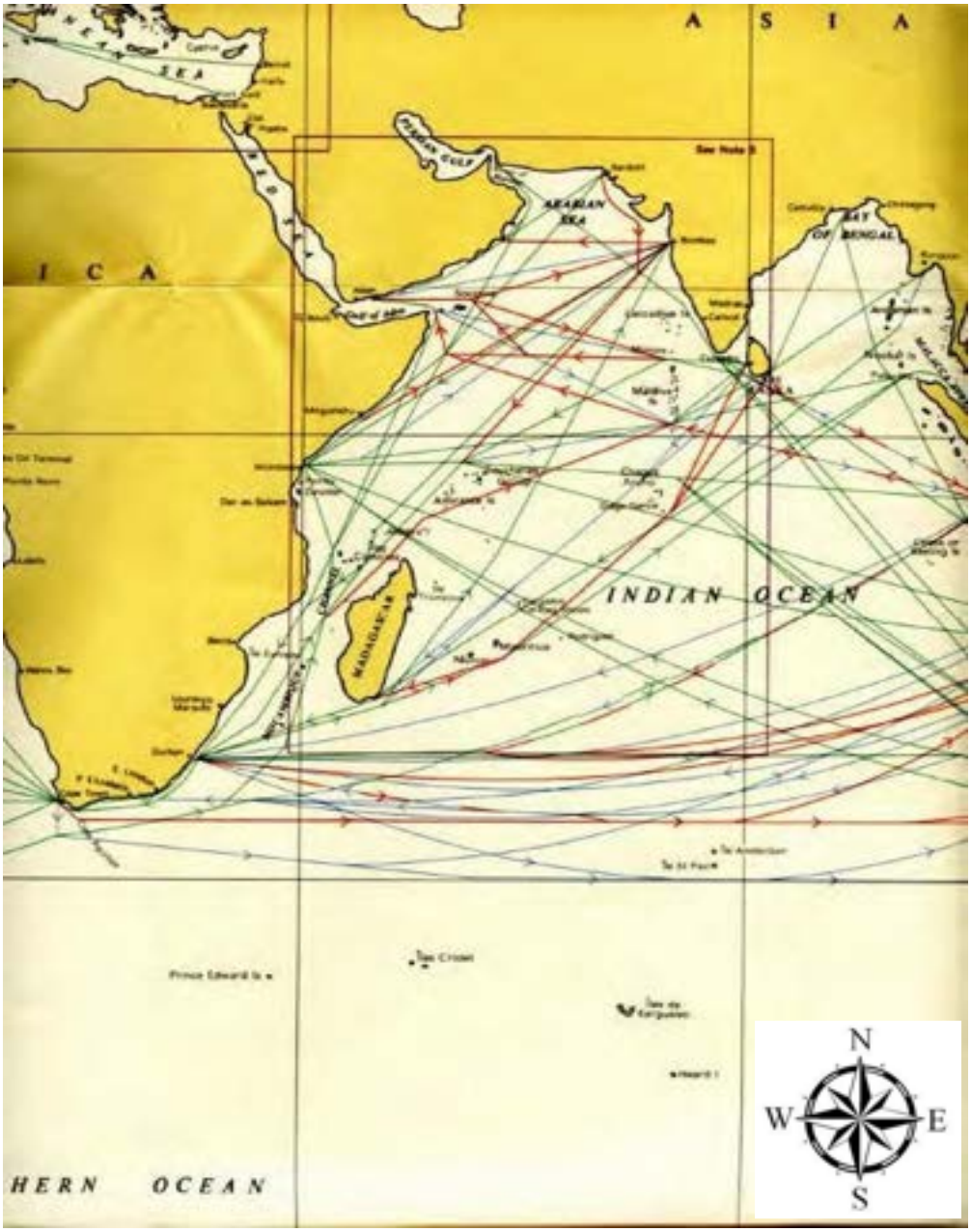
The small-scale shipping activity is characterised by local transport from the mainland to the islands and vice versa, small-scale fishing and recreational navigation between the islands of the Quirimbas Archipelago for tourism purposes.

The types of boats/vessels used in and around the Study Area vary from artisanal locally built boats (wooden canoes) to conventional vessels fitted with modern navigation equipment.

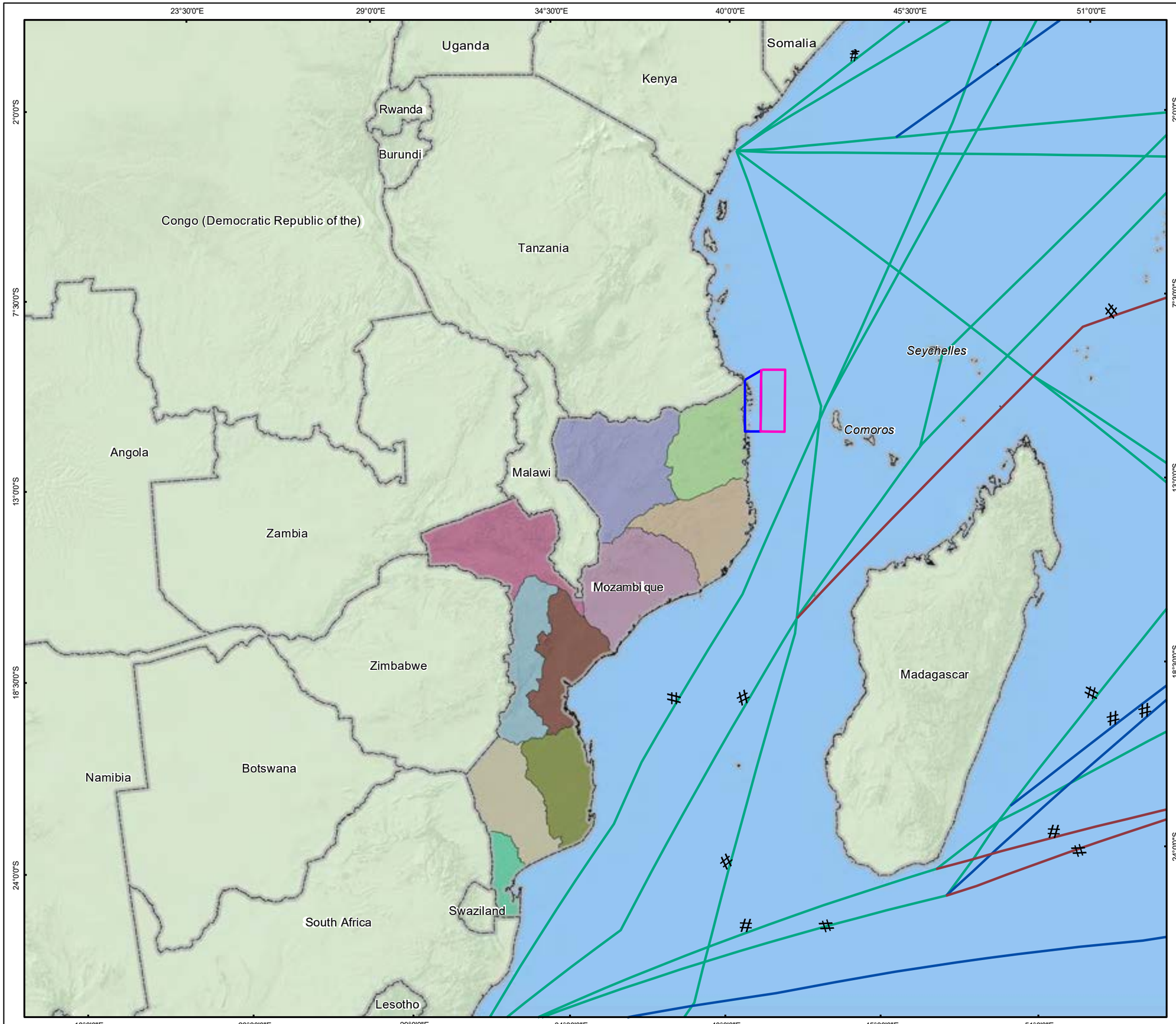
9.17.5 Actual and Proposed Shipping Routes in the Offshore Study Area

There are no formally established navigation routes within the Offshore Study Area, but regularly used routes have been adopted based on common practice. Information collected and processed by some companies, organisations and associations linked to the shipping industry show how ships have been navigating in the Indian Ocean, including the Mozambique Channel (*Figure 9.40*).

Figure 9.40 Traditional Navigation Routes in the Indian Ocean and Mozambique Channel



Source: INAMAR, 2010.



Legend

Maritime Traffic Distribution Routes

- Traffic from Persia Gulf to Africa, Americas and Europe
- Traffic of trans-shipments of Oil
- Trans-shipments of general cargo

- Area 1
- Area 4

Mozambique Provincial Boundary

- Inhambane
- Manica
- Sofala
- Maputo
- Tete
- Gaza
- Cabo Delgado
- Niassa
- Nampula
- Zambezia

MAIN MAP SCALE:

0 100 200 300 400 500

Kilometers

TITLE:

Figure 9.41: MaritimeTraffic Routes In the Mozambique Channel

CLIENT:

Anadarko Moçambique Área 1, Lda

eni

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DRAWING: Maritime Traffic Distribution Routes Moz Channel.mxd — REV: A

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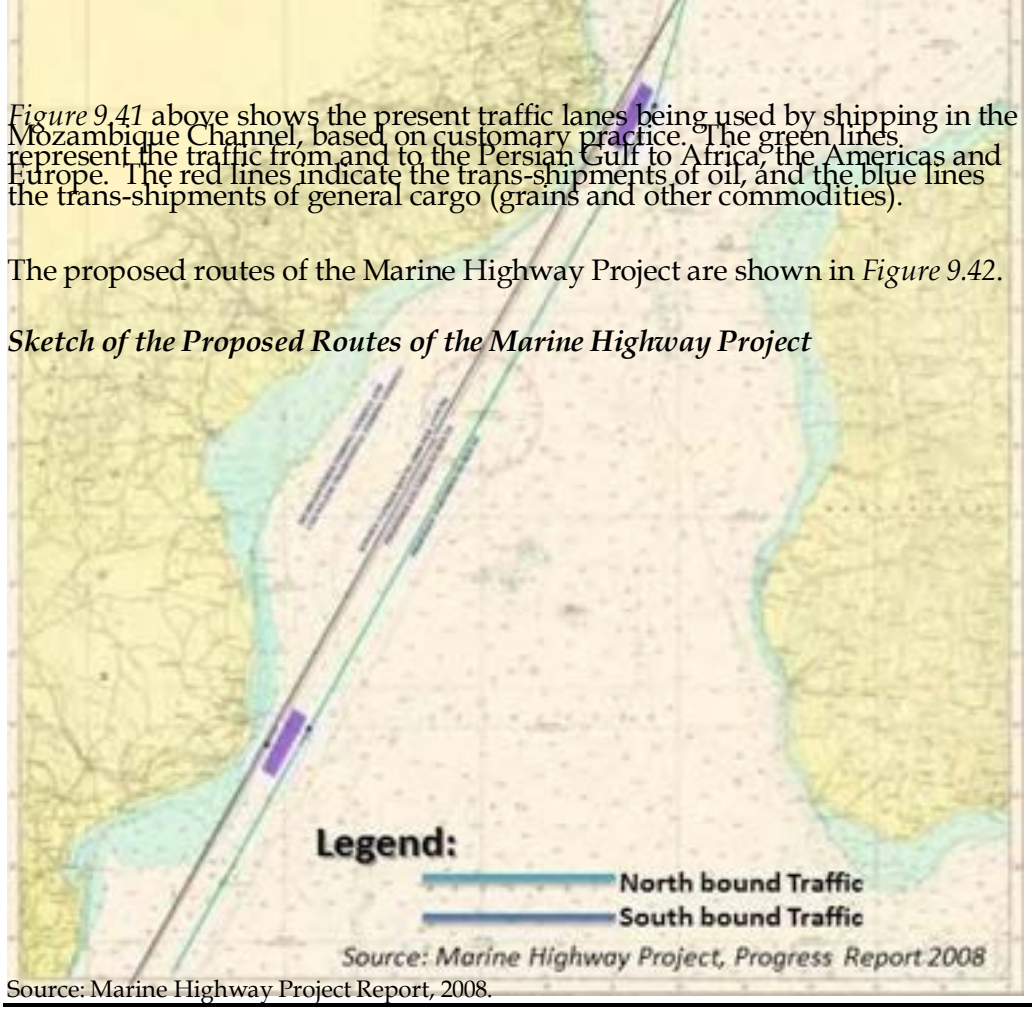
Figure 9.41 above shows the present traffic lanes being used by shipping in the Mozambique Channel, based on customary practice. The green lines represent the traffic from and to the Persian Gulf to Africa, the Americas and Europe. The red lines indicate the trans-shipments of oil, and the blue lines the trans-shipments of general cargo (grains and other commodities).

The proposed routes of the Marine Highway Project are shown in *Figure 9.42*.

Figure 9.42 ***Sketch of the Proposed Routes of the Marine Highway Project***



Source: Marine Highway Project Report, 2008.

The Marine Highway Project in the Mozambique Channel has designed three scenarios, aiming at dividing the traffic by classes of ships according to their type and use: tankers, chemical ships, nuclear ships, general cargo ships, bulk cargo ships, container ships, passenger ships and navy vessels. The project

also establishes navigation lanes based on ship type and use. The three proposed options under consideration are:

Scenario 1: the marine highway is routed a minimum distance of 20 nautical miles from the coastline, and has a distance of 10 nautical miles of separation between the navigation lanes in each direction. The route has a minimum depth of 1,000m. Being only 20 nautical miles from the coast, this option presents a risk of pollution exposure in the event of an accident involving oil tankers.

Scenario 2: the marine highway is routed a minimum distance of 50 nautical miles from the nearest point on the coastline, and has a distance of 10 nautical miles of separation between the navigation lanes in each direction. Being quite far from the coast, this option minimises the risk of pollution reaching the shore in the event of an accidental spill. Conversely, the distance from shore means that in the event of an emergency, search and rescue operations would take longer to reach stricken vessels.

Scenario 3: this option combines scenarios 1 and 2. The marine highway passes at a distance of 35 nautical miles from the nearest point of the coastline. As with the above scenarios, the marine highway maintains a 10 nautical miles distance of separation between the navigation lanes in each direction and has a minimum depth of 1,000m.

It is unclear when this project will be implemented.

9.17.6 Piracy in the Vicinity

Piracy activities in the Indian Ocean are increasing as a result of the continuous absence of an effective government in Somalia, where piracy has been used not only as a way of accumulating wealth but also as a means of supporting tribal wars and skirmishes (1).

After unsuccessful piracy attacks on ships in the south-west Indian Ocean in 2008 and 2009, a Mozambican fishing vessel *(M/V Vega 5)* was hijacked near the Bazaruto Archipelago (offshore of Inhambane Province in southern Mozambique) in December 2010, taken to Somalia and subsequently used as a mother vessel for pirate attacks. Since 2009, some vessels in transit along the Mozambique Channel, as well as companies involved in hydrocarbon exploration in the Rovuma Basin, have reported threats of piracy attacks. This was highlighted in a workshop on piracy organised by the Embassy of Norway in cooperation with the Government of Mozambique in 2011.

In September 2011, two attacks were made against ships in the Mozambique Channel, in the area of the Graciosa Island near Madagascar. The attacks were unsuccessful as the targeted ships had armed protection on board, and had initiated their anti-piracy contingency plans.

(1) NATO Shipping Centre, Information Report to the Maputo Workshop, May 2011.

Piracy Protocols and Agreements Signed by Mozambique

Mozambique is a State Party to the SUA Convention 1988 and SUA Protocol 1988 (bound from 8 April 2003), two IMO instruments on the Suppression of Unlawful Acts against Ships at Sea adopted in 1988 and in force from 1 March 1992. Nevertheless, the country still lacks specific domestic legislation to implement the provisions of these two instruments.

Mozambique is also a signatory State to the Djibouti Code of Conduct on Piracy and Armed Robbery against Ships for the Indian Ocean and Gulf of Aden, which was developed and adopted under the IMO umbrella as a platform for regional cooperation, and also as part of the international community efforts to combat piracy and armed robbery against ships.

In March 2011, the Government of Mozambique joined the International Contact Group on Piracy off the Coast of Somalia (CGPCS) during the forum session at the United Nations headquarters in New York. This group comprises 28 nations with naval fleets patrolling the main navigation routes, including a number of countries located around the Indian Ocean. It is aimed at providing protection to ships transiting the areas affected by piracy and armed robbery.

Currently, the Mozambican Navy is partnering with other key national institutions to carry out some patrolling actions, particularly in the Rovuma Basin. The Mozambican Navy is also in the process of designing a new model of maritime surveillance to address situations regarding piracy and armed robbery at sea better.

9.18 ARCHAEOLOGY AND CULTURAL HERITAGE

9.18.1 Introduction

Archaeology and cultural heritage includes tangible and intangible resources such as places, oral traditions and rituals. In the Law for Protection of Cultural Assets (Law No. 10/88, dated 22 December), a heritage resource is defined as *".any place or object of cultural significance ie of aesthetic, architectural, historical, scientific, social, spiritual, linguistic or technological value or significance"*.

9.18.2 Historical Background

The Project Onshore Footprint is located in Afungi Peninsula, and comprises the southern shore of Palma Bay (originally known as Tungi Bay). This area was once ruled by a local sociopolitical entity, and the area was known as the Sultanate of Tungi . The archaeology and cultural heritage of Afungi Peninsula is strongly influenced by the Sultanate, which reigned from Cabo Delgado Peninsula on the northern shore of Tungi Bay. *Figure 9.43* illustrates

the key archaeological sites within the East African region, some of which are referred to in this section.

Figure 9.43 ***Map Showing Principal Archaeological Sites along the East Africa Coastline***

Source: Adamowicz, 2012.

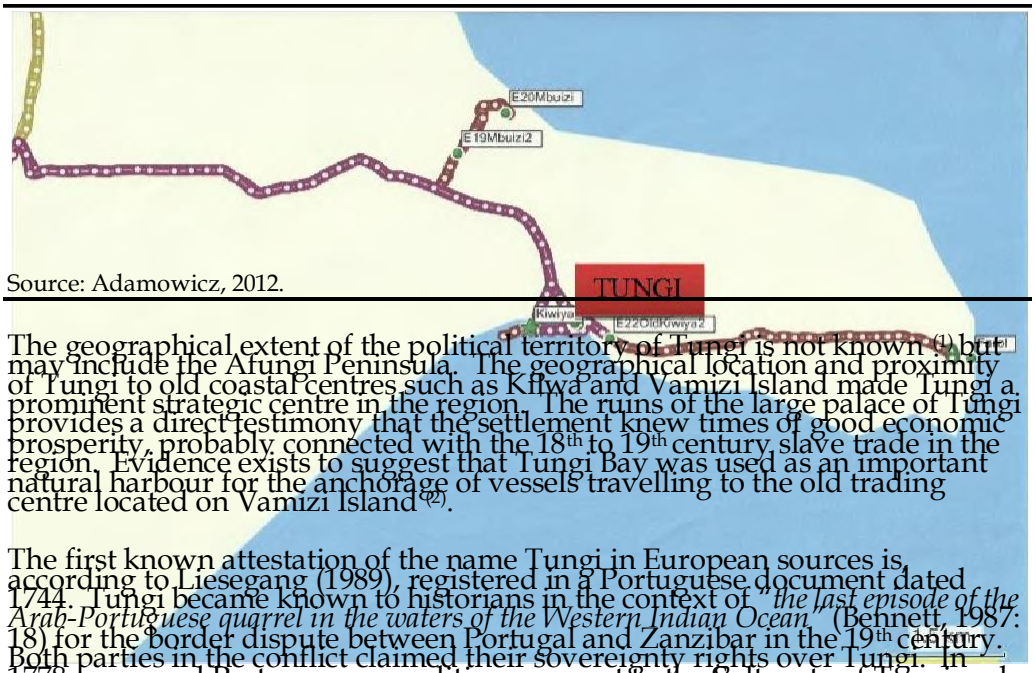
The Sultanate of Tungi [(1)]

Tungi is the historical name of the Swahili sultanate that ruled on the Cabo Delgado Peninsula until 1877. During the 18th and 19th centuries, its main political centre was located 5km west of the peninsula's tip, in the vicinity of the village today known as Kiwiya (Quiwia) (see *Figure 9.44*). It is believed that Kiwiya was previously known as Tungi, although the name also extends to a larger area, which was under the control of the Sultan of Tungi. Ruins of

(1) This section is based mostly on research and publications by Prof. Dr. Eugeniusz Rzewuski at Warsaw University (UW) in cooperation with Eduardo Mondlane University (UEM) – see: Rzewuski forthcoming.

the sultans' palace and three graves of Tungue sultans are found in the area today (Rzewuski, 1991).

Figure 9.44 ***Cabo Delgado Peninsula Showing the Location of Tungi – the Capital of the Sultanate of Tungi***



Source: Adamowicz, 2012.

The geographical extent of the political territory of Tungi is not known (1), but may include the Afungi Peninsula. The geographical location and proximity of Tungi to old coastal centres such as Kilwa and Vamizi Island made Tungi a prominent strategic centre in the region. The ruins of the large palace of Tungi provides a direct testimony that the settlement knew times of good economic prosperity, probably connected with the 18th to 19th century slave trade in the region. Evidence exists to suggest that Tungi Bay was used as an important natural harbour for the anchorage of vessels travelling to the old trading centre located on Vamizi Island (2).

The first known attestation of the name Tungi in European sources is, according to Liesegang (1989), registered in a Portuguese document dated 1744. Tungi became known to historians in the context of *"the last episode of the Arab-Portuguese quarrel in the waters of the Western Indian Ocean"* (Bennett, 1987: 18) for the border dispute between Portugal and Zanzibar in the 19th century. Both parties in the conflict claimed their sovereignty rights over Tungi. In 1778, an armed Portuguese expedition was sent to the Sultanate of Tungi and,

(1) Bennett (1987) refers to Loarer, a French commercial investigator who reported in 1848 that the zone of influence of the sultan Muhammad bin Sultan of Tungi reached, by that time, some 120 miles deep into the continent. Bennett himself describes the location of Tungi as stretching *"north of the Minanganiriver"*, which is not considered precise. He does not mention the existence of the ruins of the palace.
(2) As described by Ahmad bin Majid in the 15th century. Traditions collected by C. Velten, Prosa und Poesie der Suaheli, Berlin 1907, reproduced partially in Freeman-Grenville 1962:221-6. Rzewuski owe to Prof. C.S.P. Freeman-Crenville the information that in the same Velten's collection there is a text on the history of Tungi but it is still unavailable to Mozambican scholars.

since then, Tungi sultans played a policy of a balanced double loyalty. At least one of them, Hassani (Assani), used to receive regular payments from the Portuguese authorities in the 1820s to 1830s. The Portuguese-Zanzibar dispute involved Great Britain and Germany, as 'intermediaries' who had their own interest in the area. It was ended by the Portuguese military annexation of the disputed land in 1877. A few years later, the colonial border between the Deutsche Ostafrika (German East Africa) and Africa Oriental Portuguesa (Portuguese East Africa) was mapped along the Rovuma River, some 40km north of Tungi, which was then incorporated into the Portuguese colony.

In the Comoros chronicles (1), it is mentioned that the first people to settle on Ngazija (Grande Comore) originated from Tungi (Rotter, 1976). The same Comorian chronicle identifies Tungi among the first Swahili towns founded (Rotter, 1976: 25–27 in Rzewuski, 1991: 193). The name of the settlement also appears in oral traditions connected with the first sultan of Kilwa (Sultan Ali), who waged war against Tungi (2).

Today, land rights in some settlements in Cabo Delgado Peninsula and Afungi Peninsula belong to Makwa descendants of the Sultan of Tungi, dating back to late 17th and early 18th centuries. Over the last 200 to 300 years, the lands have been farmed or used for fishing or slave trade.

Written and Oral Manuscripts – Tungi

Oral and written traditions indicate that Tungi was ruled by the Shirazi dynasty, whose descendants still today claim to have their roots in the Comoros, Angoche and Kilwa. According to studies undertaken by Polish linguist Eugeniusz Rzewuski (1991), the corpus of oral and written texts comprise two written manuscripts and one oral narrative, referred to as TUNGI - 1, TUNGI - 2 and TUNGI - 3 respectively. These provide an insight into the Shirazi and Matungi tribes and the history of Tungi. These were collected/recorded in August 1988 from Palma, and are titled as follows:

- TUNGI – 1: Old events concerning the Shirazi Tribe;
- TUNGI – 2: Genealogical document of the Matungi Tribe; and
- TUNGI – 3: Oral manuscript by Muhammad bin Thabiti.

The texts provide some information relevant to the ethnohistory of Tungi (Mbobo and his Wampambe people are said to be the first inhabitants and to have come from Nyassa) and to the history of Shirazi migrations along the Mozambican coast. Today in Palma and Kiwiya, the Shirazi constitute the traditional elite (3). Two authors of the manuscripts described above belong to

(1) Chronicles from the Comoros Islands.

(2) Traditions collected by C. Velten, Prosa und Poesie der Suaheli, Berlin 1907, reproduced partially in Freeman-Grenville 1962: 221-6.

(3) In Kiwiya, the Shirazi comprise the major clan (*kabila*) – 32, the second in rank being Nausi (10%), who also claim their oriental origin and, according to local tradition, were the first immigrants to settle in area adjacent to Tungi Bay (numerical data taken from Lundin and Loforte, 1988: 12).

this tribe [1], and Muhammed bin Thabiti is the most respected leader of the Muslim community (*shehe*) in Palma. One characteristic and distinctive element in the Shirazian traditions of Tungi is the prominence given to the female ancestors. In the genealogical chain, only the names of women are given, whereas their husbands' names are omitted in several cases (eg Pendezeni, Amina).

According to traditional leaders, the ancient document TUNGI - 1 (shown in *Figure 9.45*) should be protected in a museum.

Figure 9.45 Ancient Written Manuscript

Source: Adamowicz, 2012.

(1) AbdulahibnSalimMungoji, the author of TUNGI - 1, although not identified, must be associated with the descendants of the royal family from Angoche (Ngoji), as his nisbaMungoji indicates.

Figure 9.46 Cultural Traditions are Well Preserved Locally and Shared with Youth

Source: Adamowicz, 2012.

The rulers/sultans who reigned over the Sultanate of Tungi, and the period they ruled, are outlined in *Table 9.60*, according to the oral and written evidence outlined in TUNGI - 1.

Table 9.60 Rulers/Sultans

Rulers/Sultans	Dates	Comments
Unknown names Sultan Ali ibn al-Hassan (since 957) - from Kilwa, waged war against Tungi	Since 1000 AD	Dynasties ruling from Kilwa [1]. Limited excavations and test pits in Kiwiya may provide more data for absolute (C14) and relative chronology in this area. [Early Kilwa pottery. Some attributes of later earthenware at Kiwiya found in association with Sassanian Islamic (?) tin glazed blue-green.]
	1310–1333	Under control of the Sultan al-HasanibnSulaiman from Kilwa (?)
Unknown names	After 15th century	Local dynasties, usurpers and clans controlled by Comoros, Oman or Zanzibar Sultanates.
	17th – 18th century AD	Tungi area under rule of local clans Wampambe from Kilindi (Late Monapo pottery).
AhmadiHassani	End of 18th century AD	From Angoche.
Selemani	1st half of 19th century AD	From Kilwa.
Yussufu	1st half of 19th century AD	Son of Selemani from Kilwa.
Idighami	1st half of 19th century AD	Dispute on succession with Shabapi, husband of his aunt ruled shortly and simultaneously with Yussufu.
Hassani II and Hassani III	1828–1830 AD	AssaneMenneMosalonaChiraze (in Portuguese documents). Ruled simultaneously and both used to receive regular payments from the Portuguese authorities in the 1820s to 1830s.
Muhammadi	1837-1860	Nicknamed Nchingama.
Muhammadi and MuhammadYussufuHamissi	1858 AD	Date from inscription of the graves, deciphered by Monteiro (1966: 56) (in Rzewuski 1991: 209).
Muhammadi	To 1860 AD	From Portuguese documents.
Abdurabi	1872 AD	Date from inscription of the graves.
Aburari	2nd half 19th century AD	Dispute on succession with paternal uncle Abdelazizi. Zanzibar and Portuguese interference.

Abdelaziz *(capitão-mor)*	1877 AD	Military annexation of Tungi by Portuguese. End of the Sultanate.

Notes:

(1) The history of Kilwa begins in 960-1000 AD when one of seven sons of a ruler of Shiraz, Persia Ali ibn al-Hassan Shirazi, steered down the African coast. Ali is said to have purchased the island of Kilwa from the local Bantu inhabitants. According to one (Strong, 1895), Kilwa was originally owned by a mainland Bantu king named Almuli. At the zenith of its power in the 15th century, the Kilwa Sultanate owned or claimed overlordship over the mainland cities of Malindi, Inhambane and Sofala and the island-states of Mombasa, Pemba, Zanzibar, Mafia, Comoro and Mozambique (plus numerous smaller places from Rovuma River, Quirimba Island, Angoche and Quelimane to Sofala) - essentially what is now often referred to as the Swahili Coast. Kilwa also claimed lordship across the channel over the myriad of small trading posts scattered on the coast of Madagascar.

Language and Cultural Significance

Palma and its surroundings is the only area along the Mozambican coast where the Swahili language is spoken. In addition, the language situation within the region represents a rare type of a stabilised 'gender diglossia' [(1)]. The use of Swahili seems to be a factor helping to maintain the social status and cultural identity of a *mwungwana* (ie civilised person) rather than a recent linguistic acquisition. Gender diglossia is also observed north of Lindi in Tanzania (see *Figure 9.47*).

9.18.3 Archaeological Survey

Overview

The archaeological survey was undertaken on Afungi Peninsula (which includes the Afungi Project Site), Palma and Cabo Delgado Peninsula in October 2011. The latter areas do not fall within the direct Project Footprint; however, due to the proximity and cultural heritage value of the known archaeological and historical sites in these areas, they were considered in the scope of the field investigation. The surveys undertaken involved identifying known archaeological and historical sites with cultural significance in the area, which were then further investigated. The extent of the survey area is shown in *Figure 9.47*.

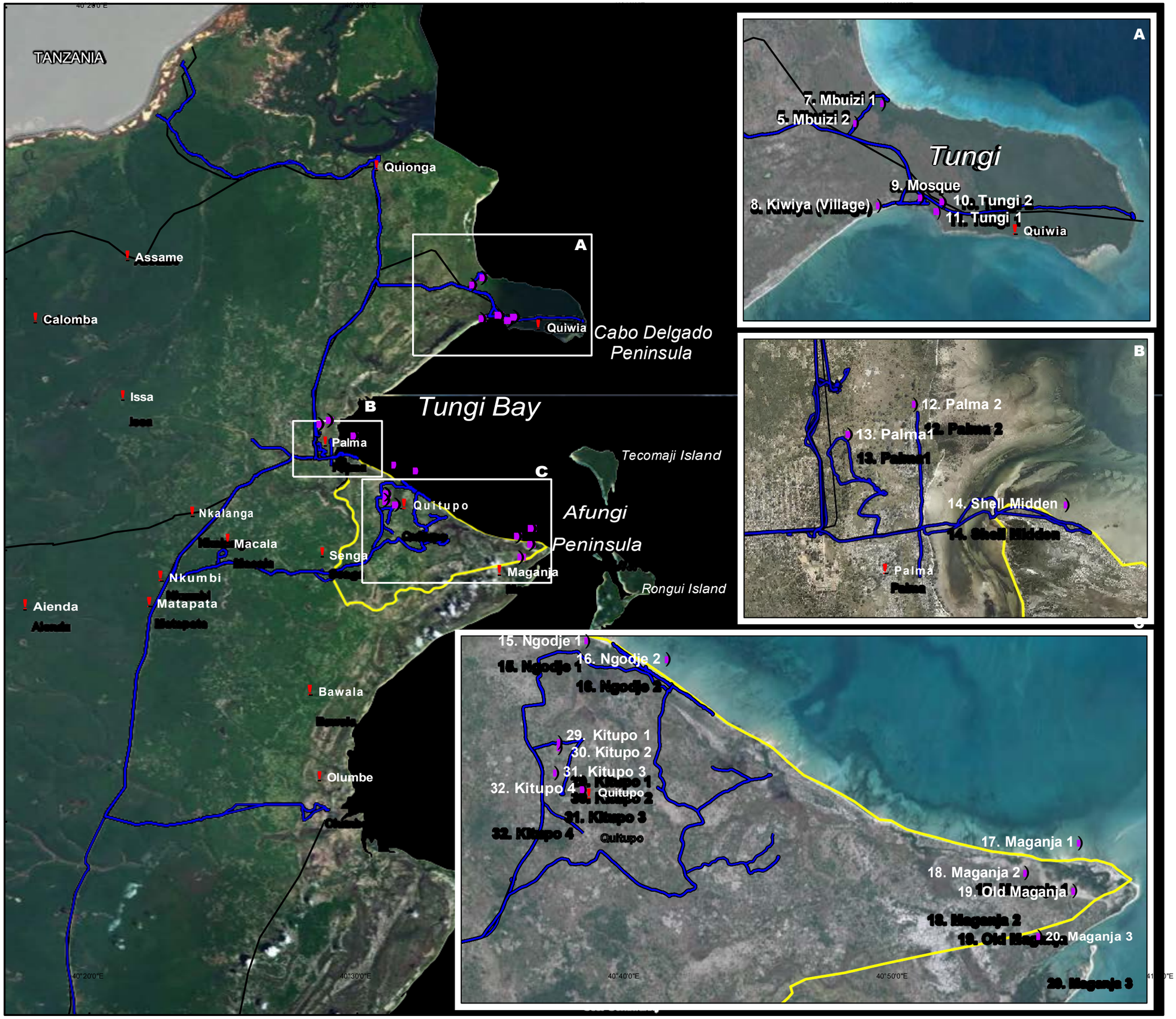
(1) A situation in which two languages are used under by men and women within a community.

A number of sites and artefacts of cultural significance were recorded during the field survey, and these are described in the sections below. Some sites, particularly those in the Maganja area of Afungi Peninsula, were surveyed in detail and recorded during a previous study in 2008. This previous survey was undertaken by an author leading the Circle of Interest of Cultural Heritage of the League of Scouts of Mozambique (LEMO) in 2008 [1]. Other sites were recorded during a trip from Palma to Pemba. Most of the recorded sites were sacred places.

Decades of agricultural activity have resulted in disturbance to the upper 30cm of soil in the area surveyed; however, the presence of sites can still be identified by the occurrence of artefacts, and deposits sometimes remaining intact at depth.

Some of the archaeological and cultural heritage evidence observed within the survey areas points towards a period of unrest (wars between Swahili towns, invasions, slavery trade, colonial occupation, etc), which had both sociopolitical and economic consequences and from which it is considered the local people have not recovered.

(1) Undertaken in conjunction with the League of Scouts of Mozambique (LEMO), in collaboration with United Nations Educational, Scientific and Cultural Organization (UNESCO) and ICOMOS (International Council on Monuments and Sites).



Legend

- Villages / Settlements
- Sites of Archaeological Importance
- Survey Tracks
- Regional Roads
- Afungi Project Site

MAIN MAP SCALE:

Kilometers

TITLE:

Figure 9.47:
Archaeology Survey Area and Location of Sites

CLIENT:

Anadarko
Moçambique Área 1, Lda
eni

DATE: Oct 2013	CHECKED: IE	PROJECT: 0133576
DRAWN: AB	APPROVED: KG	SCALE: 1 : 250 000

DRAWING: Archaeology Survey Area and Sites.mxd

REV: A

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10°30'0"S

Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

10°30'0"S

Projection: UTM Zone 37 S. Datum: WGS84
Source: Bing Maps ©2010 Microsoft Corporation.
Promap, 2012. Impacto, 2012
Inset Map: Esri Data & Maps

SIZE:
A3

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Afungi Peninsula

The sites investigated in the Afungi Peninsula are shown in *Figure 9.47* and outlined in *Table 9.61* below. The area surveyed included the Afungi Project Site and Maganja, a settlement on the tip of Afungi Peninsula. The finds were dominated by artefacts from the Late Iron Age (LIA) and included finds from the Early Iron Age (EIA).

Table 9.61 Sites of Archaeological Importance Found in Afungi Peninsula

Ref No.	Location	Longitude	Latitude	Type	Date Observed
1040Dc01	15. Ngodje 1 (E12)	S10 47 34.7	E40 31 20.0	LIA	21-10-2011
1040Dc02	16. Ngodje 2 (E14) (1)	S10 47 47.2	E40 32 10.5	LIA	21-10-2011
1040Dc03	29. Kitupo 1 (E29)	S10 48 51.0	E40 31 03.6	LIA	23-10-2011
1040Dc04	32. Kitupo 4 (E32)	S10 49 18.9	E40 31 16.3	LIA	23-10-2011
1040Dc06	30. Kitupo 2 (E30)	S10 48 54.3	E40 31 02.6	LIA	28-10-2011
1040Dc07	31. Kitupo 3 (E31)	S10 49 08.8	E40 30 59.5	EIA and LIA	28-10-2011
1040Dc08	19. Old Maganja (E19)	S10 50 21.3	E40 36 25.7	LIA	29-10-2011
1040Dc09	17. Maganja 1 (E2)	S10 49 52.1	E40 36 25.6	EIA and LIA	29-10-2011*
1040Dc10	18. Maganja 2 (E3)	S10 50 10.5	E40 35 55.6	LIA	29-10-2011*
1040Dc11	20. Maganja 3 (E4)	S10 50 49.9	E40 36 02.8	LIA	29-10-2011*

Legend:
(1) Ngodje Zone. This 'zone' seems to be too large for a single site name and quite likely should be considered as two sites of archaeological or cultural interest.
* These were initially surveyed in 2008, as described in *Section 9.18.3*.

Ten archaeological sites were recorded in the area of Afungi Peninsula surveyed, as well as one abandoned sacred place and several burial sites. Most of these sites have been affected by extensive cultivation, and those closer to the coast have been influenced by sea erosion. Among the finds collected were beads, shells (including pearl oysters, family Pteriidae), fish bones and potsherds. The quantity and diversity of shells was regarded as notable, and are shown in *Figure 9.48*.

Figure 9.48 Shell Midden at Afungi Peninsula

Source: Adamowicz, 2012.

Of 427 potsherds observed, the majority were from rims of open bowls, inturned bowls and necked vessels. Some potsherds of pottery with upturned and carinated vessels were also found, as shown in *Figure 9.49*.

Figure 9.49 Samples of Potsherds Collected at Afungi Peninsula

Source: Adamowicz, 2012.

The old Tungi decorative pattern of pottery found in the area shows many similarities with various periods of Kilwa pottery. Previous research done in northern Mozambique and the field survey undertaken supporting this study confirm historical and archaeological richness in Palma District. In the Afungi Project Site and Surrounds, sites 15 (Ngodje 1) and 18 (Maganja 2) are considered to be of particular archaeological importance, as the sites comprise shell middens and potsherds. These sites are also mentioned in the Tungi chronicles. All other sites investigated are considered to be of low heritage significance.

Palma Town

The area of Palma town was investigated, as it is the main town near the Afungi Project Site and it is considered that the cultural heritage of the town may be impacted by a population influx into the area. In Palma town, two archaeological sites were observed and are considered to be of particular archaeological importance: site 13 (Palma 3), which includes ruins of a slave market; and site 12 (Palma 2), a burial ground (see *Figure 9.50*). The locations of these are listed in *Table 9.62*. The slave market in Old Palma (lower Palma) comprises a structure possibly more than 200 years old. It is likely that the buildings were demolished following Portuguese military occupation.

Table 9.62 Sites of Archaeological Importance Found in Palma Town

Ref No.	Location	Longitude	Latitude	Type	Date Observed
1040Cd01	13. Palma1 (E02)	S10 46 06.7	E40 28 31.4	EIA and LIA	26-10-2011
1040Cd02	12. Palma 2 (E03)	S10 45 56.5	E40 28 54.6	LIA	26-10-2011
Ref No.	**Location**	**Longitude**	**Latitude**	**Type**	**Date Observed**
1040Cd03	14. Shell midden (E04)	S10 46 32.	E40 29 48.0	LIA	26-10-2011

Figure 9.50 Ruins of a Slave Market (Top Left and Right) and a Burial Ground (Bottom)

Source: Adamowicz, 2012.

Cabo Delgado Peninsula

Due to the cultural heritage importance of the Sultanate of Tungi in a regional context, and the proximity of Tungi to the Afungi Project Site, Cabo Delgado Peninsula was included in the investigation. The survey in Cabo Delgado Peninsula considered seven known archaeological sites (as shown in *Table 9.63*), including Tungi, Kiwiya and Mbuizi. Two sacred places, several ruins (palace, mosques and houses) and burial grounds (tombs) were observed that are associated with the Sultanate of Tungi, as documented in Arab, Swahili and Portuguese literature. Each of these sites is considered to be of particular archaeological importance. Finds originate from recent times, the EIA and, predominantly, from the LIA, as shown in *Table 9.63*. The evidence observed

provides insight into the period between the Early Community (3rd to 6th century AD) to the 12th century, but mostly from the 15th century to 19th century AD.

Table 9.63 Sites of Archaeological Importance Found in the Cabo Delgado Peninsula

Ref No.	Location	Longitude	Latitude	Type	Date Observed
1040Da04	5. Mbuizi 2 (E19)	S10 40 03.0	E40 34 11.7	LIA	22-10-2011
1040Da05	7. Mbuizi 1 (E20)	S10 39 46.1	E40 34 35.6	LIA	22-10-2011
1040Da06	11. Tungi 1(E62)	S10 41 14.3	E40 35 09.7	EIA & LIA.	27-10-2011
1040Da07	10. Tungi 2 (E22)	S10 41 20.8	E40 35 27.0	LIA	27-10-2011
1040Da08	8. Kiwiya (Village)	S10 41 14.3	E40 35 09.0	Recent	27-10-2011
Ref No.	**Location**	**Longitude**	**Latitude**	**Type**	**Date Observed**
1040Da09	9. Mosque (E61- 9)	S10 41 15.4	E40 35 09.8	LIA	27-10-2011

Ruins at the site of Tungi include a palace, two mosques, a small group of houses and two groups of tombs (shown in *Figure 9.51*), and probably date to the 18th century.

The ruins of many of the sites observed have been poorly conserved and heavily impacted from vegetation, as shown in *Figure* . The walls of a mosque (site 9) are close to collapse and the remaining part of the wall at Tungi (site 11) is visible only 1 to 1.2m above ground. The buildings were constructed from coral blocks. Archaeological material recovered in Tungi (sites 9, 10 and 11) indicated that the area once inhabited extended over 2km in diameter, suggesting that the town of Tungi may have once had a larger population than it does currently, or that the town was considerably more dispersed than modern and historic Swahili towns, possibly resulting from the slave trade.

Artefacts of local, Near East, Chinese and European origin were recovered in Tungi and Mbuizi. These artefacts include locally produced ceramics such as cooking pots, storage jars and small rather flat bowls or plates, the vast majority of which are damaged (as shown in *Figure 9.53*). Other local materials observed include red and white beads. Imported fragments of ceramics and glassware (bottle bases and stemware fragments) were also found and, despite their condition, a number of wares and forms were recognisable. Coarseware storage vessels were observed, as were a few examples of Chinese porcelain teacups and bowls.

Figure 9.51 ***Ruins of Tungi's Sultan's Palace, a Mosque and an Ancient Town Wall***

Source: Nhatule and Adamowicz, 2012.

Most of the potsherds observed originate from simple vessels. During the survey, only decorated potsherds of significant size/shapes were found. The arrangement and motives are shown in Figure 9.53 and include stamped motives, incisions, graphite and paintings. Pottery finds from the surface originate from the ELA (few from Nampula A and B Traditions), upper Kilwa, LIA Lumbo Tradition and recent Makonde pottery.

Figure 9.52 ***Modern Kiwiya Village (Left) and Kitchenware Used in Kiwiya Village (Right)***

Source: Nhatule (left) and Czajkowski (right), 1988.

Figure 9.53 ***Samples of Potsherds Collected from Near Tungi***

Source: Adamowicz,2012.

A tomb of an ancient Muslim queen, believed by the Mwani to be a place of good fortune, is found in Mbuizi on the north-east shore of Cabo Delgado Peninsula, and is shown in *Figure 9.54*. It is particularly sacred for the Mwani people and people travel from as far as Nampula Province to visit the site. A small hostel located near the site accommodates these pilgrims.

Figure 9.54 ***Mbuizi – Sacred Place for the Mwani***

Source: Adamowicz, 2012.

9.18.4 Offshore Archaeology

Ship Remains and Debris

There are hundreds of recorded historical wrecks in the extensive coastal waters claimed by Mozambique. Shipwreck sites reflect a diverse group of vessels that vary in age, size and type. Some shipwrecks are of no archaeological interest, whereas others are unique. This uniqueness may be due to construction method, degree of preservation or the historical context in

which the vessels were sunk. The integrity of shipwreck sites depends on a number of factors, in particular the manner in which the vessel was wrecked, the conditions on the seabed and later disturbances.

Palma Bay was used as an important natural harbour for the anchorage of vessels travelling to the old trading centre located on Vamizi Island [1]. Still today, major shipping lanes (the East Indies route) pass through the Offshore Project Footprint Area, and some shelter in the bay during bad weather. Historic data indicates that there are about three Portuguese and 12 African-Shirazi shipwrecks within Palma Bay, located near Kiwiya and in the waters adjacent to the Ngodza–Maganja coast of Afungi Peninsula.

Marine geophysical data (multibeam) within Palma Bay has been acquired and reviewed by Underwater Surveys (Pty) Ltd, which confirmed there are no large manmade structures apparent in the survey data. It should be noted, however, that without sidescan sonar, smaller archaeological anomalies of anthropogenic origin (including debris, areas of seafloor disturbance, etc) may have been missed.

The remains of an historical vessel are clearly visible today in Palma town, as shown in *Figure 9.55*. The origin of this vessel in not fully known but, due to the boat materials and design (made of iron and likely of British origin), it is believed to be a gunboat sent by the Sultan of Zanzibar with support from the British to protect the Tungi Sultanate against the Portuguese invasion. At the command of the Portuguese Captain José Raimundo de Palma Velho, boats from Zanzibar were sunk between 1876 and 1877.

(1) As described by Ahmad bin Majid in the 15th century.

Figure 9.55 Ship Remains in Palma (Note Afungi Peninsula in Background)

Source: ERM, 2012.

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