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5 Environmental Setting

An assessment of potential environmental and social impacts of the Project required development of a detailed environmental and social baseline of the study area. The study area for the ESIA study is defined specifically for each type of biophysical and social environment aspect. Baseline information has been developed using secondary literature as well as surveys conducted in the study area. References to the secondary information are provided in the text.

The proposed Lamu coal fired power plant is situated in the Kwasasi area of Hindi sub-county, Lamu County as shown in Figure 4-1.

5.1 Land use

The County Government of Lamu is in the process of developing a spatial plan for land use within the county. This plan is envisaged to include various land uses including commercial, industrial, residential, etc.

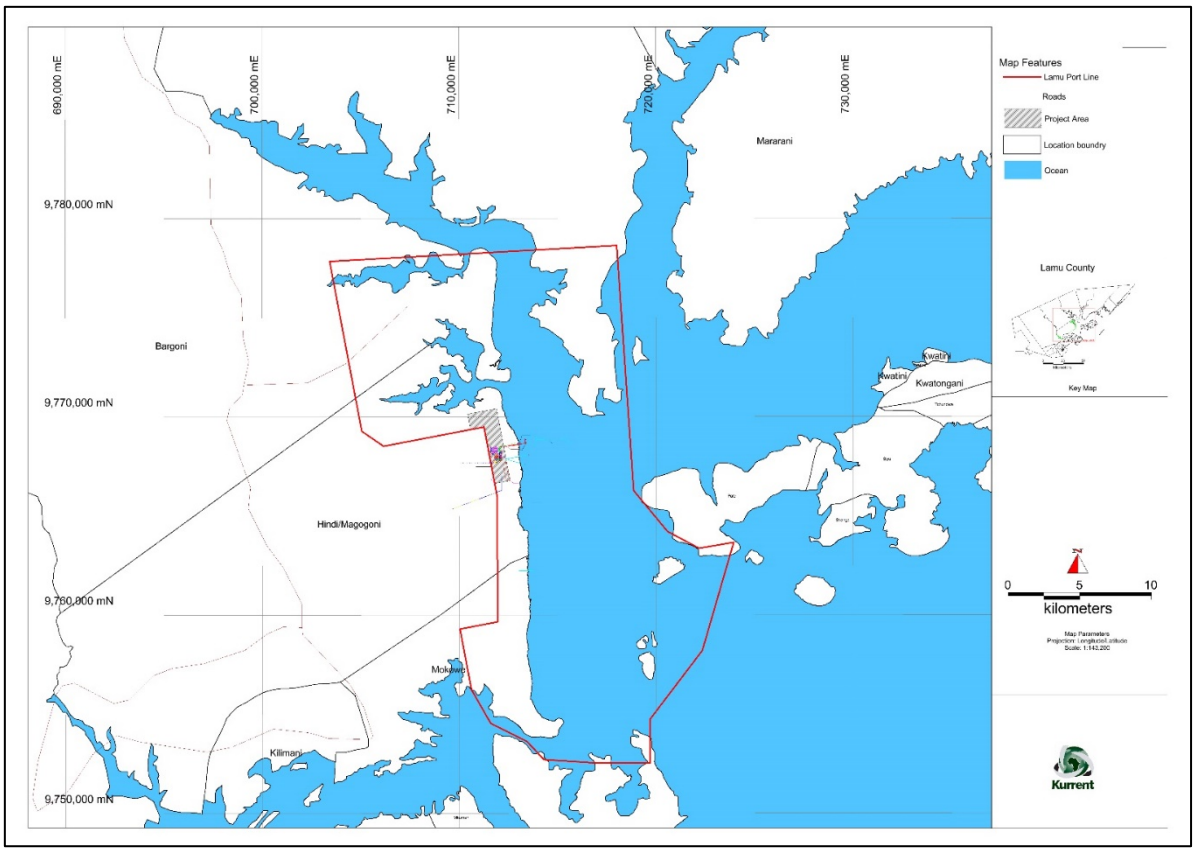
With the development of the Lamu Port South Sudan Ethiopia Transport (LAPSSET) corridor project, land use within its footprint area will change from the existing agricultural use to commercial and industrial use.

The land tenure around the proposed Lamu coal power plant is communal and held in trust for the community by the County Government of Lamu. Together with other LAPSSET related projects in Lamu, the land use at the proposed project site will convert from communal to commercial or industrial.

Through interviews conducted during the baseline field surveys, it was established that the communities within the Lamu coal power plant project area and its environs practice subsistence agriculture. Some pastoralists were also observed grazing their cattle in the project area.

Additionally, the tidal areas within Manda Bay contain sizable percentages of mangroves which provide ecosystem services to the communities. Mangroves provide provisioning services to the local communities within the Kwasasi area.

Figure 5-1: Image showing approximate location of project



5.2 Setting the Study Limits

The study limits for the proposed power plant vary from one bio-physical and social element to another. Each specialist study has required setting up of its own study limit based on secondary literature reviews and a site reconnaissance visit in January 2015. Based on this, given in Table 5-1 is the study limit for each type of specialist study undertaken in the ESIA.

Table 5-1: Setting the study limits for the ESIA

Specialist study	Study limit
Air quality	A grid of 50km x 50km from the centre of the project site
Marine ecology and sea water quality	The Manda Bay estuary specifically a radius of about 2km from the proposed jetty location
Terrestrial ecology	Project footprint area and its immediate environs
Noise and vibration	Project footprint area and its immediate environs
Hydrology	Project footprint area and its immediate environs
Hydrogeology	Project footprint area and its immediate environs
Soils and geology	Project footprint area and its immediate environs

Specialist study	Study limit
Social impacts	Key parts of Lamu County near the project area (e.g. Hindi/Magogoni, Mokowe, Bargoni, Lamu island, Faza, Chundwa, Mtangawanda, Pate, Manda, etc.)
Cultural heritage	Project footprint area including surrounding areas and Lamu stone town
Visual impacts	A 5km radius from the center of the project site
Health and safety	Project footprint area and its immediate environs

5.3 Geology

According to the geological map of Kenya (Figure 5-2), the project site is mainly covered by the Quaternary overburden layer, without any deep fault distribution around the site, and there is also no obvious fault distribution in the site with reference to data of nearby projects.

According to Meteorological Department in Kenya, the earthquake magnitude around the project site is generally less than 5 on the Richter scale; this reflects that neo-tectonic movement is weak in the site. Based on the above factors, it is deciphered that the geological tectonic conditions within the project site and its environs would be of good stability.

Figure 5-2: Geological Map of the Plant Site

The site specific geologic characteristics are given in the following sub-section.

5.3.1 Site specific geology

The study area is covered by superficial soils and marine sediments. The oldest rocks are Tertiary limestones and are largely covered by Quaternary limestones. Marine sands and clays occur in a belt varying from 16 to 24 km wide, sub-parallel to the present coast-line. Their surface is covered by sandy soils which are fluviatile in character. The Quaternary marine sediments contain raised coral reefs and wind-blown dunes sands which are often red in colour. These outcrop between the Tertiary sediments and the present coast. The Pleistocene sands and clays, like those of the Tertiary, were probably deposited under deltaic conditions in this region.

The Quaternary soils are usually grey sands and clays outcropping over the Tertiary marine sediments. Black cotton soils are present along drainage channels and are also found overlying the Tertiary and Quaternary sediments along the drainage channels. Red soils in the area may be merely better drained variants of the common grey sandy soils but they may also represent tertiary dunes or valley deposits. The alluvium of the Tana River Valley is of Quaternary age.

5.3.2 Topography and geomorphology

The project site is the bonding zone of coastal plain and the Manda Bay, with Manda Bay located on the east, terrestrial land on the west, and a wide and short seasonal gully (flooding area in spring tides) on the north.

5.4 Soil Resources

The parent material of the soils in the district originates from marine sediments. These soils are shallow and generally poor for agricultural purposes. They are also prone to waterlogging. Soils in the bottomlands and in the plains to the west of the county have high fertility while those in coastal plains have low to moderate fertility. The soils formed on former coastal beach ridges and on sand dunes also have low to very low fertility.

5.4.1 Types, capacity and uses

The project area is overlain by relatively shallow mainly black cotton soils which in some areas grade into more grayish colored loamy soils. The soils of the Kwasasi sub-location in Lamu area are classified as below. (Speck, 1978, Sombroek et al, 1982).

The quaternary soils are usually grey sands clays outcropping in and of the Tertiary marine sediments, which yield off white or buff sandy soils by reworking. Black cotton soils are present along drainage channels and are also found overlaying the tertiary and quaternary sediments along the drainage channels.

5.4.2 Fertility and potential uses of the land for agriculture

The land on which the proposed coal fired power plant is to be built is currently used for subsistence agriculture. Farmer's cultivate pockets of land to grow maize, sim sim, and other food crops which they use for subsistence purposes or as cash crops. As stated above, land in the coastal plains which includes the proposed project area, have low to moderate fertility.

5.5 Water Resources

5.5.1 Surface water

There are no rivers near the proposed project site and surface water mainly accumulates on the site during the rainy season. The topography of the site is such that the land generally slopes eastwards towards the Manda Bay; subsequently, surface water will mainly drain to the sea from west to east in a scattered mode.

The project site is at a higher elevation than the seasonal gully located towards the north of the project site; therefore the site potentially accumulates water in rainy season on the west, while sea tides on the east will have minimal flood influence on the site.

5.5.1.1 Water uses

Lamu County is generally a water scarce region of the country. The only fresh water sources are the sand dunes located on Lamu island and shallow wells dug by communities on the mainland.

Within the Kwasasi area where the proposed project is to be situated, residents walk long distances to source for water. Amu Power has purchased above ground water storage tanks for delivering water regularly to the communities living in Kwasasi.

5.5.1.2 Water quality

Most streams in the County are seasonal and far from settled areas. The water obtained from most wells is of poor quality owing to the chemical nature of the aquifers. Wells must also be protected from contamination to reduce the incidence of water-borne diseases.

5.5.2 Groundwater

Groundwater within the project area is confined to pore water in loose rocks. A geotechnical survey was undertaken at the project site onshore and offshore to determine the subsurface soil and groundwater conditions. The geotechnical survey was carried out between January and March 2015 during the local drought season; stable underground water levels were measured in each drill hole and it was determined that the depth to ground water is basically the same as the sea level.

5.5.2.1 Hydrogeological characteristics

Through the geotechnical investigation carried out at the project site, it was established that the depth to ground water within the site varies between 2.8m and 7.8m. Data for depth to groundwater was collected over a period of four months in the rainy season to determine the average depths to groundwater for purposes of foundation design.

5.5.2.2 Groundwater recharge data and potential yield

The stratum on the site is mainly sand with good water permeability, good water storage conditions, and large amount of groundwater; the site is connected to the sea and is at an elevation of between 3 and 14m above sea level. The project site has good groundwater recharge and discharge conditions; the site has good water accumulation conditions, and with the surface stratum being sand having with good water permeability, the accumulated surface water (in rainy season) will effectively be able to recharge the groundwater on the site.

5.6 Air Quality

The construction, commissioning and operation of the proposed coal fired power project may have potential negative impacts upon the ambient air quality of the local area. To determine the baseline conditions around the project site and and its environs, an air quality survey was undertaken by SGS Kenya Limited on February 10th – 17th, 2015. The coordinates and locations of the baseline air quality survey are presented below.

Table 5-2: Baseline air quality monitoring locations

Sampling point	Coordinates		Site description
	Latitude	Longitude	
Bargoni village	S02°02'50.4"	E040°47'10.0"	This is a village along Hindi-Kiunga road and its baseline data is highly impacted by traffic along the road and emissions from the houses
Ngini village	S02°03'46.7"	E040°53'40.6"	This is a small residential village off Hindi- Kiunga road. Its baseline air data will be impacted by domestic emissions from the houses
Bobo village	S02°07'59.5"	E040°49'38.7"	A village along Hindi- Kiunga road. The baseline data from this point is impacted by traffic and smoke from the commercial shades.
Mokowe Primary School	S02°14'09.4"	E040°51'00.7"	This is a school within Mokowe town. Mokowe town is considered an industrial set up hence the baseline air quality data will be influenced by traffic
Jipe village	S02°11'14.7"	E040°49'57.1"	This is a residential village mostly inhabited by farmers and most of its baseline air quality influence would be domestic smoke.
Hindi area	S02°10'48.3"	E040°48'59.1"	Hindi is a busy shopping centre with relatively heavy traffic

Sampling point	Coordinates		Site description
	Latitude	Longitude	
			influencing on the baseline air quality data.
Masjid mosque – Pate island	S02°08'49.5"	E040°59'89.2"	This area is mostly inhabited by fishermen and farmers with domestic activities as the most probable sources of baseline air data
Mikanjuni island opposite a resort – Pate island	S02°04'24.8"	E040°58'29.6"	This area is an island surrounded by the ocean. The baseline air quality at this point would be impacted by fishermen's boat.
Mtangawanda jetty – Pate island	S02°06'37.7"	E040°58'22.2"	The area's baseline air quality data is highly impacted by traffic of vehicles and motorcycles from the Jetty to Pate Island. Domstic smoke from the surrounding shades also contributes to air data.
Kwasasi – project site	S02°05'19.9"	E040°53'28.9"	This point is within the project area with sim sim farming as a major operation within the area. Sources of baseline air influence would be motorcycles and domestic smoke.

Figure 5-3: Baseline air quality sampling locations

Passive sampling tubes were used for collecting baseline air quality data on sulfur oxides and nitrous oxides. Passive sampling involves adsorption of the pollutant gas in a capture tube. The capture tubes/filters are then sent to accredited laboratories for analysis in accordance with standard methodologies (ion chromatography/GCMS). The laboratory results and sampling duration information are used to calculate the gases concentrations. Figure 5-4 shows an image of passive sampling tubes mounted on a tree to collect ambient air quality data. The tubes were left in place for a period exceeding 30 days.

Figure 5-4: Image showing passive diffusion tubes mounted on a tree branch

Minivol air samplers were used at the selected locations for fine particulate monitoring. The Minivol portable air sampler (figure 5-5) is an ambient air sampler for particulate matter. The sampler is positioned with the intake upward in an unobstructed area, free from any obstruction to airflow. The sampler is fitted with a PM_{10} inlet, which only allows for particles of an aerodynamic diameter of less than 10 μm (PM_{10}) to pass through it for PM10 sampling and a $PM_{2.5}$ inlet, which only allows for particles of an aerodynamic diameter of less than 2.5μm ($PM_{2.5}$) to pass through it for PM2.5 sampling. The sample was drawn through the unit at a predetermined flow rate and collected onto filter papers over typically 4-hr sampling periods. Figure 4-5 below shows an image of the Minivol sampler.

Figure 5-5: Image of Minivol air sampler mounted to collect particulate matter

While not a reference method sampler, the mass concentrations of the MiniVol™ TAS gives results that closely agree with reference method concentrations in accuracy and precision. The MiniVol™ TAS features a programmable timer, a constant flow control system, an elapsed time totalizer, rechargeable battery packs, and an all-weather enclosure.

5.6.1 Climate and meteorology

The average weather conditions observed during the survey period were mainly dry with clear skies. Day temperatures peaked at 32^0C and lowest at 23^0C during the day. Wind speed was typically be-tween 5m/s and 9m/s. the recorded humidity was between 54 to 59%.

5.6.2 Baseline ambient air quality results

Results of ambient air quality active measurements conducted from February 10th – 17th, 2015 are presented in table 5-3 to 5-6.

Table 5-3: Measurement results for PM2.5

Location ID	Start Date	Finish Date	PM2.5 (µg/m^3)
Bargoni village	10-Jan- 15 @ 12:20hrs	10-Jan-15 @ 16: 25hrs	18
Mtangawanda jetty (Pate island)	11-Jan- 15 @ 12:15hrs	11-Jan-15 @ 16: 15hrs	1
Mikanjuni island	11-Jan- 15 @ 12:45hrs	11-Jan-15 @ 16: 30hrs	0.45

Location ID	Start Date	Finish Date	PM2.5 (µg/m^3)
Masjid mosque (Pate island)	11-Jan- 15 @ 11:20hrs	11-Jan-15 @ 15: 25hrs	0.34
Hindi mosque	12-Jan- 15 @ 08:20hrs	12-Jan-15 @ 12: 20hrs	0.13
Jipe village	12-Jan- 15 @ 09:20hrs	12-Jan-15 @ 13: 20hrs	0.13
Mokowe Primary School	12-Jan- 15 @ 13:50hrs	12-Jan-15 @ 17: 50hrs	0.28
Bobo village	13-Jan- 15 @ 09:05hrs	13-Jan-15 @ 13: 05hrs	0.28
Ingini village	13-Jan- 15 @ 11:20hrs	13-Jan-15 @ 15: 20hrs	0.07
Kwasasi (project site)	15-Jan- 15 @ 08:55hrs	15Jan-15 @ 12: 55hrs	0.61

Table 5-4: Measurement results for PM10

Location ID	Start Date	Finish Date	PM10 (µg/m3)
Bargoni village	10-Jan- 15 @ 12:20hrs	10-Jan-15 @ 16: 25hrs	16.52
Mtangawanda jetty (Pate island)	11-Jan- 15 @ 12:15hrs	11-Jan-15 @ 16: 15hrs	0.34
Mikanjuni island	11-Jan- 15 @ 12:45hrs	11-Jan-15 @ 16: 30hrs	0.61
Masjid mosque (Pate island)	11-Jan- 15 @ 11:20hrs	11-Jan-15 @ 15: 25hrs	0.44
Hindi mosque	12-Jan- 15 @ 08:20hrs	12-Jan-15 @ 12: 20hrs	0.67
Jipe village	12-Jan- 15 @ 09:20hrs	12-Jan-15 @ 13: 20hrs	0.23
Mokowe Primary School	12-Jan- 15 @ 13:50hrs	12-Jan-15 @ 17: 50hrs	0.32
Bobo village	13-Jan- 15 @ 09:05hrs	13-Jan-15 @ 13: 05hrs	0.18
Ingini village	13-Jan- 15 @ 11:20hrs	13-Jan-15 @ 15: 20hrs	0.31
Kwasasi (project site)	15-Jan- 15 @ 08:55hrs	15Jan-15 @ 12: 55hrs	3.67

Table 5-5: SO_2 Monitoring Results

Monitoring Point	Monitoring Duration (minutes)	SO2 Results ($\mu g/m^3$)
Bargoni village	888	BDL
Ngini village	816	BDL
Bobo village	745	BDL
Jipe village	735	BDL
Hindi	840	-
Mokowe primary school	730	BDL
Mikanjuni island	864	BDL
Mtangawanda jetty – Pate island	820	-
Masjid mosque – Pate island	865	BDL
Project site - Kwasasi	768	BDL

Key:

BDL: Findings were below the detection limits i.e. 1.0µg/filter (10 $\mu g/m^3$)

" – " The sampling diffusion tubes were either destroyed or missing

Table 5-6: NO_2 Monitoring Results

Monitoring Point	Monitoring duration (minutes)	NO_X Results ($\mu g/m^3$)
Bargoni village	888	17.3
Ngini village	816	9.42
Bobo village	745	15.5
Jipe village	735	5.2
Hindi	840	-
Mokowe primary school	730	3.2
Mikanjuni island	864	2.2
Mtangawanda jetty – Pate island	820	-
Masjid mosque – Pate island	865	26.6
Project site - Kwasasi	768	10.0

5.6.3 Meteorological conditions

The climate of Lamu County is difficult to describe accurately because there are very few recording stations. However, the climate is related to the regional climatic patterns, the bi-annual movement of the Inter-tropical Convergence Zone and the two Monsoons, namely the North-Eastern ('Kazkazi') and the South-Eastern ('Kuzi').

5.6.3.1 Temperature

Table 5-7 indicates the average, average maximum and average minimum temperature data in Lamu measured over a period of 15 years. It also indicates the lowest and highest recorded temperature.

[1]Table 5-7: Air temperature records in Lamu

Parameter	Yearly average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average temperature (^{0}C)	27	28	28	29	28	27	26	25	25	26	27	28	28
Average high temperature (^{0}C)	28	30	30	31	30	28	27	26	26	27	28	30	30
Average low temperature (^{0}C)	26	26	26	27	27	26	25	24	24	25	25	26	26
Highest recorded temperature (^{0}C)	39	33	35	37	38	36	30	29	30	32	37	39	35
Lowest recorded temperature (^{0}C)	15	17	17	16	15	18	20	17	20	20	18	16	16

5.6.3.2 Wind

Figure 5-6 presents the mean monthly wind statistics for Lamu island based on observations taken between 06/2010 - 07/2015 daily from 7am to 7pm local time.

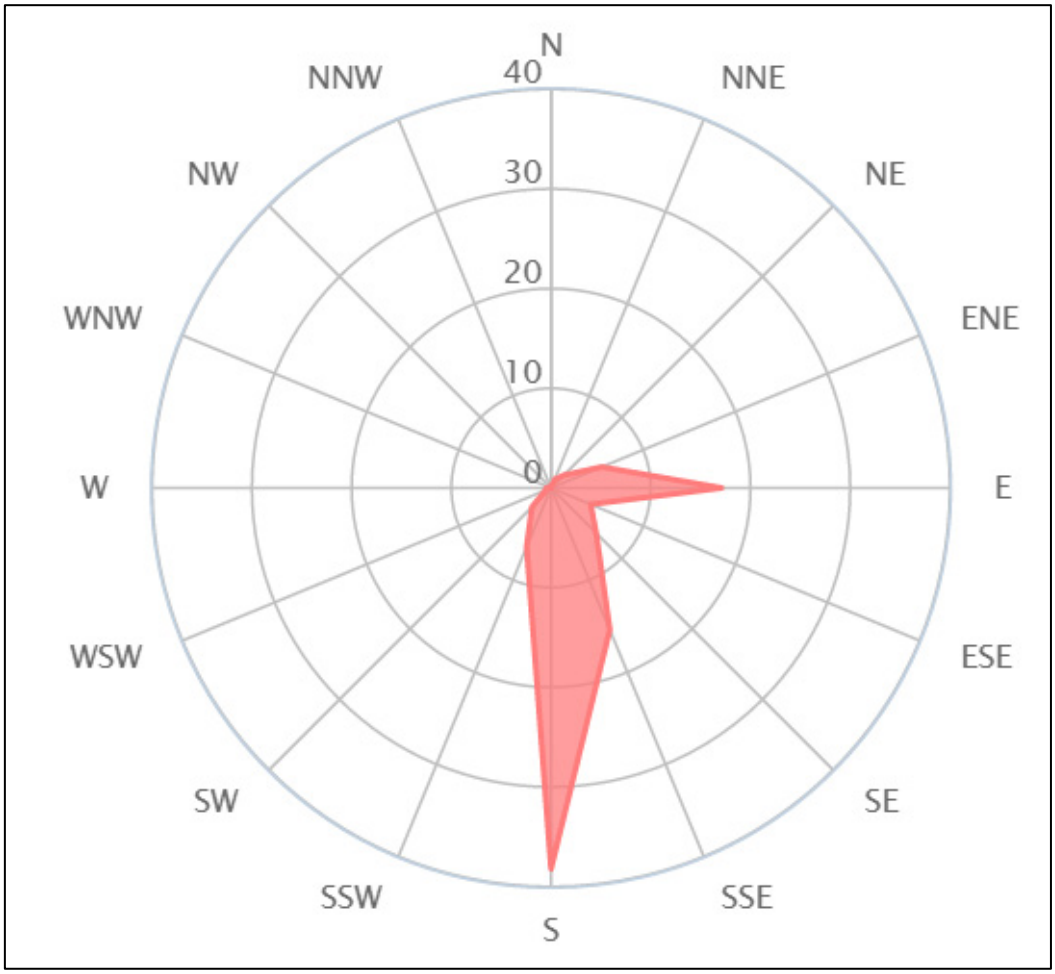
[1] Source: http://www.weatherbase.com (sampling period of 15 years – accessed July 2015)

[2]Figure 5-6: Mean monthly wind statistics for Lamu

Month of year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	01	02	03	04	05	06	07	08	09	10	11	12	1-12
Dominant Wind dir.	←	←	←	↑	↑	↑	↑	↑	↑	↑	↖	←	↑
Wind probability >= 4 Beaufort (%)	31	31	19	27	34	43	18	25	29	13	11	19	25
Average Wind speed (kts)	10	10	9	10	10	10	9	9	10	8	7	9	9
Average air temp. (°C)	29	30	31	32	29	28	28	28	29	30	30	31	29

Figure 5-7 shows the all year wind direction distribution for Lamu island based on observations taken between 06/2010 - 07/2015 daily from 7am to 7pm local time. Prevailing winds are from the South (38.2% of the time) and East (17.1% of the time) – source: http://www.windfinder.com/windstatistics/lamu_manda_airport - accessed on August 13, 2015.

[3]Figure 5-7: All year wind direction distribution for Lamu island



[2] Source: http://www.windfinder.com/windstatistics/lamu_manda_airport (accessed July 2015)
[3] Source: http://www.windfinder.com/windstatistics/lamu_manda_airport (accessed July 2015)

The numbers on the diagrams represent the percentages of time in which the average wind was blowing from a certain direction. The radius of each of the twelve segments represents the percentage of time that the wind blows from each direction segment.

5.6.3.3 Rainfall

The rainfall pattern in Lamu is bimodal with the long rains falling throughout the county from mid-April to the end of June with light showers in July. May is the wettest month. The short rains fall in November and December. January to March are usually dry months. The degree of reliability of the short rains decreases from south to north.

The amount of rainfall in the long rains decreases from a strip of about 10 km wide from the coastline into the hinterland at a rate of about 100 mm per 5 km. The short rains increase from the coastline for the first 10 km and then decrease again. The highest average annual rainfall above 1000 mm occurs about 5-20 km inland. It is however, interrupted by Mkunumbi Bay. Generally, rains in the County are likely to be heavy every 3 or 4 years and relatively light in the intervening periods. The County lies within the 600 to 1,000 mm isohyets and has three rainfall zones. The northern part of the County is semi-arid with an average annual rainfall of just over 500 mm. In the middle section, an annual rainfall of 750 mm is common. In the Southern coastal parts, rainfall in excess of 1,000 mm per year is common. The average annual rainfall thus decreases from south to north. Throughout most of the district, there is more than 30% chance of receiving less than 500 mm of rain in any one year, and in the more semi-arid north, there is more than 30% chance of receiving less than 380 mm in a year.

Rainfall data for Lamu is shown in Table 5-8.

[4]Table 5-8: Average monthly rainfall (1906 - 1985) in Lamu in millimeters

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
5.6	2.7	24.8	134.7	360.1	169.0	81.4	41.5	40.2	41.7	33.0	26.2	961.3

5.6.3.4 Relative humidity

Table 5-9 shows the relative average monthly humidity in percentage (%) measured in Lamu over a 5 year period.

[5]Table 5-9: Average monthly morning, evening and dew point humidity at Lamu (%)

Parameter	Yearly average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Morning	87	88	88	87	88	87	82	81	82	84	88	91	91
Evening	67	62	61	61	70	76	72	70	69	68	66	66	65
Dew point	22	22	22	23	24	23	21	21	21	21	22	23	23

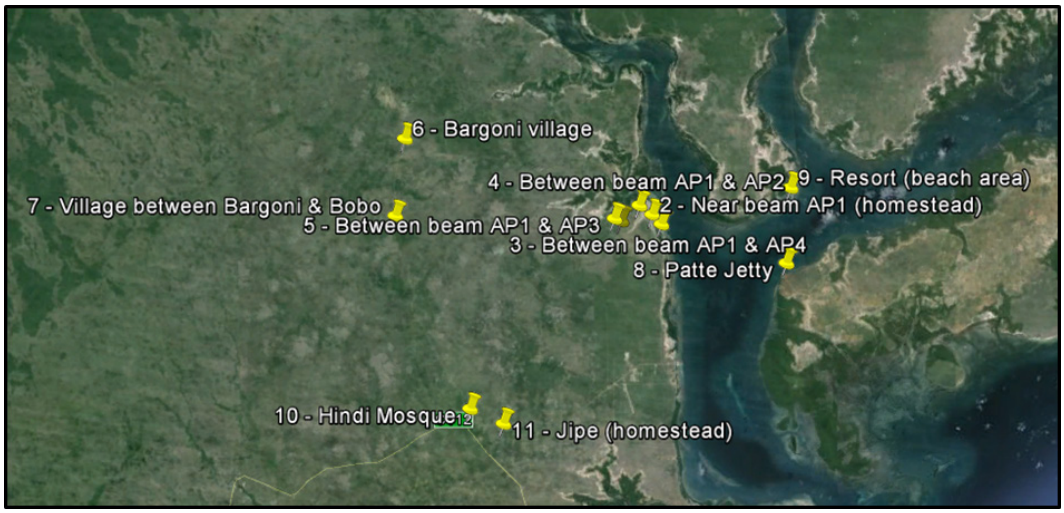
[4] Source: http://www.worldclimate.com/cgi-bin/data.pl?ref=S02E040+2100+63772W – accessed on August 13, 2015

[5] Source: http://www.weatherbase.com (sampling period of 15 years – accessed July 2015)

5.7 Noise quality

An ambient noise survey was conducted for the Project for period of 6 days from 10th January 2015 to the 15th of January 2015. The results of this survey were used to undertake noise modelling based on the types of equipment that will be used during the construction and operational phases of the project. A total of 11 daytime noise measurements were taken at locations along the Project boundary and various locations extending more than 1.5 km from the Project boundary as shown in Figure 5-8.

Figure 5-8: Locations of Ambient Noise Monitoring Locations



5.7.1 Sensitive areas

From a survey of the Google Earth satellite imagery and project drawings provided by the EPC contractor, eleven (11) locations were included in the baseline survey carried in January 2015. These locations and receptors are detailed in Figure 5-9 and 5-10 and Table 5-10 below.

Figure 5-9: Locations of Ambient Noise Monitoring Locations (All Locations)

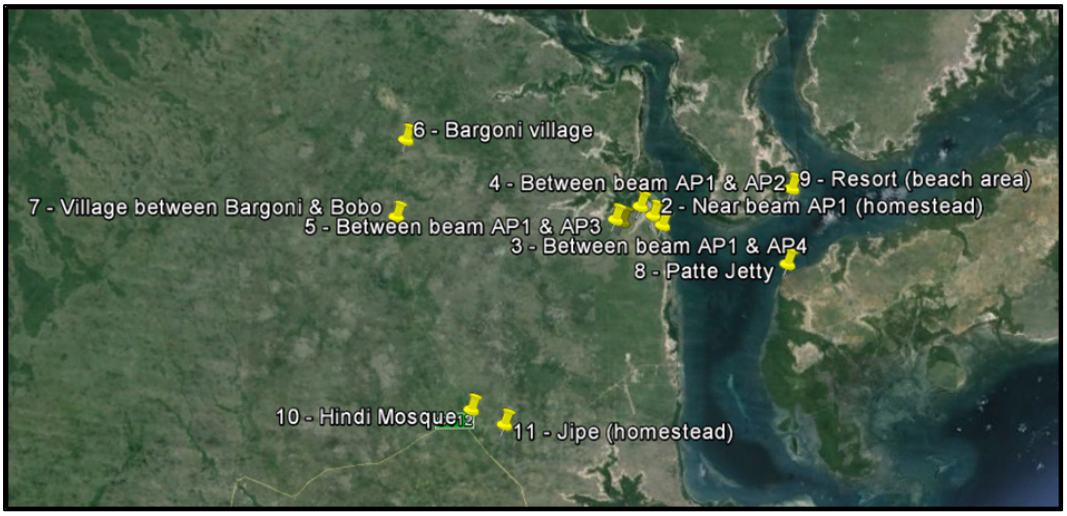


Figure 5-10: Locations of Ambient Noise Monitoring Locations (up to 1.5 km from Project Boundary)

The measurement of baseline noise is used to determine the ambient noise climate of the Project area. For the purposes of this modelling assessment, it is considered most conservative to adopt the lowest L_{Aeq} value measured on the site boundary (record No. 3 - Between beam AP1 & AP4) for use as the baseline noise level for any other locations on the boundary for which no measurement was collected, which in this case is equal to 43.8 dB(A).

5.7.2 Noise levels

The baseline noise levels measured at the eleven receptors identified are given below.

Table 5-10: Baseline Noise Levels and Receptor Descriptions

No.	Description	Coordinates	Noise Level L_{Aeq} (dB(A))				Ambient Noise Description
			L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}	
1	Near beam AP4 (homestead)	S02°05'19.6" E040°53'30.0"	53.0	31.9	54.2	85.8	(No record)
2	Near beam AP1 (homestead)	S02°05'09.3" E040°54'25.0"	47.3	39.0	50.9	68.6	(No record)
3	Between beam AP1 & AP4	S02°05'26.4" E040°54'41.0"	43.8	39.8	46.3	58.8	Waves from the ocean
4	Between beam AP1 & AP2	S02°04'52.8" E040°54'02.4"	49.4	44.2	51.7	66.9	General domestic noise

No.	Description	Coordinates	Noise Level L_{Aeq} (dB(A))				Ambient Noise Description
			L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}	
5	Between beam AP1 & AP3	S02°05'15.5" E040°53'18.3"	44.1	31.9	43.8	60.2	Birds
6	Bargoni village	S02°02'49.6" E040°47'10.0"	42.2	35.0	42.6	64.5	Noise from the mosque, traffic and domestic noise
7	Village between Bargoni & Bobo	S02°05'05.6" E040°46'51.4"	43.2	37.3	46.9	54.2	General public noise
8	Patte Jetty	S02°06'38.0" E040°58'21.0"	58.9	55.4	61.0	71.2	Traffic (motor vehicles and motorcycles), boats, ocean waves and general public noise
9	Resort (beach area)	S02°04'24.8" E040°58'30.1"	46.9	44.3	48.9	52.1	Ocean breeze
10	Hindi Mosque	S02°10'47.8" E040°48'59.1"	51.0	46.4	53.2	65.1	Traffic along Hindi road
11	Jipe (homestead)	S02°11'14.9" E040°49'57.4"	47.5	43.0	50.2	59.5	Domestic noise from chicken/ hens and dog barking

Based on initial screening, a number of NSRs were selected for assessment in this study as shown in Table 5-11. This selection has been based on the location/receptors proximity to the Project facility, and sensitivity to the construction and operational phases of the Project.

Table 5-11: Selected NSRs for Noise Impact Assessment

Noise Sensitive Receptor and Description		IFC receptor classification	Ambient Day/Night time Noise Limits[1] dB(A)	Baseline Day Time Ambient Noise dB(A)
NSR1 [2]	Near beam AP4 (homestead)	Residential	55 / 45	53.0
NSR2 [2]	Near beam AP1 (homestead)	Residential	55 / 45	47.3
NSR3 [2]	Between beam AP1 & AP4	Residential	55 / 45	43.8

Noise Sensitive Receptor and Description		IFC receptor classification	Ambient Day/Night time Noise Limits[1] dB(A)	Baseline Day Time Ambient Noise dB(A)
NSR4 [2]	Between beam AP1 & AP2	Residential	55 / 45	49.4
NSR5 [2]	Between beam AP1 & AP3	Residential	55 / 45	44.1
NSR6 [3]	Dormitory (Northwest corner)	Residential	55 / 45	43.8
NSR7 [3]	Dormitory (Northeast corner)	Residential	55 / 45	43.8
NSR8 [3]	Worker Camp (Northwest corner)	Residential	55 / 45	43.8
NSR9 [3]	Worker Camp (Northeast corner)	Residential	55 / 45	43.8
NSR10 [3]	Worker Camp (Southwest corner)	Residential	55 / 45	43.8

Note 1: Standards in accordance with IFC EHS guidelines noise limits
Note 2: NSRs 1 to 5 are classified as existing receptors
Note 3: NSRs 6 to 10 are classified as new receptors associated with worker accommodation areas

NSRs 1 to 5 are existing receptors and are representative of the impact to the existing community. NSRs 6 to 10 are considered representative of locations which will be constructed for the purpose of accommodation of workers. As these NSRs fall within the boundary of the Project site, the land use classification is technically industrial, however, given that they are designed to accommodate workers, they have been classified as residential receptors under the IFC guidelines. In the case of new NSRs, assessment was done using a direct comparison against the IFC standard, and not the change in noise from the existing ambient noise levels.

5.8 Marine ecology and sea water quality

5.8.1 Marine Biodiversity

Marine resources in Lamu County are well represented by three major communities: mangroves, sea grasses and coral reefs. The proposed Lamu coal power plant will be located next to Manda Bay that is well sheltered from the open ocean. This area is in the Northern Monsoon Current Coast ecoregion, with closer ties to the Somali coast and northern locations than to the East African Coastal Current (EACC) to the south. It experiences seasonal reversal in the flow of the two currents in response to monsoon seasons. This affects the oceanography of the area, which is characterized by upwelling of cooler nutrient rich waters.

The upwelling results in a highly productive marine ecosystem with rich populations of fish, crustaceans and mollusks, and high abundance of migratory species such as seabirds and turtles. The three main marine ecosystems (i.e., mangroves, sea grasses and coral reefs) are strongly interlinked and dependent on each other ecologically. The mangroves protect sea grasses and coral reefs from terrestrial natural and anthropogenic influences e.g., sedimentation and pollution while coral reefs protects mangroves and sea grasses from strong waves. Sea grasses filter sediments and take-up nutrients and in the process control sediments from reaching coral reefs, which are so sensitive to turbid water.

5.8.1.1 Mangroves

Mangroves of Lamu constitute 75% of mangrove forest cover in Kenya that is approximately 45,960 ha or 3.0 % of the country's forest cover (Kirui et al. 2012). Mangroves of Lamu are found in creeks, protected bays and islands, mostly in intertidal zones that have continuous seepage or discharge of ground freshwater. Seven of the nine species of mangroves found in Kenya occur in Lamu, with *Rhizophora mucronata, Ceriop tagal* and *Avicennia* marina being the dominant species (Abuodha & Kairo 2001; Taylor et al. 2003). Mangroves forests provide a wide range of ecosystem goods (including fuel wood, medicine, food, construction materials) and services (including fisheries nursery grounds, sediment trapping and sewage phytoremediation) that are of immense value to local, national and global communities (Barbier et al. 2008).

5.8.1.2 Sea grasses

Sea grasses occur between mangroves and coral reefs zones in the intertidal and subtidal areas, though they have ability to grow in 40m under water. The West Indian Ocean (WIO) region has 13 sea grasses species (Gullström et al. 2002), compared to global richness of 60 species (Short et al. 2007). In addition the East African region together south Asia and south Australia to eastern Pacific with 24 species constitute one of the six recognized global bioregions based on taxonomy and physical separation of the world's oceans. Just like the other sections of marine system in Kenya, Lamu has large areas under seagrasses area and are well represented by roughly 13 species (Short et al. 2007). Sea grasses have very high primary production and a complex habitat structure that support a variety of benthic, demersal and pelagic organisms. Many fish and shellfish species, including those of commercial interest, are attracted to seagrass habitats for foraging and shelter, especially during their juvenile life stages (Gullström et al. 2002). Seagrasses found in Kenya grow on limestone type of soils that are muddy. The organic loading is critical to growth of seagrasses, because it affects the oxygen content which they need to avoid anoxic conditions.

5.8.1.3 Coral reefs

Coral reefs are well represented along the Kenyan coastline. A 200km fringing reef dominates in the south while in the north the fringing reef is broken and occur in patches due discharges from rivers and cold upwelling Somali Currents. Compilation of coral information in the WIO for the last decade found 369 species of corals, with the majority (90%) being broadly distributed from East Africa to theWest Pacific (Obura 2012). In addition biogeographical assessment shows that coral reef communities in the south (Malindi to Dar re Salam) were significantly different from those in north (Kiunga and Somali). About two million people live on the Kenyan coast, mainly around Mombasa, with a significant percentage of them using reefs for fishing and tourism activities (Obura et al. 2002).

5.8.1.4 Sandy beaches

Sandy beaches are well represented in the Lamu. However the project area coast has narrow stretch (50 to 100m) wide, that was interspersed with mangroves forests. Sandy beaches are important feeding grounds for numerous bird species as well as habits for crabs and marine turtles.

5.8.2 Marine baseline survey

In order to carry out coastal wetlands and marine ecological assessment for the proposed 1,050MW coal power plant, a general survey was conducted for the entire footprint area of the coal power plant to assess the presence and distribution of coastal wetlands and marines critical habitats. This was carried out with the help of key informants' who provided important local ecological information on distribution and abundances of species and habitats. Key informants included chairmen of mangrove cutter associations, Beach Management Units (BMU), local leaders and administrators. Ecological information obtained was corroborated with government records and published data and literature in journals and reports.

For the marine habitats, three transects were made from shore line to the deepest point in ocean area where a jetty and several structures will be erected for intake and discharge of water for the cooling system (Figure 5-11). Each transect started from the highest watermark (HWM), perpendicular to the shore line, to a distance of between 3km to 6 km off-shore. Sampling of mangroves, sea grasses and coral reefs was carried along the three transects employing gradsect or gradient-directed transects (Bullock 2013). The method comprises establishing transects to sample intentionally the full range of floristic variation over a study area by placing quadrants at the points along the gradsect or point quadrats or line transects.

In the mangrove sections, sampling consisted of walking along transects and recording all mangroves species present in 10x10m quadrants, spaced 20 metres apart. Also observations were made on the general conditions of mangrove forest, soil and presence of human activities such as fishing, tree harvesting and natural phenomena such as beach erosion. One composite sediment sample was taken for analysis of soil physical and chemical properties as well as heavy metals.

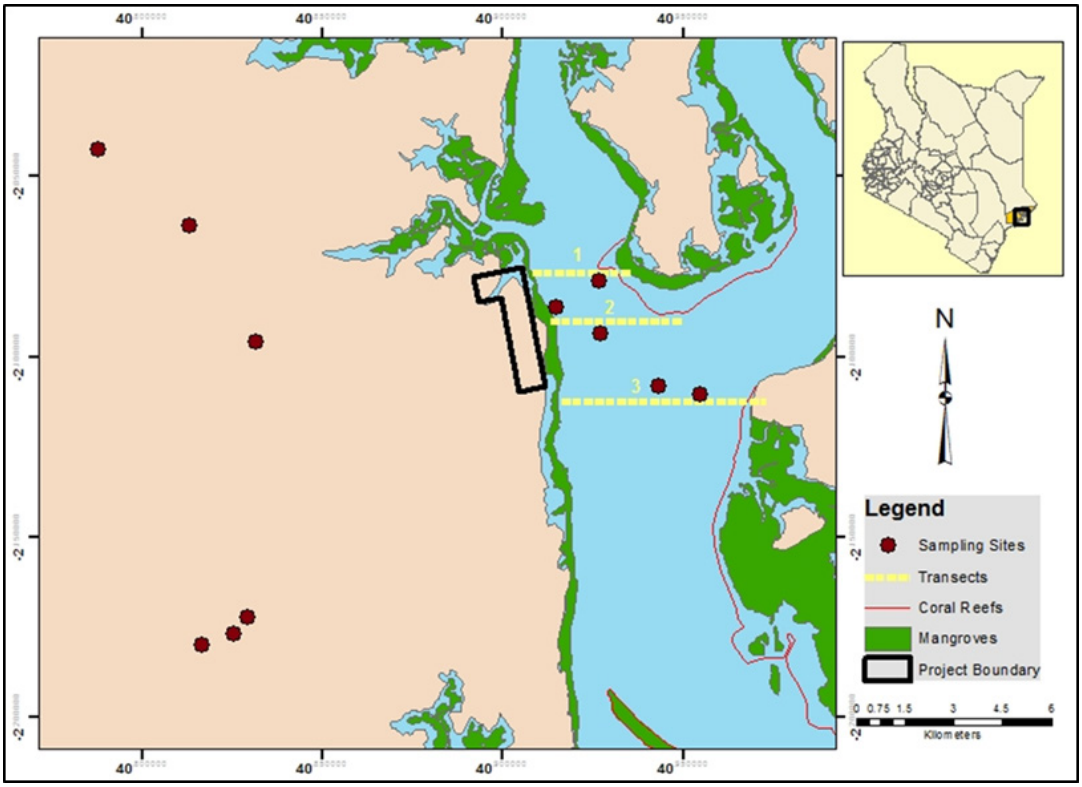
Occurrences of sea grasses were assessed by establishing quadrants of 10x10m, 250 metres apart along the three transects. In each quadrant the dominant species were used to characterize that zone or area.

Diving survey techniques were used to assess distribution and occurrences of coral reef. The area under coral reefs, sea grasses, sand and boulders was estimated along the three transects, primarily where water samples for water quality analyses were taken. More information on the general topography, distribution of sea grasses and coral reefs was solicited from key informants, fishers, mangrove cutters, fisheries and forestry officers. This information was enhanced with information published on marine biodiversity resources in the area.

Other marine taxonomic groups assessed in the study area were fisheries, macroinvertebrates, birds, sponges and algae. Information on occurrences of fishery species was solicited from key informants, representatives of BMUs and mangroves cutters who have local knowledge on where fish spawn, feed and dwell. This information was enriched with data and information obtained from Lamu County Fisheries Department and published literature (Anam & Mostarda 2012) including macroinvertebrates, birds, sponges and algae recorded along the coastline in mangroves, beaches and sea grasses meadows.

The IUCN red list for threatened species was used to determine species of conservation importance within the project zone of influence. The conservation status of species was determined by searching the scientific names of observed species on IUCN's online database. Emphasis was laid on species that were Critically Endangered, Endangered, Vulnerable, or Near-Threatened. In addition, national checklists were also used to document vulnerable species. All habitats recognized as important and critical for biodiversity conservation within Lamu County were identified and their major biodiversity concerns within them profiled. These included National Parks, National reserves and important biodiversity areas. The likelihood of species ranging into the proposed project site was also reviewed.

Figure 5-11: Map showing three marine transects



5.8.2.1 Marine habitats characterization

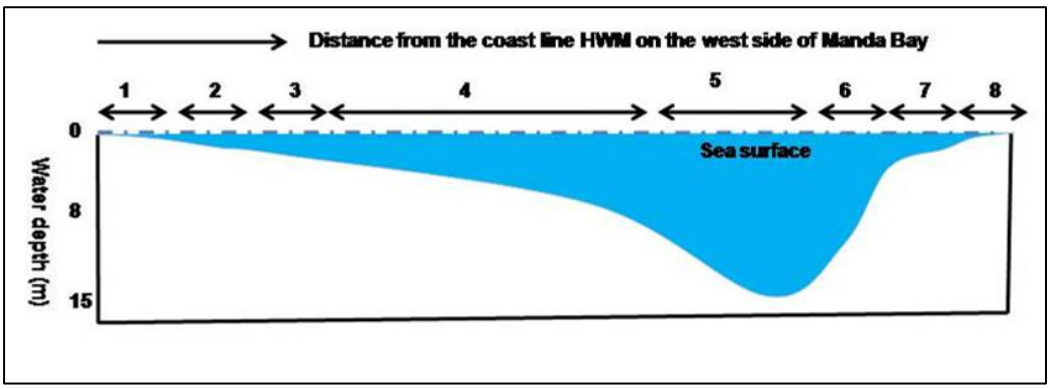
Marine habitats were characterized along three transects (Figure 5-11). It involved profiling and describing topography and substrate of the sea bottom along transects as well as location of various habitats from and at which depth from the Highest Water Mark (HWM). Generally three different topography types constituted the bottom of the ocean at Manda Bay in response to sea bed topography and slope gradient. The sea bed from HWM up to a distance of 2km offshore is very gentle sloping gradients and shallow up to a depth of 5m. Then followed a by steep gradient for the next one to two km with depth ranging from 6 to 60 metres.

Transect 1: The topography from the HWM is flat with sand deposits for 100 metres, followed by patches of mangroves forests with muddy-silty-sandy substrates for 100 metres and then 100 metres of exposed sandy and muddy beaches (Figure 5-12). From the lowest water mark (LWM) is gentle sloping seabed of sand, silt, rocky and sea grasses beds for 1.5 km (Table 5-12). Between 400m – 1500m from the shoreline, the water is moderate to clear and goes up to a depth of 9m. The length of Transect 1 was approximately 3km.

Table 5-12: Sea bed habitats, zones and topography characterization at Transect 1

Zone (from shore seawards)	Zone (m)	Depth from the HWM (m)	Sea bed habitats and coverage
1	150m	0m	100% sandy
2	150m	0.5-2m	100% mangroves, 100% silt-sandy and muddy substrates
3	100m	2-3m	100% silt-sandy
4	1500m	3-9m	50% sandy-muddy bottom and 50% rocks covered with sea grasses and algae
5	500m	9-15m	100% sandy – rocky bottom, 20 % coral reef patches
6	300m	9-3m	50% sandy-muddy bottom 50% rocks covered sea grasses and algae
7	200m	3-3m	100% mangroves, 70% silt muddy and 30% sandy.
8	100m	0-1m	100% sandy

[6]Figure 5-12: Bottom cross-section profile at Transect 1



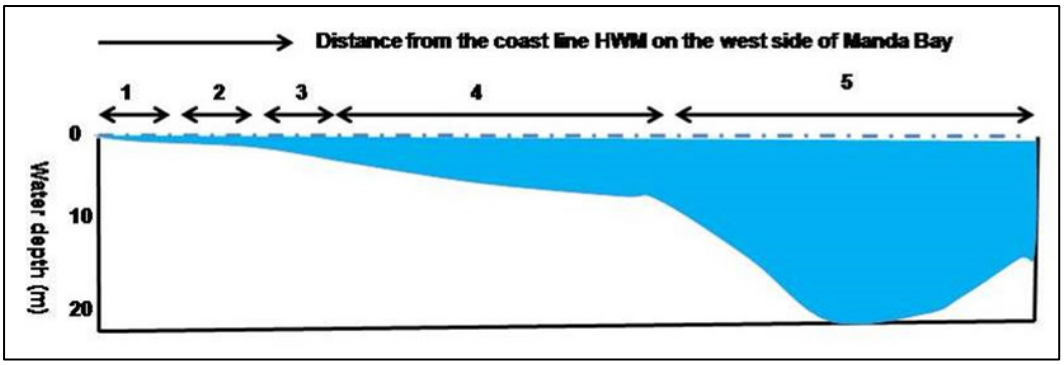
Transect 2: The topography from the HWM is flat with sand deposits for 100 metres, followed by a stretch of mangroves forests with muddy-silty-sandy substrates for 200 metres and then 100 metres of exposed sandy-muddy beaches (Figure 5-13). From LWM, the sea bed is gentle sloping and consists of sand, silt, rocky and sea grasses beds for 1.5 km (Table 5-13). The water is moderate to clear and goes up to a depth of 8m. It is then connects with deep sections of Manda Bay (9m to 20m). The bottom is covered by coral reefs, sea grasses and sandy areas. Transect Two is approximately 3.5km.

[6] Numbers 1 to 8 refers to zones' habitats and coverage as give in Table 4-10

Table 5-13: Bottom zonation and coverage at Transect 2

Zone (from shore seawards)	Zone (m)	Depth from the HWM (m)	Sea bed habitats and coverage
1	100m	0m	100% sandy
2	200m	0.5-2m	100% mangroves, 100% silt-sandy and muddy substrates.
3	100m	2-3m	100% silt-sandy
4	1500m	3-9m	30% sandy-muddy bottom and 70% rocks covered with sea grasses and algae
5	1000m	9-20m	50% coral reefs, 30% sea grasses and 20% rock bottom

[7]Figure 5-13: Bottom cross-section profile at Transect 2



Transect 3: The topography from the HWM is flat with sand deposits for 200 metres, followed by mangroves forests with muddy-silt-sandy substrates for 300 metres and then 200 metres of exposed slightly muddy sandy beaches. From the LWM, the seabed is gentle sloping with sand, silt, rocky and sea grasses beds for 1.6km (Table 5-14, Figure 5-14). The water is moderate to clear and attaining a depth of 10 metres. It is then followed by the deep sections of Manda Bay (11 to 25 metres) covering a width of 3km. The sea bed is covered with rocks, coral reefs, sea grasses and sand. Transect 3 is approximately 6km wide.

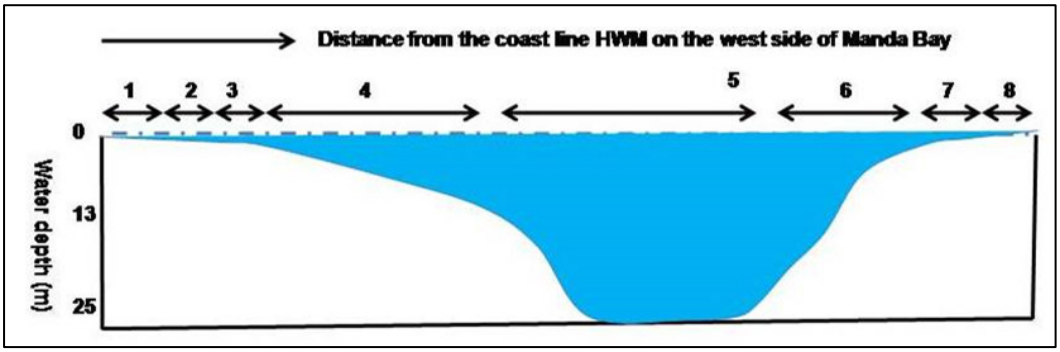
Table 5-14: Bottom zonation and coverage at Transect 3

Zone (from shore seawards)	Zone (m)	Depth from the HWM (m)	Bottom coverage
1	200m	0m	100% sandy
2	300m	0.5-2m	100% mangroves, 100% sandy-silty muddy bottom
3	200m	2-3m	100% silty sandy

[7] Numbers 1 to 5 describe zones' habitats and coverage as given in Table 4-11

Zone (from shore seawards)	Zone (m)	Depth from the HWM (m)	Bottom coverage
4	1600m	3-9m	50% sandy-muddy bottom and 50% rocks covered with sea grasses and algae
5	2500m	9-15m	100% sandy – rocky bottom, 20 % Coral reef patches
6	1000m	9-3m	50% sandy-muddy bottom 50% rocks covered sea grasses and algae
7	100m	3-3m	100% mangroves, 70% silt muddy and 30% sandy.
8	100m	0-1m	100% sandy-muddy bottom

Figure 5-14: Bottom cross-section profile at Transect 3. Numbers 1 to 8 describes habitats and coverage as given in Table 12



5.8.3 Coastal wetlands, marine water quality and sediment assessment

Water and sediment from marine and freshwater habitats around the project site are shown in Figure 5-15. Samples for coastal wetlands were collected from both freshwater sites (sites 2, 8, 10 and 13) and boreholes (6 and 9) whilst those of marine habitats were obtained from sites labeled as 1, 2, 4, 5 and 15-18. Sediment samples were obtained from four marines sites (1, 3, 13 and 18), with only one from Mbele Mbele wetland (Site 8). All samples were collected independently by SGS Kenya Limited and analyzed at the Laboratory in Mombasa according to applicable local and international standards and guidelines for sampling and analysis. Measured levels will act as baseline levels for future monitoring.

Measured water quality parameters are those whose limits have been set in the NEMA's water quality regulation (Environment Management and Coordination (Water Quality) Regulations, 2006). They include total suspended solids (mg/l), total dissolved solids (mg/l), Fluoride as F- (mg/l), Residual chlorine (mg/l), oil and greases % wt, total Nitrogen (mg/l), total cyanide (mg/l), phosphate in water (mg/l), chemical oxygen demand (mg/l), total phenols (mg/l), BOD 5 @ 20oC (mg/l), sulphides (mg/l), salinity (ppt), arsenic as As (mg/l), cadmium as Cd (mg/l), chromium as Cr (mg/l), copper as Cu (mg/l), iron as Fe (mg/l), nickel as Ni (mg/l), selenium as Se (mg/l), zinc as Zn (mg/l), total phosphorus as PO4 (mg/l), total coliform count (MPN/100ml), E. coli (MPN/100ml), permanganate index (mg/l) and anionic surfactants as MBAS (mg/l).

Similarly sediment analyses determined total cyanide (mg/kg), TPH C6-C44 (mg/kg), TPH C10 - C16 (mg/kg), TPH C16 - C22 (mg/kg), pH, arsenic as As (mg/kg), cadmium as Cd (mg/kg), chromium as Cr (mg/kg), copper as Cu (mg/kg), iron as Fe (mg/kg), nickel as Ni (mg/kg), lead as Pb (mg/kg), selenium as Se (mg/kg), zinc as Zn (mg/kg), mercury as Hg (mg/kg), total phenol (mg/kg), total nitrogen (C%), phosphates as PO4 mg/kg, organic matter (% wt), sulphides mg/l and total carbon (C %).

The results of the sampling and analysis are provided in table 5-15.

Figure 5-15: Marine water and sediment quality sampling locations

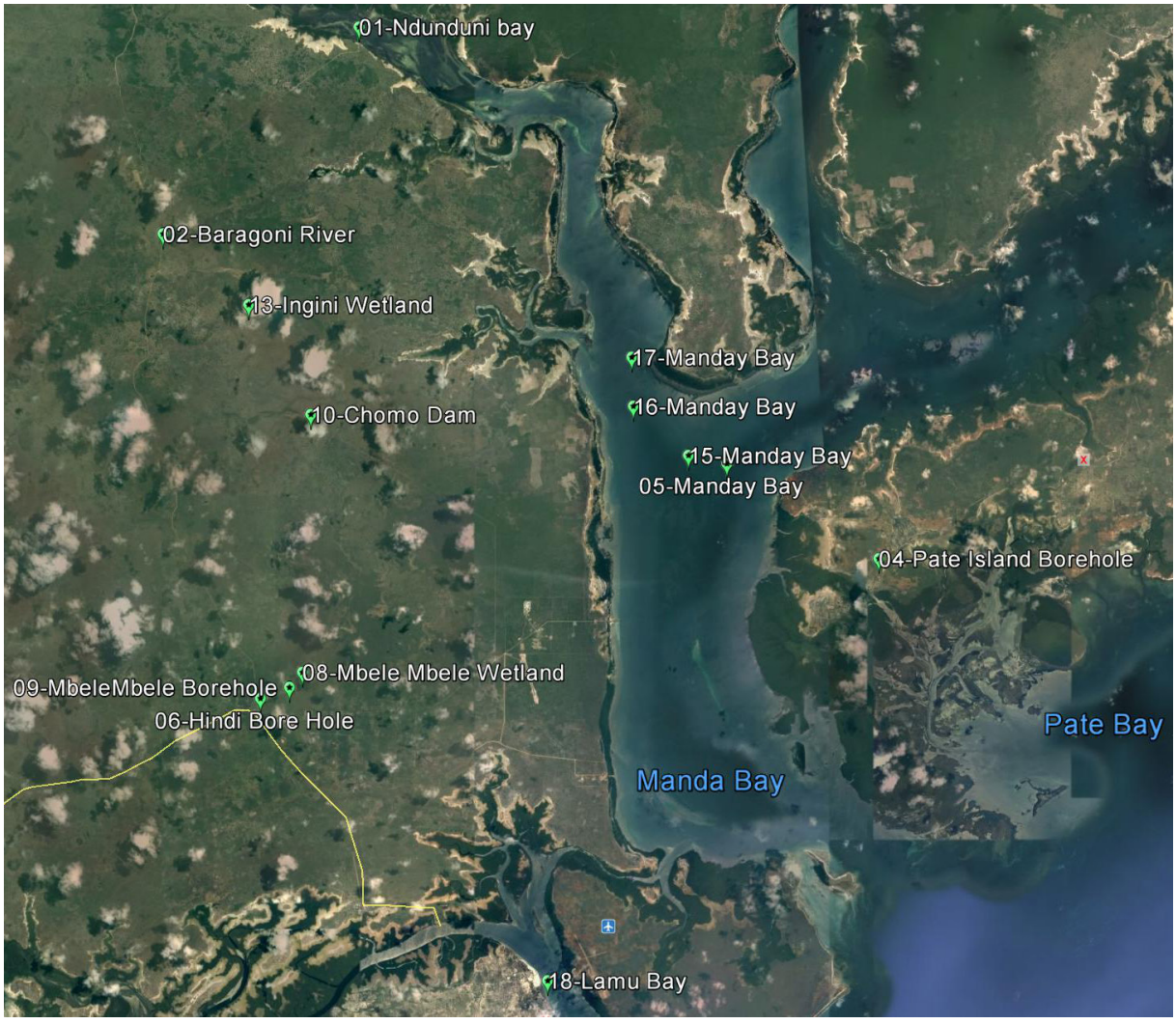


Table 5-15: Water quality measurements for Coastal wetlands, boreholes and marine

Site Number	1	2	4	5	6	8	9	10	13	15	16	17	18
Types of habitat	Marine	Coastal wetland	Bore hole	Marine	Bore hole	Coastal wetland	Bore hole	Coastal wetland	Coastal wetland	Marine	Marine	Marine	Marine
Site Name	Ndununi Bay	Baragoni River	Pate Island Borehole	Manday Bay	Hindi Bore Hole	Mbele Mbele Wetland	Mbele Mbele Borehole	Chomo Dam	Ingini Wetland	Manday Bay	Manday Bay	Manday Bay	Lamu Bay
Latitude (south)	-1.98125	-2.04256	-2.13872	-2.1106	-2.1801	-2.17236	-2.17684	-2.09603	-2.06352	-2.10814	-2.09359	-2.07908	-2.26372
Longitude (East)	40.845766	40.78765	40.99983	40.95481	40.81652	40.82898	40.82512	40.83148	40.81308	40.94342	40.92707	40.92661	40.90167
Ambient temperature (ºC)	30.5	30.9	29	29.4	26.6	31.4	25.7	29.1	29	26.9	27.3	28.9	28.3
Temperature	29.4	28.3	26.1	30	28.8	31	29.6	29.6	29.7	28	28.5	28	28
pH	7.4	6.8	7.2	6.13	6.7	6.73		6.92	7.22	7.84	7.79	7.89	7.62
Total Suspended Solids (mg/l)	2	6	5	2	2	8	2	4	2	2	2	2	5
Total Dissolved Solids (mg/l)	31860	133	4512	30660	1036.8	265	468	67.2	30360	31560	31680	30600	32886
Fluoride as F- (mg/l)	1.77	0.55	0.96	1.93	0.41	0.47	0.21	0.1	1.77	2.54	1.52	1.7	1.5
Residual chlorine (mg/l)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Oil and Greases % wt	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Total Nitrogen (mg/l)	5.8	0.9	64.84	0.99	38.74	10.6	45.66	9.28	3.8	4.42	4.7	1.46	133.63

Site Number	1	2	4	5	6	8	9	10	13	15	16	17	18
Types of habitat	Marine	Coastal wetland	Bore hole	Marine	Bore hole	Coastal wetland	Bore hole	Coastal wetland	Coastal wetland	Marine	Marine	Marine	Marine
Site Name	Ndununi Bay	Baragoni River	Pate Island Borehole	Manday Bay	Hindi Bore Hole	Mbele Mbele Wetland	Mbele Mbele Borehole	Chomo Dam	Ingini Wetland	Manday Bay	Manday Bay	Manday Bay	Lamu Bay
Latitude (south)	-1.98125	-2.04256	-2.13872	-2.1106	-2.1801	-2.17236	-2.17684	-2.09603	-2.06352	-2.10814	-2.09359	-2.07908	-2.26372
Longitude (East)	40.845766	40.78765	40.99983	40.95481	40.81652	40.82898	40.82512	40.83148	40.81308	40.94342	40.92707	40.92661	40.90167
Total Cyanide (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Phosphate In Water (mg/l)	0.9	0.2	0.9	0.9	0.1	7.7	0.3	Nil	Nil	1.1	0.3	0.3	0.1
Chemical Oxygen Demand (mg/l)	1876	577	225	1204	659	647	452	1176	2058	1526	975	475	596
Total Phenols (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
BOD 5 @ 20°C (mg/l)	1038	320	125	669	366	356	235	528	1022	704	483	250	351
Sulphides (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Salinity (ppt)	34.7	1.2	4.1	33	1.8	1.3	1.5	0.9	31.8	34.1	34.1	32.7	35.3
Arsenic as As (mg/l)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium as Cd (mg/l)	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004

Site Number	1	2	4	5	6	8	9	10	13	15	16	17	18
Types of habitat	Marine	Coastal wetland	Bore hole	Marine	Bore hole	Coastal wetland	Bore hole	Coastal wetland	Coastal wetland	Marine	Marine	Marine	Marine
Site Name	Ndununi Bay	Baragoni River	Pate Island Borehole	Manday Bay	Hindi Bore Hole	Mbele Mbele Wetland	Mbele Mbele Borehole	Chomo Dam	Ingini Wetland	Manday Bay	Manday Bay	Manday Bay	Lamu Bay
Latitude (south)	-1.98125	-2.04256	-2.13872	-2.1106	-2.1801	-2.17236	-2.17684	-2.09603	-2.06352	-2.10814	-2.09359	-2.07908	-2.26372
Longitude (East)	40.845766	40.78765	40.99983	40.95481	40.81652	40.82898	40.82512	40.83148	40.81308	40.94342	40.92707	40.92661	40.90167
Chromium as Cr (mg/l)	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Copper as Cu (mg/l)	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Iron as Fe (mg/l)	<0.007	1.02	<0.007	<0.007	<0.007	12.57	<0.007	2.92	<0.007	<0.007	<0.007	<0.007	0.34
Nickel as Ni (mg/l)	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015
Selenium as Se (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc as Zn (mg/l)	<0.002	0.02	<0.002	<0.002	0.01	<0.002	0.02	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Total Phosphorus as PO_4 (mg/l)	0.02	0.27	0.63	0.14	0.26	12.23	0.07	0.17	0.02	0.13	0.05	0.08	0.18
Total coliform count (MPN/100ml)	23	Nd	110	23	240	>1800	79	240	8	11	23	22	>1800
E. coli (MPN/100ml)	8	Nd	8	Nd	13	>1800	23	14	Nd	Nd	2	2	>1800

Site Number	1	2	4	5	6	8	9	10	13	15	16	17	18
Types of habitat	Marine	Coastal wetland	Bore hole	Marine	Bore hole	Coastal wetland	Bore hole	Coastal wetland	Coastal wetland	Marine	Marine	Marine	Marine
Site Name	Ndununi Bay	Baragoni River	Pate Island Borehole	Manday Bay	Hindi Bore Hole	Mbele Mbele Wetland	Mbele Mbele Borehole	Chomo Dam	Ingini Wetland	Manday Bay	Manday Bay	Manday Bay	Lamu Bay
Latitude (south)	-1.98125	-2.04256	-2.13872	-2.1106	-2.1801	-2.17236	-2.17684	-2.09603	-2.06352	-2.10814	-2.09359	-2.07908	-2.26372
Longitude (East)	40.845766	40.78765	40.99983	40.95481	40.81652	40.82898	40.82512	40.83148	40.81308	40.94342	40.92707	40.92661	40.90167
Permanganate Index (mg/l)	Nil	Nil	1.96	Nil	0.16	Nil	1.57	4.81	0.49	Nil	Nil	Nil	Nil
Anionic Surfactants as MBAS (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

5.9 Terrestrial ecology

A terrestrial ecological assessment was carried out over the project area and its environs. The ecological impact assessment was conducted by specialists from the National Museums of Kenya, some of whom are national focal points for their respective discipline. Assessments carried out included:

a) Vegetation and plants;

b) Avifauna;

c) Herpetofauna;

d) Invertebrate fauna; and

e) Mammals.

Each specialist undertook a review of secondary literature on ecology available for Lamu County and the project site; this provided guidance on the field survey methods for baseline data collection.

Given below is the methodology that was employed for collection of field data on each of the above terrestrial ecological aspects.

5.9.1 Plant Survey

The plant and vegetation habitat baseline data gathering was desktop-based coupled with a rapid assessment of the site. Data was obtained specifically from the 'Recorded Plants of Kenya: A Reference Manual Giving Plant Names and their Locations in Kenya', (Waliaula, 1991) and the 'Plant Specimen Database of the East African Herbarium', a Botanical Research and Herbarium Management (BRAHMS) software support, which gives detailed account of plant species diversity and distribution.

In the rapid assessment, a plotless method as developed by Hall and Swaine (1981) and used in modification by Mwachala, et al. (2004) was used to record the plant species from 8th – 14th January, 2015. Vascular plant species were recorded and specimens collected using standard methods (Foreman & Bridson, 1992). Most of the species were identified on site whereas the difficult and unique ones were collected for confirmation at the East African Herbarium. Identification of indigenous vascular plants followed Agnew (2013), Beentje (1994) and the various publications of 'Flora of Tropical East Africa (FTEA)', (Polhill, 1952-2012) which together with the 'List of East African Plants (LEAP)', (Mwachala et al. 2011) were useful in taxonomic authentication and species distribution.

The conservation status of the species was based on the IUCN Redlist publication (IUCN, 2013) and listing undertaken by the East African Plant Redlist Authority (EAPRLA), (I-VIII, since 2006). Plants and animals species protected against trade are covered in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2015) website.

5.9.2 Avifauna Survey

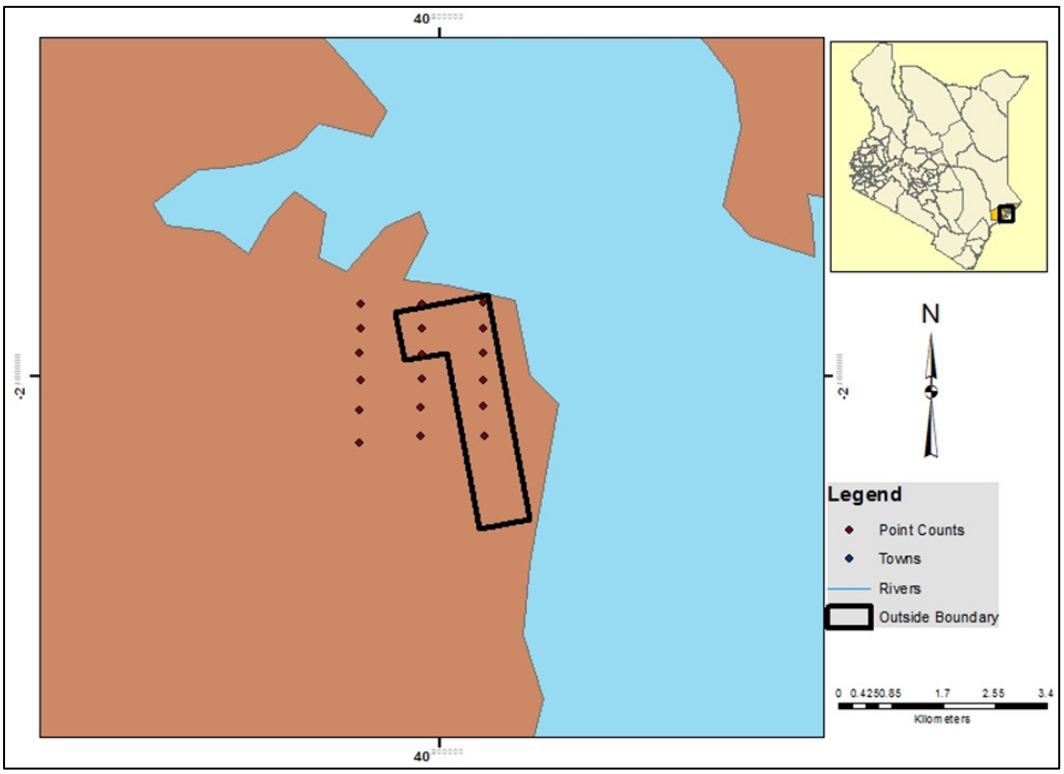
Two survey types were used to build an inventory of the bird species and their relative abundance at the site of PLCPP. These were: (i) Distribution and Abundance Surveys, where Fixed Point Counts and Timed Species Counts were used. These were used to build a species list for the site, record numbers, status (conservation, breeding and migratory status) and distribution of birds. Fixed width point counts (PCs) were set every 200m along 2km transect running North-South across the site. Three transects were set at the project site and planned buffer zone (Figure 5-16). The variables recorded for each such fixed point count included: time, species, number (number of adults/juveniles/chicks), activity (flushed, flying-display, flying-commute, perched-calling etc), cue i.e. seen or heard, distance to bird in (m), height above ground, fixed radius of count (m) and additional notes.

Timed species-counts (TSCs) method is ideal for building complete species lists quickly, and to establish the relative abundance of canopy and mid-level bird species. As many as possible 40-minute TSCs were conducted across the site and adjacent areas to cover all the different microhabitats on site. TSCs are essentially repeated lists on which are indicated the first time each species is first positively identified by sight and sound. For analysis species receive a cumulative score according to when they were first sighted on each count (ii) Vantage Point Surveys which although attempted to quantify flight activity of birds over the site and provide data for collision and displacement risk, the success was limited due to security and logistical problems on the ground.

Vantage point observations provide details on bird flight movement over the study site. An activity that is likely to be disrupted by the proposed development. Four vantage points- North, South, East and West were identified prior to the field visit and marked. We planned to spend a full day (6 a.m. to 6p.m.) at each vantage point but we only managed one point (see gaps and limitations). Ideally Vantage Point watches should be divided into three hour shifts distributed throughout the day (early morning, midday, late afternoon), to allow for observer fatigue and boredom but this was not possible. Ideally these vantage watches should be extended across a 12 month monitoring period and should provide an adequate (if minimal) sample of bird movements around the facility in relation to a representative cross-section of conditions and times of day.

The variables to be recorded for each vantage point survey include species, number (number of adults/juveniles), cloud cover, visibility, flight mode, flight direction, flight height and the movement is plotted on a topographical map.

Figure 5-16: Locations of avifauna point counts



Specialized equipment was used for gathering data accurately, quickly and efficiently. Equipment used were Binoculars (KOWA 10x42), Spotting Scope (KOWA TSN-2 60x), Field Guide (Birds of Kenya and Northern Tanzania, Zimmerman et al, 1999), GPS (Garmin E-trex 30) and a digital camera. Though avifauna field work requires a team of at least two field personnel (a spotter and recorder), we used only one person for this work.

5.9.3 Herpetofauna Survey

The study took place in the transition period between the dry and the wet season. During the study it rained only for three days whereas the rest of the days fluctuated between cloudy- misty morning and sunny afternoons. At night it was mostly cloudy and misty with some nights having slight showers.

The herpetofauna ecological field study encompassed the following: identification of habitats and microhabitats, identification of species of conservation importance as indicated by IUCN, and identification of adjacent sites and counties of Conservation Importance. A combination of field visit (Figure 5-16) and review of published literature including reports, scientific papers, maps and databases from National Museums of Kenya was used.

Amphibian and reptile sampling of species and habitats were accomplished by use of standardized time limited searches supplemented by visual encounter surveys and interviews to locals.

5.9.3.1 Time limited searches (TLS)

A 30 minute sampling period making up one time limited search (TLS) by two observers was carried out in different parts of the study site. Searches were done in all possible and amphibian micro-habitats such as wetlands, tree barks, under stones, decomposing logs, tree stumps, holes, shrubs, bushes including digging within loose soils (Karns1986, Sutherlands 1986, Heyer *et al*. 1994; Dodd, 2003). All the different species and number of reptiles and amphibians found were recorded. All the time limited searches were carried out during the day.

5.9.3.2 Visual encounter surveys (VES)

This un-standardized method used only for qualitative and semi-quantitative data mainly for presence or absence of species (Rödel & Ernst, 2004). Due to its flexibility and being opportunistic it contributes a lot in generation of species inventories.

Voucher specimens were fixed in 10% formalin after euthanasia. All the materials collected have been deposited at National Museums of Kenya (NMK), Nairobi herpetological collection. Global Positioning System (GPS) data for each point where specimens and important habitats were recorded using a Garmin receiver.

5.9.3.3 Interviews

Locals were asked question pertaining to reptiles and amphibians they encounter in the area. Initially the locals were asked to describe the species and later shown a picture of the animal in guide books (i.e. Spawls et al. 2002 and Channing and Howell, 2006).

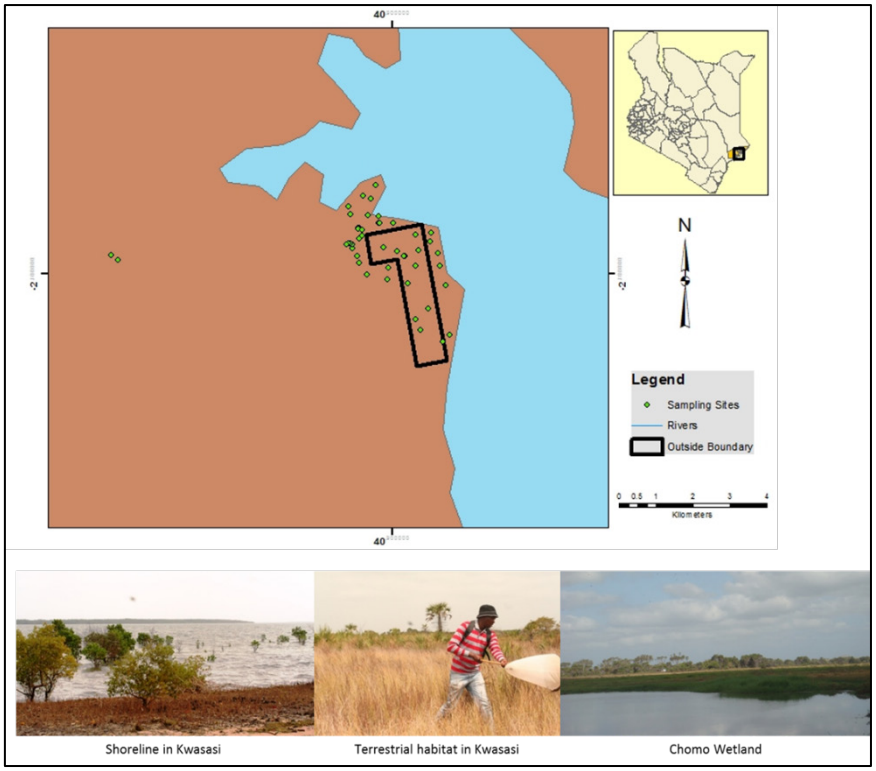
The IUCN red list for threatened species was used to determine species of conservation importance within the project site. The conservation status of species was determined by searching the scientific names of observed species on IUCN's online database. Emphasis was laid on species that were Critically Endangered, Endangered, Vulnerable, or Near-Threatened. In addition, national checklists were also used to document vulnerable species.

Figure 5-17: Sampling of herpetofauna in different habitats

5.9.4 Invertebrates Survey

Invertebrates were sampled in the terrestrial, fresh water habitats as well as in the marine ecosystem adjacent to the study site as shown in Figure 5-17. Five invertebrate sampling methods were employed. These are briefly described below together with images (Figures 5-18 – 5-24) showing invertebrate sampling methods.

Figure 5-18: Map of the study site showing the sampling points (SP) in Kwasasi



5.9.4.1 Sweep netting

This involved the use of sweep nets to collect flying invertebrates as well as those resting on vegetation. Due to the great association of invertebrates and plants, sweeping was selectively done in areas with vegetation cover as some areas had been burnt by the local community at the time of survey.

Figure 5-19: Sweep netting (left) and insect sorting and preservation in Kwasasi, Lamu County

5.9.4.2 Pond netting

Pond net method was employed to sample aquatic invertebrates both fresh water and marine habitats. It involved making scoops in the water and emptying the collection on to a sorting tray.

Figure 5-20: Pond netting in the sea (left) and A dragonfly from Chomo wetland in Kwasasi (right)

5.9.4.3 Pan trapping

Pan trapping targeted the flower visitors which are in most cases pollinators. It involved the use of flowers mimicking yellow and blue colored plates in which water with a few drops of liquid detergent had been added. In total 30 plates were used, 15 of which were yellow and 15 blue. On each trapping day, three clusters of plated were laid. Each cluster comprised of 5 yellow and 5 blue plates. The clusters were laid in three separate areas of the study site; in the two extreme ends and in the middle. They were laid in areas with many plants with flowers to maximize on collection. The traps were left in the field for two days in each point. Specimens were then collected by passing the water through a plastic sieve and put in storage vials containing ethanol.

Figure 5-21: A yellow and blue pan traps in Kwasasi, Lamu County

5.9.4.4 Pit fall trapping

Plastic cups were dug into the ground such that their openings were at the same level as the ground. They targeted the ground crawling invertebrates such as ground beetles, wild cockroaches, millipedes and scorpions. The cups were half filled with water into which little detergent and ethanol had been added. In total 15 cups were employed and laid in three separate clusters of 5 cups each. The cups were set around next to identified bushes with a lot of detritus as most ground crawling invertebrates hide in them till dusk. The clusters were located in three separate areas of the study site; in the two extreme ends and in the middle. Specimens were then collected as with pan traps.

Figure 5-22: A pit fall trap in the project site (left) and harvesting the pitfall traps (right)

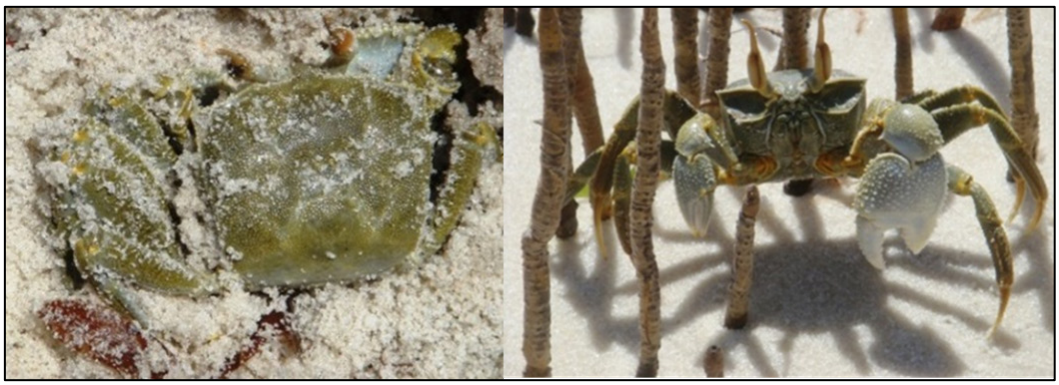
5.9.4.5 Hand picking

This method mainly targeted the marine invertebrates along the shoreline. The slow moving or sessile specimens were hand-picked and put into preservation vials. During this exercise the entire shore where this project will be located was sampled.

Figure 5-23: Hand picking of marine invertebrates along the sea in Kwasasi, Lamu County

All collected invertebrates specimens were preserved in vials containing absolute ethanol and transported to the Invertebrates Zoology Section in National Museums of Kenya for processing, identification and storage.

Figure 5-24: A horn-eyed ghost crab along the beach in Kwasasi, Lamu County



5.9.4.6 Specimen processing and identification

Terrestrial invertebrates mainly insects were first mounted on entomological pins before drying in ovens. Specimens were identified using identification keys and those difficult ones using reference collections at the Museum.

Figure 5-25: Specimens processing and identification at the Museum in Nairobi

5.9.5 Mammal Survey

Mammals were surveyed along random transects, paths and roads. The observer walked along transects paths at the speed of about 0.5km/h commencing 0630h to 1300h. Whenever an animal was detected, the following were recorded: i) Species, ii) detection sign (sighting, call, dung/pellets, spoor/footprints) and iii) location along transect.

5.10 Waste management

There is limited literature available on municipal solid waste management in Kenya and none for Lamu County. Disposal of waste in Lamu County is a significant problem as the town was not built for its current population size and waste management as there are no properly engineered waste management facilities in the County. The first County Integrated Development Plan (CIDP) for the period 2013 – 2017 developed by the Lamu County Government, identified solid waste and sewage management as key priorities under the sanitation. Under the CIDP, programs for implementation over a period of 4 years commencing 2014 includes development and implementation of a waste management strategy whose budget in 2013 was US$1.5 million. While specific initiatives have not been presented, the County Government's monitoring indictors include:

- Number of tones of wasted collected and disposed;
- Number of waste collection tools and equipment procured; and
- Number of waste management infrastructure put in place (incinerators, sewage systems).

There are a couple of dump sites on Lamu Island; the island does not have any sewage treatment plants and traditionally sewage has been in the form of pit latrines. In the Hindi/Magogoni sub-county where the proposed coal fired power plant is to be located, there are no properly engineered landfills or sewage treatment plants which can handle wastes generated by the proposed project.

The proposed coal power plant will generate a variety of wastes during the construction and operational phases of the project. Some of the details are described below.

During the construction phase, domestic and industrial wastes such as, timber skids, sewage, used lube oils and general refuse will be generated. At this stage, the estimated quantities of different types of waste streams cannot be estimated due to the lack of information. Regardless of this, all wastes generated from the project activities will need to be disposed in accordance with the Environment Management and Coordination (Waste Management) Regulations, 2006 (Legal Notice 121). There shall be a strong emphasis placed on housekeeping and cleanliness at the site in order to promote safety and minimize environmental impact. The characteristics of the wastes to be generated by the project are described below.

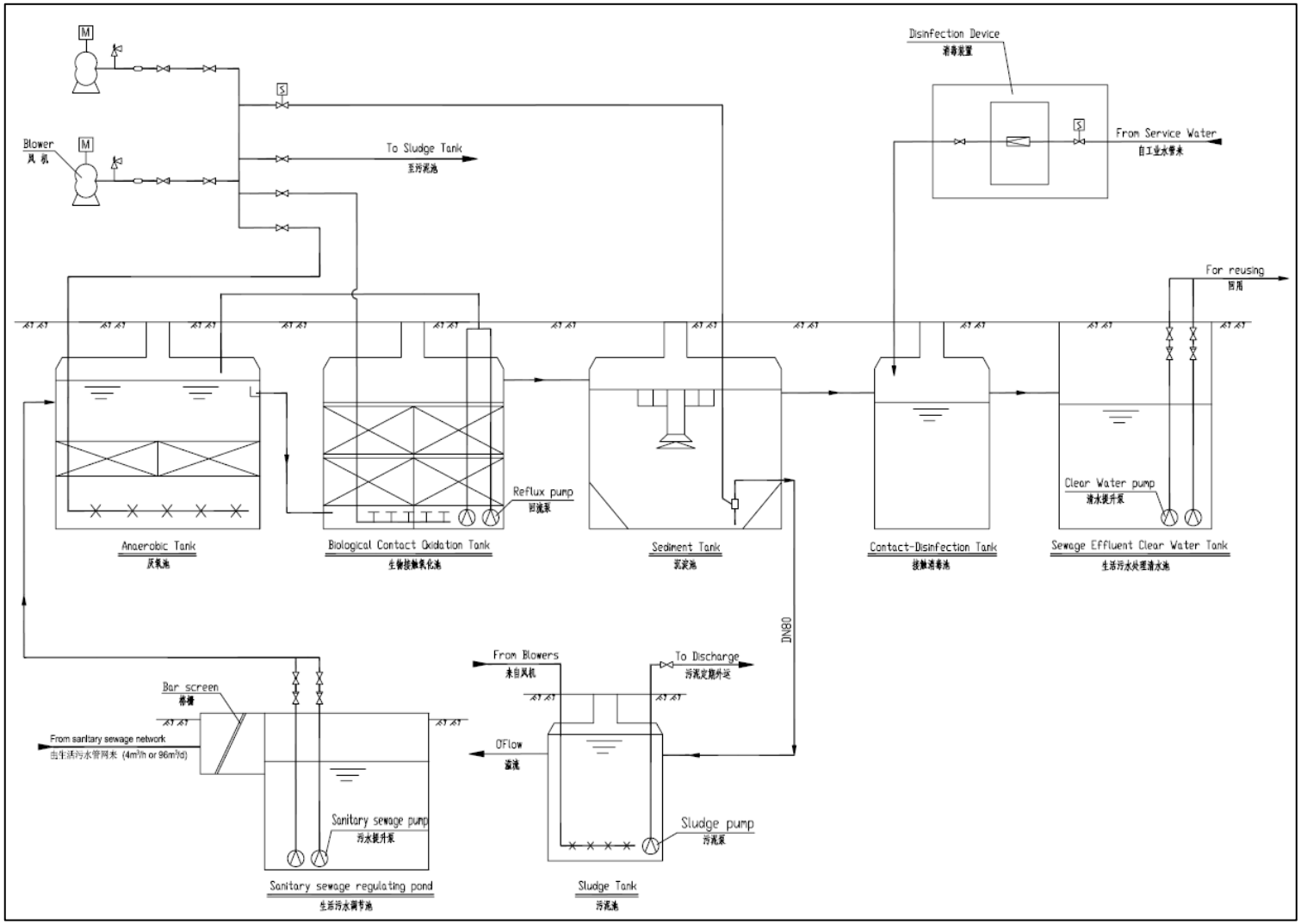
5.10.1 Domestic Wastes-construction and operational phases

The construction teams working at the project site or staying within the workers' camp are expected to be supplied with various forms of foodstuffs in a cafeteria or packed in plastic or other types of containers. This is expected to occur throughout the construction phase. Food and related types of domestic wastes generated by workers will need to be managed properly to avoid vermin. The management of such waste will be incorporated by the EPC Contractor in the Construction HSE Management Plan.

The sanitary sewage system at the proposed Lamu coal power plant will consist of sewage disposed through indoor sanitary utensils of all buildings in the power plant. It is estimated that all buildings within the power plant will generate about 96m^3/day of sanitary sewage for treatment. The sewage will first be collected in septic tanks by gravity, then flow into the sanitary sewage regulating pond through a bar screen so as to get rid of the large-sized solid impurities, then pumped into Buried Sanitary Sewage Treatment Equipment for biological contact oxidation treatment. The equipment will mainly be composed of an anaerobic tank, biological contact oxidation tank, sedimentation tank, sludge tank and disinfection tank. In the process, the oxygenated sewage will flow through the fillings in the tank to form biofilms at the fillings. After the sewage contacts the biofilms, it gets purified under the biological actions of the biofilms. The treated water is finally fed back to reuse water system where it will be used for dust suppression.

The effluent from the sewage treatment facility must comply with the discharge standards set out in the Environment Management and Coordination (Water Quality) Regulations 2006 (Legal Notice 120). A schematic of the sanitary sewage treatment system is shown in figure 5-26.

Figure 5-26: Schematic of the sewage treatment plant for the operational phase



5.10.2 Site Construction Waste-construction phase

The project is expected to generate waste from the site construction activities which includes:

- Demolition wastes;
- Excavated soils and vegetation;
- Construction equipment maintenance wastes;
- X-ray films;
- Dusts and fumes;
- Scrap metals;
- Packaging materials, etc.

As the quantities of the above categories of wastes is unavailable currently, the EPC Contractor will dispose the wastes in accordance with the applicable requirements of the Environment Management and Coordination (Waste Management) Regulations 2006 (Legal Notice 121).

5.10.3 Dust-construction and operational phases

The construction activities that will occur particularly during the site excavation process may potentially generate a considerable amount of dust and other particulates that will be released into the atmosphere. Additionally, dust may be generated from construction vehicles moving between the project site and various locations where construction materials are required to be transported from.

5.10.4 Smoke Emissions-construction and operational phases

The construction plant, machinery, equipment and trucks brought in by the EPC Contractor are expected to generate gaseous emissions when in operation during the construction activities. The concentration of emissions will depend on the maintenance levels of the equipment, machinery and trucks used by the Contractor.

5.10.5 Coal combustion products-operational phase

Coal combustion products include fly ash, bottom ash and gypsum. Fly ash and bottom ash are expected to be the primary waste generated by the Lamu coal fired power plant. The ash handling system will be designed to handle the maximum expected ash production output from 3 x 350MW boiler units. Fly ash and bottom ash will be removed separately; a dry ash mechanical conveying system for bottom ash (and economizer ash) and a pneumatic system for removal of fly ash from the hoppers. All ash will be transported to the ash yard on site via trucks minimizing dust. The ash quantity expected to be generated by the coal power plant is given in Table 5-16.

Table 5-16: Quantity of ash to be generated by Lamu coal power plant

Ash quality	1 x 350MW ash quantity (tons/hour)		
	Eskom (General)	New Vaal	Kenyan coal
Fly ash quantity	40.48	72.09	48.09
Bottom ash quantity	4.50	8.01	5.34
All ash quantity	44.98	80.10	53.43
Mill rejects quantity	1.19	1.58	1.40

The fly ash will be collected in 3 x 12m diameter storage silos.

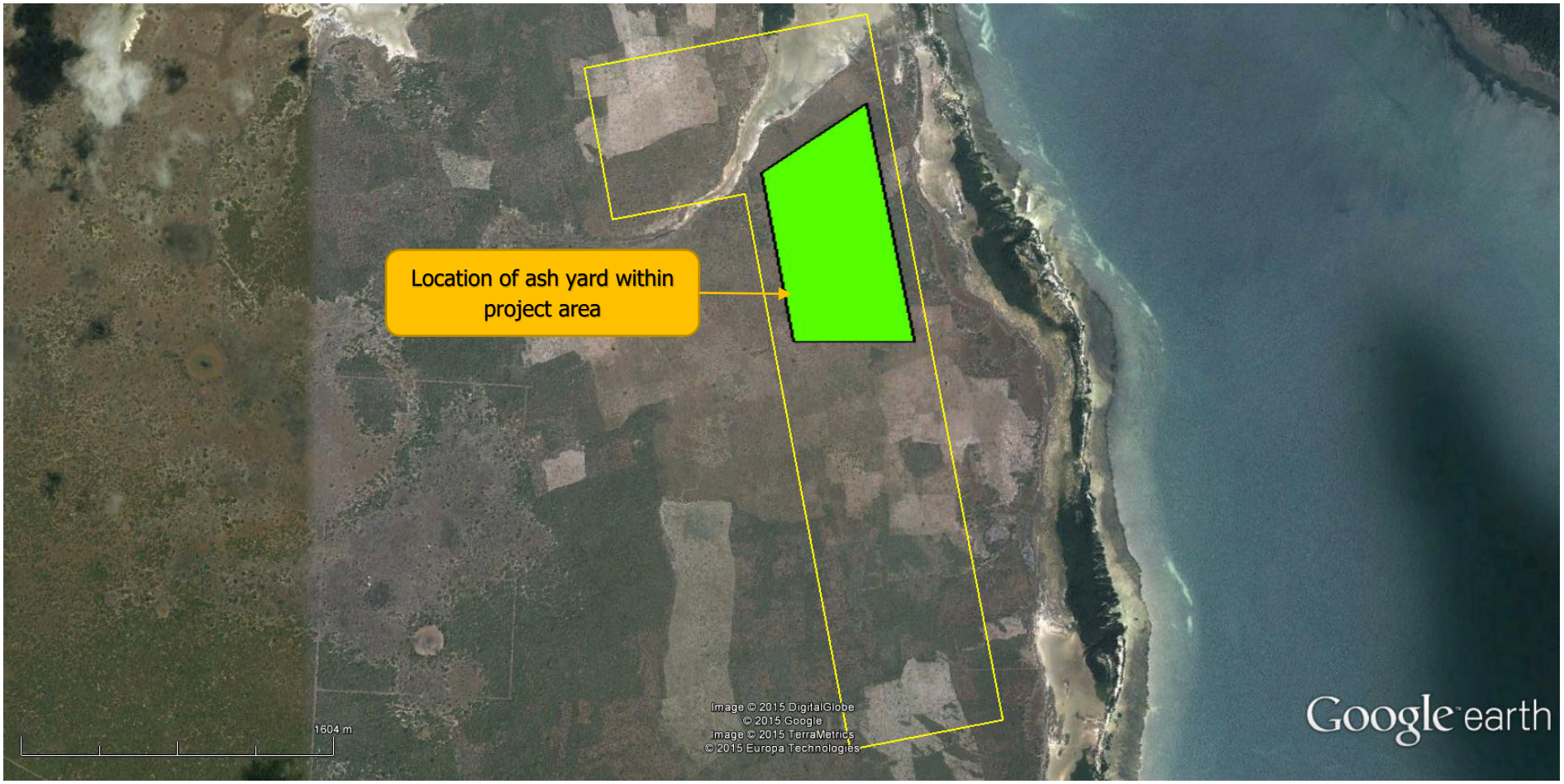
Bottom ash will be conveyed to bottom ash silo through dry slag conveyor. Pyrites in the mills will be conveyed by an electric vehicle after emptying the mills via a pneumatically operated dump gate to the vehicle bin.

The annual ash and gypsum reject load of one unit for this project is approximately 592,900 m^3. Trucks will convey bottom ash and fly ash in form power plant to the ash yard. Gypsum will be similarly conveyed to ash yard. The ash yard is located to the west of the power plant.

The ash yard occupies an area of ~162 acres (~65.8 hectares) and will be properly engineered for the life of the project; its locations is shown in Figure 5-27. The area is adequate for storing ash and gypsum for a period of 15 years. 3 units as the ash pile reaches an elevation of 25.80m with a volume of 26,740,000 m3 on completion of 15 years.

The HDPE penetration protective layer is arranged at the bottom of the ash field which will prevent the ash water from polluting the environment. The ash yard will have a total of six monitoring wells monitoring the ash yard underground water quality. The ash yard is surrounded by a 7.0 m ring road and drains, with an ash water treatment pool. The ash yard is equipped with facilities for sprinklers to spray water periodically depending on the condition of the piled ash to avoid dust pollution. The permanent slope in the ash yard will be maintained based on stability requirements at the project site.

Figure 5-27: Image showing extent of ash yard within coal power plant



5.11 Socio-economic and cultural environment

5.11.1 Data Sources

Baseline data has been developed using secondary literature as well primary information collated through stakeholder and community consultations conducted in the Study Area between January 2015 and June 2015. References to the secondary information are provided in the text.

The main secondary sources of information utilized for this baseline study include official statistics such as census reports, economic surveys, Lamu County Development Plans, maps and other available documentation on the history of the people and the area from a broad selection of recent and reliable sources, both published and unpublished. The main sources of information include:

- Kenya Population and Housing Census, 2009;
- Lamu County Integrated Development Plan (CIDP), 2013- 2017 – Revised June 2014;
- Kenya National Bureau of Statistics (KNBS) Statistical Abstracts of 2013 and 2014;
- Kenya Economic Surveys of 2013 and 2014;
- Information collected during consultations with the Lamu County Government officials;
- Information collected during consultations with the community and other stakeholders;
- Kenya National Bureau of Statistics (KNBS) and Society for International Development (SID) - Exploring Kenya's Inequalities - Lamu County (2013); and
- Other published material from the private sector, civil society and non-governmental organizations (NGOs) working within Lamu County.

5.11.2 Study area

Unless otherwise stated or implied by the context, the 'Study Area' for this study refers to Lamu County, where the proposed project will be located. While the study covers Lamu County as a whole, emphasis is placed on the proposed project site and the communities proximate to it.

Lamu County is located within the North-Eastern Coast of Kenya. It consists of a mainland and the Lamu Archipelago composed of 65 islands. The eminent islands are Pate, Lamu, Kiwayu and Manda. The proposed project site lies on the mainland.

The County covers a total land surface area of 6273.1 square kilometers with 130 kilometers of coastline and a water mass covering 308 square kilometers. The County lies between latitude $1^{0}40$, $2^{0}30$ South and longitude $40^{0}15$ and $40^{0}35$ East. It borders the Indian Ocean to the South and South East, Garissa County to the North, Somalia to North East and Tana River to the South West and West.

Lamu County has two parliamentary constituencies - Lamu East and Lamu West - and a total of ten county wards namely Shella, Mkomani, Hindi, Mkunumbi, Hongwe, Bahari, Witu, Faza, Basuba and kiunga. The proposed project site lies within Hindi ward in Lamu West constituency and covers an approximate 975.4 acres (394.9 ha.).

Table 5-17 shows Lamu County's constituencies, county wards and their sub-locations while Figure 5-28 displays Lamu County, the location boundaries and illustrates the location of the proposed project site. Figures 5-29 – 5-32 show various views of Lamu County.

Table 5-17: Lamu County area, constituency and wards

Constituency	County wards	Land Area (sq. Km)	Sub-locations
Lamu West	Shella	54.7	Shella and Manda
	Mkomani	172.5	Mkomani; Langoni; Matondoni and Kipungan
	Hindi	1150.8	Hindi; Bargoni; Mokowe and Kilimani
	Mkunumbi	1366.1	Mkunumbi; Mapenya; Uziwa and Ndambwe
	Hongwe	128.5	Hongwe and Bomani
	Bahari	123.3	Bahari; Tewe; Kiongwe and Central
	Witu	975.4	Pandanguo; Chalamula; Moa and Witu
Lamu East	Faza	79.2	Ndau; Kwatini; Kwatongani; Tchundwa; Myabogi; Siyu; Pate; Shanga and Kiwayuu
	Basuba	1708.7	Mararani; Mangai and Milimani
	Kiunga	513.9	Rubu/Mwabore; Mkokoni and Kizingitini
Total		**6273.1**	

Figure 5-28: Map of Lamu County illustrating the proposed project site

5.11.3 Views of the study area

Figure 5-29: Lamu town sea front

Figure 5-30: Kwasasi village - proposed project site

Figure 5-31: Mtangawanda, Pate Island

Figure 5-32: Sea front, Pate Island

5.11.4 Demography

5.11.4.1 Ethnic composition

Lamu County's population is a fusion of indigenous communities and a migrant community composed of individuals who have settled in Lamu for business and employment purposes. The main indigenous communities are listed below. It is important to note that all four are recorded as indigenous minority groups in Kenya.

- Orma - semi-nomadic pastoralists whose main source of livelihood is the rearing of cattle, goats and sheep.
- Sanye – one of the smallest sub-groups in Kenya. They have a Cushitic background and are traditionally hunters and gatherers. They engage in minimal farming that is mainly for subsistence.

- Boni (Aweer) – traditionally forest dwellers and hunter-gatherers. They mainly depend on the natural resources of the area for food and building material. The Boni engage in minimal farming.
- Bajuni - these trace their roots from Bantu and Arab descent. They mainly derive their livelihoods from fishing, farming

Other indigenous communities include the Korei, Swahili, Arabs, Kikuyu, Mijikenda, Pokomo/Riverine, Somali, Luo, Luhya, Taita and many others. The main ethnic group is the Bajuni. They make up about 46% of the total population. The Bajuni live in villages in the archipelago, e.g. Faza, Pate and Kizingitini and along the coastal mainland. The Boni make up 5% of the total population and reside mainly on the northern mainland. The Orma make up 2% of the population and are found in the southern part of the mainland. The Swahili/Shirazi and the Arabs, who constitute 1% and 6% of the population respectively, are mainly in the trading centres. The Kikuyu, Luo and Luhya together comprise about 24% of total of total population and the majority of them are in the Lake Kenyatta Settlement Scheme.

5.11.4.2 Population demographics

According to the 2009 National Census, which is the most recent population census conducted in the country, the population of Lamu County was at a total of 101,539 persons. The annual growth rate is recorded at 2.47%. Growth projections for the year 2015 stand at 124,092. This is projected to increase to 137,180 by 2017 (CIDP 2013- 2017). It is important to note that these projections do not take into account macro development initiatives such as LAPPSET, scheduled to be implemented in the County. That withstanding, the population is expected to grow more rapidly with the implementation of LAPPSET and its related projects. Table 5-18 illustrates Lamu County population projections by age.

[8]Table 5-18: Lamu County population projections by age

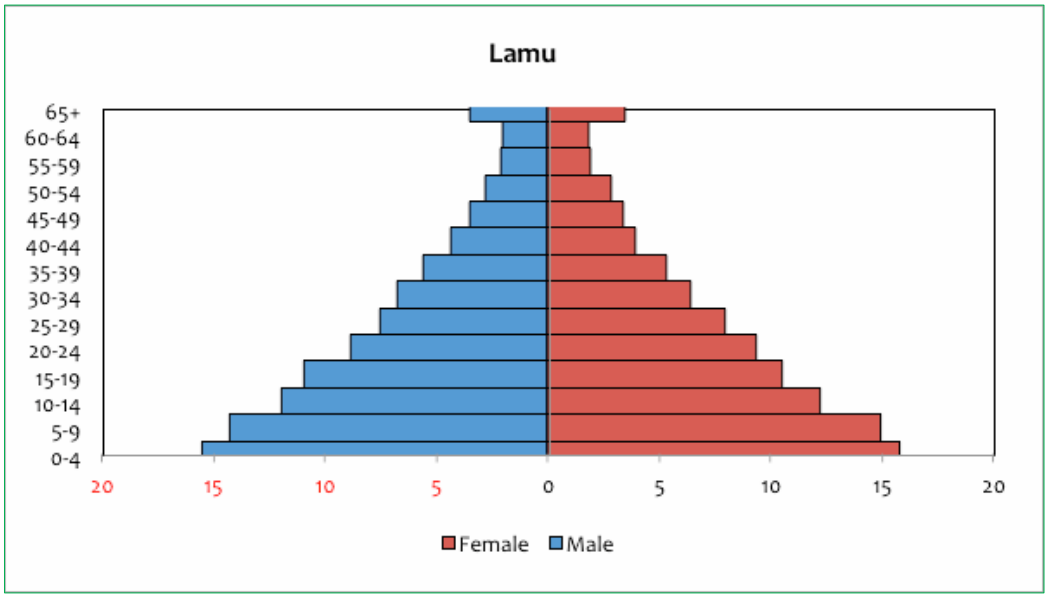
Age	2009 census			2015 projections			2017 projections		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
0-4	8,038	7,681	15,719	9,823	9,387	19,210	10,503	10,503	21,005
5-9	7,375	7,184	14,559	9,013	8,780	17,793	9,636	9,636	19,272
10-14	6,148	5,904	12,052	7,514	7,215	14,729	8,033	8,033	16,066
15-19	5,722	5,095	10,817	6,993	6,227	13,220	7,476	7,476	14,953
20-24	5,020	4,577	9,597	6,135	5,594	11,729	6,559	6,559	13,118
25-29	4,155	3,905	8,060	5,078	4,772	9,850	5,429	5,429	10,858
30-34	3,713	3,125	6,838	4,538	3,819	8,357	4,851	4,851	9,703
35-39	3,070	2,579	5,649	3,752	3,152	6,904	4,011	4,011	8,023
40-44	2,363	1,918	4,281	2,888	2,344	5,232	3,088	3,088	6,175
45-49	1,890	1,644	3,534	2,310	2,009	4,319	2,469	2,469	4,939
50-54	1,522	1,384	2,906	1,860	1,691	3,551	1,989	1,989	3,977
55-59	1,113	927	2,040	1,360	1,133	2,493	1,454	1,454	2,909
60-64	1,051	890	1,941	1,284	1,088	2,372	1,373	1,373	2,746
65-69	583	468	1,051	712	572	1,284	762	762	1,524

[8] Lamu County Integrated Development Plan (CIDP), 2013- 2017

Age	2009 census			2015 projections			2017 projections		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
70-74	533	476	1,009	651	582	1,233	696	696	1,393
75-79	228	197	425	279	241	519	298	298	596
80+	478	527	1,005	584	644	1,228	625	625	1,249
85+	43	13	56	53	16	68	56	56	112
TOTAL	**53,045**	**48,494**	**101,539**	**64,827**	**59,265**	**124,092**	**71,664**	**65,515**	**137,180**

Lamu County is stated to be at the onset of a fertility decline with 39.8% of households comprising of 0-3 members while 36% of households comprise of 4-6 members. The County has an age distribution of: 0 -14 years (41.7 %), 15 - 64 years (54.8 %), 65+ years (3.5 %). Figure 5-33 shows the Lamu County Population Pyramid.

[9]Figure 5-33: Lamu Population Pyramid



Lamu town is the main urban centre in the County with 20,572 inhabitants, as per the 2015 population projection. This is expected to grow to about 21,994 by 2017. With the envisioned macro-economic development programmes, such as LAPPSET, it is expected that new urban centres will emerge to cater for the rapidly expanding economy as well as expansion of existing market centres such as Mpeketoni and Hindi.

[9] KNBS & SID - Exploring Kenya's Inequalities - Lamu County (2013)

5.11.5 Culture

Lamu County is host to a myriad of rich ecological, archeological and cultural resources. Recorded to date back to at least the 12th century, Lamu Old Town is the oldest surviving Swahili town in East Africa. It is also the administrative capital of Lamu County today. In December 2001, Lamu Old Town was inscribed as a world heritage site by UNESCO's World Heritage Centre. It is the best-preserved Swahili settlement, retaining its original character and functions. The town is built in coral stone and mangrove timber, and is characterized by simple structural forms enriched by distinctive features such as inner courtyard, verandas and elaborated carved wooden doors. There are over 160 historic houses clustered in within the Stone Town.

Islam is the predominant religion in Lamu County, stemming from the strong influence of the Arab and Swahili cultures. The County is regarded as an important religious centre for Islam in East Africa. Swahili is the main language. The County has a very rich and pronounced Swahili culture and is a dominant cultural centre reputable for its historic past and traditional socio-cultural traditions that have been upheld to date. These traditions include religion, dressing, food, traditional medicine and crafts. Master craftsmen such as the boat builders of Matondoni and Kizingitini, masons, jewellers and woodcarvers of Lamu, leather workers of Siyu, all play dignified roles as custodians of heritage. Transfer of creative knowledge and skills to young people continues through the age-old practice of apprenticeship ensuring survival of the heritage. Figure 5-34 shows a boat builder in Mtangawanda, Pate Island.

Figure 5-34: A traditional boat builder in Mtangawanda, Pate Island

5.11.6 Gender

Majority of the local communities in Lamu County, including those within and proximate to the proposed project site are recorded as indigenous minority groups in Kenya and are considered marginalized. Women from minority and indigenous communities face multiple forms of marginalization as recognized in the Kenyan Constitution (2010). The constitution also considers women as a whole as a marginalized group along with children, the disabled, the elderly among others. In 2012, Kenya was ranked 46 out of 86 countries in the OECD Social Institutions and Gender Index, which assesses countries based on the existence of discriminatory social institutions, such as early marriage, discriminatory inheritance practices, violence against women, son preference, restricted access to public space and restricted access to land and credit. That notwithstanding, the constitutional changes geared towards affording women legal protections related to equality are yet to be fully realized. For instance, despite constituting half of the population, women only hold title to between 1% and 5% of land in Kenya[10].

Lamu County has a 52% - 48% male to female gender distribution as recorded in the 2009 National Census. Consultations held with women from the local communities highlighted the following as key challenges faced by the local women:

- Traditional and cultural biases in the allocation of roles and opportunities
- Difficulty in accessing maternal healthcare and high maternal mortality rates
- Discriminative cultural practices such as early marriages
- The triple burden of child bearing, economic production and home making, more so with the increasing number of female headed households
- Poor education levels underlined by non-progression to tertiary level training. There exist disparities in school attendance as female students constitute 47% of the total student population in the County while male students constitute 53%[11].
- Lack of adequate representation at levels of decision making and governance
- Lack of asset ownership, with emphasis on land. This has substantially undermined their access to credit services to start or improve business enterprises

5.11.7 Livelihoods

Lamu County's labor force stands at 54% of the population evenly distributed between male and female. This labor is however unskilled hence engaged in manual activities mainly in agriculture and homemaking. The County records high poverty levels standing at 31.6 %[12]. The main economic activities include employment, tourism, fishing, and agriculture (crop production and livestock husbandry). These are outlined below.

[10] challenges at the intersection of gender and ethnic identity in Kenya (2012)
[11] KNBS Statistical abstract 2014
[12] KNBS & SID - Exploring Kenya's Inequalities - Lamu County (2013)

5.11.7.1 Employment

The main contributors to employment in Lamu County include tourism, public sector service, agriculture, fisheries and livestock production. The labor force is mainly unskilled or semi-skilled. 17% of the residents with no formal education, 18% of those with a primary education and 33% of those with a secondary level of education or above are working for pay. Underemployment rate for the ages between 15 and 64 is recorded at 12.3% while the unemployment rate is at 5% as compared to the national rate of 9% as shown in table 5-19.

Table 5-19: Overall Employment by Education Levels in Lamu County

Education Level	Work for pay	Family business	Family Agricultural Holding	Intern / Volunteer	Retired/ Home-maker	Fulltime Student	Incapacitated	No work
Total %	20.9	10.8	39.4	0.9	13.1	9.2	0.4	5.3
None %	16.8	12.8	36.9	1.4	24.4	0.7	1.2	5.8
Primary %	18.1	10.3	45.0	0.7	11.3	9.3	0.2	5.1
Secondary +%	32.6	9.6	28.5	1.0	4.4	18.8	0.2	5.0

5.11.7.2 Tourism

Tourism is one of the key contributors to the economy of Lamu. This is influenced by the County's rich cultural identity, diverse flora and fauna, and listing of several world heritage sites. The main tourist attractions are Boni - Dodori National Reserve, Lamu Museum, Lamu Fort, Siyu Fort, Takwa Ruins, Swahili House, German Post Office, Lamu Old Town, Kiunga Marine National Reserve and 130 km of sandy beach coastline. The County has 183 hotels with a total bed capacity of 1,881.

5.11.7.3 Fishing

Fishing is the second largest driver of the Lamu economy. The County produces over 1,500 metric tons of fish annually valued at KShs111.8 million. 75% is from marine fishing and 25% from fish pond programmes on the main land and ox-bow lakes and water masses along the Tana River delta. A sample of typical boats used for fishing in the County is shown in Figure 5-35.

Figure 5-35: Fishermen at sea

5.11.7.4 Crop production

Crop production is mainly undertaken on the main land by small-scale farmers under rain fed conditions where annual rainfall ranges from 540 millimeters to 1,000 millimeters per year. In the County about 80% of the crops are grown during long rains while the remaining 20% are grown during short rains. The County has approximately 650,000ha of agricultural land with the overall average farms measuring 4ha each. The major crops grown include maize; sorghum; cow peas; cassava; green grams; bananas; sesame; mangoes; cotton; coconut bixa and mangroves. [13]42% of households' income is from cotton production, 14% bananas, 8% maize, 7% cassava, 6% bixa, 5% mangrove and 18% from the rest.

Figure 5-36: Harvesting of Sesame at Kwasasi

[13] Lamu County Integrated Development Plan (CIDP), 2013- 2017

5.11.7.5 Livestock husbandry

Livestock rearing is largely undertaken on the main land. The main livestock types include cattle, goats, sheep and poultry. Donkeys are also reared for local transport. The husbandry culture is generally free-range with few farmers practicing intensive feeding/ zero-grazing. Lamu County also provides grazing land for nomadic pastoralists from the surrounding Garissa and Tana River Counties which experience extended periods of drought. It is estimated that number of indigenous cattle within the County is approximately 5,000, while immigrant cattle number over 50,000.

Figure 5-37: Herd of cattle grazing by pastoralists in Roka

Figure 5-38: Community livestock watering point at Chomo

5.11.7.6 Education

Lamu County's education index stands at 0.68. [14]A total of 33% of Lamu County residents have no formal education while 54% have attained primary level of education only. Only 13% of Lamu County residents have secondary level of education or above. Lamu West constituency has the highest share of residents with secondary level of education or above. The County's literacy level is estimated at [14]70% but this proportion represents the highly exposed residents of Lamu west Sub County. Literacy levels for Lamu East are estimated to be less than 30%.

As of 2013, there were 74 primary schools, 11 high schools, and 4 tertiary institutions (Polytechnics) in the County. The county's Teacher to Pupil Ratio is 1: 40 for public primary schools and 1:39 for public high schools[15].

Figure 5-39: Bargoni primary school in Hindi Division

The County's primary and secondary school enrolment rates by year and school attendance and highest education level attained by sex are displayed through tables 5-20 and 5-21 below respectively.

[14] Lamu County Integrated Development Plan (CIDP), 2013- 2017
[15] KNBS Statistical abstract 2014

Table 5-20: Primary and secondary school enrolment by year

Education level	2007	2008	2009	2010	2011	2012	2013
Primary school enrolment	22,633	23,178	22,337	24,815	26,076	28,139	28,185
Secondary school enrolment	2,982	3,375	3,721	4,177	4,712	4,854	5,273

Table 5-21: Primary and secondary school enroment by gender

	Pre-Primary	Primary	Secondary	Tertiary	University	Total
Male	3,849	12,202	1,986	97	75	18,209
Female	3,703	10,985	1,414	93	35	16,230
Total	**7,552**	**23,187**	**3,400**	**190**	**110**	**34,439**

5.11.7.7 Health

According to the Kenya economic survey 2013, the number of health facilities listed in Lamu County was 42. There are: 1 district hospital; 2 sub-district hospitals; 20 dispensaries; 6 health centres; 12 medical clinics and; 1 nursing home. Of these, 24 are Government owned, 3 are owned by faith-based organizations, 1 is NGO owned and 14 are privately owned. These comprise of 3 level five facilities, 5 health centres, 1 nursing home and 33 dispensaries with a total bed capacity of 172 beds.

The recorded population per facility stands at 2,361 while bed distribution is recorded at 31. (Bed distribution is the number of beds per 1,000 age adjusted numbers of residents in a county). The average distance to the nearest health centre is approximately 5 kilometers.

As of 2013, the County's health personnel comprised of 4 medical doctors, 24 clinical officers, 94 nurses, 17 public health officers, 5 pharmacists and 30 technical personnel. The Doctor to Population Ratio is recorded at 1:36,343 (Lamu County Integrated Development Plan (CIDP), 2013- 2017)

Hindi ward, within which the proposed project site lies, is served by 4 health facilities namely Mokowe health centre, Hindi dispensary, Hindi Prison dispensary and Bargoni NYS dispensary. Lamu District Hospital is the main referral facility for the ward, with patients having to cross to Lamu by sea on boats from the Mokowe Jetty.

Figure 5-40: Mokowe health centre

Figure 5-41: Staff housing facilities at Mokowe health center

The prevalent diseases experienced in the County include malaria, respiratory tract infections and skin diseases (KNBS Statistical extract 2014). Infant mortality rates stand at 72/1000 while under five mortality rates are recorded at 123/1000.

5.11.8 Infrastructure and Services

5.11.8.1 Water

The County's main sources of water include rain water, ground water which is mostly saline, surface water from dams, pans, lakes, seasonal rivers and the ocean. In Lamu County, 52.9% of residents use improved sources of water while the rest rely on unimproved sources. (Improved sources of water comprise protected spring, protected well, borehole, piped water into household, and rain water collection while unimproved sources include ponds, dam, lake, stream/river, unprotected springs, unprotected wells, and water vendor). The average distance of household to access clean water is approximately 5km.

[16]Table 5-22: Source of water by County and Constituency

County and Constituency	Unimproved Sources	Improved Sources
Lamu County	47.1%	52.9%
Lamu East Constituency	82.6%	17.4%
Lamu West Constituency	39.0%	61.0%

5.11.8.2 Sanitation

Approximately 22.5% of households in Lamu County have no access to sanitation infrastructure, both improved and unimproved. These households utilize open fields and bushes for sanitation. 77.5% Lamu County households have access to sanitation infrastructure. Of these, 57% utilize improved sanitation compared to 61% nationally. Improved sanitation include flush/pour flush (to piped sewer system, septic tank, and pit latrine), ventilated improved pit latrine, pit latrine with slab, and composting toilet. 43% utilize unimproved sanitation. Unimproved sanitation include: public or shared latrine; flush/pour flush to elsewhere (not into a pit, septic tank, or sewer); pit latrine without slab; open pit latrine; bucket latrines; and hanging toilet / latrine.

Table 5-23: Sanitation and waste disposal by County and Constituency

County and Constituency	Improved Sanitation	Unimproved Sanitation
Lamu County	56.68%	43.32%
Lamu East Constituency	71.88%	28.12%
Lamu West Constituency	53.19%	46.81%

[16] KNBS & SID - Exploring Kenya's Inequalities - Lamu County (2013)

5.11.9 Transport

Lamu County is accessible by air, sea and road. The County has no rail transport.

5.11.9.1 Air transport infrastructure

Lamu County has 13 airstrips. Of these, 11 are public and 2 are privately owned. Manda airstrip is the main airstrip offering passenger travel with 3 airline companies providing daily passenger flights. Other airstrips in the County include: Manda point 11, Manda Bay Naval, Mokowe, Kiunga, Kiwayu Island and Kiwayu mainland (Mkokoni) which are fairly maintained. Other airstrips are: Witu, Mkunumbi, Faza, Kizingitini. These are under bad condition. Tenewi and Mangai are closed due to the LAPSSET project.

5.11.9.2 Road transport infrastructure

The County ranks 9th out of the 47 counties with the least road network density, standing at less than 20km/100km2 as compared to Nairobi which stands at over 430km/100km2 (road density determines the accessibility within the county, which is the ease with which goods and services and can be reached). The County's total road network stands at 688.6 Km with only 6 Km in bitumen standard (tarmac), 161.1 Km gravel surface, and 521.5 Km earth surface. Majority of the roads in the County offer rough travel by vehicles and are impassable during the rainy season.

There are two main roads that offer access into the County. These are:

- Mokowe - Garsen road
- Mokowe –Kiunga road

14-seater vans (Matatu) and commercial motorbikes (Boda boda) are the main means of public transportation within the mainland. Donkeys are the main form of transportation in Lamu Town with an estimated population of 2,200 donkeys being used for farming and transportation of provisions.

5.11.9.3 Sea transport infrastructure

There are 8 jetties in the County which include: Amu, Mokowe, Manda, Matondoni, Lamu customs, Fisheries and Hospital jetty. Amu, Matondani and Mokowe jetties are in good condition and are used by passengers, fishermen and for loading goods coming in and out of the Island. The rest are in poor conditions. Dhows, Semi-motorized dhows and speedboats are the main transport means for on-sea travel.

Figure 5-42: Lamu Customs (KPA) Jetty

Figure 5-43: Mokowe Jetty

5.11.9.4 Information and Communication Infrastructure

As of 2014, there were 2,600 fixed line telephone connections concentrated in Lamu town. Mobile phone network and connectivity covered 60% of the county with 51% of the residents owning mobile phones. Internet penetration was at 15%. Radio and television signals are extremely poor while the key national newspapers are distributed on average 1 -2 days late. Postal services are provided by the National Postal Corporation and other private courier service providers. [17]

5.11.10 Housing

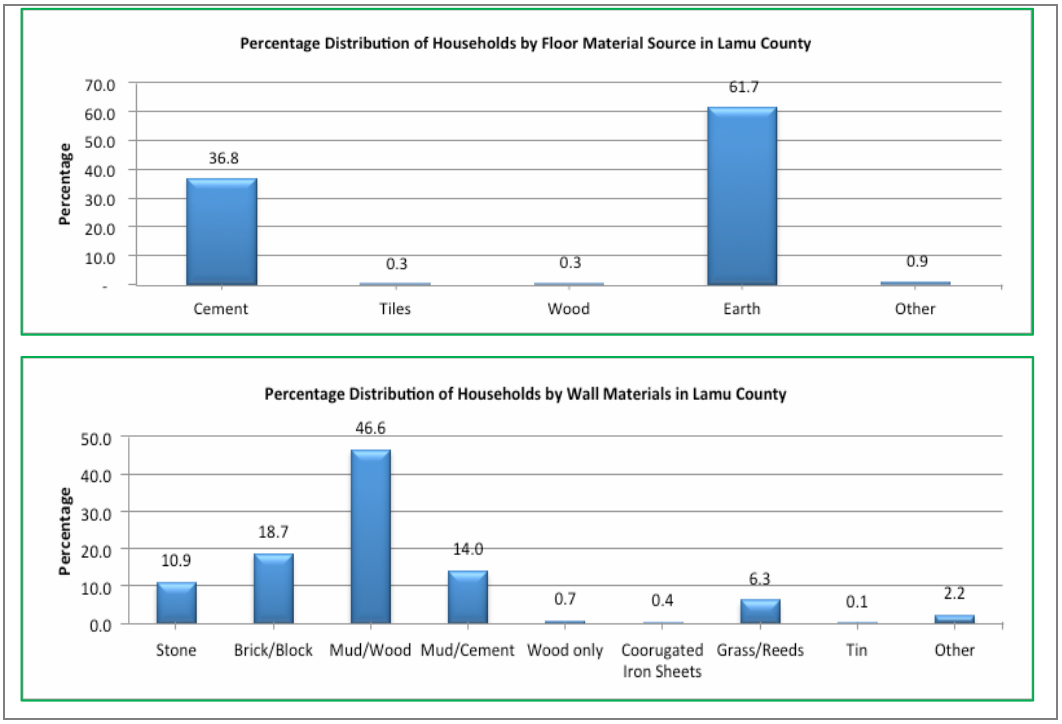
Housing is described according to the floor, wall and roofing materials.

30% of homes in the County have either brick or stone walls while 61% have mud/wood or mud/cement walls. 1% of the homes have wood walls. Less than 1% has corrugated iron walls while 6% have grass/thatched walls and 2% have tin or other walls[18].

37% of residents have homes with cement floors, while 62% have earth floors. Less than 1% has wood or tile floors[18].

11% of residents in the County have homes with concrete roofs, while 32% have corrugated iron sheet roofs. Grass and thatch roofs constitute 50% of homes, with less than 1% of the homes having mud/dung roofs[18].

Figure 5-44: Lamu County percentage distribution of households by floor, wall and roofing materials



[17] Lamu County Integrated Development Plan (CIDP), 2013- 2017
[18] KNBS & SID - Exploring Kenya's Inequalities - Lamu County (2013)

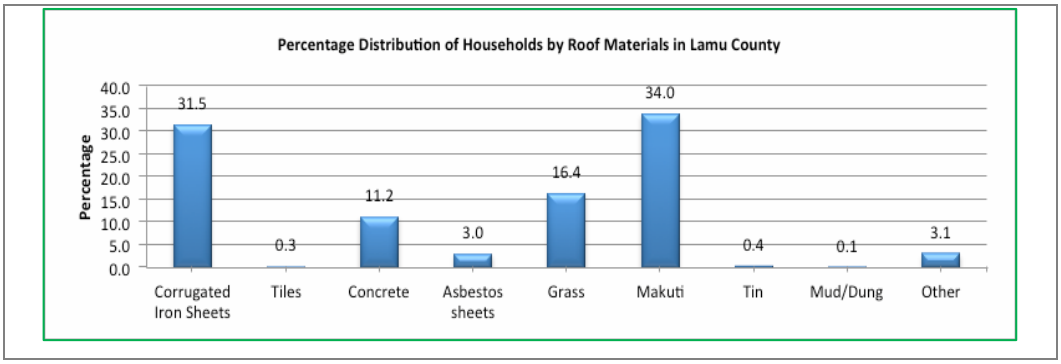


Figure 5-45: Mud/wood walls, earth floors and thatch roofed homes in Mtangawanda, Pate Island

5.11.11 Land use

Lamu County has a land surface area of 6273.1 square kilometers composed of 5,517 square kilometers of arable land 649.7 square kilometers of non-arable land, 130 square kilometers of coastline and 308 square kilometers of under water land mass. Lamu West takes 63.3% of land surface area at 3971.3 square kilometers while Lamu East takes up 36.7%. The County falls within 4 agro-ecological zones namely:

- Coconut Cassava zone (CL3)
- Cashew nut-Cassava zone (CL4)
- Livestock millet zone (CL5)
- Lowland ranching zone.(CL6)

Only 13,000 households in Lamu County have title deeds for the land they own. This translates to 42% of the total number of households in the County. The principal type of land tenure is trust/ancestral land holding. Majority of landowners are keeping their land parcels idle, without much economic activity. Most of the settlements are unplanned with scattered populations.

5.11.12 Energy

In Lamu County, the chief fuel source for cooking is firewood as utilized by 71% of the households. 23% of the households use charcoal, while 3% use paraffin. Only 1% of residents use liquefied petroleum gas (LPG). The main fuel source for lighting, as utilized by 39% of households, is tin lamps. A further 33% use lanterns while 17% of residents use electricity. 2% use fuel wood as a fuel source for lighting[19].

5.11.13 Political and Social Organizations

As of 2013, there 19 active Non-Governmental Organizations involved in various activities including capacity building, civic education, poverty eradication, HIV and Aids initiatives, women empowerment, disaster preparedness and protection of marine ecosystem; There were 33 registered cooperatives of which only 13 are active (KNBS Statistical abstract 2014)

According to the Ministry of Gender, youth and social services, Lamu County offices, there are 3,551 registered self-help groups within Lamu County undertaking activities around enterprise development, poverty eradication, drought management, HIV and Aids. 546 of these based in Hindi division. They are segmented into Youths groups, women groups, CBOs as shown in the Table 5-24 below.

Table 5-24: Civil society groups active in Lamu County

Registered Social groups within Lamu County		Registered Social groups within Hindi Division	
Self Help Groups	1,599	Self Help Groups	275
Women Groups	1,063	Women Groups	72
Youth Groups	579	Youth Groups	183
CBOs	175	CBOs	11
Persons with Disability	98	Persons with Disability	2
Support Groups	37	Support Groups	3
Total	**3,551**	**Total**	**546**

5.12 Visual impacts

Visual impacts can be defined as those impacts of the development upon views in the landscape and overall impact on visual amenity. Landscape impacts are defined as those impacts upon specific landscape elements which give rise to the landscape character of the site and its surroundings and impacts upon any special interests in and around the site.

No standards exist with regard to landscape or visual impact in any of the applicable IFC sector specific guidance, specifically Thermal Power Plants.

[19] Lamu County Integrated Development Plan (CIDP), 2013- 2017

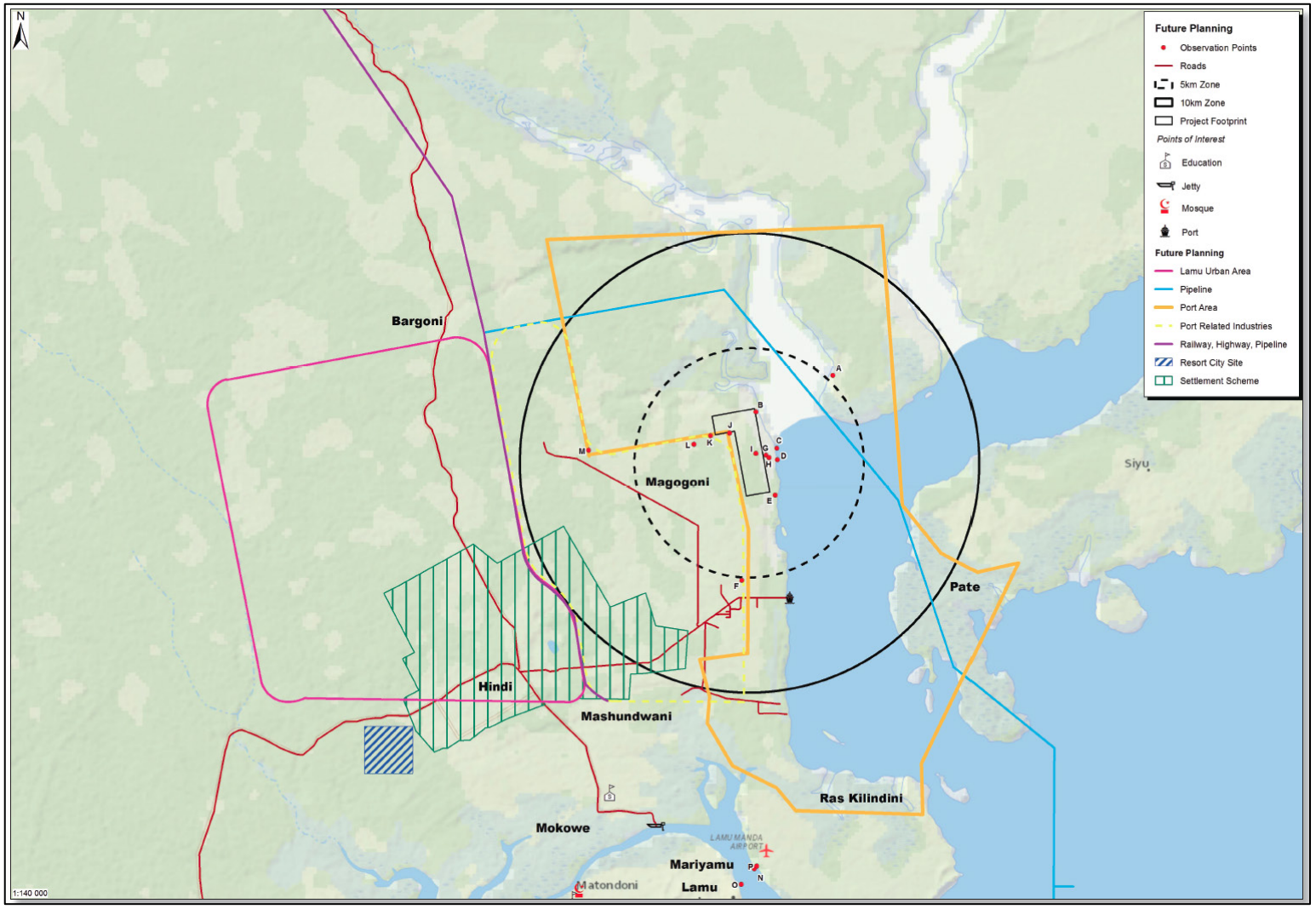
The landscape around the proposed coal fired power plant has a very low visual absorption capacity largely due to the flat topography of the area and the lack of micro-topographical features such as natural vegetation that can screen views of the project and the project will therefore be highly visible. The viewshed analysis and photomontages show that the project will be very visible and the line of sight analysis indicates that the 210m chimney will be visible from areas located more than 10km away from the project and draw people's attention to the project.

The project will also be located outside any defined urban edge or industrial area and will therefore create an initial change to the fabric and character of the landscape. The inter-relationship with land uses in adjacent lands can affect the visual sensitivity of an area. A project located within the view-shed of a tourist resort may for example be very sensitive, whereas an area surrounded by commercially developed lands may not be visually sensitive. As the Lamu Port South Sudan Ethiopia (LAPSSET) transport corridor is implemented the visual character of the area surrounding the project site will change to a commercially developed zone. The projects impact on the visual character of the area will therefore decrease over time as the area surrounding the power station changes to a commercial zone.

5.12.1 Points of Interest

The project will be a high intensity and large-scale infrastructure project lying outside any defined urban edge or industrial area and will therefore create an initial change to the fabric and character of the landscape. The inter-relationship with land uses in adjacent lands can affect the visual sensitivity of an area. A project located within the view-shed of a tourist resort may for example be very sensitive, whereas an area surrounded by commercially developed lands may not be visually sensitive. As the Lamu Port South Sudan Ethiopia (LAPSSET) transport corridor is implemented the visual character of the area surrounding the project site will change to a commercially developed zone (figure 4-45). The projects impact on the visual character of the area will therefore decrease over time as the area surrounding the power station is developed into a commercial area.

Figure 5-46: LAPSSET area of development including Lamu coal power plant site



Protection of visual values usually becomes more important as the number of viewers increase. The project area in general is not used by large numbers of people and the visual sensitivity should therefore be less. If local people and tourists in the area have only a brief glimpse of the planned infrastructure, the visual modification may not be of great concern and the visual sensitivity low. Local people and tourist in the area are generally moving slowly through the area either by foot, boat or motorbike creating longer viewing periods of the project that increases the visual modification and sensitivity.

No formal residential, tourist and/or recreation areas with a strong visual orientation towards the project exist in close proximity to the project that will increase the visual sensitivity of the project. The current main users of the project area and surrounding areas is very much limited to local subsistence farmers with very few recreational sightseers. Recreational sightseers are more sensitive to any changes in visual quality, whereas the farmers in the area who pass through the area on a regular basis may not be as sensitive to the change created by the project.

No special areas such as wilderness areas or national parks that require special consideration for the protection of the visual values occur in close proximity to the project area. Lamu town occurs within the background zone so the project will not be visible except for the 210m high concrete chimney

5.12.2 Landscape units

The project will be located approximately 20km north of Lamu town along the shoreline in the Manda Bay area. Soil types located in the project area dictate the type of vegetation that occur. Silt and sand support scrub bush, scattered palms and swamp grass. In areas less susceptible to flooding, the silty clays support thick bush consisting of palms, indigenous trees and scrubs. Grassy open swampy areas dominate where there are drainage problems due to the low altitude. In general the project area is dominated by evergreen and semi-evergreen bushland and thicket interrupted by pockets of woodland and scrub woodland with scattered trees.

Mangroves strips occur along the shoreline of the project area and the intertidal environment of the creeks and basins supports significant area of mangrove forests. Mangroves in the Lamu area constitute 70% of mangrove forest cover in Kenya and is are a major sources of wood for construction of houses, making charcoal and boats.

Coral reefs are found in the form of coral flats, lagoons, reef platforms and fringing reef. Sea grass zones occur between the Mangroves and coral reefs along the shoreline of the project area. Small sandy beaches are scattered in between the patches of mangrove forests.

The coastal belt of Kenya comprises of the following main topographical features which are closely related to the geological characteristics of the area: the Coastal Plain, the Foot Plateau, the Coastal Range and the Nyika. The altitude of the Coastal Plain is generally less than 45 m above sea level. Lamu County is generally flat and lies between zero and 50 metres above the sea level. The project area has very flat topography and is approximately 20 m above sea level.

5.12.3 Visibilities

The visual modification of a development is assumed to be the highest when the observer is very close to it and has a direct line of site. The greater the viewing distances, the lower the visual sensitivity. Visibility reduces dramatically in the background and seldom seen zones that in turn decreases the visual modification created by the infrastructure due to the increased viewing distance.

The view shed analysis for the proposed project (based on topography alone) indicates that project components will be visible to people moving within the foreground-middle ground zone (the area that can be seen for a distance of 0 - 10 kilometers) around the project. The project will be highly visible within the 5km zone around the project and a low visibility is experienced beyond the 10km zone (figure 5-46) except for the reinforced concrete chimney whose height will be approximately 210m tall and will be visible beyond the 10km zone.

Figure 5-47: Viewshed analysis showing visibility of the power plant