6 DESCRIPTION OF THE BIOPHYSICAL ENVIRONMENT

6.1 INTRODUCTION

This Chapter describes the physical and biological environment of the *Sasol Pipeline and FSO Project*. It is important to gain an understanding of the biophysical attributes of the Project Area and its surroundings, as it will provide for a better understanding of the receiving environment in which the Project is proposed. This information will be used to inform the baseline, following which the potential impacts of the proposed Project may be assessed.

Since 2001, Sasol has been present in the Project Area and currently has existing operations and ongoing exploration activities in the area. This means that there is considerable information available to describe the baseline environment of the Project Area. Most of this is documented in previous baseline studies and EIAs for Sasol's concession areas and has been used to inform the environmental description for the Project Area in this Chapter. More detailed descriptions of the baseline physical, biophysical and socio-economic environments along the pipeline route will be provided in the Environmental Impact Report (EIR).

Relevant information sources include:

- Mark Wood Consultants & Impacto (2002). Environmental Impact Study for the Temane & Pande Gas Fields – Seismic Exploration and Exploratory Development Drilling. Report on behalf of Sasol Petroleum Temane Limitada.
- Mark Wood Consultants (July 2003). National Gas Project. Regional Environmental and Social Assessment (RESA). Report on behalf of Sasol Technology.
- ERM / Consultec (March, 2008). Environmental Impact Assessment for Sasol's Offshore Exploration Project in Blocks 16 and 19 – Inhambane and Sofala Provinces. Report on behalf of Hidrocarbonetos de Mozambique and Sasol Petroleum Sofala Limitada.
- Golder Associates (2014a). EIA for the Petroleum Sharing Agreement (PSA) Development and Liquefied Petroleum Gas (LPG) Project.
- Golder Associates (2014b). Sasol PSA and LPG Project: Final Environmental Impact Assessment Report (including a number of specialist studies).
- Golder Associates (2015a). Sasol PSA and LPG Project: Final EIA Addendum (including specialist studies).
- Golder Associates (2015b). Baseline Biodiversity Studies for the proposed Pande Wells Expansion Project and associated Seismic Exploration activities (Pande and Temane Blocks).
- Golder Associates (2015c). Biodiversity Sensitivity Map for the proposed seismic exploration within the Pande and Temane areas, Mozambique. Draft Report.
- Golder Associates (2015d). Ecological studies for the Nhangonzo Coastal Stream Critical Habitat Biodiversity Assessment (for Sasol PSA Development and LPG Project Inhambane Province (EIA Addendum). Includes studies on vegetation and flora, terrestrial fauna, wetlands, fish and aquatic habitats, surface water quality, mangroves and estuaries.

6.2 PHYSICAL ENVIRONMENT

6.2.1 Climate and Long Term Climate Trends

The Mozambican climate can be described as semi-arid and subtropical in the south and tropical in the north. The southern part of the country is generally drier than the north and has strong fluctuations in temperature and precipitation, with the heaviest rainfall from October to March (Tadross and Johnston, 2012).

The most important weather systems that determine rainfall amounts and pattern over Mozambique are:

1. The Inter-tropical Convergence Zone (ITCZ);

2. Tropical Cyclones;

3. Thermal lows along the coast as result of the deepening of a semi-permanent trough over the Mozambique Channel; and

4. Incoming African easterly waves that often serve as the "seedling" circulations for a large proportion of tropical cyclones.

The monthly temperature trends from 2010 to 2013 in the Project Area are presented in *Table 6.1*. Average temperatures typically range between 19°C and 27°C, with the highest average temperatures between December and March.

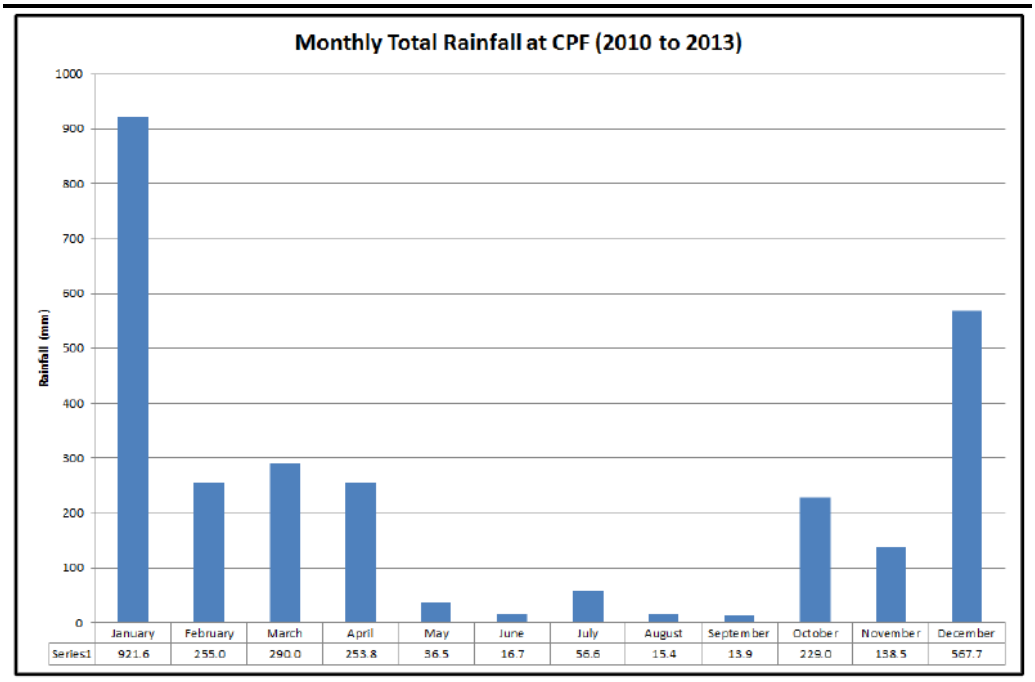
Table 6.1 Minimum, Maximum and Mean Temperatures at CPF Site (2010 to 2013)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	19.2	19.0	17.9	14.0	10.6	4.9	7.7	8.8	9.7	13.8	14.9	17.2
Average	27.0	26.4	26.2	23.3	21.4	19.9	18.8	20.3	22.9	24.1	25.6	26.6
Maximum	35.0	36.1	35.4	32.9	33.8	32.3	31.0	32.5	37.1	35.3	37.3	35.6

Source: Golder, 2014b

There is a clear seasonal variation in the amount of rainfall in Mozambique with a dry and cooler season from May to September and a rainy and hot season, lasting from October to April. These seasonal variations are associated with the ITCZ and its movement southward over the country. Rainfall in Mozambique is also affected by local variations in altitude, with the higher altitude areas often experiencing more rainfall. Heaviest rainfall is associated with the movement of tropical cyclones which originate from the Indian Ocean and pass along the Mozambique Channel, usually from north to south, and can result in heavy floods (Tadross, 2009). The monthly average rainfall in the Project Area (as measured at the CPF) from 2010 to 2013 is shown in *Figure 6.1* below. Highest rainfall typically occurs between December and March. Rainfall is highly variable in the region.

Figure 6.1 Rainfall Measured at Sasol's Onshore Central Processing Facility: 2010 to 2013



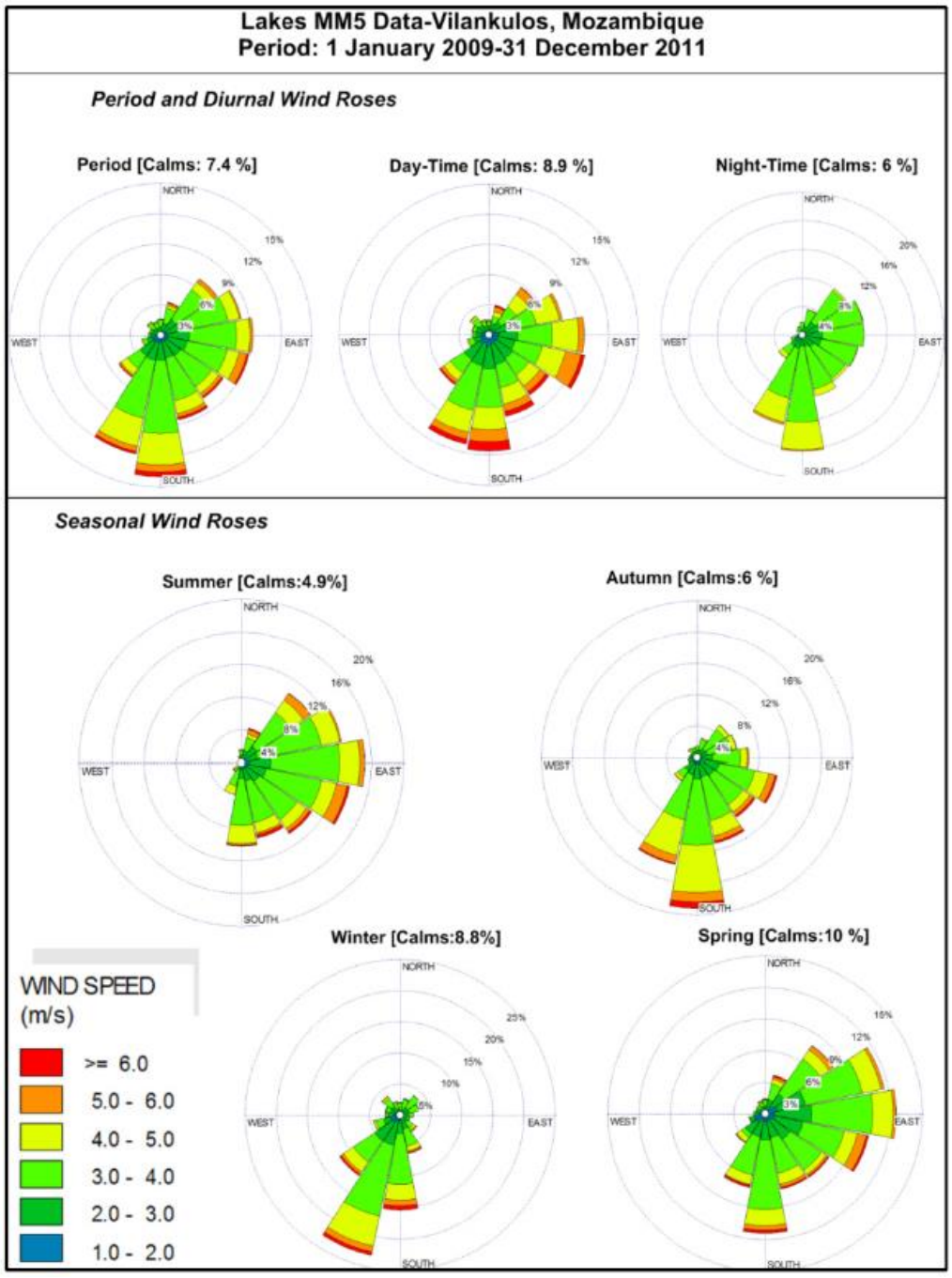
Source: Golder, 2014b

The onshore winds in the Project Area are predominantly from the southeast and strengthen in the afternoon. Prevailing onshore winds are southerly and easterly (*Figure 6.2*). Onshore wind speeds of between 3 and 4 m/s occur for about 43 percent of the time, and speeds exceed 6 m/s for about 5.6 percent of the time[1].

Observations from Voluntary Observing Ships (VOS) for the period 1968 to 1998, indicate that the winds in the offshore region east of the archipelago are predominantly from the south to southeast and are strongest in the summer months (*Figure 6.3*).

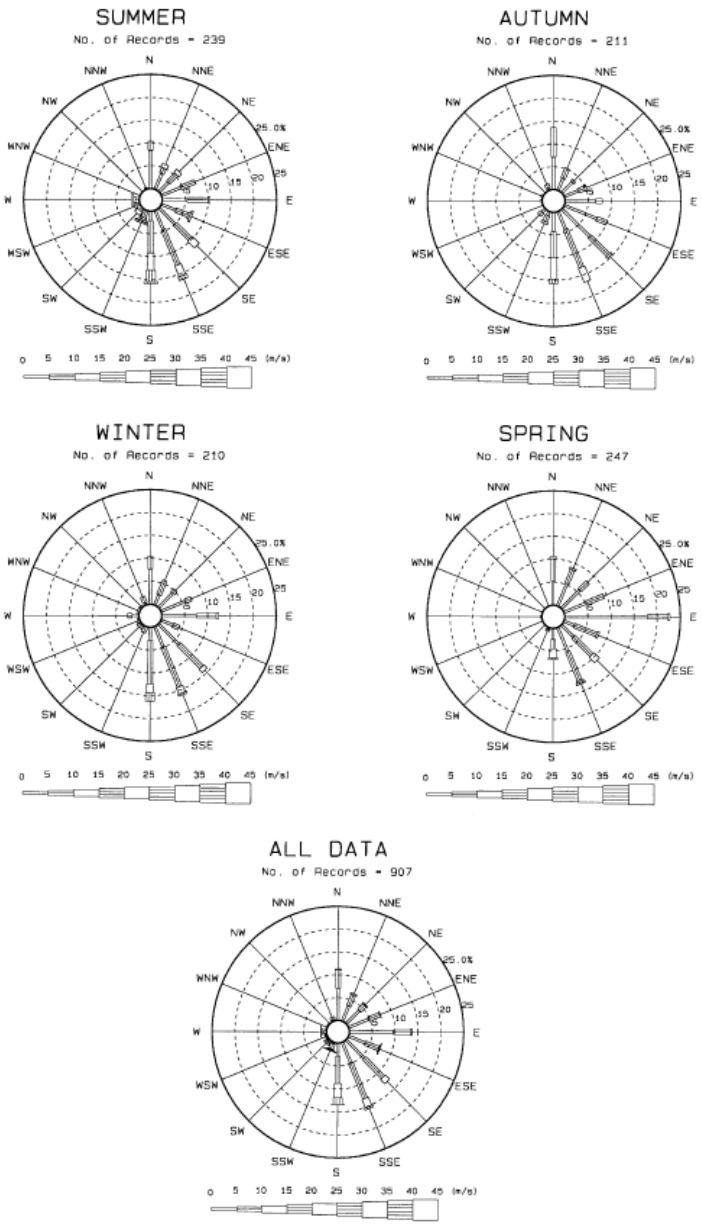
[1] The Lakes MM5 wind data for Vilankulos has been used because it provides upper level winds, which are important in air quality dispersion analysis. Sasol's wind recorder at the CPF does not measure upper level winds. However, the Lakes and Sasol ground level wind data are very similar and the Lakes data can therefore be used with confidence

Figure 6.2 Onshore Period and Diurnal Wind Roses



Source: Golder, 2013

Figure 6.3 Offshore Wind Speed and Direction Occurrences



CSIR, 2006

Mozambique is prone to cyclones with Northern Inhambane classified as having the highest risk of cyclones by the National Institute of Natural Disaster Management. Since 1970 at least nine cyclones have hit the coast of northern Inhambane (*Table 6.2* and *Figure 6.4*), with three having occurred since 2001. The worst cyclone in living memory to strike the coast, Cyclone Favio, occurred in February 2007; a category 4 event which caused delays to Sasol's drilling programme and damaged coastal infrastructure. The cyclone season in this region extends from December to March, peaking in December and January, and causing seasonal flooding and damage to property.

Table 6.2 Cyclone History in Mozambique since 1956

Year	Month	Name
1956	April	Unknown
1994	March	Nadia
1996	January	Bonita
2000	February	Eline
2001	March	Dera
2003	January	Delfina
2003	March	Japhet
2007	February	Favio
2008	March	Jokwe
2012	January	Funso

Source: Grab and Fitchett, 2014

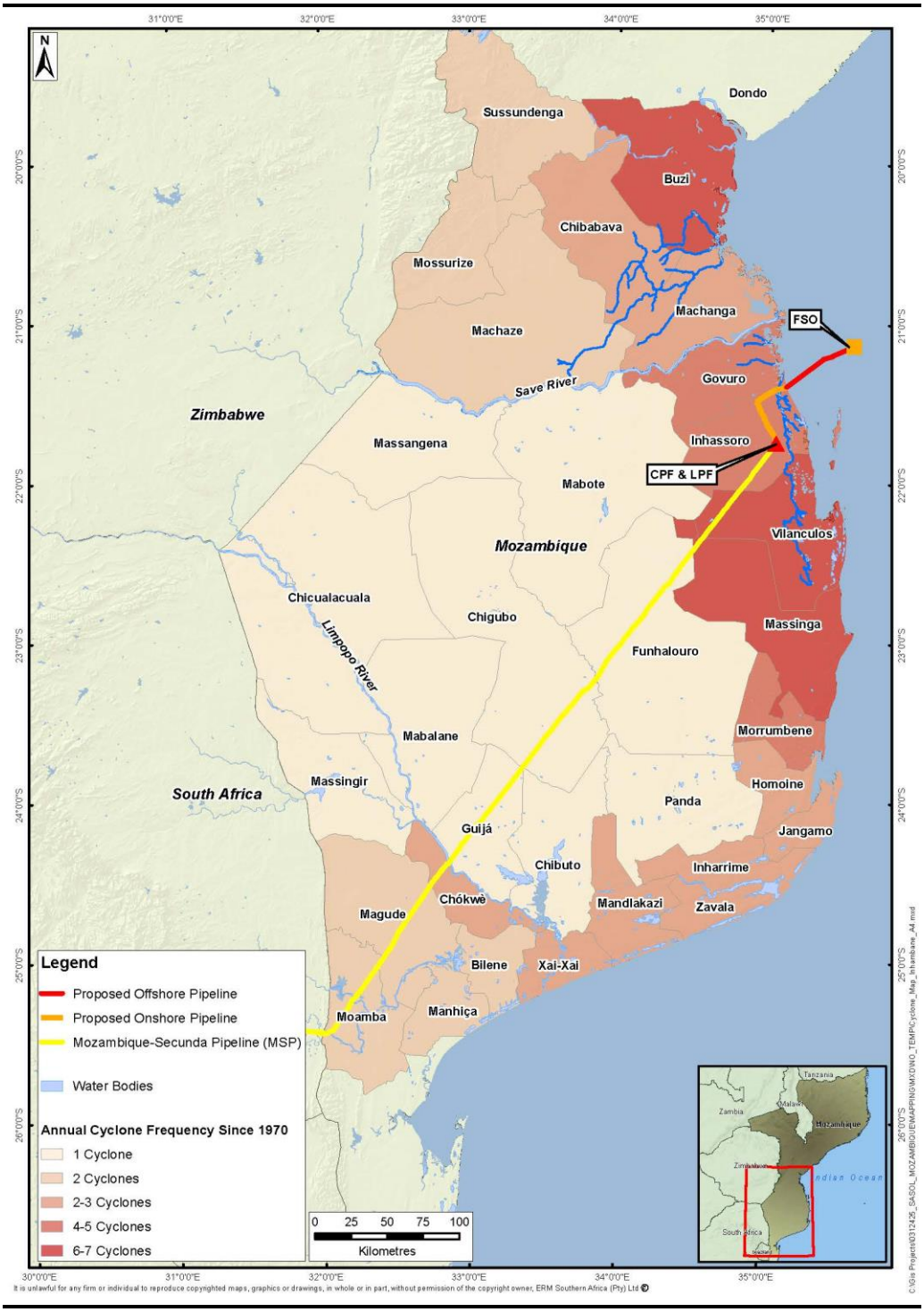
Long Term Climate Trends

The inter-annual variability of the climate of Mozambique is often influenced by large scale global patterns of change such as the El Niño Southern Oscillation (ENSO). Sea Surface Temperatures (SST) in the Indian Ocean (which are at times associated with El Niño) also have a strong influence on the climate of Mozambique. Whilst warm SSTs in the Indian Ocean can lead to drier conditions inland, high SSTs over coastal regions in the Mozambique Channel may result in increased humidity and rainfall.

Mozambique is vulnerable to climatic events such as floods, droughts and cyclones and climate change. Tropical cyclones have become more frequent in recent years leading to major floods events, such as those that occurred in 2008 and 2009. Climate change is expected to lead to greater variability in rainfall and more frequent and intense extreme weather, as well as sea-level rise and temperature increases of up to 3°C (INGC, 2009).

In March 2015, the Inter-tropical Pacific sea surface temperatures were 0.5°C above the average as a result of El Niño. For Southern Africa, El Niño usually means less rain, and as a result of this climatic event Mozambique has been experiencing a drought since 2015 (OCHA, 2015).

Figure 6.4: Occurrence of Tropical Cyclones in Southern Mozambique from 1970



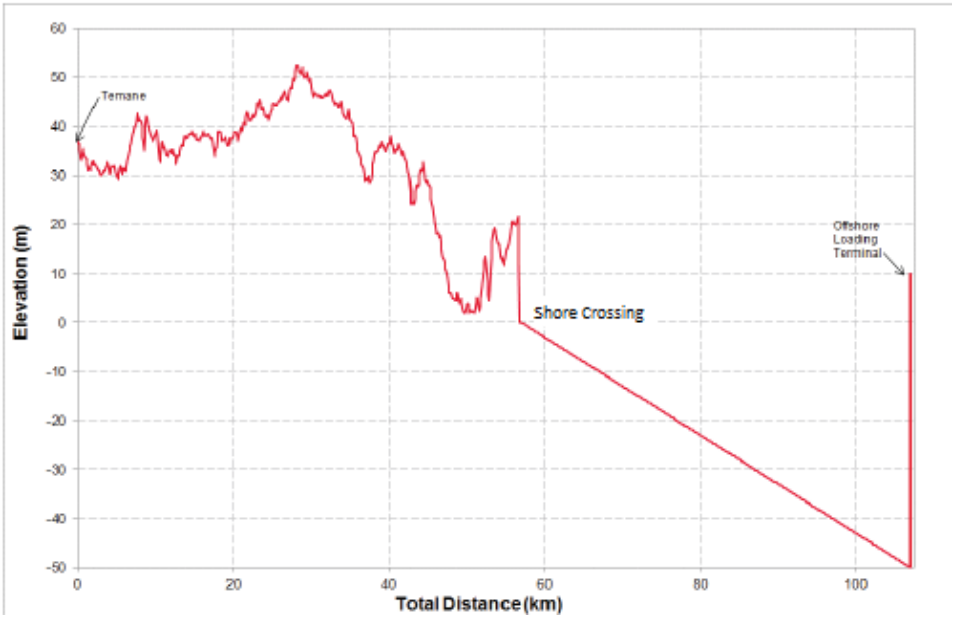
Source: Golder, 2014b

6.2.2 *Topography and Seabed Bathymetry*

The onshore Project Area is situated on the broad southern coastal plain of Mozambique, which rarely exceeds 50 m above sea level (mamsl) (*Figure 6.5*). The terrain along the proposed pipeline route between the CPF and the shore crossing is relatively flat to slightly sloping.

The proposed shore crossing area (*Figure 6.6*) is characterised by a gently sloping beach leading from the sea up to 10 to 35 m high cliffs. The offshore pipeline route shows an approximate one metre drop in sea level every kilometre from the nearshore shallow water (average water depth of 10 m) to the proposed FSO location (approximately 50 m deep).

Figure 6.5 Topography of the Offshore and Onshore Pipeline Routes



Source: Genesis, 2014

Figure 6.6: Proposed Shore Crossing Location

Source: ERM, 2015

6.2.3 *Geology, Soils and Seabed Sediments*

The coastal plain of Mozambique consists of unconsolidated fine to medium textured sands of aeolian (and/or marine) origin that overlay the karstified limestone and calcarenites of the Jofane Formation.

Two types of soils occur in the Project Area: Soil Type A – Clay Loams and Soil Type C - Coastal Sands. Clay loams (Soil Type A) appear to dominate the area to the west of the Govuro River. Coastal sands (Soil Type 'C) dominate the area to the east of the Govuro River, and are quite extensively cropped with maize and groundnuts, but with sufficient trees and shrubs present to limit wind erosion. The coastal soils consist of deep or very deep, grey or very pale yellow-grey sands.

The Bazaruto Archipelago is composed mainly of unconsolidated Quartz sand, with a minor carbonate component from the skeletons of marine organisms (CSIR, 2006), and beachrock. Beachrock formation is an ongoing process which continues to provide the foundation for the continued existence of the islands (ERM, 2006). Additionally, the beachrock outcrops provide the only suitable substrate on which the coral reefs in the area can form (Dutton and Zohla, 1990). There are extensive sand flats present inshore of the islands and to the north and south of the archipelago. These are more intertidal in nature to the south of the islands, and are slightly deeper to the north. The sediments in these areas primarily comprise sand and sandy mud (CSIR, 2006). Further north of the Archipelago, the sediment becomes muddier closer to the Save River Delta due to the silt deposits from the rivers in the region (Pereira *et al,* 2014).

The seabed sediment characteristics in the Project Area are currently unknown but expected to be predominantly sandy. The nature of these sediments will be investigated during the Marine Ecology studies as part of the EIA.

6.2.4 *Surface and Ground Water*

Surface Water

The Govuro River (*Figure 6.7*) is approximately 185 km long and flows roughly parallel to the coastline from south (Cheline) to north (passing Macovane and ending at the Govuro Estuary near the Bartolomeu Dias peninsula. The proposed onshore pipeline crosses the Govuro River approximately 12 km north of Macovane on the western side of the river and near Chibo on the eastern side of the River (*Figure 6.7*). At Nova Mambone, approximately 48 km north of the pipeline shore crossing, the Govuro River and Save River combine to form an extensive coastal estuary, consisting mainly of highly diverse mangrove swamps. The southern margin of this estuary system is approximately 3 to 5 km north of the proposed onshore pipeline, and is protected by a coastal dune system known as the Bartolomeu Dias Peninsula, where several lodges are located.

Extensive seasonal and permanent wetlands are associated with the southern reaches of the Govuro River. In the vicinity of Inhassoro and Vilanculos, a series of coastal lakes occur which vary significantly in size. Most of these contain fresh water and appear to be fed by groundwater but, in some instances, a surface connection to the Govuro floodplain is evident from the satellite imagery. The hydrological drivers supporting these permanent lakes have never been investigated. None of the permanent lakes are located in proximity to the proposed onshore pipeline, the nearest one being approximately 10 km to the south and the majority located over 20 km to the south.

Figure 6.7 The Govuro River

Source: J Hughes 2015

Flow data for the Govuro River suggest an average annual flow of 121 Mm^3 per year (Golder, 2015). Flow varies seasonally and in the lower reaches, as far south as the Inhassoro bridge, it exhibits some degree of tidal influence.

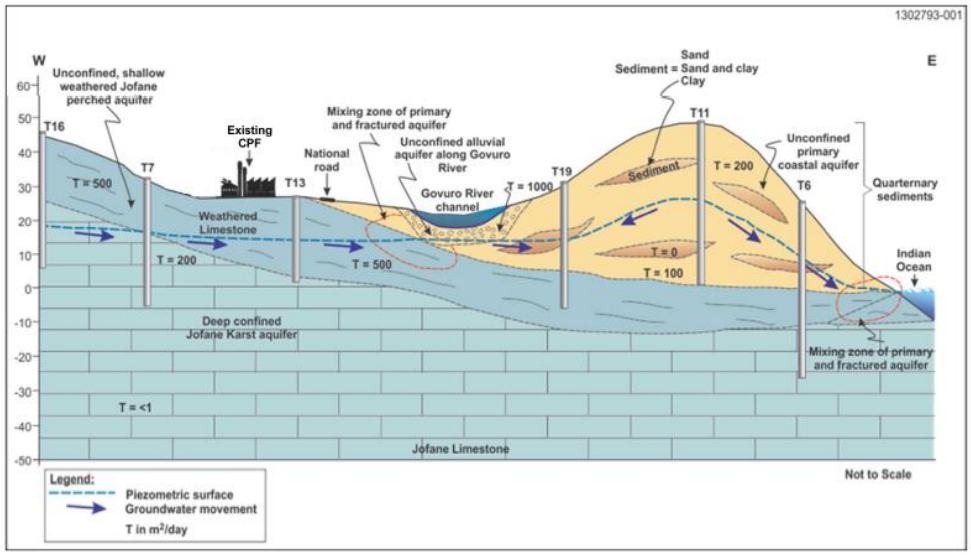
The water quality of the Govuro River is good, with the water being fresh, clear (low turbidity) and having low salinity values. Based on sampling done by Golder (2014) surface water in the Govuro River is more saline and has a higher concentration of Total Dissolved Solids (TDS) in the lower reaches than in the upper reaches. Further north, near the pipeline crossing and increasing towards the estuary, tidal influence results in increased conductivity.

Groundwater Flow

Groundwater flow is controlled by topography, meaning underground water moves from high lying to low lying areas. Groundwater flow in the Inhassoro area largely mimics topography (Golder, 2015), and it is likely to do the same further north in the area of the proposed pipeline. According to the EIA of the PSA Development (Golder, 2014), the Temane area has a general groundwater level elevation of 16 to 25 mamsl and flows towards the Govuro River to the east (*Figure 6.8*).

The areas to the north east towards Inhassoro are characterised by deeper water levels (>31 mamsl), creating a localised water divide between the coastal dunes and the Govuro River. A similar situation occurs towards the southeastern coastal area (Chipongo area). The water table depth decreases closer to the Govuro River. During the rainy season, increased flow in the Govuro River recharges the groundwater system. During low-flow conditions in winter, groundwater feeds the river system, indicating close interaction between the surface and groundwater systems.

Figure 6.8 Conceptual Model of the Hydrogeology of the Project Area



Source: Golder, 2015a

Groundwater Quality

Groundwater quality is controlled by annual recharge of the groundwater system, rock type and flow dynamics within the aquifers, and in some instances, by sources of pollution. Sampling shows that groundwater quality is dominated by calcium and magnesium ions (Ca and Mg) west of Temane and sodium chloride (NaCl) towards the coast. The latter is typical of the saline environment associated with the Jofane Limestone aquifer that occurs in the area and which is the dominant water source for communities in the Temane area. The high concentrations of total dissolved solids, especially sodium and magnesium, result in water tasting brackish (slightly saline). Nearer the coast in the Inhassoro area (and possibly similar in the onshore pipeline area), there is a dune aquifer overlying the Jofane limestones with fresh groundwater due to recharge from rainfall and the Govuro River. Here communities rely on shallow hand dug wells that reach this unconfined aquifer.

Aquifer Parameters

The boreholes tested in the PSA area to the south of the pipeline varied in depth from 20 m to 150 m. The transmissivity of the groundwater (ie rate of horizontal water flow) varies between 541 and 9245 m^2/d (Golder, 2014b), which means that aquifer attributes are not directly related to a deeper lying limestone aquifer, but rather to a mixture of systems. Transmissivity through the limestone aquifer was on average 551 m^2/ day with water in the upper shallow zone moving around 16 m^2/day. The higher transmissivities are likely to be associated with either highly karstified limestone and/or with permeable sand aquifers closer to the coastline.

6.2.5 *Physical Oceanography*

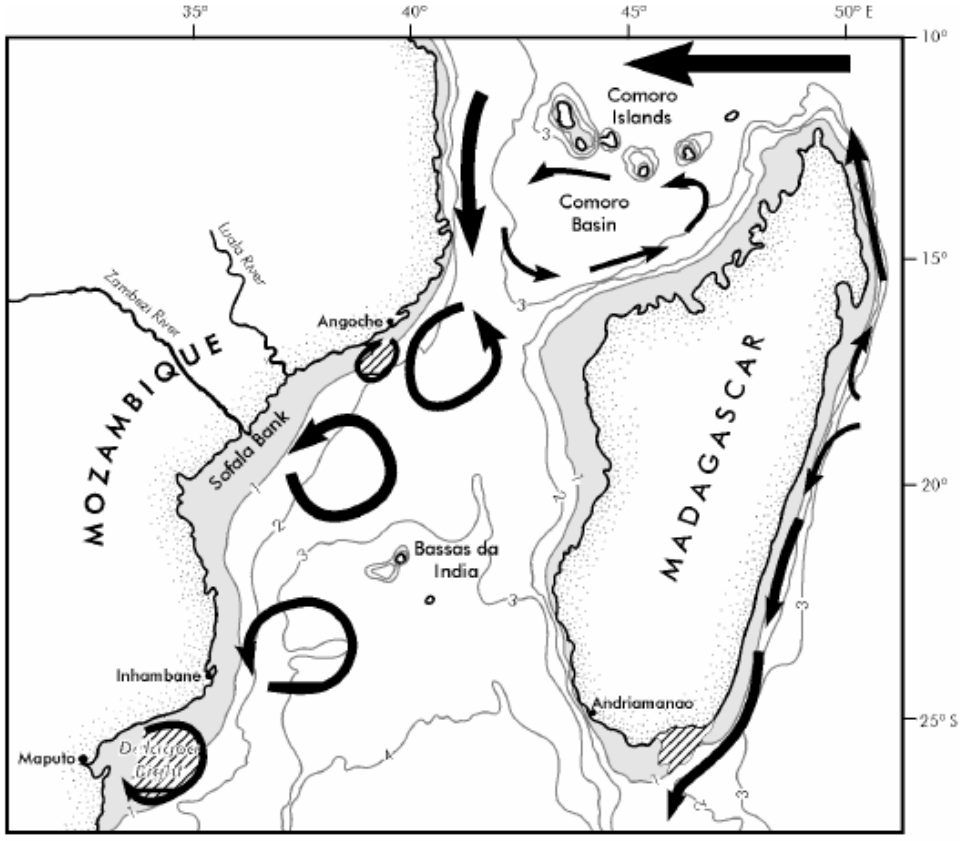
Distinct circulation patterns are recognised for the continental shelf, open ocean and Bazaruto Bay. The circulation of the open ocean adjacent to Bazaruto Archipelago is governed by the Mozambique Channel circulation system which comprises a series of intermittent large-scale eddies drifting southward (*Figure 6.9*). Surface currents associated with this circulation system are known to flow southward throughout the year, with flow speed varying with the seasons. This current is predominantly southwards and is strongest in summer (October to February), attaining speeds of up to 2 m/s during this period and 1.3 m/s at other times during the year (ERM, 2006).

However, for the inshore region of the Archipelago, there is an indication of intermittent inshore counter currents which flow predominantly northward with speeds of approximately 0.8 m/s. These currents are known to be highly variable in both speed and direction and are wave-driven and consistent with the wave patterns of this region. In the bay, the main feature of circulation is the occurrence of strong tidal currents that drive water into the bay during the flood phase of the tides and out of the bay during the ebb tide (ERM, 2006).

Within the Bazaruto Archipelago the water temperature ranges from 23ºC in winter to 27 ºC in summer and the salinity ranges from 35.4 PSU in winter to 34.7 PSU in summer (Dutton and Zolho, 1990).

The tides are semi-diurnal. The mean spring tidal range is approximately 3 m during normal spring tides, increasing to approximately 4.4 m during equinoctial spring tides. The tidal range at spring highs produces strong tidal currents in the channels between the islands that transport vast quantities of sand to form extensive flood- and ebb-tide deltas. These strong tidal flows also maintain the deep channels on the landward side of the islands and transport sand across the tidal flats (ERM, 2006).

Figure 6.9 The Major Circulatory Features in the Mozambique Channel

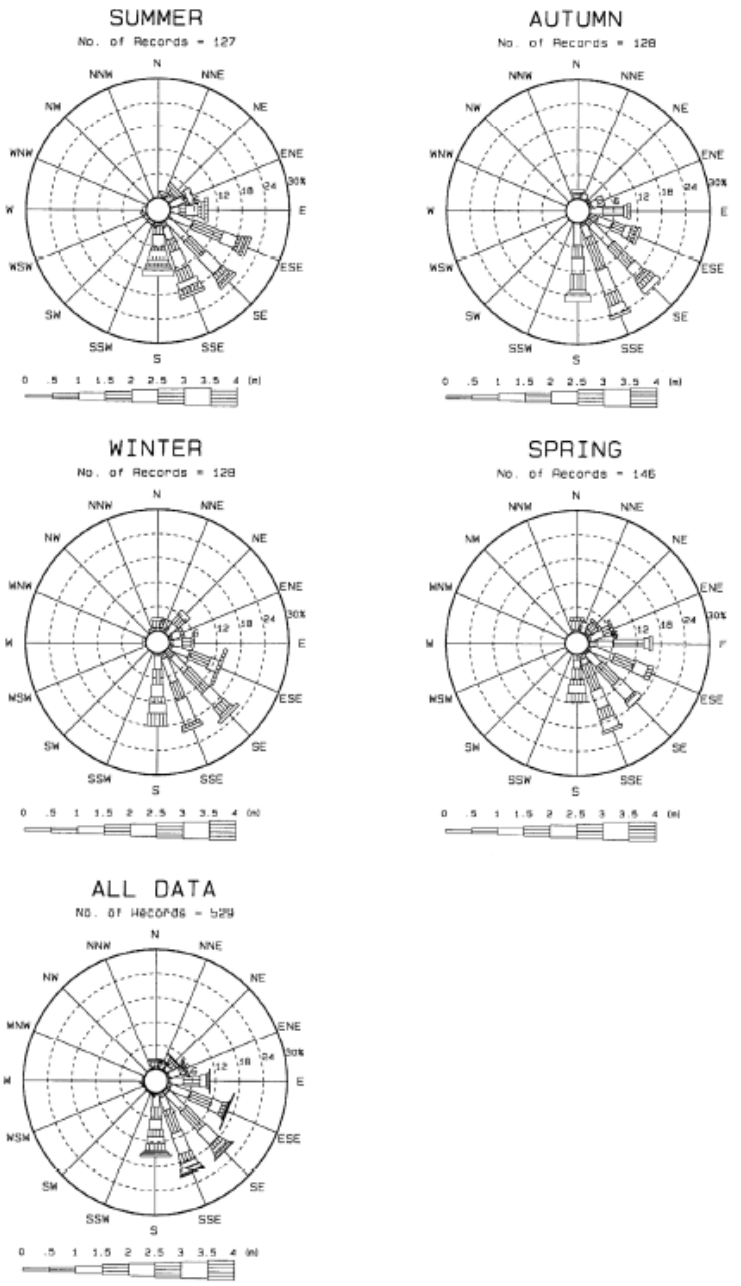


Source: Lutjeharms, 2006

The offshore wave environment is driven by winds and dominated by a south-easterly wave origin (*Figure 6.10*), with the highest waves originating from the south during the summer months (October to February) (ERM, 2006).

Closer inshore, surrounding the islands of the Archipelago and within the Bay, wave action is restricted to the seaward side of the islands, including coastal areas further north of the Archipelago, where the proposed development occurs. The wave action in these areas prevents the formation of extensive intertidal flats, such as those which are present to the south of the Archipelago and inshore of the islands. The leeward side of the islands is sheltered from direct wave energy, and thus have more tranquil conditions, which is dominated more by tidal energy (CSIR, 2001; ERM, 2006; Everett *et al,* 2008).

Figure 6.10 Offshore Wave Height and Direction



CSIR, 2006[2]

[2] observations from voluntary observing ships in a block (21°30′-22°30′S ; 35°-36°E) and for the period 1968 to 1998

6.2.6 *Physico-Chemical Regime of Offshore Water Masses*

The physico-chemical characteristics of the water masses of Bazaruto Bay and the nearshore areas north of the Bay exhibit spatial and temporal variability. Salinity along the coast is seasonally affected, where evaporation and low river runoff increases salinities (to between 35 and 36 PSU) in the dry season and an increase in freshwater inputs decreases salinity (to between 33 and 35 PSU) during the wetter summer months. During the rainy season, spatial variation in salinity occurs across the Bay with higher salinities in the eastern part and lower salinities along the coast in the western part. The western coastal areas are estuarine and in the wet season are increasingly influenced by the freshwater inputs from the Save River outflow (ERM, 2006).

6.2.7 *Air Quality*

Onshore

The onshore pipeline route extends from the northern perimeter of the CPF through rural and largely unsettled areas to the coast. Increased dust during pipeline construction is the primary air quality pollutant likely to be generated by the Project, particularly in areas such as the Govuro floodplain which comprises fine grey dust. Fortunately, there appear to be few settlements in this area apart from Macovane, located at the edge of the floodplain.

Sasol has conducted regular ambient and stack monitoring campaigns at the CPF over the past number of years (Mark Wood Consultants, 2015) to check compliance with the limits specified in the Operational Environmental Management Plan (oEMP). The baseline monitoring programme for the PSA Development EIA (Golder, 2014b) confirmed that the CPF has caused a negligible change in air quality beyond the boundaries of the site over the past 10 years. Ambient concentrations of SO_2, NO_2 and organic pollutants are measured at the boundary of the CPF and remain within the target levels specified in the oEMP. However dust levels have occasionally exceeded target levels due to construction activities at the CPF: high dust levels recorded in 2011 show a decline from 2012 to within target levels coinciding with reduction in earthmoving activities (Airshed, 2015).

Ambient air quality in the rural areas along the pipeline route is mainly impacted by the burning of woodland and grassland for clearing agricultural land and for grazing, hunting and settlement, as well as burning of waste and fuels. Annual burning during the dry winter months preceding the rain season typically results in hazy and dusty conditions.

Offshore

The offshore pipeline and FSO will be located in the marine environment remote from any industries, settlements or other onshore sources of air pollution. The only offshore sources of air pollution are from vessels (eg container and tanker vessels etc) travelling along shipping lanes in proximity to the Project, and vessels (eg shuttle tankers, supply vessels etc) involved in oil and gas operations in the area. The offshore air quality is considered to be essentially unaffected by anthropogenic sources.

6.2.8 Noise

Onshore

The onshore pipeline route is in a quiet rural environment unaffected by road noise or industrial noise sources. At the CPF, noise levels are elevated due to the operation of mechanical equipment and the flare stack, reaching 65dB(A) at the plant boundary, but this quickly decreases to the natural background ambient away from the plant. Where the pipeline crosses the EN1, the sound environment is only influenced by passing traffic, particularly buses and trucks.

Offshore

Anthropogenic noise in the offshore region is minimal due to the lack of industrial and other activities. Current levels of noise and vibration offshore are due to natural sources (water movement and weather events) with contributions from existing vessel traffic.

6.3 ONSHORE BIOLOGICAL ENVIRONMENT

6.3.1 Introduction

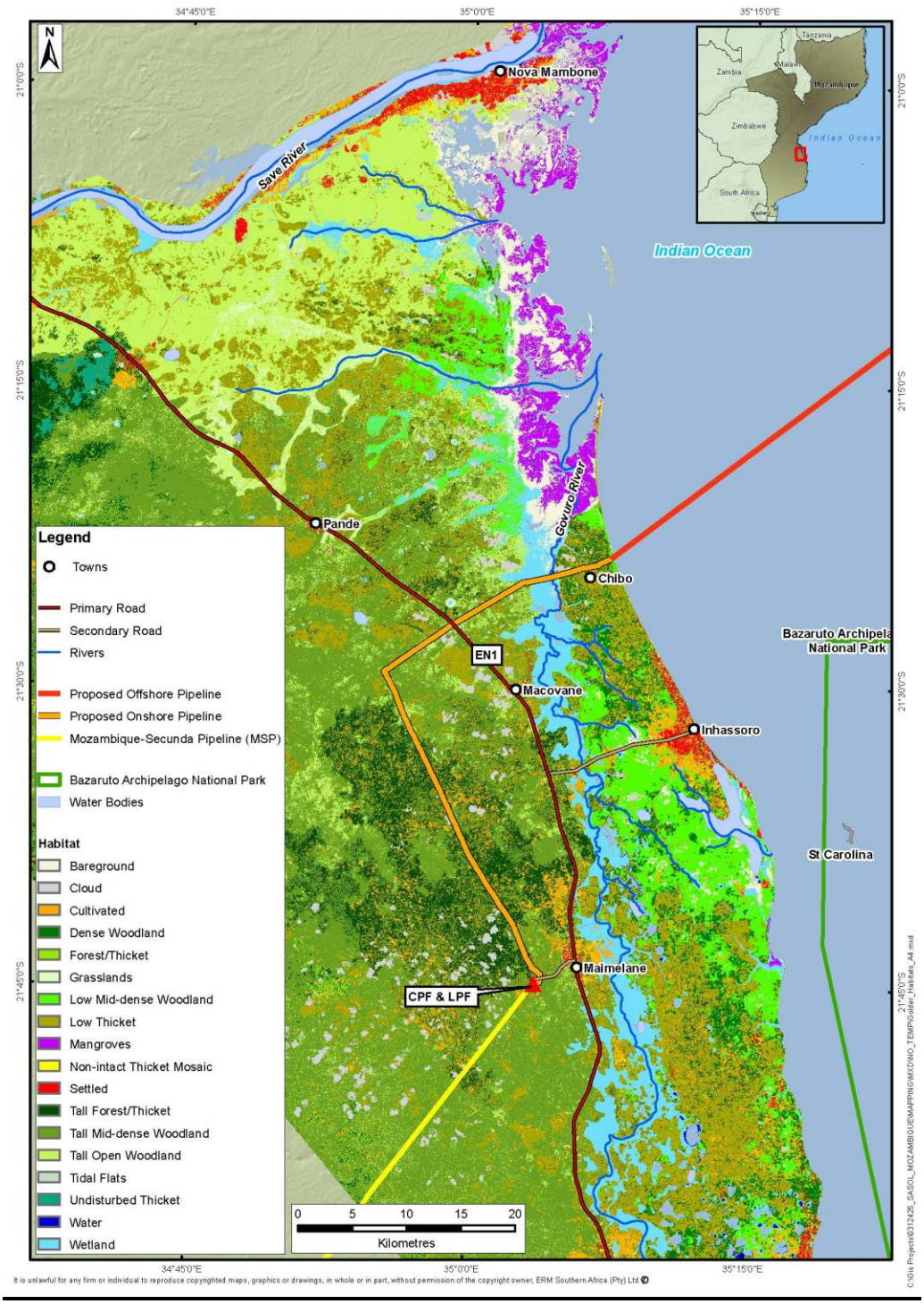
A number of surveys have been conducted recently in the broader onshore pipeline area. These include surveys in Pande Block (approximately 2 to 20 km to the north of the onshore pipeline) for the PSA Development EIA (Golder, 2015b) and for the EIA of exploration and development activities in the Pande, Temane and Inhassoro (PTI) Blocks (hereafter referred to as PTI EIA). The biodiversity data from these studies is considered broadly representative of some of the woodland and forest habitats along the FSO pipeline route. The biodiversity identified during these studies that is considered relevant to the FSO pipeline route are summarised below. Seasonal field surveys in the onshore pipeline corridor will be undertaken to confirm habitats and species that may be impacted in the area of influence of the pipeline.

6.3.2 *Vegetation and Flora*

Vegetation

Structural habitat types and land cover units in Sasol's area of operation and exploration have been mapped from 2014 satellite imagery (*Figure 6.11*) (Golder, 2015c). Habitat types traversed by the onshore pipeline are summarised in *Table 6.3*.

Figure 6.11 Habitat and Land Cover Types in the Project Area



Source: Golder 2015c

Table 6.3 Vegetation/Habitat Units Occurring in the Project Area

Vegetation/habitat type	Description
Mixed Woodland and Thicket Mosaic (Unit 1)	A mosaic of woodland and dense thicket vegetation with frequent, small patches of tall forest or thicket on termite mounds. It comprises the largest habitat unit in the Temane / Inhassoro portion of the Project Area. It occurs only west of the Govuro River between the Save River in the north and Inhambane in the south (about 300 km) and between ~20 to 60 km inland from the coast. Dense thickets contain trees up to 18 m high whereas short thickets often have 95 – 100% canopy cover and are impenetrable. Species richness and cover of woody climbers is high with many flora species largely or entirely restricted to this habitat. Ilala palms (*Uchema*), used for making palm wine, occur throughout vegetation/habitat units 1 and 2. Logging, mostly illegal, has resulted in severe over-exploitation of the Pod Mahogany tree.
Julbernardia-Brachystegia Short Woodland and Thicket (Unit 2) (includes coastal forests and dune forests)	This vegetation is dominant in the area east of the Govuro River, and comprises short thicket communities with high species diversity. Regionally, the largest and best conserved patches of coastal forest and dune forest along 90 km of coastline occur within this habitat, with trees of up to 18 m in coastal forest (although not within the FSO pipeline corridor). The trees *Julbernardia globiflora* and *Brachystegia spiciformis* were not recorded anywhere else within the Project Area. An absence of large trees is probably the result of current and historical use of fire to clear land for cultivation. *Julbernardia* and *Brachystegia* in the east of the Project Area appear to be unsustainably harvested for sale as firewood.
Govuro River Floodplain	Wetland systems occurring on the coastal plain include riverine floodplains, swamps and pans, largely situated within the Govuro River floodplain, and mangrove (tidal) forests along the coast. Marsh vegetation and hygrophilous grassland plant communities are entirely restricted to the Govuro River and its floodplain within the Project Area . A critically endangered species of cycad, *Encephalartos ferox* subsp *emersus,* has been recorded in the Govuro floodplain (Rousseau, 2015). Various plant species appear to be largely or entirely restricted to these types of coastal floodplains, including a sedge - a new record for Mozambique - and a grass likely to represent a unique 'ecotype' (both confirmed near the Nhangonzo coastal stream approximately 25 km south of the pipeline). The Govuro River plays a crucial role in maintaining the mangrove swamps at its mouth in Bartolomeu Dias Bay, regarded as some of the most species - rich mangroves on the entire East Africa seaboard (http://ramsar.wetlands.org), where it supports commercial and subsistence fisheries. The river supplies drinking water, building material (the reed *Caniço*) and termite-resistant thatching grass (*D'jeca or Musule*) to local communities, and assists with flood attenuation. The Govuro River provides important fishing resources, especially from the lower reaches and estuary.

Vegetation/habitat type	Description
Ephemeral Drainage Lines (only flow in response to heavy rainfall and can experience no flow for long intervals, years or even decades)	Various ephemeral streams and large ephemeral wetland flats occur east of and drain into the Govuro River. They have important functional value by maintaining hydrological patterns and water quality in the systems into which they discharge. Several plant species have been recorded only from Ephemeral Drainage Lines. No coastal streams traverse the coastal plain near the onshore pipeline route but several occur nearer Vilanculos, some of which are assessed as Critical Habitat mainly due to the presence of peat wetlands (Golder, 2014a). These occur approximately 25 km south of the pipeline route.
Mangrove Swamps	The mangrove forests of the Govuro and Save River estuaries comprise the largest remaining and largely intact area of estuarine mangroves along the coastline of Sofala Bay. The next nearest estuary is the Nhangonzo estuary, located to the south. These mangrove forests exhibit high species diversity relative to those in South Africa, with eight of the 11 mangrove species recorded for Mozambique confirmed here. The edge of the mangrove forest on the seaward side is surrounded by mud flats where large flocks of waders occur. Mangroves fringe the Govuro River approximately 4 km north of the proposed pipeline crossing and become more extensive in the estuary itself. None occur at the pipeline crossing.
Hummock Dune Pioneer Communities (pioneer communities of salt tolerant species (halophytes) restricted to primary dunes).	This is a unique ecosystem which occurs along an approximately 3 km length of coastline on small primary dunes on the landward side of bands of mangrove forest situated below the high water mark. The landward side of the dunes consists of freshwater wetlands formed by non-perennial tributaries of coastal streams and seepage from high frontal dunes (with dune forest communities). These vegetated dunes are likely to play a critical role in allowing freshwater seepage into the mangrove swamps, whilst preventing the influx of tidal surges into the tributaries.

Flora

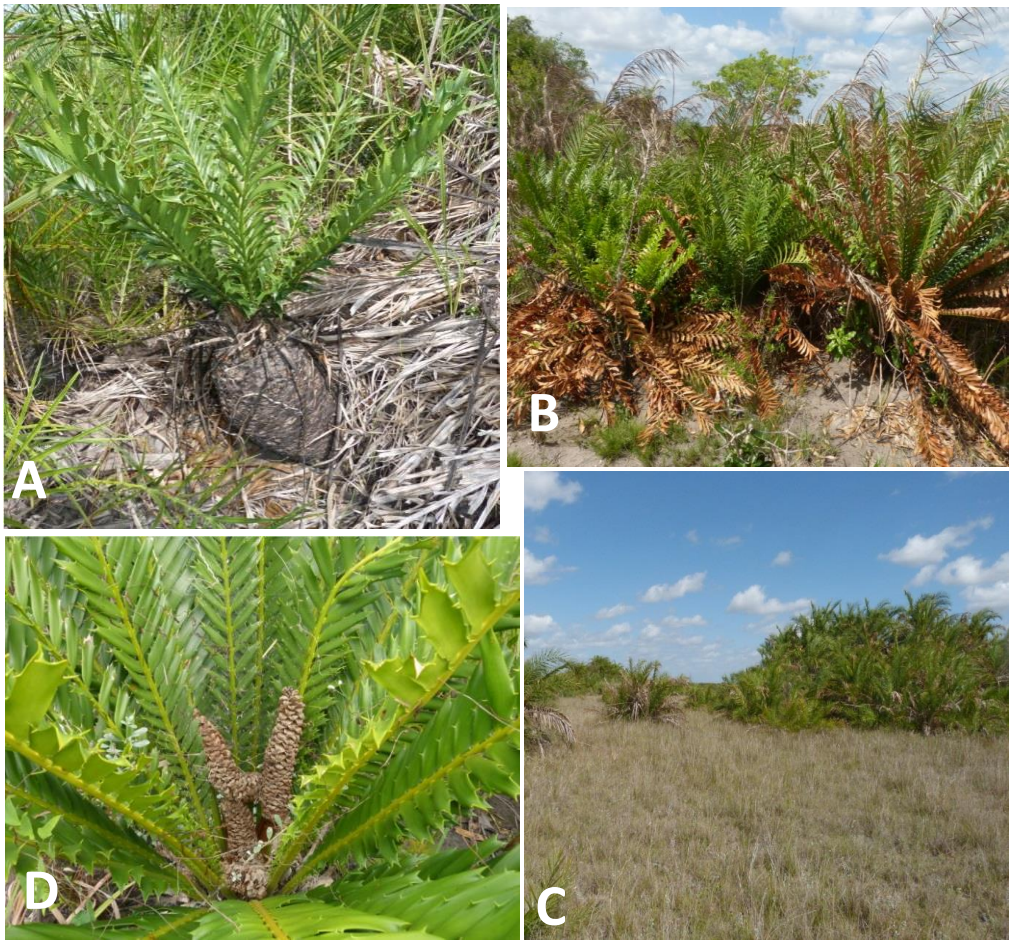
A number of plant species of conservation concern have been found in the Project Area, either because they are IUCN red-listed species, at risk of extinction, or because they are endemic species with localised distribution. These include:

- A critically endangered subspecies of cycad – *Encephalartos ferox* subsp *emersus* – recorded on the Govuro River floodplain (*Figure 6.12*).

- Three tree species of conservation concern (*Dalbergia melanoxylon*, *Pterocarpus angolensis* and *Afzelia quanzensis*) that are listed as Near Threatened on the IUCN red list (2015).

- *Xylia mendoncae* (Vulnerable species on Mozambique red list, endemic to Inhambane Province but relatively common on the coastal floodplain (listed as Data Deficient by IUCN); *Crinum stuhlmannii* (listed as declining on the South African Red Data List), and two endemic and Data Deficient species - *Carissa praetermissa* and *Ziziphus pubescens* (recorded in coastal habitats).

Figure 6.12 Cycad Encephalartos ferox subspecies emersus and its Typical Habitat



A = Adult Plant; B = Plants damaged by a recent fire; C = Typical cycad habitat; D = Male cones

Source: Rousseau 2015

6.3.3 Terrestrial Fauna

An estimated 29 frog species, 56 reptile species, 275 bird species and 94 mammal species are expected to occur in the region (Golder, 2014b). Woodland and thicket vegetation types potentially support the most diverse range of terrestrial fauna (~363 species) followed by coastal wetlands with 156 species, and the Govuro River and floodplain with 143 species. The majority of mammal and bird fauna species expected to occur are widespread habitat generalists.

Mammals

Based on anecdotal reports and field reconnaissance, most large animals (eg elephant, lion, and hippopotamus) no longer occur in the Project Area of the pipeline, although they may occur in the lower Govuro River and the Save River valley. However, a wider diversity of buck and other mammals can be expected to occur in dense woodland and thickets in the more inaccessible northern portions of the pipeline Project Area.

Few, if any, Red Data mammal species are expected to be found in the woodlands of the area and it is only the striped leaf-nosed bat and leopard that probably occur in small numbers in the denser, more isolated parts of the Project Area.

The Govuro and Save estuaries and inshore coastal habitats provide favourable habitat for the marine mammal, the dugong, listed as globally Vulnerable on the IUCN red list (refer to *Section 6.4.1* and *6.4.4*).

Birds

Bird diversity in terrestrial habitats is expected to be relatively high, especially in woodland and forest habitats. The majority of Red Data bird species confirmed or likely to occur are widely distributed and with large home ranges and include: white-headed vulture, bateleur eagle, pallid harrier, martial eagle, crowned eagle, sooty falcon, European roller, plain-backed sunbird and secretary bird. The Near-Threatened lesser flamingo may visit the barrier lake wetlands and estuarine habitats, while the Vulnerable wattled crane may be seasonal visitors to the Govuro floodplain wetlands.

Along the coast, mangroves and the extensive estuarine mud flats provide feeding grounds for freshwater and marine wading birds.

Reptiles and Amphibians

Previous surveys of reptiles and amphibians were restricted to localised areas, particularly in the southern portion of the Project Area. New distributional records of reptile species and possibly a new species of lizard (Golder, 2014b) were recorded in the coastal streams of Nhangonzo near Inhassoro, to the south of the pipeline. One Red Data reptile, the Zambezi flat-shelled terrapin, is expected to occur in the coastal estuarine area downstream of the onshore pipeline. The majority of reptiles in the Project Area are expected to be widely distributed across the woodland habitats. No amphibian species are expected to be restricted to localised areas of the pipeline corridor as few wetland types are present and the Govuro floodplain is fairly uniform along its length.

6.3.4 Aquatic Ecology

The Govuro River is the only perennial river crossed by the proposed pipeline and comprises the flowing river course (aquatic) and the associated floodplain (riparian). The aquatic habitats of the Govuro River are largely unmodified in the area of the pipeline crossing, although the riparian zones are cultivated close to settlements in upper reaches of the river.

The only noteworthy use of plant resources along the river system is the harvesting of reeds (*Phragmites australis*), saw grass (*Cladium mariscus*) and Ilala palms (*Hyphaene coriacea*), which are dominant species within the central zone of the floodplain. Riparian trees are scarce as the riverine zone rapidly merges into the terrestrial woodland system.

The in-stream habitats of the Govuro River are fairly similar for most of its length comprising an incised channel with water weeds and emergent lilies. There are no riffle rocky substrate areas although calcrete outcrops occur in the river in places. This limited habitat diversity is expected to restrict the biodiversity of aquatic biota - a total of 49 fish species are expected in the Govuro River system (Golder, 2013), of which 26 species have been collected in surveys associated with Sasol. Six fish species were reasonably common in the coastal streams to the south of the study area near Inhassoro; namely the sharptooth catfish, eastern river bream, Mozambique tilapia, black tilapia, many-spined climbing perch and mesh-scaled topminnow.

The tidal influence on water quality results in the occurrence of some species tolerant of estuarine conditions in the lower reaches of the river. Several estuarine or marine species, such as the oxeye tarpon, round moony, butterfly fish, rock flagtail, longspine glassy, river bream, flathead mullet and large-scale mullet have been recorded near the existing pipeline crossing (Golder, 2013).

Although fish surveys to date under-represent actual fish diversity due to sampling difficulty, only one threatened species has so far been recorded in the Govuro River: the orange-breasted river bream (Endangered), caught in 2004. Mozambique tilapia is regularly caught by the local fishermen and is Near-Threatened.

Twelve barrier lakes are situated between the Govuro River and the coastline to the south of the pipeline crossing. Although the terrestrial flora and fauna along the barrier lakes is diverse, the aquatic diversity in the lakes is low (Deacon, 2014). Notwithstanding the low diversity, the presence of fresh water as a source of drinking water and the presence of fish as food for humans create an ecosystem that has high conservation value. None of these barrier lakes are within the area of influence of the pipeline.

6.3.5 Protected Areas and Species

No onshore protected areas occur near the onshore pipeline. The Zinave National Park occurs to the west of Pande Block and the Coutada 4 Hunting Reserve on the north side of the Save River (*Figure 6.16*).

Certain species within the Project Area are protected, as follows:

- Forest and Wildlife Law (*Decree No 12/2002*) provides for the protection of timber trees; many medium to large mammals and birds. Protected trees species relevant to the onshore pipeline will be determined and listed in the EIR.

6.4 OFFSHORE BIOLOGICAL ENVIRONMENT

6.4.1 Marine Fauna

Phytoplankton and Zooplankton

Plankton are microscopic organisms which drift in the seawater column. There are two main categories of plankton, which are phytoplankton (microscopic plants) and zooplankton (microscopic animals). Phytoplankton are the primary producers in the food chain and form the basis of the marine trophic web and are therefore a key indicator of the productivity of a local ecosystem. Zooplankton, which includes eggs and larval forms of various marine life, play a significant role in the marine trophic web by transferring energy from phytoplankton through to higher trophic levels when they are eaten by larger marine animals.

Little information is available on phytoplankton in offshore Mozambique. Phytoplankton abundance and distribution in the region is strongly dependent on the environmental and oceanographic conditions, such as currents and upwelling, as well as river run off (Sá *et al,* 2013).

As with phytoplankton, information on zooplankton in the Mozambique Channel is scarce. A survey of the western Mozambique Channel in 1980 indicated higher levels of mesozooplankton in inshore regions compared to offshore regions (Nehring *et al,* 1987). During this survey, the inshore region of the Bazaruto Archipelago was seen to be among the most productive along the Mozambican Coast (Nehring *et al,* 1987; Ternon *et al,* 2014).

Large Invertebrates

Crustaceans are a diverse group of fauna which includes shrimp, lobsters and crabs. They are widespread and found in nearly all marine habitats in the Project Area. Rock lobsters are found in the intertidal rocky shore and in deep recesses of the rocky reefs while crabs are found in a diversity of habitats ranging from sandy flats and shores, rocky shores, mangroves as well as salt marshes, seagrass, coral reefs, and deeper water. Mangrove mud crab (*Scylla serrata*) are common in the estuaries and the mangrove creeks at Sofala Bank (from Govuro Bay and northward) while the blue crab species (*Portunus sanguinolentus*) is abundant in the turbid but saline shallow waters (depth<20 m) of the Sofala Bank.

Several species of squid, cuttlefish and octopus species may occur in the Project Area and adjacent habitats. Squid species are common in the deep open sea. In Bazaruto Bay, deep channels nearshore allows some squid species to be caught by the beach seine fishery. Most individuals caught are juvenile (immature) specimens of the diamond-back squid and Indian squid. The cuttlefish (*Sepia pharaonis*) is common in shallow waters and dominates the beach seine fishery along the coast of Vilanculos and Inhassoro Districts (ERM, 2008).

Benthic Community

There are no data available on the benthic fauna of the Bazaruto region. As in other marine environments, benthic community structure is expected to be linked to sediment properties (Newell *et al,* 1998). Benthic data will be collected along the offshore pipeline route in the marine ecology specialist study during the EIA phase.

Seabirds

Pelagic seabird species are considered to be rare around the Project Area, including the Archipelago, due to the proximity to the coast and lack of upwelling water to produce a constant supply of food. However, previous sightings of pelagic species in the BANP Area include the red-footed booby, the cape gannet, the greater frigate bird and the lesser frigate bird (ERM, 2006; ORI, 2008).

Marine Mammals (Whales, Dolphins, Dugongs and Seals)

Whales and Dolphins

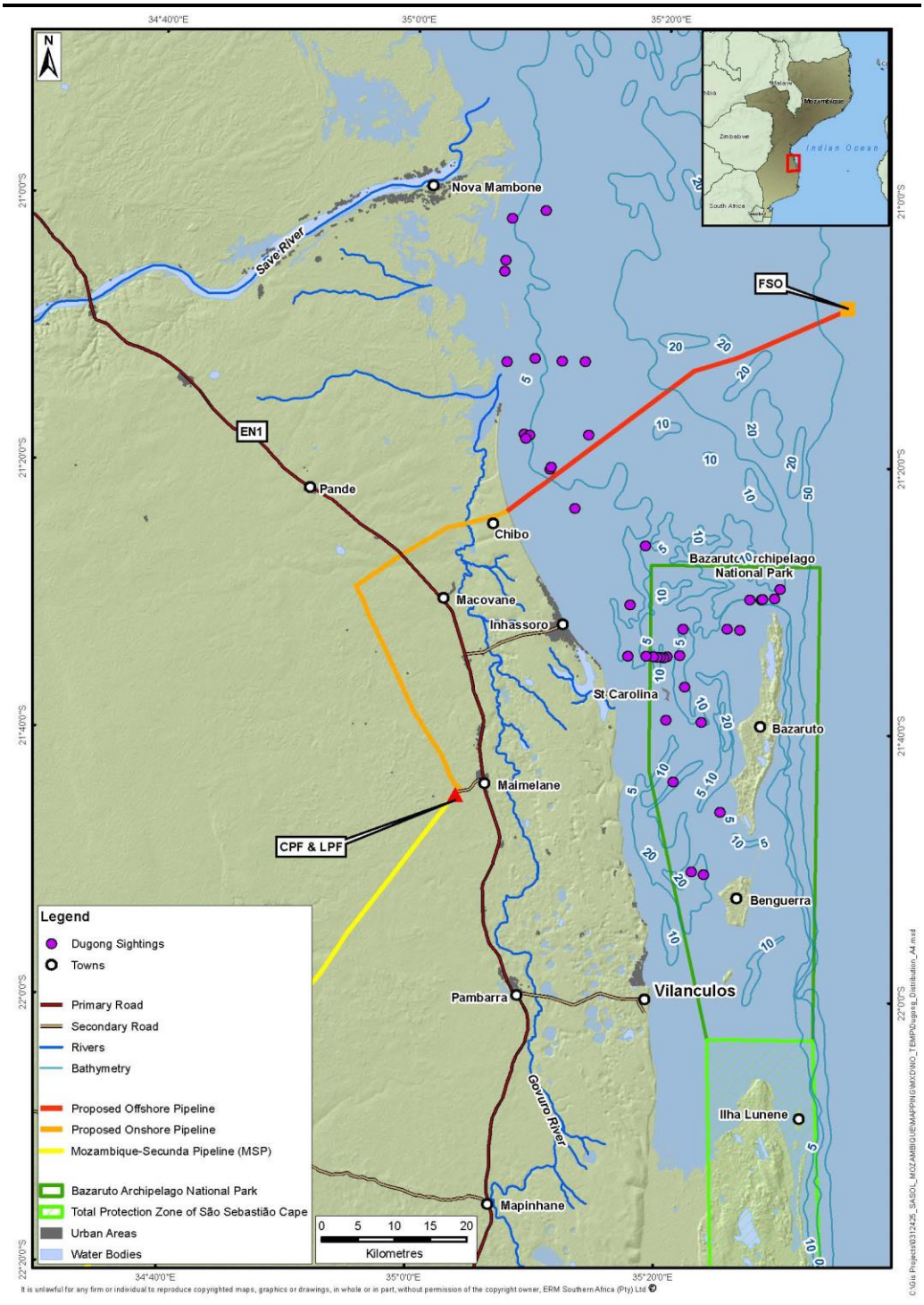
Five species of dolphins (namely the common, humpback, bottlenose, spinner and spotted dolphins), five species of toothed whales (namely the short-finned, false, beaked, sperm, and dwarf sperm) and two species of baleen whales (Minke and humpback whales) have been recorded in the Project Area (ERM and Impacto, 2011). All cetaceans are considered protected species in Mozambique (Forest and Wildlife Law *Decree No 12/2002*).

Dugongs

Dugongs occur mainly in shallow waters of the sheltered bay between the islands of the Bazaruto Archipelago region, from Cabo São Sebastião in the south to the Save River mouth in the north (Findlay et al. 2011; Allen 2013; Samoilys et al. 2015) and are often seen in the vicinity of seagrass beds where they feed (*Figure 6.13*). Small calves have been observed in the area, suggesting the dugong population is breeding. This population is considered regionally important and the last remaining viable population along the Western Indian Ocean coastline, where it is estimated to number 200 to 250 individuals (EWT, 2013). They are listed by IUCN as Vulnerable to extinction but have been assessed as regionally Endangered[3]. In Mozambique dugongs are considered a protected species under the Forest and Wildlife Law (*Decree No 12/2002)*. Anthropogenic threats to dugongs include habitat loss, hunting, incidental killing in fisheries and collision with boats.

[3] Second signatory state meeting of the Memorandum of Understanding on the Conservation and Management of Dugongs and their Habitats throughout their Range, 2013, cited in EWT 2013.

Figure 6.13: Dugong Adult Distribution in the Project Area



Sources: Cockcroft et al, 2008 and EWT, 2014

Seals

Two seal species, namely the crabeater seal and sub-antarctic fur seal are occasionally found in the area (Guissamulo & Cockroft, 1996) but these records are of vagrants considered to be outside of their normal distribution range (ERM, 2006).

Marine Turtles

Five species of sea turtles are likely to occur in the Project Area, namely the green, loggerhead, olive-ridley, leatherback and hawksbill turtles (ERM, 2006).
The species that may occur in the Project Area are classified as threatened (IUCN, 2016):

- Loggerhead turtle: Vulnerable (global population) and Near threatened (South West Indian Ocean subpopulation);
- Leatherback turtle: Vulnerable (global population) and Critically Endangered (Southwest Indian Ocean subpopulation);
- Green turtle: Endangered (global population);
- Hawksbill turtle: Critically Endangered (global population); and
- Olive-ridley turtle: Vulnerable (global population).

*T*he green turtle and the loggerhead turtle are caught in the inshore beach seine fishery which indicates the presence of these species in the inshore waters of Inhassoro and Bazaruto Bay (Chacate, 2005). Most catches of adults occur between October and December.

The sandy beaches along the coast from Inhassoro to the Govuro River mouth, especially those areas characterized by small dunes, larger beach width and weak erosion (such as on the Nhamábuè Point) are suitable nesting areas of the loggerhead turtle and possibly of the green turtle (Marshall *et al*, 2015). Green and olive ridley turtle remains were recorded in the São Sebastião area (Jacobsen *et al*, 2008) although it was not clear if they breed here. Leatherback turtles also nest in the São Sebastião area (*Figure 6.16*). The nesting season of these turtle species is between October and February and hatched turtles are found between January and April. These periods are critical for nesting, although resident turtle species, such as the green turtle, may occur year round (ERM, 2008). All sea turtles are considered protected species in Mozambique (Forest and Wildlife *Decree No 12/2002*).

Fish

The fish which occur around the Archipelago represent more than eighty percent of all marine fish families of the Indo-pacific region (CSIR, 2001). Recruitment of fish to the Archipelago will be reasonably secure in view of the large area of their distribution. Sailfish, three species of marlin, sharks and migratory tuna are common in the deeper waters off the continental shelf.

Within the floodplains of the Govuro and Save Rivers the following fresh water fish are known to occur: Red-breasted Tilapia, Mozambique Tilapia and Black Tilapia.

Mozambique Tilapia and Black Tilapia are particularly abundant in the barrier lakes and form an important part of the subsistence fisheries in the area (Mark Wood Consultants, 2002).

6.4.2 Sensitive Coastal Habitats

This section describes a number of coastal habitats that are regarded as sensitive due to their ecological importance or vulnerability to disturbance.

Sand Dunes

The dunes most sensitive to human disturbance would be those on the eastern seaboard of the islands. These are mobile and are advancing in a westerly direction. The fore-dunes on the western side are mainly bare coastal sand dunes with few pioneer plant species.

Removal of these pioneers destabilizes the dunes. Likewise, the seaboard coast of São Sebastião at the sand spit known as Ponat Minga, the coast north of Vilanculos and the coast south of the Govuro River mouth and estuary (along the Bartolomeu Dias Peninsula), have recently established dunes with white sands, showing the same features of instability as those of the islands. The older dunes along some stretches of the coast from Vilanculos and along the northern coast of Inhassoro District, have suffered severe erosion caused by wind, human settlement and rainfall.

Sandy Beaches

Sandy beaches occur along most of the coast of the mainland between Cabo São Sebastião and Bartolomeu Dias Point, where they make up most of the east and west coasts of the islands of the Archipelago. Beaches are typically relatively narrow and of shallow gradient, and in the Project Area are backed by a steep dune of ~35 m height (*Figure 6.6*).

In the area of the shoreline crossing the sand is reddish because of erosion of ancient elevated dunes. Beaches further north between the Govuro estuary and along the Bartolomeu Dias Peninsula are dominated by soft white sand. Some sandy beaches both within the Archipelago and along the adjacent coastline on the seaward facing coastlines are exposed to strong wave action, long-shore currents and cyclones. Coastal erosion of the dune system and embankments by wind and tidal action is increasingly evident in these areas, which has caused collapse of some tourism infrastructure in exposed areas such as Bartolomeu Dias Peninsula and in Inhassoro. The dunes in this area are therefore highly dynamic. North of Bartolomeu Dias Peninsula, sandy beaches are replaced by mangroves at the Save River mouth.

Two species of ghost crabs (*Ocypode ryderi* and *O. ceratophthalmus)*, typically occur on the sandy beaches exposed to the open sea. These beaches are also important shelter and feeding areas for several seabirds and waders during high tide.

Estuaries

In the southern African context the following is a generally accepted definition of an estuary: "*it is a partially enclosed, coastal body of water which is either permanently or periodically open to the sea and within which, there is a measurable variation of salinity due to the mixture of sea water with fresh water derived from land drainage*" (Day, 1980). There are two main estuaries in the Project Area, namely the Govuro and Save River estuaries. The fresh water and nutrients provided by these rivers is vitally important in maintaining the mangroves that is an integral part of these estuaries and the seagrass meadows along the coast. These estuaries are important fish nursery areas which provide sheltered fishing for local communities.

Mangroves

The mangroves in the region of the Govuro and Save River mouths are among the best developed mangrove systems occurring in Mozambique (de Freitas, 1984). Mangroves start to occur approximately 8 km downstream of the onshore pipeline crossing on the Govuro River. Bazaruto, Benguerua and Santa Carolina islands, as well as the Nhangonzo stream (90 km to the south) also have small but viable mangrove communities. Five species of mangrove are represented comprising the red mangrove (*Rhizophora mucronata*), black mangrove (*Bruguiera gymnorrhiza*), Indian mangrove (*Ceriops tagal)*, and white mangrove species (*Avicennia marina* and *Sonneratia alba*). *Sonneratia alba*, found at Inhambane within the Bazaruto Archipelago, is close to its southernmost limit of distribution on the East African coast (de Freitas, 1984). Other mangrove species occurring in the Govuro and Save River mouth areas are black mangrove (*Lumnitzera racemosa),* looking-glass mangrove *(Heriteria littoralis)* and cannon-ball mangrove (*Xylocarpus granatum*) (Mark Wood Consultants, 2002). Mangroves are under significant harvesting pressure as a timber resource in many parts of the coastline although there appears to be relatively little pressure on the mangroves in the Govuro estuary at present.

6.4.3 Sensitive Marine Habitats

This section describes marine habitats that are considered sensitive due to their ecological importance or vulnerability to disturbance.

Seagrass Meadows

Seagrass habitats are highly productive ecosystems and play an important ecological role as nursery grounds for fish and crustaceans, as a food source and shelter for many organisms, and in the recycling of nutrients (Richmond, 1997). Their importance in Bazaruto Bay, where they occur between the Save estuary in the north and São Sebastião and Pomene Points in the south, is elevated due to their importance as a food source for populations of threatened green turtle and dugong that are resident in the area (Cockroft *et al*, 2008; Findlay *et al*, 2011). Seagrass meadows are also important as fishing grounds for the artisanal beach seine fishery.

Knowledge of seagrass species composition, extent and distribution in Bazaruto Bay mainly comes from boat-based transect surveys done in 2008 between Inhassoro and the Save estuary as part of a dugong study for Sasol's Block 16/19 EIA (Cockroft *et al,* 2008). The extent and density of seagrass meadows varies in the bay (*Figure 6.14*) with greater abundance and distribution closer to Inhassoro where they may extend 10 km offshore (Guissamulo, 2006) in depths generally less than 10 m (Cockcroft *et al*, 2008). Seagrass meadows were sparser closer to the Save estuary. Seagrass species mapped in this area included *Thalassodendron ciliatum, Halophila ovalis, Halodule uninervis, H wrightii* and *Cymodocea rotundata.* These species occur in different densities and compositions in different portions of the coastline (Cockroft *et al,* 2008).

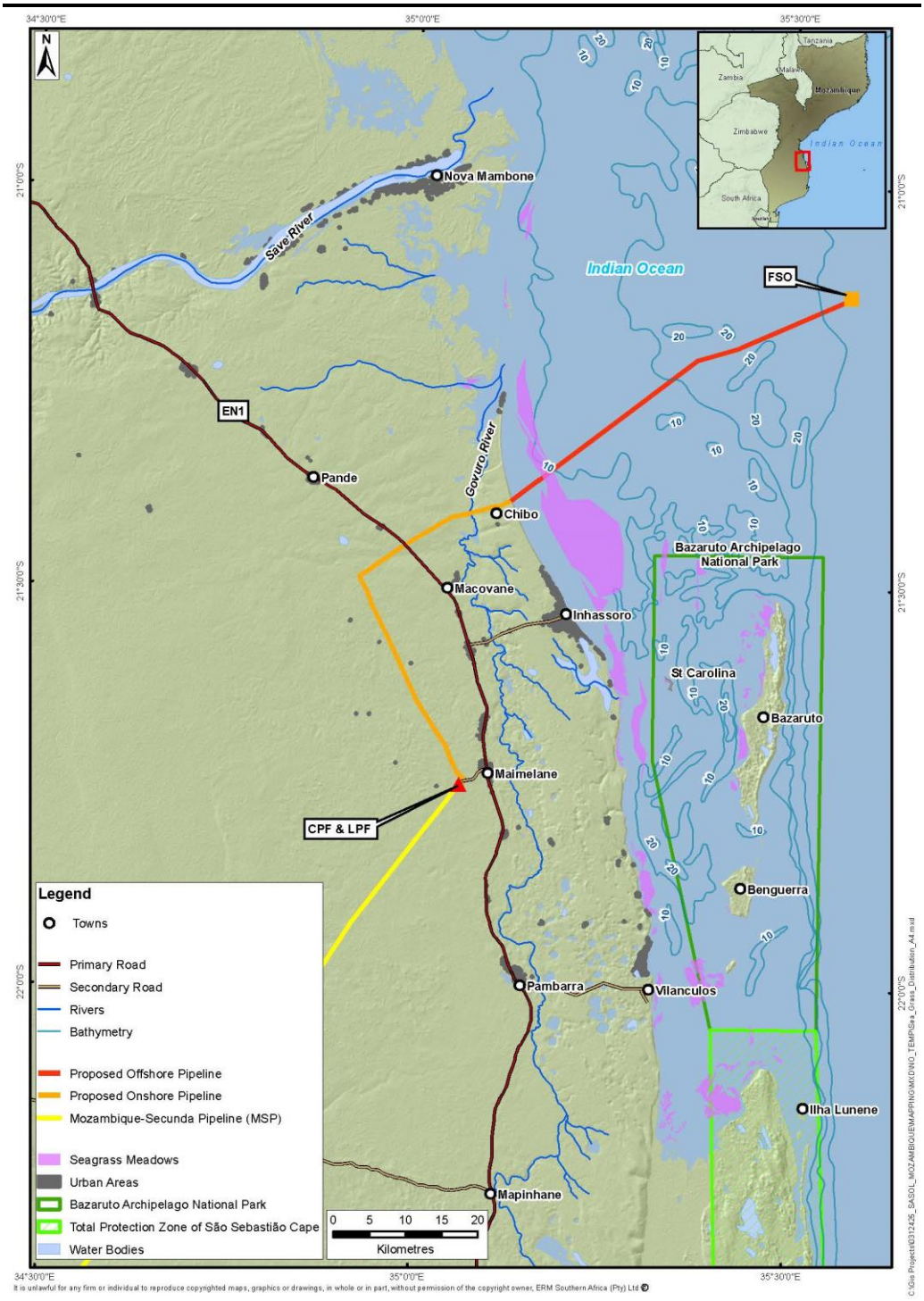
Coral Reefs and Coral

The coastline of Mozambique incorporates a full spectrum of reef types, covering an estimated area of 1 290 km^2 in total (Rodrigues *et al*, 2000). The majority of the reef formation occurs in the north, along the coral coast eco-region of Mozambique, where the reefs are found almost continuously along the coast, and the region is characterised by fringing reefs and island reefs with clear, warm water (Pereira *et al,* 2014) and dominated by hard corals (Schleyer *et al,* 1999). The reefs characterising the Archipelago are variable in nature, due to the oceanographic conditions, and range from a sparse growth or a thin veneer of corals on underlying Pleistocene sandstone substrata to true hermatypic reef formations (Pereira *et al,* 2014). The majority can be divided into three main types: patch reef, submerged sandstone reefs and submerged fringing reefs (Everett *et al,* 2008). Schleyer and Maggs (2008) further categorised the reefs as submerged offshore reefs, submerged rocky massifs, fringing reefs, barrier reefs or sedimented rocky shelves. The reefs in the Archipelago are concentrated mainly on the eastern side of Bazaruto Island, where there are large submerged offshore reefs and fringing reefs exposed to deep water, particularly on the seaward side of the island. Several of these offshore reefs are sought after recreational fishing areas such as 25-mile reef to the north of Bazaruto Island (*Figure 6.15*). Inshore of the islands, on the extensive sand flats, the area is dominated by seagrass beds, although isolated smaller reefs do occur (Schleyer and Celliers 2005).

The Archipelago has representatives of the two main orders of corals: Scleractinia (hard corals) and Alcyonacea (soft corals) with the other orders being Gorgonacea (sea fans) and Antipatharia (black corals). Hard corals dominate the coral reef fauna and include the genera: *Porites, Acropora, Pocillopora, Stylophora, Montipora, Pavona, Favia, Platygyra / Leptoria*, and *Dendrophyllia*. Soft corals are represented by the mushroom-shaped colony *Sarcophyton*.

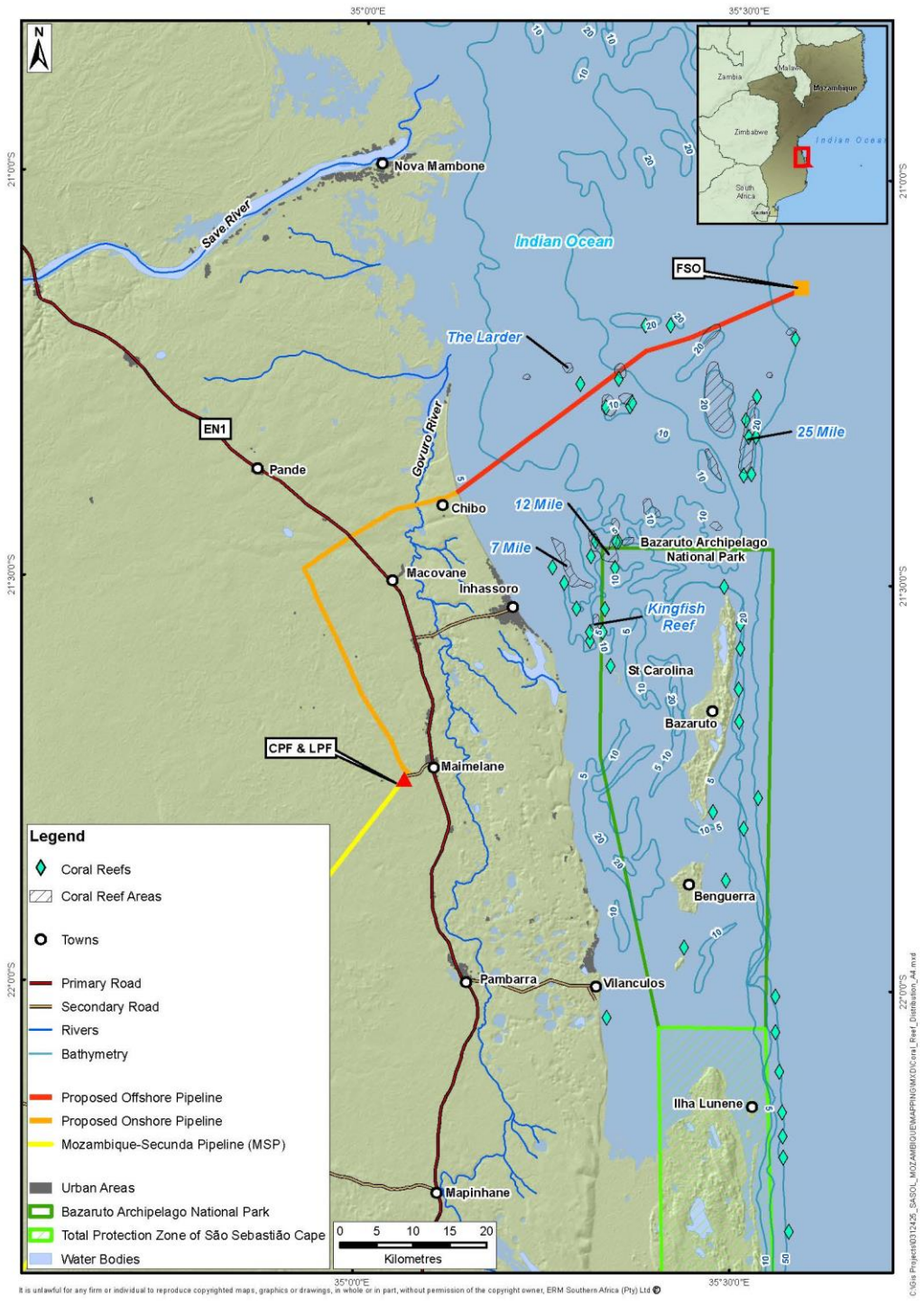
The reefs present in the Project Area are relatively unknown. Surveys of the offshore pipeline route will be conducted as part of the Marine Ecology Study to confirm the presence of coral reefs and potential risks.

Figure 6.14 Distribution of Seagrass Meadows in the Project Area



Source: Guissamulo, 2006

Figure 6.15 Coral Reefs Distribution in the Project Area



Sources: ERM 2006; Mahon (Variprint) downloaded from www.sealine.co.za

Other Marine Habitats

Hard substrate ledges: Approximately 50 m offshore of Bazaruto Island, sandstone ledges have been found on the seabed. They are generally dominated by marine algae and some have minimal coral growth. The structure varies with sloping flat ledges and drop-offs of between 0.5 to 3 m.

The ledges are also colonised by numerous benthic organisms (echinoderms, crustaceans, sponges, ascidaceans, and molluscs, including the giant clam *Tridacna*, which is common on these reefs), and provide refuge and food for a variety of fish life.

Channels - deeper coarse sandy channels occur between the islands, characterised by strong currents with depth varying from 5 to 26 m. These channels are the routes of tidal water movement between the islands and the mainland. Where there is reef in the channels it is low profile and dominated by marine algae, with little to no coral growth and low benthic fauna numbers (CSIR, 2000).

6.4.4 Protected Areas and Species

Bazaruto Archipelago National Park

The Bazaruto National Park (BNP) was created in 1971 with an aim to protect the marine fauna, specifically dugongs and sea turtles. The area covered three islands namely the Bangue, Magaruque and Benguerua Islands in the district of Vilanculos. In 2001, new boundaries of the BNP were defined through the *Decree No 39/2001*. With the implementation of the new boundaries, the Bazaruto and the Santa Carolina Islands in the Inhassoro District were incorporated within the Park, which was then designated the 'Bazaruto Archipelago National Park' (BANP). The BANP is a conservation area managed by the Park Administration, under the jurisdiction of the Tourism Ministry. The Park has a Management Plan for 2002-2006, approved by the Ministry of Tourism (*Figure 6.16*). Most of the park management's efforts are focused on regulating fishing and tourism activities, and the protection of marine resources, notably dugong, turtles and coral reefs.

The BANP Management Plan is currently being reviewed and updated by the National Administration of Conservation Areas (ANAC). ANAC have advised that once the final management plan is released to the public there will be guidance on mitigation and monitoring activities that will need to be implemented during the Project activities in order to ensure the sensitive species (eg: dugongs, dolphins and turtles) present in the Project Area are protected. These mitigation and monitoring measures will be reviewed by Sasol and, where appropriate, incorporated into the relevant EMPs for the Project.

Protected Area of São Sebastião

The Total Protection Zone of the Cabo São Sebastião, located to the south of the BANP, was created under the *Decree Nº 18/2003,* with an objective to protect the natural resources of the São Sebastião Peninsula. The "Vilanculos Coastal Wildlife Sanctuary" Project has a concession area of approximately 25 500 ha designated for the establishment of a Private Nature Reserve.

Protected Species

Certain coastal and marine species within the Project Area are protected, as follows:

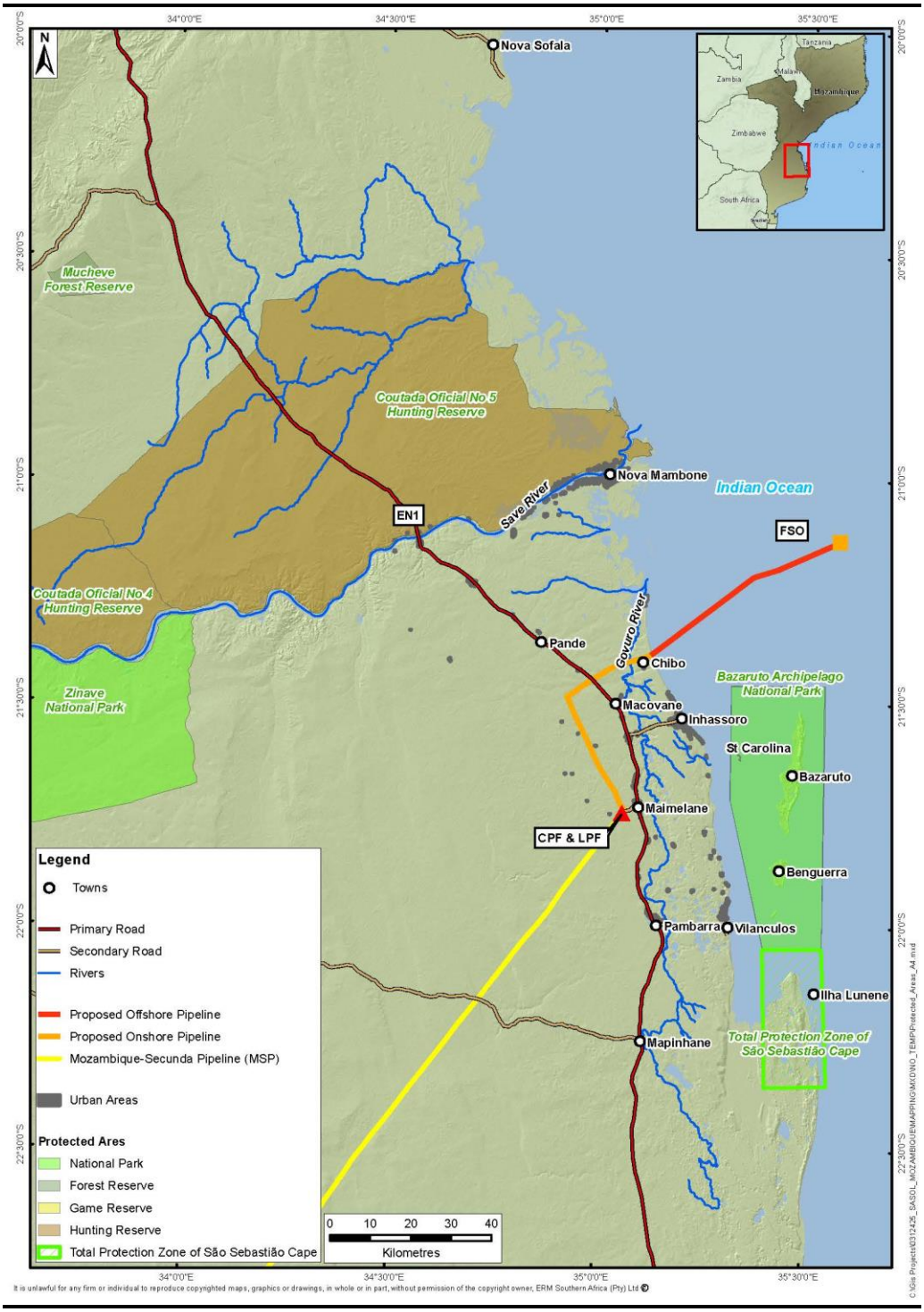
- Regulations under the Forest and Wildlife Law *Decree No 12/2002* provides for the protection of dugongs, turtles, and certain species of coastal and marine birds (eg flamingos, pelicans and storks);

- Regulations under the Sport and Recreational Fishing *Decree No 51/1999* provides for protection of dugongs, whales, dolphins, sea turtles and some species of fish, bivalves and gastropods;

- Regulations on Pollution Prevention and Protection of Coastal and Marine Environment (Decree no. 45/2006, 30th November), protects coastal and marine sensitive ecosystems such as mangroves.

Note: the new Conservation Law, *Act 16 of 2014*, includes stricter penalties for illegal activities relating to protected species in protected areas and lists prohibited activities similar to those under current legislation.

Figure 6.16 Protected Areas Present in the Project Area



6.5 SUMMARY OF THE BIOPHYSICAL ENVIRONMENT

Table 6.4 Summary of the Biophysical Environment

Climate	• The Mozambican climate can be described as highly variable and is vulnerable to climatic events such as floods, droughts and cyclones as well as climate change. • Mozambique is currently experiencing effects of climate change manifesting through coastal erosion and extended drought.
Air Quality	• Onshore industrial air quality measured at the boundary of the CPF meets requirements of the CPF Operational EMP and Mozambique and IFC air quality standards. • Onshore rural air quality is mainly impacted by the seasonal burning of woodland and grassland, as well as localised burning of waste and fuels. • Offshore air quality is generally good as the only source of air pollution is from vessels travelling along shipping lanes, including those involved in oil and gas operations in the area.
Noise	• Onshore industrial noise measured at the CPF meets IFC requirements (nighttime noise level of 45 dBA). • Onshore rural noise is largely unaffected by noisy activities except traffic noise along transport routes. • Offshore rural noise is influenced largely by ambient natural noise sources (water movement and weather events) with contributions from existing vessel traffic.
Water Quality	• The water quality of the Govuro River is generally good, with the water mainly fresh and clear (low turbidity) and having low but variable salinity levels as it exhibits tidal influence. • Groundwater quality increases in salinity towards the coast. • The physico-chemical characteristics of the water masses of Bazaruto Bay and the nearshore areas north of the Bay exhibit spatial and temporal variability.
Geology, Soils and Seabed Sediments	• In the coastal areas of Inhassoro District, the soils are variable but are generally sandy and of low arable potential. • The seabed sediment characteristics in the Project Area are currently unknown but expected to be predominantly sandy.
Topography and Seabed Bathymetry	• The terrain along the proposed pipeline route between the CPF and the shore crossing is relatively flat to slightly rolling and intersected by the south to north draining Govuro River and floodplain. • The proposed shore crossing area is characterised by a gently sloping beach leading from the sea up to 10 to 35 m high cliffs. • The offshore pipeline route shows an approximate one meter drop in sea level every kilometer from the nearshore shallow water (average water depth of 10 m) to the proposed FSO location (approximately 50 m deep).
Physical Oceanography	• The circulation of the open ocean adjacent to Bazaruto Archipelago is governed by the Mozambique Channel circulation system which comprises a series of intermittent large-scale eddies drifting southward.

Onshore Biological Environment	• Vegetation along the pipeline corridor comprises a mosaic of woodland and thicket for most of the route and the Govuro River floodplain wetland systems. Mangroves and estuarine habitats occur in the lower Govuro River system north of the pipeline route. • A number of plant species occur in the Project Area, some of which are of conservation concern, either as they are IUCN red listed species with a high risk of extinction or because they are endemic species of localised distribution. This includes a critically endangered subspecies of cycad. • The fauna found in habitats along the onshore pipeline route is expected to be more diverse in the more remote areas where human presence is lower and may include various medium to large mammals and a high diversity of birds. • Sensitive coastal habitats include vegetated sand dunes, sandy beaches, estuaries and mangroves.
Offshore Biological Environment	• Marine fauna includes phytoplankton and zooplankton, large invertebrates, seabirds, marine mammals (whales, dolphins, dugongs and seals), marine turtles and fish. • The marine mammals (dolphins, whales, dugongs and seals) present in the Project Area are considered protected species in Mozambique. • The dugong population present in the Project Area are of conservation importance as they are the last remaining viable population along the Western Indian Ocean coastline and they are on the IUCN list as Vulnerable to extinction. • All sea turtles (green, loggerhead, olive-ridley, leatherback and hawkbill turtles) present in the Project Area are considered protected species in Mozambique and are all on the IUCN list as threatened and therefore are of conservation importance. • Sensitive marine habitats comprise seagrass meadows, coral and coral reefs as well as channels that act as the routes of tidal water moving into and out of the area between the islands and the mainland. • Protected Areas present in the Project Area include Bazaruto Archipelago National Park (BANP) and the Cabo São Sebastião. These areas are important conservation areas for marine specifically dugongs and sea turtles.