CHAPTER-5
BIOLOGICAL ENVIRONMENT

Biological study of the ecosystem is essential to understand the impact due to project development activities on existing flora and fauna of the area. The present study was undertaken to document the baseline information about the biological environment in the study area so as to understand the changes as a result of proposed activities and to suggest measures for maintaining the conditions. The field survey for the biological study was conducted during the dry season i.e., month of May and June, 2010.

5.1 TERRESTRIAL FLORA

5.1.1 Floristics

A total of 258 plant species belonging to 61 families were recorded in the project area. The dominant plant family was Fabaceae constituting 15.1% of the total species followed by Poaceae and Euphorbiaceae with 14.3% and 7.8% respectively. Families with monospecies were 29 included Ulmaceae, Sterculiaceae, Salvadoraceae, Sapindaceae, Sapotaceae, Scrophulariaceae and Myrtaceae. The most abundant tree species included *Albizia coriaria, Albizia grandibracteata, Albizia zygia* while among the shrubs and herbs the most abundant species included *Bidens pilosa, Cynodon dactylon, Hyparrhenia diplandra, Hyparrhenia filipendula, Hyparrhenia rufa, Imperata cylindrica, Indigofera arrecta. Senna spectabilis* were the most abundant alien invasive plant species recorded in the project area. **Annexurex 5.1** provides complete details of the floral species encountered during the survey along with their conservation status.

5.1.2 Plant communities

There are four major plant communities that were distinguished during the survey. These include farmland, wooded grassland, riverine vegetation and islands vegetation. Within the wooded grassland were sub-communities dominated by various plant species.

a) Farmland

Farmlands are largely dominated by gardens of Simsim (*Sesamum indicum*), Tomatoes (*Lycopersicon esculentum* var. *esculentum*), Cassava (*Manihot esculentus*) and millet (*Eleusine coracana*); these garden spp. are not included in the list of the floral species as they are artificailly grown. These

farmlands were mainly found around the intake area, weir, powerhouse and surge tunnel and are interspersed with scattered trees and fallow land dominated by *Albizia zygia, Leonotis nepetifolia, Bidens pilosa, Chloris gayana, Imperata cylindrica, Acacia hockii, Panicum maximum, Markhamia lutea, Acacia polyacantha, Combretum molle* and *Terminalia glausescens.* Other species close to the intake area include *Antiaris toxicaria* and *Milicia excels* **(Figure 5.1).**

In terms of conservation significance, this area is categorised as low as most of the area is farmland and there are no unique habitats. Furthermore, the species richness is relatively lower because of farming activities. This area is important from an ethno botanical perspective in the sense that people use plant resources for firewood, medicines etc.

Figure 5.1: Agricultural farmland and fallow land

b) Riverine vegetation

These mainly refer to the plant communities found along the banks River Nile in the study area. At the Weir site, the left bank is largely dominated by *Albizia zygia, Acacia hockii, Acacia polyacantha and Rhus natalensis*. The dominant graminoids include *Panicum maximum, Sporobolus africanus* and *Bridelia micrantha.*

The right bank is dominated by *Imperata cylindrica, Kigelia africana, Acacia polyacantha, Setaria sphacelata, Pennisetum purperium,* and *Acacia hockii.* Species recorded on the small islands within the river include *Eichhornia crassipes* (Water hyancith), *Phragmites mauritianum, Aspilia africana, Hibiscus diversifolius, Cyperus papyrus* and *Panicum maximum* **(Figure 5.2-A to D).**

Reverine vegetation play very important role in the stabilization of river banks and prevention of soil erosion. In addition, this vegetation type is very important for the protection of the river from siltation and sedimentation. In terms of the conservation value, reverine vegetation is the most species rich area with several microhabitats. Several species including *Dalbergia melanoxylon, Milicia excels and Dombeya rotundifolia* have also been recorded here which fall in the lower risk category as per IUCN.

(A)

(B)

(C)

(D)

Figure 5.2: Some of the species growing along the banks River Nile and some aquatic macrophytes A: *Milicia excelsa* (Mvule) on the left bank **B:** small island dominated by *Phragmites mauritianum* and *Cyperus papyrus* **C:** *Eichhornia crassipes* (Water hyancith) an alien invasive species along the bank of the river **D:** *Triumfetta brachyceras* near the Kampala fishing site along the Nile river bank

c) Wooded grassland vegetation

This type of vegetation is generally reported inside the Karuma Wildlife Reserve. The predominant woody plant species in the wooded grassland included *Acacia polyacantha, Acacia hockii, Acacia sieberiana, Albizia coriaria, Albizia zygia, Combretum molle, Combretum colliunum, Strychnos innocua, Grewia mollis* and *Vitex doniana.* The dominant graminoids include *Chloris gayana, Eragrostis racemosa, Hyparrhenia filipendula, Hyparrrhenia rufa, Panicum maxium and Sprobolus pyramidalis.* **Figure 5.3** gives a general impression of the vegetation of the Karuma Wildlife Reserve.

Figure 5.3: The general Vegetation of Karuma Wildlife Reserve and that along the access road

There are three plant sub communities that are observed within the wooded grassland. These included the thick woody vegetation sub community especially along the access route dominated by *Terminalia glausescens, Acacia polyacantha, Bridelia micrantha* and occassionaly *Milicia excelsa.* The vegetation along the proposed access route is dominated by *Phoenix reclinata* and *Albizia zygia* along the wetter sections.

Second is the *Grewia mollis* **(Figure 5.4)** dominated sub-community that was associated with *Combretum molle, Combretum collinum* and scattered plantation of *Terminalia glausescens* trees. Dominant graminoids included *Sporobolus pyramidalis, Panicum maximum* and *Chloris gayana.*

Figure-5.4: *Grewia mollis* dominated plant Sub-community

Figure 5.5: *Vepris nobilis* dominated sub-community

Another conspicuous plant sub-community is the *Vepris nobilis* **(Figure-5.5)** associated with species including *Lannea schimperi*, *Sclerocarya birrea*, *Mallotus oppositifolius*, *Sapium ellipticum*, and *Pseudarthria hookeri*. This sub-community is also associated with *Dalbergia melanoxylon*, which is redlist plant species (IUCN, 2010) but not categorized as globally threatened.

d) Islands Vegetation

The tree vegetation in the islands comprised of *Albizia zygia* and *Phoenix reclinata* while *Leonotis nepetifolia* and *Hoslundia opposita* are the most abundant among the shrubs. In herbs category; *Justicia flava*, *Achyranthes aspera*, *Amaranthus graecizans*, *Chloris pycnothrix* and *Kyllinga erecta* are recorded whereas *Eragrostis racemosa* is the most common among the grasses.

5.1.3 The ethnobotany in the study area

Some of the plant species in the project area are reported to be used by the local inhabitants for various purposes. A list of some commonly occurring plant species recorded during the survey with their miscellaneous uses is given in **Table 5.1** below.

Table 5.1 Recorded Plants with ethnobotanical importance

Scientific name	Local name (Luo)	Use
Acacia sp.	Okutoi	Root infusion used for gastro-intestinal problems
Bidens pilosa	Ononot	Leaves infusion used as antiseptic for wounds
Kigelia africana	Yago	Fruit infusion used in post-natal problems
Momordica foetida	Bomoo	Leaf infusion used to treat gastro-intestinal problems
Solanum spp.	Ocwiga	Used as vegetable
Amaranthus sp.	Dodo	Used as vegetable

5.2 TERRESTRIAL FAUNA

The terrestrial fauna covers a wide variety of the taxa from vertebrates and invertebrates. In the context of present study status of mammals, birds, amphibians, reptiles and butterflies in the study area has been assessed. Information about the fauna aspect presented in this chapter has been collected during the field surveys conducted in the month of July 2010 (dry season) using direct and indirect sightings method; transact method and Interaction with the local residents.

5.2.1 Butterflies

Invertebrates serve an extremely important role in the community. Studies indicate that insects, as a whole, have a large influence on plant diversity and particular species of insect serve keystone functions in the community. Butterflies satisfy most selection criteria for use as bioindicators. Butterflies respond

quickly to environmental changes and there is now considerable amount of data on how particular species contend with alterations in land-use, and thus may play a valuable role in ecological monitoring (Daily and Ehrlich, 1995). The influence of seasonality on the presence or absence of adults of certain species, and on their morphology, as well as knowledge of species ecology must always be considered. However, the compilation of species lists may be used both qualitatively and quantitatively, to comment on a habitat (its condition and vegetation) and to identify conservation and monitoring needs. Increasingly, therefore, butterflies are being used as tools in ecological monitoring strategies (Pollard and Yates, 1993; Sparrow *et al.,* 1994).

5.2.1.1 Species identification and status

98 species of butterflies are recorded in the study area with the access road returning the highest number of species (66%). Areas along the adits and near the power generation site returned 41% and 40% respectively of the species recorded. The lagoon site had the least number of butterflies with only 8% of the total species recorded by these surveys. No species of significant conservation concern are recorded. No IUCN category species were recorded, however, number of habitat specific species, for example 17 forest specific species, are recorded along the access road route and one swamp specific species, *Metisella midas* is recorded both along the access route as well as in the Adits **(Annexure 5.2)**. However these species are not restricted in Karuma area only and are found in the whole country.

5.2.2 Herpetofauna

Amphibians comprise three major groups: frogs and toads (order Anura), salamanders and newts (order Caudata) and caecilians (order Apoda or Gymnophiona) (Frost, *et al*., 2006) of which about ninety eight (98) species have been recorded in Uganda (Goodman, unpublished report).

Amphibians are arguably the least known, least conspicuous but easy to study inhabitants of tropical habitats (Schiøtz 1975 and 1999,). They are most abundant and common in habitats such as wetlands where they fulfill their amphibious habits and are therefore well suited to serve as biological indicators. Their taxonomy is relatively well known and stable compared to lower taxa such as insects though not as well known as the higher taxa, and their ecology is only partly understood. They occupy a broad geographical range and a large number of habitat types. They are entirely dependent on the existence of the right kind of habitat.

Some amphibians specialise within narrow habitat bands and are thus sensitive to habitat change. Because amphibians often have limited habitat ranges, they are more likely to be affected by habitat changes than other vertebrates. This makes them good indicators of environmental change - one of the current factors driving inventory and monitoring efforts (Blaustein, 1994; Blaustein and Wake, 1990). Environmental degradation can be reflected in decreases in amphibian populations and species diversity and an increase in the occurrence of deformities (Olson and Leonard, 1997). Some amphibian fauna such as *Amietophrynus vittatus* are known to be common inhabitants of the littoral and ecotone zones of lacustrine ecosystems and have been found to be useful indicators of how far inland the flood zones of the lakes and rivers extend (Behangana, 2004).

Reptiles are composed of snakes, skinks and lizards, terrapins, tortoises, geckoes, chameleons, crocodiles among others for which 150 species are known in Uganda. Most reptiles are versatile and can be good indicators of serious habitat degradation. In such case, the otherwise common groups of reptiles such as skinks and lizards disappear because of the habitats disturbance or destruction. Most reptiles are specialists and have unique niches. For example, some snakes specialize on feeding on molluscs, others on frogs, while others specialize on rodents. Chameleons are known to specialize on insects while lizards feed on a whole array of arthropods, and sometimes birds, birds' eggs or even their own.

Some reptiles, such as the water cobra, *Naja melanoleuca*; the water snakes, *Grayia* sp.; and the marsh snakes *Natriciteres* sp. are important predators of fish and amphibians. The Nile crocodile, *Crocodylus niloticus* uses aquatic ecosystems for its habitation and feeding and is always found in proximity to water. The Nile monitor, *Varanus niloticus* constantly uses the wetlands fringing aquatic ecosystems as a habitat and constantly visits the littoral zone to feed on fish (Behangana, 2004).

5.2.3 Amphibian and Reptilian Fauna of the Study Area

Thirteen amphibian species are recorded in the study area **(Table 5.2).** All the species recorded are of Least Concern (LC) according to the IUCN red listing (http://www.redlist.org) because they either have a very wide distribution, tolerant to a broad range of habitats or presumed to have large populations, except for *Bufo vitattus* that is considered Data Deficient (DD).

Sixteen reptilian species are recorded in the study area **(Table 5.3).** The Nile Crocodile- *Crocodylus niloticus* is recorded as Least Concern (LC) according to the IUCN red listing (http://www.redlist.org)

and is also a CITES appendix II listed species for Uganda. All the other species have been not yet evaluated as per IUCN.

There are no critical habitats for amphibians, reptiles or other animal groups because these could be found elsewhere within the vicinity of the KHPP.

Table 5.2: Amphibian fauna of Karuma Hydropower Project Study Area

Species	Common Name	IUCN Status
Afrixalus osorioi	Osorio's Spiny Reed Frog	Least Concern (LC)
Amietia angolensis	Angola River Frog	Least Concern (LC)
Bufo gutturalis	African Common Toad	Least Concern (LC)
Bufo vittatus	-	Data Deficient (DD)
Hemisus marmoratus	Marbled Snout-burrower	Least Concern (LC)
Hoplobatrachus occipitalis	Crowned Bullfrog	Least Concern (LC)
Hyperolius pusillus	-	Least Concern (LC)
Hyperolius viridiflavus	Common Reed Frog	Least Concern (LC)
Kassina senegalensis	-	Least Concern (LC)
Leptopelis bocagii	-	Least Concern (LC)
Phrynobatrachus natalensis	Natal Dwarf Puddle Frog	Least Concern (LC)
Ptychadena porosissima	-	Least Concern (LC)
Xenopus victorianus	Mwanza Frog	Least Concern (LC)

Table 5.3: Reptilian fauna of Karuma Hydropower Project Study Area

Species	Common Name	IUCN Status
Agama agama	Orange-headed Agama	Not Evaluated
Bitis gabonica	Gaboon Viper	Not Evaluated
Bitis nasicornis	Rhinoceros Viper	Not Evaluated
Chamaeleo gracilis	Gracile Chamaeleon	Not Evaluated
Crocodylus niloticus	Nile Crocodile	Least Concern (LC)
Dendroaspis jamesoni kaimosae	Western Forest Green Mamba	Not Evaluated
Geochelone pardalis	Leopard Tortoise	Not Evaluated
Hemidactylus brooki	Brook’s Gecko	Not Evaluated
Kinixys belliana	Bell’s Hinged Tortoise	Not Evaluated
Leptotyphlops scutifrons	Peter’s worm Snake	Not Evaluated

Species	Common Name	IUCN Status
Naja melanoleuca	Forest/Water Cobra	Not Evaluated
Python sebae	Rock Python	Not Evaluated
Thelotornis kirtlandi	Twig Snake	Not Evaluated
Typhlops lineolatus	Lineolate Blind Snake	Not Evaluated
Typhlops punctatus	Spotted Blind Snake	Not Evaluated
Varanus niloticus	Nile Monitor	Not Evaluated

5.2.4 Mammals

Mammals (especially the larger species) represent a group of animals which together with birds quickly draws the attention of Wildlife Reserves and Park Managers as well as the wider community. They are often easy to be spotted in the right habitats, for which reason they support tourism and impacts on or from them such as poaching, crop raiding and damage as well as injuries to people could represent significant issues.

5.2.4.1 Habitats

The left bank upstream from the Karuma bridge is generally raised to over 20m high in most places, characterized by steep slopes that had some gardens in several places. Right from the edge of the slopes inland, the land is cultivated with subsistence agriculture dominating the area. Downstream from the bridge, the left bank is in the KWR, characterized by wooded savannah and woodland. The right bank on the other hand is low lying and a few meters high from the river and can be prone to flooding when the river bursts its banks. The bank downstream the bridge is in the Wildlife Reserve while upstream of the bridge, it is in the community area. At the point proposed for weir construction, rocky outcrops and small islands are present in the river. The low-lying habitats adjacent to the river support wetland vegetation such as papyrus, water reeds, and *Phragmites*. The surveys for the present study are conducted in both the reserve savanna area and the settled and cultivated community areas.

5.2.4.2 Small Mammals

Small mammals could present a very useful taxon for measuring impacts on habitats to biodiversity. Their population turnover is faster than that of larger mammals and given their shorter life span impacts on the mammalian fauna can easily be measured based on them. At least 15 species of small mammals

including rodents, insectivores and bats have been recorded in the study area **(Table 5.4).** None of the species of conservation category as per IUCN was recorded in the study.

Table 5.4: Small Mammals species recorded in the study area of Karuma HPP

S.N.	Common Name	Species Name	IUCN Status
1	Yellow-winged Bat	*Lavia frons*	Least Concern
2	Hildegarde's Musk Shrew	*Crocidura hildegardeae*	Least Concern
3	Brant's Climbing Mouse	*Dendromus mesomelas*	Least Concern
4	Northern Bush Rat	*Aethomys hindei*	Least Concern
5	Kaiser's Bush Rat	*Aethomys kaiseri*	Least Concern
6	Common Thicket Rat	*Grammomys dolichurus*	Least Concern
7	Common Striped Grass Rat	*Lemniscomys striatus*	Least Concern
8	Eastern Brush-furred Rat	*Lophuromys flavopnctatus*	Least Concern
9	Common Brush-furred Rat	*Lophuromys sikapusi*	Least Concern
10	Northern Savanna Multimammate Rat	*Mastomys hildebrandtii*	Not Evaluated
11	Pygmy Mouse	*Mus minutoides*	Least Concern
12	Grey-bellied Pygmy Mouse	*Mus triton*	Least Concern
13	Crested Porcupine	*Hystrix cristata*	Least Concern
14	Geofrey's Ground Squirrel	*Xerus erythropus*	Least Concern
15	Northern Savanna Gerbil	*Gerbilliscus validus*	Least Concern

5.2.4.3 Large Mammals

Together with previously known records Karuma wildlife reserve has over 15 species of medium to large sized mammals of which only 11 species are recorded in the study area during the current study **(Table 5.5).** Of these only Buffalo seemed to occur in fairly large concentrations, the number of hippo tracks also suggested intense use by the species. All other species did not appear to be in high densities in the area of impact. The concentration of the larger mammals is in the Karuma WR section and only anecdotal records and reports in the community area. Of the species recorded the Elephant and Hippos are considered vulnerable using the IUCN criteria (IUCN 2010).

Table 5.5: Large Mammals species recorded in the study area of Karuma HPP

S.N.	English name	Scientific name	IUCN Status
1	Vervet Monkey	*Chlorocebus pygerythrus*	Least Concern
2	Olive Baboon	*Papio anubis*	Least Concern
3	Guereza (Black & White) Colobus	*Colobus guereza*	Least Concern
4	African Elephant	*Loxodonta africana*	Vulnerable
5	Aardvark (Ant Bear)	*Orycteropus afer*	Least Concern
6	Red River Hog	*Potamochoerus porcus*	Least Concern
7	Hippopotamus	*Hippopotamus amphibius*	Vulnerable
8	African Buffalo	*Syncerus caffer*	Least Concern
9	Bushbuck	*Tragelaphus scriptus*	Least Concern
10	Common (Bush) Duiker	*Sylvicapra grimmia*	Least Concern
11	Oribi	*Ourebia ourebi*	Least Concern

5.2.4.4 Human disturbance

For mammalian conservation in the area, we only consider the reserve side (i.e. KWR) to be important in the study area. The community area is already cleared of mammalian concentrations although the reports from local communities and UWA rangers indicated that animals occasionally cross from the KWR into the community land. Within the KWR, snares were removed from a number of locations by UWA officials and one dead Bush buck was found in a snar during the visit to study area **(Figure 5.6).** Members of the local community are already under arrangements with UWA allowed controlled access into the reserve to harvest resources including wood products for fuel and poles.

Figure 5.6: A recovered snare and a Bushbuck dead in a snare in Karuma WR area to be traversed by the proposed access road

5.2.5 Avifauna

Birds are generally day active animals that are quite vocal and easy to identify and therefore inventory. These facts together make them a suitable taxon for assessment and monitoring studies. Birds are agreeably sensitive indicators of the health of the environment and sustainability, reflecting trends in other biodiversity, being responsive to change, high in food chains, inexpensive to survey and the best known and most popular component of wildlife (Birdlife international). Surveys of avian diversity are also conducted to provide a baseline situation for assessing potential impacts of the activities associated with development of Karuma HPP.

Altogether, 84 species are recorded comprising 30 species along the access road, 46 species in the fallow area, and 31 species in adits area details are enclosed in (**Annexure 5.3)**. Species with a preference for some level of forest cover dominated the records and in addition a few water birds are also recorded in the study area. Together, seven species of conservation concern (Brown Snake Eagle, Spot-flanked Barbet, White-headed Saw-wing, Grey-capped Warbler, Papyrus Gonolek, Golden-backed Weaver, and Cardinal Quelea) are recorded in the study area **(Table 5.6).**

Table 5.6: Bird species of particular conservation concern

S. No.	Species	Status	Habitat	Regional threat status	IUCN Status
1	Brown Snake Eagle *Circaetus cinereus*	R(B)		R-NT	Least Concern
2	Spot-flanked Barbet *Tricholaema lacrymosa*	RB		R-RR	Least Concern
3	White-headed Saw-wing *Psalidoprocne albiceps*	RB, AfM/NB	f	R-RR	Least Concern
4	Grey-capped Warbler *Eminia lepida*	RB	fW	R-RR	Least Concern
5	Papyrus Gonolek *Laniarius mufumbiri*	R(B)	W	R-NT/RR	Near Threatened
6	Golden-backed Weaver *Ploceus jacksoni*	RB	W	R-RR	Least Concern
7	Cardinal Quelea *Quelea cardinalis*	RB		R-RR	Least Concern

Status: habitat and threat category are based on Wilson (1994) and Carswell *et al* (2005); RB - resident breeder, R (B) - resident, breeding not proved (but likely), AfM/B - intra-African migrant, breeding, NB - not breeding

Habitat: - W - always resident in or near water, w - often resident or observed in or near water, F - Forest resident, f - resident in and near forests

Regional threat status (based on Carswell *et al* 2005)

R-NT - regionally near-threatened
R-RR- species of regional responsibility

5.3 AQUATIC ECOSYSTEM ASSESSMENTS

5.3.1 Assessment of baseline phytoplankton composition, distribution and abundance

All the phytoplankton samples collected as detailed in methodology section yielded a total of 86 species belonging to six classes of phytoplankton comprised by Blue-green algae; Cryptomonads; Diatoms; Dianoflagelates; Euglenoids and Green algae (**Table 5.7**, **Table 5.8** and **Table 5.9**). Sampling locations used for aquatic data collection area shown in **Figure 5.7**.

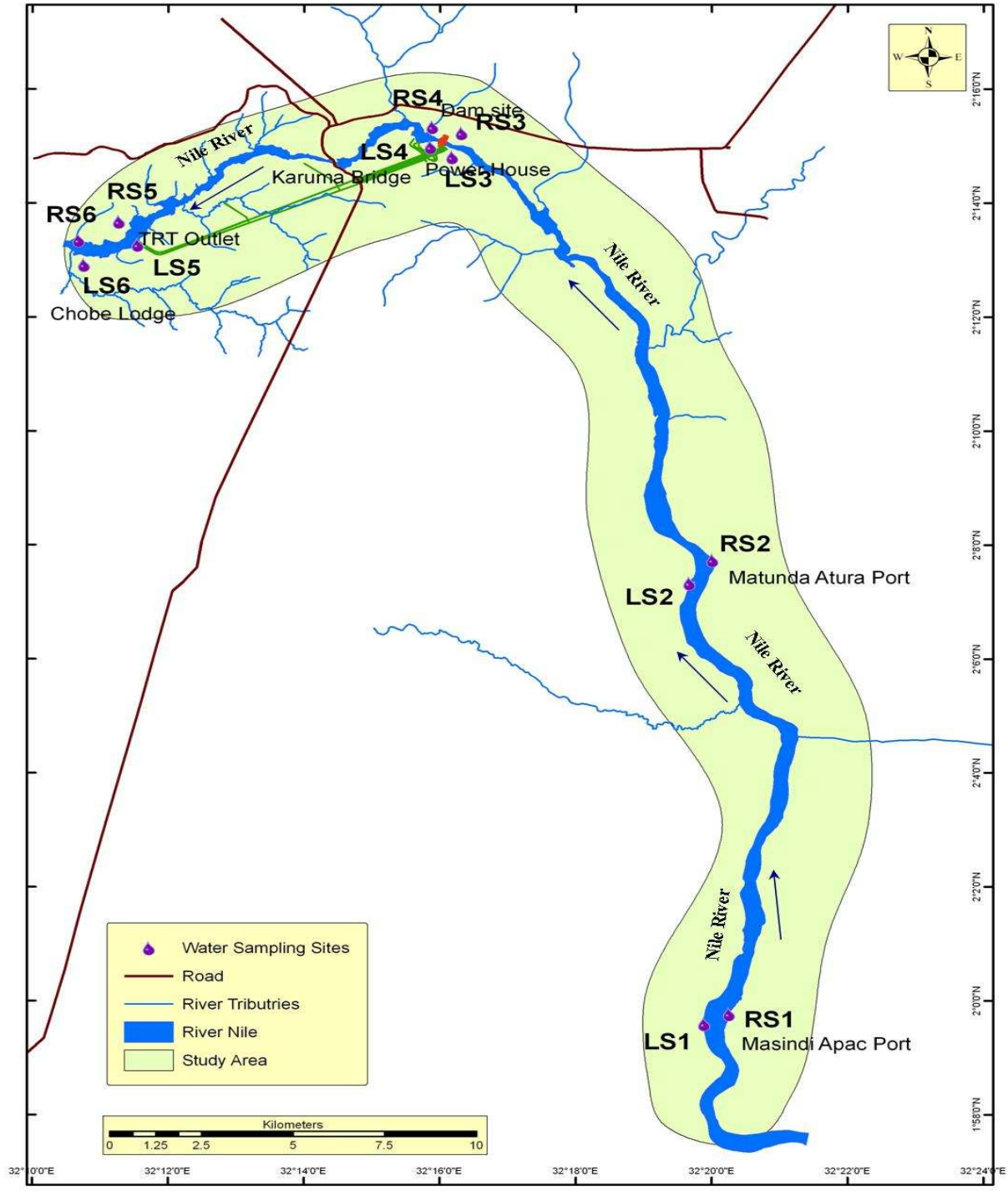

Figure: 5.7: Water sampling sites along the River Nile for Karuma HPP

Green algae had the highest number of species at 37. Bluegreen algae comprised 24 species, Diatoms 17 species, Cryptomonads 4 species while Dianoflagelates and Euglenoids registered 2. Species richness did not differ markedly among most sites in the study area of the Karuma Hydropower Project. The number ranged from 43 species at the right shores of the Apac/Masindi Port transect upstream to 33 species at the right shore site opposite the location of the tunnel outflow. The only exception was the site at the left shore across from the Chobe Lodge site which yielded 54 species of phytoplankton. Diatoms are represented at all sites sampled by the species *Aulacoseira ambigua* or by *Aulacoseira granulata*. The highest biovolume of the Diatom *A. granulata* (2.32 mm^3L^{-1}) came from the Apac/Masindi Port transect at the right shore site while the highest biovolume for *A. ambigua* (1.68 mm^3L^{-1}) is recorded at the shore of the Nora/Awoo transect downstream of the proposed location of the weir. Other species of Blue-green algae (*Anabaena* and *Microcystis*) highly studied because of their succession in slightly calm water were present at only seven sites i.e. Atura, Chobe Lodge left shore, Opposite/Tunnel Outflow (i.e. right shore site) , Kampala Beach, Mutunda/Atura (left shore), and at the left shore sites of both transects of Nora/Awoo (upstream and downstream of weir).

The biovolume are low for all the sites as is typical for large fast flowing rivers (Wehr and Descy, 1998). The highest total biovolume (4.5 mm^3L^{-1}) is recorded from the right shore site at Apac/Masindi Port transect. Diatoms contributed over half the volume (2.9 mm^3L^{-1}). The least biovolume (0.8 mm^3L^{-1}) is recovered from left shore at the Awoo/Nora transect downstream of the weir. Blue-green algae registered the highest biovolume (1.9mm^3L^{-1}) at the shores of Kampala Beach. Other classes like the Cryptomonads, Dianoflagelates and Euglenoids appeared in marginal volumes and their contribution to the relative abundance are shielded off by the big three i.e. Blue-green algae, Diatoms and Green algae **(Figure 5.8).**

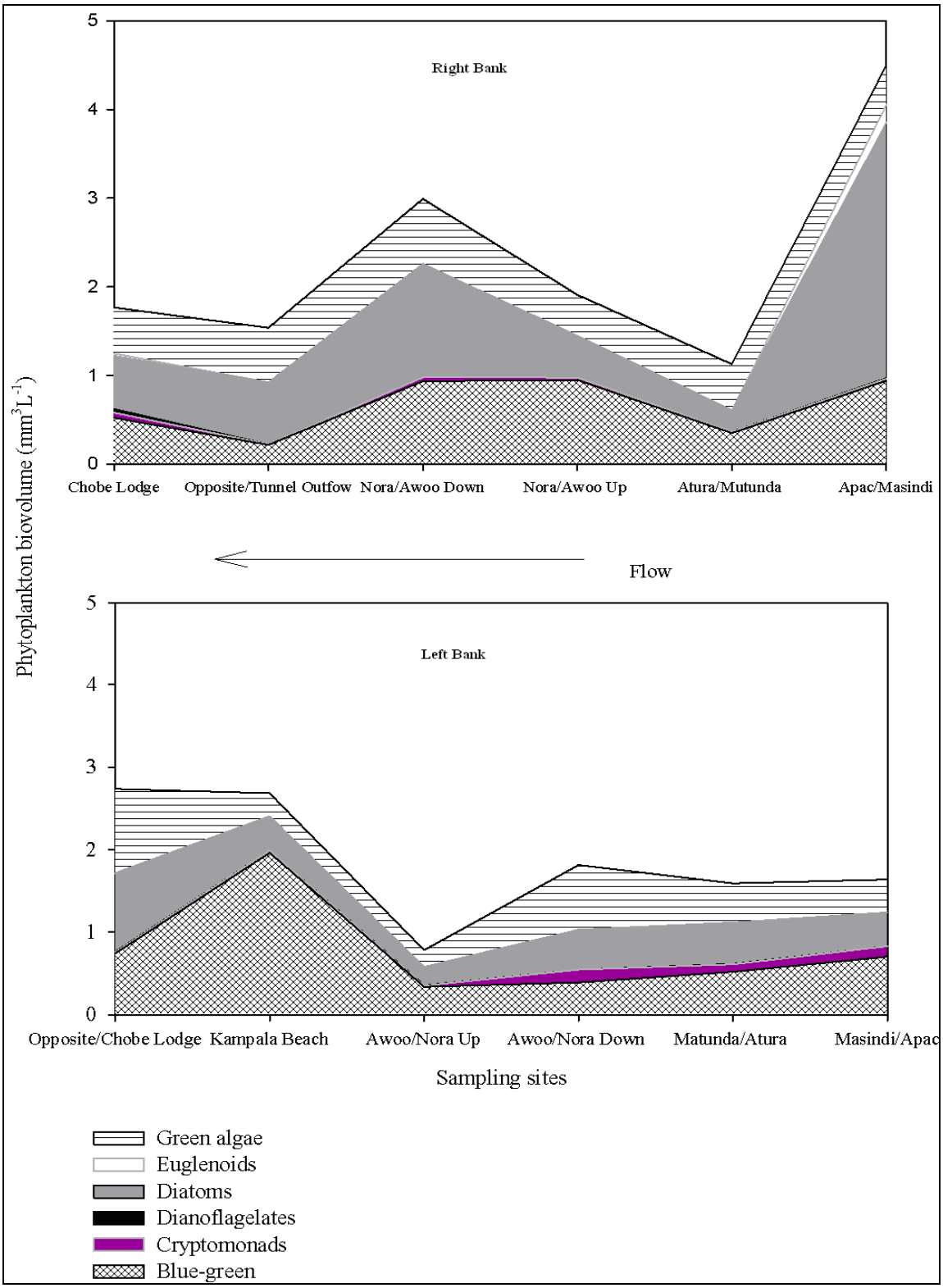

Figure 5.8: Phytoplankton abundance and composition along the shores of River Nile in the study area of the Karuma Hydropower Project

Table 5.7 Baseline species composition and distribution of Blue-green algae, Cryptomonads and Dianoflagelates from the study area of the proposed Karuma HPP

Class	Species	1	2	3	4	5	6	7	8	9	10	11	12
Blue-green algae	*Anabaena circinalis*												√
	Anabaena flos-aquae						√	√					
	Aphanocapsa delicatissima	√	√	√	√	√	√	√	√	√	√	√	√
	Aphanocapsa incerta	√			√		√		√		√		√
	Aphanothece limnetica									√	√		
	Aphanothece microscopica									√	√		
	Aphanothece ridulans								√				
	Aphanothece sp	√	√		√							√	√
	Blue greens	√		√	√	√		√				√	√
	Chroococcus dispersus	√	√	√	√	√	√	√	√	√	√	√	√
	Chroococcus limneticus	√	√	√	√	√	√	√	√	√	√	√	√
	Coelosphaerium kutzingianum	√	√				√		√			√	√
	Cylindrospermopsis africana	√			√	√		√		√	√		
	Cylindrospermopsis cupsis	√		√									√
	Cylindrospermopsis sp			√					√				
	Merismopedia glauca				√								√
	Merismopedia tenuissima	√	√	√	√	√	√	√	√	√	√	√	√
	Microcystis flos-aquae				√				√			√	√
	Microcystis viridis		√	√									
	Planktolyngbya circumcreta	√	√	√	√	√	√	√	√	√	√	√	√
	Planktolyngbya												√

Class	Species	1	2	3	4	5	6	7	8	9	10	11	12
	contarta												
	Planktolyngbya limnetica	√	√	√	√	√	√	√	√	√	√	√	√
	Pseudanabaena limnetica								√				
	Romeria gracile					√						√	√
Cryptomonads	*Cryptomonas caudata*	√			√	√			√		√	√	√
	Rhodomonas lens												√
	Rhodomonas minuta		√	√	√	√			√		√		√
	Rhodomonas sp	√					√	√					
Dianoflagelates	*Glenodinium sp*					√					√		√
	Peridium sp	√						√					
Total species		**15**	**10**	**11**	**14**	**12**	**10**	**11**	**14**	**10**	**13**	**12**	**20**

Right Shore : 1 = Apac/Masindi Port; **2** = Atura/Mutunda; **3** = Nora/Awoo Upstream; **4** = Nora/Awoo Downstream; **5** = Opposite Tunnel Outflow; **6** = Chobe Lodge;

Left shore : 7 = Masindi Port/Apac; **8** = Mutunda/Atura; **9** = Awoo/Nora Upstream of Weir; **10** = Awoo/Nora Downstream of Weir; **11** = Kampala Beach; **12** = Chobe Lodge.

Note: Please refer Figure 5.7 for details of sampling locations

Table5.8: Baseline species composition and distribution of Diatoms and Euglenoids from the study area of the proposed Karuma HPP

Class	Species	1	2	3	4	5	6	7	8	9	10	11	12
Diatoms	*Amphora ovalis*	√							√				
	Aulacoseira ambigua	√			√	√	√					√	√
	Aulacoseira granulata	√	√	√		√				√			√
	Cyclostephanodiscus astrea												√
	Cyclostephanodiscus sp	√	√	√	√	√	√	√	√	√	√	√	√
	Cyclotella sp							√		√	√	√	
	Cymbella grossestriata												√
	Diatoma sp	√		√		√	√	√	√	√	√	√	√

Class	Species	1	2	3	4	5	6	7	8	9	10	11	12
	Fragilaria construens			√	√								√
	Fragilaria sp		√		√				√		√		
	Navicula gastrum	√									√		√
	Navicula radiosa			√		√						√	√
	Nitzschia acicularis	√	√	√	√	√	√	√	√	√	√	√	√
	Nitzschia fonticola	√	√	√	√	√	√	√	√	√	√	√	√
	Rhizosolenia victoriae											√	
	Rhopalodia gibba		√	√							√		
	Synedra cunningtonnii	√	√	√	√	√	√	√	√	√	√	√	√
Euglenoids	*Euglena sp*	√											
	Phacus curvicauda								√				
	Trachelomonaus sp												√
Total species		**10**	**7**	**9**	**7**	**8**	**6**	**6**	**8**	**7**	**9**	**9**	**13**

Right shores : 1 = Apac/Masindi Port; **2** = Atura/Mutunda; **3** = Nora/Awoo (Upstream); **4** = Nora/Awoo (Downstream); **5** = Opposite Tunnel Outflow; **6** = Chobe Lodge;

Left shores : 7 = Masindi Port/Apac; **8** = Mutunda/Atura; **9** = Awoo/Nora Upstream of Weir; **10** = Awoo/Nora Downstream of Weir; **11** = Kampala Beach; **12** = Chobe Lodge.

Note: Please refer Figure 5.7 for details of sampling locations

Table 5.9: Baseline composition and distribution of Green algae from the likely area of influence of the proposed Karuma HPP

Class	Species	1	2	3	4	5	6	7	8	9	10	11	12
Green algae	*Actinastrum hantzschii*		√	√				√		√			
	Ankistrodesmus falcatus	√	√	√	√	√	√	√	√	√	√	√	√
	Ankistrodesmus fusiformis	√	√	√		√		√	√	√			
	Ankistrodesmus setigera	√	√	√	√		√	√	√	√	√		√
	Chodatella subsalsa	√	√	√	√	√	√	√	√	√	√	√	√
	Closterium aciculare												√
	Coelastrum cambricum			√	√		√	√	√	√	√		√
	Cosmarium depressum	√			√				√				

Class	Species	1	2	3	4	5	6	7	8	9	10	11	12
	Crucigenia apiculata		√	√			√	√	√	√		√	√
	Crucigenia quadrata												√
	Didymocystis tuberculata	√	√	√				√		√		√	√
	Golenkia radiata	√		√	√			√					
	Kirchneriella contarta											√	
	Oocystis elliptica									√			
	Oocystis lacutris	√	√	√	√			√	√			√	√
	Oocystis parva									√			
	Oocystis solitaria	√	√	√	√	√	√	√	√	√	√		√
	Pediastrum boryanum		√		√		√						√
	Pediastrum duplex	√		√	√		√		√				√
	Pediastrum simplex		√		√	√			√	√		√	√
	Pediastrum sp										√		√
	Pediastrum tetras		√			√						√	
	Rhaphidium braunii		√										
	Scedesmus intermedius	√											
	Scenedesmus acuminatus	√	√	√	√	√	√	√	√	√	√	√	√
	Scenedesmus acutus		√			√		√	√		√	√	√
	Scenedesmus bicuadatus	√	√	√	√	√	√	√	√	√	√	√	√
	Scenedesmus ecornis												√
	Scenedesmus obliguus	√	√	√	√	√	√	√		√			
	Scenedesmus obtusicolus						√						√
	Scenedesmus quadricuada	√	√	√	√	√	√	√	√	√	√	√	√
	Scenedesmus sp											√	
	Spirogyra sp			√				√	√	√			
	Stuarastrum gracile	√		√		√	√	√					√
	Stuarastrum trigonum								√				
	Tetraedron minimum	√	√	√	√		√		√	√	√	√	√
	Tetraedron trigonum	√	√	√	√	√	√	√	√	√	√	√	√
Total species		**18**	**20**	**20**	**17**	**13**	**16**	**19**	**19**	**19**	**12**	**15**	**23**

Right shore : 1 = Apac/Masindi Port; **2** = Atura/Mutunda; **3** = Nora/Awoo Upstream; **4** = Nora/Awoo Downstream; **5** = Opposite Tunnel Outflow; **6** = Chobe Lodge; **Left shore : 7** = Masindi Port/Apac; **8** = Mutunda/Atura; **9** = Awoo/Nora Upstream of Weir; **10** = Awoo/Nora Downstream of Weir; **11** = Kampala Beach; **12** = Chobe Lodge.

Note: Please refer Figure 5.7 for details of sampling locations

5.3.2 Taxonomic composition of zooplankton

The zooplankton community consisted of two crustacean groups: Copepoda and Cladocera (water fleas) and one non-crustacean group, Rotifera. Each of the three broad taxonomic groups is constituted by several genera and species.

5.3.2.1 Copepoda

Two types of copepods: calanoid and cyclopoid are encountered. Calanoid copepods are represented by a single species, *Thermodiaptomus galeboides* while two Cyclopoid genera each with one species (*Afrocyclops* sp. and *Thermocyclops neglectus*) are found. Representatives of two development stages of copepods, cyclopoid/calanoid copepodites and nauplius larvae are of regular occurrence in the samples.

5.3.2.2 Cladocera

Cladocerans are represented by five genera each with a single species (*Alona* sp., *Bosmina longirostris, Chydorus* sp, *Daphnia lumholtzi*, and *Diaphanosoma excisum*.

5.3.2.3 Rotifera

Five rotiferan genera (*Brachionus, Trichocerca, Keratella, Lecane* and *Synchaeta* are encountered. Only the genus *Brachionus* contained two species (i.e. *B. angularis* and *B. plicatilis*) while the rest had one species each.

5.3.3 Species richness and spatial distribution patterns

Species richness and spatial distribution of zooplankton is recorded in Table 5.10. An upstream-downstream diminishing of zooplankton species richness is identified. It is noteworthy that all the 5 species of Cladocera are only recovered at a single site at the southern site of Apac/Masindi Port transect. It is also notable that copepod species and developmental stages (copepodites and nauplius larvae) appeared to be rare/absent in the downstream sites at Chobe. Three rotifer species namely

Keratella tropica, *Lecane bulla* and *Synchaeta* spp. and three developmental stages of copepods were the more regular members of the zooplankton community, registering between 40-80% frequency of occurrence in the field samples. In general, the zooplankton community of the river section sampled is generally comparable to those found in most running water bodies in Uganda - associated with poor zooplankton species richness. The large quantity of tiny organic debris which characterised all samples assessed rendered sample processing very difficult and might have contributed to the observed results.

Table 5.10: Baseline zooplankton species occurrence in the study area of the proposed Karuma HPP

Transect Name	**Apach/ Masindi Port**		**Atura/ Mutunda**	**Nora/Awoo Downstream of weir**	**Kampala Beach**	**Across from Tunnel Outflow**	**Chobe Lodge**
Site sampled	RS	LS	RS	LS	LS	RS	RS
Water depth (m)	**2**	**3**		**3**	**0.5**	**0.8**	**2.6**
Species							
Copepoda							
Afrocyclops sp.				P			
Unidentified Copepod				P			
Thermocyclops neglectus		P			P	P	
Thermodiaptomus galeboides	P	P					
Calanoid copepodites		P					
Cyclopoid copepodite	P	P				P	
Nauplius larvae		P		P			
Cladocera:							
Alona sp.		P					
Bosmina longirostris		P					
Chydorus spp.		P					
*Daphnia lumholtzi(*helm*)*		P					
Diaphanosoma excisum		P					
Rotifera:							

Transect Name	Apach/ Masindi Port		Atura/ Mutunda	Nora/Awoo Downstream of weir	Kampala Beach	Across from Tunnel Outflow	Chobe Lodge
Brachionus angularis				P			
Branchionus plicatilis		P					
Trichocerca cylindrica							P
Keratella tropica							P
Lecane bulla		P					P
Synchaeta spp.		P		P	P	P	P
No. of Species	**2**	**13**		**5**	**2**	**3**	**4**

Key: RS = Right shore; LS = Left shore;

5.3.4 Taxonomic composition, distribution and relative abundance of Macro benthos

The full species list of all macro-benthos identified in the study area are listed in **Table 5.11**, separated into key taxa and minor taxa. Macro-invertebrate taxa regarded as key or important exhibited greater occurrence and/or abundances. The minor ones are found much less frequently and in smaller numbers.

In **Figure 5.9** to **Figure 5.11** the species composition and relative abundance of the Gastropoda, Bivulvia and Ephemeroptera at the various transects are presented. Among the three key species of Gastropoda *Melanoides tuberculata* is generally the most abundant, with mean densities (ind/m^2) ranging from 0 to 749. The highest density of *M. tuberculata* is at left shore of Masindi port/Apac transects and the species is found at all river banks except at the Right bank site opposite the Tunnel outflow location and Chobe Lodge site. *Gabbia humerosa* and *Gabbia senaeriensis*, had mean densities of 126 and 56, respectively, at Masindi port and are more abundant at this transect than at others. *Gabia humerosa* is also present at Atura-Mutunda and Nora-Awoo, while *G. senaeriensis* is found only at Masindi port.

Table 5.11: List of macro-benthos recovered from sites along both banks of River Nile in the study area of the proposed Karuma HPP

Key Taxa	**Minor Taxa**
Gastropoda *Melanoides tuberculata;Gabbia humerosa* *Gabbia senaeriensis*	**Gastropoda** *Lenistes carinaius*
Bivalvia Ephemeroptera; *Byssanodonta parasitica* *Corbicula africana;Sphaerium* sp	**Bivulvia** *Caelatura* sp
Ephemeroptera *Povilla adusta;Caenis* sp ;Tricorythidae	**Ephemeroptera** Polycentropodidae; *Heptagenia* sp *Baetis* sp; *Ephemerelia* sp
Chironomidae *Chirononomus* sp ; *Alabesmyia* sp *Cryptochironomus* sp	**Chironomidae** *Chironomini;Clirotantpus* sp
Members of **Oligochaeta**	Membres of **Hirudinia**
	Membres of **Ceratopogonidae**
	Tricoptera *Hydropcyche* sp; *Leptocelia* sp *Polycentopus* sp

Among Bivalvia the species *Byssanodonta parasitica* is the most abundant with a significantly higher mean density of 6580 at Masindi port as compared to about 0-154 at other transects. *B. parasitica* occurred in all transects except at Kampala and at the right bank across from Tunnel outflow transects. *Corbicula africana* is only found at Apac/Masindi Port and Atura-Mutunda transects with mean densities of 182 and 42, respectively. *Sphaerium spp.* is only found at Nora-Awoo, Kampala, and Chobe Lodge, with mean densities of 70, 14 and 34, respectively.

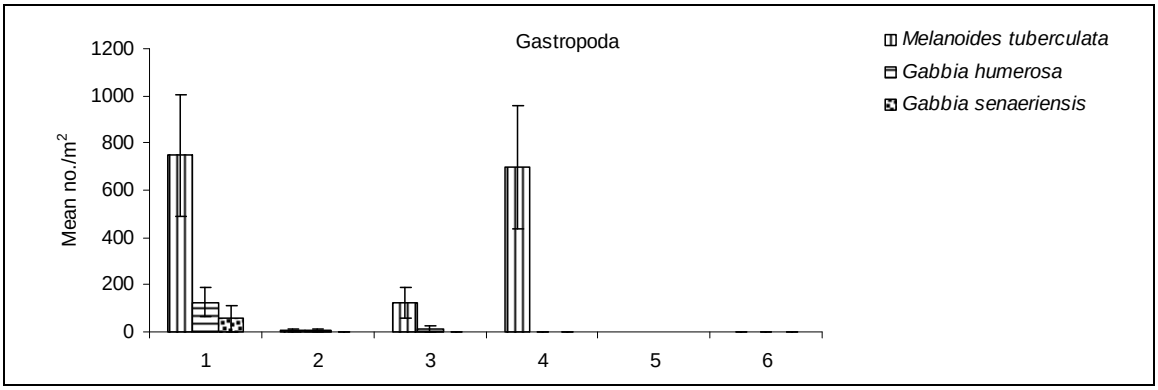

Figure 5.9: Composition and relative abundance (mean ± SE) of key species of Gastropoda within the study area of proposed Karuma hydro power project

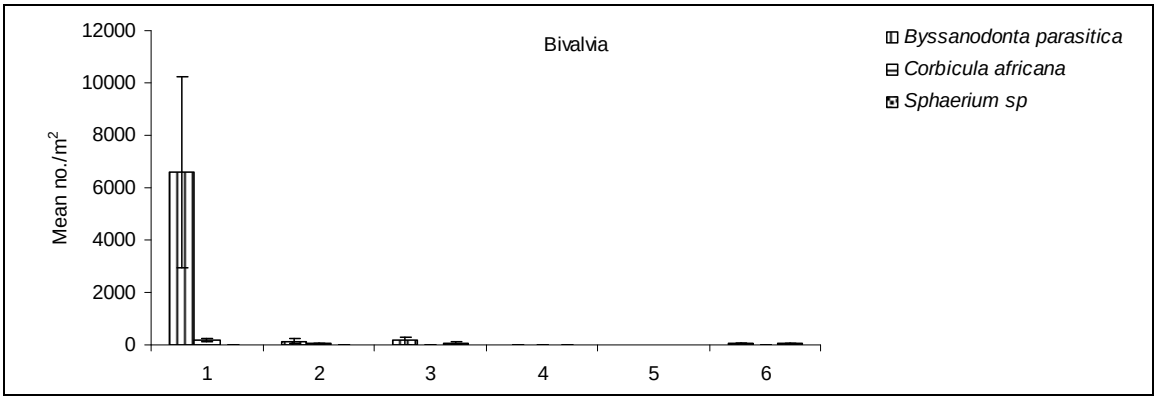

Figure 5.10: Composition and relative abundance (mean ± SE) of key species of Bivulvia within the study area of proposed Karuma hydro power project

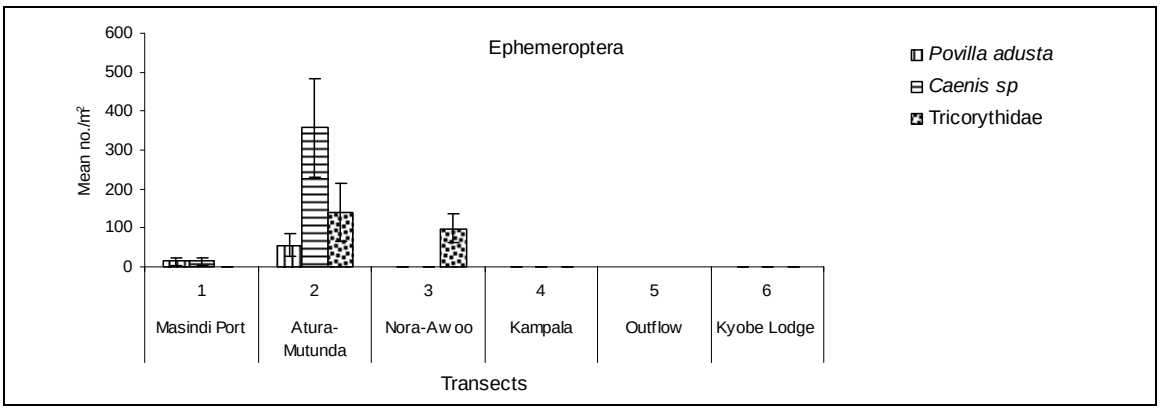

Figure 5.11: Composition and relative abundance (mean ± SE) of key species of Ephemeroptera within the study area of proposed Karuma hydro power project

Among Ephemeroptera **(Figure 5.11),** *Povilla adusta* and *Caenis spp.* are only found at Masindi port and Atura-Mutunda. Their densities ranged from 14 to 357; the highest density being that of the latter species at Atura-Mutunda. Tricorythidae only occurred at Atura-Mutunda and Nora-Awoo, with densities of 140 and 98, respectively.

The *Chirononomus* sp and *Ablabesmyia* sp (Chironomidae), are recovered only in the three upstream transects of Masindi port, Atura-Mutunda and Nora-Awoo, **(Figure 5.12).** The *Cryptochironomus spp* were only present at the tunnel outflow. Among these species, *Chirononomus spp*. were the most abundant, especially at Masindi port which had a density of 630. Next in abundance within transects, is the *Ablabesmyia* sp. They are also found to be more abundant (308) at Masindi port than in any other transects. The *Cryptochironomus* sp at the tunnel outflow site is about 126 in mean density.

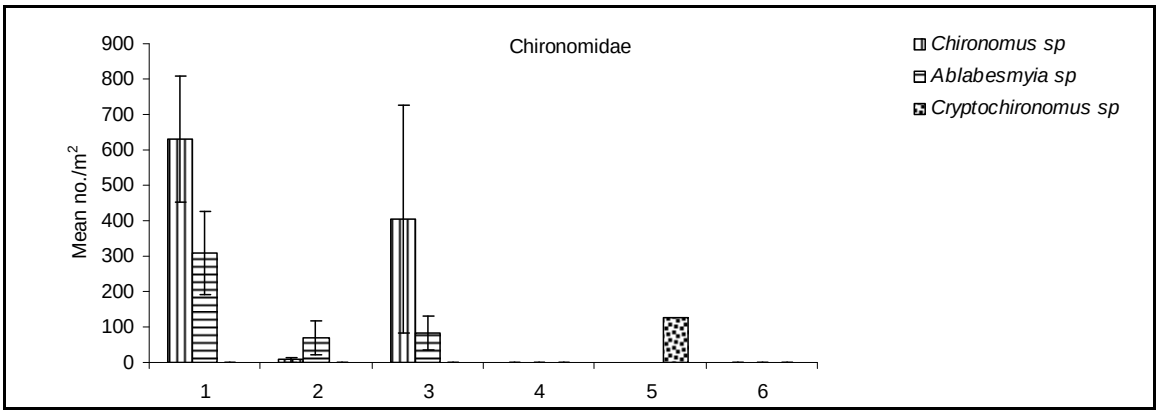

Figure 5.12: Composition and relative abundance (mean ± SE) of key species of Chironomidae within the study area of proposed Karuma hydro power project

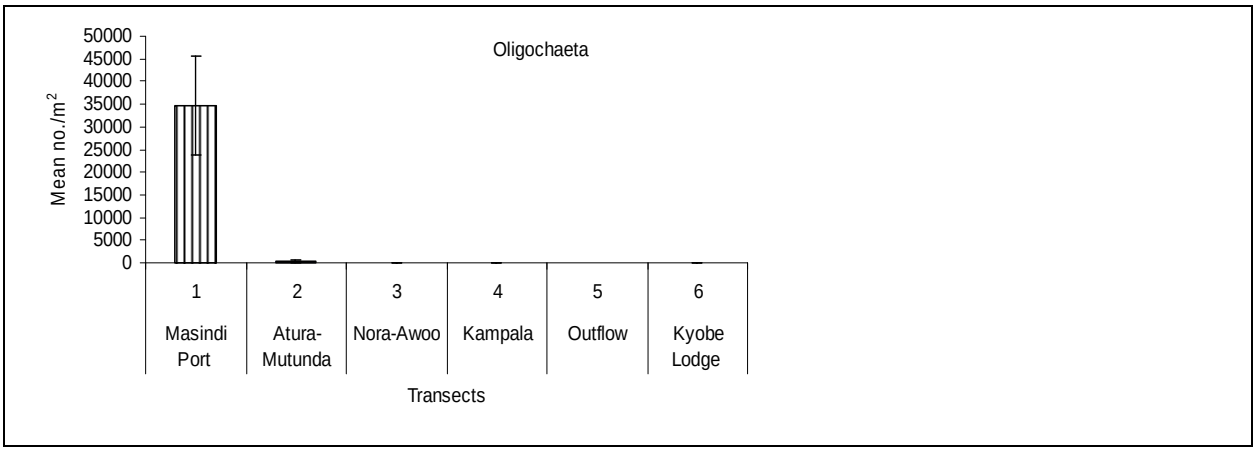

Figure 5.13: Composition and relative abundance (mean ± SE) of key species of Oligochaeta within the study area of proposed Karuma hydro power project

Oligochaeta is only found at the first three transects of Masindi port, Atura-Mutunda and Nora-Awoo (**Figure 5.13.**). Their mean densities are, 34566, 378 and 56, respectively. The mean density of Oligochaeta at Masindi port, is significantly higher than the rest of the transects sampled. This mean density is also the highest among densities of the key macro-invertebrate taxa found at all transects.

The composition, distribution and relative abundance of other macro-invertebrate taxa within the study area of the project are presented in **Table 5.12.**

Table 5.12: Composition, distribution and relative abundance (mean ± SE) of other macro-invertebrates at the transects within study area of the proposed Karuma HPP along River Nile

Transect	Transect No,	n	Gastropoda	Bivalvia	Ephemeroptera				Chironomidae		Hirudinae	Ceratopogonidae	Trichoptera		
			Lanistes carinalus	*Caelatura sp*	*Polycentropodidae*	*Heptagenia* sp	*Baetis* sp	*Ephemerella* sp	*Chironomini*	*Clinotanypus* sp			*Hydropsyche* sp	*Leptocella* sp	*Polycentopus* sp
Masindi Port	1	6	7±7	0	0	0	0	0	0	7±7	238±92	14±9	35±35	28±21	0
Atura-Mutunda	2	6	0	0	0	0	0	0	35±17	0	7±7	0	0	0	0
Nora-Awoo	3	3	0	14±14	14±14	0	0	0	0	0	0	0	0	0	0
Kampala	4	3	0	0	0	0	0	0	0	0	0	28±14	0	0	0
Outflow	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Kyobe Lodge	6	5	0	0	0	8	8	25±17	8±8	0	0	0	0	0	17±10

In summary, the upstream transects of Apac/Masindi Port, Atura/Mutunda and Nora/Awoo hosted more taxonomic diversity and numerical abundance of macro-benthos than the downstream transects in the study area of the KHP project. The difference is attributable to habitat types at the three upstream transects comprising favourable environmental conditions such as adequate dissolved oxygen, detritus and plant material, moderately flowing water and relatively soft bottom containing sand among others. The habitats of the down-stream transects are dominated by rocky bottom with shallow fast flowing water. On the whole, the composition and taxonomic richness of the macro-benthos in the study area of the KHP indicate a status close to unpolluted natural aquatic ecosystem.

5.3.5 Major habitat types, fishes and the fishery

For the purpose of fishery study including the aquatic habitats types for fishes the study area defined for the project was divided into three part i.e., submergence/ inundation zone; drawdown zones and re-fill zones. Habitat features at sites sampled and information on commonly caught fish species and the fishery in these zones are presented in **Table 5.13** as below.

Altogether 21 species are recorded in the study of area of which all the species recorded in the inundation zone while, only 18 are recorded in the Drawdown and Re-fill zone **(Table 5.13).** No species of conservation importance are recorded during the survey; however, interaction with local fisherman/ communities confirms that most of the spp. recorded except Haplochromine group, *Brycinus sadleri, Xenoclarias sp and Astatoreochomis spp* were of economic importance to the local community. Out of 21 species, only 4 migratory species were reported.

Table 5.13: Fish species reported within the study area of the proposed Karuma HPP

S. No.	Scientific names	Reported in Study Area of Karuma HPP.		IUCN Status	Stream/river migration	Economic importance
		Inundation zone	Drawdown & re-fill zones			
1	**Protopteridae**					
a.	*Protopterus aethiopicus*	Yes	Yes	NE	No	Yes
2	**Mormyridae**					
a.	*Mormyrus kannume*	Yes	Yes	LC	No	Yes
b.	*Mormyrus macrocephalus*	Yes	Yes	LC	No	Yes
c.	*Gnathonemus victoriae*	Yes	-	NE	No	Yes
d.	*Petrocephalus catostoma*	Yes	-	NE	No	Yes
3	**Alestidae**					
a.	*Brycinus jacksonii*	Yes	Yes	NE	No	Yes
b.	*Brycinus sadleri*	Yes	-	NE		No
4	**Cyprinidae**					
a.	*Barbus altianalis*	Yes	Yes	NE	No	Yes
b.	*Rastrineobola argentea*	Yes	Yes	NE	No	Yes
c.	*Labeo victorianus*	Yes	Yes*	NE	Yes	Yes
5	**Bagridae**					

S. No.	Scientific names	Reported in Study Area of Karuma HPP.		IUCN Status	Stream/river migration	Economic importance
a.	*Bagrus docmac*	Yes	Yes	NE	No	Yes
6	**Schilbeidae**					
a.	*Schilbe intermedius*	Yes	Yes	NE	Yes	Yes
7	**Clariidae**				No	
a.	*Clarias gariepinus*	Yes	Yes	NE	No	Yes
b.	*Xenoclarias sp*	Yes	Yes	-	No	No
8	**Mochokidae**					
a.	*Synodontis afrofischeri*	Yes	Yes*	NE	Yes	Yes
b.	*Synodontis victoriae*	Yes	Yes*	NE	Yes	Yes
9	***Latidae***					
a.	*Lates niloticus*	Yes	Yes	NE	No	Yes
10	**Cichlidae**					
a.	*Oreochromis niloticus*	Yes	Yes	NE	No	Yes
b.	*Tilapia zillii*	Yes	Yes	NE	No	Yes
c.	Haplochromine group	Yes	Yes	-	No	No
d.	*Astatoreochomis spp*	Yes	Yes	-	No	No
	Total recorded species	**21**	**18**		**4**	**17**

Legend: Lc = Least concern; '*' = Commonly reported only upstream of Karma Falls

Haplochromine group *Astatoreochomis spp*

5.4 BIOLOGICAL ENVIRONMENT OF SUBMERGENCE AREA

From the details of project layout, it is noticed that in the upstream area of submergence zone of proposed Karuma HPP, a few islands are present and the Nile river bank at few locations has typical micro habitat. Accordingly a detailed account of the biological features including physical description is presented below. **Figure 5.14** depicts the location map of the island.

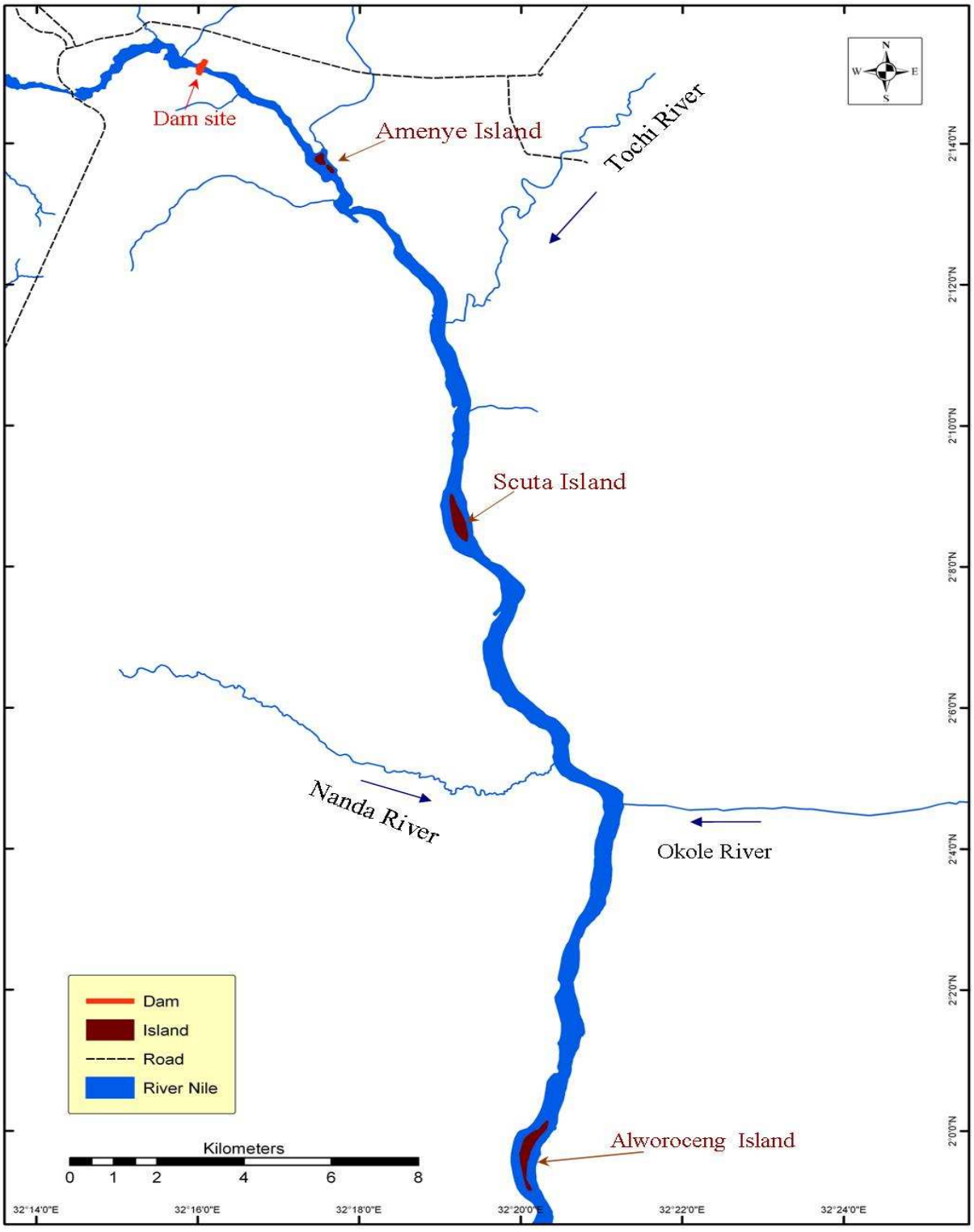

Figure 5.14: Location map of islands

5.4.1 Amenye Islands

Located at N 02°13'38.4", E 32°17'37.7" with average elevation of 1043m, the Amenye group of islands **(Figure 5.15)** is comprised by at least four permanent islands arranged along the river flow. The largest vegetation cover is of papyrus. Two of the islands have a rocky foundation with trees and shrubs in the middle, virtually surrounded by extensive papyrus mats especially to the downstream side. A little rocky outcrop with small trees and shrubs lay in the foreground of the main island.

These islands shows no major features to make it a critical habitat for the floral/faunal species, but it cannot be ruled out that these islands are used by some wildlife including a congregation of Cormorants, Vervet monkeys, Sitatunga. Interactions with locals have confirmed the occasional presence of Crocodiles in these islands.

These islands group is a popular fishing ground for *Barbus altianalis* (Ocang/Kicang), *Mormyrus kannume* (Menye/Kasurubana), *Bagrus docmac* (Semutundu), *Lates niloticus* (Mputa), *Oreochromis niloticus* (Apok), *Oreochromi variabilis (*Apok*), Protoperus aethiopicus* (Lut) and *Clarias gariepinus* (Twang).

Figure 5.15: Amenye Islands – Note large area covered by papyrus

5.4.2 Acuta Islands

Acuta islands comprises of two islands located near each other at N $02^0$08’46.8”, E $32^0$19’11.17” with elevation 1035 m and N $02^0$08’37.1”, E $32^0$19’09.6” with elevation 1028m respectively. The two islands, both aligned along the flow of the river, are dominated by papyrus. The island is predominantly covered by the luxurious succession of hippograss (*Vossia cuspidata*) and papyrus sp. **(Figure 5.16** and **Figure 5.17)**, almost entirely fringed by water hyacinth on one side of the island. An area of shallow water is covered with a water lily *Nymphaea sp* at the downstream tip of the larger island.

Birds such as the African Darter, Cormorants and Blue eyed Starlings are observed during the survey while, interaction with local revealed the presence of Hippos and Crocodiles in the island.

Commonly fishes reported in island are *C. gariepinus, O. niloticus P. aethiopicus, M. kannume, Mormyrus macrocephalus* (Masese), *B. docmac, O. niloticus* etc. During the rainy season *Intermedia mystus* and *Synodontis victoriae* species were reported.

Figure5.16: Papyrus sp. and *Vossia cuspidata* vegetation on Acuta Island

Figure 5.17: Water hyacinth vegetation on Acuta Island

5.4.3 Alworoceng islands

Close to Alworoceng fish landing beach, two islands, one small and the other fairly extensive located at N 01^{o} 58’ 39.15”, E 032^{o} 20’26.2” with elevation -1042m is present. The dominant vegetation on the island is papyrus fringed by hippograss at various levels of succession in water hyacinth mats. The two islands mark the most upstream location on River Nile likely to be impacted by the rising water level due to the proposed Karuma HPP.

The landing site in these islands is characterized by highly eroded sand banks with some rock outcrops. Such sandy bank are a suitable nesting ground for Crocodiles but, the landing site of these island is being used by the local community and they also access the river through this location for fishing, watering animals and washing of clothes **(Figure 5.18).** Therefore, continued human activity does not allow Crocodiles and other animals to use it. Also, no reports of wildlife presence are received from the locals for this area although bird species including Cormorants are observed.

This zone of River Nile is a vital fishing ground as viewed in **Figures 5.18**. The commercial fishes landed at the time of this survey were *O. niliticus, P. aethiopicus, M. macrocephalus,* B. docmac and C.

gariepinus. The other fish species from this zone of the river include *M. kannume. I. mystus, L. victorianus and S. victoriae*.

Figure 5.18: The shoreline at Alworoceng

5.4.4 Shoreline aquatic habitats of River Nile in the submergence area of Karuma HPP

The banks of River Nile slope gently to the water edge along at least two thirds of the zone. The portion close to the weir is mostly precipitous. The shoreline is dominated by two primary vegetation features. About one quarter of the zone starting from the weir is partly bare with scattered patches of papyrus mats. The rest is dominated by almost continuous cover of papyrus mats dotted with *Sudia saggittifolia* in some sections. Stationary mats of water hyacinth constitute the first secondary vegetation feature located mainly in the sediment deposition bends and shallower stretches of the river. The second, secondary vegetation feature is formed when native aquatic plants – mostly hippograss, *Cyperus spp*, ferns and *Sudia saggittifolia* – invade fringing water hyacinth. Plant succession then develops mostly into a hippograss dominated climax. These vegetation features are common along the entire zone of the river likely to be inundated. The three aquatic vegetation features extend up to Lake Kioga. They nurture and are host for a wide variety of invertebrates, baby and some fishes. They offer vital feeding ground for fish, large and small and for birds. The vegetation fringe filters storm water by retaining soil and debris and excess nutrients. The young of most fish species are associated with the shoreline habitats. The fishes mostly caught at the papyrus fringe include *P. aethiopicus, C. gariepinus, O. leucostictus, M. petrocephalus.* The fishes commonly caught at fringing water hyacinth and at the succession herbitats include *O. niloticus, M. kanume, P.aethiopicus, C.gariepinus, O, leucostictus, M. petrocephalus.*

5.4.5 Dominant features of intermittent tributaries in the submergence area

River Tochi and River Okole drain into River Nile within the zone likely to be inundated due to weir construction for the KHP. The major aquatic habitats of the two rivers are outlined below.

1. River Tochi

At the bridge across the Kamdini to Apac road over river Tochi at N02^{o}13'2.2", E032^{o}20'22.5"; with Elevation1028m lay in a relatively narrow river valley. The river had been reduced to isolated water pools and mud by prolonged severe dry weather. Aquatic vegetation was scattered tufts of Phagmites sp. River Tochi has been reported by native fishermen to carry large quantities of upriver migratory spawners notably *I. mystus, L. victorianus and S. victoriae.* Other fishes commonly caught include *M. kannume. C. gariepinus and P. aethiopicus.*

2. River Okole

River Okole drains into river Nile in a huge crescent formation. Shoreline vegetation along the crescent is mostly papyrus fringed in parts by stationary water hyacinth at various levels of invasion by hippograss, ferns, sedges, and *Sudia saggittifolia*. An extensive floodplain wetland lies behind the shoreline crescent covered in patchwork of papyrus and hippograss as the dominant flora. *Raphia farinifera* palms and other trees stand out prominently in the background wetland. The mouth of River Okole is located at N02^{o}04'26.7", E32^{o}21'19.0".Going further about five km upstream of Okale River mouth, the floodplain wetland is more open. Extensive stretches of papyrus and pathes of hippograss dominated the wetland vegetation. A similar picture is noted at the crossing on Apac – Loro road. The vast, low lying, highly impressive Okole River floodplain looked like a virgin wetland.

The common fauna in this area comprised of Hammerkops and Pied Kingfishers. The papyrus cover may provide a refuge for hippos although they are not present. In addition to these, crocodiles are also reported as frequent although none were seen on this visit. At one location near the bridge on Okore river at elevation of 1034 m, a destroyed nest of Crocodile **(Figure 5.19)** was recorded with broken egg shells as well as dried out carcasses of baby crocodiles.

The fish fauna expected in the wetland were *Clarias spp,* P. aethiopicus plus the anadromus spawners notably *L. victorianus and S. victoriae. Tilapia zillii, Oreocromis leucostictus and O.niloticus* possibly gained entry to the large open water pools during heavy rain seasons.

Figure 5.19: Destroyed Crocodile nest near the Okore Bridge at El. 1034

5.5 PROTECTED AREA

Area of wildlife conservation concern falling in the vicinity and downstream of proposed project are discussed below.

5.5.1 Karuma Wildlife Reserve

The proposed project area partially falls within the Karuma Wildlife Reserve (KWR) which is contiguous with the southern section of Murchison Falls National Park (MFNP). Nearly 238.6 ha of land from KWR is to be acquired from the Uganda Wildlife Authority for the purpose of proposed project. The location of the Tail Race System, the access adits and surge chambers will be located within Karuma Wildlife Reserve. However, the weir, the underground power house and Head Race Channel will be located - outside the Wildlife Reserve area.

Karuma Wildlife Reserve (KWR) was established in 1963 under the Game (Preservation and Control) Ordinance 1959, Legal Notice 366/1963 as an area adjacent to MFNP to serve as a 'buffer zone' to MFNP with controlled hunting permitted. It measures about 678 km^2 in area and forms a long strip along the southern and eastern flanks of the Nile River and includes a 15km length of the Victoria Nile as far as Karuma Falls. The vegetation of the area falls under Acacia-*Combretum savanna*. It is characterised by deciduous trees dominated by *Terminalia* and *Combretum*. The ground layer is dominated the grasses genera Hypparhenia and Brachiaria. From an ecological point of view, the riverine vegetation along the flanks of the Nile within the reserve area are species rich and support several faunal species.

5.5.2 Murchison Falls Protected Area

Murchison Falls National Park is Uganda's largest national park. It measures approximately 3,893 sq km. Together with the adjacent Bugungu Wildlife Reserve and the Karuma Wildlife Reserve, the park forms a Murchison Falls Protected Area which is spread nearly in area of 5,072 sq km **(Table 5.14).**

Table 5.14: Area of the different component PAs of MFPA

Wildlife Estate	**Sq. km**
Murchison Falls National Park	3,893
Bugungu Wildlife Reserve*	501
Karuma Wildlife Reserve	678
Total wildlife estate	**5,072**
***Budongo Forest**	
Budongo overlap with Bugungu	135
Budongo overlap with Karuma	99
Budongo outside UWA estate	591
Total area Budongo Forest	**825**

*The excision of the settled area at Biiso (27 sq. km) reduces the total area of Bugungu to 474 sq. km

MFPA comprises the Sudanian vegetation form in East Africa. Sudanian vegetation is characterised by a mosaic of woodlands often dominated by *Combretum* and *Acacia* species and extends from Senegal to Ethiopia. In addition, it is the only protected area where the tall grass savanna of the Albertine Rift is represented extensively. The Protected Area supports an exceptional diversity of plant communities, equaled in Uganda only by Queen Elizabeth National Park.

As wildlife populations decline across the African continent, MFPA is increasingly significant as a safe enclave for large mammals, particularly elephants, buffaloes, giraffes, kob, hartebeest and hippopotami. It is a habitat to the last viable breeding populations of Nile crocodile and Rothschild's giraffe and has Uganda's largest population of Jackson's hartebeest, and other important species including the soft-shelled turtle and the chimpanzee. Over 450 Bird species are recorded from the MFPA and PA also supports a host of migrants, both palaearctic and continental. Therefore, MFPA has been internationally accorded a high level of conservation priority by the World Conservation Union (IUCN).

Murchison Falls Protected Area where the Karuma Wildlife Reserve falls is endowed with unique and special features and attributes of local, national and international significance which includes landscapes that are of tourist and cultural value. The detail on tourism value of the MFPA is covered under Socio Economic Environment (Chapter -6).

5.5.3 Murchison Falls-Albert Delta Wetland System

Murchison Falls-Albert Delta Wetland System with total area 17293 ha was designated as Ramsar site no.1640 on 15th September 2006. The site stretches from the top of Murchison Falls (falls within MFPA), where the River Nile flows through a rock cleft some 6m wide, to the delta at its confluence with Lake Albert. The convergence between Lake Albert and the delta forms a shallow area that act as a staging and roosting area for migratory water bird species and is important for water birds, especially the Shoebill, Pelicans, Darters and various heron species. The delta is an important spawning and breeding ground for Lake Albert fisheries, containing indigenous fish species; the rest of the site is dominated by rolling savannas and tall grass with increasingly thick bush, woodlands and forest patches in the higher and wetter areas to the south and east. It forms a feeding and watering refuge for wildlife in the National Park during dry seasons.

The Ramsar site is located nearly 60.82 km (aerial distance) downstream from the proposed Dam Site of Karuma HPP while, along the river distance of Ramsar site is 75.28 km **(Figure 5.20).**

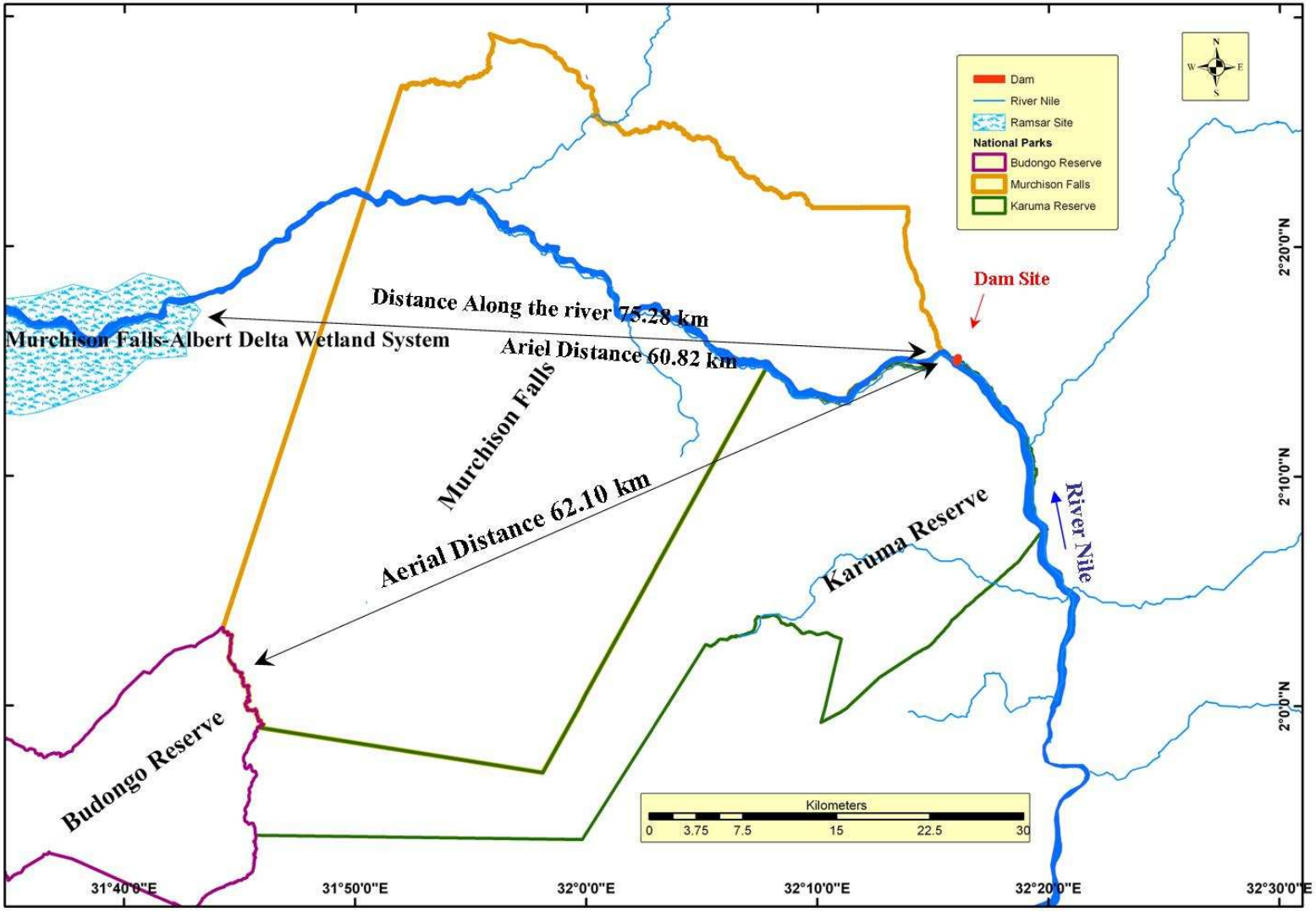

Figure 5.20: Distance of protected areas from Karuma HPP