1,050MW Coal Fired Power Plant

Ecological Impact Assessment Study

Report Prepared for

Amu Power Company Limited

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1 Introduction

This specialist study presents an assessment of the potential impacts of the Project on terrestrial and marine ecology. The assessment has identified sensitive ecology receptors within the Project's zone of influence and considered the potential for these receptors to be impacted upon by the Project activities. The assessment follows the recommendations and requirements of the International Finance Corporation (IFC) Performance Standards 6 (PS6): Biodiversity Conservation and Sustainable Management of Living Natural Resources and other applicable standards.

In order to assess potential impacts, this chapter provides a description of the approach to the study. The scoping process is detailed, during which receptors were identified through an analysis of survey data, and a review of local, national and international requirements and standards. This chapter describes the spatial and temporal boundaries used in the assessment, the baseline conditions within these areas, the assessment methodology, the mitigation measures required to avoid or minimize any significant adverse effects, and the likely residual effects after these measures have been implemented. The most important impacts are predicted to arise during the Construction and Pre-Commissioning Phase.

This Project adheres to the 'mitigation hierarchy' as defined in IFC PS6, i.e. impacts should be progressively avoided, minimized, restored or offset if necessary, with priority given to the actions which are earliest in the hierarchy. Therefore, the Project will seek to avoid impacts on biodiversity. When avoidance of impacts is not possible, measures to minimize impacts and to restore biodiversity will be implemented. Offsetting is only considered if these measures do not result in a reasonable expectation of no net loss of biodiversity (or a net gain in respect of critical habitats). Given the complexity in predicting project impacts on biodiversity over the long term, the Project will adopt a practice of adaptive management in which the implementation of mitigation and management measures are responsive to changing conditions and the results of monitoring, until the necessary management objectives have been achieved.

1.1 Scoping

The ecological impact assessment for the Project was defined through a scoping process, which identified ecological receptors and potentially significant impacts related to the Project. An important component of the scoping process was the definition of existing baseline conditions (i.e. the prevailing ecological characteristics against which the potential impacts of the Project could be assessed). Baseline conditions were identified through the review of limited ecological information available for the project area of influence and physical surveys undertaken in January and March 2015.

Key steps in the scoping process for the ecological impact assessment comprised the following:

- Secondary literature review including ecological impacts associated with thermal power plants;
- Review of preliminary layout drawings provided by the EPC contractor showing the infrastructure to be built and its potential impacts on terrestrial and marine ecology;
- Ecological receptors within the Project's likely area of influence were identified through a review of secondary data, physical surveys, and professional expertise;

- Review of available databases of ecological related information for Lamu County and its environs; and
- A review of relevant national and international legislative requirements and lender requirements for compliance.

The marine environment in Manda Bay contains a number of potential receptors and is, therefore, an important consideration in the ESIA process. Marine ecological receptors are diverse and include a wide variety of organisms and habitats. For the purpose of this assessment, marine biota is broadly grouped into the following topics: plankton, benthic communities, fish, seabirds and marine mammals. In addition, the habitats that these organisms inhabit and the ecological processes of these habitats are considered as receptors.

1.2 Analysis of alternatives

The land on which the coal power plant is to be constructed is to be provided by the Ministry of Energy and Petroleum (MoEP) who is the client for the project. The MoEP identified three alternatives for the development of the coal power plant as described in Chapter 6 of the ESIA Study.

The MoEP undertook an informal comparative ecological analysis of the three alternative locations and decided that being a strategic installation, the power plant must be located in an isolated area on the mainland. Fortunately, the final site selected for the power plant, did not have significant localized ecological issues and was identified as the most suitable site.

1.3 Spatial and temporal boundaries

The Project Area is divided into onshore and nearshore sections. This division is based on technical consideration of different construction activities to be employed in each section, and therefore the terms 'onshore section' and 'nearshore section' have no ecological meaning in this sense.

1.3.1 Spatial boundaries

The onshore section includes the ~360 hectares of land over which the terrestrial power plant facilities will be constructed. Additionally, a wider area of approximately 13km was studied for this study.

The nearshore section was taken to include the coal receiving jetty, circulating water intake and circulating water outfall approximately 700m from the shoreline.

1.3.2 Temporal boundaries

The assessment includes the four phases of the Project namely:

- Design phase;
- Construction phase;
- Operational phase; and

- Decommissioning phase.

Therefore, the temporal boundary for the assessment is the end of the Decommissioning Phase, including associated demolition, removal of infrastructure and restoration works.

2 Baseline data

2.1 Introduction

A review was undertaken of available literature about the project area and the wider study area. Additionally, consultation was undertaken with statutory bodies who provided contextual information on potential terrestrial ecology receptors (habitats and species) within the Wider Study Area, and on their ecology, distribution, and pertaining threats. This information provided the contextual base upon which further field surveys were planned.

In order to identify the potential presence of plant and animal species of conservation importance within the Study Areas, international assessments of extinction risk were consulted. This included the IUCN Red Data List of species which uses the criteria given in Table 2-1 below. This publication provides taxonomic, conservation status and distribution information for each listed species.

Table 2-1: IUCN Red Data List classification

IUCN Category	Definition
Extinct in the wild (EXW)	-
Critically endangered (CR)	Species facing an extremely high risk of extinction in the wild
Endangered (EN)	Facing a very high risk of extinction in the wild
Vulnerable (VU)	Facing a high risk of extinction in the wild
Near Threatened (NT)	Close to qualifying for or is likely to qualify for a threatened category in the near future
Data Deficient (DD)	Inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and / or population status.
Least Concern (LC)	Widespread and abundant taxa are included in this category

The IUCN considers species listed as VU and above to be species of particular conservation concern due to their high risk of extinction in the wild. Species classified as VU or above on the IUCN Red List are referred to as 'threatened' in this study.

For ease of reference, all species which are listed on the IUCN Red List are referred to in this study as 'red list species', or as species of conservation concern/importance.

2.2 Data gaps

A review of secondary data provided information on the likely presence of habitats and species within the Wider Study Area. However, secondary data alone was insufficient to accurately determine habitat type and quality, as well as species presence or absence within the Study Area. Field surveys (for primary data) were therefore undertaken to obtain this information, so that potential impacts could be assessed.

Another data gap in this study was that for most field work, one season survey was carried out in January 2015 which is the time after the short rains in Lamu. This was recognized as a data gap and subsequently, some of the ecologists who said they wanted to collect additional data went out in March 2015 during the long rains to undertake another set of surveys.

A third study gap is that all one season terrestrial ecological field surveys were carried out over a rectangular project area of 206 hectares (~500 acres) which was one of the alternative land parcel areas provided by the MoEP. Later in March 2015 when the parcel size changed to an inverted "L" shape of 360 hectares (~880 acres), the second season survey was carried out over the new area. While there is no significant difference between the two alternatives with respect to the localized impacts, some ecologists only carried out their field work on a smaller parcel size.

2.3 Baseline characteristics

This section characterizes the ecology of the study area. The information used for this section was derived from a review of the limited secondary literature available for Lamu County.

2.3.1 Study area

2.3.1.1 Vegetation

The vegetation within the project site generally belongs to the Zanzibar – Inhambane evergreen and semi-evergreen bushland and thicket. The region occupies a coastal belt from south Somalia (1^o N) to the mouth of the Limpopo River (25^o S). This is composed mainly of scrub woodland with scattered trees (8m tall or more) including *Adansonia digitata*, *Terminalia spinosa* and *Hyphaene compressa*, *Afzelia quanzensis* and *Tamarindus indica*. Mangrove forests are represented by species such as *Rhizophora mucronata*, *Sonneratia alba*, *Xylocarpus mollucensis*, *Ceriops tagal*, *Bruguiera gymnorrhiza* and *Avicennia marina*. With the topography of the area being largely flat, several water pans, ponds and seasonal swamps exist in the area with Chomo swamp being the largest permanent swamp.

The desktop study revealed a total of 709 species recorded for Lamu County. The field survey recorded 183 species of which 99 were new to the existing list to make a combined total of 808 species.

About 80 species were recorded as threatened with possibility of extinction according to IUCN (2014), with 7 being recorded on the project site. These include; *Dalbergia melanoxylon*, *Dialium orientale*, *Haplocoelum inopleum* and *Crotalaria rhynchocarpa* among others. Three species were found to be rare or principally endemic to the region and three species are protected against international trade under CITES. Although no obvious cases of invasive species colonization observed, 8 species are known for Lamu County so far.

2.3.1.2 Invertebrates

The proposed project is located in an area that contains diverse habitats such as mangroves, coral reefs and sea grass beds. A few marine invertebrate species that have been recorded previously in Lamu and Kiunga areas, are reported to be threatened. These are Triton shell (*Charonia tritonis*), Seahorse (*Hippocampus kuda*) and Spiny lobster (*Palinurus sp.*).

2.3.1.3 Herpetofauna

The proposed site for development of the Amu coal power plant lies in a predominantly shrub savanna with open to closed canopy thorny bush of *Commiphora* and *Salvadora persica*. This is associated with the coastal biome herpetofauna assemblage.

Several different habitat types were identified during the field surveys namely farmland, woodland, grassland, mangroves and wetlands which support a variety of herpetofauna. These habitats are important for the habitation of amphibians and reptiles. The mangroves serve as the breeding sites for the sea turtle along the sandy beaches.

From previous and ongoing studies in the region and its surroundings, 154 species of reptiles (105) and amphibians (49) are known to occur. During the on-site visit 20 species of herpetofauna were recorded. Out these, 5 were amphibians and the rest were reptiles.

2.3.1.4 Birds

The proposed site for development of the coal power plant lies in a predominantly shrub savanna habitat with open to closed canopy thorny bush of *Commiphora* and *Salvadorapersica*. This is associated with the Somali-Masai biome avifaunal assemblage (Evans and Fishpool 2001). The marine shoreline adjacent to the site has mud flats used for feeding by a variety of shorebirds and high tide roosts. From records held at the National Museums of Kenya databases, there are over 300 species of birds known to occur in the vicinity of the proposed project site (Quarter Degree Square 91 A-D; Lewis and Pomeroy 1989). Among these are 15 species listed in the IUCN Red list of threatened species (3 endangered; 4 vulnerable; 8 near threatened), and 62 Palearctic migrant species and 39 Afrotropical migrants.

2.3.1.5 Mammals

The project site has been reported to be a ranging site for a number of large mammal species including the Topi, Buffalo, Elephant and Wild Dog, Giraffe, Buffalo, Hippopotamus, Lamu topi, Waterbuck and Gazelle have also been reported.

2.3.1.6 Marine flora and fauna

Lamu County is endowed with rich marine resources. The habitats of marine resources are important for sustenance of biological diversity and socioeconomic activities in Lamu County. Mangroves of Lamu constitute about 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).

Sea grasses occur between mangroves and coral reefs zones in the intertidal and subtidal areas. In the Lamu archipelago, large areas under seagrasses are well represented by roughly 13 species (Short et al. 2007). Sea grasses found in Kenya grow on limestone type of soils that are muddy.

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 broke and occur in patches due discharges from rivers and cold upwelling Somali currents.

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

2.3.2 Habitats, flora and fauna

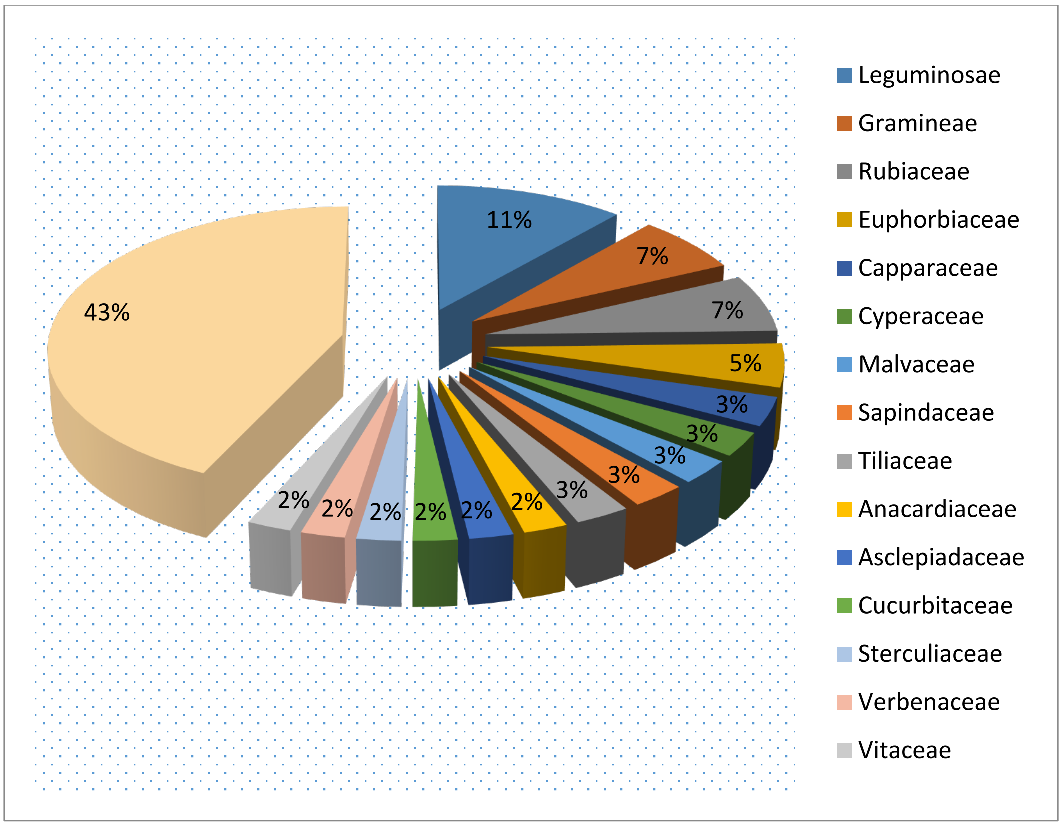
2.3.2.1 Vegetation

Based on the desktop and a rapid field assessment, a total of 808 plant species were compiled for Lamu County. This includes 183 records gathered during the physical plant survey with 99 being recorded for the first time or data about them not available (including a few cultivated species).

80 out of the 183 species are listed in the IUCN Redlist of Threatened Plants as shown in the appendix I. Despite the species richness, the area covered by the Lamu coal fired power plant is cultivated land with *Sesamum indicum* being the common crop cash crop grown.

Within the project site, the species were represented by 161 genera in 61 families. 15 plant families were represented by at least 4 species with the dominant being *Leguminosae* (21), *Gramineae* (12), *Rubiaceae* (12), *Euphorbiaceae* (9) and *Capparaceae* (6). The species distribution within the project site is shown pictorially in Figure 2-1 below.

Figure 2-1: Dominant plant families observed within the project site



Microhabitats within the project site

Although the vegetation of the area is highly disturbed by human activities, at least 5 habitat types where identified during the rapid vegetation assessment period. Notably, preparation of farms for planting is chiefly by burning, in which case it has greatly affected the species diversity of the area as large chunks of land are converted for arable use.

Woodland, Bushland and thicket

Scattered woodland and thicket bushland form patches of uncultivated parts of the highly disturbed project site. Large trees of up to 10m tall seen within the project site include *Tamarindus indica*, *Adansonia digitate* (Figure 2-2), *Terminalia spinosa*, *Sclerocarya birrea*, *Euphorbia candelabrum*, *Hyphaene compressa* and *Afzelia quazensis*. Bushland areas are predominantly occupied by species such as *Dichrostachys cinerea* (Figure 2-2), several *Grewia* spp. and *Markhamia zanzibarica*. Minor Threatened flora comprising *Dialium orientale*, *Lannea schweinfurthii*, *Haplocoelum inopleum*, *Crotalaria rhynchocarpa* and *Croton talaeporos* are sparsely distributed across the project site in low numbers except for *Dalbergia melanoxylon* which has a higher representation outside the project site in the area around Chomo Swamp located a few kilometers from the project site.

Figure 2-2: ***Adansonia digitat*** **woodland (left) and** ***Dichrostachys cinerea*** **bushland (right)**

Mangroves

Pockets of mangrove thickets are restricted to the shoreline and creeks in the vicinity of the project site coastline. The principal mangrove species are *Rhizophora mucronata*, *Sonneratia alba*, *Xylocarpus mollucensis*, *Ceriops tagal* and *Bruguiera gymnorrhiza* on the seaward fringes while *Avicennia marina* and *Lumnitzera racemosa* occupy the landward and creek zones. The flat topography on the landward margins of the mangrove thickets supports open low grass and shrub mixture characteristic of saline soils. Species such as *Sporobolus virginicus*, *Arthrocnemum indicum*, *Salicornia pachystachya*, *Sesuvium portulacastrum*, *Ipomoea pes-caprae*, *Suaeda monoica*, and *Dondonaea viscosa* are found here within a few metres from the high water mark. The parasitic *Oncocalyx cordifolious* and *Agelanthus kayseri* are also strictly restricted to this zone.

Figure 2-3: Image showing mangrove stands near the project site

Figure 2-4: littoral vegetation dominated by ***Arthrocnemum indicum***

Farmlands

A significant portion of the land within the project site is under cultivation with Sesame being the commonly cultivated plant as a cash crop. However, since the farmlands are not properly weeded, herbaceous species such as *Jacquemontia tamnifolia*, *Ipomoea pes-tigridis*, *Peponium vogelii*, *Waltheria indica*, *Oxygonum atriplicifolium*, *Rottboellia cochinchinensis*, *Dactyloctenium bogdanii* and other weeds of cultivation are common. Also observed are shrub coppices after previous felling or fire episodes in abandoned farms such as *Dialium orientale*, *Polysphaeria parvifolia*, and *Markhamia zanzibarica*.

Figure 2-5: Cultivation of *Sesamum indicum* (Sesame)

Red list plant species

From a desktop study of the wider area around the project site, a total of 80 threatened species was compiled for Lamu County (see Appendix 1) out of which 7 were recorded within the study site as shown in Table 2-2. With land preparation for farming mainly done by burning, there is a danger of these species becoming wiped out and hence the need for conservation during the construction phase of the project.

Table 2-2: Threatened plant species within the project site

Family	Genus	Species	*Life Form	IUCN Threat Category
Anacardiaceae	*Lannea*	*schweinfurthii*	T	Lower Risk/near threatened ver 2.3
Burseraceae	*Commiphora*	*obovata*	T	Lower Risk/near threatened ver 2.3
Euphorbiaceae	*Croton*	*talaeporos*	T	VU B2ab(iii)
Leguminosae	*Crotalaria*	*rhynchocarpa*	H	EN B1ab(iii)+B2ab(iii)
Leguminosae	*Dalbergia*	*melanoxylon*	S	Lower Risk/near threatened ver 2.3
Leguminosae	*Dialium*	*orientale*	T	VU B1ab(iii)+B2ab(iii)
Sapindaceae	*Haplocoelum*	*inopleum*	S	Lower Risk/near threatened ver 2.3
Life Form; T= tree, S=shrub, C= climber & H= herb				

Figure 2-6: Image of *D. melanoxylon*

Figure 2-7: Image of *Dialium orientale*

All succulent Euphorbias and Orchids are protected against international trade under Appendix II of the CITES list of plants (http://www.cites.org/sites/default/files/eng/app/2015/E-Appendices-2015-02-05.pdf). Although no trade in such is expected, those recorded in the project site are shown in Table 2-3 while their images are shown in Figures 2-8 to 2-10.

Table 2-3: List of plants protected against international trade

Family	Genus	Species
Euphorbiaceae	*Euphorbia*	*candelabrum*
Euphorbiaceae	*Euphorbia*	*cuneata*
Orchidaceae	*Angraecum*	*dives*

Figure 2-8: Euphorbia candelabrum

Figure 2-9: Euphorbia cuneata

Figure 2-10: Angraecum dives

Invasive species

Dodonaea is one of the recent indigenous species to be found rapidly invading pasture lands and natural ecosystems. As observed elsewhere, it has already caused an outcry in Laikipia and specifically East Pokot around Churo and Tangul Bei. Although no obvious cases of serious invasiveness by any of these species was recorded within the project area, monitoring is recommended during the construction and operational phase of the project.

Figure 2-11: image of Dodonaea viscosa shrubs	Figure 2-12: Seedlings (right, foreground) growing on the littoral zone
	

The mosaic of habitats described in the previous section as well as their relative floristic diversity, provide suitable foraging, breeding and sheltering habitat for a range of fauna in the project area and its environs. During the field surveys undertaken in January and March 2015, a variety of invertebrate, herpetofauna, birds and mammals' species were recorded across the habitat types present within the study area. The results of these surveys are detailed below.

2.3.2.2 Invertebrates

A total of 145 invertebrates were collected from the study site and it immediate surroundings. With 119 species, the terrestrial habitat yielded the greatest number of the species. The marine ecosystem and Chomo wetland produce 26 and 19 species respectively. The beetles and the butterflies were the most dominant groups in the study site with 43 and 26 species respectively. A species checklist with their distribution is provided in Appendix 2.

From this great diversity, a few invertebrate groups were identified as important for future monitoring of possible effects of the coal plant on the normal functioning of the ecosystem. These included all species of wild bees, ground beetles (Carabidae), several species of darkling beetles, one species of jewel beetles, a species of wild cockroaches, one species of millipede and swimming crabs. These groups of invertebrates were chosen because they are known to have a high sensitivity to environmental pollutants (Gary and Orie, 1980) and also because several have been used elsewhere to investigate the effects of pollution. The ground beetles for instance have been used in Russia to investigate the impact of uranium pollution on soil macro fauna (Gongalsky, 2003). These ground beetles, darkling beetles, wild roaches and the millipedes do not migrate far from their habitats. Their close associations with detritus also make them suitable candidates to monitor the effects of environmental changes that may be caused by for instance acid rains among other things. The interaction between different species of bees and flowering plants cannot be over emphasized. Any impact that negatively affects flowering plants is likely to be easily detected by observing the behavior of the bees. The phytophagous (leaf feeding) beetle, *Sternocera* castanea will be used to monitor any deleterious effects on vegetation. The close interaction between the swimming crab and the sea water makes them better candidates to monitor any effects in the sea from the desalination plant than the sand crabs found on the shoreline. The ease of collection and identification of these groups also made them ideal candidates for future monitoring.

Figure 2-13: Part of the collection from Kwasasi, Lamu County

Species richness and relative abundance

2.3.2.2.1 Wild bee species

A total of 8 species of wild bees were collected in the pan traps. Their relative abundances for the 6 days of sampling are given in Table 2-4. *Macrogalea candida* was the most abundant bee at the time of sampling. This is known to withstand dry conditions such as those prevailing during the survey.

Table 2-4: Species composition and relative abundances of wild bees in Kwasasi

Family	Common names	Genus	species	Count (No.)
Apidae	-	*Apis*	*mellifera*	1
Apidae	-	*Ceratina*	*sp1*	4
Apidae	-	*Ceratina*	*sp2*	1
Apidae	-	*Macrogalea*	*candida*	196
Halictidae	Sweat bees	*Allodape*	*sp.*	1
Halictidae	Sweat bees	*Lasioglossum*	*sp*	12
Halictidae	Sweat bees	*Pseudapis*	*sp*	1
Megachilidae	Leaf cutter bees	*Megachile*	*sp*	1

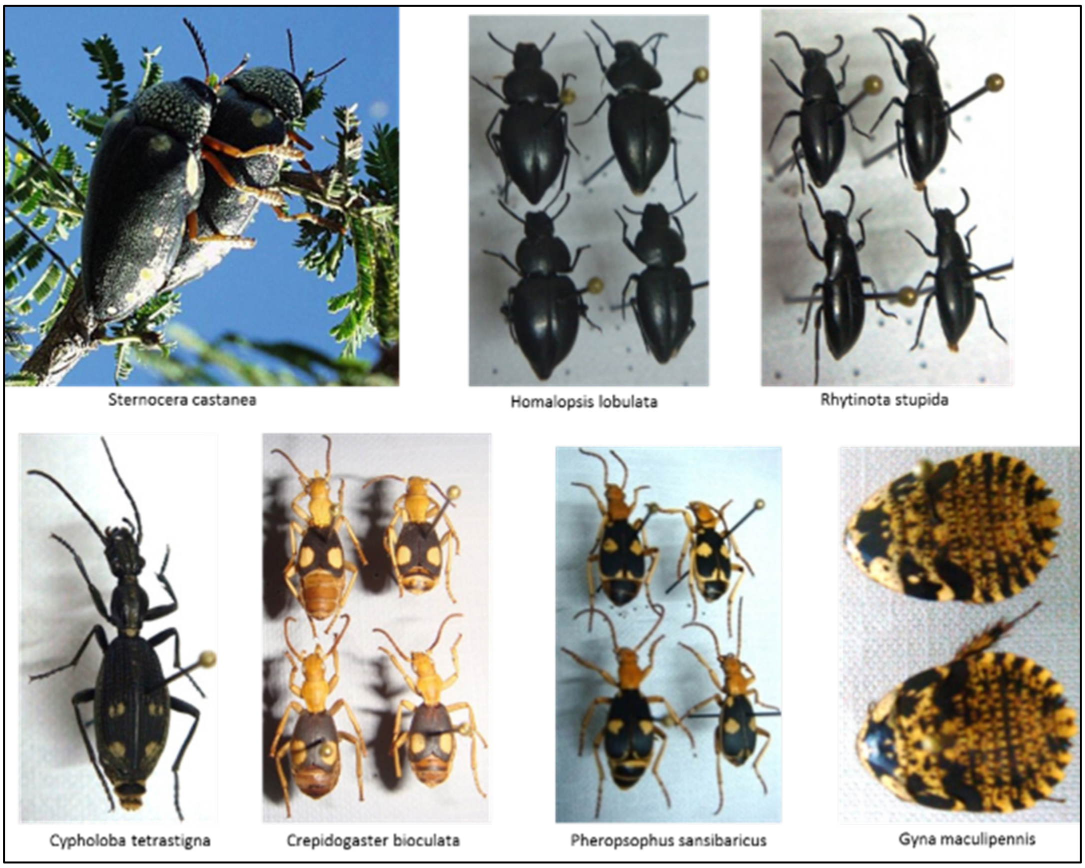
2.3.2.2.2 Beetles and wild cockroaches

Two families of beetles and one species of wild cockroaches were identified as a key for future monitoring. The two beetle families are *Carabidae* (Groung beetles) and *Tenebrionidae* (Darkling beetles).These were two species of ground beetles and three species of darkling beetles were found to be good candidates. *Gyna maculipennis* was the only wild cockroach included for monitoring due to its high abundance and interaction with detritus. Their relative abundances for the 6 days of trapping are given in Table 2-5.

Table 2-5: Species composition and relative abundances of ground beetles and wild cockroaches in Kwa sasi

Order	Family	Common names	Genus	species	No.
Blattodea	Blattidae	Wild Cockroaches	*Gyna*	*maculipennis*	94
Coleoptera	Carabidae	Ground beetles	*Crepidogaster*	*bioculata*	7
Coleoptera	Carabidae	Ground beetles	*Pheropsophus*	*sansibaricus*	24
Coleoptera	Tenebrionidae	Darkling beetles	Rhytinota	stupida	11
Coleoptera	Tenebrionidae	Darkling beetles	Homolopsis	lobulata	42
Coleoptera	Tenebrionidae	Darkling beetles	Zophosis	punctatafasciata	94

Figure 2-14: Key species of beetles identified in Kwasasi for future monitoring of project impacts



The abundances of the millipedes and the crabs were not estimated during the study period. The millipedes were collected in pit fall traps in very small numbers owing to the prevailing dry weather conditions during the time of the survey. However, large populations that were hard to count could be spotted clustered together deep inside shaded thickets.

2.3.2.2.3 Invertebrates of conservation concern in the region

There was no Red data listed invertebrate species collected from the project site in the Kwasasi area. A general lack of information on invertebrates of conservation concern in Kenya made it hard to generate this kind of information for the proposed project site. However, the larger Lamu area is known to have a few species of conservation concern. A recently discovered new species of tiger beetle *Dromica schaumi* sub species *schaumi* is one such species. In Kenya it has only been recorded from Witu near Lamu (Cassola & Miskell, 2001).

2.3.2.2.4 Aquatic macro-invertebrates

The project site is also adjacent to the sea. It has approximately 3 kilometers of shoreline on the eastern boundary of the project site. A great diversity of marine invertebrates was collected from this shoreline mainly in the intertidal zone. The species list is given in table 2-6 below.

Table 2-6: List of marine species collected from the sea adjacent to the proposed project site

Phylum	Class/ infra order	Common names	Family	Genus	species
Crustacea	Decapoda	Crabs	Gecarcinidae	*Uca*	*inversa inversa*
Crustacea	Decapoda	Crabs	Gecarcinidae	*Uca*	*latea annulipes*
Crustacea	Decapoda	Crabs	Gecarcinidae	*Uca*	*urvillei*
Crustacea	Decapoda	Crabs	Grapsidae	*Chiromantes*	*eulimene*
Crustacea	Decapoda	Crabs	Grapsidae	*Metopograpsus*	*oceanicus*
Crustacea	Decapoda	Crabs	Ocypodidae	*Ocypode*	*ceratophthalma*
Crustacea	Decapoda	Crabs	Pilumnidae	*Eurycarcinus*	*natalensis*
Crustacea	Decapoda	Crabs	Portunidae	*Charybdis*	*natator*
Crustacea	Decapoda	Crabs	Portunidae	*Portunus*	*pelagicus*
Crustacea	Decapoda	Crabs	Portunidae	*Thalamita*	*sp*
Crustacea	Decapoda	Prawns	Sergestidae		
Mollusca	Bivalvia	Bivalves	Mactridae	*Mactra*	*ovalina*
Mollusca	Bivalvia	Bivalves	Oestreidae	*Striostrea*	*margaritacea*
Mollusca	Bivalvia	Bivalves	Pinnidae	*Atrina*	*vexillum*
Mollusca	Gastropoda	Sea slug	Bullidae	*Bulla*	*ampulla*
Mollusca	Gastropoda	Sea slug	Hexabranchidae	*Hexabranchus*	*marginatus*
Mollusca	Gastropoda	Snails	Fasciolaridae	*Pleuroploca*	*trapezium*
Mollusca	Gastropoda	Snails	Janthinidae	*Janthina*	*janthina*
Mollusca	Gastropoda	Snails	Littorinidae	*Littoraria*	*pallescens*
Mollusca	Gastropoda	Snails	Littorinidae	*Littoraria*	*scabra*

Phylum	Class/ infra order	Commo n names	Family	Genus	species
Mollusca	Gastropoda	Snails	Melongenidae	*Volema*	*pyrum*
Mollusca	Gastropoda	Snails	Melongenidae		
Mollusca	Gastropoda	Snails	Muricidae	*Chicoreus*	*ramosus*
Mollusca	Gastropoda	Snails	Potamididae	*Cerithidea*	*decollata*
Mollusca	Gastropoda	Snails	Potamididae	*Terebralia*	*palustris*

2.3.2.3 Herpetofauna

The proposed site for development of the Amu coal power plant lies in a predominantly shrub savanna with open to closed canopy thorny bush of *Commiphora* and *Salvadora persica*. This is associated with the coastal biome herpetofaunal assemblage.

The woodland, grassland, wet and open habitats as well as the ecotones (habitat edges) between them provide suitable habitat for amphibian and reptile species. From previous and ongoing studies in the region and its surroundings 154 species of reptiles (105) and amphibians (49) are known to occur (see Appendix 3). During the field survey, 20 species of herpetofauna were recorded as shown in figure 2-15 – 2-23. Out these 5 were amphibians and the rest were reptiles. The reptiles list were:

- 3 snakes;
- 1 chameleon;
- 1 skink;
- 1 agama;
- 1 turtle;
- 4 geckos;
- 1 crocodile; and
- 1 monitor lizard.

Figure 1-24 shows a Google Earth map showing the locations where the various amphibians and reptiles were identified in the project site and its environs.

Figure 2-15: Tree skink

Figure 2-16: white headed gecko

Figure 2-17: black headed tree agama

Figure 2-18: tropical forest gecko

Figure 2-19: Anchieta's ridged frog

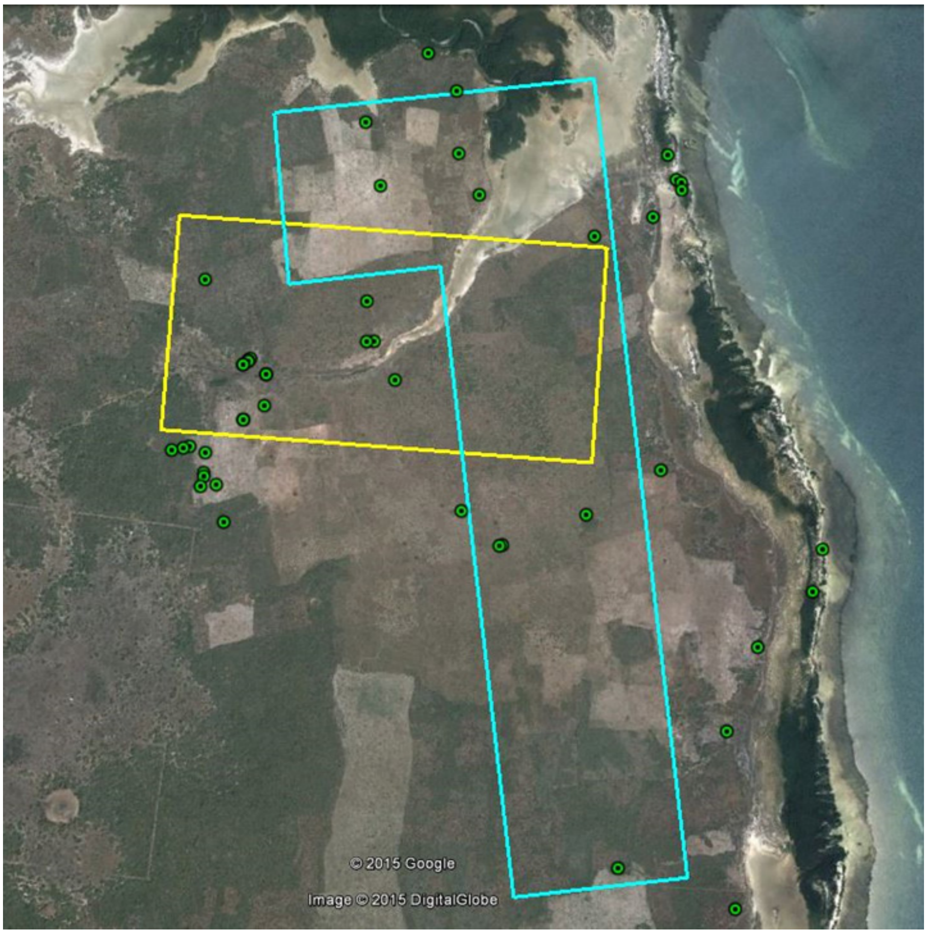
Figure 2-20: guttural toad

Figure 2-21: Scheffler's puddle frog

Figure 2-22: Eastern Bark Snake

Figure 2-23: Flap-necked chameleon

Figure 2-24: Map showing the various points that were sampled and where species were found



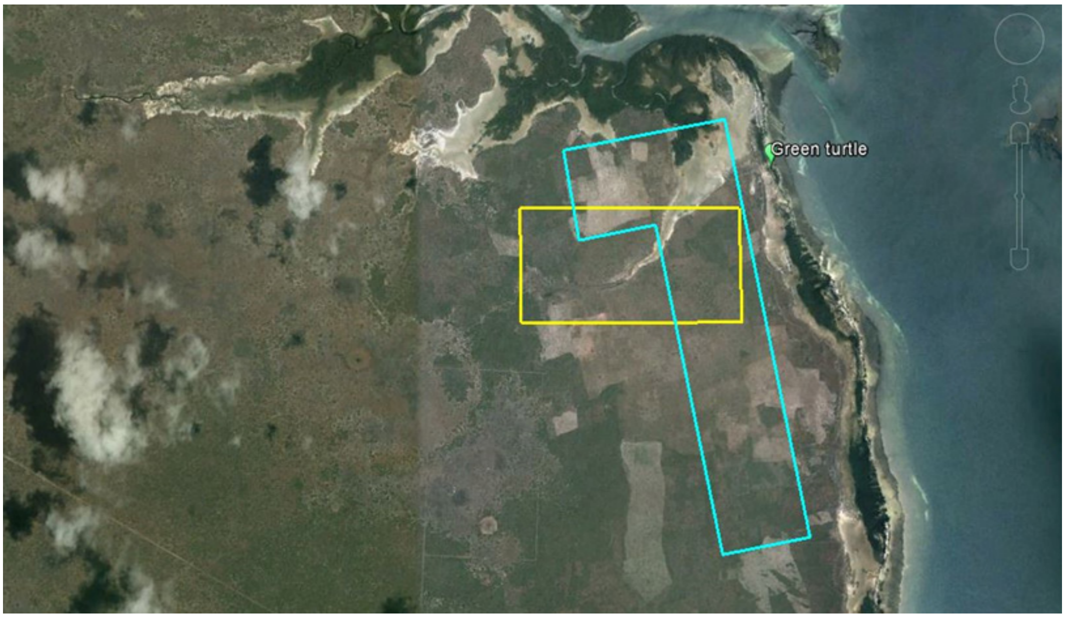
Species of conservation importance

Out of the known herpetofauna species eight (8) were identified through the IUCN species red list as either endangered (EN) or vulnerable (VU) as shown in table 2-7. Out of these, only one Olive Ridley turtle (Green turtle) was observed during the field survey at the location shown in figure 2-25.

Table 2-7: IUCN cited herpetofauna species known to occur in the area

Scientific name	Common name	Type	IUCN status
Afrixalus sylavaticus	Forest spiny reed frog	Amphibian	EN
Arthroleptis xenodactyla	Eastern squeaker	Amphibian	VU
Boulengerula changamwensis	Changamwe African Caecilian	Amphibian	EN
Caretta caretta	Loggerhead turtle	Reptile	EN
Chelonia mydas	Green turtle	Reptile	EN
Eretmochelys imbricita.	Hawksbill Turtle	Reptile	EN
Hyperolius rubrovermiculatus	Shimba Hills Reed Frog	Amphibian	EN
Lepidochelys olivecea	Olive Ridley turtle	Reptile	EN

Figure 2-25: Map showing location where the Chelonia mydas (Green turtle) was sited



2.3.2.4 Birds

The proposed site for development of the coal power plant lies in a predominantly shrub savanna habitat with open to closed canopy thorny bush of *commiphora* and *salvadora persica*. The marine shoreline adjacent to the site has mud flats used for feeding by a variety of shorebirds for feeding and high tide roosts.

From records held at the National Museums of Kenya databases there are over 300 species of birds known to occur in the vicinity of the proposed Lamu- CPP (Quarter Degree Square 91a-d; Lewis and Pomeroy 1989). Among these are 15 species listed in the IUCN Red list of threatened species (3 endangered; 4 vulnerable; 8 near threatened; see Table 1.0), and 62 Palearctic migrant species and 39 Afrotropical migrants (see Appendix 4).

In Kenya, 92 bird species are known to belong to the Somali-Maasai biome of which 22 occur around the Lamu area however only 6 Somali-Maasai biome were recorded during this survey. The site also lies next to a sandy/muddy beach (Kwasasi beach) used for feeding and roosting by a number of shorebirds some in internationally important numbers. Twenty-one bird species shown in Table 2-8 were observed feeding/roosting at Kwasasi beach over a four hour observation period.

Table 2-8: Bird species observed feeding/roosting on Kwasasi beach over a four hour-observation period

Common Name	*Scientific name*	*Status	Number counted
Whimbrel	*Numenius phaeopus*	*pm*	10
Curlew Sandpiper	*Calidris ferruginea*		14
Red-eyed Dove	*Streptopelia semitorquata*		
Little Egret	*Egretta garzetta*		1
Striated Heron	*Butorides striata*		1
Common Sandpiper	*Actitis hypoleucos*	pm	4
Grey Plover	*Pluvialis squatarola*	pm	30
Western Reef Heron	*Egretta gularis*	am	1
African Fish Eagle	*Haliaeetus vocifer*		2
Osprey	*Pandion haliaetus*	pm	1
Greater Sand Plover	*Charadrius leschenaultii*	pm	2
Pied Kingfisher	*Ceryle rudis*		1
Sanderling	*Calidris alba*	pm	11
Ruff	*Philomachus pugnax*		
Ruddy Turnstone	*Arenaria interpres*	pm	4
Sooty Gull	*Larus hemprichii*		3
Crab-plover	*Dromas ardeola*		17
Lesser Black-backed Gull	*Larus fuscus*		14
Lesser Crested Tern	*Sterna bengalensis*	am	5
White-winged Black Tern	*Chlidonias leucopterus*		2
Roseate Tern	*Sterna dougallii*		3
***pm=Palearctic migrant; am=Afro-tropical migrant**			

Avifauna abundance and diversity

During the field survey over a 9 day period in January 2015, 142 bird species in 43 families were recorded (see Appendix 4). Based on the Time Species Counts (TSCs), the Common Bulbul was the most common bird species observed as shown in Table 2-9. However these results were attained from 6 TSCs (due to limitations imposed by the security apparatus in Lamu County). Even though the Bateleur was the second most common bird species, there may only be a single pair sighted in all TSCs and not many different birds. The Barn swallow-a Palearctic migrant, was the most commonly encountered bird species during point counts at the site as shown in Table 2-10. The overall bird density recorded was 0.06 birds m^{-2}.

Table 2-9: Most common bird species observed based on six 40-minute Timed-Species Counts (TSCs)

Common Name	*Scientific name*	Abundance index	IUCN Status
Common Bulbul	*Pycnonotus barbatus*	14	
Bateleur	*Terathopius ecaudatus*	11	NT
Speckled Mousebird	*Colius striatus*	9	
Northern Carmine Bee-eater	*Merops nubicus*	8	
Rufous Chatterer	*Turdoides rubiginosa*	8	
Crested Francolin	*Francolinus sephaena*	7	
Reichenow's Seedeater	*Crithagra reichenowi*	7	
Grey-headed Bushshrike	*Malaconotus blanchoti*	6	
Rattling Cisticola	*Cisticola chiniana*	6	
Tawny-flanked Prinia	*Prinia subflava*	6	
Common Drongo	*Dicrurus adsimilis*	5	
Barn Swallow	*Hirundo rustica*	5	
Scaly Babbler	*Turdoides squamulata*	5	

Table 2-10: Encounter rates of birds based on the 18 point counts

Common Name	Scientific Name	Encounter rate (%)
Barn Swallow	*Hirundo rustica*	6
Emerald-spotted Wood Dove	*Turtur chalcospilos*	5
Crested Francolin	*Francolinus sephaena*	4
Ring-necked Dove	*Streptopelia capicola*	4
Flappet Lark	*Mirafra rufocinnamomea*	3
Northern Carmine Bee-eater	*Merops nubicus*	3
Reichenow's Seedeater	*Crithagra reichenowi*	3
Tropical Boubou	*Laniarius aethopicus*	3

Common Name	Scientific Name	Encounter rate (%)
Black-headed Heron	*Ardea melanocephala*	2
Black-headed Oriole	*Oriolus larvatus*	2
Black-necked Weaver	*Ploceus nigricollis*	2
Common Drongo	*Dicrurus adsimilis*	2
Grey-backed Camaroptera	*Camaroptera brachyura*	2
Rufous Chatterer	*Turdoides rubiginosa*	2
Scaly Babbler	*Turdoides squamulata*	2
Speckled Mousebird	*Colius striatus*	2

Bird species of conservation interest

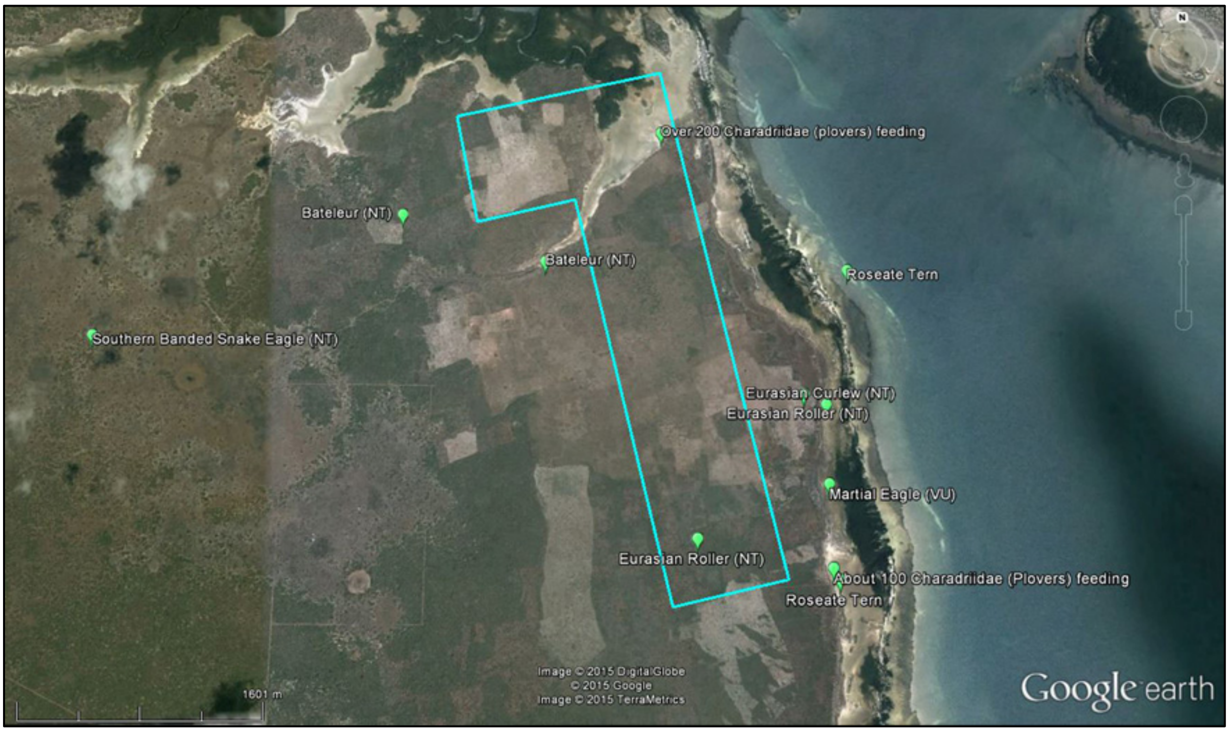
From databases held at the National Museums of Kenya (NMK), there are 7 bird species in the *IUCN Red list of threatened species* known to occur in the vicinity of the proposed project site (see Table 2-11) and a further 9 are listed as near-threatened. Of these, only one threatened species namely, the Martial Eagle *Polemaetus bellicosus* was recorded during the field survey. 4 near-threatened species namely, Bateleur *Terathopius ecaudatus*, Eurasian Curlew *Numenius arquata,* Southern Banded Snake Eagle *Circaetus fasciolatus* and Eurasian Roller *Coracias garrulus* were recorded during the field survey. Figure 2-26 shows sites where these species were recorded.

Table 2-11: Bird species Listed in the IUCN Red list of Threatened species (2014) known to occur in the Lamu region

Species Name	Scientific Name	Status
Grey Crowned Crane	*Balearica regulorum*	EN
Spotted Ground Thrush	*Zoothera guttata*	EN
White-backed Vulture	*Gyps africanus*	EN
Bateleur	*Terathopius ecaudatus*	NT
Black-tailed Godwit	*Limosa limosa*	NT
Eurasian Curlew	*Numenius arquata*	NT
Eurasian Roller	*Coracias garrulus*	NT
Fischer's Turaco	*Tauraco fischeri*	NT
Great Snipe	*Gallinago media*	NT
Maccoa Duck	*Oxyura maccoa*	NT
Malindi Pipit	*Anthus melindae*	NT
Southern Banded Snake Eagle	*Circaetus fasciolatus*	NT
Lappet-faced Vulture	*Torgos tracheliotus*	VU
Madagascar Pratincole	*Glareola ocularis*	VU
Martial Eagle	*Polemaetus bellicosus*	VU
White-headed Vulture	*Trigonoceps occipitalis*	VU

Species Name	Scientific Name	Status
EN-Endangered; VU-vulnerable; NT-near threatened		

Figure 2-26: Sites where IUCN red list bird species were recorded



Migratory species: 32 bird species recorded were Palearctic migrants (visitors from the northern tropics Sept to Apr) and 9 bird species were afro tropical migrants (intra African migrants). Most were recorded along the shoreline adjacent (Kwasasi beach) to the project site.

Other species of conservation concern:

The following three species are not listed in the IUCN red list but occur in the area in globally significant numbers and are therefore of conservation concern in the region:

i). **Roseate Tern** *Sterna dougallii*- Upto 1200 pairs are known to regularly breed on islets near Kiunga. Over 5000 pairs were recorded in 1970.

ii). **Crab Plover** *Dromas ardeola*- This species breeds in the Gulf of Oman and Gulf of Aden in the Middle East. Most of the species global population winters on the Kenyan coast.

iii). **Coastal Black Boubou** *Laniarius nigerrimus*- This species is endemic to the Lamu area of Kenya and extreme southern tip of Somali. The Kenyan population of the species has always wrongly been identified as sub-species of the more common Tropical Boubou. Recent DNA study has shown that this is not the case and that the Kenyan birds are *Laniarius nigerrimus*, formerly a southern Somali endemic (Turner and Pearson 2015).

2.3.2.5 Mammals

According to the LAPSSET Study of 2011, the project site was reported to be part of a ranging site for a number of large mammal species including the Topi, Buffalo, Elephant, Wild Dog, Giraffe, Buffalo, Hippopotamus, Lamu Topi, Waterbuck and Gazelle. During the field survey, the mammals shown in Table 2-12 were observed using various means as indicated in the table and shown in Figure 2-27.

Table 2-12: List of mammal species encountered during the survey

Common name	Species	Identification method
Pygmy Mouse	*Mus minutoides*	Specimen collected, is at NMK
Olive Baboon	*Papio anubis*	Sightings and photos
Crested Porcupine		Spike found
Yellow-winged Bat	*Lavia frons*	Sightings
Topi	*Damaliscus korrigum*	Sightings, photos and fecal
Cape Buffalo	*Syncerus caffer*	Sightings, photo and fecal
Hippopotamus	*Hippopotamus amphibius*	Sightings, photo, fecal and footprints
Vervet Monkey	*Chlorocebus pygerythrus*	Fecal and sightings
Dik dik	*Madoqua*	Foot prints and fecal
Cape Hare	*Lepus*	Foot prints and fecal

Figure 2-27: Mammals and mammal signs recorded on site

Clockwise from top left: Hare Scat, Buffalo print, Topi and Olive Baboon

Small mammals such as bats have been recorded in previous surveys of the area including Tomb Bat *Taphozous spp.*, Heart-nosed Bat *Cardioderma cor,* Yellow-winged Bat *Lavia frons,* Epauletted Fruit Bat *Epomophorus sp.,* and Yellow-bellied House Bat *Scotohilus colias*.

The poorly known and endemic Kenyan Wattled Bat *Glauconycteris kenyacola* is of particular importance, occurring only at the North Coast. The species is only known from its type collection. Other bat species likely to occur on site include those listed in Table 2-13. The Kenyan coast is an important area for bats, which roost in Baobab trees and caves along the shores of the ocean.

Table 2-13: Bats species found along the coastal strip which may also be found at the project site

Order	Family	Scientific Name	Common Name
Megachiroptera	Pteropodidae	*Epomophorus walbergi*	Wahlberg's Epaulleted Fruit Bat
		Lissonycteris angolensis	Angolan soft-furred fruit bat
		Rousettus aegyptiacus	Egyptian rousette
		Rousettus lanosus	Long-haired Rousette
Microchiroptera	Emballonuridae	*Coleura afra*	African sheath tailed bat
		Taphozous hildergardae	Hildegardes Tomb Bat
		Taphozous mauritianus	Mauritian Tomb Bat
		Taphozous perforatus	Egyptian Tomb Bat
	Nycteridae	*Nycteris Grandis*	Large slit faced Bat
		Nycteris hispida	Hairy slit-faced Bat
		Nycteris macrotis	Large Eared Slit-faced Bat
		Nycteris Thebaica	Egyptian slit- faced Bat
	Megadermatidae	*Cardioderma cor*	Heart-nosed Bat
		Lavia frons	Yellow-winged Bat
	Rhinolophidae	*Rhinolophus deckenii*	Deckens Horseshoe Bat
		Rhinolophus Eloquens	Eloquent Horseshoe Bat
		Rhinolophus Fumigatus	Rupell's Horseshoe bat
		Rhinolophus Landeri	Landers Horseshoe Bat
	Hipposideridae	*Hipposideros Caffer*	Sundevall's Leaf- faced Bat
		Hipposideros Gigas	Giant Leaf-nosed Bat
		Hipposideros ruber	Noack's Leaf-nosed Bat
		Hipposideros Vitattus	Striped Leaf-nosed Bat

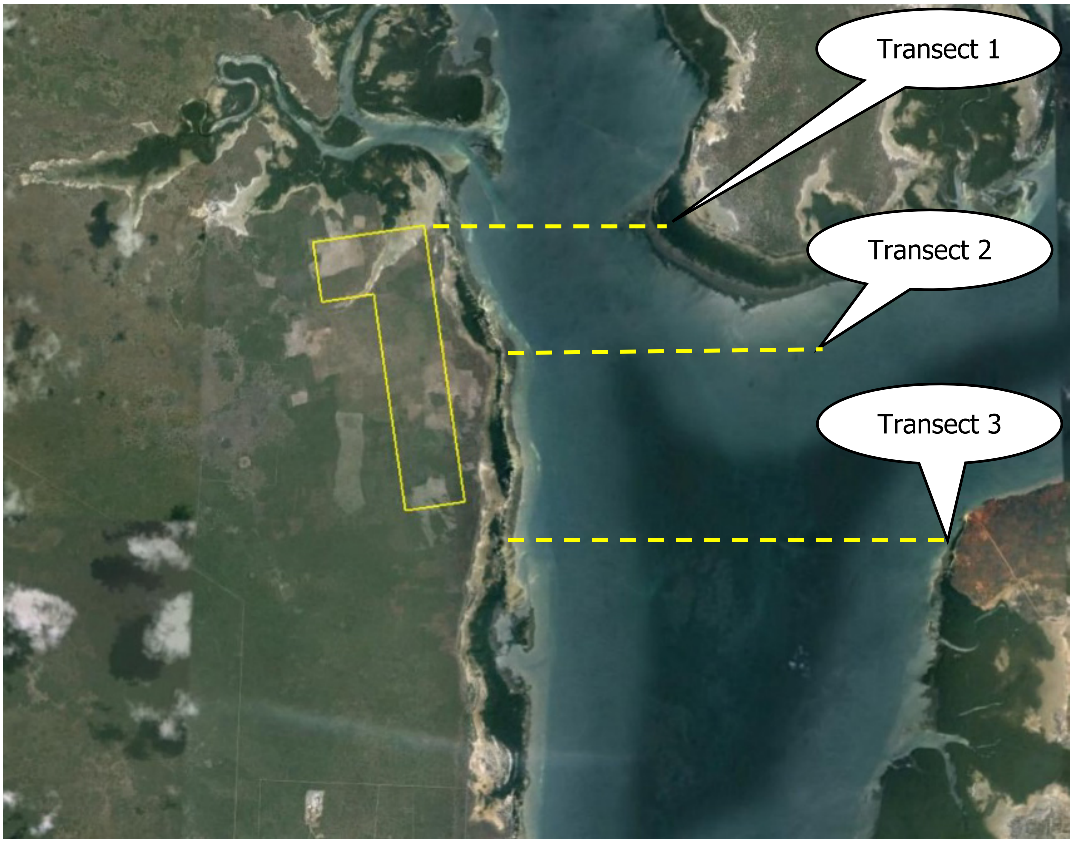
Order	Family	Scientific Name	Common Name
		Triaenops Persicus	Persian Trident Bat
	Vespertillionidae	*Miniopterus minor*	Least long-fingered Bat
		Myotis Bocagi	Rufous Myotis
		Neoromicia Nanus	Banana pipistrelle
		Neoromicia rendalli	Rendall's Serotine
		Scotoecus hindei	Hinde's Lesser house Bat
		Scotoecus hirundo	Dark-winged lesser house Bat
		Scotophilus dingani	Yellow-bellied house Bat
		Scotophilus colias	Yellow-bellied House Bat
		Glauconycteris kenyacola	Kenyan Wattled Bat
		Scotophilus nigrita	Giant House Bat
	Molossidae	*Chaerophon pumilus*	Little free-tailed Bat
		Mops condylurus	Angolan Free-tailed Bat
		Otomops martiensseni	Large eared Giant mastiff Bat

2.3.2.6 Marine flora and fauna

In order to characterize the marine habitats around the offshore project infrastructure (circulating water discharge, circulating water intake and coal receiving jetty), three transects were made from the shore line to the deepest point in the Manda Bay as shown in figure 2-28. Each transect started from the highest watermark (HWM), perpendicular to the shore line, to a distance of 2 to 3 km off-shore (i.e. the point where the shipping jetty will be stationed). The field survey involved profiling and describing the topography and substrate of the sea bottom along each transect as well as location of habitats from the HWM and their respective depths.

Generally three different topography types constituted the bottom of the sea bed at Manda Bay. In all three transects, the sea bed from the HWM up to a distance of 2km offshore is made of gently sloping gradients and is shallow up to a depth of 5m. This is followed by a steep gradient for the next one to two kilometers with depth ranging from 6 to 20 metres.

Figure 2-28: Map showing approximate location of three transects sampled



Given below is a description of the three transects and their topographical features based on the field survey.

Transect 1

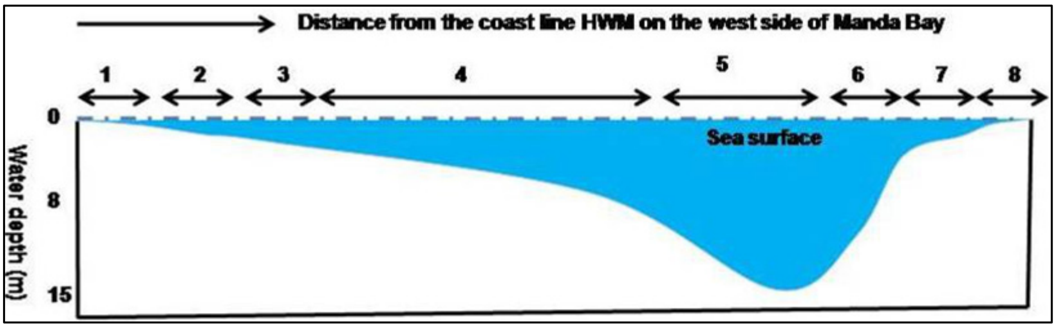
The topography from the HWM is flat with sand deposits for 100 metres, followed by patches of mangroves forests with muddy-silty-sandy substrates for 100 metres and then 100 metres of exposed sandy and muddy beaches. From the lowest water mark (LWM) is gentle sloping seabed of sand, silt, rocky and sea grasses beds for 1.5 km (Table 2-14); Figure 2-29 shows the bottom cross-sectional profile of transect 1. The water is moderate to clear and goes up to a depth of six metres. The length of Transect one was approximately 3km and covered whole of Manda Bay.

Table 2-14: Sea bed habitats, zones and topography characterization at Transect 1

Zone (from shore into Manda Bay)	Zone length (m)	Depth from the HWM (m)	Sea bed habitats and coverage
1	150	0m	100% sandy
2	150	0.5-2m	100% mangroves, 100% silt-sandy and muddy substrates
3	100	2-3m	100% silt-sandy
4	1500	3-9m	50% sandy-muddy bottom and 50% rocks covered with sea grasses and algae
5	500	9-15m	100% sandy – rocky bottom, 20 % coral reef patches

Zone (from shore into Manda Bay)	Zone length (m)	Depth from the HWM (m)	Sea bed habitats and coverage
6	300	9-15m	50% sandy-muddy bottom 50% rocks covered sea grasses and algae
7	200	3-3m	100% mangroves, 70% silt muddy and 30% sandy.
8	100	0-3m	100% sandy

Figure 2-29: Bottom cross-section profile at Transect 1



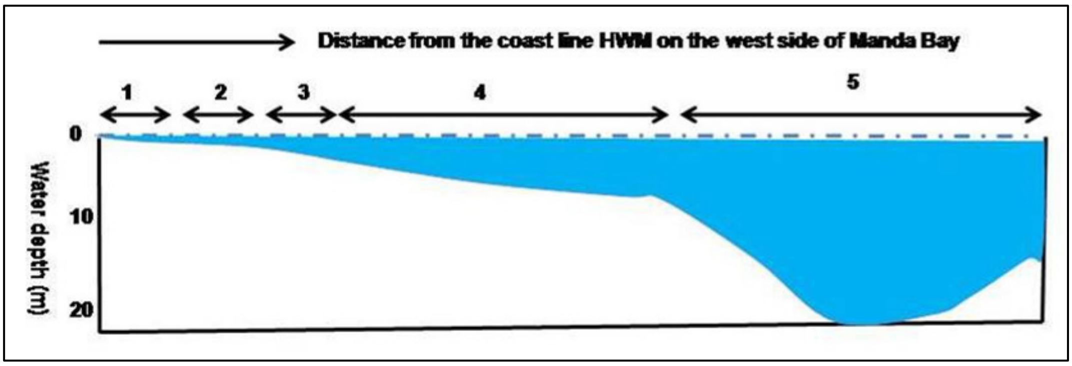
Transect 2

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. From the LWM, the sea bed gently slopes and consists of sand, silt, rocky and sea grasses beds for 1.5 km (Table 2-15); figure 2-30 shows the bottom cross-sectional profile of transect 2. The water is moderate to clear and goes up to a depth of eight metres. It then connects with deep sections of Manda Bay (9 to 20 metres). The bottom is covered by coral reefs, sea grasses and sandy areas. Transect 2 was approximately 3.0km long.

Table 2-15: Sea bed habitats, zones and topography characterization at Transect 2

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

Figure 2-30: Bottom cross-section profile at Transect 2



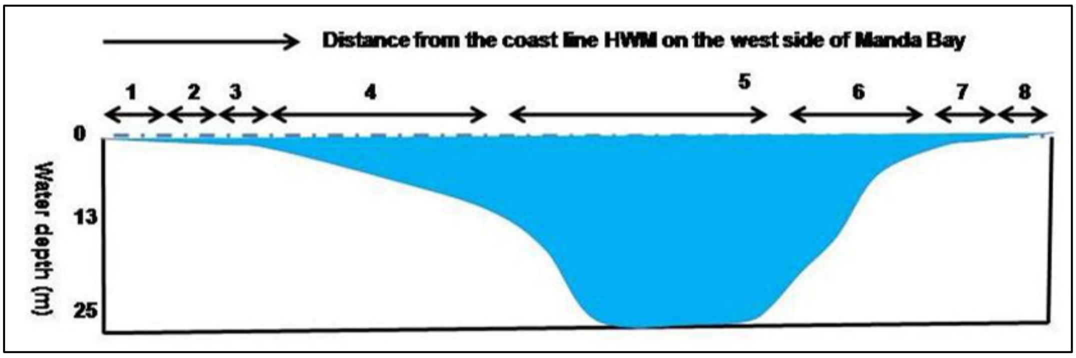
Transect 3

The topography from the HWM is flat with sand deposits for 200 metres, followed by mangroves with muddy-silt-sandy substrates for 300 metres and then 200 metres of exposed slightly muddy sandy beaches. From the LWM, the seabed gently slopes with sand, silt, rocky and sea grasses beds for 1.6km (Table 2-16); figure 2-31 shows the cross-sectional profile of transect 3. 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 2-16: Sea bed habitats, zones and topography characterization at Transect 3

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

Figure 2-31: Bottom cross-section profile at Transect 3

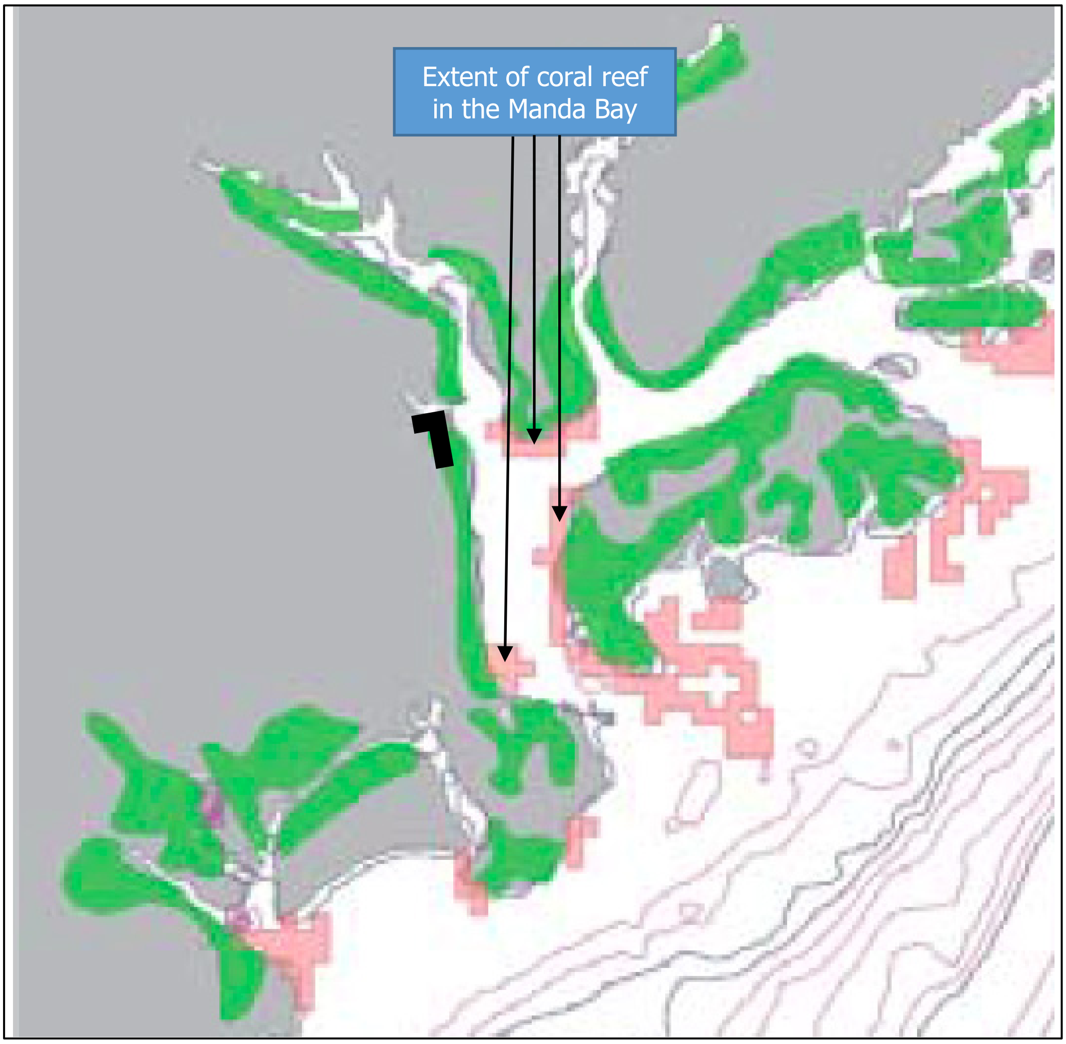


Figures 2-32 and 2-33 shows examples of typical images of the of sea bed characteristics used to describe coverage and habitats percentages.

Figure 2-32: Silt-sandy zones between mangroves and open water

Figure 2-33: exposed sea grasses beds on silt-sandy muddy beaches

[1]**Figure 2-34: Image showing extent of coral reef in the Manda Bay (pink areas)**



[1] Source: Obura, D.O., Church, J.E. and Gabrié, C. (2012). *Assessing Marine World Heritage from an Ecosystem Perspective: The Western Indian Ocean*. World Heritage Centre, United Nations Education, Science and Cultural Organization (UNESCO). 124 pp.

2.3.2.7 Sampling methodology for marine habitats

Sampling of mangroves, sea grasses and coral reefs was carried along transects using gradsect or gradient-directed transects (Bullock 2013). This method comprises establishing transects to intentionally sample 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 areas, sampling consisted of walking along transects and recording mangrove species present in 10x10m quadrants, spaced 20 metres apart. 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 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 long 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. This was done to a depth of 15 metres. The area under coral reefs, sea grasses, sand and boulders was estimated along the three transects, primarily where 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, fishery and forestry officers. This information was enhanced with information published on marine biodiversity resources in the area.

Other marine taxonomic groups assessed on the study area were fishery, macroinvertebrates, birds, sponges and algae. Information on occurrences of fishery species was solicited from our key informants, representatives of BMUs and mangroves cutter 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). 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.

2.3.2.8 Marine habitat description

Given below are descriptions of the marine habitats and fisheries near the proposed project site based on field surveys.

2.3.2.8.1 Mangroves

Mangroves in Lamu County occupy 33,500 ha, representing 75% mangrove forest area in Kenya. This is a significant area and endowed with rich biodiversity that is foundation for the many ecosystems services offered by the marine systems in the area including high primary productivity that support fishery, forestry and tourism economies (Abuodha & Kairo 2001) as well as regulating sediments and pollutants from reaching coral reefs. The occurrence of marine biota within the mangroves intertidal area was found to be rich though influenced by presence and extent mangroves, beaches and water pools. Significant numbers of water birds were observed feeding on silt-mud and sand beaches. Similarly high numbers of crustaceans were found in the mangroves and sandy beaches while mangroves stems and roots are abundantly colonized by bivalves. Water pools within the mangroves were important nursery habitats for juvenile fish and crustaceans. Gastropods were recorded though in low abundances.

Mangroves mainly occupy the intertidal zone where they are interspersed with sand-silt-mud habitats and water pools. In the project area, mangroves are found along the western edge of the Manda Bay channel in narrow stretches (ca. 50 to 200m wide) that run along the coast line. It was observed that the species *Xylocarpus granatum* occupy the landward side, while the species *Avicenia marina*, *Rhizophora mucronata* and *Sonneratia alba* occur on the sea side; the species *Bruguiera gymorrhiza* and *Ceriops tagal* are found in the middle sections. Mangroves are harvested based on licenses issued to stakeholders by the Kenya Forestry Service (KFS) which is the lead agency responsible for mangroves management in Kenya. An image of harvested mangroves is shown in Figure 2-35.

Figure 2-35: Harvested mangroves used as building poles at Mokowe Jetty

2.3.2.8.2 Sea grasses

Sea grasses were well represented in the surveyed area. They were interposed by macroalgae in the intertidal and subtidal area between the mangroves and coral reefs. Seven species were found to be common. They comprised extensive monospecific and multispecific stands of *Halodule wrightii* and *Cymodocea rotunda* on the HWM, followed by *Thalassia hemprichii* (common in shallow water next to mangroves), *Enhalus acoroides, Thalasondedron ciliatum, Halophila spp* and *Syringondium isoetifolium* in the shallow to the medium deep waters in the coral reef zones. Other species infrequently encountered were *Ruppia maritina, Halophila ovalis, Halodule spp* and *Cymodocea spp* that were found in mono and mixed stands with *T. hemprichii* while the rare species such as *Halophila ovalis* and *Halophila stipulacea* appeared more in the raised sandy bumps in the infralittoral zone. Seagrasses remained completely inundated during neap tide but vast areas were exposed during spring tide. Overall eleven species out of the thirteen known to occur in this area were encountered during the field survey. Images of sea grasses encountered during the field survey are shown in Figures 2-36 to 2-39.

Figure 2-36: Image of Syringondium isoetifolium sea grass

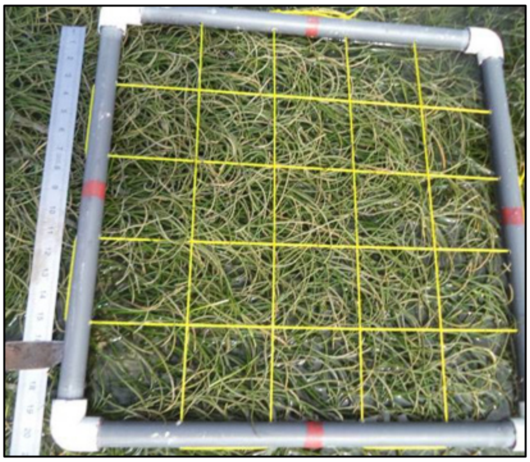
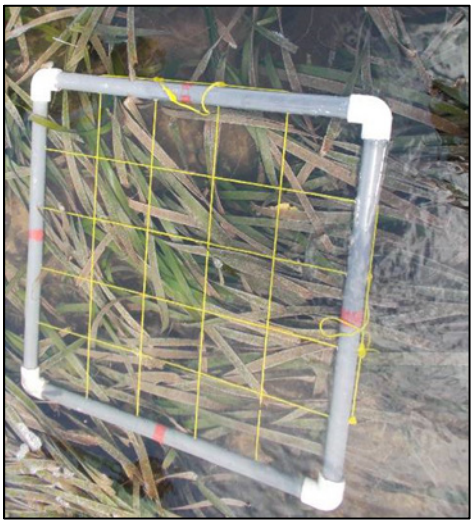


Figure 2-37: Image of Thalassia hemprichii sea grass

Figure 2-38: Image of Thalasondedron ciliatum sea grass

Figure 2-39: Image of Enhalus acoroides sea grass



2.3.2.8.3 Coral reefs

The field survey confirmed occurrences of coral reefs in Manda Bay in the deeper sections of the three transect made. Assessment of coral reefs involved determination of their coverage and identification of common species. Specifically coral reefs occupied between 10 to 30% of the deep section of Manda Bay. The reefs were of the inner type, fringed in patchy communities in the sheltered sections of the bay. They are rarely exposed to heavy wave energy but do experience strong tidal currents and high levels of turbidity due to sediments from adjacent mangrove and intertidal systems. These findings were consistent with Obura & Church (2004) maps of coral reefs in the area, which shows the coral mostly occurring in the deep and sheltered sections of Manda Bay. There are about 157 species of coral reef in Lamu which compare well with 154 species of Kiunga National Reserve in the north (Obura 2008). Coral reefs support hard coral species, with soft coral species occurring occasionally. Common families and species found in Manda Bay are given in Table 2-17.

Table 2-17: Species and distribution of mangroves, seagrasses and coral reefs found in Manda Bay

Category	Families	Species name (local names)	Distribution patterns, abundances and uses
Mangroves	N/A	*Rhizophora mucronata* (Magoni, Mkoko, Mkoko mwenye mwenye)	Abundant in distribution Have good roofing poles of different sizes. Sources of quality firewood
		Sonneratia alba (Mlilana, Mpira)	Common Boat making
		Avicenia marina (Mchu)	Abundant Highly exploited for charcoal. Used in making making boats and accessories.
		Xylocarpus granatum (Mkomafi)	Common species. Highly exploited for charcoal and boat making
		Bruguiera gymmorrhiza (Mshinzi, Muia, Mkoko wimbi)	Occasional in distribution. Good poles for corner and centre of houses. High quality charcoal.
		Ceriops tagal (Mkandaa mwekundu, Mkokomtune, Mkoko mwekundu)	Abundant in occurrences. Have good roofing poles of smaller sizes as well overall building materials
		Lumitzera racemosa (Kilalamba duma, Kikandaa,Mkaa pwani)	Ocassional in occurences Charcoal and sometimes building materials
Sea grasses	N/A	*Halodule wrightii*	Common in HWM zones
		Cymodocea rotunda	Common in HWM zones
		Thalassia hemprichii	Abundant in shallow waters
		Enhalus acoroides	Abundant
		Thalasondedron ciliatum	Abundant
		Halophila spp	Occasional
		Syringondium isoetifolium	Abundant
		Ruppia maritina,	Occasional
		Halophila ovalis	Rare
		Halodule spp	Occasional

Category	Families	Species name (local names)	Distribution patterns, abundances and uses
		Halophila stipulacea	Rare
Coral reefs	Pocilloporidae	*Pocillopora* spp *Pocillopora damicornis* *Pocillopora verrucosa*	Abundant. Fast growing genera and very sensitive to environment stresses that easily lead to 100% mortality levels.
	Poritidae	*Porites* spp *Porites lutea* *Porites nigrescens*	Abundant. Very sensitive to environmental stresses.
	Faviidae	*Favites pentagona*	Abundant. Sensitive to environmental stresses.
	Faviidae	*Platygyra daedelea*	Abundant. Sensitive to environment stress.
	Faviidae	*Goniastrea* spp	Common.
	Acroporidae	*Acropora* spp *Acropora eurystoma*	Common. Fast growing genera and very sensitive to environment stresses that easily lead to 100% mortality levels.
	Faviidae	*Echinopora* spp *Echinopora gemmacea*	Occasional. Fast growing. Sensitive to environmental stresses.
	Oculinidae	*Galaxea astreata* *Galaxea fascicularis*	Common. Fast growing. Very sensitive to environment stresses that easily lead to 100% mortality levels.
	Acroporidae	*Montipora* spp *Montipora tuberculosa* *Montipora informis*	Occasional. Sensitive to environmental stresses.
	Agariciidae	*Pavona* spp *Pavona varians*	Common. Moderate sensitive to environment stresses.
	Pocilloporidae	*Stylophora* spp	Occasional, fast growing.
	Pocilloporidae	*Seriatopora guttatus*	Common, fast growing
	Siderastreidae	*Horastrea indica*	Occasional, regional endemic and prefer turbid and deep waters.
	Acroporidae	*Astreopora* spp	Occasional. Sensitive to environmental stresses.

Category	Families	Species name (local names)	Distribution patterns, abundances and uses
	Merulinidae	*Hydnophora* spp *Hydnophora exesa*	Common. Sensitive to environment stresses.
	Faviidae	*Favia pallida* *Favia favus* *Favia* spp	Common. Sensitive to environment stresses
	Alcyoniidae	*Sinularia polydactyla* *Sinularia* spp	Occasional. Moderate sensitive to environment stress
	Poritida*e*	*Goniopora* spp	Occasional. Moderately insensitive to environmental stresses
	Poritidae	*Alveopora* spp	Occasional. Moderately insensitive to environmental stresses

2.3.2.8.4 Fisheries

Mangroves, seagrasses and coral reefs are important habitats for fishes, gastropods, mollusks and crustaceans. During their lifetime, these organisms spend time and utilize the mangroves, sea grasses and coral reefs for breeding, growing or nursery, feeding or dwelling. As result these habitats are important grounds for fishery activities. Fisheries in Lamu County are mainly marine-based with only a small percentage from freshwater wetlands. The fisheries sector is major source of revenue for the County, with 70% of the population in Lamu East relying solely on fishing and 30% in Lamu West. Fisheries in Lamu generated more than KShs 350 million in 2014 (Table 2-18), which represented 41% of national marine fisheries earnings (NEMA 2011). There are 5,000 fulltime fishers with 1,300 fishing boats with varying fishing equipment and gears. Only 20% of the fishing boats have engines. Most of the fishing occurs in the territorial waters and there are 14 fish landing sites.

[2]**Table 2-18: Fishery production (kg) in Lamu County**

Major groups	Family	Years		
		2012	2013	2014
Tilapias	Cichlidae	26507	85200	73046
Clarias	Clariidae	1458	61844	106908
Protoperus (Lung fishes)	Protopteridae	271	55332	70661
Rabbit (e.g., Siganus)	Siganidae	235185	277733	252130
Scavenger (e.g., Dolphin fishes)	Coryphaenidae	228529	262690	251891

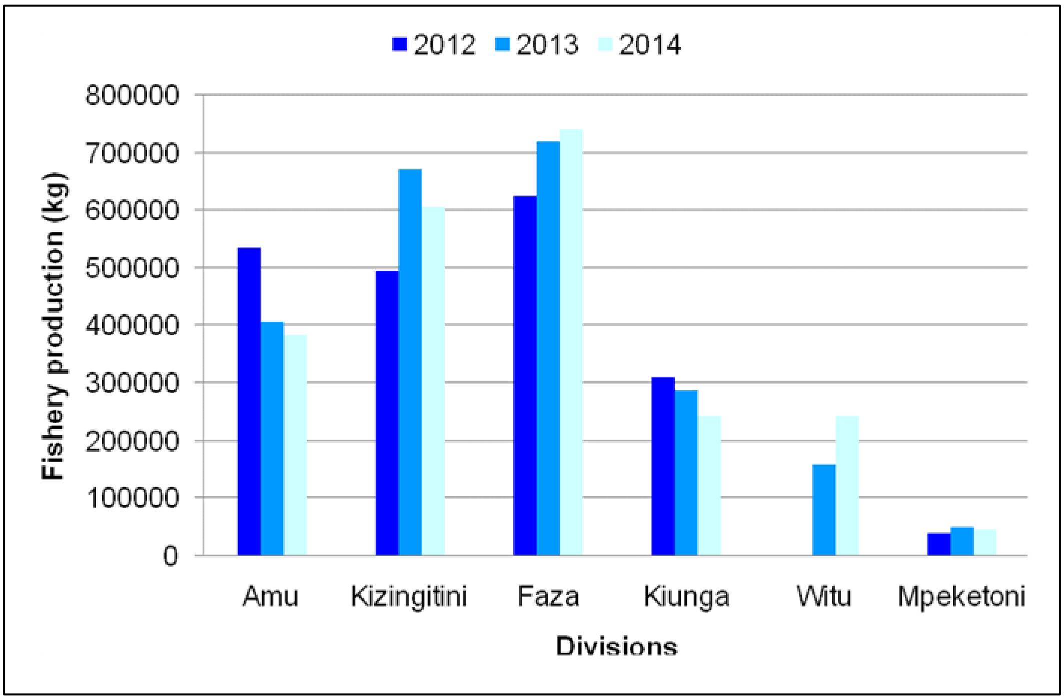
[2] Source: Mr. Fuad Sheyumbe Fishery Officer, Lamu County January 2015

Major groups	Family	Years		
		2012	2013	2014
Snappers (Lutjanus sp.)	Lutjanidae	79535	61125	81500
Parrot (Scarus)	Scaridae	135407	247122	203891
Unicorn (Naso)	Acanthuridae	17061	13030	14568
Surgeon (Acanthurus)	Acanthuridae	9608	23477	21248
Grunter (Pomadasys)	Pomadasyidae	49429	40623	46015
Pouter (Mojarras, Silverbiddies)	Gerreidae	55601	52497	64568
Blue skin (Polysteganus)	Sparidae	87929	81858	73148
Cat fish (Galeichthys)	Ariidae	28517	29379	19356
Roc cod (Cephalopholis)	Serranidae	51530	43962	49688
Goat Fish (Mulloides)	Mullidae	39507	32938	14888
Mixed Dermesal (e.g., Stegastes, Bluespotted ribbontail rays)	Pomacanthide	383711	353401	304736
Cavilla (Cavallo)	Acanthuridae	56052	56571	50664
Mullets (Liza)	Mugilidae	113323	89600	87032
Baracuda (Sphyraena)	Sphyraenidae	54640	58976	38830
Milk Fish (Chanos)	Chanidae	25503	20199	11660
King Fish (Carangoides)	Carangidae	11269	9246	13706
Queen Fish (Scomberoides)	Carangidae	23452	17296	11069
Sail fish (Istiophorus)	Istiophoridae	6575	6711	6101
Bonito (Sarda)	Scombridae	9487	10152	12660
Mix Pelagic e.g. Herrings,	Clupeidae Engraulidae	32465	40110	35919

Major groups	Family	Years		
		2012	2013	2014
Sardines, Anchovies)	Chirocentridae			
Lobsters (Crustacea)	Palinuridae	28254	44504	89797.6
Prawns (Crustacea)	Penaeidae	11656	8966	10744
Crabs (Crustacea)	Aidae	74558	80819	89427
Beche de mer (dried sea urchins for ornamental)	Class: Echinoidea	9832	8782	5103
Sharks (Carcharinus)	Carcharhinidae	20161	26919	16703
Cowries (Porcelaines)	Cypraeidae,	350	500	9223
Shells (Mollusks, gastropods)	e.g., Xenophoridae, Turritellidae, Nautilidae	32202	7235	13397
Octopus	Octopodidae	32932	18952	17843
Squids	Loliginidae	11,050	15088	13394
Others		33803	55391	73053
Grand total (KG)		**2,007,349**	**2,298,228**	**2,266,179**
Total value in KShs		**235,533,614**	**317,589,617**	**354,141,141**

Given in Figure 2-40 is data on fishery production for the years 2012, 2013 and 2014 for the six divisions of Lamu County: Faza, Kizingitini, Kiunga, Lamu, Witu and Mpektoni. Major fish catches are rabbit fish, scavenger, snapper, cat fish, cavalla jacks, mackerel, blackskins, barracuda, mullets, queen fish, sail fish, tuna, prawns, lobsters, crabs, and sharks/rays in dried form, sardines, oysters and octopus. Other fisheries utilized are prawns, lobster, crabs, sharks, shells, shrimp and fin fish.

Figure 2-40: Fishery production in the six divisions of Lamu County



2.3.2.8.5 Other marine organisms

The investigated area also supported a variety of other marine organisms. Some of the recorded organism groups are macroinvertebrates as shown in Table 2-19.

Table 2-19: Marine macroinvertebrates recorded in the project area

Common names	Phylum	Family	Species
Bivalves	Mollusca	Mactridae	*Mactraovalina*
Bivalves	Mollusca	Oestreidae	*Striostreamargaritacea*
Bivalves	Mollusca	Pinnidae	*Atrinavexillum*
Crabs	Crustacea	Gecarcinidae	*Ucainversa inversa*
Crabs	Crustacea	Gecarcinidae	*Ucalatea annulipes*
Crabs	Crustacea	Gecarcinidae	*Ucaurvillei*
Crabs	Crustacea	Grapsidae	*Chiromanteseulimene*
Crabs	Crustacea	Grapsidae	*Metopograpsusoceanicus*
Crabs	Crustacea	Ocypodidae	*Ocypodeceratophthalma*
Crabs	Crustacea	Pilumnidae	*Eurycarcinusnatalensis*
Crabs	Crustacea	Portunidae	*Charybdisnatator*
Crabs	Crustacea	Portunidae	*Portunuspelagicus*
Crabs	Crustacea	Portunidae	*Thalamitasp*
Prawns	Crustacea	Sergestidae	
Sea slug	Mollusca	Bullidae	*Bullaampulla*
Sea slug	Mollusca	Hexabranchidae	*Hexabranchusmarginatus*

Common names	Phylum	Family	Species
Snails	Mollusca	Fasciolaridae	*Pleuroplocatrapezium*
Snails	Mollusca	Janthinidae	*Janthinajanthina*
Snails	Mollusca	Littorinidae	*Littorariapallescens*
Snails	Mollusca	Littorinidae	*Littorariascabra*
Snails	Mollusca	Melongenidae	*Volemapyrum*
Snails	Mollusca	Melongenidae	
Snails	Mollusca	Muricidae	*Chicoreusramosus*
Snails	Mollusca	Potamididae	*Cerithideadecollata*
Snails	Mollusca	Potamididae	*Terebraliapalustris*

2.3.2.9 Marine water quality and sediment assessment

Water and sediment from marine habitats were collected from a variety of locations within Manda Bay during the field surveys as shown in Figure 2-41. The samples were independently collected by a NEMA accredited laboratory – SGS Kenya Limited for analysis. All samples were analyzed at SGS Kenya Limited Laboratory in Mombasa according to local and international standards and guidelines for sampling and analysis. Measured levels will act as baseline levels during future monitoring. The results of the analysis are presented in Table 2-20.

Measured water quality parameters are those that their levels in the environment have been set in the NEMA's water quality standard guidelines (NEMA 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 @ 20^{0}C (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 %).

Figure 2-41: Water and sediment sampling locations in Manda Bay

Table 2-20: Water and sediment baseline analysis at various sampling locations in Manda Bay

Site Number	1	5	15	16	17	18
Site Name	Ndununi Bay	Manda Bay	Manda Bay	Manda Bay	Manda Bay	Lamu Bay
Latitude (south)	-1.98125	-2.1106	-2.10814	-2.09359	-2.07908	-2.26372
Longitude (East)	40.845766	40.95481	40.94342	40.92707	40.92661	40.90167
Ambient temperature (°C)	30.5	29.4	26.9	27.3	28.9	28.3
Temperature	29.4	30	28	28.5	28	28
pH	7.4	6.13	7.84	7.79	7.89	7.62
Total Suspended Solids (mg/l)	2	2	2	2	2	5
Total Dissolved Solids (mg/l)	31860	30660	31560	31680	30600	32886
Fluoride as F- (mg/l)	1.77	1.93	2.54	1.52	1.7	1.5
Residual chlorine (mg/l)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Oil and Greases %wt	Nil	Nil	Nil	Nil	Nil	Nil
Total Nitrogen (mg/l)	5.8	0.99	4.42	4.7	1.46	133.63
Total Cyanide (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil
Phosphate In Water (mg/l)	0.9	0.9	1.1	0.3	0.3	0.1
Chemical Oxygen Demand (mg/l)	1876	1204	1526	975	475	596
Total Phenols (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
BOD 5 @ 20°C (mg/l)	1038	669	704	483	250	351
Sulphides (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil
Salinity (ppt)	34.7	33	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
Cadmium as Cd (mg/l)	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Chromium as Cr (mg/l)	<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

Site Number	1	5	15	16	17	18
Site Name	Ndununi Bay	Manda Bay	Manda Bay	Manda Bay	Manda Bay	Lamu Bay
Latitude (south)	-1.98125	-2.1106	-2.10814	-2.09359	-2.07908	-2.26372
Longitude (East)	40.845766	40.95481	40.94342	40.92707	40.92661	40.90167
Iron as Fe (mg/l)	<0.007	<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
Selenium as Se (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc as Zn (mg/l)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Total Phosphorus as PO_4 (mg/l)	0.02	0.14	0.13	0.05	0.08	0.18
Total coliform count (mpn/100ml)	23	23	11	23	22	>1800
E. coli (MPN/100ml)	8	Nd	Nd	2	2	>1800
Permanganate Index (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil
Anionic Surfactants as MBAS (mg/l)	Nil	Nil	Nil	Nil	Nil	Nil

3 Critical habitat assessment

3.1 Introduction

The proposed project is located in the terrestrial habitats, in proximity to the coastal and marine environment. Its adjacency to the coastline and planned utilization of the coastal/marine resources for its activities calls for a thorough scrutiny of its potential interactions with critical habitats. However, critical habitats require to be identified in order to establish elements of project development that will affect them and the mechanism through which these elements will cause harm on the habitats. An understanding of critical habitat is imperative in the process of identification and rationalization of characteristics of critical habitats in a more acceptable manner. The International Finance Corporation provides a through scrutiny of various types of development projects in relationship with biodiversity and human environment.

Adoption of IFC requirements in biodiversity frameworks is important in streamlining biodiversity conservation at local levels. Relevant to this task review is the Performance Standard 6 (PS6; IFC 2012a) and the associated Guidance Note 6 (GN6; IFC 2012b) which are explore to come up with opportunities for protecting and conserving (Stefan et al., 2013) important marine and terrestrial biodiversity in Amu/Lamu area. In specific, sections in the IFC documents that covers critical habitat is given more attention in order to acquire guidance on how to handle conservation issues surrounding the habitats.

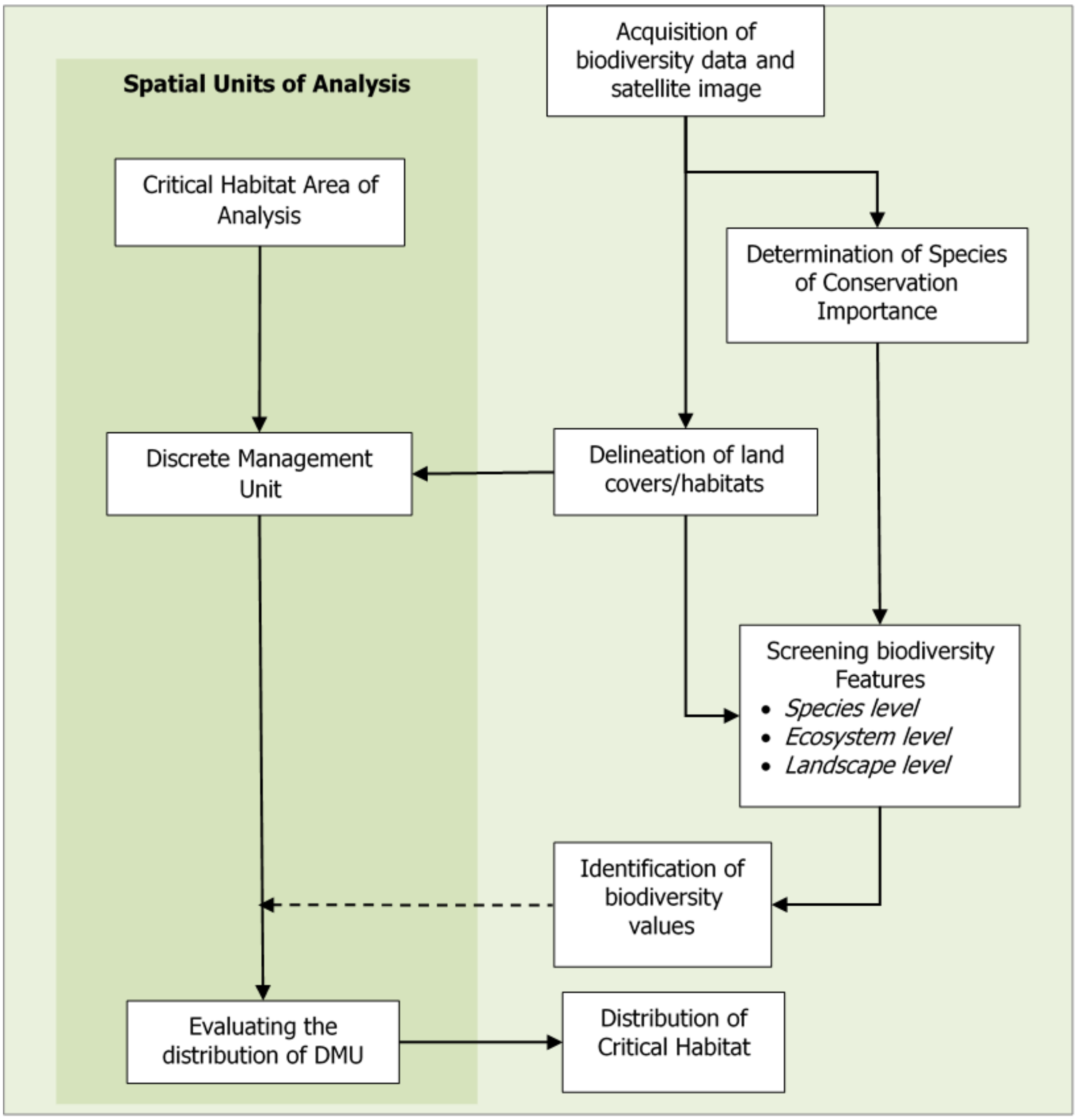
Since the requirement for review and assessment of CH is prompted by the proposed Amu Coal Power Project, one would be bias and develop a tendency to focus on the immediate environment of the project site. This does not provide for a proper ranking of habitats on a wider landscape based on their values. However, it is important to note that the identification of CH could have been conducted independent of Amu coal power project and the extent should not be defined by the size of project foot-print. Moreover, the process can be conducted without reference to the power project. Thus, when this project was proposed at Amu, an existing CH area should be used in scrutinizing the potential impacts of the project.

Despite all these, this task is conducted with the main objective of determining critical habitats in the wider landscape and assessing how the proposed coal power project would affect the habitats or species community. The identification of critical habitat in Amu/Lamu area was conducted through the IFC Guidance Note (2012) based on criteria for identifying critical habitat. This process is however not necessarily limited to the above criteria; a combination of expert guided experience and [other recognized high biodiversity values as stipulated in IFC Guidance Note 2012] can be used in order to support a critical habitat designation. Appropriateness of this decision would be evaluated on a case-by-case basis according to the concepts of irreplaceability and vulnerability.

3.2 Identification of critical habitat

The identification of critical habitats for the proposed 1,050MW coal fired power plant was undertaken using a systematic and structured process which his depicted in Figure 3-1 showing a flowchart of critical habitat identification. A description of the process flow chart steps is given thereafter.

Figure 3-1: summary of the process of delineating critical habitats



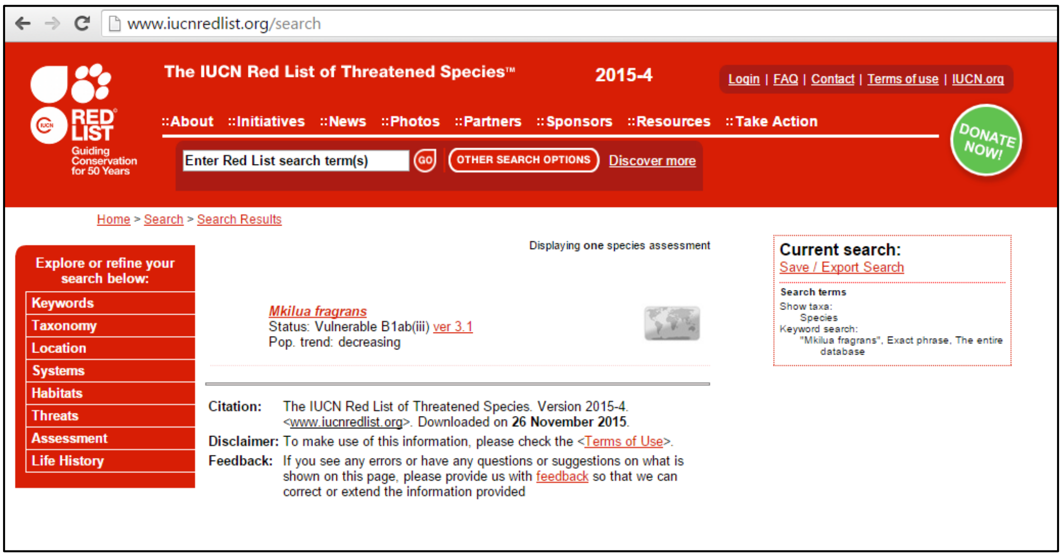
3.2.1 Acquisition of biodiversity data and satellite imagery

Biodiversity data was acquired from existing databases (desktop and online) and field observation data. Species point data was acquired from the database of the National Museums of Kenya while the satellite layer (Landsat image) was downloaded from the Global Land Cover Facility for processing land cover units for the year 2010. A field survey that was conducted provided data that was used for screening species of conservation importance.

3.2.2 Determination of Species of Conservation Status

Species data was acquired from the existing databases and field observation made at the project site and its environs. This data was scrutinized using the search engine for the IUCN Red list of threatened species 2015 (Figure 3-2) to determine conservation status. There are different categories of conservation status of species that are described in the IUCN red list data. These categories include Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Lower Risk, Data Deficient and Not Evaluated. Names of species were entered in the IUCN Red list search engine for verification. The conservation status of species identified in the project area and its environs is provided in the biodiversity section below.

Figure 3-2: Search engine for the IUCN Red list of threatened species



3.2.3 Delineation of land cover units

The acquired Landsat image was processed in ArcGIS 10.2 using unsupervised classification process. Land cover units generated were manually re-clustered based on the depictions of the image reflectance and the unit assigned classes.

3.2.4 Identification of biodiversity values

Seven biodiversity values were adopted from the IFC (2012) and the Biodiversity Consultant (2012) as a checklist for validation of habitats in Lamu area. The process of identifying species of conservation importance aided by providing conservation status of animal and plant species. Thus, from the process, an area would be assigned as a:

- Habitat of significant importance to Critically Endangered and/or Endangered species;
- Habitat of significant importance to endemic and/or restricted-range species;
- Habitat supporting globally significant concentration of migratory species and/or congregatory species;
- Highly threatened and/or unique ecosystems; and/or;
- Area associated with key evolutionary processes;

- Legally protected areas and internationally recognized areas; and/or
- Area of other biodiversity values

3.2.5 Critical Habitat Identification

Criteria developed by IFC 2012 for identifying critical habitats were explored by scrutinizing conservation data for species against the seven criteria. These criteria are based on the biodiversity values that are identified above; hence, the process is a precursor of this stage. Biodiversity values are ranked based on their importance values; thus, the first value is regarded very important and reduces up to the seventh biodiversity value.

The first three criteria are graded on importance which is varied based on the numerical thresholds derived from the IUCN Best Practice Protected Area Guidelines. The thresholds form a basis for a tiered approach in that numerical threshold is used to assign Criteria 1 to 3 to Tier 1 or Tier 2 Critical Habitat designation. According to IFC, Tier 1 Critical Habitat is provided highest importance; development is very difficult to implement and offsets are generally not possible except in exceptional circumstances. In Tier 2 Critical Habitat, development may be possible and offsets may be possible under some circumstances (Biodiversity Consultancy Ltd, 2012).

3.2.6 Method for identifying Critical Habitats

An approach by Stefan et al., (2013) was adopted for identification of CH in the project area. Critical habitats was identified using fieldwork data and local informants who had knowledge on areas utilized by some of the species of conservation importance. Field data was collected based on the biodiversity taxa by the experts; plants, mammals, invertebrates, reptiles and amphibians in both terrestrial and aquatic habitats. This provided information on the taxa distribution and habitat associations (Stefan et al., 2013).

Consultation of local informants was carried out to understand the biodiversity value present in the vicinity of the project areas and identifying existing conservation concerns. Critical habitat was identified using spatial unit of analysis (Critical Habitat Area of Analysis (CHAA) and Discrete Management Unit). This was achieved through screening biodiversity features (i.e. at the species, ecosystem and landscape scales), and evaluating the distributions of CH (Stefan et al., 2013).

3.2.7 Critical habitat Area of Analysis (CHAA)

Critical Habitat Area of Analysis for the Amu Coal Power Project was identified as an ecologically relevant area surrounded and including the anticipated extent of the project influence on biodiversity. According to Stefan (2013), CHAA was used as the geographical extent to screen biodiversity features to assess the Critical Habitat. CHAA was considered at the scale in which CH was identified and used to map the limit of the potential effects of the project.

3.2.8 Discrete Management Unit

Areas were demarcated and assigned as Discrete Management Unit (DMU), which are areas in which biological communities and/or management issues have more in common with each other than they do with those in adjacent areas (IFC GN, 2012). Species of conservation importance were considered for delineating DMU. In this case, DMU are the adjacent habitats that support species of conservation importance and unique ecosystem characteristics.

3.2.9 Results

3.2.9.1 Species of Conservation Importance

Given in Table 3-1 is a summary of the conservation status of various species found within the environs of the proposed coal fired project site. Under the IUCN red list of threatened species, species that are Near Threatened up to critically endangered are enlisted in the table below.

Table 3-1: Conservation status of species found in the project area environs

Species	Common Name	Taxa	Habitat	Where found	IUCN Conservation Status
Rhynchocyon petersi	Black and Rufous Sengi	Mammal	Forest	Boni and Dodori national reserve	Vulnerable B1ab(iii)
Rhynchocyon chrysopygus	Golden-rumped Sengi	Mammal	Forest	Boni and Dodori national reserve	Endangered B1ab(iii,v)
Chelonia mydas	Green Turtle	Reptile	Seagrass	Near project footprint, Kiunga National Reserve	A 2bd ver 3.1
Newtonia erlangeri		Plant	Woodland	Near project footprint	EN A4ad
Nesaea parkeri parkeri		Plant	Woodland	Near project footprint	EN B2ab(iii)
Nesaea stuhlmannii		Plant		Near project footprint	EN B2ab(ii,iii)
Monanthotaxis faulknerae		Plant	Forest		Endangered B2ab(ii,iii,v) ver 3.1
Cephalophus adersi		Mammal	Mammals	Dodori National Reserve	Critically Endangered A4cd
Euphorbia tanaensis					Critically Endangered B1+2c, D

3.2.9.2 Biodiversity Values

Based on field surveys and literature review, the data was screened to identify biodiversity values as stipulated by the IFC 2012. After the process, three important values were identified and include:

- Habitat of Critically Endangered and/or Endangered species;
- Habitat of significant importance to endemic and/or restricted-range species; and
- A legally protected areas and internationally recognized areas.

3.2.10 Critical habitat Area of Analysis

3.2.10.1 Habitat of Critically Endangered and/or Endangered species

Among the sizable list of species of plants, birds, mammals, reptiles and amphibians found in the project area and its environs, a few species were positively screened using the IUCN red list of threatened species. Among the screened list of species, their habitat and IUCN conservation status are shown in Table 3-2. Images of the species are shown in Figures 3-3 to 3-6 while maps showing the critical habitat areas are shown in Figures 3-7 to 3-9 respectively.

Table 3-2 : Habitat and IUCN status of screened list of species

Species	Taxa	Habitat	Location	IUCN Conservation Status
Chelonia mydas	Reptile	Seagrass	Near project footprint, Kiunga National Reserve	A 2bd ver 3.1
Newtonia erlangeri	Plant	Woodland	Near project footprint	EN A4ad ver 3.1
Nesaea parkeri parkeri	Plant	Woodland	Near project footprint	EN B2ab(iii) ver 3.1
Nesaea stuhlmannii	Plant		Near project footprint	EN B2ab(ii, iii) ver 3.1
Cephalophus adersi	Mammals	Mammals	Dodori National Reserve	Critically Endangered A4cd ver 3.1
Euphorbia tanaensis				*Critically Endangered B1+2c, D*

Figure 3-3: "Green Sea Turtle grazing on seagrass" by P.Lindgren

Figure 3-4: Ader's duiker (source: http://cca.kws.go.ke/BoniDodori.html)

Figure 3-5: "Rhynchocyon petersi one" by ZeWrestler

Figure 3-6: Beatragus hunter

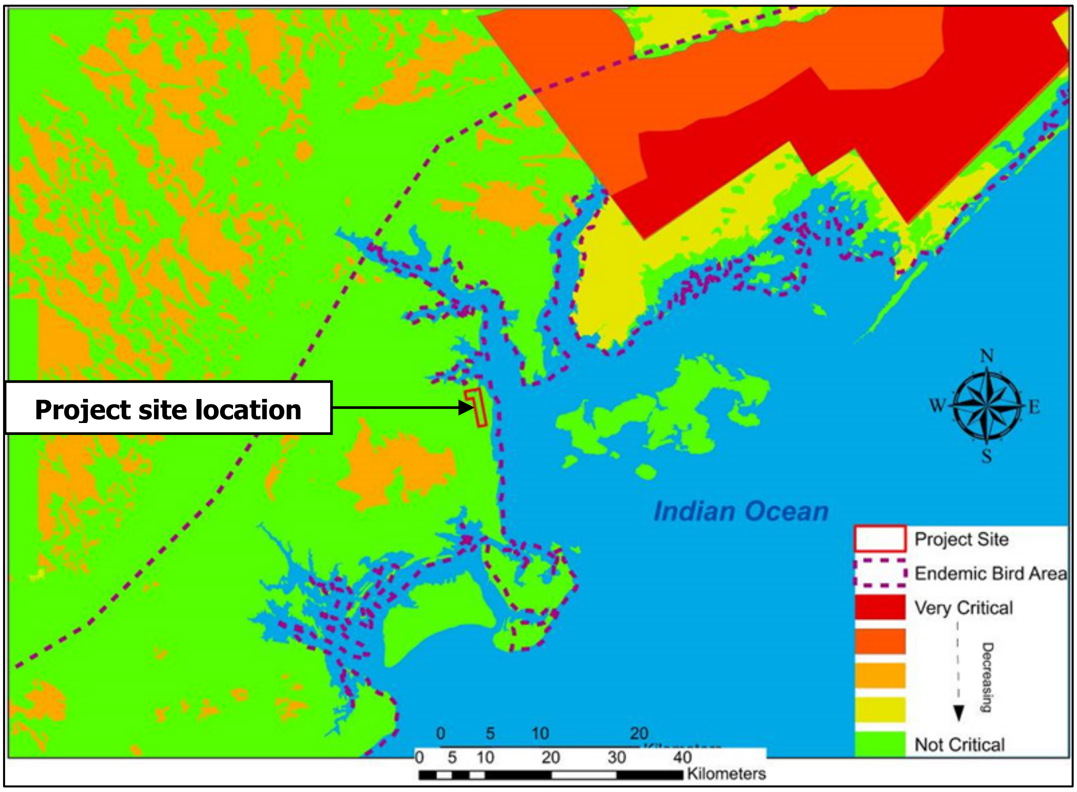
Chelonia mydas Adult green sea turtles mostly eat marine plant life such as seagrass, kelp and algae, while juveniles have a more carnivorous diet. Thus, they potentially occur on seagrass areas

According to information from Kenya Wildlife Service, Dodori Creek is a breeding place for Dugongs;

Aders' duiker, *Cephalophus adersi* is a small antelope endemic to the coastal forests of east Africa (Boni and Dodori). It is threatened by habitat loss and hunting; the species is categorized as Critically Endangered on the IUCN Red List.

Hirola is a unique and threatened animal. Its distribution is bound to the arid, grassy plains bound by semi-desert inland and coastal forests on the south-eastern coast of Kenya and Somalia. Hirola is classified as Critically Endangered by the IUCN (1996), with fewer than 400 living individuals currently estimated. Hirola has been identified between seven herds of Hirola were identified between Boni Reserve and the Tana River in North-Eastern Kenya In January 2013.

Figure 3-7: Critical habitat areas of the terrestrial environment



- **Very critical areas** consist of confirmed habitats for the critically endangered and endangered species. These areas have the habitat characteristics for these species and are protected by the Kenya Wildlife Service.
- **Moderately critical areas** are areas that have habitat characteristics for the critically endangered and endangered species; however, not protected and existence of the species is not confirmed
- **Less critical areas are areas** that have no habitat characteristics for the critically endangered and endangered species; however, their existence could have been affected environmental changes.
- **Habitat of significant importance to endemic and/or restricted-range species:** These areas are important for habitat-based conservation of birds. The natural habitat in most endemic bird areas EBAs (83%) is forest, especially tropical lowland forest and moist montane forest. Kenya coastal area is a potential area for EBA. Areas in the north coast that have forests are thus potential habitats for the endemic bird species and therefore serve as critical habitats.

Figure 3-8: Critical Habitat Area in the marine environment

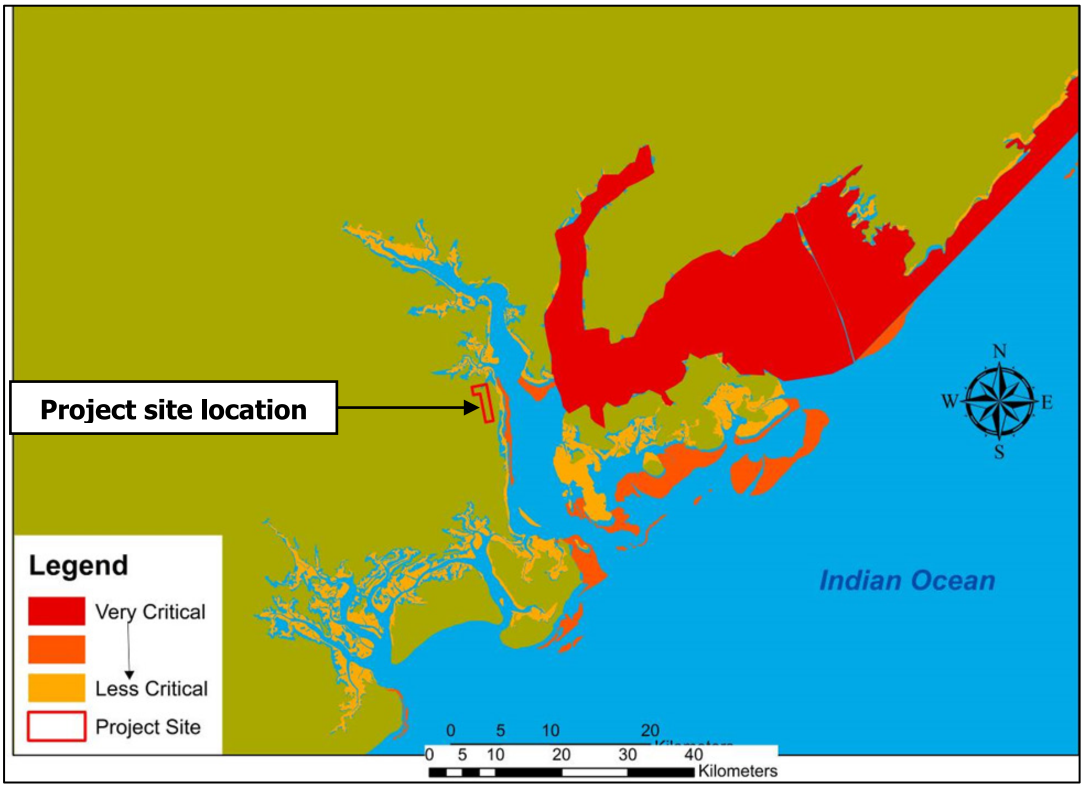
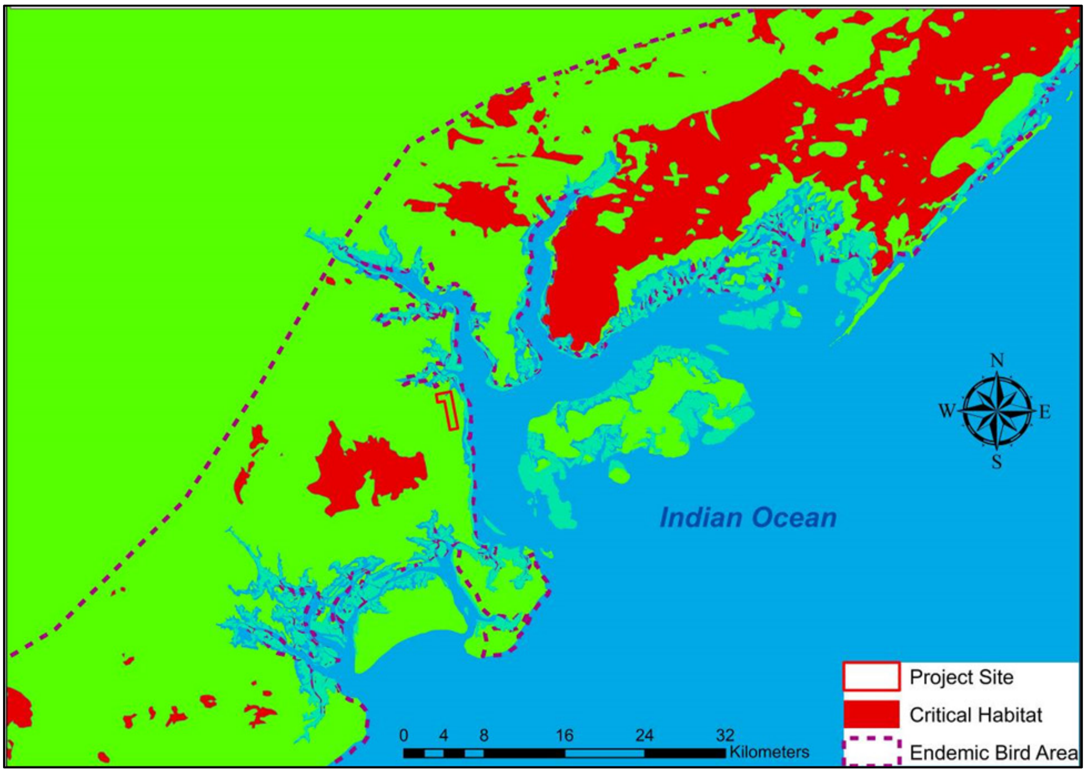


Figure 3-9: Critical Habitat Area with respect to EBAs in the coastal region



3.2.11 Legally protected areas

3.2.11.1 Kiunga National Reserve

Kiunga Marine National Reserve (KMNR)is situated along the Indian Ocean coast in Lamu County, Kenya. Kiunga Park covers 270 square kilometers (100 square miles). The park covers an area with approximately 50 islands and coral reefs in the Lamu Archipelago. It borders the Boni and Dodori National Reserves.

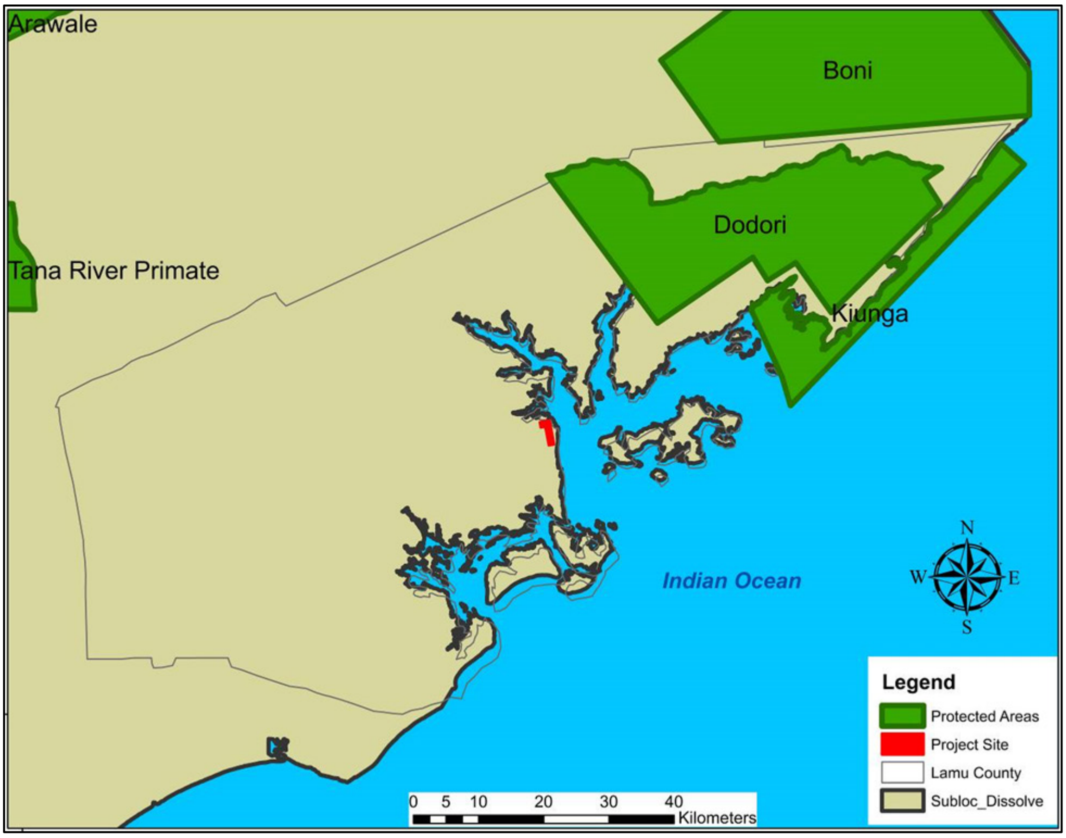
The Kiunga Marine National Reserve (KMNR) was designated as a reserve on June 11, 1979, and is legally registered on the Boundary Plan 216/39. In 1980, KMNR was designated a Biosphere Reserve covering 60,000 ha. The biosphere reserve is important for nesting seabirds, green turtles (*Chelonia mydas*) and dugongs (*Dugong dugon*) and hosts relatively pristine mangroves.

3.2.11.2 Dodori National Reserve

Dodori hosts a vegetal diversity mainly consisting of coastal and riverine forests, mangroves, swampy grasslands and savannah.

Dodori reserve was named after the river ending in the Indian Ocean at Dodori Creek, a breeding place for dugongs. Dodori National Reserve was gazatted in 1976. It is situated in Lamu County and has a unique indigenous open canopy forests of the Northern Zanzibar-Inhambane coastal forest mosaic. The reserve host Aders' duiker, *Cephalophus adersi* which is a small antelope endemic to the coastal forests of east Africa and the hirola, Hunter's Hartebeest (*Beatragus hunteri*). The location of Dodori National Reserve in relation ot the project site is indicated in Figure 3-10.

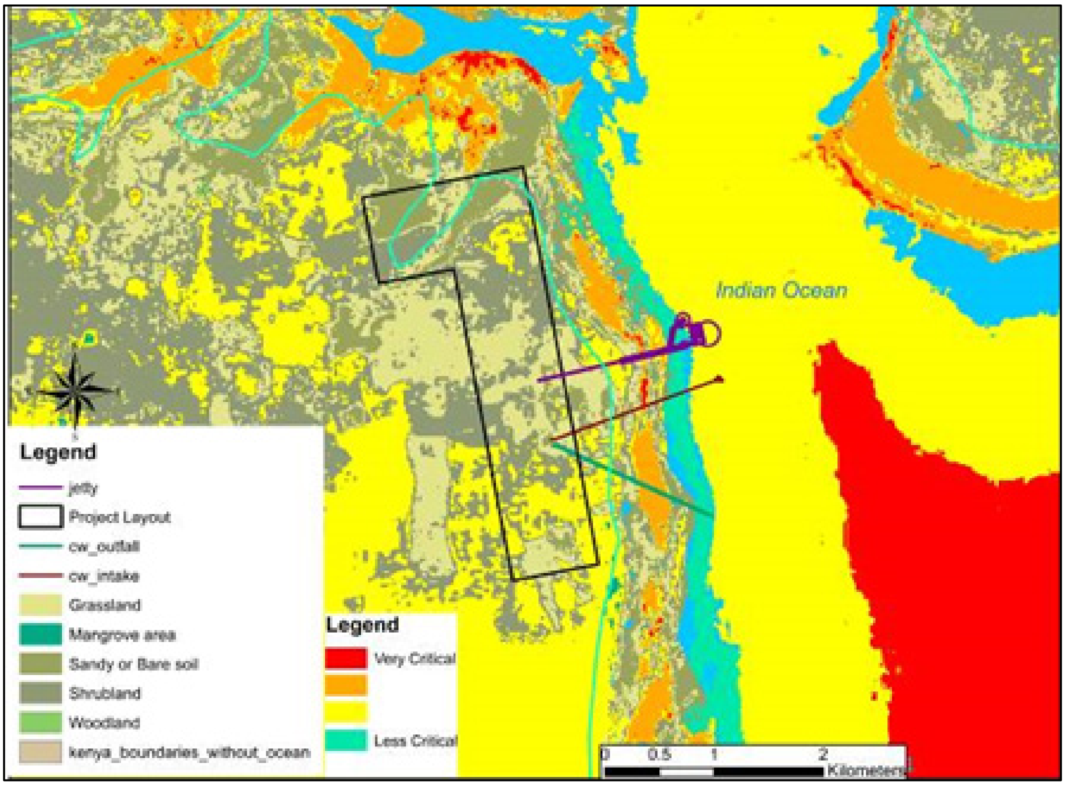
Figure 3-10: Legally protected reserves



3.2.12 Discrete Management Unit

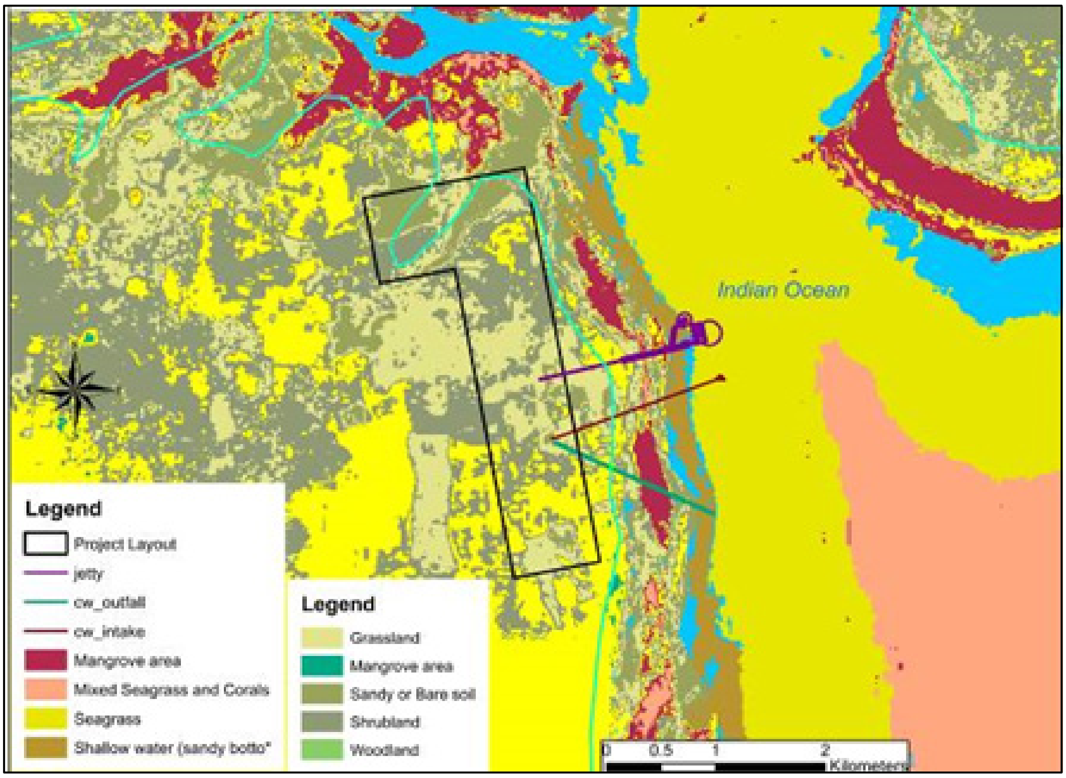
Adjacent areas to the project site indicate potential critical habitats that are delineated using DMU. These habitats include the mangrove areas, seagrass areas and coral habitat. The mangrove area is predominantly occupied by mangrove tree species; however in front of it to the sea side, seagrass zonation is predominant in most of the mangrove forest. Seagrass area is predominantly occupied by seagrasses with sparse distribution of corals within the hard substrate areas. Coral reefs are associated by the coral species; shallow areas are also inhabited by some seagrass species as shown in Figure 3-11.

Figure 3-11: image of discrete management unit



Based on the above discrete management unit, Figure 3-12 is a map showing the marine and terrestrial habitats in the project area.

Figure 3-12: Image overlay of terrestrial and marine habitats in the project area



Very critical habitat: Coral habitats are considered very critical since they are sensitive to disturbance caused by smothering or scouring, and by increase in temperature within the water media; they respond by bleaching. The habitat forms breeding grounds for fisheries species; hence they are very important for local fisheries, as well. Due to the fact that they are inter-sparsed by seagrass, they provide potential foraging grounds for species of conservation importance such as the Green Turtle and Dugong.

Moderately critical habitat: In the Manda Bay, the habitat comprises of seagrasses as shown by the yellow shaded area in figure 1-53. Seagrasses however is not sensitive to increase in water temperature but to mechanical scouring and smothering by sedimentation. Any scouring can aggravate removal of seagrasses by the scouring force of breaking waves and current. This habitat is, however known to be a foraging ground for the Green Turtles and Dugong.

Less critical habitat: The mangrove areas are considered to be less critical on the scale of weighting coral and seagrass habitats role on sustenance of species of conservation importance even though they form important ecosystem in the coastal-marine environment.

3.2.13 Implications of Critical habitats

The spatial identification of critical habitat at the baseline provides the foundation for applying the mitigation hierarchy. IFC PS6 requires that projects operating in Critical Habitat take particular measures to safeguard biodiversity. The critical habitat maps can be overlaid to build a constraints landscape which assists in guiding modifications to the project design in order to achieve a maximum level of avoidance. Such maps can guide efforts to mitigate impacts to critical habitats.

Critical habitat assessment assists in focusing an impact assessment to critical areas rather than all areas. The IFC states that projects located in critical habitats must have a net positive effect over a reasonable period of time and on the biodiversity value for which the critical habitat was designated. Baseline critical habitat maps can be overlaid with the proposed project footprints, and non-footprint effects (e.g. noise, dust) considered, to evaluate project impacts to biodiversity values.

According to IFC 2012, when a project occurs in critical habitats supporting exceptional biodiversity value, a net gain in biodiversity value is required. For instance, the guidelines recommend a project to be implemented in areas in critical habitat only when the following are demonstrated:

- No other viable alternatives within the region exist for development of the project on modified or natural habitats that are not critical;
- The project does not lead to measurable adverse impacts on those biodiversity values for which the critical habitat was designated, and on the ecological processes supporting those biodiversity values;
- The project does not lead to a net reduction in the global and/or national/regional population of any Critically Endangered or Endangered species over a reasonable period of time, and;
- A robust, appropriately designed, and long-term biodiversity monitoring and evaluation program is integrated into the client's management program.

3.3 Ecosystem services

The benefits from an ecosystem are principally classified as Provisioning, Regulating, Cultural and Supporting services (Millennium Ecosystem Assessment 2005). Within the proposed project site, provisioning services include wood fuel, fodder, foods from wild fruits like *D. orientale*, *A. digitata, S. spinosa, X. americana, T. indica*, etc., honey, vegetables (*S. portulacastrum*), fish (see Figure 3-13), crabs, oysters, shrimps, monitor lizards and various species of mammals and birds. Some plants are also used as herbal medicine e.g. *Abrus precatorius*. Timber for construction, fencing and canoe-making is sought from hardwoods such as the endangered *D. melanoxylon*, mangroves (*R. mucronata*), *A. quazensis* with, *H. compressa* leaves provide the roofing material (see Figure 3-14). In addition, the latex from the latter is harvested to make the local brew - *Mkoma* (name derived from the Swahili name of the plant, also known as Doum Palm). Wetlands in the area provide water for domestic use since there's no municipal water available.

Cultural services were limited with no spiritual and sacred places or shrines encountered. However, recreational activities such as hunting and fishing, especially at Chomo swamp and the sea were observed. Ecotourism and scientific explorations and education were also conspicuously missing within the project area.

Regulating and supporting services are exemplified inter alia, by climate regulation and carbon sequestration, waste decomposition, air purification, pollination, natural hazards mitigation, primary production, nutrient capture and recycling. For instance, mangrove forests protect shorelines from damaging storm and hurricane winds, waves, and floods, form suitable habitats for other species to thrive in and help in prevention of erosion by stabilizing sediments with their tangled root systems. They also maintain water quality and clarity, filtering pollutants and trapping sediments originating from land as well as important in sequestering and storing carbon.

Figure 3-13: Fish caught from Chomo Swamp and Kwa Sasi sea side

Figure 3-14: H. compressa used for harvesting local beer (left) and buildings thatched with leaves of the same plant

Invertebrates provide a source of cheap proteins for both humans and other animals (see Figure 3-15). Being near the bottom of the trophic level, they are depended on by various other organisms for food. Major freshwater fisheries, especially those of salmonids, are supported largely or entirely by aquatic insects. Some invertebrates, especially the marine ones are of great economic value. Crustacean and mollusc farming for food and trade are very common among the coastal communities and so is marine curio trade involving marine invertebrates (Richmond, 2002). Mangrove crab fishing for instance is an important livelihood along the Kenyan coast. The African honey bee (*Apis mellifera*) is a well-known source of honey all over the world.

Figure 3-15: Edible invertebrates from Kwasasi

Pollination by native species of insects is the best known and probably understood ecosystem service provided by the invertebrates (see Figures 3-16 and 3-17). It is estimated that about 87% of flowering plants are pollinated by insects and other animals within the tropics (Ollerton et al, 2011).

Figure 3-16: A bee pollinating a flower

Figure 3-17: watermelon in a farm

Marine curio trade provides a source of income for the locals. This is mainly through the sale of shells or jewellery made of shells to tourists or shell collectors. This is very common all along the Western Indian Ocean. Shells of the Bull-mouth helmet (*Cypraeacassis rufa*), the Great green turban (*Turbo marmoratus*), *Trochus spp*, *Pinctada spp*. and Oysters shells have been export from Kenya and Madagascar for many years for commercial button production as well as for specialized lime (Richmond, 2002).

Some insects are beneficial as predators and parasitoids, helping to keep most pests below economically damaging levels. Were it not for them, the loss emanating from pest damages would have been many times higher.

Figure 3-18: Mealy bugs pest on simsim (left) and lady bird beetles predating on them (right) in Kwasasi

Detritus feeding invertebrates such as wild cock roaches have a high capability of recycling nitrogen back in to the ecosystem. This is normally accomplished with the help of bacteria such as *Blattabacterium* within their bodies (Sabree et al, 2009). Other efficient nutrient recyclers are the dung beetles (Nichols et al, 2008) with different species specializing on dung from different mammals as well as termites (Freymann et al. 2008) and millipedes.

Invertebrates have long been used as ecological indicators to detect changes in the ecosystems in which they live. They are used to give an early warning for ecological disturbances (Niema et al, 2004). A good number of invertebrates are highly sensitive to changes in the ecosystems caused by pollution, sediments, temperature changes, levels of dissolved oxygen among other things. A few others tolerate negative changes. Their diversity is also indicative of whether or not an ecosystem can support populations of other groups such as amphibians, fish and birds. For these reasons they have been used in monitoring the health status of ecosystems with a lot of success (Graham et al. 2004).

4 Methodology for ecological impact assessment

4.1 Identification of potential ecological impacts

Identification of impacts was guided by IFC's performance Standards, Guidance Note 1. This guidance note relates to Assessment and Management of Environmental and Social Risks and Impacts of a specific project. It emphasizes that the client should establish and maintain a process for identifying the environmental and social risks and impacts of the project. The type, scale, and location of the project guides the scope and level of effort devoted to the risks and impacts identification process. The scope of the risks and impacts identification process should be consistent with good international industry practice, and determine the appropriate and relevant methods and assessment tools. The process of risk and impact identification should be based on recent environmental and social baseline data at an appropriate level of detail. The process should consider all relevant environmental and social risks and impacts of the project, including those that relate to biodiversity and natural resources.

4.2 Methodology for assessing ecological impacts

Assessment of impacts for the proposed project was done using International Finance Corporation's guidance note 6 on Biodiversity Conservation and Sustainable Management of living Natural Resources. Specifically, paragraph 7 requires that the risks and impacts identification process to consider direct and indirect project-related impacts on biodiversity and ecosystem services, and identify any significant residual impacts. The process is expected to consider relevant threats to biodiversity and ecosystem services, focusing on habitat loss, degradation and fragmentation, invasive alien species, overexploitation, hydrological changes, nutrient loading, and pollution. Additionally, the process is expected to take into account the differing values attached to biodiversity and ecosystem services by affected communities and other stakeholders.

The client is expected to seek avoidance on impacts on biodiversity and ecosystem services. Measures to minimize impacts and restore biodiversity and ecosystem services should be implemented when avoidance of impacts is not possible. The client is expected to take cognizance of the fact that predicting impacts on biodiversity and ecosystem services is a complex process. Therefore, the client should adopt a practice of adaptive management in which the implementation of mitigation and management measures are responsive to changing conditions and the results of monitoring throughout the project's lifecycle.

Depending on the complexity of impacts, the client is expected to retain competent professionals to assist in conducting the risks and impacts identification process. They are also expected to retain external experts with appropriate regional experience to assist in the development of a mitigation hierarchy that complies with this Performance Standard and to verify the implementation of those measures.

Based on these Standards, Kurrent Technologies Ltd developed an Ecological Risk Assessment Matrix. This matrix will be used to assess the potential impacts of the project to biodiversity. The extent of impact can be limited to the project site and to specific activity at a particular period, or affect areas beyond the project site. The duration in which the project takes place is also considered in the evaluation of the impact. The period can be specific to the period of certain activities or could be related to the occupancy period of the project development. Therefore, in terms of duration, the impact can be short, medium, long term or permanent. The potential impacts associated with the proposed development will be assessed using the criteria given below. The magnitude of an impact is derived from the proportion of the environmental entity affected, that is, impact can be partial or complete. For example, an impact can destroy a small part of the habitat, ecological process or a small population of a species. The probability of an impact to happen will be estimated as a function of the four characteristics described above.

EXTENT

Localized (At localized scale and a few hectares in extent)	**1**
Study area (The proposed site and its immediate environs)	**2**
Regional (County level)	**3**
National (Country)	**4**
International (Beyond Kenya)	**5**

MAGNITUDE

Small and will have no effect on the environment	**0**
Minor and will not result in an impact on the processes	**2**
Low and will cause a slight impact on the processes	**4**
Moderate and will result in process continuing but in a modified way	**6**
High (processes are altered to the extent that they temporarily cease)	**8**
Very high and results in complete destruction of patterns and permanent cessation of the processes	**10**

DURATION

Very short (0 – 1 Years)	**1**
Short (1 – 5 Years)	**2**
Medium term (5 – 15 years)	**3**
Long term (>15 years)	**4**
Permanent	**5**

PROBABILITY

Highly improbable (<20% chance of occurring)	**1**
Improbable (20 – 40% chance of occurring)	**2**
Probable (40% - 70% chance of occurring)	**3**
Highly probable (>70% - 90% chance of occurring)	**4**
Definite (>90% chance of occurring)	**5**

Method used to determine the environmental risk

Risk = (Extent + Duration + Magnitude) x Probability

		CONSEQUENCE (Extent+Duration+Magnitude)																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PROBABILITY	1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	2	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
	3	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
	4	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64	68	72	76	80
	5	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100

Significance criteria		
Low	<30	Where this impact would not have a direct influence on the decision to develop in the area
Medium	30-60	Where the impact could influence the decision to develop in the area unless it is effectively mitigated
High	>60	Where the impact must have an influence on the decision process to develop in the area

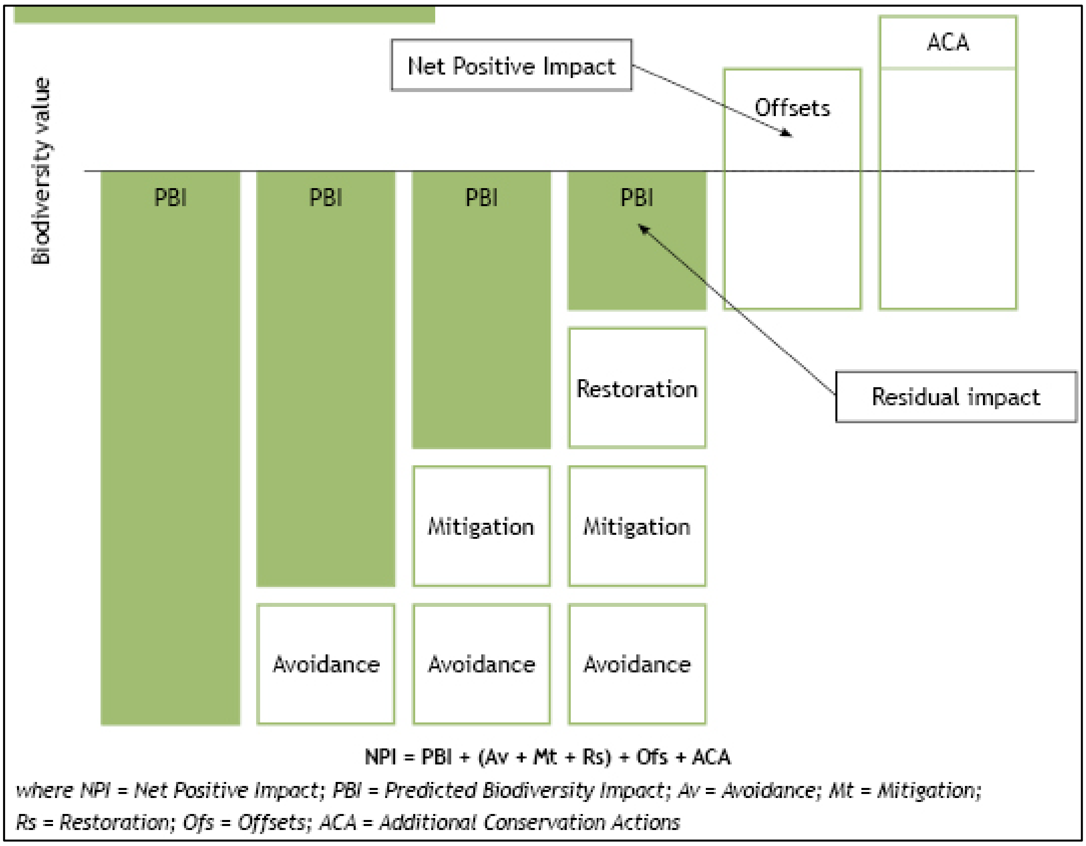
4.3 Hierarchy of mitigation

The IFC's Performance Standard 6 is used to guide the process of impact mitigation. This Standard is supported by several other conservation-based multilateral organizations, including Fauna and Flora International and Convention for Biological Diversity (CBD). To comply with the IFC's Performance Standard 6, and the performance standards of several other multilateral finance institutions, a project proponent must develop and verify the implementation of a mitigation hierarchy that complies with the Standard. This hierarchy consists of prioritized steps to alleviate environmental harm as far as possible through avoidance, minimization (or reduction) and restoration of detrimental impacts to biodiversity. Further, biodiversity offsetting is only considered to address residual impacts after appropriate avoidance, minimization and restoration measures have been applied. This mitigation hierarchy favours early awareness and action to proactively and efficiently achieve 'no net loss', or preferably 'net positive impact', to biodiversity. The mitigation hierarchy uses a step by step approach as follows, and is represented in Figure 1-60.

1. **Avoidance**: which includes activities that change or stop actions before they take place, in order to prevent their expected negative impacts on biodiversity and decrease the overall potential impact of an operation. Specific actions may include adjusting the location, scope or timing of a development could avoid negative impacts to a vulnerable species or sensitive ecosystem. Avoidance helps protect the integrity of valuable and threatened biodiversity and ecosystem services and also makes good business sense, e.g. by reducing later steps in the mitigation hierarchy.
2. **Minimization**: These are measures taken to reduce the duration, intensity, extent and/or likelihood of impacts that cannot be completely avoided.
3. **Restoration**: This involves deliberate measures to alter an area in a way intended to re-establish an ecosystem's composition, structure and function, usually bringing it back to its original (pre-disturbance) state or to a healthy state close to the original. This step aims at to returning an ecosystem to a former natural condition and to restore ecological function.
4. **Biodiversity offsets**: These are measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts

arising from project development and persisting after appropriate avoidance, minimization and restoration measures have been taken. Biodiversity offsets are usually regarded as the last resort. Biodiversity offset should be designed and implemented to achieve measurable conservation outcomes that can reasonably be expected to result in no net loss and preferably a net gain of biodiversity.

Figure 4-1: Mitigation hierarchy adopted for ecological impact assessment



5 Assessment of impacts

This section assesses the potential impacts of the Project on terrestrial and marine ecology receptors and presents mitigation measures. Impacts are presented based on discussion according to receptor type, to give a complete picture of the effects of the Project on a given habitat or species group. However, because mitigation is mainly applied at source rather than receptor, it is more appropriate to list mitigation measures according to project activity. This allows a clearer perspective of how an activity can be managed as a whole to minimize, mitigate or manage terrestrial or marine ecological impacts.

5.1 Potential impacts on flora

As a result of the extensive vegetation clearance, terrain shaping and soil excavation for construction of the power plant infrastructure and associated facilities, several plant species will be lost such as *Dalbergia melanoxylon*, *Dialium orientale*, and *Haplocoelum inopleum*, as well as mangroves. This will have adverse impacts on these species in the wild; although most of the other species likely to be lost might not be threatened, their destruction will further reduce the vegetation cover over the project area. Clearing of vegetation may lead to changes in surface runoff flow direction and quantity in the area.

The community may also lose the ecosystem services such as herbal medicine, wood fuel and aesthetics value provided by some of the species lost as a result of the construction phase activities.

Destruction of ecosystems can also be caused indirectly if emissions from a coal-power plant reduce productivity of vegetation. Dust for instance will affect plant growth by interrupting physiological processes like transpiration when lodged on leaf surfaces thereby blocking their stomata. Stack emissions such as Sulphur dioxide, nitrogen oxides, carbon monoxide and heavy metals like mercury may contribute to acid rain which in turn pollute and affect plants growth by corrosion of their surfaces and causes acidification of aquatic ecosystems.

Human activities are responsible for most of the loss in biodiversity throughout the world and with the onset of the project related activities such as construction of access roads, an upwelling of human population is expected in the area as project staff, suppliers, opportunistic job-seekers and new settlements spring up due to opening up of the area. This may impact negatively on the biodiversity of the area due to increased pressure on ecosystem services. Of particular concern is the unsustainable harvesting of *D. melanoxylon* which is highly targeted for its hardwood timber and in the carving industry. Overexploitation of medicinal plants and wild fruit trees such as *Dialium orientale*, *Tamarindus indica* and *Adansonia digitata* may also occur. Clearing of vegetation for settlements and expansion of farmlands may lead to loss of important plant species.

Elevated demand for fresh water for domestic use will affect the aquatic flora and maybe convert the permanent swamps into seasonal ones. Excessive collection of fuelwood by workers during construction or operation can also lead to deforestation as well as increased charcoal burning.

Increased domestic waste production, sewage and non-biodegradable material may cause environmental pollution. Using chemical fertilizers, insecticides and herbicides to increase food production may lead to emission of toxic chemicals in the air, soil and water.

With the expected habitat disturbance during the implementation of the project, invasive species may likely increase in the area. Clearing of natural vegetation opens up gaps that are immediately occupied by opportunist invasive and weedy species when conditions become favorable. Movement of trucks and soil from one point to another might spread seeds of these species along the communication and travel paths. Exotic species might also be introduced in the area either passively as people dispose of fruit seeds in the environment or by design during landscaping activities.

Table 5-1: Impact significance on flora - construction and operational phases

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study Area	Long term	High	Highly probable
	2	4	8	4
	Result: (-56) Medium negative			
Mitigation measures	**Comments/Mitigation:** • Based on the characterization provided in this study, the project developer should plant seedlings of species of conservation importance at their established nursery. Once ready for transplanting, the developer should plant such trees within the project area and its environs with the aid of an expert. • Prior to construction and with the aid of an expert, the EPC contractor should relocate and endangered species to less disturbed environs within the project site, community lands or established botanic gardens. • A thorough reference voucher specimen collection for storage at the East African Herbarium (the national/regional repository for botanical collections) should be done for future scientific research as representative collections from the area • A germplasm and accompanying relevant field data collection program for *ex situ* conservation at the National Genebank of Kenya should be developed and implemented. This could be used for future habitat restoration programs if need be. • A wet season survey and collection of annual plants missed during the dry season should be done to avoid loss of the ephemeral species. • The EPC contractor should avoid clearing vegetation where it is not necessary to do so. • All earthmoving and excavation equipment and transport vehicles should be inspected and cleaned of any extraneous soil and debris that may harbor invasive species propagules. This should be done in designated areas using preferably high-pressure washing machines • Construction materials such as sand and gravel should be obtained from weed-free sites • Only seed collected from indigenous plants in the vicinity of the project should be used for re-vegetation programs. Exotic species should be avoided			

	• Cultivated fruit seeds should be properly disposed to avoid finding their way into natural vegetation areas. • Minimize unnecessary soil and vegetation disturbance • Monitoring of the invasive species coverage to be done			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study Area	Long-term	Low	Improbable
	2	4	4	2
	Result: (-20) Low negative			

5.2 Potential impacts on invertebrates

The excavation of land for construction of the coal plant, ash yards, coal stock pile areas, housing estate and access roads will lead to loss of habitats especially for the ground dwelling species. Natural vegetation will be cleared affecting the species that depend on it for food and shelter. There will therefore be loss of breeding and nesting areas. This loss is not projected to be significant for invertebrates since only a fraction of the larger area will be excavated and the study did not identify a species that has a very restricted habitat that was within the areas to be cleared.

Air contaminants accumulate in insects tissues by ingestion, respiration or penetration through the cuticle. For example, there are known interactions between sulfur compounds from coal plants and insects which show changes in population dynamics induced by sulfur compound pollution stress (Eric and Robert, 1977). Sulfur and nitrogenous gases emitted from the combustion of fossil fuels contributes to the formation of acid rain that may lead to the following potential impacts on invertebrates:

- The loss of vegetation cover due to acid rain together with the covering of vegetation with soot which might contain heavy metals will in turn affect a variety of leaf feeding invertebrates such as grasshoppers and leaf beetles;
- Contamination with various pollutants emanating from a coal power plant has been shown to affect the abundance social bees such as the African honey bee even at very low concentrations (Gary and Orie, 1980). Decline of these major pollinators will result in reduced pollination which in turn will affect the agricultural productivity of the farming communities bordering the project area. Due to their extensive foraging activities, bees contact, gather and consume environmental pollutants. The stress from these pollutants has been shown to lead to reduction in brood rearing, pollen collection, depressed flight and increased mortality (Eric and Robert, 1977). Svoboda (1962) found that about 500 bee colonies were destroyed within a 6 km radius of a coal power plant that released arsenic into the air;
- Predatory and parasitic invertebrates depend on others for their survival. They play a big role in checking the populations of others especially the harmful ones such as agricultural pests. Parasitic wasps have been shown to suffer from coal plants emissions (Gary and Orie, 1980). Decline of these predators and parasitic groups have been shown to lead to a rapid increase of several plant feeding insects (Gary and Orie, 1980);
- A number of insect groups with a strong sensory system such as predacious beetles e.g. ground beetles have been shown to reduce in abundance due to pollutants emanating from coal (Gary and Orie, 1980). These beetles live in very close association

with the soils and detritus. Hence any interference with their habit is likely to have an effect on them.

There is likely to be increased emissions and dust from vehicles to and from the construction site. These two are likely to affect the vegetation which in turn will have some effects on invertebrates that depend on them. This may however not be widespread but localized in the immediate areas next to the access road.

Different ground dwelling invertebrate groups require different pH conditions of the soil. The dispersal of ash from the disposal yards is likely to increase the pH of the soils in the surrounding areas. This will have an effect of those species that require neutral or acidic soil conditions for survival.

The project will have a desalination plant to provide clean process water for the coal power plant, firewater for the fire protection system, potable water for the workers and provision of a clean water point for the community at the power plant bouandary. Desalination of sea or ocean water is a widespread technology used in many countries in the world to solve the problem of quality water. It is commonly used in the North Africa, the Middle East, (Pantell, 1993) and fast growing in United States of America (Jenkins and Wasyl, 2005). The improper mitigation of brine from the Lamu coal power desalination plant might have potential effects on marine invertebrates during the release of brine back into the sea. These impacts of sea water desalination will be attributed to the four issues highlighted below.

- Impingement happens when large marine invertebrates suck as crabs and Lobsters are trapped on the intake screen, resulting in their injury or death. On the other hand, entrainment happens when organisms that are small enough to pass through the intake screens, such as plankton and larvae of invertebrates, are killed during processing of the salt water. Entrained organisms are either killed by the pumping or by chlorine and other chemicals used to prevent corrosion and fouling. For a long term project like the Lamu Coal Plant, these kills or injuries will eventually be significant. The designs and intake and discharge technologies have been found to determine the rate of impingement and entrainment (McClary et al, 2013). Although there are several measures available to reduce impingement, fewer measures are available to minimize losses due to entrainment (Cooley et al. 2013). For this reason, habitat restoration is often used to mitigate these losses (Strange, 2012).
- It has been estimated that salinity levels of the discharge brine is approximately double that of the intake sea water which equals to 64-70 ppt (part per thousands) (Rashad, 2007). The average salinity of the sea water is approximately 30-37 ppt (Millero and Sohn, 1992). In general, salinity patterns off the Kenyan coast are influenced by the outflow of low-salinity water coming from the Bay of Bengal (Newell, 1959) and by the Indian Ocean Dipole (IOD) (Vinayachandran and Nanjundiah, 2009). In the Lamu area, the salinity is usually less than 34% (Kitheka, 1997). Changes to salinity can play a significant role in the growth and size of aquatic life and the marine species distribution. These effects can either be positive as in the case of shellfish (Rashad, 2007) or negative especially on marine invertebrates incapable of osmoregulation. There could be some effects on those species that have become accustomed to the low salinity along the Kenya coast. There is however very limited number of documented studies or performed experiments about the impacts of salinity on the flora species or sedentary organism (Rashad, 2007).
- Increased alkalinity in the discharge water due to basic/alkaline chemicals used during desalination (calcium carbonate and calcium sulfate). According to Younos (2005), the following chemicals are typically used in desalination processes.
    1. Sodium hypochlorite NaOCl or free chlorine - for chlorination to prevent biological growth in the membrane facility.

2. Ferric chloride $FeCl_3$ or aluminum chloride $AlCl_3$ used as disinfectants for flocculation and removal of suspended matter from the water.
3. Sulfuric acid $H2SO_4$ or hydrochloric acid HCl to adjust the pH of the seawater.
4. SHMP (sodium hexameta phosphate) $(NaPO_3)_6$ and similar materials have been used to prevent scale formation on the pipes and on the membrane.
5. Sodium bisulphate $NaHSO_3$ is used to neutralise any remains of chlorine in the feed water.
6. Crystalline acid EDTA (Ethylene diamine tetra acetic acid) $C_{10}H_{16}N_{20}O_8$ is used to remove the carbonate deposits from the desalination facilities.
7. Citric acid $C_6H_8O_7$, EDTA and Sodium polyphosphate $NaPO_3$, which are weak acid detergents are used 3 to 4 times annually to clean the membrane.

This alkalinity fluctuation might negatively affect marine invertebrates. Normally the total alkalinity of the discharge brine is almost double that of average seawater (Rashad, 2007) which is approximately 2.32×10-3mol/K (Millero and Sohn 1992).

- Thermal pollution of discharge brine due to the high temperatures used in some desalination plants. The average surface temperature of the sea water is approximately 27°C at the equator (Millero and Sohn, 1992). With the technologies involving heating, the temperature of the discharge is normally higher than the ambient ocean water temperature. The accepted temperature variation at discharge is 3°C. Many marine biologists believe that a significant impact can occur to the natural balance and distribution of the marine life if a temperature alteration is applied to the ambient environment (Buros, 1994). However, these impacts are not always negative. It has for instance been show that increased temperatures have positive effect on reproduction biology and the growth rate of several species of plankton (Vijverberg, 1980). Little information is available about the negative effects of increased salinity, alkalinity and temperatures on marine invertebrates.

Artificial lighting is expected in the evenings all through the construction phase as well as from security lights around the perimeter and within the coal power plant during the operational phase. An expected effect is that, artificial light will attract large amounts of both nocturnal and diurnal invertebrates mainly insects. Some of the groups highly attracted to light are moths, beetles, midges, crane flies, mayflies, ant lions, bush crickets, and the water bugs (Eisenbeis, & Hassel, 2000). Many types of marine invertebrates, such as late-stage crab larvae, are also attracted to artificial light (Porter et al, 2008); it is estimated that about a third of all insects attracted to street lighting, usually die (Eisenbeis, 2006). In a study carried out in Finland, it was found that even light as little as that of a light trap can lead to extinction of some moth that have very small populations (Väisänen & Hublin, 1983). Most of these attracted invertebrates do not find their way into the natural habitats but rather rest on the ground where they are either trampled or predated on. Artificial lighting also repels some species that operate under the cover of darkness. These include earwigs, cockroaches, woodlice, earthworms and scorpion (Camp & Gaffin, 1999). This affects their feeding and breeding patterns and it is highly probable that it threatens their survival prospects.

The development of the construction phase temporary worker camps and operational phase permanent worker colony are likely to cause a proliferation of undesirable species. The influx of several workers in the area and mushrooming of residential estates to accommodate them will result in the generation of tons of garbage and sewage. This will in turn attract undesirable invertebrate species such as house flies (*Musca domestica*) and blow flies (*Chrysomya spp*). Production of sewage and forming of other organically enriched water pools from these residential facilities will create conducive breeding habitat for mosquitoes *(Culex quinquefascitus)* which is an urban mosquito that thrives in organically contaminated waters. Besides being a source of great biting nuisance, it is the main vector of elephantiasis in urban areas. This was found in large populations in Lamu Island and Mokowe during the study period. The housing estates together with the expected urban development will most certainly bring with it the two nuisance cockroach species *Blatella germanica* and *Periplaneta americana* and to a smaller extent the *Psychodid* moth flies.

Runoff water from the paved area and roadside pool resulting from access road construction will create breeding grounds for *Anopheles gambiae* and *An. funestus* mosquitoes. These two are the principle vectors of malaria in Africa.

Locally sourced construction materials such as sand from nearby rivers will distort the ecosystems from which they are sourced. Sand harvesting from rivers particularly affects the dragonflies in the family *Gomphidae* that specifically breed in sandy substrates in rivers and streams.

The assessment of potential impacts on invertebrates is described in the tables below.

Table 5-2: Impact significance on loss of habitat-construction phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study Area	Permanent	Low	Definite
	2	5	4	5
	Result: (-55) Medium negative			
Mitigation measures	**Comments/Mitigation:** • If possible creation of new access roads should be avoided. Existing roads should be improved for use to the site. • The EPC contractor should not use burning as a method to clear vegetation. Other methods of clearing vegetation should be used. This will allow as many species as possible in the affected areas to migrate to the non-affected areas. • The developer should consider development of an artificial garden to support species which fall under pollinators and parasitoids. • Habitat conservation – a conserved area should be considered well beyond the buffer zone to act as a safe haven for the threatened invertebrates. This will provide them with a safe feeding, breeding and nesting area and ensure a stable supply of pollinators and other beneficial groups such as the parasitoids and predators.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study Area	Medium term	Minor	Improbable
	2	3	2	2
	Result: (-14) Low negative			

Table 5-3: Impact significance of air emissions and dust-operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Short	Low	Probable
	1	2	4	3

	Result: (-21) Low negative			
Mitigation measures	**Comments/Mitigation:** • The specification of coal to be used in the power plant should be consistently managed to ensure that when burned, it does not produce harmful emissions which exceed the World Bank Group's 2008 emission guidelines for thermal power plants • The continuous emissions monitoring system should be maintained in a good state of repair always to ensure that it provides the correct readings of monitored gases. • The developer should consider creation of an artificial garden where several plant species are planted to allow the population of pollinators (many species of wild bees, wasps, flies and butterflies) to ensure that farmlands continue receiving this ecosystem services. These should be set up in areas adjacent to the project site. • The developer should consider starting a honey bee project for the communities in areas outside the project site will enhance their population in the area. This will not only help conserve a key pollinator species but will be a source of livelihood to the local community through honey and its associated products.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Short	Minor	Improbable
	1	2	2	2
	Result: (-10) Low negative			

Table 5-4: Impact significance of vehicle emissions-construction and operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Regional	Short	Minor	Highly probable
	3	2	2	4
	Result: (-28) Low negative			
Mitigation measures	**Comments/Mitigation:** • The EPC contractor should use efficient trucks and earth movers with a capacity for low emissions throughout the construction phase. • The EPC contractor should use dust suppression techniques on access roads especially during the dry season in an attempt to minimize dust. This will not only be of help to the diversity next to the road but also to the human communities bordering the site. • The developer should consider tarmacking some of the access roads when the construction phase is completed			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**

With mitigation	Regional	Short	Minor	Improbable
	3	2	2	2
	Result: (-14) Low negative			

Table 5-5: Impact significance of ash yard-construction and operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study area	Long term	Low	Highly probable
	2	4	4	4
	Result: (-40) Medium negative			
Mitigation measures	**Comments/Mitigation:** • The EPC contractor should restrict the excavation area that demarcated for the ash yard. • The O&M Company should periodically wet the ash yard and compact it to minimize dispersal by winds. • If acceptable to them, ash may be packaged and sold to farmers to treat acidic soil conditions instead of lime. However tests should be conducted first to ensure it contains no heavy metals. Flue gas desulfurization products have been shown to improve growth responses of some forage plants such as alfalfa (*Medicago sativa*), white clover (*Trifolium repens*), orchard grass (*Dactylis glomerata*), tall fescue (*Festuca arundinacea*), switch grass (*Panicum virgatum*), and eastern gama grass (*Tripsacum dactyloides*) in acidic soils. (Clarka and Baligara, 2003). These products have also been shown to increase the retention of phosphorous in the soil thereby decreasing its loss through surface runoff (William et al., 2003). • Re-creation of restored version of the natural habitat in the ash yards should be considered. Plants that can grow in ash should be planted. These will not only prevent the ash from being blown by winds but will also support a certain portion of biodiversity.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study area	Long term	Minor	Improbable
	2	4	2	2
	Result: (-16) Low negative			

Table 5-6: Impact significance of desalination plant effluent discharge-operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study area	Medium term	Moderate	Probable
	2	3	6	3

	Result: (-33) Medium negative			
Mitigation measures	**Comments/Mitigation:** • The developer should consider using fine mesh screens to prevent entrainment of large-sized marine invertebrates • Locate inlet and outlets in areas of the sea with lesser biodiversity or fewer sensitive species such as corals • The O&M Company should consider alternative sources of water for the power plant needs. For example, the developer should consider water supply using boreholes as an alternative water supply source. • The O&M Company should consider non-heating and non-chemical utilizing methods which release no brine such as evaporation ponds, solar stills, and condensation trap (solar desalination) can be utilized instead. • Appropriate distribution of the discharge plume into the seawater should be incorporated into the design. This should involve many and widely distributed outlets that slowly release brine into the sea as opposed to one main outlet. This will allow for faster dilution.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study area	Medium term	Low	Improbable
	2	3	4	2
	Result: (-18) Low negative			

Table 5-7: Impact significance of artificial light pollution-construction and operations phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study Area	Long term	Low	Probable
	2	2	4	3
	Result: (-24) Low negative			
Mitigation measures	**Comments/Mitigation:** • The EPC contractor should design the lighting for the construction and operational phases to minimize the number of lights in the power plant. This will lower the overall levels of light pollution and reduce the impact that lighting will have on wildlife; • The EPC contractor should design the outdoor lighting such that the brightness/wattage of the lamps does not exceed 150W per lamp; • The EPC contractor should use low pressure sodium lamps or narrow spectrum LED lights that incorporate full cut-off shielding;			

	• The EPC contractor should use low pressure sodium lamps with full cut-off shielding, which produce an orange monochromic light; • The direction in which light shines should be pointed towards the ground to illuminate the way for pedestrians and vehicles and away from natural habitats such as hedgerows, trees, water bodies and grassland; • Security lighting should have motion-sensor switches to keep lighting off when it is not required. They should be kept on the minimum time-setting and sensors which can be tripped by road and footway users or large animals should be avoided; • Lighting adjacent to waterbodies (such as the jetty and pier) should be absolutely minimized and any lighting that is needed should be carefully shielded to prevent it from shining directly on the water surface.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study area	Long term	Magnitude	Improbable
	2	4	2	2
	Result: (-16) Low negative			

Table 5-8: Impact significance of worker accommodation-construction and operational phases

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Localized	Long term	Low	Probable
	1	4	4	3
	Result: (-27) Low negative			
Mitigation measures	**Comments/Mitigation:** • The EPC contractor should design a proper garbage and sewage management and disposal system in order to keep garbage breeding flies such as house flies and filth flies in check. • To avoid the nuisance Culex mosquitoes, Lake and Moth flies, a closed sewage treatment plant should be designed and implemented. • All residential units should have screened windows to prevent insects entering them			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Long term	Minor	Improbable
	1	4	2	2
	Result: (-14) Low negative			

5.3 Potential impacts on herpetofauna

The construction of the project footprint areas and upgrading of access roads leading to the site will lead to habitat loss for herpetofauna ecology in the project area. Removal of vegetation and trees/tree trunks will lead to the clearing of herpetofauna habitats which are home to amphibians and reptiles. It will also remove the source of food such as insects which are eaten by lizards who are in turn eaten by snakes thereby interfering with the food chain.

Excavation of soils in the project area, backfill with imported hardcore fill and compaction of the same will lead to the destruction of burrows which herpetofauna use for breeding purposes.

Cleared vegetation will expose herpetofauna to predators especially when they cross roads and in open spaces such as the access roads for the project area; additionally, the animals will be prone to being crushed on the road by vehicles. This is especially during the wet season when the animals have more movement in search of mates for breeding. With their greater visibility in cleared spaces, some reptiles which form part of the diet for the local people, will be more exposed to getting killed. The Nile monitor Lizard (*Varanus niloticus*) is one such reptile that the local community kills for food.

During the clearing of vegetation, trees and other micro-habitats, animals like snakes and lizards will move to other areas. Due to the sudden change of environment there could potentially be aggression from agitated snakes trying to escape. The snakes may also move to other sites that are near the project area. The population of snakes and lizards such as the Nile monitor lizards may increase leading to competition for available resources thus giving rise to hunting near homes and feeding on domesticated animals. Increased snake bites and snake encounters may be likely to workers and the surrounding general population. A construction camp is going to be established holding about 3000 workers. Waste and new habitats formed will attract lizards and rodents which in turn attract snakes this might cause human life conflict.

The cooling water intake pipes could potentially suck in marine turtles which could lead to their death if the water inlet does not have traveling screens. The thermal effluent released from the circulating water discharge could potentially impact turtles within the theoretical zone of mixing as these animals are dependent on the ambient temperature to keep their body temperature regulated. The green turtle is endangered due to the harvesting of eggs by humans for food. Marine turtles lay their eggs on clean sandy beaches and consequently any spillages of oils and chemicals, raw sewerage, fly ash trace elements on the eggs can lead to decline in their food sources which are mainly sea weed, algae and sea grass (IUCN website, Spawls *et al.* 2004).

Table 5-9 : Impact significance due to loss of habitats – construction phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study Area	Short	Moderate	Highly probable
	2	2	6	4
	Result: (-40) Medium negative			
Mitigation measures	**Comments/Mitigation:** • A reforestation program should be implemented during the preconstruction phase of the project to provide an alternative habitat for herpetiles.			

	• The EC contractor should limit clearing of vegetation and trees to the project footprint areas only to avoid destroying habitats in non-construction areas. • If possible, the EPC Contractor should avoid vegetation clearance during the rainy (wet) season when herpetiles usually breed. • Together with herpetologist, the EPC contractor should relocate those herpetiles that move slowly and are found within the site during clearing and excavation. • During the construction phase (about 42 months), the EPC contractor should monitor the reforested habitats surrounding the project site and its environs for changes in species diversity and abundance.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study area	Short	Low	Improbable
	2	2	4	2
	Result: (-16) Low negative			

Table 5-10: Impact significance of human-herpetiles conflict-construction and operational phases

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study area	Medium term	Low	Probable
	2	3	4	3
	Result: (-27) Low negative			
Mitigation measures	**Comments/Mitigation:** • The EPC contractor should provide all workers with ankle height safety shoes to prevent hazards such as snake bites. • The EPC contractor should engage a herpetologist institution (such as the National Museums of Kenya or Bio-Ken Snake Farm) to educate workers about the dangers from snake bites and how to prevent them. • The EPC contractor's infirmary should be equipped with readily available anti-venom which must be administered by a licensed person. • The EPC Contractor should contract a company such as Bio-Ken Snake Farm in Malindi to train doctors to identify types of bites and how to treat them • All solid wastes generated by human activities should be disposed of in accordance with the Waste Management Regulations 2006. • Trap and rid the site of any rodents which attract snakes			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study area	Medium term	Minor	Improbable

	2	3	2	2
	Result: (-14) Low negative			

Table 5-11: Impact significance of circulating water intake and discharge on marine herpetofauna-operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study area	Medium term	Moderate	Probable
	2	3	6	3
	Result: (-33) Medium negative			
Mitigation measures	**Comments/Mitigation:** • The submerged water intake should incorporate mechanically operated traveling screens which prevent marine fauna from getting entrained in the intake pipes. • The temperature of the thermal effluent should not exceed 3^0C in a scientifically established mixing zone. • The thermal effluent discharged from the circulating water discharge should comply with the Water Quality Regulations, 2006 (L.N. 120).			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study area	Short	Low	Improbable
	2	2	4	2
	Result: (-16) Low negative			

5.4 Potential impacts on Birds

Potential impacts on birds during the Construction Phase include the direct loss of breeding habitat. Species of conservation concern such as Coastal Black Boubou and Eurasian Curlew, are likely to be displaced and their numbers reduced in the absence of mitigation measures. There is also the potential for individual birds which are nesting within these habitats to be killed or injured and for their nests to be damaged.

Breeding birds may also be affected by noise and visual disturbance from construction activity. Noise modelling has been undertaken at ten locations within and around the project site to predict the likely noise levels associated with construction experienced at various locations within the Study Area. The construction noise threshold has been set at 65dB(A) (IFC's guideline value of 55dB(A) + 10dB(A) allowed under BS5228). The noise modelling predicts that during construction, noise levels will be experienced of between 45.2dB(A) and 53.2dB(A) depending on the activities being undertaken, compared to an ambient background levels of between 43 - 53.2 dB 43.8dB(A) and 53.0dB(A).

The increase in human population and associated activities e.g. waste disposal is likely to attract and increase populations of scavenging and invasive bird species e.g. Marabou Stork and Indian House Crows. This will have a direct effect on populations of indigenous species through mainly predation.

As has been discussed above for the species of conservation concern, construction activities will result in the loss of potential breeding bird habitat, potential killing, injury and disturbance to individuals, potential damage to nests, and potential loss of foraging habitat. The proportion of habitat affected when compared to the amount of available habitat within the Study Area is unlikely to be sufficient to affect the ability of the breeding bird assemblage to breed and survive within the local area, either during construction or in the long term.

Residue ash may potentially contain trace elements such as mercury and arsenic (e.g. see *http://www.sourcewatch.org/index.php/TVA_Kingston_Fossil_Plant_coal_ash_spill*). Entry of the heavy metals in the food chain impacts on avifauna through lesser egg production, survival rates and mortality of adult birds (Fry 1995). Birds at the top of the food chain are usually the most severely affected.

There is a risk that low flying birds may collide with the chimney of the coal power plant. Electrocution may also occur when birds collide with the power transmission lines (Bevanger 1994). For migrating birds, a combination of bad weather and artificial lighting at night will attract them to the site. This is more of a factor especially during bad weather and at night for flocks of migrating birds.

Table 5-12: Impact significance on loss of habitat and displacement on avifauna-construction and operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study Area	Medium term	Low	Probable
	2	3	4	3
	Result: (-27) Low negative			
Mitigation measures	**Comments/Mitigation:** • It is recommended that a pre-construction monitoring program be implemented to provide baseline information about birds and bats. This will be in addition to the one season survey undertaken during the initial baseline studies. • Post-construction monitoring should be implemented to assess the impact of habitat loss, particularly on species of conservation concern. • During the construction period, activity should be restricted to the project footprint area. Access to the rest of the project site should be strictly controlled to prevent unnecessary disturbance to birds			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study area	Medium term	Minor	Improbable
	2	3	2	2
	Result: (-14) Low negative			

Table 5-13: Impact significance of invasive bird species-construction and operational phases

Mitigation Status	Extent	Duration	Magnitude	Probability
	Study area	Duration	Low	Probable

Without mitigation	2	4	4	3
	Result: (-30) Medium negative			
Mitigation measures	**Comments/Mitigation:** • The EPC Contractor should implement a strict waste management policy for all food related wastes emanating from the temporary worker camps during the construction phase of the project. • The O&M Company should implement a strict waste management protocol within the workers' colony during the operational phase of the project in accordance with the Kenyan Waste Management Regulations 2006. • All wastes generated during the construction and operational phases must be kept in properly designed receptacles which should be stored under strict supervision of the Environmental Control Officer and camp administration manager. • All wastes must be transported in fully enclosed trucks that do not allow trash to be dropped as it is transported to a final waste disposal site. • The EPC contractor and O&M Company shall ensure that all wastes generated by the project are handled, stored and disposed of in accordance with Kenyan legislation on waste management and in its absence, appropriate international standards.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study area	Duration	Minor	Probability
	2	4	2	2
	Result: (-16) Low negative			

Table 5-14: Impact significance of noise on birds-construction and operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study area	Long term	low	Probable
	2	4	4	3
	Result: (-30) Medium negative			
Mitigation measures	**Comments/Mitigation:** • Both the EPC contractor and O&M Company should ensure that the all noise sources during the construction and operational phases respectively comply with Kenyan environmental noise standards.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study area	Long term	Minor	Improbable
	2	4	2	2
	Result: (-16) Low negative			

5.5 Potential impacts on Mammals

Direct impacts due to landtake activities including clearing of vegetation, soil excavation and construction of facilities may alter the habitat for mammals in the project area. The population of trees and other plant species will be reduced through clearing of vegetation to pave way for the power plant and its associated infrastructure. It is expected that vegetation will be stripped in several parts within the project site leading to loss of ecological functional areas such as woodlands, wetlands and bushes consequently reducing wildlife ranging, foraging and roosting areas. In addition to the above, there is the potential for indirect effects due to changes in air quality, introduction of pollutants and invasive species.

Spatial occupation of the area through fencing of the project site will displace mammals passing through it and create a temporary barrier effect which will alter their dispersal patterns. For example, the approximately 5 buffaloes seen in the project area will be displaced through fencing of the project site which could potentially lead to human-wildlife conflict as some of them could move to human-occupied areas in the vicinity of the project.

Mammals' species including bats are sensitive to human occupation. Disturbances include flood lights, vehicle lights and noise from machinery and vehicles. This will affect movement of mammal species across the landscape, and may result in occasional road kills. Occupation of the area by project facilities will render the site inaccessible to mammals. This will reduce faunal foraging options by barring the site as a foraging ground. Noise and vibrations from the heavy machinery may interfere with the foraging, ranging, breeding and nesting behavior of mammals within and around the ecosystem in the project site.

There is a potential for bat collision with the stack of the coal power plant. This is expected to be more intense at during hours of heightened bat activity (typically 18hrs to 24hrs).

Table 5-15 : Impact significance for habitat alteration-construction phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study Area	Short Term	Moderate	Probable
	2	2	6	3
	Result: (-30) Low negative			
Mitigation measures	**Comments/Mitigation:** • The EPC Contractor should minimize the clearing of trees and other vegetation in order to reduce the impacts on mammalian habitats within the project site • During the rehabilitation and reinstatement phase after completion of construction, APCL should plant a sufficient number of trees within the project site to restore destroyed habitats. • Areas devoid of human activities should be left intact or rehabilitated and allowed to regenerate.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study Area	Medium Term	Minor	Improbable
	2	3	2	2
	Result: (-14) Low negative			

Table 5-16: Impact significance for mammal displacement-construction and operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study Area	Short Term	Low	Probable
	2	2	4	3
	Result: (-24) Low negative			
Mitigation measures	**Comments/Mitigation:** • APCL should engage Kenya Wildlife Services (KWS) to translocate any mammals found within the project site to safe areas • Alternatively, APCL should consider working with the KWS to create a conservation area for mammals that need to be translocated from the within the project site			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study Area	Medium term	Small	Improbable
	2	3	4	2
	Result: (-18) Low negative			

Table 5-17: Impact significance of altering mammal movement and behavior - construction and operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Regional	Medium Term	Low	Probable
	3	3	4	3
	Result: (-30) Low negative			
Mitigation measures	**Comments/Mitigation:** • Noisy construction plant and equipment should where practical, be fitted with silencers/mufflers to reduce ambient noise levels • Where practical, construction plant and equipment operations should be restricted during the day between 6am to 6pm to reduce noise exposure periods. • Floodlights should be limited to camps and their uses be minimized in areas perceived to be used by the animals frequently. • Improvement of habitat (vegetation) connectivity should be enhanced by conserving grasses, bushes and trees that occur in the wider landscape. • Potential road kills of large mammals can be reduced by limiting speed to 30 kilometers per hour (kph) at night and 40 kph during the day to reduce impacts of accidents when vehicle collide with animals.			

	• Vehicles should avoid use of full lights at night as this confuses animals while on road and increases chances of accidents.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Regional	Medium Term	Minor	Improbable
	3	2	2	2
	Result: (-14) Low negative			

Table 5-18: Impact significance on bat collision with stack-operational phase

Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
Without mitigation	Localized	Long term	Low	Probable
	1	4	4	3
	Result: (-27) Low negative			
Mitigation measures	**Comments/Mitigation:** • If possible, APCL should use radar techniques to deter bats from venturing on site.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Localized	Long Term	Minor	Improbable
	1	4	2	2
	Result: (-14) negative			

5.6 Potential impacts on Marine flora and fauna

During heavy downpours in the construction phase, the proposed power plant will generate significant amount of silt laden storm water that is likely to flow directly into the Manda Bay. This problem will be exacerbated if the construction plant and equipment leaks oil into the environment due to lack of proper maintenance. It is feasible that with over 3,000 workers on site, there will be a mushrooming of kiosks and other informal settlements that will generate contaminated stormwater run-off which could discharge into the Manda Bay.

Other accompanying developments such as residential areas, schools, hospitals and other similar types of structures are projected to add more contaminated waste water into the sea as the Kwasasi area lacks any drainage and stormwater management infrastructure.

Domestic effluents and storm water are major sources of water pollutants in the form of sediments and nutrients. Nutrient enrichment leads to eutrophic systems that favor algae blooms, trigger incidents of anoxic conditions in the water column and subsequently degradation and loss of habitats and elimination of vulnerable species.

During the fuel oil backloading process into the coal tanker, there are potential risks related to spills at the coal jetty which would adversely impact the marine ecology. Fabricius (2005) and (Veron et al. 2009) reported that coral reefs and coral communities are highly sensitive to water quality, that are largely a product of sediment loads (which affects light penetration), nutrients and environmental contaminants. Terrestrial runoff from urban development, agriculture and deforestation are the principal causes of diminished water quality. Indeed runoff impacts have become such a worldwide phenomenon, that only reefs well-removed from highly populated landmasses have escaped degradation of some sort. A sample of water collected next to Lamu Town during this assessment study showed elevated levels of total nitrogen and coliform bacteria counts. This project is major development initiative and is likely to add significant wastes into the sea thus causing significant adverse effects if they reach vulnerable environments particularly if no mitigation measures are put in place.

The proposed project will use once-through cooling water for the condenser in order to cool the boiler steam back into the water phase. At the circulating water discharge point, the water temperature may be higher than the ambient by about 9^0C. This temperature rise can have both positive and adverse impacts on marine ecology. In some countries, it has been found that elevated once through cooling water temperatures can have positive effects on marine ecology while in other locations, it can have negative effects. As the ambient seawater temperature in Manda Bay around the project area is about 27^0C, a temperature increase of 9^0C (i.e. exit temperature of 36^0C) could potentially have negative effects on marine ecology if not adequately mitigated. The IFC Guidelines on thermal effluent state that the cooling water discharge temperature should not exceed 3^0C at the edge of a scientifically established mixing zone.

Impingement and entrainment of organisms is likely to occur during the intake of large quantities of seawater for cooling. Impingement occurs when marine organism are carried by water velocity and trapped against intake screens while entrainment occurs when smaller organisms pass through an intake screen and into the process equipment. The fate of impinged organisms differs and depends on intake designs and marine organism under consideration i.e. species type, age and water conditions. Whereas some hardy species may be able to survive impingement and be returned to the sea, the general exposure to this experience causes stress. Organisms entrained into the process equipment just perish. The number of affected organisms will vary considerably with the volume and velocity of feed water and mitigation measures in place to minimize impingement and entrainment. If intake velocities are sufficiently low, fish may be able swim away to avoid impingement or entrainment. The swimming performance for different species of fish can predict the types and ages most vulnerable, however, even large fish are frequently caught on intake screens, indicating that swimming ability is not the only factor in impingement. Seasonal variations in age-selective migrations or growth are also factors. If not adequately designed, the potential impact of the intake/outfall upon the marine organism could be of minimum to moderate.

Table 5-19: Impact significance of surface water pollution on marine ecology-construction phase

<table>
<tr><th>Mitigation Status</th><th>Extent</th><th>Duration</th><th>Magnitude</th><th>Probability</th></tr>
<tr><td rowspan="3">Without mitigation</td><td>Study area</td><td>Short</td><td>Moderate</td><td>Probable</td></tr>
<tr><td>2</td><td>2</td><td>6</td><td>3</td></tr>
<tr><td colspan="4">Result: (-30) Medium negative</td></tr>
<tr><td>Mitigation measures</td><td colspan="4">Comments/Mitigation:
• The EPC Contractor should reduce the movement of suspended sediment from the dredging area by dredging during favorable times of the tidal cycle.
• Minimize spillover of silt plume from the dredging and disposal operation can by selecting dredging methods that uses best available technologies (BATs), using of silt and sediment curtains to reduce spreading of silt and sediment plume.</td></tr>
</table>

	• Alternatively, to control spread of sediments, plan properly dredging and disposal schedules to avoid strong wind, current and tides that might disperse and facilitate spread of sediments. • Continuously monitor water quality to establish effects of dredging activities and whether environmental management plan objectives for the project are being implemented.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study area	Short	Minor	Improbable
	2	2	2	2
	Result: (-12) Low negative			

Table 5-20: Impact significance of surface water pollution on marine ecology-operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Regional	Short term	Moderate	Probable
	3	2	6	3
	Result: (-33) Medium negative			
Mitigation measures	**Comments/Mitigation:** • All wastewater shall be treated to comply with effluent relevant and applicable discharge standards stipulated in L.N. 120: Environment Management and Coordination (Water Quality) Regulations 2006. • APCL will monitor the quality of water within Manda Bay arising from their operations in order to establish effects of wastewater discharge in the sea. • APCL will develop and implement an emergency response plan specifically to deal with incidents of spillage around the coal off-loading berth in Kililana.			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Regional	Short term	Low	Improbable
	3	2	4	2
	Result: (-18) Low negative			

Table 5-21: Impact significance of thermal effluent on marine ecology – operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study area	Long term	High	Highly probable
	2	4	8	4
	Result: (-56) Medium negative			

Mitigation measures	**Comments/Mitigation:** • A screening study should be undertaken to determine the most suitable location of the circulating water discharge outlet based on a theoretically modeled mean low tide and mean high tide • Subsequent to the above, a 3-D hydrodynamic thermal plume modeling study should be undertaken to determine a scientifically established mixing zone for the circulating water discharge outlet • The 3-D hydrodynamic modeling study should propose alternative designs of diffusers having different numbers of ports and diameter sizes			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study area	Long term	Minor	Probable
	2	4	2	3
	Result: (-24) Minor negative			

Table 5-22: Impact significance of impingement and entrainment of organisms-operational phase

Mitigation Status	Extent	Duration	Magnitude	Probability
Without mitigation	Study area	Long term	Moderate	Probable
	2	4	6	3
	Result: (-36) negative			
Mitigation measures	**Comments/Mitigation:** • APCL will ensure that the location of the circulating water intake is not in an area where fish spawning, migration areas or fish nurseries are located • APCL will optimize water velocities in the intake channels to limit sedimentation • APCL will monitor the intake pipes for seasonal occurrence of macrofouling • The design of the seawater intake structures should include traveling screens			
Mitigation Status	**Extent**	**Duration**	**Magnitude**	**Probability**
With mitigation	Study area	Long term	Minor	Improbable
	2	4	2	2
	Result: (-16) Low negative			

6 Ecological management plan

In order to conform to International safeguards such as those recommended by IFC's Guidance note 6, a consistent biodiversity monitoring action plan must be formulated. The Kenyan government (through the ministries of Environment, Water and Natural Resources) should be constantly updated on any environmental issues related to Lamu Coal Power Project. They must also work closely with local institutions such as County government of Lamu, local environmental and conservation institutions such as National Environmental Management Authority (NEMA), Kenya Wildlife Service (KWS), National Museums of Kenya (NMK), Nature Kenya (NK) and Kurrent Technologies. Local communities should also be involved in implementing the EMP as they are directly in contact with the project's operations and rely heavily on their environment for livelihoods. In addition, Lamu Coal Power Project should safeguard environmental standards while ensuring it's updated to any changes and development in cleaner environmental technologies.

The Environmental Management Plan stipulates the actions that must be taken into account to ensure the protection, conservation and sustainability use of the ecological components in relation to the development of the Lamu Coal Power Plant. The EMP outlines the details of project activities, impacts and proposed mitigation measures, time schedules and responsibilities to avoid/ minimize ecological impacts.

Table 6-1: Ecological Management Plan for the proposed Lamu Coal Fired Power Plant

Aspect Affected	Potential Impact	Project Components	Activity/Risk	Mitigation	Monitoring Aspect	Responsibility
• **Provisioning services (Food, water, Medicine, Construction Materials)**	• Loss of ecosystem services and Function	• Vegetation Clearance	• Vegetation Clearing • Excavation • Construction	• Enforce fishery laws to control overexploitation, fishing in non-designated areas / protected and use of destructive fishing methods. • Construction of watering points for both domestic and livestock use. • Create alternative source of livelihoods e.g., alternative sources building materials and medicine (promote agro forestry), protein (bee-keeping for honey, empower fishers to starting fishing in deep waters, practicing fish farming) etc	• Vegetation cover • Density and composition of fish at fish landing sites • Number of fishermen fishing in deep waters	• Project proponent and its Service Contractors
• **Regulatory (Erosion Control)**	• Loss of ecosystem services and Function	• Excavation • Vegetation Clearance	• Vegetation Clearing • Excavation	• Topsoil should be removed and stored for use in re-afforestation programme • Roadside trenches should not be channeled on bare soils without existing vegetation, especially where water flow would be expected to be high such as in culverts exits. • Where possible, earth-moving activities should not be done in days with heavy rainfall • Grass should be planted on bare areas to help stabilize the soil. • Any spillages (e.g. of oils and greases) should be cleaned immediately before	• Vegetation cover • Erosion Monitoring • Runoff monitoring	• Project Proponent or its Service Contractors

Aspect Affected	Potential Impact	Project Components	Activity/Risk	Mitigation	Monitoring Aspect	Responsibility
				spreading to other areas by run-off water		
• **Terrestrial Habitat Loss/Alteration**	• Terrestrial habitat •	• Excavation • Vegetation Clearance • Construction of facilities	• Excavation • Vegetation Clearance • Construction • Human habitation	• Recreation of habitat of equivalent size outside the project site • Initiation of tree planting programmes outside the study area. • Areas devoid of human activities should be left intact or rehabilitated and allowed to regenerate. • Culverts should be constructed where the road runs across the sloping terrain at an interval of 50 m until where the sloping ends. This will allow passage of water to the other side of the road • Avoid destruction of trees and bushes. • Construction activities should be accompanied with water sprinklers should be used whenever earthworks are undertaken to reduce dusts released into the surroundings. • If possible creation of new access roads should be avoided. Improve and use existing roads to the site • No burning should be employed to clear vegetation. Employ alternative methods such as clearing by machines. This will allow as many species as possible in the	• Species diversity • Vegetation regeneration	• Project Proponent or its Service Contractors

Aspect Affected	Potential Impact	Project Components	Activity/Risk	Mitigation	Monitoring Aspect	Responsibility
				affected areas to migrate to the non-affected areas.		
• **Degradation of Marine Habitats**	• Degradation of marine habitat • Loss of marine biodiversity	• Desalinization Plant • Discharge of Plant Cooling Water into the sea	• Loss of Marine biodiversity	• Redesign the project to include mesh at the intake to a stage where wastes of salts and freshwater obtained during desalination phases are mixed again before discharging them back into the sea. Quality of the waste water discharges must be of similar quality to that of the sea. • Measure be undertaken to treat and purify storm water and effluents originating from the plant and associated developments. • Conduct habitats inspection and monitoring (corals, mangroves, sea grasses) and water quality at specific areas.	• Quarterly Habitat Assessment and monitoring (corals, mangroves, sea grasses) and water quality at specific areas.	• Project proponent and its service contractors
• **Animal Displacement(Birds, Mammals and Herpetofauna)**	• Altered fauna movements and behavior	• Flood lights • Vehicle lights • Noise and vibrations from machinery and vehicles	• Noise and vibrations	• Improvement of habitat (vegetation) connections should be enhanced by conserving grasses and bushes that occur in the wider landscape. • Potential road kills of large mammals can be reduced by limiting speed to 30 at night and 40 day time to reduce impacts of accidents when vehicle collide on animals also the speed can give drivers lapsing period for braking.	• Animal ranging patterns • Animal behavior • Road kills	• Project Proponent or its Service Contractors

Aspect Affected	Potential Impact	Project Components	Activity/Risk	Mitigation	Monitoring Aspect	Responsibility
				• Vehicles should avoid use of full lights at night as this confuses animals while on road and increases chances of accidents. • Noisy equipment should be fitted with appropriate silencer for noise control • Construction activities should be done within a short period to avoid prolonged period of noise and contact • Operations should be restricted during the day between 6 am to 6pm to minimize periods of noise emission. • Floodlights should be limited to camps and their uses be minimized in areas perceived to be used by the animals frequently.		
• **Invasive Species and Human Wildlife Conflict**	• Altered vegetation structure • Influx of invasive birds (e.g. Indian house Crow).	• Construction • Operation • Human and vehicle movement	• Movement of people and vehicles	• Construction activities should be accompanied with water sprinklers should be used whenever earthworks are undertaken to reduce dusts released into the surroundings. • Vehicles and other equipment should be cleaned thoroughly to remove sticking soils on wheels and other parts of the vehicle to avoid carrying seeds of invasive species to the site. • Soils used for compaction of murram roads should be obtained locally to avoid incidental carrying of propagules	• Vegetation structure • Bird species composition	• Project Proponent or its Service Contractors

Aspect Affected	Potential Impact	Project Components	Activity/Risk	Mitigation	Monitoring Aspect	Responsibility
				of invasive plant species from other places. • All workers be equipped with protective gear like heavy duty shoes and tough pants • Educate local people of dangers from snake bites and how to prevent them • Equip local hospitals with anti-venom readily available in Bio-ken Malindi. • Train doctors to identify types of bites and how to treat • Dispose all solid waste according to NEMA waste management regulations 2006 and EMCA act 1999 • Trap and rid-off the site of any rodents which attract snakes		
• **Dust and Exhaust**	• Altered plant function	• Excavation • Construction • Vehicle movement	• Dust generation • Exhaust fumes from construction machinery	• Construction activities should be accompanied with water sprinklers should be used whenever earthworks are undertaken to reduce dusts released into the surroundings. • Low speed limit should be adopted for operation in the area to avoid vehicles generating dust. • Water sprinklers should be used when intense operation of vehicles is to take place.	• Vegetation structure and function	• Project Proponent or its Service Contractors

Aspect Affected	Potential Impact	Project Components	Activity/Risk	Mitigation	Monitoring Aspect	Responsibility
• **Chemical Spillages**	• Pollution of Terrestrial and marine Environments	• Machine operations	• Chemical Spills	• A log of all dangerous chemicals be kept, how to be used, transported stored and disposed • Keep all dangerous chemicals, oils, greases, solvents, and residues in a strong room. • Have a standard operating procedure manual on how to deal with spills and how to prevent them • Have a spills response team • Train worker on spills and how to deal with them • Have a containment and disposal plan for all hazardous material (where to dispose) • All oils and hazardous materials disposed of according to NEMA waste management regulations 2006 and EMCA act 1999	• Spillage incidences	• Project Proponent or its Service Contractors
• **Collision and Electrocution (Birds and Bats)**	• Bird and Bat Mortality	• Smoke Stack • Transmission Line	• Collision and Electrocution	• Minimize the insect population on site to prevent bats from foraging on site. • Use radar techniques to deter bats from venturing on site. • Use bird friendly electricity transmission structures e.g. use inverted 'T" poles and anti- collision markers	• Number of bird and bat fatalities	• Project Proponent or its Service Contractors

Aspect Affected	Potential Impact	Project Components	Activity/Risk	Mitigation	Monitoring Aspect	Responsibility
				• Temporary closure during period of peak migration by birds		
• **Increased Demand for Water**	• Pressure on available water resources	• Influx of workers/ project staff	• Degradation of available water reources	• The project needs to drill more bore holes to compensate for the increase in water demands.	• Status of water resources (water quantity and quality)	• Project Proponent or its Service Contractors
• **Water Pollution**	• Degradation of water resources	• Dredging	• Degradation of available water resources	• Reduce the movement of suspended sediment from the dredging area by dredging during favorable times of the tidal cycle. • Minimize spillover of silt plume from the dredging and disposal operation can by selecting dredging methods that uses best available technologies (BATs), using of silt and sediment curtains to reduce spreading of silt and sediment plume. • Alternatively, to control spread of sediments, plan properly dredging and disposal schedules to avoid strong wind, current and tides that might disperse and facilitate spread of sediments. • Continuously monitor water quality to establish effects of dredging activities and whether environmental management plan objectives for the project are being implemented.	• Status of water resources (water quantity and quality)	• Project Proponent or its Service Contractors

Aspect Affected	Potential Impact	Project Components	Activity/Risk	Mitigation	Monitoring Aspect	Responsibility
• **Rise in sea water temperature**	• Degradation of marine biodiversity	• Cooling system (release of cooling water back to the sea)	• Thermal influx that could lead to degradation of marine environment	• Use the dry types cooling systemthat donot release back to the sea. • Alternatively design the stage of releasing cooling back to the sea so that it cooled to the same temperatures like sea water before release.	• Sea temperature at point of release	• Project Proponent or its Service Contractors
• **Impingement and entrainment of Marine Organisms**	• Loss of Marine biodiversity	• Storm water originating from the plant's facilities • Oil Spills	• Release of storm water/oil spills into the marine environment	• Treatment of storm water as well as effluents originating at the plant as well as associated developments. • Continuously monitor water quality to establish effects of wastewater discharge in the sea. • Put in measure to minimize oil spills at the jetty as well as in plant by having designs that will incorporate oil interceptor sand traps. • Initiate a monitoring program to assess performance of management/mitigation measures outlined above.	• Water quality	• Project Proponent or its Service Contractors

7 Gaps in knowledge and uncertainties encountered

7.1 Avifauna study

Our survey only conducted 6 TSCs and 18 point counts during the survey period while it is recommended that at least 20 TSCs and 50 point counts are ideal for each study site (Bennun, 2002). This was mainly because of the insecurity situation in place at the site during the survey including a dusk to dawn curfew. Though we had planned four vantage observations for bird activity over the site, we only managed one and this only for a few hours. This inconveniences affected our field survey in the following ways:

i.) **Starting time for bird surveys:** We could not start our surveys on time preferably at 6 am. This is because bird activity starts at this time and peaks before 7 am. We got to the field at around 11 am when bird activity was considerably low. This affected the overall number of birds recorded.

ii.) **Security issues:** Two days were lost due to security advice to keep off the site.

iii.) **End time**: Ideally we would have liked to conduct some TSCs in the late afternoon to dusk period, but this again was not possible due to the curfew. But activity does increase during this period

iv.) **Lack of existing avifaunal survey for the area.** There was very little bird studies conducted at the site in the past mainly because of accessibility reasons due to security and remoteness of the area.

Therefore this report has temporal gaps (early morning, late afternoon and nights not surveyed).

7.2 Herpetofauna Study

As limited herpetofauna studies have been carried out in Lamu County, this study should be treated with caution. Since the area is in the coastal belt all the herpetofauna data used will be based on the available information from the coastal area. The on-site study of the area was carried out for a limited number of days (precisely five working days) and night sampling was not carried out due to security reasons. The on-site study was carried out in the dry season and no data for the wet season is available.

7.3 Mammal study

Limitation of sampling time to only 5 days in the field meant that sampling of key mammalian taxa such as bats, small mammals (including small carnivores) was not possible. Besides, night sampling was not possible due to security concerns. Typically, a dry and wet season survey would have been more appropriate but time was a limiting factor.

7.4 Micro-invertebrate Fauna Study

A review of secondary data for information on threatened species in large Lamu areas provided very little data on invertebrates. Most studies in the past have tended to concentrate on vertebrate species. For this reason not much information is available on the conservation status of most invertebrate species found near the study site. There is for instance very limited information on the biogeography, ecology and systematics of Cnidarians, Echinoderms, Mollusks and Crustaceans in the critical habitats such as sea grass beds, coral reefs, estuaries, mangroves, lagoons and rocky shores. Information on the effect of abiotic factors such as temperature, salinity, tides, currents, seasons and water depth on the larval development, speciation and reproduction of many marine invertebrates is also very scanty. Also inadequate is information on impacts of anthropogenic influences, natural threats such as El Nino and ocean dynamics on marine invertebrate biodiversity in all the critical habitats.

7.5 Coastal freshwater wetlands and marine biodiversity

Study of these two important components was largely based on rapid reconnaissance survey. They primarily focused on locating and mapping major habitats within and surrounding the proposed site. Sampling efforts for the five major taxonomic groups (marine invertebrates, seagrasses, fishery, coral reefs and mangroves) was low because there were only ten days of sampling. As noted above some information was obtained from Key Informants as such it might have some errors. However all the information obtained was carefully corroborated with published articles, reports and manuals.

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Table 7-1: Appendix 1-Vegetation species listed in the IUCN Red List of Threatened Plants for Lamu County

Family	Genus	Species	Subspecies	Variety	*Life Form	IUCN Threat Category
Acanthaceae	Anisotes	*galanae*			T	vu B2ab(iii)
Acanthaceae	Blepharis	*pratensis*			H	vu B2ab(ii,iii,iv)
Acanthaceae	Dicliptera	*inconspicua*			H	vu B2ab(iii)
Anacardiaceae	*Lannea*	*schweinfurthii*			T	Lower Risk/near threatened ver 2.3
Annonaceae	*Asteranthe*	*asterias*	*asterias*		T	Near Threatened ver 3.1
Annonaceae	*Mkilua*	*fragrans*			S	VU B2ab(iii)
Annonaceae	*Monanthotaxis*	*faulknerae*			C	VU B2ab(iii)
Annonaceae	*Polyalthia*	*stuhlmannii*			S	VU B2ab(ii,iii,v)
Annonaceae	*Uvaria*	*denhardtiana*			S	NT
Annonaceae	*Uvaria*	*kirkii*			S	Near Threatened ver 3.1
Boraginaceae	*Cordia*	*guineenis*		*mutica*	S	EN B2ab(iii)
Boraginaceae	*Heliotropium*	*benadirense*			H	VU B1ab(iii)c(iv)+B2ab(iii)c(iv)
Burseraceae	*Commiphora*	*campestris*		*wajirensis*	T	VU D2
Burseraceae	*Commiphora*	*obovata*			T	Lower Risk/near threatened ver 2.3
Canellaceae	*Warburgia*	*stuhlmannii*			T	EN B1ab(iii)
Capparaceae	*Maerua*	*calantha*			S	NT
Chenopodiaceae	*Atriplex*	*farinosa*		*keniensis*	S	EN B2ab(i,ii,iii,iv)
Combretaceae	*Pteleopsis*	*tetraptera*			T	VU B1ab(iii)+B2ab(iii)
Compositae	*Brachylaena*	*huillensis*			T	Lower Risk/near threatened ver 2.3
Compositae	*Emilia*	*bellioides*			H	EN B1ab(iii)+B2ab(iii)
Compositae	*Ethulia*	*angustifolia*			H	NT
Compositae	*Ethulia*	*faulknerae*			H	EN B1ab(i,ii,iii,iv,v)+B2ab(i,ii,iii,iv,v)
Compositae	*Grauanthus*	*linearifolius*			H	EN B2ab(i,ii,iii,iv,v)
Compositae	*Vernonia*	*homilantha*			H	VU B1ab(iii)+B2ab(iii)
Connaraceae	*Ellipanthus*	*madagascariensis*			T	Lower Risk/near threatened ver 2.3

Family	Genus	Species	Subspecies	Variety	*Life Form	IUCN Threat Category
Convolvulaceae	*Convolvulus*	*jefferyi*			C	VU B1ab(iii)+B2ab(iii)
Convolvulaceae	*Ipomoea*	*garckeana*			C	VU B2ab(iii)
Convolvulaceae	*Stictocardia*	*macalusoi*			C	EN B2ab(iii)
Cucurbitaceae	*Corallocarpus*	*ellipticus*			C	VU B1ab(iii)+B2ab(iii)
Cyperaceae	*Cyperus*	*chordorrhizus*			H	EN B2ab(iii)
Ebenaceae	*Diospyros*	*greenwayi*			T	NT
Euphorbiaceae	*Acalypha*	*echinus*			S	VU B2ab(iii)
Euphorbiaceae	*Croton*	*megalocarpoid es*			S	EN B2ab(iii)
Euphorbiaceae	*Croton*	*talaeporos*			T	VU B2ab(iii)
Euphorbiaceae	*Erythrococca*	*pubescens*			S	VU B1ab(iii)+B2ab(iii)
Euphorbiaceae	*Euphorbia*	*nyikae*		*nyikae*	T	NT
Euphorbiaceae	*Euphorbia*	*tanaensis*			T	CR B2ab(iii); D
Euphorbiaceae	*Jatropha*	*hildebrandtii*		*hildebrandtii*	S	EN B2ab(ii,iii,iv)
Euphorbiaceae	*Meineckia*	*fruticans*		*engleri*	S	VU B1ab(iii)+B2ab(iii)
Euphorbiaceae	*Meineckia*	*ovata*			S	Vulnerable D2 ver 2.3
Euphorbiaceae	*Mildbraedia*	*carpinifolia*		*carpinifolia*	S	Vulnerable B1+2b ver 2.3
Euphorbiaceae	*Oldfieldia*	*somalensis*			T	NT
Euphorbiaceae	*Phyllanthus*	*kaessneri*		*kaessneri*	S	VU B2ab(iii)
Flacourtiaceae	*Bivinia*	*jalbertii*			S	Lower Risk/near threatened ver 2.3
Icacinaceae	*Iodes*	*usambarensis*			C	EN B2ab(ii,iii,iv,v)
Labiatae	*Leucas*	*tsavoensis*		*tsavoensis*	H	NT
Leguminosae	*Alysicarpus*	*glumaceus*	*macalusoi*		H	NT
Leguminosae	*Angylocalyx*	*braunii*			T	VU B2ab(iii,v)
Leguminosae	*Crotalaria*	*malindiensis*			H	VU B1ab(iii)+B2ab(iii)
Leguminosae	*Crotalaria*	*rhynchocarpa*			H	EN B1ab(iii)+B2ab(iii)
Leguminosae	*Dalbergia*	*melanoxylon*			S	Lower Risk/near threatened ver 2.3
Leguminosae	*Dialium*	*orientale*			T	VU B1ab(iii)+B2ab(iii)
Leguminosae	*Indigofera*	*malindiensis*			H	EN B2ab(iii)

Family	Genus	Species	Subspecies	Variety	*Life Form	IUCN Threat Category
Leguminosae	*Indigofera*	*wituensis*			H	NT
Leguminosae	*Indigofera*	*zanzibarica*			H	VU B2ab(iii)
Leguminosae	*Newtonia*	*erlangeri*			T	EN A4d
Leguminosae	*Prioria*	*msoo*			T	Vulnerable B1+2b ver 2.3
Leguminosae	*Sesbania*	*speciosa*			H	VU B2ab(iii)
Leguminosae	*Vigna*	*membranacea*		haplantha	C	EN B1ab(iii)+B2ab(iii)
Loganiaceae	*Mostuea*	*microphylla*			S	NT
Loranthaceae	*Oncella*	*curviramea*			S	VU B2ab(iii)
Lythraceae	*Nesaea*	*parkeri*		*longifolia*	H	VU D2
Lythraceae	*Nesaea*	*parkeri*		*parkeri*	H	EN B2ab(iii)
Lythraceae	*Nesaea*	*pedicellata*			H	VU B2ab(iii)
Lythraceae	*Nesaea*	*stuhlmannii*			H	EN B2ab(ii,iii)
Melastomataceae	*Warneckia*	*mouririifolium*			S	VU B1ab(iii)+B2ab(iii)
Menispermaceae	*Anisocycla*	*blepharosepala*	*tanzaniensis*		C	VU B2ab(iii)
Moraceae	*Dorstenia*	*hildebrandtii*		*hildebrandtii*	H	NT
Moraceae	*Milicia*	*excelsa*			T	Lower Risk/near threatened ver 2.3
Ochnaceae	*Ochna*	*kirkii*		*multisetosa*	T	VU B2ab(iii)
Rhamnaceae	*Lasiodiscus*	*pervillei)*		*ferrugineus*	S	VU B1ab(iii)+B2ab(iii)
Rubiaceae	*Canthium*	*kilifiense*			S	Vulnerable B1+2c ver 2.3
Rubiaceae	*Coffea*	*pseudozangue bariae*			T	NT
Rubiaceae	*Lagynias*	*pallidiflora*			S	Vulnerable B1+2b ver 2.3
Rubiaceae	*Pachystigma*	*loranthifolium*		*loranthifolium*	S	Vulnerable B1+2b ver 2.3
Rubiaceae	*Psydrax*	*faulknerae*			S	Vulnerable B1+2b ver 2.3
Rutaceae	*Vepris*	*sansibarensis*			T	Vulnerable B1+2b ver 2.3
Sapindaceae	*Chytranthus*	*obliquinervis*			T	Vulnerable B1+2c ver 2.3
Sapindaceae	*Haplocoelum*	*inopleum*			S	Lower Risk/near threatened ver 2.3

Family	Genus	Species	Subspecies	Variety	*Life Form	IUCN Threat Category
Sapotaceae	*Synsepalum*	*subverticillata*			T	Endangered B1+2c ver 2.3
***Life Form T= tree, S=shrub, C= climber & H= herb**						

Table 7-2: Appendix 2-Checklist and distribution of invertebrates from the proposed project site

Order	Family	Genus	species	Study site
Blattodea	Blattellidae	*Gyna*	*maculipennis*	x
Blattodea	Blattellidae	*Pseudoderopeltis*	*petrophila*	x
Blattodea	Blattellidae	*Pseudoderopeltis*	*rhombifolia*	x
Blattodea	Blattidae	*Blatella*	*sp*	x
Blattodea	Blattidae	*Deropeltis*	*sp*	x
Coleoptera	Buprestidae	*Acmaeodera*	*virgo*	x
Coleoptera	Buprestidae	*Agrilus*	*sp*	x
Coleoptera	Buprestidae	*Anthaxia*	*sp*	x
Coleoptera	Buprestidae	*Damarsila*	*albomarginata*	x
Coleoptera	Buprestidae	*Sternocera*	*castanea*	x
Coleoptera	Carabidae	*Chilanthia*	*carvernosa*	x
Coleoptera	Carabidae	*Crepidogaster*	*bioculata??*	x
Coleoptera	Carabidae	*Cypholoba*	*tetrastigma ssp quadriplagiata*	x
Coleoptera	Carabidae	*Pheropsophus*	*sansibaricus*	x
Coleoptera	Carabidae	*Pheropsophus*	*Unknown*	x
Coleoptera	Carabidae	*Systolocranius*	*validus*	x
Coleoptera	Cerambycidae	*Plocaederus*	*bennigseni*	x
Coleoptera	Chrysomelidae	*Gynandropthalma*	*sp*	x
Coleoptera	Chrysomelidae	*Phaedonia*	*areata*	x
Coleoptera	Coccinelidae	*Brumoides*	*fulviventris*	x
Coleoptera	Coccinelidae	*Cheilomenes*	*sulphurea*	x
Coleoptera	Coccinelidae	*Chilocorus*	*nigrita*	x
Coleoptera	Coccinelidae	*Epilachna*	*fulvostignata polymorpha*	x
Coleoptera	Coccinelidae	*Exochomus*	*nigromaculatus*	x
Coleoptera	Coccinelidae	*Micraspis*	*striata*	x
Coleoptera	Coccinelidae	*Platynaspis*	*6-guttata*	x
Coleoptera	Coccinelidae	*Platynaspis*	*sexguttata*	x
Coleoptera	Dytiscidae	*Cybister*	*senegalensis*	

Order	Family	Genus	species	Study site
Coleoptera	Dytiscidae	*Cybister*	*tripunctatus*	
Coleoptera	Dytiscidae	*Hydrocanthus*	*sp*	
Coleoptera	Dytiscidae	*Laccophilus*	*lineatus*	
Coleoptera	Dytiscidae	*Synchortus*	*simplex*	
Coleoptera	Dytiscidae	*Yola*	*spp*	
Coleoptera	Gyrinidae	*Dineutes*	*subspinosus*	
Coleoptera	Hydrophilidae	*Amphiops*	*globus*	
Coleoptera	Hydrophilidae	*Globaria*	*sp*	
Coleoptera	Hydrophilidae	*Helochares*	*pallens*	
Coleoptera	Hydrophilidae	*Regimbartia*	*inflata*	
Coleoptera	Meloidae	*Decapotoma*	*affiris*	x
Coleoptera	Meloidae	*Mylabris*	*rorifera*	x
Coleoptera	Meloidae	*Mylabris*	*Unknown*	x
Coleoptera	Tenebrionidae	*Gonocephalum*	*dermestoides*	x
Coleoptera	Tenebrionidae	*Himatismus*	*gedyei*	x
Coleoptera	Tenebrionidae	*Homolopsis*	*lobulata*	x
Coleoptera	Tenebrionidae	*Psammodes*	*castanopterus*	x
Coleoptera	Tenebrionidae	*Rhytinota*	*stupida*	x
Coleoptera	Tenebrionidae	*Selinus*	*sp*	x
Coleoptera	Tenebrionidae	*Zophosis*	*punctatafasciata*	x
Diptera	Asilidae	*Promachus*	*sp*	x
Diptera	Glossinidae	*Glossina*	*austeni*	x
Gastropoda	Achatinidae	*Achatina*	*fulica*	x
Hemiptera	Belastomatidae	*Sphaerodena*	*nephoides*	
Hemiptera	Coreidae	*Acanthomia*	*horrida*	x
Hemiptera	Naucoridae	*Neomacrocoris*	*sp*	
Hemiptera	Nepidae	*Nepa*	*primitiva*	
Hemiptera	Notonectidae	*Anisops*	*debilis*	
Hemiptera	Pentatomidae	*Acrosternum*	*punasis*	x
Hemiptera	Pentatomidae	*Bagrada*	*stolida*	x
Hemiptera	Plataspidae	*Brachyplatys*	*testudonigra*	x
Hemiptera	Plataspidae	*Coptosoma*	*marginella*	x
Hemiptera	Reduviidae	*Coranus*	*sp*	x
Hymenoptera	Chrysididae	*Chrysis*	*sp*	x

Order	Family	Genus	species	Study site
Hymenoptera	Eumenidae	*Ancistrocerus*	*sp*	x
Hymenoptera	Formicidae	*Camponotus*	*maculatus*	x
Hymenoptera	Formicidae	*Dorylus*	*nigricans*	x
Hymenoptera	Formicidae	*Paltothyreus*	*tarsatus*	x
Hymenoptera	Ichneumonidae	*Netelia*	*sp*	x
Hymenoptera	Scoliidae	*Cathimeris*	*hymenaea*	x
Hymenoptera	Scoliidae	*Micromeriella*	*hyalina*	x
Hymenoptera	Sphecidae	*Bembix*	*sp*	x
Hymenoptera	Sphecidae	*Dasyproctus*	*sp*	x
Hymenoptera	Family	*Genus*	*species*	x
Hymenoptera	Apidae	*Macrogalea*	*candida*	x
Hymenoptera	Apidae	*Apis*	*mellifera*	x
Hymenoptera	Apidae	*Ceratina*	*sp1*	x
Hymenoptera	Apidae	*Ceratina*	*sp2*	x
Hymenoptera	Halictidae	*Lasioglossum*	*sp*	x
Hymenoptera	Halictidae	*Allodape*	*sp.*	x
Hymenoptera	Halictidae	*Pseudapis*	*sp*	x
Hymenoptera	Megachilidae	*Megachile*	*sp*	x
Lepidotera	Hespiriidae	*Andronymus*	*neander*	x
Lepidotera	Hespiriidae	*Borbo*	*sp*	x
Lepidotera	Hespiriidae	*Borbo*	*sp*	x
Lepidotera	Hespiriidae	*Borbo*	*sp.*	x
Lepidotera	Hespiriidae	*Borbo*		x
Lepidotera	Hespiriidae	*Spialia*	*zebra*	x
Lepidotera	Lycaenidae	*Anthene*	*unnulata*	x
Lepidotera	Lycaenidae	*Axiocerses*	*sp*	x
Lepidotera	Lycaenidae	*Lepidochrysops*	*sp.*	x
Lepidotera	Lycaenidae	*Leptotes*	*sp.*	x
Lepidotera	Nymphalidae	*Acraea*	*epinona*	x
Lepidotera	Nymphalidae	*Acraea*	*neobula*	x
Lepidotera	Nymphalidae	*Byblia*	*ilithyia*	x
Lepidotera	Nymphalidae	*Danaus*	*chrysippus*	x
Lepidotera	Nymphalidae	*Junonia*	*hierta*	x
Lepidotera	Nymphalidae	*Junonia*	*orithya*	x

Order	Family	Genus	species	Study site
Lepidotera	Papilionidae	*Papilio*	*demodocus*	x
Lepidotera	Pieridae	*Belenois*	*aurota*	x
Lepidotera	Pieridae	*Belenois*	*subeida*	x
Lepidotera	Pieridae	*Colotis*	*amatus*	x
Lepidotera	Pieridae	*Colotis*	*danae*	x
Lepidotera	Pieridae	*Colotis*	*euippe*	x
Lepidotera	Pieridae	*Colotis*	*evagore*	x
Lepidotera	Pieridae	*Colotis*	*ione*	x
Lepidotera	Pieridae	*Eurema*	*hecabe*	x
Lepidotera	Pieridae	*Leptosia*	*sp.*	x
Mantodea	Mantidae	*Teodera*	*bokiana*	x
Odonata	Libellulidae	*Acisoma*	*panorpoides*	
Odonata	Libellulidae	*Brachythemis*	*leucosticta*	
Odonata	Libellulidae	*Diplocoides*	*lefebvrei*	x
Odonata	Libellulidae	*Urothemis*	*assignata*	
Odonata	Libellulidae	*Pantala*	*flavescens*	x
Orthoptera	Acrididae	*Acrida*	*sp*	x
Orthoptera	Acrididae	*Acrotylus*	*blondeli*	
Orthoptera	Acrididae	*Morphacris*	*fasciata*	x
Orthoptera	Gryllidae	*Phaeophilacris*	*sp*	x
Orthoptera	Gryllidae	*Scapsipedus*	*marginatus*	x
Orthoptera	Pyrgomorphidae	*Chrotogonus*	*sp*	x
Spirobolida	Pachybolidae	*Epibolus*	*pulchripes*	x

Table 7-3: Appendix 3-List of reptiles and amphibians found during the on-site study

Scientific Name	Common name	Type	Status
Amietophrynus gutturalis	Guttural toad	Amphibia	LC
Phrynobatrachus scheffleri	Scheffler's Puddle Frog	Amphibia	LC
Phrynomerus bifasciatus	Banded rubber frog	Amphibia	LC
Ptychadena anchietae	Anchieta's ridged frog	Amphibia	LC
Ptychadena mascareniensis	Mascarene ridged frog	Amphibia	LC
Acanthocercus atricollis	Black necked tree agama	Reptile	LC
Bitis arietans	Puff-udder	Reptile	LC
Chelonia mydas	Green turtle	Reptile	EN

Scientific Name	Common name	Type	Status
Crocodylus niloticus	Nile crocodile	Reptile	LC
Gerrhosaurus major	Sudan plated lizard	Reptile	LC
Heliobolus spekii	Speke's sand lizard	Reptile	LC
Hemidactylus isolepis	Uniform scaled gecko	Reptile	LC
Hemidactylus maboiua	Tropical House gecko	Reptile	LC
Hemirhagerrhis hildebrantii	Eastern Bark Snake	Reptile	LC
Lygodactylus mombasicus	White-headed dwarf gecko	Reptile	LC
Lygodactylus picturatus	yellow-headed dwarf gecko	Reptile	LC
Naja ashei	Ashe's spitting cobra	Reptile	LC
Trachylepis planifrons	Tree Skink	Reptile	LC
Trioceros dilepis	Flap-necked Chameleon	Reptile	LC
Varanus niloticus	Nile monitor lizard	Reptile	LC

Table 7-4: Appendix 4-List of birds recorded in Lamu during the field survey

Spp.#	Common Name	Scientific Name	*Status
1.5	**Numididae: guineafowl**		
4	Vulturine Guineafowl	*Acryllium vulturinum*	
4.5	**Phasianidae: quails, francolins, spurfowl and allies**		
6	Coqui Francolin	*Francolinus coqui*	
12	Crested Francolin	*Francolinus sephaena*	
17	Red-necked Spurfowl	*Francolinus afer*	
18	Yellow-necked Spurfowl	*Francolinus leucoscepus*	
20	Harlequin Quail	*Coturnix delegorguei*	am
21.5	**Anatidae: ducks and geese**		
25	Spur-winged Goose	*Plectopterus gambensis*	
27	Egyptian Goose	*Alopochen aegyptiaca*	
28	African Pygmy Goose	*Nettapus auritus*	
64.5	**Ciconiidae: storks**		
69	Woolly-necked Stork	*Ciconia episcopus*	
70	White Stork	*Ciconia ciconia*	PM
71	Saddle-billed Stork	*Ephippiorhynchus senegalensis*	
72	Marabou Stork	*Leptoptilos crumeniferus*	
72.5	**Threskiornithidae: ibises and spoonbills**		
73	Sacred Ibis	*Threskiornis aethiopicus*	
75	Hadada Ibis	*Bostrychia hagedash*	

Spp.#	Common Name	Scientific Name	*Status
78.5	**Ardeidae: herons, egrets and bitterns**		
83	Striated Heron	*Butorides striata*	
87	Cattle Egret	*Bubulcus ibis*	am
88	Grey Heron	*Ardea cinerea*	am, pm
89	Black-headed Heron	*Ardea melanocephala*	
95	Little Egret	*Egretta garzetta*	
96	Western Reef Heron	*Egretta gularis*	AM
97	Dimorphic Egret	*Egretta dimorpha*	
100.5	**Scopidae: Hamerkop**		
101	Hamerkop	*Scopus umbretta*	
107.5	**Phalacrocoracidae: cormorants**		
108	Reed Cormorant	*Phalacrocorax africanus*	
129.5	**Accipitridae: diurnal birds of prey other than falcons**		
131	Osprey	*Pandion haliaetus*	PM
137	Black Kite	*Milvus migrans*	am, pm
138	African Fish Eagle	*Haliaeetus vocifer*	
150	Brown Snake Eagle	*Circaetus cinereus*	
151	Southern Banded Snake Eagle	*Circaetus fasciolatus*	Near Threatened
153	Bateleur Terathopius	*ecaudatus Near Threatened*	Near Threatened
154	Western Marsh Harrier	*Circus aeruginosus*	PM
158	African Harrier Hawk	*Polyboroides typus*	
178	Tawny Eagle	*Aquila rapax*	
186	Martial Eagle	*Polemaetus bellicosus*	VU
226.5	**Dromadidae: Crab-plover**		
227	Crab-plover	*Dromas ardeola*	AM
229.5	**Charadriidae: plovers**		
233	Spur-winged Plover	*Vanellus spinosus*	
235	Senegal Plover	*Vanellus lugubris*	
241	Grey Plover	*Pluvialis squatarola*	PM
242	Common Ringed Plover	*Charadrius hiaticula*	PM
243	Little Ringed Plover	*Charadrius dubius*	PM
246	White-fronted Plover	*Charadrius marginatus*	
247	Kentish Plover	*Charadrius alexandrinus*	PM

Spp.#	Common Name	Scientific Name	*Status
249	Lesser Sand Plover	*Charadrius mongolus*	PM
250	Greater Sand Plover	*Charadrius leschenaultii*	PM
252.5	**Jacanidae: jacanas**		
254	African Jacana	*Actophilornis africanus*	
254.5	**Scolopacidae: sandpipers and relatives**		
261	Bar-tailed Godwit	*Limosa lapponica*	PM
262	Whimbrel	*Numenius phaeopus*	PM
263	Eurasian Curlew	*Numenius arquata*	PM; Near Threatened
265	Common Redshank	*Tringa totanus*	PM
267	Common Greenshank	*Tringa nebularia*	PM
270	Terek Sandpiper	*Xenus cinereus*	PM
271	Common Sandpiper	*Actitis hypoleucos*	PM
273	Ruddy Turnstone	*Arenaria interpres*	PM
275	Sanderling	*Calidris alba*	PM
277	Little Stint	*Calidris minuta*	PM
281	Curlew Sandpiper	*Calidris ferruginea*	PM
283	Broad-billed Sandpiper	*Limicola falcinellus*	PM
285	Ruff	*Philomachus pugnax*	PM
298.5	**Laridae: gulls, terns and skimmers**		
299	Sooty Gull	*Larus hemprichii*	
301	Lesser Black-backed Gull	*Larus fuscus*	PM
303	Pallas's Gull	*Larus ichthyaetus*	PM,
309	Lesser Crested Tern	*Sterna bengalensis*	am
312	Roseate Tern	*Sterna dougallii*	
313	Common Tern	*Sterna hirundo*	PM
314	White-cheeked Tern	*Sterna repressa*	
316	Saunders's Tern	*Sternula saundersi*	RS
332.5	**Columbidae: pigeons and doves**		
333	Feral Pigeon	*Columba livia*	
342	Red-eyed Dove	*Streptopelia semitorquata*	
343	Ring-necked Dove	*Streptopelia capicola*	
344	Laughing Dove	*Streptopelia senegalensis*	
345	Emerald-spotted Wood Dove	*Turtur chalcospilos*	
408.5	**Caprimulgidae: nightjars**		

Spp.#	Common Name	Scientific Name	*Status
416	Plain Nightjar	*Caprimulgus inornatus*	AM, (pm)
421	Gabon Nightjar	*Caprimulgus fossii*	
423.5	**Apodidae: swifts**		
428	African Palm Swift	*Cypsiurus parvus*	
437.5	**Coliidae: mousebirds**		
438	Speckled Mousebird	*Colius striatus*	
444.5	**Coraciidae: rollers**		
446	Lilac-breasted Roller	*Coracias caudatus*	am
448	Eurasian Roller	*Coracias garrulus*	PM; Near Threatened
449.5	**Alcedinidae: kingfishers**		
450	Grey-headed Kingfisher	*Halcyon leucocephala*	am
455	Mangrove Kingfisher	*Halcyon senegaloides*	
461	Pied Kingfisher	*Ceryle rudis*	
461.5	**Meropidae: bee-eaters**		
463	Little Bee-eater	*Merops pusillus*	
465	Cinnamon-chested Bee-eater	*Merops oreobates*	
468	White-throated Bee-eater	*Merops albicollis*	AM
472	Northern Carmine Bee-eater	*Merops nubicus*	AM
481.5	**Bucerotidae: hornbills**		
484	African Grey Hornbill	*Tockus nasutus*	
493.5	**Capitonidae: barbets and tinkerbirds**		
501	Red-fronted Tinkerbird	*Pogoniulus pusillus*	
511	Black-collared Barbet	*Lybius torquatus*	
524.5	**Picidae: wrynecks and woodpeckers**		
527	Nubian Woodpecker	*Campethera nubica*	
529	Mombasa Woodpecker	*Campethera mombassica*	
537	Cardinal Woodpecker	*Dendropicos fuscescens*	
543.5	**Platysteiridae: batises, wattle-eyes and relatives**		
554	Black-headed Batis	*Batis minor*	
557.5	**Malaconotidae: helmetshrikes, bushshrikes, tchagras and puffbacks**		
563	Grey-headed Bushshrike	*Malaconotus blanchoti*	
566	Sulphur-breasted Bushshrike	*Chlorophoneus sulfureopectus*	
571	Brown-crowned Tchagra	*Tchagra australis*	
572	Three-streaked Tchagra	*Tchagra jamesi*	

Spp.#	Common Name	Scientific Name	*Status
574	Black-crowned Tchagra	*Tchagra senegalus*	
576	Black-backed Puffback	*Dryoscopus cubla*	
580	Slate-coloured Boubou	*Laniarius funebris*	
583	Tropical Boubou	*Laniarius aethiopicus*	
586	Brubru	*Nilaus afer*	
607.5	**Oriolidae: orioles**		
608	Eurasian Golden Oriole	*Oriolus oriolus*	PM
613	Black-headed Oriole	*Oriolus larvatus*	
613.5	**Dicruridae: drongos**		
615	Common Drongo	*Dicrurus adsimilis*	
616.5	**Monarchidae: monarch flycatchers**		
618	Little Yellow Flycatcher	*Erythrocercus holochlorus*	
623.5	**Corvidae: crows and allies**		
625	House Crow	*Corvus splendens*	
627	Pied Crow	*Corvus albus*	
637.5	**Hirundinidae: saw-wings, swallows and martins**		
642	Plain Martin	*Riparia paludicola*	
645	Barn Swallow	*Hirundo rustica*	PM
648	Wire-tailed Swallow	*Hirundo smithii*	
652	Lesser Striped Swallow	*Cecropis abyssinica*	
655.5	**Alaudidae: larks**		
662	Flappet Lark	*Mirafra rufocinnamomea*	
676.5	**Cisticolidae: cisticolas and allies**		
684	Rattling Cisticola	*Cisticola chiniana*	
688.5	Winding Cisticola	*Cisticola galactotes*	
705	Tawny-flanked Prinia	*Prinia subflava*	
714	Yellow-breasted Apalis	*Apalis flavida*	
725	Grey-backed Camaroptera	*Camaroptera brachyura*	
728.5	**Pycnonotidae: bulbuls**		
729	Common Bulbul	*Pycnonotus barbatus*	
739	Zanzibar Greenbul	*Andropadus importunus*	
742	Yellow-bellied Greenbul	*Chlorocichla flaviventris*	
745	Northern Brownbul	*Phyllastrephus strepitans*	
804.5	**Timaliidae: illadopses, babblers and chatterers**		

Spp.#	Common Name	Scientific Name	*Status
811	Scaly Chatterer	*Turdoides aylmeri*	
812	Rufous Chatterer	*Turdoides rubiginosa*	
848.5	**Turdidae: thrushes**		
855	African Bare-eyed Thrush	*Turdus tephronotus*	
858.5	**Muscicapidae: chats, wheatears and Old World flycatchers**		
873	Spotted Palm Thrush	*Cichladusa guttata*	
874	Bearded Scrub Robin	*Cercotrichas quadrivirgata*	
876	White-browed Scrub Robin	*Cercotrichas leucophrys*	
877	Rufous Bush Chat	*Cercotrichas galactotes*	PM
900	Pale Flycatcher	*Bradornis pallidus*	
912.5	**Nectariniidae: sunbirds**		
918	Collared Sunbird	*Hedydipna collaris*	
925	Amethyst Sunbird	*Chalcomitra amethystina*	
948.5	**Passeridae: sparrow weavers, Old World sparrows and petronias**		
958	Grey-headed Sparrow	*Passer griseus*	
960.5	**Ploceidae: weavers, bishops and widowbirds**		
970	Black-necked Weaver	*Ploceus nigricollis*	
984	Village Weaver	*Ploceus cucullatus*	
993	Dark-backed Weaver	*Ploceus bicolor*	
1014.5	**Estrildidae: waxbills**		
1030	Red-cheeked Cordon-bleu	*Uraeginthus bengalus*	
1047	Bronze Mannikin	*Spermestes cucullatus*	
1059.5	**Motacillidae: wagtails, longclaws and pipits**		
1065	African Pied Wagtail	*Motacilla aguimp*	
1068	Yellow-throated Longclaw	*Macronyx croceus*	
1071	Grassland Pipit	*Anthus cinnamomeus*	
1073	Long-billed Pipit	*Anthus similis*	
1081.5	**Fringillidae: canaries, citrils, seedeaters and relatives**		
1086	Reichenow's Seedeater	*Crithagra reichenowi*	
1088	Yellow-fronted Canary	*Crithagra mozambica*	
***PM=Palearctic migrant; AM=Afro-tropical migrant**			