Aquatic Ecology Monitoring: Water quality, algae, invertebrates, fish, fish catch, sanitation and disease vectors

Monitoring No. 26

Date: 4th – 9th June 2020

Monitoring carried out by:

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On behalf of :
Bujagali Energy Limited (BEL)

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1.0 BACKGROUND

The construction of river dams brings about alteration of original habitats, obstruction of water flow, changes in socio-economic productivity of flood-plains and human sub-systems and creation of new ecosystem conditions upstream and downstream which favour or stress particular biota and functioning (Agostinho et al., 2008; Baxter R.,1977; Scudder, 1980; Saha & Barrow, 1981). Adverse effects of dam construction for power generation have been observed on rivers in Africa e.g., River Zambezi (Arthur et al.,2017, Scudder, 1980 and 1973), Kafue in Zambia (William & Howard, 1977), Tana in Kenya (Hughes,1984 & 1983), Aswa high dam (White, 1988), and River Senegal (Watti, 1981). Impoundments on Danube, Dnieper and Dniester rivers in Europe (Tolmazin, 1979) resulted into reduced fishery yields in the Black Sea and the Sea of Azovo.

Pre-construction ecological monitoring baselines, April 2000 and April 2006 were conducted on the Upper Victoria Nile at one upstream site (Kalange-Makwanzi transect) and three downstream sites (Buyala-kikubamutwe, Kirindi-Matamu and Namasagali-Bunyamira) to establish the prevailing water quality determinants, biology and ecology of fishes and food webs, fish stock and fish catch including economic aspects of catch and sanitation/vector situation (bilharzias and river blindness). These baseline assessments were followed by eight ecological monitoring surveys: September 2007, April 2008, April 2009, October 2009, April 2010, September 2010, April 2011 and September 2011 during construction period.

This ecological monitoring survey No. 26 (4th -9th June 2020) on the Upper Victoria Nile is the sixteenth one to be undertaken after completion of construction of 250 MW Bujagali hydropower plant commissioned in September 2012. During the post construction period, ecological monitoring have been conducted at the original two sampling transects Kalange-Makwanzi and Buyala-Kikubamutwe and third one (mid-reservoir) established in the mid reach (30 m deep) of the new reservoir to track any developments/changes in the water environment and aquatic biota.

In the post-construction monitoring surveys, the assessments of algae, zooplankton and benthic macro-invertebrates which had been dropped since April 2008 were reverted to. The biannual (every April and September) ecosystem monitoring surveys of the Bujagali Hydropower Project impacts have regularly been undertaken since 2006. From climatic records, April represents the peak of the rainy season while September represents a dry-wet period. Due to the COVID-19 pandemic and associated lockdown, the planned regular ecological monitoring survey No. 26-April 2020 period was differed to June 2020. However, the period through May and June experienced more rain than normal and there was considerable water level rise and discharge in the project catchment area. Therefore, in discussions with Project management, the June 2020 sampling was considered to represent more or less similar hydrological conditions as would normally be experienced in April.

This report presents observations made on the above-mentioned ecological aspects of the Upper Victoria Nile and draws comparisons of the present results with those made in the previous monitoring at the three transects.

2.0 GENERAL METHODOLOGY AND DATA COLLECTION

2.1. Materials and Methods

This is the twenty sixth monitoring survey at Kalange-Makwanzi and Buyala-Kikubamutwe, upstream and downstream transects respectively where water quality, fish abundance, diversity and distribution, fish biology, fish catch, sanitation conditions, bilharzia and river blindness vectors have been assessed. A third transect, the mid-reservoir was established when a reservoir spanning beyond Kalange-Makwanzi was created by the Bujagali Dam for assessment of parameters as at the upstream and downstream transects, including assessment of algae, zooplankton and benthic macro-invertebrates.

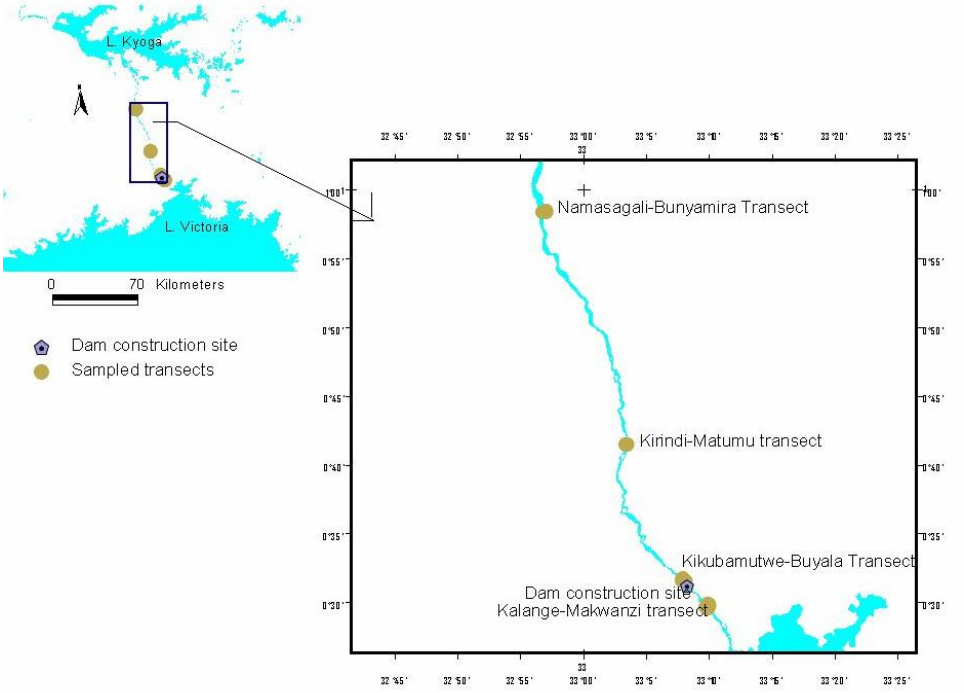

Figure 2.1a *A map showing the Upper Victoria Nile where the BHPP is located and river segments where baseline as well as monitoring samples were taken*

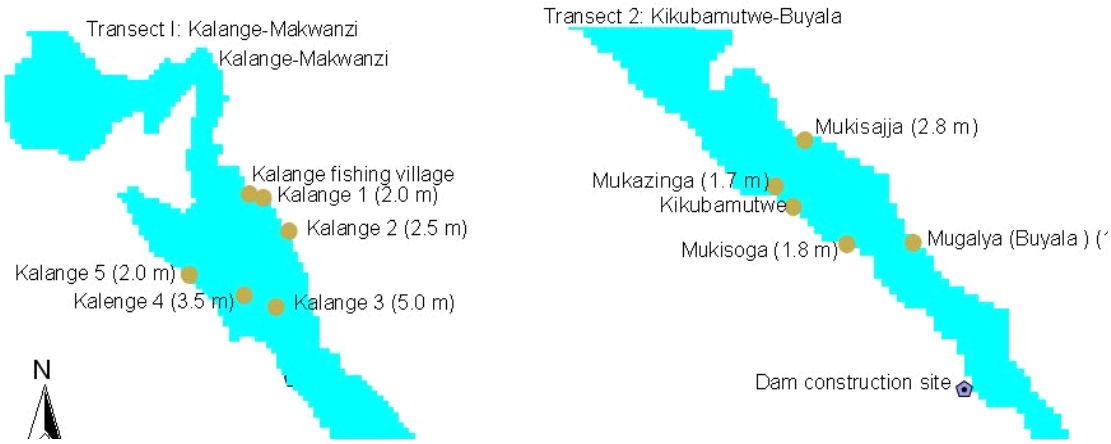

Figure 2.1b *Detailed maps of the two sampled transects: Transect 1 = Kalange-Makwanzi and Transect 2 = Buyala-Kikubamutwe and associated locations on the Upper Victoria Nile.*

During the monitoring episodes, sampling, analytical procedures and techniques used have been summarised as below:

Assessment of algae

At each sampling site, 20 ml of water for assessment of phytoplankton is drawn at 0.5m depth, fixed with Lugol´s solution (Utermöhl, 1958), and stored away from light (Wetzel and Likens, 2000). The sedimentation method of Utermöhl (1958) is used to count the phytoplankton under an inverted microscope (Leica DM IL). Taxonomic identification is made with the help of standard literature (John et al. 2002; Komarek and Anagnostidis, 1999). Species counts are made at a 400X magnification. For each sample, in the sedimentation chamber are counted and the average recorded. *Nitzschia* and *Planktolyngbya* are counted as filaments, and their total length and width measured using the micrometer scale inserted into the eyepiece (1 unit in the scale equal to 2.5 µm). Other species such as *Anabaena*, *Chroococcus*, *Merismopedia* and *Oocystis* are counted as single cells. Cell lengths and widths are determined for bio-volume calculation (Hillebrand et al. 1999; Wetzel and Likens 2000). The bio-volume is calculated by multiplying the mean cell volume with cell density.

Assessment of zooplankton

Sampling of zooplankton is done at designated field stations using conical plankton net of 0.25 metre mouth diameter and 60 µm mesh, towed vertically through the water column from just above the bottom sediments to the surface. Three tows taken at each sampling point are combined to make a composite sample, preserved in 4% sugar-formalin in a clean, labelled, plastic sample bottle. Species identification is done with the help of available published taxonomic keys (Boxshall & Braide, 1991; Korinek, 1999; Korovchinsky, 1992; Koste, 1978; Rutner-Kolisko, 1974) each species separately counted and recorded. Species numbers are noted and areal density estimates calculated for each station in conjunction with the diameter of the sample net and depth of sampling.

Assessment of benthic macro-invertebrates

Benthic macro-invertebrates are identified and classified using keys from Merrit & Cummins 1997, Pennak 1989 and Mandahl-Barth 1954, and enumerated as mean numbers per square meter.

Catch rates / biomass estimates

Catch rates i.e. catch per net per night as a measure of standing biomass, were estimated according to three gillnet size categories: small (1 to 2 ½ inches stretched mesh), medium (3 to 4 ½) and large (5 to 8 inches) to indicate relative abundance of fish species from the transects.

Estimation of fishing effort

Fishing effort and catchability coefficients are used to measure fishing mortality whose variations can be used to assess trends in stocks of natural fish populations (Arreguín-Sánchez,

1996). Since 2006, Fish Catchment assessment Surveys (CAS) and Frame surveys are conducted on the Upper Victoria Nile at the Bujagali Hydro-power dam construction Project area by assessing fishing effort and fish catch trends to estimate periodic fish yield due to fishing. Besides estimation of fishery yields, information that guides formulation of sustainable management advice alongside development projects such as dam construction is provided. Thus, monitoring of fish effort and catches can help to detect environmental concerns that might require mitigation measures to ameliorate negative impacts of river ecosystem functioning and loss of aquatic biota, particularly fish.

Malacological assessments of Schistosomiasis (Bilharzia) Vector snails

Snails are collected at the designated transects and placed on white plastic trays to pick out vector snails (*Bulinus sp.* and *Biomphalalia sp*) from the rest. The vector snail samples are placed in labelled containers and transferred to the NAFFIRI laboratory for further identification using the standard field key guide from the Danish Bilharziasis Laboratory-DBL (Kristensen, 1987). In the laboratory, the vector snails are placed in 5 ml of clean water in petri dishes and exposed to light for at least two hours to induce cercarial emergence. Every 20 min, the snails are checked for cercaria shedding using a dissecting microscope. Snails found shedding cercaria are transferred into individual tubes to completely identify the shedding snails. The number of snails shedding cercariae is recorded. The shed cercariae are identified as described by (Frandsen and Christensen, 1984).

3.0 RESULTS

3.1 Status of Water Quality

3.1.1. Physico-chemical parameters

Table 3.1.1 *Trends in mean values of physico-chemical parameters at the monitored sites of the Upper Victoria Nile*

Parameter	Site	Monitoring Dates																										
		Apr. 06	Sept. 07	Apr. 08	Apr. 09	Sept. 09	Apr. 10	Sept. 10	Apr. 11	Sept. 11	Apr. 12	Sept. 12	Apr. 13	Sept. 13	Apr. 14	Sept. 14	Apr. 15	Sept. 15	Apr. 16	Sept. 16	Apr. 17	Sept. 17	Apr. 18	Sep. 18	Apr. 19	Sep. 19	Jun. 20
Dissolved Oxygen (mg/L)	Kalanga-Makwanzi	4.2	7.2	5.6	4.5	5.9	6.7	5.4	4.8	6.3	5.9	6.3	7.7	5.5	6.13	4.9	5.88	5.75	6.18	5.83	5.2	5.2	4.9	4.4	5.2	7	7.9
	Mid-reservoir										5.2	6.4	7.02	5.3	6.27	5.5	6.06	6.78	6.3	5.67	4.9	5.4	5.3	4.8	5.1	6.5	8.7
	Buyala-kikubamutwe	6.3	7.7	7	7.2	7.2	9.3	7.8	7.1	7.5	7.5	5.9	7.5	6.1	6.96	6.1	5.69	6.29	7.03	5.9	5	5.3	4.1	5.1	5.8	6.9	8.6
	NEMA Std	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
pH	Kalanga-Makwanzi	7	7.3	8.2	6.7	7.6	6.8	7.1	7.4	7	8.5	7.1	7	7	7.05	7.5	7.12	7.46	6.87	8.03	8	8	8.1	7.9	7.4	7.9	8.5
	Mid-reservoir										8.2	7.5	7.4	7.4	6.65	7.5	7.25	8.86	6.95	7.93	8.1	7.6	8.4	8.2	7.3	7.5	8.5
	Buyala-kikubamutwe	7.4	7.4	7.7	6.8	7.4	7	7	7.3	7	8.2	7.4	7.17	6.9	8.59	7.7	7.24	8.01	7.23	7.97	8	7.4	8.2	7.7	7.4	7.5	8.6
	Upper NEMA Std	8	8	8. 0	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	Lower NEMA Std	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Temperature (°C)	Kalanga-Makwanzi	26.7	26.1	26.2	26.4	25.7	25.6	24.8	26.4	24.9	25.9	25.3	26.9	25.2	26.6	25	26.2	25.9	24.4	26.1	27.5	25	26	26.2	27.1	25.1	25.8
	Mid-reservoir										26.1	25.4	26.9	25.3	26.7	25	26.4	25.9	25.1	26.1	27.3	25	26	26	27	25.3	25.9
	Buyala-kikubamutwe	26.4	25.7	26.9	26.8	25	25.8	25.4	26.9	26.5	26.1	25.3	27.1	25.6	27.2	25	26.5	26.1	26	26.2	27.5	26	26	26.9	27.3	25.5	26.2
	Upper NEMA Std	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	Lower NEMA Std	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Conductivity (µS/cm)	Kalanga-Makwanzi	103	112	81.1	95.5	96.9	87.3	100	129	105	92.3	90	101	110	101	98	99.7	101	100	102	96.1	103	101	103.1	104.4	97.3	66.3
	Mid-reservoir										97.4	95	102	110	102	98	99.3	103	104	102	96.2	103	101	104.9	104.6	97.2	66.4
	Buyala-kikubamutwe	88.5	114	82.8	97.6	97.7	86.1	102		114	94.8	100	102	112	112	99	99.4	102	108	103	96.1	102	101	103.3	104.4	97.1	66.5
Secchi Visibility (m)	Kalanga-Makwanzi	1.9	1.6	1.9	2.2	2.2	2.3	2.2	2.2		1.5	2.1	1.72	2.03	1.71	2.4	1.26	1.83	0.83	1.93	1.6	2	1.6	1.8	2	2.2	1.6
	Mid-reservoir										1.7	2.1	1.62	2.16	1.59	2.3	1.35	1.85	0.72	1.97	1.6	2.3	2.1	2.1	0.6	2	1.9
	Buyala-kikubamutwe	1.7	1.8	1.8	2.3	1.9	1.9	2.1	2.5	1.3	1.4	1.5	1.63	1.77	1.56	2.1	1.25	1.9	1.14	2.05	1.4	1.6	2.1	1,7	0.6	1.6	1.3
Total Suspended Solids (mg/L)	Kalanga-Makwanzi	2	2.7	4.2	7.9	3.7	3.5	2.9	3	2.4	3.1	3.3	1.92	1.78	1.2	3.3	4.13	1.22	7.8	5.21	4	2.6	1.6	4	3.3	3.1	1.5
	Mid-reservoir										3.6	3.3	1.5	3.6	4.67	5.4	3.4	2.67	5.8	7.45	3	5.7	4.1	2,4	3.6	2.6	2.4
	Buyala-kikubamutwe	2	4.2	3.6	5.4	3.6	3.2	2.5	4.9	4.3	3.2	2.8	1.67	3.07	2.53	4.7	2.47	1.44	5.73	3.89	4	4.3	0.8	2.2	4.1	1.8	2.5
	NEMA Std	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Oil & Grease (mg/L)	Kalanga-Makwanzi	0.6	0.1	0	0.02	0.08	0.04	0.06	0.07	0	0.17	0.18	0.12	0.13	0.19	0.2	0.06	0.16	0.01	41.3	0.48	0.1	0.3	1.5	1.8	5.1	4.6
	Mid-reservoir										0.21	0.17	0.14	0.19	0.23	0.2	0.08	0.18	0.02	49.6	0.54	0.7	0.6	0.6	2.6	4.3	4.7
	Buyala-kikubamutwe	0.9	0.8	0	0.06	0.5	0.08	0.08	0.08	0.13	0.22	0.18	0.1	0.16	0.21	0.2	0.11	0.18	0.02	106	0.54	1.1	0.2	2.4	0.9	6.2	5
	NEMA Std	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

During this reporting period-June 2020, mean dissolved oxygen concentration along the stream flow from the Kalange-Makwanzi transect, through the mid-reservoir to Buyala-Kikubamutwe transect varied somewhat (Table 3.1.1) but remained well above the permissible National Environment Management Authority (NEMA) lower limit of 3 mg/L, required for survival of most aquatic organisms including fish. Highest dissolved oxygen concentration (8.7±0.1 mg/l) occurred at the mid-reservoir and lowest (7.9±0.2 mg/l) at Kalange-Makwanzi transect. This observation however, did not positively correlate with the algal biomass (Chlorophyll-a) since highest chlorophyll-a concentration (12.5±2.4 µg/l) was at Kalange-Makwanzi transect and lowest (7.9±1.2 µg/l) was at the mid-reservoir.

The mean pH at the three sites happened within a narrow range of 8.5±0.01 at Kalange-Makwanzi transect, 8.6±0.03 at Buyala-Kikubamutwe transect and 8.5±0.01 in the mid-reservoir. The pH was

slightly above the the permissible NEMA upper limit of 8, the deviation however was closer to the permissible range of 6 to 8.

At the three sites, average water temperatures steadily increased along the stream flow, registering 25.8±0.05 °C at Kalange-Makwanzi transect, 26.2±0.02 °C at Buyala-Kikubamutwe transect. This mean water temperature range was within the permissible NEMA range of 20 ºC to 35 ºC.

Average water electrical conductance during this monitoring period-June 2020 was the lowest ever recorded since 2006. It measured 66.3±0.02 µS/cm at Kalange-Makwanzi transect, 66.4±0.02 µS/cm at the mid-reservoir and 66.5±0.02 µS/cm at Buyala-Kikubamutwe transect. The low electrical conductance was probably due to dilution effects since this data was collected during when water levels rose above annual levels by 1.33 m in L. Victoria. Still, values recorded were within acceptable ranges of ≤ 120 µS/cm, typical of unpolluted sites of Lake Victoria.

During this period-June 2020, the highest water clarity of 1.93±0.02 m was noted at the mid-reservoir. This kind of transparency could have been attributed to settling of particulate matter due to a relatively longer residence time there compared to Kalange-Makwanzi reaches which registered 1.61±0.10 m, while Buyala-Kikubamutwe that receives the outflow from the reservoir had the lowest water clarity of 1.28±0.08 m. To note is that highest water clarity (at the mid-reservoir) was associated with lowest chlorophyll-a at that site.

The concentrations of TSS were far below the permissible NEMA upper limit of 100 mg/l, and increased along the stream flow, registering the lowest (1.47±0.13 mg/l) at Kalange-Makwanzi and the highest (2.53±0.71 mg/l) at Buyala-Kikubamutwe transect.

During this monitoring period, the concentration of oil and grease was much higher than during April 2019 at all sites. It increased along the stream flow i.e. 4.6±0.2 mg/l at Kalange-Makwanzi transect, 4.7±0.5 mg/l at the mid-reservoir and 5.0±0.2 mg/l at Buyala-Kikubamutwe transect but was within the NEMA permissible upper limit of 10 mg/l.

Vertical profiles for major water physico-chemical parameters at the mid-reservoir showed a relatively stable thermocline between 15 and 20 m at the deepest (30 m) part of the reservoir. Dissolved oxygen concentration at the thermocline was 8.6 mg/l, mean pH 8.5 and water conductance was 66.4 µS/cm.

3.1.2 Nutrient (nitrogen, phosphorus and silica) concentrations and algal biomass

During this monitoring-June 2020, the average surface waters (0 to 2 m) concentration of ammonium-nitrogen (NH_4-N) was lowest (9.86±1.55 µg/l) in the mid-reservoir and highest (19.24±6.60 µg/l) at Buyala-kikubamutwe transect (Table 3.1.2). At Kalange-Makwanzi transect 11.91±2.11 µg/l was registered (Table 3.1.2). The observed spatial variations of ammonia concentrations were far below the NEMA permissible upper limit of 10,000 μg/l.

The average concentration of nitrite-nitrogen (NO_2-N) decreased along the stream flow, both Kalange-Makwanzi and the mid-reservoir transects registering 2.25±0.10 µg/l while a mean of 1.75±0.00 µg/l was recorded at Buyala-kikubamutwe transect. The low levels of both NH_4-N and NO_2-N indicate a healthy system since conversion of the former into the latter, a process known as nitrification or oxidation of ammonia was effectively done. As noted in previous assessments, the average concentrations of NO_2-N were far below the NEMA permissible upper limit of 20,000 μg/l.

The highest (80.16±7.96 µg/l) average nitrate-nitrogen (NO_3-N) concentration was recorded at the mid-reservoir and the lowest mean of 61.93±17.29 µg/l was registered at Kalange-Makwanzi. The observed variations in the concentration of NO_3-N remained lower than the permissible NEMA upper limit of 20,000 μg/L.

Unlike average nitrate-nitrogen (NO_3-N) concentrations, average concentration of Total Nitrogen (TN) increased along the stream flow. At Kalange-Makwanzi transect the lowest mean TN of 379.23±32.36 µg/l was recorded and the highest mean of 516.77±48.54 µg/l was registered at Buyala-kikubamutwe transect. This observed TN concentration range remained below the NEMA permissible upper limit of 10,000 μg/L.

During this monitoring period, the average concentration of soluble reactive phosphorus (PO_4-P) decreased along the stream flow, varying within a narrow range from 36.58±0.93 µg/l at Kalange-Makwanzi transect to 33.89±0.54 µg/l at Buyala-kikubamutwe transect. The average concentrations of PO_4-P recorded were below the permissible NEMA upper limit of 5,000 µg/l.

Total Phosphorus (TP) steadily increased along the stream flow, the kowest concentration of 64.94±1.23 μg/l being registered ar Kalange-Makwanzi transect and the highest of 79.12±7.40 μg/l. at Buyala-kikubamutwe transect. The recorded TP concentrations were remained below the NEMA permissible upper limit of 10,000 μg/l.

Like TP, the concentration of Soluble Reactive Silica (SRSi) increased along the stream flow; with Kalange-Makwanzi transect registering the lowest mean concentration of 49.97±2.41 µg/l and the highest of 54.27±2.89 µg/l at Buyala-kikubamutwe.

The highest algal biomass of 12.51±2.41 µg/l was recorded at Kalange-Makwanzi transect and lowest of 7.88±1.23 µg/l at the mid-reservoir.

Table 3.1.2 *Trends in mean concentrations of nutrients and algal biomass (chlorophyll-a) in surface waters (0-2m) at monitored sites*

Chemical parameter	Site	Monitoring Dates																									
		Apr. 06	Sept. 07	Apr. 08	Apr. 09	Sept. 09	Apr. 10	Sept. 10	Apr. 11	Sept. 11	Apr. 12	Sept. 12	Apr. 13	Sept. 13	Apr. 14	Sept. 14	Apr. 15	Sept. 15	Apr. 16	Sept. 16	Apr. 17	Sept. 17	Apr. 18	Sep. 18	Apr. 19	Sep. 19	Jun. 20
Ammonium Nitrogen, NH_4-N (μg/L)	Kalanga-Makwanzi	42.3	20.2	79.4	88	186	137.2	75.3	58	1.5	8.7	11.4	7.59	86.92	88.86	72.68	11.95	8.17	7.78	3.81	30.6	23.3	7.6	19.6	51.2	77.9	11.9
	Mid-reservoir										10.5	4.9	7.4	81.74	45.17	36.11	13.44	0.51	18.4	4.83	30	24.6	9.2	8.9	42.5	66.7	9.9
	Buyala-kikubamutwe	29.5	24	97.9	79.4	137	111.8	68.2	45.8	2	10.6	3.2	6.11	87.56	73.32	93.76	14.01	11.63	9.76	5.46	23.1	53.7	8.5	4.5	37.6	43.2	19.2
	NEMA Std	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Nitrite-Nitrogen, NO_2-N (μg/L)	Kalanga-Makwanzi	8.7	9.5	4	3.1	3	4.2	7.3	4.7	2.9	5.8	2	10.6	4.53	13.35	4.94	13.55	3.01	4.41	3.81	10	5.4	6.1	4.8	30.3	0.7	2.3
	Mid-reservoir										6.3	2.8	10.6	5.36	12.75	7.34	14.37	1.37	6.64	4.83	11.5	6.6	6.1	3.6	22.4	0.9	2.3
	Buyala-kikubamutwe	8.7	2.8	6.1	2.6	4	5.3	4.1	4.3	4	6.6	3.8	10.46	5.08	13.35	17.52	14.98	5.83	5.42	5.46	10.6	6.6	6.4	6	30	0.9	1.8
	NEMA Std	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Nitrate-Nitrogen, NO_3-N (μg/L)	Kalanga-Makwanzi	12.5	36	146.3	26.4	114	120.8	47.4	36.1	46.9	55.7	20.2	44.79	79.12	74.27	63.26	46.9	9.38	196.07	84.42	46.7	32.8	43.8	56	110.2	48.2	61.9
	Mid-reservoir										50.4	18.4	54.72	91.09	140.93	81.06	55.05	15.01	214.3	48.71	56.2	21.4	55.3	40.8	156.9	62.7	80.2
	Buyala-kikubamutwe	12.6	94	182.5	35	76	148.6	49.2	54.7	61.2	51.5	18.6	55.38	94.65	477.8	281.05	78.55	23	197.51	49.39	47.9	20.1	25.8	31	164.7	69	73
	NEMA Std	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Total-Nitrogen, TN (μg/L)	Kalanga-Makwanzi	1174	2093.5	1925	306.7	2,362	1046.6	666.7	2196	1471.1	1,817.60	2,382.70	1,853.70	2,044.84	1,042.26	1,557.62	3,167.76	3,651.33	782.94	1,132.10	214.8	2,514	382.6	382.6	698.2	342.2	342.2
	Mid-reservoir										1,606.90	4,337.30	1,335.20	394.05	1,070.04	1,266.39	3,343.18	2912.06	806.75	1,663.87	548.1	1,422	349.4	349.4	690	262.7	262.7
	Buyala-kikubamutwe	1192.5	2138.8	2492.3	216.7	2,421	2991.8	597.3	2104	2450.3	1,464.70	2,485.10	1,594.47	457.54	1,030.36	4,037.26	5,322.92	3,417.02	814.68	1,822.62	881.4	2,234	349.4	349.4	169.7	183.2	183.2
	NEMA Std	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Total Phosphorus, TP (μg/L)	Kalanga-Makwanzi	108.6	54.5	58.5	60.3	36	186.3	84.6	30.3	32.2	65.2	106.4	48.3	50.3	46.06	29.09	50.77	113.15	63.03	79.52	50.5	117	62.3	193.8	42.6	63.5	64.9
	Mid-reservoir										41.8	107.6	33.9	56.97	52.73	31.52	59.08	156.16	58.79	95.76	86	108.2	63.1	370.4	35.5	46.5	68.5
	Buyala-kikubamutwe	100.8	48.7	76.3	47.3	45	271.9	88.8	64.1	35.6	107.7	112	41.1	48.48	32.73	112.73	52.68	167'52	57.58	124.85	61.9	124.9	59.6	87.9	40	39.4	79.1
	NEMA Std	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Soluble Reactive Phosphorus, SRP (μg/L)	Kalanga-Makwanzi	19	24.2	11.7	6.9	27	15.7	21.1	31.6	9.8	6.4	20	12.7	11.17	12.18	14	10.45	9.64	16.92	18.69	17.8	61.5	33	16	7.7	27.9	36.6
	Mid-reservoir										7	17.6	12.7	10.61	18.85	15.82	11.38	11.39	21.08	25.36	19.6	46.1	31.7	18.3	10.3	22.3	35
	Buyala-kikubamutwe	19.2	27.7	18.9	16.6	32	24.8	25.6	20	11.7	6.6	21.4	12.7	15.61	14	42	9.53	16.05	17.85	20.51	21.9	47.5	33.9	18.7	10.6	26.5	33.9
	NEMA Std	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Soluble Reactive Silica, SRSi (μg/L)	Kalanga-Makwanzi	319.9	539.7	238.4	501.2	859	521.1	265.9	149.6	23.8	176.8	146.9	309.4	406.14	408.24	783.08	410.31	629.96	1,236.78	336.16	102.6	162.3	379.8	158.8	89.4	60.5	50
	Mid-reservoir										268.1	268.5	256.8	458.77	396.38	803.5	379.63	588.96	1,573.23	321.73	103.2	104.3	285.1	152.5	91.6	58.9	51.4
	Buyala-kikubamutwe	309.4	530.7	282.8	496.7	847	521.7	201.5	68.8	43.8	248.1	244.6	238.8	432.46	369.37	239.73	401.65	645.77	1,268.92	288.88	110.9	96.1	165.2	266.2	89.8	59.2	54.3
Chlorophyll-a (μg/L)	Kalanga-Makwanzi										5.1	6.3	10.2	12.51	10.01	4.32	7.26	3.55	1.48	5.56	3.7	14.7	10.3	29	15.8	4.9	2.3
	Mid-reservoir										5.6	10.1	5.6	13.44	4.26	5.1	8.03	1.44	1.76	3.24	3.9	12.3	6.6	10.2	47.5	3.9	3.9
	Buyala-kikubamutwe										6	9.7	6	9.27	5.37	13.9	5.87	2.67	0.93	3.71	2.8	11.7	8.3	8.3	16.4	3.1	1.8

3.1.3 Algae and aquatic macrophytes/weeds

Table 3.1.3 *The number of species and occurrence of major algal types at the three sites over the monitoring periods*

Major algal group	English name	Transects/sites	Monitoring dates														
			Sept. 12	Apr. 13	Sept. 13	Apr. 14	Sept. 14	Apr. 15	Sept. 15	Apr. 16	Sept. 16	Apr. 17	Sept. 17	Apr. 18	Sep. 18	Apr. 19	Sep. 19	Jun. 20
Cyanophtes	Blue-greens	Kalange-Makwanzi	9	15	12	14	12	14	11	6	25	16	14	16	15	14	18	35
		Mid-Reservoir	20	14	14	16	9	19	11	11	28	17	11	18	14	20	17	30
		Buyala-Kikubamutwe	19	18	12	15	14	20	14	11	27	16	16	15	13	15	11	32
Chlorophytes	Greens	Kalange-Makwanzi	4	8	6	4	6	6	9	4	23	7	7	14	5	7	6	30
		Mid-Reservoir	8	7	6	5	7	11	12	5	17	12	12	10	6	5	14	32
		Buyala-Kikubamutwe	7	7	7	5	3	5	8	7	14	7	7	9	9	8	10	30
Bacillariophytes	Diatoms	Kalange-Makwanzi	4	4	5	2	6	6	2	5	10	4	4	8	5	3	7	16
		Mid-Reservoir	3	2	3	4	2	6	3	2	9	4	4	5	4	4	5	14
		Buyala-Kikubamutwe	2	5	3	4	2	5	3	5	12	5	5	6	5	2	7	13
Euglenophytes	Uni-cellular flagellated algae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
		Mid-Reservoir	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Dinoflagellates		Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2
		Mid-Reservoir	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		Buyala-Kikubamutwe	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
Cryptophytes		Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1
		Mid-Reservoir	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	3
Total number of species		Kalange-Makwanzi	**17**	**27**	**23**	**20**	**24**	**26**	**22**	**15**	**58**	**28**	**28**	**38**	**26**	**26**	**32**	**86**
		Mid-Reservoir	**25**	**30**	**23**	**25**	**18**	**36**	**18**	**27**	**55**	**33**	**33**	**34**	**25**	**30**	**36**	**78**
		Buyala-Kikubamutwe	**30**	**30**	**22**	**24**	**19**	**30**	**25**	**25**	**54**	**28**	**38**	**31**	**28**	**26**	**30**	**80**

During the current monitoring-June 2020, the algae community comprised of 53 species belonging to six taxonomic groups; blue-green algae, diatoms, green algae, dinoflagellates, euglenophytes and cryptophytes (Table 3.1.3). Comparatively, during April and September 2019 respectively, 51 and 38 species were recorded. The highest occurrence of species occurred at Kalange-Mwakwanzi, followed by Buyala-Kikubamutwe and least at mid-reservoir. The community was mainly dominated by blue-green, green algae and diatoms (Table 3.1.3). The other species contributed < 5 % to the total occurrence per zone.

Table 3.1.4 *Species composition of algal types at the three sites during June 2020 monitoring period (+ denotes presence).*

Major algal group	Algal species	Kalange-Makwanzi (upstream)	Mid-Reservoir	Buyala-Kikubamutwe (Downstream)
Blue-green algae (Cynophyta)	*Anabaena circinalis*	+	+	+
	Anabaena flos-aquae	+		
	Anabaena species	+		+
	Anabaenopsis tanganyikae	+	+	+
	Ankistrodesmus falcatus	+		
	Aphanocapasa species	+		
	Aphanocapsa delicatissima	+	+	+
	Aphanocapsa elachista	+	+	+
	Aphanocapsa holistica	+	+	+
	Aphanocapsa incerta	+	+	+
	Aphanocapsa nubilium	+	+	+
	Aphanocapsa species	+	+	+
	Chroococcus aphanocapsiodes			+
	Chroococcus dispersus	+	+	+
	Chroococcus distans		+	
	Chroococcus limnetica	+	+	+
	Chroococcus minutus	+	+	+
	Chroococcus species	+		+
	Chroococcus turgidus	+	+	+
	Coelastrum microporum	+		
	Coelomoron pusila	+	+	+
	Coelomoron tropicale	+	+	+
	Coelosphaerium kuetzingianum	+	+	+
	Coelosphaerium nagelianum		+	
	Cylindrospermopsis africana	+	+	
	Cylindrospermosis raciborskii	+	+	+
	Dolichospermum circinale	+	+	+
	Merismopedia elagans	+	+	+
	merismopedia glauca		+	+
	Merismopedia tenuissima	+	+	+
	Microcystis aeruginosa	+	+	+
	Microcystis flos-aquae	+	+	+
	Microcystis wesenbergii	+		+
	Planktolyngbya circumcreta	+	+	+
	Planktolyngbya contorta	+	+	+
	Planktolyngbya limnetica	+	+	+
	Planktolyngbya tallingii	+	+	+
	Planktolyngbya undulata			+
	Psuedonabaena limnetica	+	+	+
	Psuedonabaena species	+		
Number of species		**35**	**30**	**32**

Major algal group	Algal species	Kalange-Makwanzi (upstream)	Mid-Reservoir	Buyala-Kikubamutwe (Downstream)
Diatoms (Baciliaphyta)	*Aulacoseira distans*		+	
	Aulacoseira granulata	+	+	+
	Centric diatom	+	+	+
	Centric diatom	+	+	+
	Cocconeis placentula			+
	Cyclostephanodiscus sp			+
	Cyclotella sp	+	+	+
	Cymbella sp	+		
	Epithemia argus	+		
	Navicula cuspidata			+
	Navicula gastrum	+	+	+
	Navicula radiosa	+	+	+
	Nitzschia acicularis	+	+	+
	Nitzschia asterionelloides			+
	Nitzschia fonticola	+	+	+
	Nitzschia nyassensis	+		
	Nitzschia sp			+
	Pediastrum tetras		+	
	Rhopalodia sp			+
	Stephanodiscus astraea	+	+	+
	Synedra cunningtonii	+	+	+
	Synedra sp		+	
	Nitzschia bacata		+	
Number of species		16	14	13

Green algae (Chlorophyta)	*Actinastrum hantzschii*			+
	Actinastrum species	+	+	
	Ankistrodesmus falcatus	+	+	+
	Ankistrodesmus fusformis		+	
	Ankistrodesmus stegera	+		+
	Botryococcus braunii		+	
	Chlorella vulgaris		+	+
	Chodatella subsalsa	+	+	+
	Closterium kuetzingii	+		
	Closterium species	+	+	+
	Coelastrum costatum	+		
	Coelastrum microporum	+		+
	Coelastrum proboscideum		+	
	Coelastrum species	+	+	+
	Cosmarium habitat			+
	Cosmarium species	+	+	+
	Crucigenia apiculata		+	
	Crucigenia crucifera	+	+	+
	Crucigenia fenestrata	+	+	+
	Crucigenia tetrapoda			+
	Dictyosphaerium species			+
	Didymocystis tuberculata	+		
	Kirchnereilla contorta	+	+	+
	Kirchneriella lunaris	+		+
	kirchneriella obesa	+	+	+
	kirchneriella species	+		+
	Monoraphidium contortum	+	+	+
	Monoraphidium minutum	+		
	Monoraphidium species	+		+
	Oocystis borgei		+	
	Oocystis gigas	+	+	+
	Oocystis species	+		
	Pediastrum boryanum		+	
	Pediastrum duplex		+	+
	Pediastrum simplex	+	+	+
	Pediastrum tetras		+	
	Scenedesmus acuminatus	+	+	+
	scenedesmus apiculatus		+	+
	Scenedesmus armatus	+	+	
	Scenedesmus perfolatus	+	+	+
	Scenedesmus quadricauda		+	+
	scenedesmus species	+	+	
	Selenestrum gracile		+	+
	Selenestrum species	+		+
	Staurastrum gracile	+	+	+
	Staurastrum longiradiatum		+	
	Tetraedron trigonum	+	+	
Number of species		30	32	30

Euglenopyta	*Phacus species*	+		+
	Trachelomonas			+
Number of species		1	0	2
Dinoflagellates	*Ceratium hirudina*	+		+
	Glenodinium species	+		
Number of species		2	0	1
Cryptophyta	*Cryptomonas erosa*			+
	Cryptomonas marssonii	+	+	+
Number of species		1	1	2
Total numbers of species		86	78	80

In terms of bio-volume, algal community was dominated by diatoms, mainly *Nitzschia acicularis* at Kalange-Mwakwanzi and Buyala-Kikubamutwe transects while blue-green algae, mostly made up of *Planktolyngbya limnetica* were dominant at the mid-reservoir transect. Usually, green algae in lakes are represented by a high number of species, but often with smaller bio-volume compared to other algal types. Species of green algae which included; *Dictyosphaerium, Kirchneriella, Pediastrum and Selenastrum* occurred at Buyala-Kikubamutwe transect but were neither found at Kalange-Mwakwanzi nor at the mid-reservoir (Table 3.1.3). The rare groups such as Cryptophyta made a noticeable contribution during this monitoring compared to the previous monitoring periods. The mid-reservoir registered the highest bio-volume, attributed to mainly blue-green algae (Figure 3.1.2).

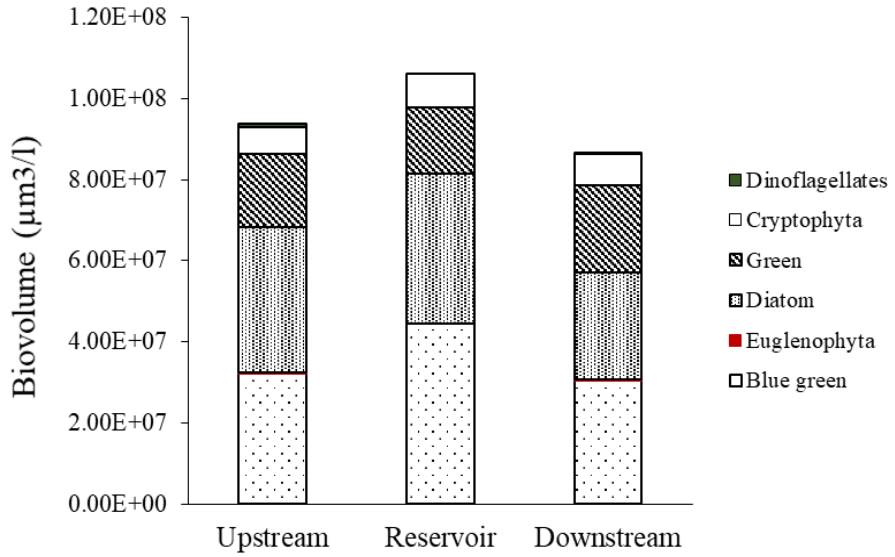

Figure 3.1.2 *Algal biovolume ($\mu m^3 L^{-1}$) by taxa at the three transects (Upstream, mid-Reservoir & Downstream)*

During the current monitoring-June 2020, relative abundance of blue-green algae was 51.3% compared to 36.2%, 19.8% and 53.2% recorded during September-2019, April-2019 and September-2018 respectively (Figure 3.2A). This was mainly attributed to the increment in bio-volume by species such as *Anabaenopsis tanganyikae* (75%), *Planktolyngbya limnetica* (74.1%), *Aphanocapsa holistica* (26.4%) and *Coelomoron tropicale* (33.3%). The overall abundance

during June-2020 was lower than during the previous monitoring periods (Figure 3.1.2). Although, diatoms were composed of *Stephanodiscus astraea* (75%), *Nitzschia acicularis* (46%), *Aulacoseira granulata* (50%), centric diatoms (65%);. their relative abundance reduced to 13.6% during the current monitoring. The relative abundance of *Synedra cunningtonii* increased by 12.6% while that of green algae, dinoflagellates, euglenophytes reduced by 0.9%, 0.4%, 0.2% respectively. This monitoring was done during a period of increased water levels and flooding which implied a higher flushing rate than before, reducing on the growth environment for some algae. This could affect the algae abundance as a source of food for invertebrates and fish.

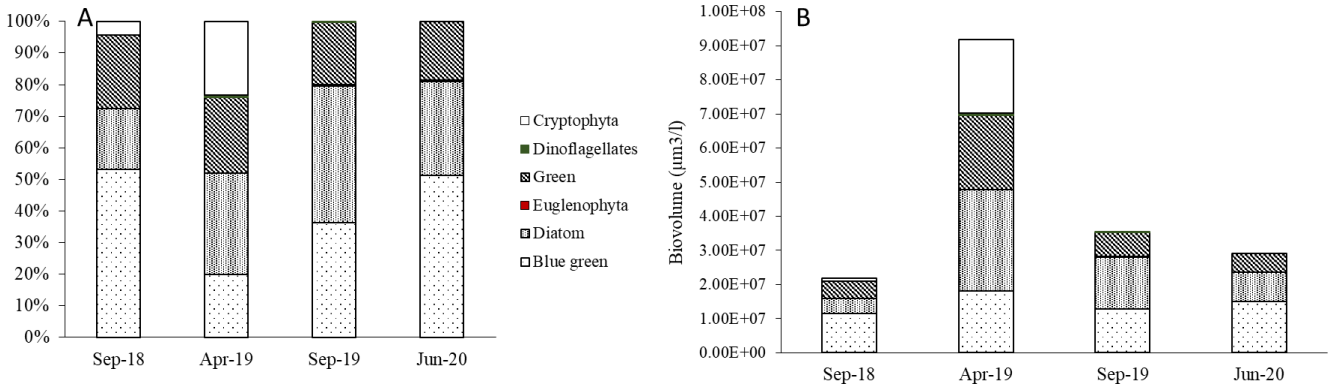

Figure 3.1.3 *Relative abundance of algal community composition during September 2018, April 2019, September 2019 and June 2020.*

Aquatic macrophytes

The major aquatic macrophytes were water hyacinth (*Eichhornia crassipes*), hippo grass (*Vossia cuspidata*) and water primrose (*Ludwigia* sp.). During this monitoring-June 2020, cover abundance of aquatic macrophytes reduced at most sites compared to what was recorded during September 2018 and had not established along the banks of the reservoir and the river. The non establishment of aquatic macrophytes was exercerbated by the high water levels as a result of enhanced water release from Nalubaale and Kiira Dams.

Water hyacinth dominated Kalange-Makwanzi transect shores during this monitoring period and decreased from 2.5 ha during September 2019 to 1.5 ha during this period. Its percentage coverage was highest at Kasenyanku (51.4% or 0.8 ha), followed by Naava (20.3% or 0.3 ha), Kalange (108% or 0.2 ha), Muluwanvu (9.1% or 0.1 ha) and Hudson (5.1% or 0.1 ha). At the rest of the sites, water hyacinth was rare, with cover abundance of <1%. Other aquatic macrophytes included *Vossia cuspidata* whose cover abundance increased from 1.3 ha in September 2019 to 2.2 ha during this monitoring period. Other macrophytes reduced in their cover abundance and exhibited rare occurrence.

The mid-reservoir zone was devoid of common aquatic macrophytes, although water hyacinth dominated the shores and decreased its coverage from 2.5 ha during September 2019 to < 1 ha during this monitoring period, with much of it (82.9% or 0.8 ha) and less than 8% or <0.1 ha at both Bujagali, Kyabirwa and Kyekidde. Cover abundance of *V. cuspidata* increased from 1.8 ha during September 2019 to 3.8 ha during the current monitoring, while the rest of the

macrophytes reduced to insignificant levels during this period. Thus to date, aquatic macrophytes had not established along the mid-reservoir banks. Significant increase in water levels as a result of enhanced release from Nalubaale and Kiira dams has contributed to the decolonization of the banks by macrophytes due to flooding.

At Buyala-Kikubamutwe transect, much of the river bank (> 60%) had been cultivated down to the highest water level, and trees such as eucalyptus had been grown thus leaving little room for establishment of aquatic macrophytes. Due to remarkable increase in water level that had resulted in inundation of low lying adjacent areas to the river banks, aquatic macrophytes at this transect were not encountered. Instead, there were terrestrial macrophytes submerged due to flooding.

3.2 Zooplankton (Water column micro-invertebrates)

Species diversity and distribution trends

Twenty species were recorded at Kalange-Makwanzi, 19 species at the mid-reservoir and 19 species at Buyala-Kikubamutwe (Table 3.2.1). Rotifers were the most species rich group of zooplankton accounting for 45%, 47.4% and 36.8% of the total species at Kalange-Makwanzi, mid-reservoir and Buyala-Kikubamutwe respectively. The contribution of rotifers to the total species richness in June 2020 monitoring was higher than previously recorded in September 2019 at Kalange-Makwanzi, but lower than recorded at the mid-reservoir and Buyala-Kikubamutwe. Percentage contribution to total species richness was >52% during April 2019. This is a lower percentage contribution of rotifers to the total zooplankton species richness recorded during June 2020 monitoring. Like recorded in previous monitoring, copepods were the second species rich group comprising of seven species at Kalange-Makwanzi, six species at mid-reservoir and seven species at Buyala-Kikubamutwe site. Cladocerans contributed <26.3% of the species at each site. In the current survey, the number of species at each site was within the range previously observed at the sites (Table 3.2.1).

Table 3.2.1. *Species richness of taxonomic groups of zooplankton at the three study sites from September 2016 to June 2020.*

Monitoring sites		Kalange-Makwanzi (Upstream transect)								Mid-reservoir								Buyala-Kikubsmutwe (Downstream transect)							
Monitoring period		16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	19-Sep	20-Jun	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	19-Sep	20-Jun	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	19-Sep	20-Jun
No of species of major zooplankton groups	Copepoda	7	7	7	7	5	6	7	7	7	5	6	6	7	5	6	6	7	6	7	3	5	6	5	7
	Cladocera	4	5	4	3	6	3	4	4	6	4	4	6	7	2	5	4	6	3	3	0	6	3	1	5
	Rotifera	9	8	10	4	9	10	8	9	8	9	12	8	11	10	10	9	12	9	8	4	10	10	11	7
Total no. of species		20	20	21	14	20	19	19	20	21	18	22	20	25	17	21	19	25	18	18	7	21	19	17	19

Table 3.2.2 a. *Trends in numerical abundance (ind. m^{-2}) and diversity of Copepod species at the monitored sites,* September *2016 to June 2020.*

Broad taxa	Species name	Upstream-Kalange-Mawkanzi								Mid-reservour								Downstream-Buyala-Kikubamutwe							
		16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	19-Sep	20-Jun	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	19-Sep	20-Jun	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	19-Sep	20-Jun
Copepods	*Thermocyclops incisus*	696	606	236	472		67	853	56	898				359				1,482	202	494				81	494
	Mesocyclops sp.	1,100	808	314	269			449	112	449	404	236	943	449		943	135	1,752	180	180		449	67		202
	Thermocyclops emini	4,289	1,145	393	1,617	1,213	741	1168	1347	5,389		5,541	1,179	1,505	1,078	707	404	15,494		157		898	269		202
	Tropocyclops confinnis	38,197	7,410	6,130	3,503	7,399	1,011	3,952	1,291	21,108	4,244	10,807	4,884	8,713	674	1,740	1,527	55,511	1,752	3,234	674	6,175	606	445	2,133
	Thermodiaptomus galeboides	6,490	6,130	707	808	1,291	808	1841	2807	4,222	6,198	2,043	5,053	1,538	4,177	1,448	382	15,764	1,482	831			1,347	317	1,055
	Thermocyclops neglectus	25,353	7,276	3,851	10,846	3,020	1,684	2,964	954	2,066	14,259	4,283	8,758	4,323	4,985	2,066	2,425	19,536	472	550	606	1,763	1,684	728	1,145
	Tropocyclops tenellus	27733	7,747	6,602	4,244	6,411	1,145	5,344	2,526	10,060	25,465	9,038	7,444	7,983	1,954	3,840	2,470	19,267	6,086	7,388	4,379	6,591	876	1,725	1,549
	Total copepod species abundance	**103,858**	**31,124**	**18,234**	**21,759**	**19,334**	**5,456**	**16,571**	**9,093**	**44,193**	**50,570**	**31,949**	**28,261**	**24,870**	**12,868**	**9,801**	**7,208**	**128,806**	**10,172**	**12,833**	**5,659**	**15,876**	**4,849**	**3,215**	**6,286**
	Cyclopoid copepodite	94,471	56,386	70,225	28,395	52,782	22,568	86,140	31,017	90,541	67,390	88,812	59,283	99,266	28,092	33,818	23,332	254,648	21,849	49,829	10,779	56,622	16,235	11,122	12,081
	Calanoid copepodites	18,885	8,286	4,323	7,579	2,077	1,954	4,985	1,572	9,072	6,804	4,205	3,267	3,896	9,970	3,323	2,650	31,797	2,111	1,707	404	505	3,840	1,240	988
	Nauplius larvae	507,724	139,585	150,195	141,842	157111	73,026	108,932	27,845	315,009	171,023	196,959	295,675	188078	106,440	107,832	69,141	654,539	113,648	112,155	138,035	129,996	101,219	43,479	27,755
	Total copepod developmental stages abundance	**621,080**	**204,257**	**224,743**	**177,816**	**211,970**	**97,548**	**200,057**	**60,434**	**414,622**	**245,217**	**289,976**	**358,225**	**291,240**	**144,502**	**144,973**	**95,123**	**940,984**	**137,608**	**163,691**	**149,218**	**187,123**	**121,294**	**55,841**	**40,824**

Abundance and distribution trends

The copepods: *Mesocyclops* sp., *Thermocyclops emini*, *Tropocyclops confinnis*, *Thermodiaptomus galeboides*, *Thermocyclops neglectus*, *Tropocyclops tenellus* were recorded at the three sites. The copepod, *Thermocyclops incisus* was only recorded at Kalange-Makwanzi and Buyala-Kikubamutwe sites and has not been recorded at the mid-reservoir since April 2019 (Table 3.2.2a).

Among the Cladocera species, only *Ceriodaphnia cornuta* and *Bosmina longirostris* were encountered at the three sites. Rotifers were the most diverse zooplankton with species such as *Brachionus angularis, Keratella cochlearis, Keratella tropica, Synchaeta* sp., *Polyarthra vulgaris* and *Trichocerca cylindrica* encountered in the three sites during the current monitoring. Among rotifers, *Keratella cochlearis* was the most common species encountered at all sites (Table 3.2. 2b).

Table 3.2.2 b. *Trends in numerical abundance (ind. m^{-2}) and diversity of Cladocera (water fleas) species at the monitored sites, September 2016 to June 2020*

Broad taxa	Species name	Upstream-Kalange-Mawkanzi								Mid-reservour								Downstream-Buyala-Kikubamutwe							
		16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	19-Sep	20-Jun	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	19-Sep	20-Jun	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	19-Sep	20-Jun
Cladocerans	*Daphnia lumholtzi*		135					90								45									
	Chydorus sp.									90			472				270	269							
	Daphnia lumholtzi (helm)				135				112	90			236	101				269				56			
	Ceriodaphnia cornuta	1999	1,886	79			404	135	56	629	808	1,100	269	180		45	135	2,425		236		56	202		135
	Diaphanosoma excisum	1347	606	1,022			135	225	281	90	2,313	354	707	404		79		3,773	67						337
	Moina micrura	2448	1,347	1,415	2,425					1,617	202	1,690	2,122	359	135	472	943	5,120	337	1,033		225	135		202
	Bosmina longirostris	2,740	876	2,436	1,684		741	988	1291	1,437	629	4,598	1,179	1,213	404	651	270	2,695	516	685		1,819	337	202	831
	Macrothrix sp.																								67
	Total Cladocera abundance	**2,740**	**4,850**	**4,952**	**4,244**	**-**	**1,280**	**1,438**	**1,740**	**3,953**	**3,952**	**7,742**	**4,985**	**2,257**	**539**		**1,618**	**14,551**	**920**	**1,954**	**-**	**2,156**	**674**	**202**	**1,572**

Table 3.2.2 c. *Trends in numerical abundance (ind. m^{-2}) and diversity of Rotifer (wheel animalcules) species and overall zooplankton density at the monitored sites, September 2016 to June 2020*

Broad taxa	Species name	Upstream-Kalange-Mawkanzi								Mid-reservour								Downstream-Buyala-Kikubamutwe							
		16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	19-Sep	20-Jun	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	19-Sep	20-Jun	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	19-Sep	20-Jun
Rotifers	*Asplanchna sp.*					146		45				157		112	202			674						40	
	Ascomorpha sp.											79				45	67					56			
	Euclanis sp.	2246	269			427				719		472		191				1,213				168		40	
	Brachionusfalcatus		269						224			79		45	269	359		135							
	Filinia longiseta															45	135						67	34	
	Polyarthra sp.	180		157														269	225						
	Filinia opoliensis	135	337	707			269			180	180	550		337	269			1,347				45	202		
	Brachionus picatilis																								
	Brachionus forticula			157																		56			
	Keratella cochlearis	90		2279		719	202	3,009	1,067	180		1,336	2,964	1,112		6,377	4,379	269	898	1,729	539	1,235	67	2,082	1,909
	Brachionus calyciflorus		337	314		90					606	236		56	135				135	427		292	67		472
	Trichocerca cylindrica	808		1415	135	1,639	876	629	1,347	1,976	180	1,926	2,863	3,267		719	1,302	1,482	404	707		2,549	269	438	1,087
	Brachionus angularis	180	472	236		1,415	606	45	954	898	786	2,161	404	1,067	3,368	472	539	3,234	225	427		763		81	719
	Brachionus budapestinensis													56											
	Brachionus bidentatus							45	112				135		135										
	Hexathra sp.																								
	Lecane bulla	5,771	1,415	4480	674	5,333	1,549	3,099	393	10,869	3,570	4,834	674	6,288	1,617	1,314		31,932	1,482	1,134	1,617	4,480	404	1,159	
	Lecane luna						67				629	275				550	1,302						67	34	
	Lepadella sp.						1,179																		
	Synchaeta sp.	2,852	1,617	629	3032	1,033	10,307	2,156	617	3,683	3,840	786	2,594	1,796	9,566	5,446	3,368	5,255	853	786	1,886	1,156	3,503	761	674
	Keratella tropica	4,222	4,783	314	2796	1,235	1,280	853	56	3,054	4,222		1,718	2,717	6,669	797	359	8,219	4,087	516		2,526	2,695	1,179	337
	Brachionus patulus																	135							
	Cephalodella sp.					1,505					2,380		236	1,718	236				2,156	79		1,976			
	Polyarthra vulgaris					472	674		561						1,482		2,515				337		67	81	314
	Total Rotifer abundance	**14,103**	**9,499**	**10,688**	**6,637**	**14,014**	**17,009**	**9,881**	**5,331**	**21,559**	**16,393**	**12,891**	**11,588**	**18,762**	**23,948**	**16,124**	**13,966**	**54,164**	**10,465**	**5,805**	**4,379**	**15,302**	**7,408**	**5,929**	**5,512**
Overall zooplankton abundance		**714,048**	**249,728**	**258,616**	**210,456**	**245,318**	**121,293**	**227,947**	**76,598**	**484,326**	**316,132**	**342,557**	**403,059**	**337,129**	**181,857**	**173,133**	**118,050**	**1,138,505**	**159,167**	**184,284**	**159,256**	**220,457**	**134,225**	**65,268**	**54,688**

During the current monitoring-June 2020, highest average zooplankton abundance of 118,050 ind.m^{-2} was recorded at the mid-reservoir, 76,602 ind.m^{-2} at Kalange-Makwanzi and lowest of 54, 680 ind.m^{-2}at Buyala-Kikubamutwe. Zooplankton abundances recorded during June 2020 were the lowest since April 2018 (Table 3.2.2c). In general, the total abundance of zooplankton since April 2018 at the mid-reservoir and Buyala-Kikubamutwe has been gradually declining mainly due to changes in the abundance of copepod developmental stages (Table 3.2.2c). At Kalange-Makwanzi, abundance has been consistently highest during the September monitoring periods and lowest during April (including current one) monitoring periods. During the current monitoring, copepods still remained the numerically abundant zooplankton followed by rotifers, a consistence observed during the previous monitoring periods (Tables 3.2.2a-c). The abundance of copepod species and cladocerans were highest at Kalange-Makwanzi and lowest at the Buyala-Kikubamutwe. Abundance of rotifers and copepod developmental stages were highest at the mid-reservoir and lowest at the other two sites. Among copepods, copepod developmental stages were still the most abundant group of zooplankton accounting for 86-93% of the abundance of copepods and 75-81% of the abundance of total zooplankton at the sites. Among copepod developmental stages, the order of numerical abundance was nauplii > cyclopoid copepodites > calanoid copepodites at the mid-reservoir and Buyala-Kikubamutwe and cyclopoid copepodites > nauplii > calanoid copepodites at the Kalange-Makwanzi (Table 3.2.2a).

Table 3.2.3. *The Percent Similarity Index (PSI) of zooplankton community between the sites during the different monitoring periods*

Percent Similarity Index (PSI) comparisons between sites	Monitoring periods								
	16-Apr	16-Sep	17-Apr	17-Sep	18-Apr	18-Sep	19-Apr	19-Sep	20-Jun
Kalange-Makwanzi and Mid-reservoir	**76.7**	**73.5**	**66.6**	**77.5**	**37.1**	**88.4**	**88.3**	**79.2**	**97.7**
Kalange-Makwanzi and Buyala-Kikubamutwe	61.8	74.7	58.7	70.1	68.5	81.6	82	76.1	61.5
Mid-reservoir and Buyala-Kikubamutwe	**72.7**	**86.4**	**65.6**	**63.8**	**42**	**87.6**	**82.5**	**92.2**	**73.7**

Degree of similarity of species abundance distributions (PSI) between the sites was higher between Kalange-Makwanzi and mid-reservoir than observed between mid-reservoir and Buyala-Kikubamutwe, and between Kalange-Makwanzi and Buyala-Kikubamutwe, indicating fairly similar zooplankton communities between Kalange-Makwanzi and mid-reservoir (Table 3.2.3). Since April 2016, the lowest PSI values indicating different zooplankton communities between sites were between Kalange-Makwanzi and mid-reservoir (37.1%) and between mid-reservoir and Buyala-Kikubamutwe (42%) in the April 2018 period (Table 3.2.3).

Discussion

In general, rotifers have consistently remained the most species-rich zooplankton group at the three sites; Kalange-Makwanzi, mid-reservoir and Buyala-Kikubamutwe. The large sized zooplanktons (copepods and cladocera) have tended to be low species- rich over the monitoring

periods. During the current monitoring-June 2020, the number of species in each zooplankton group was less than ten (10) at all sites. The environmental conditions that underpin zooplankton communities survival across the transects seem not vary so much to cause distinct communities among sites. In addition, level of connectivity among the sites allows environmental flow as Percent Similarity Index (PSI) indicated high similarity in zooplankton assemblage between Kalange-Makwanzi and mid-reservoir which are close to one another than observed between Kalange-Makwanzi and Buyala-Kikubamutwe which are more distant. The current monitoring period coincided with increased water levels, which could have led to increase in amount of water discharged by the dam, and therefore reduction in water residence time. According to Basu and Pick (1996), there is a positive relationship between zooplankton abundance and water residence time. Different zooplankton communities appear to have distinctive responses to water residence time. According to Thorp *et al*. (1994), zooplankton abundance was found to be inversely correlated with water discharge or velocity, and the low zooplankton abundance observed across all sites during June sampling could be a result of changes in the water flow velocity at the dam area, limiting zooplankton reproduction.
Like during previous monitoring periods, the abundance of zooplankton was still determined by the abundance of copepods which have been consistently recorded as the most abundant zooplankton group. The abundance of copepods was in turn determined by the abundance of copepod developmental stages which comprised over 86% of the copepod abundance, a common pattern observed in Lake Victoria and other freshwater habitats (Vasquez and Rey 1992, Sampaio and Lopea 2000). The high density of immature copepods which is a result of continuous reproduction (Neves et al. 2003) is important for zooplankton population dynamics and trophic aspects.

Conclusion

The zooplankton community was still characterized by rotifer-driven species richness and copepod-dominated numerical abundance at all sites.

In comparison with previous monitoring periods, abundance of zooplankton was lowest during the current monitoring period at all sites, suggesting that the high water levels could have led to increased water discharge at the dam limiting zooplankton production.

The numerical abundance of zooplankton especially at Kalange-Makwanzi and mid-reservoir was relatively high, suggesting that these sites can still support fish production.

3.3 Benthic macro-invertebrates

During this monitoring-June 2020, total highest benthic snail density of 1162 ind. m^{-2} occurred at the mid-reservoir transect and much of this density was exclusively made up of *Bellamya unicolor* at 1099 ind. m^{-2} (Table 3.3.1 a). At the mid-reservoir, snail density was 24 ind. m^{-2} during the September 2019 and 49 ind. m^{-2} during April 2019 (Table 3.3.1a). At Kalange-Makwanzi and Buyala-Kikubamutwe transects, *Bellamya unicolor* registered a paltry density of 9 ind. m^{-2} respectively during the current monitoring of June 2020. During the previous monitoring-September 2019, highest snail density of merely, 47 ind. m^{-2} occurred at Kalange-Makwanzi entirely represented by one species, *Melanoides tuberculata* (Table 3.3.1a). Earlier on

during April 2019 monitoring, a low density of 9 ind. m^{-2} was recorded which was also represented by one species, *Gabbia humerosa*. At Buyala-Kikubamutwe transect, the snail density was 51 ind. m^{-2} during April 2019, 346 ind. m^{-2} during September 2019 and 28 ind. m^{-2} during this monitoring period-June 2020 (Table 3.3.1a). The snail species encountered at this site were *Bellamya unicolor* at a density of 9 ind. $m^{-2}$and *Melanoides tuberculata* at density of 19 ind. m^{-2}. Between April 2018 and April 2019, the snail assemblage was so poor with overall densities below 50 ind. m^{-2}. During the current monitoring-June 2020, snail density increased at the mid-reservoir transect, including a density of 28 ind. $m^{-2}$for *Bulinus sp.,* a schistosomiasis vector.

Table 3.3.1a *Trends of benthic density and number of species of water snails at the monitored sites*

Broad taxa	Species/family name	Site/Transect	Monitoring time																			
			Apr-06	Aug-07	Apr-08	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep.14	Apr-15	Sep.15	Apr.16	Sep.16	Apr.17	Sep.17	Apr.18	Sep.18	Apr.19	Sep.19	Jun.20
Gastropoda (water snails)	*Bellamya unicolor*	Kalange-Makwanzi	33	173	5	33	0	0	299	0	0	0	0	35	0	0	0	0	0	0	0	9
		Mid-Reservoir				0	0	4	154	296	23	14	98	1097	61	42	21	7	21	21	5	1069
		Buyala-Kikubamutwe	98	126	11	42	65	285	14	23	47	579	9	37	5	33	0	0	5	23	0	9
	Melanoides tuberculata	Kalange-Makwanzi	28	107	257	14	19	5	19	0	0	14	0	56	177	79	19	140	47	0	47	313
		Mid-Reservoir				0	0	77	5	5	9	145	35	5	107	133	28	119	28	21	19	65
		Buyala-Kikubamutwe	33	224	100	121	33	33	9	33	0	42	14	0	56	196	47	51	56	23	229	19
	Biomphalaria choanomphala	Kalange-Makwanzi	0	14	5	0	0	0	9	0	0	5	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				2	0	4	7	25	0	0	0	61	9	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	19	11	0	5	9	5	9	5	23	5	5	0	0	0	0	0	0	5	0
	Anisus natalensis	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	5	0	0	0	0	0	0	0	5	0	0	5	0	0	5	0	0
	Gyraulus sp.	Kalange-Makwanzi	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	47	0	5	0	0	0	0	0	0	0	0	0	0	0	0
	Segmentorbis sp.	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	47	9	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gabbia humerosa	Kalange-Makwanzi	0	79	5	0	0	5	23	0	0	0	0	0	0	0	5	0	0	9	0	0
		Mid-Reservoir				0	0	4	5	33	0	0	0	5	14	0	0	7	0	7	0	0
		Buyala-Kikubamutwe	0	0	121	1027	677	135	0	0	9	42	0	196	23	9	0	0	0	0	93	0
	Bulinus sp	Kalange-Makwanzi	5	9	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	12	0	0	0	0	14	0	0	0	0	0	0	0	28
		Buyala-Kikubamutwe	5	5	5	0	19	65	0	5	0	0	0	5	0	0	0	0	5	0	19	0
	Pila ovata	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total snail abundance at each site/transect		Kalange-Makwanzi	**65**	**383**	**275**	**51**	**19**	**9**	**350**	**0**	**0**	**19**	**0**	**91**	**177**	**79**	**23**	**140**	**47**	**9**	**47**	**322**
		Mid-Reservoir	**0**	**0**	**0**	**9**	**3**	**88**	**182**	**358**	**33**	**159**	**133**	**1181**	**191**	**175**	**49**	**133**	**49**	**49**	**24**	**1162**
		Buyala-Kikubamutwe	**135**	**373**	**252**	**1242**	**808**	**602**	**28**	**75**	**61**	**686**	**28**	**247**	**84**	**238**	**51**	**51**	**65**	**51**	**346**	**28**

During this monitoring-June 2020, a total bivalve density of 177 ind. m^{-2} was recorded at Kalange-Makwanzi (Table 3.3.2 b). The density of bivalves at this site has since September 2018 been declining from 201 ind. m^{-2} to 89 ind. m^{-2} during April 2019 to 65 ind. m^{-2} during September 2019. Bivalval density at the mid-reservoir was 231 ind. m^{-2} during September 2018, 336 ind. m^{-2} during April 2019, 201 ind. $m^{-2.}$ during September 2019 and 126 ind. m^{-2} during the current monitoring of June 2020. At Buyala-Kikubamutwe transect, the density was 116 ind. m^{-2}during September 2018, 150 ind. m^{-2} during April 2019 and 122 ind. m^{-2}during September 2019 ind. m^{-2} and just 53 ind. m^{-2} during this monitoring-June 2020 (Table 3.3.1 b). During the previous monitorings-April and September 2019, overall bivalval abundance was highest at the

mid-reservoir and lowest at Kalange-Makwanzi. During this monitoring-June 2020, highest bivalve density occurred at Kalange-Makwanzi and the lowest at Buyala-Kikubamutwe. At the mid-reservoir, the density of *Byssanodonta parastica* was 126 ind. m^{-2} during-April 2019, 47 ind. m^{-2} during September 2019 and further reduced to 37 ind. m^{-2} during this monitoring-June 2020. During this period-June 2020, *B. Parastica* density increased at Kalange-Makwanzi and decreased at Buyala-Kikubamutwe transect from 9ind. $m^{-2}$to 56 ind. m^{-2} and from 23 ind. $m^{-2}$to 5 ind. m^{-2} during September 2019 respectively. The density Caelatura *sp*. at the mid-reservoir during this recent period was merely 14 ind. m^{-2} , It was 49 ind. m^{-2} during April 2019 and 9 ind. m^{-2} during September 2019. Tremendous decline at this site also happened for *Corbicular Africana*, reducing to 23 ind. m^{-2} during the current monitoring, 26 during September 2019, from 147 ind. m^{-2} during April 2019. At Kalange-Makwanzi and Buyala-Kikubamutwe transects, the density of these two bivalve species ranged from 5 to 28 ind. m^{-2}. Very rare bivalval species, *Mutela sp*., and *Pisidium victorianus* were encountered during this monitoring –June 2020, albeit at low densities ranging from 5 to 7 ind. m^{-2}. The bivalve, *Sphaerium victoriae* made a debut in the benthos at all sites, registering densities of 63 ind. m^{-2}, 47 ind. m^{-2}, and 12 ind. m^{-2} at Kalange-Makwanzi, mid-reservour and Buyala-Kikubamutwe transects respectively.

Table 3.3.1 b *Trends of benthic density and number of species of bivalves at the monitored sites*

Broad taxa	Species/family name	Site/Transect	Monitoring time																			
			Apr-06	Aug-07	Apr-08	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep.14	Apr-15	Sep.15	Apr.16	Sep.16	Apr.17	Sep.17	Apr.18	Sep.18	Apr.19	Sep.19	Jun.20
Bivalvia (Clams/mussels)	*Byssanondota parasitica*	Kalange-Makwanzi	79	145	252	61	75	42	121	14	0	9	0	133	5	70	9	159	19	33	9	56
		Mid-Reservoir				23	95	686	380	801	28	79	58	42	56	112	56	182	21	126	47	37
		Buyala-Kikubamutwe	0	19	63	317	9	117	733	159	205	75	149	140	61	369	79	47	9	37	23	5
	Corbicula africana	Kalange-Makwanzi	56	126	182	47	219	514	98	222	19	145	9	413	19	131	37	154	93	14	19	5
		Mid-Reservoir				5	25	196	44	581	140	481	7	406	19	427	77	448	154	147	28	23
		Buyala-Kikubamutwe	65	131	205	65	28	79	56	47	126	126	93	175	51	1116	327	0	19	70	14	0
	Caelatura spp	Kalange-Makwanzi	149	93	229	79	79	47	0	124	9	84	47	133	103	19	28	131	42	42	14	28
		Mid-Reservoir				9	20	28	23	44	33	5	58	135	14	7	42	105	49	49	9	14
		Buyala-Kikubamutwe	37	61	63	37	5	5	47	23	51	28	75	47	107	107	145	9	65	19	5	7
	Pisidium victoriae	Kalange-Makwanzi	0	5	0	0	9	0	0	0	0	0	0	0	0	0	0	0	9	0	9	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	47	0	0	7	0	0	0	56	5
		Buyala-Kikubamutwe	0	0	32	19	5	0	0	0	0	0	0	0	0	0	14	0	0	0	5	0
	Mutela sp	Kalange-Makwanzi	0	0	0	5	5	0	0	7	0	9	7	0	0	0	0	19	0	0	0	9
		Mid-Reservoir				0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	5	5	16	0	0	0	0	0	0	9	0	7	0	0	0	9	0	14	5	0
	Sphaerium victoria	Kalange-Makwanzi	5	51	14	0	0	0	0	14	0	9	0	7	5	0	9	5	33	0	9	65
		Mid-Reservoir				2	0	0	2	14	5	14	0	9	0	0	7	0	0	14	61	47
		Buyala-Kikubamutwe	0	19	0	23	0	0	5	0	61	23	5	7	0	0	0	0	19	5	51	12
	Sphaerium stuhlm	Kalange-Makwanzi	0	0	0	9	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				5	146	18	2	26	0	0	7	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	9	5	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0
	Aspantharia sp	Kalange-Makwanzi	9	9	5	5	5	5	0	5	0	14	0	0	0	0	0	0	5	0	5	9
		Mid-Reservoir				0	0	0	0	0	0	5	0	19	0	0	0	7	7	0	0	0
		Buyala-Kikubamutwe	5	0	0	0	0	0	0	5	0	5	0	0	5	0	0	5	5	5	5	0
	Etheria eliptica	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
		Mid-Reservoir				0	0	0	0	0	0	14	7	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	5	5	0	0	0	0	0	0	0	9	23	0	0	0	0	0	14	0
Total bivalve abundance at each site/transect		Kalange-Makwanzi	**299**	**430**	**682**	**205**	**392**	**607**	**229**	**385**	**28**	**271**	**63**	**686**	**131**	**219**	**84**	**467**	**201**	**89**	**65**	**177**
		Mid-Reservoir	**0**	**0**	**0**	**44**	**286**	**928**	**453**	**1466**	**205**	**598**	**138**	**677**	**89**	**546**	**189**	**742**	**231**	**336**	**201**	**126**
		Buyala-Kikubamutwe	**112**	**233**	**383**	**476**	**51**	**201**	**840**	**233**	**444**	**266**	**331**	**385**	**247**	**1592**	**565**	**70**	**116**	**150**	**122**	**23**

During this monitoring-June 2020, may fly species at the mid-reservoir recorded 9 ind. m^{-2}, 93 ind. m^{-2} at Buyala-Kikubamutwe and 37 ind. m^{-2} at Kalange-Makwanzi transect (Table 3.3.1c).

Previously-during September 2019, they were not encountered at Kalange-Makwanzi but were at mid-reservoir and Buyala-Kikubamutwe transects at low density of 19 ind. m^{-2} and 84 ind. m^{-2} respectively (Table 3.3.1 c). In April 2018, mayflies were only recovered at Buyala-Kikubamutwe.

Dragon flies were recovered at Kalange-Makwanzi and mid-reservoir transect at very low densities, ranging from 5 to 9 ind. m^{-2} . During September 2019, Caddis flies were recovered at all sites at low densities ranging from 5 to 14 ind. m^{-2} but during this monitoring-June2020, the density recorded was 267 ind. m^{-2} at Kalange-Makwanzi, 23 ind. m^{-2} at mid-reservoir and 24 ind. m^{-2} at Buyala-Kikubamutwe. Compared to the previous period-September 2019, dipteran density decreased at all sites from 243 to 23 ind. m^{-2} at Kalange-Makwanzi, from 178 to 23 ind. m^{-2} at the mid-reservoir and from 88 to 12 ind. m^{-2} at Buyala-Kikubamutwe during this monitoring June 2020. The density of Chironominae at Kalange-Makwanzi reduced from 187 ind. m^{-2} during September 2019 to 14 ind. m^{-2} during the current monitoring and at the mid – reservoir, the density increased from 33 to 23 ind. m^{-2} over the same period interval. Density drastically decreased at Buyala-Kikubamutwe from 70 to 7 ind. m^{-2}. During April 2019, no *Chaoborus sp*. appeared in the benthos at all sites but during september 2019, they were recovered at densities of 37 ind. m^{-2}, 145 ind. m^{-2} and 23 ind. m^{-2} at Kalange-Makwanzi, mid-reservoir and Buyala-Kikubamutwe transects respectively; during this monitoring June 2020, the respective densities reduced to 9 ind. m^{-2}, nil and 5 ind. m^{-2}. Ceratopogonidae was encountered only at Buyala-Kikubamutwe at a very low density of 5 ind. m^{-2} during September 2019 but during this monitoring June 2020, they were absent at all sites.

Table 3.3.1 c *Trends of benthic density and number of species of insect types at the monitored sites*

Broad taxa	Species/family name	Site/Transect	Monitoring time																		
			Apr-06	Aug-07	Apr-08	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep.14	Apr-15	Sep.15	Apr.16	Sep.16	Apr.17	Sep.17	Apr.18	Sep.18	Apr.19	Sep.19	Jun.20
Ephemeroptera (May flies)	*Povilla adusta*	Kalange-Makwanzi	19	163	9	28	0	14	0	9	0	0	0	0	0	0	14	0	0	5	0	5
		Mid-Reservoir				5	3	144	245	5	0	70	12	0	5	0	35	0	0	0	19	9
		Buyala-Kikubamutwe	5	9	63	28	5	37	9	28	0	19	5	79	5	0	5	23	0	0	84	0
	Baetis sp.	Kalange-Makwanzi	5	9	0	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	9
		Mid-Reservoir				0	3	0	0	0	79	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	23	5	0	0	5	0	0	0	19	0	0	0	0	0	0	5	0	0	0	0
	Caenis sp.	Kalange-Makwanzi	19	75	19	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	7	0	0	0	9	0	0	0	0	14	0	0	0	0	0
		Buyala-Kikubamutwe	0	9	26	37	9	313	0	23	0	0	0	0	0	0	0	28	23	0	0	0
	Cloeon sp.	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	37	0	0	0	9	9	0	0	0	0	0	0	0	0	0	0	5	0	0	0
	Leptophlebidae	Kalange-Makwanzi	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
		Mid-Reservoir				0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	5	9	0	0	0	0	0	0	0	0	0	0	0	0	5
	Trichorythidae	Kalange-Makwanzi	0	89	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	23
		Mid-Reservoir				0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	5	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	89
Total Mayflies abundance at each site/transect		Kalange-Makwanzi	**42**	**350**	**28**	**33**	**0**	**14**	**5**	**9**	**5**	**0**	**0**	**0**	**0**	**0**	**23**	**0**	**5**	**5**	**0**	**37**
		Mid-Reservoir	**0**	**0**	**0**	**5**	**6**	**151**	**268**	**5**	**79**	**79**	**12**	**0**	**5**	**0**	**49**	**0**	**0**	**0**	**19**	**9**
		Buyala-Kikubamutwe	**65**	**23**	**89**	**70**	**28**	**383**	**19**	**51**	**19**	**19**	**5**	**79**	**5**	**0**	**5**	**56**	**28**	**0**	**84**	**93**

Odonata (Dragon flies)	*Hagenius* sp.	Kalange-Makwanzi	19	0	9	0	5	0	0	7	0	0	0	0	0	0	0	0	0	5	0	0
		Mid-Reservoir				0	3	0	0	0	0	0	7	33	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	5	0	0	5	5	0	0	5	0	0	5	0	5	0	5	0	0	0	0	0
	Gomphoides sp.	Kalange-Makwanzi	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	19	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
	Libellulidea	Kalange-Makwanzi	9	33	0	5	0	14	5	0	0	0	0	7	0	5	0	0	0	0	0	5
		Mid-Reservoir				2	0	18	2	2	0	0	0	84	0	14	7	0	0	0	0	9
		Buyala-Kikubamutwe	0	5	37	5	5	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cordulidae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
	Coenagrion sp.	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	5	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0
	Protoneuridae	Kalange-Makwanzi	0	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total dragonflies abundance at each site/transect		Kalange-Makwanzi	**33**	**42**	**23**	**5**	**5**	**14**	**5**	**7**	**0**	**0**	**0**	**7**	**0**	**5**	**5**	**0**	**5**	**5**	**0**	**5**
		Mid-Reservoir	**0**	**0**	**0**	**2**	**3**	**18**	**2**	**2**	**0**	**0**	**7**	**117**	**0**	**14**	**7**	**0**	**0**	**0**	**0**	**9**
		Buyala-Kikubamutwe	**9**	**23**	**42**	**9**	**9**	**14**	**0**	**5**	**5**	**0**	**9**	**0**	**9**	**0**	**5**	**0**	**0**	**0**	**0**	**0**
Trichoptera (Caddis flies)	Dipseudopsis	Kalange-Makwanzi	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0
		Mid-Reservoir	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	14
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hydropsychidae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	5	0	0	0	0	5	0	0	0	0	248
		Mid-Reservoir				0	0	0	257	0	0	0	12	0	56	0	0	0	0	0	0	9
		Buyala-Kikubamutwe	0	19	16	5	0	9	0	5	0	0	5	14	0	0	0	0	14	0	0	17
	Brachycentridae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Psychomyiid	Kalange-Makwanzi	0	2	0	0	0	5	9	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	3	4	7	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Polycentropodidae	Kalange-Makwanzi				0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0
		Mid-Reservoir	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	56	0	0	0	0	0	0	0
	Leptoceridae	Kalange-Makwanzi	0	0	0	0	0	5	0	0	5	0	0	0	0	0	0	0	0	9	0	0
		Mid-Reservoir				0	0	0	0	0	5	0	0	0	0	42	0	28	0	0	0	0
		Buyala-Kikubamutwe	0	2	3	0	0	5	0	0	0	0	0	0	0	0	0	5	0	0	0	0
	Economidae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	9	19
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	77	0	0	14	5	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	7
Total Caddisflies abundance at each site/transect		Kalange-Makwanzi	**0**	**2**	**0**	**0**	**0**	**9**	**9**	**0**	**5**	**5**	**0**	**0**	**14**	**0**	**9**	**0**	**0**	**14**	**9**	**267**
		Mid-Reservoir	**0**	**0**	**0**	**0**	**3**	**4**	**264**	**0**	**5**	**0**	**12**	**0**	**66**	**42**	**77**	**28**	**0**	**14**	**5**	**23**
		Buyala-Kikubamutwe	**0**	**21**	**18**	**7**	**0**	**14**	**0**	**5**	**0**	**0**	**5**	**14**	**56**	**0**	**0**	**5**	**14**	**0**	**14**	**24**

Hemiptera (water bugs)	Nepidae	Kalange-Makwanzi	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Aphelocheiridae (*Aphelocheirus* sp.)	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
Total waterbugs abundance at each site/transect		Kalange-Makwanzi	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Mid-Reservoir	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Buyala-Kikubamutwe	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Coleoptera (beetles)	Elmidae	Kalange-Makwanzi	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Chironominae (True flies)	Kalange-Makwanzi	271	331	238	201	47	117	191	5	0	9	208	56	490	9	962	0	14	51	187	14	
		Mid-Reservoir				201	73	98	26	27	0	0	63	51	182	21	259	0	28	14	33	23	
		Buyala-Kikubamutwe	84	56	58	84	9	75	37	19	0	14	84	12	182	33	145	19	23	75	70	7	
	Tanypodinae (True flies)	Kalange-Makwanzi	19	33	23	5	14	33	37	19	61	5	63	21	9	56	0	5	0	0	19	0	
		Mid-Reservoir				0	8	42	42	56	47	0	0	56	42	0	28	28	28	0	0	0	
		Buyala-Kikubamutwe	23	42	5	26	0	14	56	0	28	42	75	7	9	14	0	28	33	5	0	0	
	Chaoborus sp (Phantom midges)	Kalange-Makwanzi	9	23	9	9	42	28	70	196	0	37	96	126	7	0	84	175	14	0	37	9	
		Mid-Reservoir				0	8	53	47	40	5	5	14	5	14	0	21	0	7	0	145	0	
		Buyala-Kikubamutwe	5	5	0	65	0	0	23	5	23	14	14	0	28	0	0	0	0	0	23	5	
	Ceratopogonidae (Biting midges)	Kalange-Makwanzi	5	14	0	9	0	0	0	5	84	0	0	0	0	0	0	0	0	0	0	0	
		Mid-Reservoir				0	0	0	0	0	0	5	0	14	5	0	0	0	0	0	0	0	
		Buyala-Kikubamutwe	0	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	0	
	Psychodidae (Moth flies)	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	
		Mid-Reservoir				0	0	0	5	0	0	0	0	0	0	0	7	0	0	0	0	0	
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total trueflies abundance at each site/transect		Kalange-Makwanzi	**303**	**401**	**271**	**224**	**103**	**177**	**299**	**224**	**145**	**51**	**366**	**203**	**507**	**65**	**1050**	**180**	**28**	**51**	**243**	**23**	
		Mid-Reservoir	**0**	**0**	**0**	**201**	**90**	**193**	**119**	**123**	**51**	**9**	**77**	**126**	**243**	**21**	**315**	**28**	**63**	**14**	**178**	**23**	
		Buyala-Kikubamutwe	**112**	**107**	**63**	**175**	**9**	**89**	**117**	**23**	**56**	**70**	**173**	**19**	**219**	**47**	**145**	**47**	**56**	**79**	**98**	**12**	

Table 3.3.1 d *Trends of benthic density of other benthic macro-invertebrates at the monitored sites*

Broad taxa	Species/family name	Site/Transect	Monitoring time																			
			Apr-06	Aug-07	Apr-08	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep.14	Apr-15	Sep.15	Apr.16	Sep.16	Apr.17	Sep.17	Apr.18	Sep.18	Apr.19	Sep.19	Jun.20
Oligochaeta (earth worms)	*Nais* sp.	Kalange-Makwanzi	0	5	5	14	5	0	28	0	9	5	14	21	23	5	5	19	0	14	33	70
		Mid-Reservoir				0	0	11	16	56	5	9	49	191	42	49	7	7	0	0	56	7
		Buyala-Kikubamutwe	0	33	11	9	5	0	19	0	9	28	42	0	19	9	0	5	0	5	9	103
Hirudinea (leeches)	Glosophomidae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	37
		Mid-Reservoir				0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	5	0
		Buyala-Kikubamutwe	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	0	103
Ostracoda (seed shrimps)	Seed shrimps	Kalange-Makwanzi	0	0	0	0	5	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir				229	11	0	7	2	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Decapoda (Shrimps)	*Caridina nilotica*	Kalange-Makwanzi	0	5	0	5	0	0	5	0	0	9	0	0	0	0	0	0	0	0	0	14
		Mid-Reservoir				7	3	0	5	14	0	5	0	70	0	0	0	0	0	0	14	0
		Buyala-Kikubamutwe	0	5	32	0	0	0	5	0	0	126	5	0	0	0	0	0	0	0	0	9
Total other benthic macroinvertebratess abundance at each site/transect		Kalange-Makwanzi	**0**	**9**	**5**	**19**	**9**	**0**	**42**	**0**	**9**	**14**	**14**	**21**	**23**	**5**	**5**	**19**	**0**	**23**	**33**	**121**
		Mid-Reservoir	**0**	**0**	**0**	**236**	**14**	**11**	**28**	**72**	**5**	**14**	**49**	**261**	**42**	**49**	**7**	**7**	**0**	**28**	**75**	**7**
		Buyala-Kikubamutwe	**0**	**37**	**47**	**9**	**5**	**0**	**28**	**0**	**9**	**154**	**47**	**0**	**19**	**9**	**0**	**5**	**0**	**28**	**9**	**215**

After six monitoring consecutive periods, Nile shrimps (*Caridina nilotica*) have been absent in the benthos, they were recovered at the mid-reservoir transect, albeit at low density of 14 ind. m^{-2} during September 2019 (Table 3.3.1 d). During this monitoring-June 2020, Nile shrimps were absent at the mid-reservoir and present at Kalange-Makwanzi and Buyala-Kikubamutwe transects at low densities of 14 ind. m^{-2} and 9 ind. m^{-2} respectively. The waterworms

(Oligocheata) were recovered during September 2019 at densities of 33 ind. m^{-2}, 56 ind. m^{-2} and 9 ind. m^{-2} at Kalange-Makwanzi, mid-reservoir and Buyala-Kikubamutwe transects respectively. During this period-June 2020, water worms increased at Kalange-Makwanzi and Buyala-Kikubamutwe transects to densities of 70 ind. m^{-2} and 100 ind. m^{-2} respectively. They were absent during September 2018. Seed shrimps have remained unseen in the benthos for the last 12 surveys. However after the previous 9 monitoring periods, not appearing in the benthos, leeches were encountered at all sites with low densities ranging from 9 ind. m^{-2}at Kalange-Makwanzi to 28 ind. m^{-2} at the mid-reservoir during the April 2019. Currently, leeches were absent at the mid-reservoir but were recovered at Kalange-Makwanzi and Buyala-Kikubamutwe transects at densities of 37 ind. m^{-2} and 103 ind. m^{-2} respectively. Usually the presence of leeches in the benthos indicates deteriorating water environment conditions, especially when they occur exclusively.

Major observations

At the mid-reservoir, *Bellamya unicolor* contributed 94 % of the total snail density (1172 ind. m^{-2}). This density is comparable to that observed in Lake Victoria shallow areas. However, the density of *Bellamya unicolor at* Kalange-Makwanzi and Buyala-Kikubamutwe transects was dismal at 9 ind. m^{-2} respectively.

Over the monitoring periods, two bivalve species; *Byssanodonta parastica* and *Corbicular Africana* are notably common/present at the transects (Table 3.3.1 b). These are common bivalve species in Lakes Victoria, Nabugabo, Kyoga and Albert. Very rare bivalval species, *Mutela sp*., and *Pisidium victorianus* were encountered during this monitoring –June 2020, albeit at low densities ranging from 5 to 7 ind. m^{-2}.

During this monitoring-June 2020, may fly species were recovered at all sites but made the greatest debut at Buyala-Kikubamutwe at 93 ind. m^{-2} (Table 3.3.1 c). Similarly, Caddis flies were recovered at all sites at low densities (5 - 14 ind. m^{-2}) but featuring the density of 267 ind. m^{-2} at Kalange-Makwanzi.

Compared to the previous period-September 2019, dipteran density decreased at all sites from 243 to 23 ind. m^{-2} at Kalange-Makwanzi, from 178 to 23 ind. m^{-2} at the mid-reservoir and from 88 to 12 ind. m^{-2} at Buyala-Kikubamutwe during this monitoring June 2020.

Despite Nile shrimps (*Caridina nilotica*) being absent in the benthos during six monitoring periods before April 2019, they were recovered at the mid-reservoir transect, albeit at low density of 14 ind. m^{-2} during September 2019 (Table 3.3.1 d) and during this monitoring-June 2020, they were absent at the mid-reservoir and present at Kalange-Makwanzi and Buyala-Kikubamutwe transects at low densities (9 ind. m^{-2} - 14 ind. m^{-2}).

3.4 Fish Species Composition and Relative Abundance

3.4.1 Catch composition

During the previous monitoring period-September 2019, 8 taxa (7 species and Haplochromines-species group) were recorded at the three transects from Kalange-Makwanzi area to Buyala-Kikubamutwe along the Upper River Nile. During the current monitoring, June 2020, nine taxa (8 species and haplochromines-species group) were recorded. Six taxa were recorded from Kalange-Makwanzi transect, seven in the mid-reservoir and five at Buyala-Kikubamutwe (Table 4.4.1 a & b).

The eight species recorded from the transects were: *Bagrus docmak, Coptodon zillii, Lates niloticus, Mormyrus kannume, Oreochromis niloticus, Oreochromis variabilis, Synodontis afrofischeri*. Four of these species*: Synodontis victoriae*. *Bagrus docmak, O. variabilis* and *Synodontis afrofischeri* were found at the three transects (Kalange-Makwanzi, mid-reservoir and Buyala-Kikubamutwe).

Tables 3.4.1 *a & b Fish species recorded overtime at the monitored sites.a)*

Family names	Scientific names	English names/local names (Luganda)	Transects/Sites	Monitoring Dates																								
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
				Apr. 2006	Sep. 2007	Apr. 2008	Apr. 2009	Sep. 2009	Apr. 2010	Sep. 2010	Apr. 2011	Sep. 2011	Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017	Apr. 2018	Sep. 2018	Apr. 2019	Sep. 2019	Jun. 2020
Bagridae	*Bagrus docmak*	Catfish (Semutundu)	Kalange-Makwanzi		P			P																				
			Mid-Reservoir										P	P	P	P	P	P	P	P	P		P	P	P		P		P
			Buyala-Kikubamutwe		P		P								P	P						P				P			
Latidae	*Lates niloticus*	Nile perch (Mputa)	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
			Mid-Reservoir										P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
			Buyala-Kikubamutwe	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P	P	P		P
Characidae	*Brycinus jacksonii*	Victoria robber *(Nsoga)*	Kalange-Makwanzi																										
			Mid-Reservoir																										
			Buyala-Kikubamutwe	P																									
	B. sadleri	(Nsoga)	Kalange-Makwanzi	P																P				P		P			
			Mid-Reservoir																										
			Buyala-Kikubamutwe																										
Cichlidae	*Oreochromis esculentus*	Tilapia	Kalange-Makwanzi																									P	
			Mid-Reservoir																										
			Buyala-Kikubamutwe																										
	Oreochromis niloticus	Nile tilapia (Ngege-kibati)	Kalange-Makwanzi	P	P	P		P			P	P	P					P	P	P		P	P	P	P	P	P	P	P
			Mid-Reservoir												P							P							
			Buyala-Kikubamutwe	P	P	P	P	P		P			P	P	P	P	P									P	P	P	P	P
	O. leucostictus	Black tilapia (Ngege)	Kalange-Makwanzi	P	P																			P		P			
			Mid-Reservoir																										
			Buyala-Kikubamutwe	P	P		P																				P		
	O. variabilis	Tilapia (Ngege)	Kalange-Makwanzi	P	P	P	P	P	P	P	P		P	P	P	P			P	P		P	P	P	P	P	P	P	P
			Mid-Reservoir										P				P												
			Buyala-Kikubamutwe	P	P		P			P	P	P	P				P		P	P						P	P		
	Coptodon zillii	Red-belly tilapia (Ngege)	Kalange-Makwanzi	P	P	P	P	P	P	P	P		P	P	P	P				P		P	P	P	P	P	P	P	P
			Mid-Reservoir										P		P	P													
			Buyala-Kikubamutwe	P	P	P	P	P		P			P	P			P		P	P			P	P	P	P	P	P	P
	Haplochromines	(Nkejje)	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P	P
			Mid-Reservoir										P		P	P	P	P	P	P	P	P	P	P	P	P		P	P
			Buyala-Kikubamutwe	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P	P
Clariidae	*Clarias gariepinus*	Mudfish (Male)	Kalange-Makwanzi			P	P							P	P								P						
			Mid-Reservoir										P	P															
			Buyala-Kikubamutwe			P	P		P			P				P						P							

b)

Family names	Scientific names	English names/local names (Luganda)	Transects/Sites	Monitoring Dates																								
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
				Apr. 2006	Sep. 2007	Apr. 2008	Apr. 2009	Sep. 2009	Apr. 2010	Sep. 2010	Apr. 2011	Sep. 2011	Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017	Apr. 2018	Sep. 2018	Apr. 2019	Sep. 2019	Jun. 2020
Cyprinidae	*Labeobarbus altianalis*	Barbel fish (Kisinja)	Kalange-Makwanzi	P	P	P	P		P				P															
			Mid-Reservoir										P	P	P														
			Buyala-Kikubamutwe	P	P	P	P		P	P		P	P		P		P						P						
	Enteromius paludinosus	Barbel fish (Kisinja)	Kalange-Makwanzi																										
			Mid-Reservoir																										
			Buyala-Kikubamutwe	P																									
	Labeo victorianus	(Ningu)	Kalange-Makwanzi																										
			Mid-Reservoir																										
			Buyala-Kikubamutwe		P					P																			
	Rastrineobola argentea	Silver fish (Mukene)	Kalange-Makwanzi							P																			
			Mid-Reservoir																										
			Buyala-Kikubamutwe	P	P		P		P																				
Cyprinodontidae	*Aplocheilichthys pumilus*	Gambusia	Kalange-Makwanzi																										
			Mid-Reservoir																										
			Buyala-Kikubamutwe		P																								
Protopteridae	*Protopterus aethiopicus*	Lung fish (Mamba)	Kalange-Makwanzi						P																				
			Mid-Reservoir																										
			Buyala-Kikubamutwe				P																						
Mochokidae	*Synodontis afrofischeri*	Tiger fish (Nkolongo)	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
			Mid-Reservoir										P		P	P			P		P	P		P	P			P	
			Buyala-Kikubamutwe		P	P	P	P	P	P		P	P	P	P	P	P	P	P	P		P		P	P	P		P	P
	S. victoriae	Tiger fish (Nkolongo)	Kalange-Makwanzi			P		P	P		P			P	P	P	P	P		P									
			Mid-Reservoir										P	P		P		P	P	P		P	P	P	P	P			P
			Buyala-Kikubamutwe											P					P	P			P						P
Mormyridae	*Mormyrus kannume*	Elephant snout fish (Kasulubana)	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P
			Mid-Reservoir										P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
			Buyala-Kikubamutwe	P	P	P	P	P	P	P	P	P	P	P	P				P	P									P
	Gnathonemus longibarbis		Kalange-Makwanzi																										
			Mid-Reservoir														P		P										
			Buyala-Kikubamutwe																										
Total number of fish species			Kalange-Makwanzi	10	10	10	8	9	9	7	8	5	8	8	8	6	5	6	6	9	4	7	8	9	7	9	7	7	6
			Mid-Reservoir										10	7	8	7	6	5	7	5	5	6	5	6	6	7	6	4	5
			Buyala-Kikubamutwe	11	13	8	12	6	6	10	4	7	8	7	7	7	7	3	7	7	2	6	4	3	5	4	4	4	7

3.4.2 The Haplochromines

During the current monitoring-June 2020, five haplochromine cichlids were encountered, made up of three species and two other taxa; *Haplochromis* and *Pundamilia* (Tables 3.4.2 a, b & c). During the previous monitoring period- September 2019, 7 genera of haplochromines were recovered.

Tables 3.4.2 a, b and c *Haplochromine species recorded over time at the monitored sites*

a)

Genus	Species names	Tmsects/Sites	Monitoring Dates																								
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
			Apr. 2006	Sep. 2007	Apr. 2008	Apr. 2009	Sep. 2009	Apr. 2010	Sep. 2010	Apr. 2011	Sep. 2011	Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017	Apr. 2018	Sep. 2018	Apr. 2019	Sep. 2019	Jun. 2020
Astatoreochromis	*A. alluaudi*	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P								P	P		P	
		Mid-Reservoir																										
		Buyala-Kikubamutwe	P	P	P	P	P			P						P		P										
Astatotilapia	*A. brownae*	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
		Mid-Reservoir										P				P						P	P	P	P	P	P	P
		Buyala-Kikubamutwe		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P	P		
	A. "cylindrical"	Kalange-Makwanzi			P																							
		Mid-Reservoir																										
		Buyala-Kikubamutwe																										
	A. "elongate"	Kalange-Makwanzi	P	P	P	P	P	P	P																			
		Mid-Reservoir										P																
		Buyala-Kikubamutwe			P		P			P																		
	A. "purple dorsum"	Kalange-Makwanzi		P								P				P	P											
		Mid-Reservoir																										
		Buyala-Kikubamutwe												P	P													
	A. "red dorsum"	Kalange-Makwanzi				P	P		P		P		P											P	P			
		Mid-Reservoir																										
		Buyala-Kikubamutwe					P	P	P							P												
	Astatotilapia sp	Kalange-Makwanzi			P	P	P			P				P	P		P	P						P	P	P	P	
		Mid-Reservoir												P	P			P								P		
		Buyala-Kikubamutwe		P	P	P	P				P			P	P	P		P						P	P	P	P	
	A. nubila	Kalange-Makwanzi															P											P
		Mid-Reservoir																						P				
		Buyala-Kikubamutwe																P										
Gaurochromis	*Gaurochromis sp*	Kalange-Makwanzi		P																								
		Mid-Reservoir																										
		Buyala-Kikubamutwe																										
Haplochromis	*H. lividus*	Kalange-Makwanzi									P													P				
		Mid-Reservoir																										
		Buyala-Kikubamutwe																										
Harpagochromis	*H. guiarti*	Kalange-Makwanzi	P	P	P	P	P		P	P	P	P						P	P		P	P	P	P			P	
		Mid-Reservoir																										
		Buyala-Kikubamutwe	P		P	P	P		P			P	P			P		P					P			P		
	H. serranus	Kalange-Makwanzi																										
		Mid-Reservoir																										
		Buyala-Kikubamutwe	P																									

b)

Genus	Species names	Trnsects/Sites	Monitoring Dates																								
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
			Apr. 2006	Sep. 2007	Apr. 2008	Apr. 2009	Sep. 2009	Apr. 2010	Sep. 2010	Apr. 2011	Sep. 2011	Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017	Apr. 2018	Sep. 2018	Apr. 2019	Sep. 2019	Jun. 2020
Labrochromis	*L. humilior*	Kalange-Makwanzi		P																							
		Mid-Reservoir																									
		Buyala-Kikubamutwe																									
Lithochromis	*Lithrochromis sp*	Kalange-Makwanzi		P		P	P												P								
		Mid-Reservoir																									
		Buyala-Kikubamutwe					P												P								
Lipochromis	*L. microdon*	Kalange-Makwanzi					P																				
		Mid-Reservoir																									
		Buyala-Kikubamutwe																									
	L. parvidens	Kalange-Makwanzi			P			P																			
		Mid-Reservoir																									
		Buyala-Kikubamutwe							P			P															
Mbipia	*M. mbipi*	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P				P				P	P	P	P	P		P	
		Mid-Reservoir										P			P		P	P		P	P	P	P	P		P		
		Buyala-Kikubamutwe	P	P	P	P	P	P	P	P	P	P	P		P	P		P				P	P		P	P		
Neochromis	*N. "elongate"*	Kalange-Makwanzi										P																
		Mid-Reservoir																									
		Buyala-Kikubamutwe						P																				
	N. greenwoodi	Kalange-Makwanzi	P							P																		
		Mid-Reservoir																									
		Buyala-Kikubamutwe		P																							
	N. rufocaudalis	Kalange-Makwanzi		P	P	P	P	P	P	P		P															
		Mid-Reservoir										P			P	P											
		Buyala-Kikubamutwe		P																							
	Neochromis sp	Kalange-Makwanzi																						P			
		Mid-Reservoir																	P								
		Buyala-Kikubamutwe																P									
Paralabidochromis	*P. "black para"*	Kalange-Makwanzi				P			P			P															
		Mid-Reservoir														P											
		Buyala-Kikubamutwe			P						P																
	P. cyaneus	Kalange-Makwanzi																									
		Mid-Reservoir																									
		Buyala-Kikubamutwe	P																								
	P. "earthquake"	Kalange-Makwanzi	P				P			P																	
		Mid-Reservoir																									
		Buyala-Kikubamutwe	P																								
	P. flavus	Kalange-Makwanzi																									
		Mid-Reservoir																									
		Buyala-Kikubamutwe					P				P																
	P. rock kribensis	Kalange-Makwanzi					P				P												P				
		Mid-Reservoir																									
		Buyala-Kikubamutwe																									
	P. "scarlet anal"	Kalange-Makwanzi	P						P	P	P	P				P			P								
		Mid-Reservoir																									
		Buyala-Kikubamutwe					P										P										
	P. "yellow"	Kalange-Makwanzi																									
		Mid-Reservoir																									
		Buyala-Kikubamutwe	P																								
	Paralabidochromis sp	Kalange-Makwanzi	P																					P			
		Mid-Reservoir														P											
		Buyala-Kikubamutwe	P	P	P													P									
	P. crassilabris	Kalange-Makwanzi																P							P		
		Mid-Reservoir																									
		Buyala-Kikubamutwe																									

c)

Genus	Species names	Trnsects/Sites	Monitoring Dates																									
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
			Apr. 2006	Sep. 2007	Apr. 2008	Apr. 2009	Sep. 2009	Apr. 2010	Sep. 2010	Apr. 2011	Sep. 2011	Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017	Apr. 2018	Sep. 2018	Apr. 2019	Sep. 2019	Jun. 2020
Prognathochromis	*P. "shovel mouth"*	Kalange-Makwanzi	P	P			P	P	P	P	P																	
		Mid-Reservoir																										
		Buyala-Kikubamutwe				P			P			P	P															
Psammochromis	*P. aelecephalus*	Kalange-Makwanzi		P					P																			
		Mid-Reservoir																										
		Buyala-Kikubamutwe		P					P																			
	P. riponianus	Kalange-Makwanzi	P	P	P	P	P		P	P		P	P					P				P		P	P		P	P
		Mid-Reservoir												P		P				P			P	P				
		Buyala-Kikubamutwe	P		P		P		P				P	P	P	P		p					P		P		P	
	Psammochromis sp	Kalange-Makwanzi															P				P	P				P		
		Mid-Reservoir																										
		Buyala-Kikubamutwe															P									P		
Ptyochromis	*P. sauvagei*	Kalange-Makwanzi	P		P		P			P	P	P										P	P		P			
		Mid-Reservoir																										
		Buyala-Kikubamutwe	P		P				P					P									P					
	P. xenognathus	Kalange-Makwanzi																P										
		Mid-Reservoir																										
		Buyala-Kikubamutwe																										
Pundamilia	*P. "black"*	Kalange-Makwanzi		P	P	P	P	P	P	P	P																	
		Mid-Reservoir																										
		Buyala-Kikubamutwe					P	P																				
	P. "orange anal"	Kalange-Makwanzi		P																								
		Mid-Reservoir																										
		Buyala-Kikubamutwe																										
	P. igneopinnis	Kalange-Makwanzi										P																
		Mid-Reservoir																										
		Buyala-Kikubamutwe																										
	P. macrocephala	Kalange-Makwanzi										P																
		Mid-Reservoir																										
		Buyala-Kikubamutwe																										
	P. "orange tail"	Kalange-Makwanzi		P						P																		
		Mid-Reservoir																										
		Buyala-Kikubamutwe																										
	P. pundamilia	Kalange-Makwanzi										P																
		Mid-Reservoir																										
		Buyala-Kikubamutwe																										
	P. "red tail"	Kalange-Makwanzi	P			P																						
		Mid-Reservoir																										
		Buyala-Kikubamutwe				P																						
	Pundamilia sp	Kalange-Makwanzi		P																P	P	P	P	P	P	P	P	
		Mid-Reservoir																				P		P				P
		Buyala-Kikubamutwe																		P			P	P		P		
Xystichromis	*X. phytophagus*	Kalange-Makwanzi	P			P		P	P												P						P	
		Mid-Reservoir																		P								
		Buyala-Kikubamutwe									P																P	
Unidentified	Haplochromines	Kalange-Makwanzi				P																						P
		Mid-Reservoir																										
		Buyala-Kikubamutwe																										P
Total number of taxa		Kalange-Makwanzi	14	17	12	15	16	9	14	14	11	14	5	3	3	4	6	7	9	4	7	7	8	11	9	5	8	4
		Mid-Reservoir										4		2	3	5	1	2	5	5	1	3	3	6	1	3	1	2
		Buyala-Kikubamutwe	10	8	10	7	12	5	9	4	6	5	8	5	5	7	3	8	7	2	1	2	7	2	5	6	3	1

3.2.3 Catch rates / biomass estimates

Fish abundance as depicted by observations from the experimental gillnets was generally low, with seven of the eight detected species represented by 1-12 individuals only. Across the transects, Kalange-Makwanzi recorded the highest fish abundance by number (48.9%) followed by the mid-reservoir (44.2%). The abundance by number was dominated by *L. niloticus* and haplochromines (Table 3.4.3). The mid-reservoir had the highest fish abundance by weight (54.3%) followed by Kalange-Makwanzi transect (31.8%). The most dominant fish species by weight was *Lates niloticus* at both Kalange-Makwanzi and Buyala-Kikubamutwe while *M. kannume* was the most dominant at the mid-reservoir (Table 3.4.4).

Table 3.4.3 *Relative abundance (numbers) of fish species caught by gillnets during June 2020 monitoring*

Transects/sites	Kalange-Makwanzi	Mid-Reservoir	Buyala-Kikubamutwe
Bagrus docmak	-	7.2	-
Coptodon zillii	2.2	-	7.7
Haplochromines	30.4	12	7.7
Lates niloticus	59.8	65.1	53.8
Mormyrus kannume	1.1	12	7.7
Oreochromis niloticus	4.3	-	7.7
Oreochromis variabilis	2.2	-	-
Synodontis afrofischeri	-	-	7.7
Synodontis victoriae	-	3.6	7.7

Table 3.4.4 Relative abundance *(weight (g) of fish species caught by gillnets during June 2020 monitoring*

Transects/sites	Kalange-Makwanzi	Mid-Reservoir	Buyala-Kikubamutwe
Bagrus docmak	-	7.5	-
Coptodon zillii	1.7	0	8.4
Haplochromines	8.3	1.2	1.1
Lates niloticus	51.3	41.3	64.3
Mormyrus kannume	7.2	46.7	6
Oreochromis niloticus	22.1	-	14
Oreochromis variabilis	9.4	-	0
Synodontisafrofischeri	-	-	2.9
Synodontis victoriae	-	3.4	3.2

3.2.4 Fish species recovery

Since the April 2010 survey, the number of species so far recorded has remained at 63; therefore, there has been no new species added to the species list (Figure 3.4.1). The number of taxa (nine) detected in all stations during the present sampling event June 2020, is well below that found out in the earlier monitoring periods (Figure 3.4.1). The abundance of the taxa by number and weight, reflected in catch rates has generally decreased overtime. Rebuilding of abundance and conservation of the fish taxa are required. This requirement underscores the importance of strengthening habitat conservation in the Upper Victoria Nile. A big leap towards this has been taken by the Government of Uganda since the declaration of Kalagala-Itanda offset areas (EKIOA) as a forest reserve. Within the reserve aquatic biodiversity and fisheries will be sustainably managed, offsetting the impacts. The mitigation actions undertaken by BEL such as shoreline management should be strengthened by limiting fishing effort.

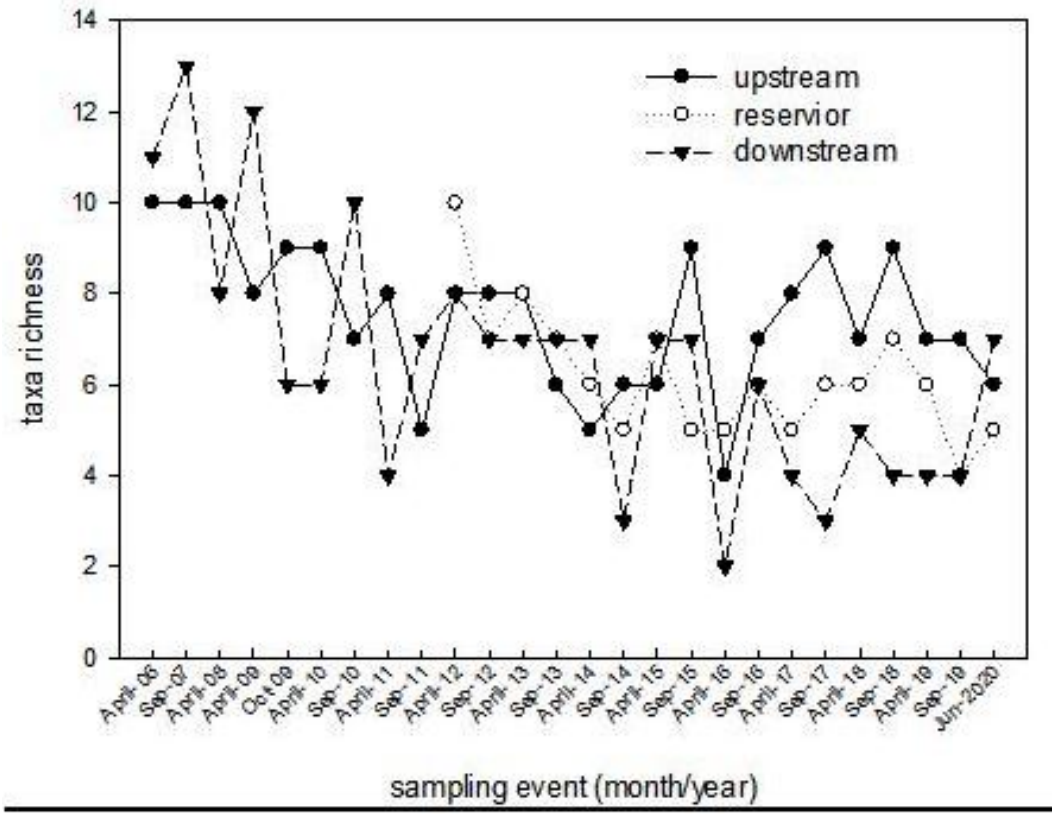

Figure 3.4.1 Cumulative *number of fish species recovered from the monitored transects on the Upper Victoria Nile over the monitoring period.*

3.5 The Food and Trophic Ecology of the Fishes

During the recent survey of June 2020, *Lates niloticus* was recorded from all the three transects. The diet of Nile perch from Kalange-Makwanzi transect comprised of 51.9 % *Caridina nilotica* and 48.1% fish. The fish prey included: 29.6% *Rastrineobola argentea*, 16.2% haplochromine cichlids and 2.2% unidentifiable fish material. However, during the previous survey of September 2019, Nile perch recorded from this transect only ingested haplochromine cichlids.
Diet of Nile perch from the mid-reservoir comprised of 84.1% *C. nilotica,* 6.8% fish and 9.1% unidentifiable insect material. The fish prey included: 3.8% *R. argentea* and 3.0% haplochromine cichlids. During the previous survey of September 2019 however, *R.argentea* was the only prey item for the species that was recorded at this transect. The food of Nile perch from Buyala-Kikuamutwe transect included 76.5% fish and 23.5% *C. nilotica*. The fish prey comprised of 52.9% *R. argentea* and 23.5% unidentifiable fish material. Differences in the diet of Nile perch was attributed to seasonal variation in availability of the prey items of the species.

Like Nile perch, *Mormyrus kannume* was recorded from all the three transects during this monitoring of June 2020. The species from Kalange-Makwanzi transect had ingested only Ephemeropteran nymphs. From the mid-reservoir transect, the diet of *M. kannume* comprised of 78% insects, 18.1% mollusc and 3.9% *C. nilotica*. The insect prey included 43.9% ephemeropteran nymphs, 25.8% odonata nymphs and 8.4% chironomid larvae. Dominance of insect prey in diet of *M. kannume* in the mid-reservoir was also observed during the previous survey of September 2019. The diet of *M..kannume* from Buyala-Kikubamutwe transect comprised of 80% ephemropteran and 20% odonata nymphs.

The Tiger fish, *Synodontis afrofischeri* was only recorded at Kalange-Makwanzi transect during the recent survey of June 2020 and its diet comprised of only ephemeropteran nymphs. However, in the previous survey of September 2019, the diet of the species from the same transect comprised of 60% ephemeroptera nymphs and 40% chironomid larvae.

Like the tiger fish, *Oreochromis variabilis* was only recorded at Kalange-Makwanzi transect during the current survey of June 2020, but the gut was empty. During the previous monitoring of September 2019, *O. variabilis* from the same transect had ingested 60% detritus, 17% diatoms, 15% high plant *material* and 8% blue-green algae.

During this monitoring- June 2020, the Nile tilapia, *Oreochromis niloticus* was recorded from Kalange-Makwanzi and Buyala-Kikubamutwe transects. The food of the species from Kalange-Makwanzi comprised of 30% high plant material, 20% detritus, 15% diatoms, 10% bluegreen algae, 10% ostracods and 5% green algae. .In Transect 2, the diet of the species from Buyala-Kikubamutwe included: 45% detritus, 15% high plant

material, 15% ostracods, 12% diatoms, 7% bluegreen algae and 6% green algae. In the previous monitoring of September 2019, the diet of *O. niloticus* recorded from the same transect was dominated by high plant material.

Table 3.5.1 *Dominant food types of common fish species caught over time at monitored sites*

Family name	Species scientific name	English (local) name	Sites/transects	Monitoring dates															
				10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
				Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017	Apr. 2018	Sep. 2018	Apr. 2019	Sep. 2019	Jun. 2020
Bagridae	*Bagrus docmak*	*Cat fish (semutundu)*	Kalange-Makwanzi			E	E						CRB		CG					
			Mid-Reservoir	SYN	CAR	SYN	CAR	FR	Hap	CAR	LN	RAS	E	ODT	CG	CAR		CAR		RAS
			Buyala-Kikubamutwe				FR						FR				CHR			
Centropomidae	*Lates niloticus*	*Nile perch (Mputa)*	Kalange-Makwanzi	HAP	ODT	LN	HAP	HAP	RAS	HAP	CAR	LN	HAP	CAR	HAP	HAP	CAR	HAP	HAP	CAR
			Mid-Reservoir	RAS	CAR	RAS	CAR	CAR	CAR	CAR	CAR	RAS	CAR	CAR	CAR	CAR	CAR	RAS	RAS	CAR
			Buyala-Kikubamutwe	FR	CRB	HAP	HAP	HAP	RAS	HAP	HAP	RAS	HAP	RAS	E	RAS	HAP	HAP		RAS
Cichlidae	*Oreochromis niloticus*	*Nile tilapia (engege kibati)*	Kalange-Makwanzi	MOL				HPM	E	E	E		HPM	DETR	DETI	BGA	DETR	DETR	E	HPM
			Mid-Reservoir			CHA							IR							
			Buyala-Kikubamutwe	INS	EPH	EPH	HPM	BGA								E		EPH	HPM	DETR
	O. variabilis	*Black tilapia (engege)*	Kalange-Makwanzi	BGA	BGA	INS	DETR	BGA		DETR	BGA		DET	DETR	BGA	E	E	EPH	DETR	E
			Mid-Reservoir					BGA												
			Buyala-Kikubamutwe	BGA				BGA		E	DETR						E	HPM		
	Coptodon zillii	*Red belly tilapia (engege)*	Kalange-Makwanzi	EPH	E	HPM		ODT			DETR		HPM	HPM	HPM	HPM		EPH	E	E
			Mid-Reservoir	E		E	E													
			Buyala-Kikubamutwe	EPH	HPM		HPM	HPM		HPM	HPM			E	HPM	HPM	CHR	EPH	E	E
Claridae	*Clarias gariepinus*	*mud fish (Male)*	Kalange-Makwanzi		E	MOL	MOL							CRAB						
			Mid-Reservoir	EPH	EPH								E							
			Buyala-Kikubamutwe				EPH						E							
Cyprinidae	*Barbus altianalis*	*Barbel fish (Kisinja)*	Kalange-Makwanzi	DETR																
			Mid-Reservoir	MOL	MOL	MOL														
			Buyala-Kikubamutwe			MOL		E					E							
Mochokidae	*Synodontis afrofischeri*	*Tiger fish (Nkolongo)*	Kalange-Makwanzi	MOL	EPH	EPH	CHR	CHR	CHR	EPH	CHR	CHR	EPH	CHR	CHR	EPH	CHR	E	EPH	
			Mid-Reservoir	CHR		EPH	EPH			CHR		EPH	EPH		EPH				CHR	
			Buyala-Kikubamutwe		EPH	EPH	EPH	CHR	E	EPH	ODT		EPH		E	EPH	CHR		EPH	EPH
Momyridae	*Mormyrus kannume*	*Elephant snout fish (kasulubana*	Kalange-Makwanzi	EPH	CHR	EPH	EPH	CHR	EPH	CHR	EPH	CHR	CHR	CHR	E	EPH	E	E		EPH
			Mid-Reservoir	EPH	EPH	CHR	EPH	CHR	CHR	MOL	CHR	EPH	EPH	CHR	MOL	CHR	CHR	EPH	EPH	CHR
			Buyala-Kikubamutwe	E	ODT	INS				E	CHR					INS				EPH

Food types: *HAP = Haplochromines, FR = Unidentifiable fish remains, CAR = Caridina nilotica, MOL = Mollusk, BGA = Blue-green algae, GRA = Green algae, EPH = Ephemeroptera, INS = Unidentifiable insect material, HPM = High plant material (water weeds), E = Empty stomachs, ODT = Odonata*

3.3.1 Maturity and Breeding

During this monitoring - June 2020, signs of breeding activity were observed in five fish species namely: *L. niloticus, M. kannume, O. niloticus, Bagrus docmack* and *Coptodon zillii*. Three species respectively from Kalange-Makwanzi and mid-reservoir transects were found in high breeding state and two from Buyala-Kikubamutwe transect. The species that indicated signs of breeding at Kalange-Makwanzi included: *M. kannume, O. niloticus* and C. *zillii.* At the mid-reservoir, signs of breeding were recorded in *M. kannume, L. niloticus* and *B.docmack* whereas at Buyala-Kikubamutwe , fish breeding

activity was only recorded in *O. niloticus* and C. *zillii* In the previous monitoring of September 2019, signs of breeding activity were observed in only three fish species. Fish breeding at Kalange-Makwanzi during June 2020 was found in 3 species and in 2 species during the previous monitoring of September 2019. At In Buyala-Kikubamutwe, no breeding activity was recorded during September 2019. At the mid-reservoir, the number of fish species in breeding condition during this monitoring of June 2020 was 3 species and 2 species during September 2019 were in breeding state.

Table 3.5.2 *Proportion (%) of breeding fishes over time among commonly encountered fish species at monitored sites*

Family name	Species scientific name	English (local) name	Sites/transects	Monitoring date																
				10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
				Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016	Sep. 2016	Apr. 2017	Sep. 2017	Apr. 2018	Sep. 2018	Apr. 2019	Sep. 2019	Jun. 2020
Bagridae	*Bagrus docmak*	*Cat fish (semutundu)*	Kalange-Makwanzi		0	0	0						0		100					
			Mid-Reservoir	50	25	40	14.3	0	0	20	30	0	0	0	100	100				
			Buyala-Kikubamutwe		0	0	0						0							
Centropomidae	*Lates niloticus*	*Nile perch (Mputa)*	Kalange-Makwanzi	0	0	0	0	0	0	4.3	5.6	0	0	0	0	15	0	0	0	0
			Mid-Reservoir	1	0	7.1	0	0	8.3	2.4	0	8	8	0	4	0	0	0	0	12
			Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
Cichlidae	*Oreochromis niloticus*	*Nile tilapia (engege kibati)*	Kalange-Makwanzi	0				6.7	100	0	0		100	40	0	48.5	0	33.3	0	33.3
			Mid-Reservoir			0	0						0					0	0	0
			Buyala-Kikubamutwe	0	0	60	0	10.5								0	0	0	0	100
	O. variabilis	*Black tilapia (engege)*	Kalange-Makwanzi	0	0	14.3	45.5	46.2		0	33.3		75	30	25	50	0	52.4	0	0
			Mid-Reservoir					0										0	0	
			Buyala-Kikubamutwe	0				11.1		0	100									
	Coptodon zillii	*Red belly tilapia (engege)*	Kalange-Makwanzi	33.3		0	0	57.1			0		0	37	25	29	0	33.3	28.2	50
			Mid-Reservoir			0	0													
			Buyala-Kikubamutwe	0			75	6.1		0	50			50	0	0	0	5.3	0	100
Claridae	*Clarias gariepinus*	*mud fish (Male)*	Kalange-Makwanzi		0	0	50							50						
			Mid-Reservoir	0	0								50							
			Buyala-Kikubamutwe				0						0							
Cyprinidae	*Barbus altianalis*	*Barbel fish (Kisinja)*	Kalange-Makwanzi	0																
			Mid-Reservoir	50	50	0														
			Buyala-Kikubamutwe			50		0					50							
Mochokidae	*Synodontis afrofischeri*	*Tiger fish (Nkolongo)*	Kalange-Makwanzi	7.9	35.3	34	68	54.8	98.8	100	96.4	100	92.6	40.2	83.3	100	68.3	0	0	0
			Mid-Reservoir	6.7	12.5	16.7	25			33.3		25	0	0	60	75			100	100
			Buyala-Kikubamutwe	0		70	100	16.7	100	100	87.5		100	0	0	0	50		0	0
Momyridae	*Mormyrus kannume*	*Elephant snout fish (kasulubana*	Kalange-Makwanzi	17.6	33.3	45.5	28.6	25	0	38.9	25	25	100	50	100	30	0	33.3		100
			Mid-Reservoir	25	44.2	42.1	44.4	61.9	88.9	25.8	18.9	56.3	24.6	64	83.3	48	50	33.3	20.2	70
			Buyala-Kikubamutwe	0	33.3	100				100	100									

Major observations

Compared to the previous monitoring - September 2019, a dietary shift from that dominated by fish prey to one dominated by *Caridina nilotica* for Nile perch has been observed at Kalange-Makwanzi and mid-reservoir transects during the recent survey of June 2020. At Buyala-Kikubamutwe , *R. argentea* was the major prey for Nile perch during June 2020.

During this monitoring period, the diets of *S. afrofischeri* and *M. kannume* were dominated by insect prey as was also observed in previous period- September 2019.

The diet of *O. variabilis* at Kalange-Makwanzi in the previous period- September 2019 was dominated by detritus whereas in the recent one of June 2020 the examined specimens had empty guts.

The diet of *O, niloticus* from Kalange-Makwanzi was dominated by high plant material in June 2020 whereas in the previous period-September 2019, the specimens examined had empty guts. At Buyala-Kikubamutwe, the diet of *O. niloticus* was dominated by detritus material in June 2020 whereas in the previous period- September 2019, the species had ingested mainly high plant material.

Lastly, breeding condition at the three transects was found in 5 fish species during this monitoring period-June 2020 whereas during September 2019, it was noted in 3 fish species.

3.6. THE COMMERCIAL FISHERY

Since 2006 to-date, fish stocks of natural fish populations of the UVN have been monitored using Fish Catch Assessment Surveys (CAS) and Frame surveys to estimate fishing effort, catchability coefficients (a measure of fishing mortality) and fishery yield before, during and after the construction of Bujagali Hydro Power Dam. The aim of these monitoring surveys is to assess impacts of the dam on the fisheries and livelihoods of the dependent communities. Arreguín-Sánchez, 1996 used fishing effort and catchability coefficients as indicators of impact change on the fisheries and livelihoods of the dependent communities. Compared to pre-dam construction period, the Bujagali dam reservoir is now associated with slight increase in fishing effort and fish yields, especially for the introduced Nile perch. This monitoring report documents the pre- and post-dam construction trends in in the commercial fisheries (fishing effort, fish catches and socio-economics) as a basis for monitoring the hydropower dam impacts on the fisheries and riparian community livelihoods.

3.6.1 Fishing effort in the fishery

There were 75 fishing boats at the three transects during the June-2020 monitoring, indicating a 42 % decline in comparison to those recorded during September, 2019 (Table 3.6.1a). The Mid-reservoir registered the highest number of fishing boats (32.42%). The decline in fishing crafts across the three transects could be attributed to increased volumes of water being released from the Upstream dams; Kiira and Nalubale estimated at >2000 m^3/s due to the rising water levels in Lake Victoria (UNMA, 2020). The changes in Lake Victoria environment have direct impacts on physical-chemical and biological conditions along the river Nile including the fisheries activities (Plates.3.6.1 & 3.6.2).

***Table 3.6.1a**. Trends in numbers of fishing boats using particular fishing gears at sites that are monitored.*

Number of fishing gears in use	Sites	Monitoring periods																							
		Apr-09	Sep-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18	Apr-19	Sep-19	Jun-20
Total number fishing boats	Kalange-Makwanzi	22	18	23	23	18	32	15	20	19	24	27	27	32	25	40	31	37	45	25	29	42	35	30
	Mid-Reservoir	-	-	-	-	-	-	16	13	18	27	44	60	38	51	46	48	41	22	29	67	32	62	32
	Buyala-Kikubamutwe	26	32	23	15	12	15	34	19	28	40	20	32	25	21	18	14	21	11	13	20	79	33	13
Number of boats using gillnets	Kalange-Makwanzi	10	6	7	13	6	8	9	9	7	12	15	9	6	10	3	11	7	9	7	4	2	6	6
	Mid-Reservoir	-	-	-	-	-	-	13	3	4	12	20	21	13	12	11	9	10	6	5	5	7	4	0
	Buyala-Kikubamutwe	7	6	1	2		1	4	2	7	3	1	10	1	4	7	3	-	1	1	1	26	0	1
Number of boats using long line hooks	Kalange-Makwanzi	3	1	2	2	0	2	1	4	6	5	8	5	3	4	3	6	-	5	4	2	9	7	10
	Mid-Reservoir	-	-	-	-	-	-	1	0	-	5	-	6	6	2	7	6	3	-	3	6	0	10	3
	Buyala-Kikubamutwe	6	6	13	6	3	7	10	7	-	-	-	-	6	-	4	3	3	-	-	-	9	0	5
Number of boats using cast nets	Kalange-Makwanzi	-	5	4	1	1	5	1	0	3	3	2	6	5	2	5	4	6	6	5	5	6	3	5
	Mid-Reservoir	-	-	-	-	-	-	0	0	-	2	-	-	2	7	3	2	10	-	-	7	7	0	0
	Buyala-Kikubamutwe	6	3	1	1	3	0	7	2	-	2	-	-	7	-	1	3	1	-	-	-	6	5	0
Number of boats using Hand line hooks	Kalange-Makwanzi	9	5	4	2	6	8	3	3	1	3	1	1	4	-	6	3	10	2	3	6	5	4	0
	Mid-Reservoir	-	-	-	-	-	-	1	7	3	0	16	23	9	14	9	13	13	12	11	20	12	20	4
	Buyala-Kikubamutwe	9	14	9	2	2	3	12	5	2	5	5	7	3	17	3	2	2	5	1	4	-	6	0
Number of boats using scoop nets	Kalange-Makwanzi	-	1	6	4	4	4	1	2	3	2	-	-	4	-	-	-	2	-	-	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	6	3	12	8	8	8	8	-	10	16	9	-	-	7	4	1	3
	Buyala-Kikubamutwe	1	1	-	1	2	1	1	0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of boats using Traps	Kalange-Makwanzi	-	-	-	-	-	-	-	0	-	0	-	5	7	7	7	3	12	21	14	9	19	15	9
	Mid-Reservoir	-	-	-	-	-	-	-	0	-	0	-	-	-	1	6	2	3	3	6	19	3	15	2
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	11	20	30	14	15	8		21	6	15	5	12	15	33	22	7
Number of boats using Small seine.	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	1	3	2	2	4	2	2	3	3	1	0	0
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	3	-	-	3	6	11	18
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-



***Plate 3.6.1.** A fisherman returning from a fishing expedition at Kalange fish landing site on the UVN.*

The fishers reported loss of fishing gears and crafts due to the increased water levels and fast running waters for the reason that it was difficult to propel fishing boats during fishing operations and some fishers had to abandon fishing to search for alternative livelihood options. Fishers usually migrate between fishing areas in search for areas with better fish catches and fish prices (Gehrke et al., 2002; Lwenya *et al.,* 2009; Binet et al., 2012; Njock & Westlund, 2008), but the impacts of rising water levels have affected entire UVN system, with landing sites and river banks piled with tree trunks carried by water (Plate 3.6.3). During this monitoring period-June 2020, fishers' migrations were limited and difficult to fish normally. Prior knowledge about fish migrations informs the migration patterns of fishers while others opt out completely from fishing for alternative livelihood sources. The general decrease in number of fishing boats at all transects are therefore associated to loss fishing gear and opting out of fishing by some fishers due to the rising water levels and flooding of river banks.



Plate 3.6.2. *Fishers at Kalange (Upstream transect) returning with empty basket traps*

In terms of vessel gear combinations, the mid-reservoir registered the highest number (6) of gear categories. There were 6 boats using gillnets at Kalange-Makwanzi transect and one at Buyala-Kikubamutwe transect (Table 3.6.1 b). At the mid-reservoir, the fishing boats using small seines increased by 63% from the September 2019 monitoring period. There were no boats using this gear at Kalange-Makwanzi transect and Buyala-Kikubamutwe transects (Table 3.6.1c/0. Fishing boats using Hand line hooks drastically decreased by 87% across the three transects, four boats were recorded at the mid-reservoir and no boat was registered at Kalange-Makwanzi transect and Buyala-Kikubamutwe transects during June 2020 (Table 3.6.1c.). Most of the gears used were undersize and therefore illegal (Table 3.6.1 b-c). The choice of fishing gear at a particular fishing ground is influenced by target fish species, cost of fishing gear, catch per unit of effort (CPUE) and fishing habitat (Hovgêrd and Lassen,2008). However, the drastic changes of water levels characterized by high velocity along the river may have impacted

on fishing gears and fishing methods used (Odhiambo, 2013). Fishing was concentrated close to the river banks and sheltered bays, which have slow water velocity compared to middle parts of the river. The decline in numbers and composition of fishing gear encountered at each of the transect on the UVN is therefore, an indication of adverse effects of high water levels characterized by high water velocities. Additionally, the species such as *Mormyrus kannume* that had been previously fished mainly as live baits using basket traps registered tremendous decline in fishing effort (number basket traps) at the three transects, yet this has been the main fishery on UVN since 2016.

Eight fishing gear types were used in the harvest of fish along the UVN (Tables 3.6.1 a-c). The Longline hooks and basket traps were the most dominant gear across all transects (Table 3.6.1c). At Kalange-Makwanzi, long lines recorded the highest number of individual gear units, followed by the basket traps, which were also the most dominant gear at Buyala-Kikubamutwe transect. Fifty six gillnets were recorded at Kalange-Makwanzi, 54 at the mid-reservoir and 2 at Buyala-Kikubamutwe (Table 3.6.1b). All gillnets were below 2.5 inches mesh size. The small seine (lamapra) nets and Scoop nets were only encountered at the mid-reservoir transect where they were involved exclusively in harvesting *Rastrineobla argentea* (mukene) (Table 3.6.1c). Cast nets were exclusively recorded at Kalange-Makwanzi and monofilament gill-nets at the mid—reservoir (Table 3.6.1 c).

The undersized and illegal gillnets along the UVN were evident of unsustainable fisheries exploitation, targeting mainly the immature individuals of the target species (e.g. *Nile perch, Tilapia spp, Labeo spp, Barbus spp,* and *Mormyrus kannume*). These exploitation patterns could lead to the collapse of the target species if no management interventions are enforced. The composition and distribution of fishing effort (boats, fishing gears and gear sizes) at the three monitored sites during the June 2020 compared to the previous monitoring of September 2019 declined. The catches too reduced, which had a direct bearing on the livelihoods of the dependent communities. Fishers often change fishing gears and grounds as they respond to seasonal variations in catches of the target species. They switch between fishing gear and methods depending on presence and abundance of the target species and can even abandon a particular gear(s), gear sizes and fishing ground when the catch of the target species drastically reduce (Lwenya et al., 2009; Binet et al., 2012; Njock & Westlund, 2008).

Boats using small seines at the mid-reservoir increased and individual fishing units of longline hooks drastically increased at Kalange-Makwanzi and Buyala-Kikubamutwe (3.6.1 c). The reason why fishing effort shifted to the use of longlines hooks as main gear is because they endure high water velocities which happened during this monitoring period-June 2020. Fishers indicated that with this fishing gear, and setting hooks along river banks, large fish species are caught which imply that most of fish species might have shifted and concentrated along river banks.

The choice of fishing gear at a particular fishing ground is influenced by the target fish species, the cost of fishing gear, the catch per unit of effort (CPUE), the habitat and the suitability of the gear with respect to that particular site (Hovgêrd & Lassen, 2008). The fishing gears encountered at the three sites during the current survey could therefore give an insight of the possible target fish species at those sites. It should be noted that the choice of target species determines the choice of fishing gear(s) to use in exploitation.

Table 3.6.1 b. *The trend in numbers of gillnets per mesh and total number per boat at sites* that are monitored

Average number of gillnets per mesh per boat	Sites	Monitoring periods																						
		Apr-09	Sep-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18	Apr-19	Sep-19	Jun-20
Gillnets - ≤2½"	Kalange-Makwanzi	-	1			4		2	0		1	11	2	8	1	6	19	5	14	10	4	-	4	54
	Mid-Reservoir	-	-	-	-	-	-	0	0		0	8	3	9		3	8	13	20	10	-	-	-	-
	Buyala-Kikubamutwe	-	10		2	-	-	0	0	12	0		38		11	-	-	-	3	3	0	53	-	2
Gillnets 3"	Kalange-Makwanzi	-	3	1	6	-	-	8	0		10	4	15	6		13	6	2	1	1	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	0	4		16	5	39	35	9	12	19	13	3	3	2	-	-	-
	Buyala-Kikubamutwe	4	-	-	9	-	-	10	0		0			15		7	6	-	-	-	2	41	-	-
Gillnets 3½"	Kalange-Makwanzi	-	1	1	4	-	5	16	0		0	1	3	1	8	-	1	-	-	-	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	0	3		12	7	16	5		16	8	7	-	-	-	-	-	-
	Buyala-Kikubamutwe	-	-	-	-	-	-	3	11	3	0	-	-	-	-	-	-	-	-	-	3	-	6	-
Gillnets 4"	Kalange-Makwanzi	21	8	2	26	20	20	10	0	-	18	35	17	1	-	6	3	-	3	-	11	-	4	-
	Mid-Reservoir	-	-	-	-	-	-	0	0	-	5	98	16	1	-	-	-	15	11	-	-	-	-	-
	Buyala-Kikubamutwe	-	-	1			13	0	0	-	0	10	-	-	-	-	-	-	-	-	-	-	-	-
Gillnets 4½"	Kalange-Makwanzi	5	-	-	2	2	12	4	0	-	0	3	-	-	-	-	-	-	-	-	-	4	-	
	Mid-Reservoir	-	-	-	-	-	-	0	0	-	0	-	8	1	-	-	3	5	-	-	-	-	-	-
	Buyala-Kikubamutwe		6	1	-	-	-	0	0	-	12	-	-	-	-	-	-	-	-	-	-	5	-	-
Gillnets 5"	Kalange-Makwanzi	12	1		-	-	-	1	0	-	0	3	-	-	-	-	-	-	-	-	-	-	100	-
	Mid-Reservoir	-	-	-	-	-	-	14	0	-	0	-	1	-	-	-	2	10	-	-	-	-	-	-
	Buyala-Kikubamutwe	-	-	-	-	-	5	0	0	-	0	-	-	-	-	-	3	-	-	-	-	-	-	-
Gillnets 6"	Kalange-Makwanzi	-	-	-	4	-	8	-	2	-	8	-	-	-	-	-	-	-	-	6	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	22	0	-	0	-	-	-	32	-	-	-	-	-	6	-	-	-
	Buyala-Kikubamutwe	18	15	-	-	-	-	-	0	9	0	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillnets 6½"	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillnets 7"	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	8	-	-	-
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillnets 8"	Kalange-Makwanzi	-	-	-	-	-	-	-	0	8	0	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	0	0	0	-	-	-	-	-	-	-	-	-	-	-		
Total gillnets	Kalange-Makwanzi	38	20	24	42	28	43	41	2	8	37	57	37	16	18	25	29	7	18	29	7	5	14	54
	Mid-Reservoir	-	-	-	-	-	-	36	7	0	33	118	87	51	32	31	40	63	34	13	19	-	108	-
	Buyala-Kikubamutwe	22	37	4	11	-	18	13	11	24	12	10	38	15	11	7	6	-	3	3	2	124	-	2

***Table 3.6.1c**. The trend in numbers of fishing gear types per boat at monitored sites.*

Average number of fishing gear types per boat	Sites	Monitoring periods																						
		Apr-09	Sep-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18	Apr-19	Sep-19	Jun-20
Long line hooks	Kalange-Makwanzi	550	200	650	280	-	500	70	800	687	860	1360	950	230	626	250	1060	910	440	650	233	910	350	1050
	Mid-Reservoir	-	-	-	-	-	-	50	-	-	70	-	580	378	200	140	154	112	-	55	88	-	645	70
	Buyala-Kikubamutwe	277	180	380	142	110	482	525	420	-	-	-	-	1100	420	56	420	300	-	-	-	1096	-	180
Cast nets	Kalange-Makwanzi	-	5	4	1	1	5	1	0	-	3	2	6	5	2	5	3	6	6	5	5	6	3	5
	Mid-Reservoir	-	-	-	-	-	-	0	0	-	2	-	-	2	7	3	2	-	-	-	7	-	-	-
	Buyala-Kikubamutwe	6	3	1	1	3		7	2	2	2	-	-	7		1	3	1	-	-	-	13	5	-
Hand line hooks	Kalange-Makwanzi	105	124	26	3	18	88	35	4		26	2	10	35		30	1	10	12	15	61	20	9	50
	Mid-Reservoir	-	-	-	-	-	-	6	14			69	276	65	218	50	73	61	36	85	83	103	224	6
	Buyala-Kikubamutwe	97	152	32	16	8	5	51	24	2	5	5	39	18	63	18	-	4	15	10	14	-	66	-
Scoop nets	Kalange-Makwanzi	-	1	6	4	4	4	1	2	3	2	-	-	4		-	-	2	-	-	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	6	3	12	8	8	8	8	15	10	16	9	-	-	7	2	1	3
	Buyala-Kikubamutwe	1	1		1	2	1	1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Small seine nets	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	3	3	2	2	4	2	2	3	3	1	-	-
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	3	-	-	3	2	59	109
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-
Monofilament nets	Kalange-Makwanzi	-	-	-	-	-	-	0	29	15		38		16		25	24	23	18	15	7	2	-	-
	Mid-Reservoir	-	-	-	-	-	-	21	0	13	3	113	56	47	43	28	34	30	34	30	2	12	-	3
	Buyala-Kikubamutwe	-	-	-	-	-	-	0	0	-	-	4				7	10	12	3	2	2	-	-	-
Number of Traps	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	43	48	1	124	41	189	110	164	192	407	303	180
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	10	105	22	44	36	59	207	8	215	12
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	56	151	461	460	190	97	55	39	53	127	29	62	175	601	272	100

3.6.2. Fish catch composition and catch rates

Fish catch composition

Eight commercial fish types (*Lates niloticus, Oreochromis niloticus, Coptodon zillii, Bagrus docmak, Mormyrus kannume, Synodontis afrofischeri, Rastrineobola argentea,* and Haplochromines group), were recorded at the three transects during the June 2020 monitoring (Table 3.6.2*)*. The species belong to six families (Bagridae, Latidae, Cichlidae, Cyprinidae, Mochokidae, and Mormyridae). Two species; *Lates niloticus* and *Bagrus docmac* were recorded at all the three transects. Compared to the September 2019 monitoring, the catches for *O. niloticus* and *C. zillii* declined at the transects they were present. Six species were recorded at Buyala-Kikubamutwe, 5 at Kalange-Makwanzi and 3 at mid-reservoir transect. Composition of fish species encountered at transects flacuatated with commercial species e.g. *O. niloticus* and *M. kannume* species completely missed in catches landed at the mid-reservoir transect (Table 3.6.2). Generally, only five species (*B. docmak*, *L. niloticus*, *O. niloticus*, *C. zillii* and *M. kannume*) have consistently appeared in the commercial catch at the three transects for at least every monitoring period since 2009 (Table 3.6.2). During this monitoring–June 2020, *Rastrineobola argentea* dominated catches at mid-reservoir transect despite the rise in river water levels and flow speed. Since 2009, *Labeobarbus altianalis, Labeobarbus victorianus,*

Protopterus aethiopicus, O. leucostictus, and O. variabilis have been inconsistent in the commercial catches from the three transects of UVN.

Upstream to downstream fish migratory routes and patterns of spawning stocks are affected by obstructions due to Hydropower dams, interfering with the spawning and breeding patterns hence affecting stock recruitment (Jellyman and Harding, 2012; Smokorowski and Pratt, 2007). Eventually, populations for the intolerant species decline and may collapse completely. There is therefore need to design specific mitigation measures and management interventions prior to river damming. The highest number of 15 species was recorded in 2014. During the previous monitoring period- September 2019 and June 2020, eight species have been recorded.

Fish catch rates (kg/boat/day)

During this current monitoring-June 2020, catch per unit effort (CPUE) for most fish species landed declined at the three transects (Table 3.6.2). A CPUE of 13.8 kg for *R. argentea* was recorded and the highest registered during June 2020 monitoring. However compared to the highest CPUE during September 2019, a drop of 61% has been enlisted. CPUE of 4.41kg/boat/day for *L. niloticus* was recorded at the mid-reservoir during this monitoring-June 2020, 12% more compared to the CPUE during in September 2019. There was a decline in the CPUE of *Bagrus docmak* at all three transects. The CPUE of *S. afrofischeri* declined at Kalange-Makwanzi and Buyala-Kikubamutwe transects (Table 3.4.2). There was a slight increase (13%) in catches for *R. argentea* at the mid-reservoir transect. The CPUE for *O. niloticus* at Kalange-Makwanzi transect during June 2020 was lower than that during September 2019 (Table 3.6.2).

A major concern to fisheries biologists, conservationists and managers is that hydropower dams influence fish populations with negative effects such as diversion of water volume and flow, sedimentation, changes in fish species composition, community assemblages (relative abundance and species diversity) and catch rates (Hortle & Nam, 2017). Some populations may increase in number because they able to adapt to new habitat conditions, others may be decimated to even extinction (Agostinho, et al., 2008).The barriers created by the dams obstruct and interfere with the migratory patterns of aquatic organisms during spawning periods (Hafiz, et al., 2014; Hall, Jordan, & Frisk, 2011; and Roberts, 2001) and affect fish recruitment and growth (Agostinho, et al , 2008; Lin , 2011). This hinderance to fish migration negatively affect breeding process by restricting access to suitable breeding grounds and sometimes limits acess to preffered mates.

The banks of UVN have been eroded (Plate 3.6.4a & 3.6.5) through soil erosion leading to siltation, sedimentation and washing away plants and vegetation where fish and fish prey anchor. These habitats serve as breeding and spawning areas for most species. The increased water flow due to opening and closure turbines at the upstream dams might also have a part to play in the observed changes especially on the ecological and biological

performances of fish species. Sudden change of river ecology, environmental and physical parameters affect the fish catches and productivity (Ligon, Dietrich, and Trush, 1995).



Plate 3.6.4 Risen water levels at some of the sites at the transects that are monitored.

The reservoir created between the Dam and upstream transect in 2012 after completion of the dam construction could have continuously impacted the fisheries activities i.e. supporting some species communities and assemblages tolerant to lentic habitats. These could be immediate and long term impacts resulting from hydropower dam construction in the monitored area. Such post-dam construction effects do not only affect species diversity, distribution and abundance, but also adversely affect the riparian fisher communities whose livelihoods are either directly or indirectly derived from fishing and fishery related jobs. Some riverine commercial species such as *P. aethiopicus, C.* gariepinus, *O. variablis, O. leucosticus, L. victorianus* have consistently not been recovered in commercial catches and were absent in June 2020 survey. There is need for a strategic management and conservation plan for the fisheries in the study area.

Hydro-power dams create barriers that obstruct migratory patterns of aquatic organisms. Some riverine fish species move between upstream and the downstream sites during spawning periods (Hafiz, et al., 2014; Hall, Jordan, & Frisk, 2011; and Roberts, 2001) and as such dams affect fish populations and hence their construction and operation are a major concern to fisheries biologists, conservationists and managers. Some of the

negative effects of dam construction include diversion of water flow and volume, sedimentation (Hortle and Nam, 2017), changes in fish composition and community assemblages, catch rates, relative abundance and species diversity. Some populations may increase in numbers, others will decline or even go extinct (Agostinho *et al.*, 2008). Water flow stimulates ovulation and spawning process but barriers created across riverflow obstruct fish movement and migration patterns, which then can affect breeding process, limit access to suitable breeding grounds and sometimes limits access to preffered mates hence affecting fish recruitment and growth (Agostinho *et al.* , 2008; Lin , 2011). Thus, species able to adapt to new habitat conditions can survive while those unable can be completely wiped out.

The number of fish species has reduced from 14 species in 2009 to eight species currently. This observation concurs with Agostinho et al., (2007), who explained that species composition tend to increase during the initial stages of the reservoir creation due to the mixture of local fish assemblages formerly distributed in a range of fluvial environments become flooded and homogenized. During these monitoring periods, it has been observed that at the mid-reservoir, more species are being recovered; this change could be an attributed to the creation of lentic-like environmental conditions, which community of fish assemblages is adapting to. Such post-dam construction effects do not only affect species diversity, distribution and abundance, but also impact negatively on the riparian fishers whose livelihoods are either directly or indirectly derived from fishing and fishery related jobs on the UVN. Some commercial species e.g. *P. aethiopicus* previously landed has remained absent. There is need for a strategic management and conservation plan for the fisheries in the study area.

Table 3.6.2 *Trend of fish catch rates (kg/boat/day) of the main fish species from all gears at the monitored sites*

Family name	Species name (Luganda	Sites/Transects	Monitoring periods																						
			Apr-09	Sep-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18	Apr-19	Sep-19	Jun-20
BAGRIDAE	*Bagrus docmak* (Semutundu)	Kalange-Makwanzi	0.4	0.27	0.08	0.15	0.09	0.5	0.53	0.09	0.5	0.8	1	0.7	0.2	1	0.9	1	1.7	2	0.3	0.6	0.6	0.95	0.33
		Mid-Reservoir	-	-	-	-	-	-	0.18	6	0.2	1.1	0.9	1.2	0.3	1.6	1.1	2	1.2	4.2	1.8	2	0.9	2.6	0.33
		Buyala-Kikubamutwe	0.03	0.21	0.17	0.06	0.83	0.16	0.94	1	0.5	1.4	-	8	0.2	2	1.6	2.3	-	4	0.4	0.04	0.6	2.5	0.39
CENTROPOMIDAE	*Lates niloticus* (Mputa)	Kalange-Makwanzi	0.78	2.12	0.64	0.76	0.52	0.11	1.79	1.8	1.6	2.9	2.5	5.9	0.4	2.7	2.8	1.9	2.6	2	3.3	1.6	3.2	1.83	3.59
		Mid-Reservoir	-	-	-	-	-	-	0.43	3.5	0.8	1.9	2.5	2.6	1.6	2.5	1.6	2.8	2.3	3.3	3.9	2.9	3	3.92	4.41
		Buyala-Kikubamutwe	1.01	0.79	1.3	0.38	1.97	3.58	1.41	1.5	0.6	4.9	2	-	0.2	1.8	0.1	8	-	1.4	-	0.7	4.6	1.2	0.32
CICHLIDAE	*Oreochromis niloticus* (Ngege-Kibati)	Kalange-Makwanzi	0.86	2.81	1.16	0.1	0.48	1.27	0.06		0.6	0.6	1.2	1.2	0.4	1.5	0.6	1	1.4	0.5	-	0.3	1.2	1.05	2.18
		Mid-Reservoir	-	-	-	-	-	-	0.3	0.3	-	0.6	1.9	0.3	0.2	1.5	0.3	2.3	2.8	0.1	1.8	1.8	0.4	0.45	-
		Buyala-Kikubamutwe	0.95	0.14	-	0.14	0.84	0.02	0.16	0.6	0.2	4.1	0.2	-	1.4	0.3	-	-	-	-	-	-	0.2	-	-
	Oreochromis leucostictus (Ngege-Nabutono)	Kalange-Makwanzi	0.01	0.13	0.01	-	-	-	-	-	-	-	0.2	0.1	0.01	0.2	-	-	-	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Oreochromis variabilis (Ngege-Kadugala)	Kalange-Makwanzi	1.44	0.88	1.03	0.68	0.23	0.61	0.65	0.4	0.7	1.7	2	1.7	0.2	1.6	1	1.2	0.4	0.4	-	0.3	0.3	-	-
		Mid-Reservoir	-	-	-	-	-	-	0.48	0.1	-	-	0.3	0.3	-	0.3	-	-	-	0.1	-	-	-	-	-
		Buyala-Kikubamutwe	-	0.06	0.25	0.1	1.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Coptodon zillii (Ngege)	Kalange-Makwanzi	0.23	1.04	0.21	0.22	-	0.12	0.39	0.1	0.1	0.9	1.1	0.3	0.02	1	0.2	0.8	1	0.7	0.1	0.2	1.2	0.6	-
		Mid-Reservoir	-	-	-	-	-	-	1.13	0.1		0.8	0.5	0.2	0.02	0.5	0.2	-	-	-	-	0.7	-	-	-
		Buyala-Kikubamutwe	-	0.01	0.15	0.04	-	-	-	-	0	0.5	-	-	-	0.6	0.2	-	-	-	-	-	0.3	-	0.2
	Haplochromines (Nkejje)	Kalange-Makwanzi	0.02	0.04	0.01	0.01	0.01	0.15	0.03	-	-	0.1	-	0.02	0.01	0.1	0.1	0.2	0.2	0.3	-	0.1	15.1	0.05	-
		Mid-Reservoir	-	-	-	-	-	-	0.01	-	-	-	0.1	-	-	0.1	0.1	-	-	0.1	0.3	-	-	-	-
		Buyala-Kikubamutwe	-	0.01	-	0.02	0.1	0.01		-	-	0.6	0.2	0.04	0.2	0.8	-	-	0.3	-	-	0.1	0.2	-	0.2
CLARIIDAE	*Clarias gariepinus* (Male)	Kalange-Makwanzi	0.18	0.07	-	0.04		0.22	1.77	0.5	0.2	3.5	3.8	1.5	0.1	2.8	-	-	-	-	-	-	5.9	-	-
		Mid-Reservoir	-	-	-	-	-	-	1.35	-	-	-	-	-	-	3.1	-	4.5	8	4.8	-	-	-	-	-
		Buyala-Kikubamutwe	0.18	-	-	-	-	-		-	0	-	-	0.3	0.1	-	-	-	-	-	-	-	-	-	-
CYPRINIDAE	*Barbus altianalis* (Kisinja)	Kalange-Makwanzi	3.98	5.11	2.27	2.87	1.66	0.28	6.05	0.1	0.2	1.2	9.8	-	-	9.8	-	-	-	2.1	-	1.9	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	0.95	-	-	0.5	-	0.7	-	-	-	-	-	-	-	4	-	-	-
		Buyala-Kikubamutwe	1.17	0.54	2.1	1.58	1.13	2.98	1.4	1.5	-	-	-	9.4	-	-	-	3	-	15	-	-	1.2	-	-
	Rastrineobola argentea (Mukene)	Kalange-Makwanzi	-	-	11.4	2.96	34.5	-		43	-	-	24	21	-	-	5	-	-	-	-	-	21	-	-
		Mid-Reservoir	-	-	-	-	-	-	115	23.5	4.3	-	22	-	7.2	51	73.3	23	25	-	26	32	19.7	22..3	13.8
		Buyala-Kikubamutwe	5.3	-	-	3.05	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PROTOPTERIDAE	*Protopterus aethiopicus* (Mamba)	Kalange-Makwanzi	0.06	-	0.05	0.48	-	-	0.05	-	0.1	-	-	12	-	-	-	-	-	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	-	0.04	-	-
MOCHOCIDAE	*Synodontis afrofischeri* (Nkolongo)	Kalange-Makwanzi	-	-	0.02	0.01	-	0.01	0.2	-	-	-	0.3	0.4	0.4	0.7	0.3	1.9	-	0.2	0.5	0.6	0.4	0.4	0.2
		Mid-Reservoir	-	-	-	-	-		0.06		-	0.5	0.1	0.2	-	0.5	0.2	0	-	0.5	0.3	0.4	-	0.2	-
		Buyala-Kikubamutwe	-	-	0.01	-	-	-	-	-	-	0.5	0.5	1	-	0.4	0.4	-	-	1.7	-	0.3	0.04	-	0.33
	Synodontis victoriae (Nkolongo-Kadugala)	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	0.3	-	-	0.2	-	0.9	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	0.4	-	0.3	0.5	-	0.1	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	0.1	-	-	0.2	-	-	-	-	-	-	-	-	-	-
MORMYRIDAE	*Mormyrus kannume* (Kasulubana)	Kalange-Makwanzi	2.93	0.43	1.84	2.03	0.25	0.7	5.47	1.5	1.4	1.4	0.7	2.3	2.2	1.1	2.1	0.3	0.3	2.2	0.5	0.6	11.5	0.96	-
		Mid-Reservoir	-	-	-	-	-	-	1	4.7	1	3.4	3.3	4.8	0.4	2.7	2.7	0.8	0.6	5.8	1.1	0.5	4.2	0.98	0.5
		Buyala-Kikubamutwe	0.23	0.19	0.39	0.06	1.04	0.61		2.3	4.1	4.3	3.2	3.9	2.5	2.3	9.7	2.3	1.6	7.5	1	10.6	1.8	1	0.71

3.63. Estimates of total fish catches

The overall monthly fish catches across the three transects declined from 44.9 t in September 2019 to 24.7 t during June 2020, a 45% reduction (Table 3.6.3) and correspondingly, monthly catches of individual fish species decreased. The catch of *R. argentea* contributed the highest proportion of catch of 13.2 t at 53%, followed by7.5 t of *L. niloticus* at 30 % and 0.078 t of *Haplochromines at* 0.3%. At the mid-reservoir, 17.7 tons of catch were recorded, 74 % of which was contributed by *R. argentea* (Table 3.6.3). The drastic decline of fish catches at the three transects could be attributed to use of inappropriate fishing gears and the increase in water levels. The increase in water levels

resulted into a corresponding increase the speed water movements thus making it difficult for the fishers to set stationery (passive) fishing gears for the fear of being swept away. Fishers reported continuous loss of fishing gears and crafts associated to increase in water speed with some temporarily abandoning fishing for other land based alternative livelihood options.

Fishery yields increase with increasing fishing efforts up to a point of maximum sustainable yield (MSY), beyond which further increase in fishing inputs results into diminishing returns. Similar studies on fish production models, fishing efforts and stock biomass (Jennings &Polinin, 1996) have shown that biomass decreases with increase in fishing intensity. The interactions between fishing effort and catch per unit effort show that high fishing effort lead to a slight increase in CPUE, while high CPUE attracts additional fishing effort, which in the long term leads to the reductions in CPUE. In a virgin stock, introduction of small amount of fishing effort will result into high catch rates (catch-per-unit-effort), this can further increase beyond the MSY later resulting into a decline in CPUE thus decrease in stock biomass. Catch per unit effort at times is used as a measure of biomass index (stock size of the species).

The number of fishing boats and gears targeting different exploitable fish species across the study transects in the UVN have fluctuated since the onset of the monitoring surveys in 2009 (Table 3.6.1).The fluctuations in effort (fishing crafts and gears) have also been reflected by the changes in mean catch rates, monthly catches and beach revenue of total catch (Tables 3.6.3 and 3.6.6). Reductions in both catch rates and fish biomass are thus signals to over-exploitation which if not checked could lead to a total collapse in the commercial fishery and exploitable stocks at the monitored sites.

The observed fisheries challenges are attributed not solely to dam construction but also ineffective management and enforcement of the legal fisheries regulations. There are barely fisheries staffs in the area to enforce the regulations while the BMU structures have been completely broken down. The use of illegal (undersize and destructive) fishing gears and methods is rampant across all the monitored transects (table 3.6.1). For instance, the effort (basket traps) targeting *M. Kannume* for bait is illegal and should not be existent in the fishery yet it is the dominant gear at the DS transect due to weak enforcement. These gears target mainly the juveniles of *M. Kannume* for bait in the Nile perch fishing on lakes Victoria and Kyoga. The price for the bait has always fetched high market prices than the mature individuals and this has been the main incentive for harvesting the live juveniles of the target species in large quantities. Although live fish fetch high prices in a short term, harvesting juveniles has many ecological consequences as fish are not allowed to attain mature stages to reproduce which in the long term will affect recruitment, growth and may lead to reductions in fish stocks. The harvest of juvenile individuals for bait also deprives the riparian communities of the rich fish protein hence may lead to prevalence of malnutrition among the fisher communities.

Due to unsustainable harvest of *M. kannume* described above, current trends reveal a drastic decline in catches for the species at the three transects. There is hence urgent need to regulate this fishery by eliminating all basket traps from the study area. A total ban on harvesting of juvenile individuals of the species should be enforced since they are declared illegal under the Uganda fisheries rules and regulations (*The Fish (Fishing Rules) 2010).*

Table 3.6.3 *Trends of total fish catch estimates (kg) at monitored sites*

Family name	Species name (Luganda	Sites/Transects	Monitoring periods																					
			Sep-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18	Apr-19	Sep-19	Jun-20
BAGRIDAE	*Bagrus docmak* (Semutundu)	Kalange-Makwanzi	68.4	52.8	59.8	33.9	355.1	139.8	381.7	267.7	130.9	376.8	491.4	228.4	305.0	1448.3	481.7	1362.0	2498.0	52.5	318.0	738.0	890.6	292.5
		Mid-Reservoir						68.4	481.5	74.3	187.1	1133.4	2068.4	283.8	1724.1	1014.8	697.8	1940.6	2579.0	265.0	1606.5	900.0	4421.9	316.8
		Buyala-Kikubamutwe	191.6	109.9	25.8	195.3	73.5	396.7	128.6	397.0	360.8	-	7200.0	116.9	740.6	164.6	398.6	-	1232.0	10.5	4.8	1528.6	2289.2	152.8
CENTROPOMIDAE	*Lates niloticus* (Mputa)	Kalange-Makwanzi	532.2	422.1	303.1	193.1	78.3	473.6	870.7	948.7	3940.2	1950.1	4418.1	375.6	1252.4	6865.8	1,052,8	4452.2	2305.0	1048.4	864.1	4046.0	1429.7	3231.0
		Mid-Reservoir	-		-	-	-	-	163.1	248.7	305.7	347.1	3183.1	4689.0	1536.3	2469.8	3502.1	1748.5	3836.3	1876.0	1024.2	2753.9	2200.0	6041.3	4240.0
		Buyala-Kikubamutwe	707.8	840.6	163.5	463.5	1612.5	592.7	117.1	449.7	452.3	1200.0	-	151.9	1074.0	63.0	617.1	168.0	400.0	-	21.0	7188.6	1188.0	123.5
CICHLIDAE	*Oreochromis niloticus* (Ngege-Kibati)	Kalange-Makwanzi	705.7	765.1	39.9	179.0	7.5	14.6		384.6	96.6	950.0	842.4	376.3	1317.7	875.6	468.6	1081.9	592.0	-	37.8	553.5	828.0	1953.0
		Mid-Reservoir	-		-	-	-	112.8	25.5	-	102.3	2392.8	453.6	177.2	70.9	220.5	1007.3	4057.7	6.0	270.0	1080.0	311.3	777.2	-
		Buyala-Kikubamutwe	124.4	-	60.2	197.0	907.8	70.0	10.3	161.6	1069.2	120.0	-	888.3	24.0	-	-	-	-	-	-	405.2	-	-
	Oreochromis leucostictus (Ngege-Nabutono)	Kalange-Makwanzi	32.4	6.6	-	-	-	-	-	-	-	153.0	90.3	8.5	-	-	-	-		-	-	-	-	-
		Mid-Reservoir	-		-	-	-	-	-	-	-	-	-		-	-	-	-		-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-		-	-	-	-	-
	Oreochromis variabilis (Ngege-Kadugala)	Kalange-Makwanzi	221.8	679.4	271.2	623.6	434.9	172.6	352.0	380.4	273.2	1515.7	1278.6	227.7	391.7	912.0	379.6	120.0	417.0	-	30.0	424.4	-	-
		Mid-Reservoir	-		-	-	-	184.2	8.0	-	-	314.8	468.0	12.3	-	-	-	-	52.0	-	-	-	-	-
		Buyala-Kikubamutwe	52.3	161.7	43.0	53.9	-	-	-	-	-		-	0.0	-	-	-	-	-	-	-	-	-	-
	Tilapia zillii (Ngege)	Kalange-Makwanzi	261.5	138.5	87.7	88.9	87.7	103.5	96.2	62.4	146.1	803.8	240.7	15.7	174.3	298.7	265.3	553.5	796.0	210.0	22.8	1447.3	285.0	-
		Mid-Reservoir	-		-	-	-	429.5	6.4		13.9	650.7	288.0	22.7	-	140.0	-	-	-	-	105.0	-	-	-
		Buyala-Kikubamutwe	5.0	97.0	17.2	52.9	2.1	-	-	16.8	13.9	-	-	0.0	159.1	85.5	-	-	-	-	-	613.2	-	78.0
	Haplochromines (Nkejje)	Kalange-Makwanzi	9.8	6.6	4.0	4.7	108.3	6.7	-	0.2	7.9	-	15.0	4.6	32.0	215.1	63.8	186.3	385.0	-	7.2	18573.0	52.5	-
		Mid-Reservoir	-		-	-	-	3.5	-	-	-	88.2	-	0.0	-	84.0	-	-	6.0	41.0	-	-	-	-
		Buyala-Kikubamutwe	7.5	-	8.6	24.5	3.0		-		166.3	93.0	27.0	131.5	120.0	-	-	71.1	-	-	12.0	438.0	-	78.0
CLARIIDAE	*Clarias gariepinus* (Male)	Kalange-Makwanzi	17.0	-	16.0		-	467.0	109.2	102.8	554.4	2870.6	1147.0	85.1	210.0	-	-	4320.0	-	-	-	-	-	-
		Mid-Reservoir	-		-	-	-	515.5	-	-	-	-	-	0.0	1098.3	-	969.1	-	2957.0	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	159.0	-		23.9	-	-	270.0	52.6	-	-	-	-	-	-	-	-	-	-
CYPRINIDAE	*Barbus altianalis* (Kisinja)	Kalange-Makwanzi	1282.5	1497.2	1144.5	436.4	200.6	1597.8	30.0	141.7	190.1	7501.8	-	-	-	-	-	-	2583.0	-	228.8	-	-	-
		Mid-Reservoir	-		-	-	-	362.7	-	-	89.1	-	1200.0	-	-	-	-	-	-	-	600.0	-	-	-
		Buyala-Kikubamutwe	482.8	1357.9	679.7	266.6	1341.0	515.5	209.4	-	-	-	8460.0	-	-	-	90.0	-	4620.0	-	-	2671.8	2671.8	-
	Labeo Victorianus (Ningu)	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	87.6	-	-
	Rastrineobola argentea (Mukene)	Kalange-Makwanzi	-	6463.8	2109.5	2152.8	-		1105.7		-	18371.9	15795.0	-	-	428.6	-	-	-	-	-	25830.0	-	-
		Mid-Reservoir	-	-	-	-	-	13128.0	1480.5	1627.6	-	27706.5	-	7057.1	23000.0	22000.0	4731.4	1500.0	-	2340.0	9600.0	10259.5	22550.3	13214.1
		Buyala-Kikubamutwe	-	-	980.4	1960.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PROTOPTERIDAE	*Protopterus aethiopicus* (Mamba)	Kalange-Makwanzi	-	33.0	191.4	-	-	12.0	-	26.4	-	-	9025.7	-	-	-	-	-	-	-	-	-	-	-
		Mid-Reservoir	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOCHOCIDAE	*Synodontis afrofischeri* (Nkolongo)	Kalange-Makwanzi	-	13.2	4.0	-	10.4	52.8	-	31.9		229.6	305.9	409.0	426.1	245.4	864.1	-	293.0	148.5	85.2	430.5	373.9	-
		Mid-Reservoir	-		-	-	-	22.9	-		89.1	125.9	324.0		124.9	154.0	8.6	-	308.0	67.5	240.0	-	159.4	180.0
		Buyala-Kikubamutwe	-	6.5	-	-	-		-		13.2	300.0	900.0		158.5	292.5	-	-	524.0	-	36.0	87.6	-	130.0
	Synodontis victoriae (Nkolongo-Kadugala)	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-		248.2		-	144.0	-	1083.6	-	-	-	-	-	-
		Mid-Reservoir	-		-	-	-	-	-	-	-	251.9	729.0	7.9	108.9	441.0	-	57.6	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	26.4	-	-	125.6	-	-	-	132.0	-	-	-	-	-	-
MORMYRIDAE	*Mormyrus kannume* (Kasulubana)	Kalange-Makwanzi	106.9	1213.6	809.5	389.6	500.1	1444.1	357.6	783.2	214.1	562.6	1753.3	1986.0	831.7	2733.3	95.7	208.8	2807.0	374.6	254.4	14083.5	804.7	450.0
		Mid-Reservoir	-		-	-	-	381.8	374.7	365.5	605.2	4136.0	8568.0	348.9	508.1	3283.0	172.3	1296.1	3581.0	397.5	273.6	3141.0	1779.4	-
		Buyala-Kikubamutwe	169.2	252.2	25.8	57.8	276.0	-	842.1	3248.0	1135.2	1900.0	3465.0	1607.1	834.8	8821.9	417.4	520.7	2310.0	350.4	5629.7	3907.6	990.0	276.9
TOTAL		Kalange-Makwanzi	3238.3	11291.9	5040.4	4097.3	2842.0	4484.5	3308.1	3141.0	2066.0	36626.2	35651.7	3383.8	4940.9	14166.8	3671.7	10368.2	12675.0	1687.0	1847.4	74182.7	4665.3	6106.5
		Mid-Reservoir	-		-	-	-	15417.2	2625.2	2400.4	1559.0	40633.1	21245.0	9507.9	30008.9	30839.4	9335.1	12688.3	11365.0	4800.0	16259.0	16811.7	35729.1	17770.9
		Buyala-Kikubamutwe	1740.7	2825.8	2004.2	3247.0	3315.6	1647.3	1309.3	4468.7	6850.0	3613.0	20322.0	3830.0	3110.9	9427.5	1523.2	892.4	9086.0	403.0	5703.5	16928.1	4476.2	839.2

3.6.4. Estimates of total beach value of the catch

Generally, compared to the September 2019 monitoring survey, the unit fish prices in the June 2020 monitoring survey were lower for some species and higher for others (Table 3.6.4). The unit (per kilogram) prices of fish at beach level varied with sizes for the large-bodied species (> 20 cm, total length – TL). The large *L. niloticus* (> 1 kg) fetched higher unit (kilogram) prices (UGX: 6,000 - 9000) than the smaller ones (UGX: 3000 - 5000). On the contrary, the larger (adult) *M. kannume* sold for human consumption fetched lower price values (UGX: 3000 per kilogram) compared to the juveniles sold for bait (UGX ~29000 per kilogram). The juvenile *M. kannume* (50-100 grams) were sold individually for a cost of 2000 to 2500 shillings per fish. The estimated price per kilogram weight of the species was therefore based on the number of individuals contained in one kilogram (10 – 20 fish). Given the high demand for the juvenile *M. kannume* as bait, research should explore possibilities of farming the species as a way of reducing fishing pressure on the wild stocks for sustainability and species conservation.

Table 3.6.4. *Trend of monthly gross value of fish catches (UGX) at monitored sites*

Family name	Species name (Luganda name)	Sites/Transects	Monitoring periods																					
			Sep-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18	Apr-19	Sep-19	Jun-20
BAGRIDAE	*Bagrus docmak* (Semutundu)	Kalange-Makwanzi	137	158	105	102	1,065	462	1,365	803	349	2,548	57,600	193	1,055	5,122	534	4,086	10,743	578	1399	1,476.0	3,829.7	914.0
		Mid-Reservoir	-	-	-	-	-	226	1,565	230	967	2,456	8,029	248	5,251	3,653	360	10,565	10,108	3,705	6,827	3,735.0	21,488.4	1,267.0
		Buyala-Kikubamutwe	431	110	45	586	662	1,312	450	1,489	1,443	-	983	27	7,406	494	270	-	4,928	368	19	1,555.6	10,686.7	1,018.0
CENTROPOMIDAE	*Lates niloticus* (Mputa)	Kalange-Makwanzi	998	760	550	869	274	1,299	3,295	2,189	1,772	9,165	16,568	369	6,053	34,166	366	10,957	10,132	9,762	5,063	25,011.7	14,297.2	20,770.0
		Mid-Reservoir	-	-	-	-	-	447	746	1,089	1,239	12,398	23,575	3,929	10,957	14,592	589	29,960	14,156	7,298	21,936	19,281.9	44,705.4	34,980.0
		Buyala-Kikubamutwe	1,888	1,821	296	1,101	12,255	1,625	386	2,248	15,761	8,400	-	69	9,559	410	900	1,680	4,004	-	168	52,716.3	11,880.0	452.0
CICHLIDAE	*Oreochromis niloticus* (Ngege-Kibati)	Kalange-Makwanzi	776	1,530	84	179	2	33	-	813	117	3,606	3,791	168	5,534	2,773	446	7,573	1,777	-	104	6,900.4	6,216.2	14,322.0
		Mid-Reservoir	-	-	-	-	-	256	77	-	307	7,179	1,524	106	213	551	428	30,143	-	2,700	5,504	1774.1	5,440.5	-
		Buyala-Kikubamutwe	187	-	126	197	19	159	31	323	2,138	360	-	808	56	-	-	-	-	-	-	-	-	-
	Oreochromis leucostictus (Ngege-Nabutono)	Kalange-Makwanzi	32	13	-	-	-	-	-	-	-	536	181	1	-	-	-	-	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Oreochromis variabilis (Ngege-Kadugala)	Kalange-Makwanzi	277	1,359	651	624	1,160	376	1,049	1,024	724	6,366	4,560	153	1,735	1,824	273	720	1,000	-	236	1,877.7	-	-
		Mid-Reservoir	-	-	-	-	-	402	24	-	-	787	1,544	2	-	-	-	-	26	-	-	-	-	-
		Buyala-Kikubamutwe	78	162	103	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tilapia zillii (Ngege)	Kalange-Makwanzi	167	277	175	89	175	241	266	150	365	2,713	409	4	558	597	300	3,321	2,387	17	45	6,126.9	1,425.0	-
		Mid-Reservoir	-	-	-	-	-	1,000	19	-	278	1,627	950	5	-	233	-	-	-	-	105	-	-	-
		Buyala-Kikubamutwe	7	97	34	53	4	-	-	-	278	-	-	-	676,11.3	171	-	-	-	-	-	3,495.2	-	78.0
	Haplochromines (Nkejje)	Kalange-Makwanzi	5	3	3	4	54	-	-	-	4	-	-	0	-	215	122	233	557	-	7	3,714.6	52.5	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	44	-	-	-	84	-	-	-	22	-	-	-	-
		Buyala-Kikubamutwe	-	-	6	20	2	-	-	-	-	47	11	60	60	-	-	143	-	-	12	2,190.0	-	39.0
CLARIIDAE	*Clarias gariepinus* (Male)	Kalange-Makwanzi	17	-	32	-	636	1,132	328	257	2,772	8,612	4,588	15	560,00.0	-	-	21,600	-	-	-	14,514.0	-	-
		Mid-Reservoir	-	-	-	-	-	1,249	-	-	-	-	-	-	3,844	-	360	-	35,482	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	1,350	17	-	-	-	-	-	-	-	-	-	-
CYPRINIDAE	*Barbus altianalis* (Kisinja)	Kalange-Makwanzi	1,924	2,246	1,824	873	501	4,411	75	482	855	22,506	-	-	-	-	-	-	9,041	-	1368	-	-	-
		Mid-Reservoir	-	-	-	-	-	1,001	633	-	267	-	3,600	-	-	-	-	-	-	-	3600	-	-	-
		Buyala-Kikubamutwe	802	2,580	1,083	800	6,705	1,623	-	-	-	-	38,070	-	-	-	450	-	32,340	-	-	18,702.6	-	-
	Labeo victorianus (Ningu)	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	175	-	-
	Rastrineobola argentea (Mukene)	Kalange-Makwanzi	-	2,353	894	1,722	-	-	514	-	-	12,248	15,043	-	-	171	-	-	-	-	-	258,300.0	-	-
		Mid-Reservoir	-	-	-	-	-	2,864	945	814	-	18,891	-	834	21,956	22,000	1,800	4,500	-	58,500	240,000	228,639.7	387,684.9	173,338.0
		Buyala-Kikubamutwe	-	-	416	1,568	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PROTOPTERIDAE	*Protopterus aethiopicus* (Mamba)	Kalange-Makwanzi	-	23	351	-	-	36	-	53	-	-	27,077	-	-	-	-	-	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	64	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOCHOCIDAE	*Synodontis afrofischeri* (Nkolongo)	Kalange-Makwanzi	-	10	2	-	10	52	5	-	-	344	336	191	481	245	90	-	256	163	112	-	1,420.6	360.0
		Mid-Reservoir	-	-	-	-	-	23	-	-	-	252	567	-	219	159	45	-	154	2,109	240	-	797.1	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	600	90	-	206	146	-	-	524	-	36	43.8	-	65.0
	Synodontis victoriae (Nkolongo-Kadugala)	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	385	-	-	144	-	264	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	441	1,750	2	218	441	-	1,625	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	115	-	-	-	-	-	-
MORMYRIDAE	*Mormyrus kannume* (Kasulubana)	Kalange-Makwanzi	89	1,744	1,160	390	450	1,960	572	1,391	416	1,153	7,013	11,207	1,291	21,121	180	418	14,574	11,531	5,774	39,049.5	16,416.2	1,350.0
		Mid-Reservoir	-	-	-	-	-	518	375	749	1,149	5,700	17,993	174	1,201	9,723	180	5,647	14,921	11,717	8,550	25,834.7	29,063.5	-
		Buyala-Kikubamutwe	338	202	37	0	331	-	2,105	24,360	11,352	9,658	15,593	5,260	4,202	48,288	546	2,950	6,930	3,212	115	76,477.0	22,050.0	7,863.0
TOTAL		Kalange-Makwanzi	4,423	10,476	5,831	4,850	6,596	10,003	7,468	7,162	7,435	69,797	80,935	12,649	17,267	66,378	2,310	50,533	50,487	22,050	13,979	357,186.1	43,657.9	37,716.0
		Mid-Reservoir	-	-	-	-	-	7,987	3,750	2,883	4,209	49,774	59,533	5,300	43,858	51,437	3,761	80,931	74,847	86,050	286,659	279,265.5	489,359.9	209,855.0
		Buyala-Kikubamutwe	3,731	4,972	2,148	4,378	19,977	4,720	3,605	28,485	46,733	19,065	112,713	6,251	22,164	49,509	2,166	5,038	48,726	3,579	115,440	171,655.5	44,616.7	9,517.0

Table 3.6.5. *Trends of the mean unit prices (shs/kg) of the most common fish species at the beach level along the Upper Victoria Nile.*

Year	Month	*Lates niloticus*	*Oreochromis niloticus*	*Barbus altianalis*	*Mormyrus kannume*	*Oreochromis variabilis*	*Bagras docmak*	*Clarias gariepinus*
2009	April	2,188	1,409	1,666	983	1,450	-	-
	October	2,423	1,189	2,250	1,416	1,357	-	-
2010	April	2,000	2,000	1,722	1,310	1,929	-	-
	September	1,813	2,100	1,594	1,433	2,400	-	-
2011	April	3,286	1,000	2,250	667	1,000	-	-
	September	6,429	2,500	4,000	986	2,667	-	-
2012	April	2,750	2,300	2,760	1,400	2,200	-	-
	September	2,785	3,000	3,370	1,825	2,860	-	-
2013	April	3,063	2,250	3,400	3,886	2,692	-	-
	September	3,830	2,278	3,750	4,600	2,650	3,950	5,000
2014	April	4,363	3,429	3,000	2,635	4,045	3,028	3,000
	September	4,571	3,686	3,375	3,444	3,500	3,780	4,333
2015	April	5,198	3,286	3,000	2,709	3,350	2813	3,000
	September	4,945	3,526	-	2,877	4,300	3,542	2,875
2016	April	4,689	2,900	-	5,787	2,000	3,540	-
	September	5,700	4,850	5,000	5,353	3,033	4,885	4,000
2017	April	8,500	7,300	-	4,000	6,000	4,200	5,000
	September	6,250	3,000	5,600	4,800	2,100	4,150	12,000
2018	April	8,600	5,500	-	27,300	-	7,600	-
	September	7,215	3,500	6000	23,000	3,500	4,200	-
2019	April	7,710	4,233	7000	8,349	4,425	7,900	2000
	September	9,133	7,333	-	20,227	-	4,618	-
2020	June	6,916	6,500	-	26,090	-	5,136	-

Since April 2009, the mean price per kilogram for the commercial fish species landed have been flactuating(Table 3.6.5). The unit price for *M. kannume* and *B. docmak* increased during this monitoring in compared to September 2019, Mormyrus kannume was the most highly priced fish species per kilogram weight during June 2020 monitoring, followed by *L. niloticus*, and the least priced species was *B. dockmak* (Table 3.6.5). The monetary value, measured as mean price per kilogram weight of fish is very important in fishery monitoring as it provides insights for management and socio-economic implications.

The increment in the prices of *M. kannume*, *L. niloticus*, and *B. docmak* during the current monitoring could be due to the scarcity of fish supply and the ensuing high demand for fish. As mentioned above, the type of species, size of fish, and quantity of fish supplied at a given time determine the market value of the commodity. Low fish supply on market often leads to increases in the market prices and the reverse is true

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The beach revenue from fish catches is determined by factors that include; the type, quantity and size of fish species landed, season, forces of demands and supply in the market. During the June 2020 period, monthly beach revenue of UGX 257.1 million was generated from the 24.7 t of fish landed at the three transects(Table 3.6.5), a 55.5% reduction in comparison to the UGX 577.6 million estimated during the previous monitoring September 2019. The gross beach revenue of 209.8 million was from the mid-reservoir transect accounting for 81.6% of total beach revenue, 37.7 million from Kalange-Makwanzi, representing 14.7% and 9.5 million from Buyala-Kikubamutwe, just contributing 3.7%. During the June 2020 monitoring, *R. argentea* at the mid-reservoir transect generated a gross monthly beach revenue of UGX 173 million, contributing 67.4% of the monthly gross beach revenue. A beach value of *Lates niloticus* was 56.2 million and accounted for 22% while for the *M. kannume* was 9.2 million, representing 3.6%. Compared to September 2019, the gross beach revenue from *M. kannume* reduced seven-fold during the current monitoring.. The Haplochromines fetched the least beach revenue of 0.04 million due to their low unit price value and negligible quantities landed. Despite the declines in the economic value of fisheries observed for the current survey, fisheries still remain an important component to the livelihoods of the riparian communities who depend on fishing along the UVN for income and food. This calls for proper fisheries management measures that minimize the negative impacts of the dam and unsustainable fishing to the riverine fisheries and their habitats.

3.6.5 Estimated total catches and revenue of individual fishing units

Compared to the September 2019 monitoring survey, a remarkable decline in the total monthly catch landings and the corresponding gross beach revenue during the June 2020 monitoring was registered (Tables 3.6.3 & 3.6.4). However, catch landings at Kalange-Makwanzi increased by 30 % while the beach revenue decreased by 13%. At the mid-reservoir transect, both catch and revenue registered a decline of 17% and 57% while at Buyala-Kikubamutwe transect, they registered 18% and 21% reduction respectively. The high catch landings and low revenue registered at Kalange-Makwanzi transect could be explained by low market prices for the small sized fish. The main incentive for investment in basket trap bait fishery dominating the riverine Upper Victoria Nile fisheries especially at Buyala-Kikubamutwe transect is due to high beach value for the live juvenile *M. kannume*. While high fish catches are good for the riparian communities to meet household nutritional and economic demands, indiscriminate over exploitation of fish species will only yield short term benefits with severe long term impacts that may range from loss of biodiversity and income, unemployment and reduced livelihood sources. There is need for effective management measures aimed at sustaining fish catches in the Bujagali Dam area through enforcement of legal fishing gears and methods as well as exploring alternative live bait sources including the farming of *M. kannume* to reduce the current pressure on the its fishery as a long term strategy to facilitate its stock recruitment and recovery.

Table 3.6.6 *Trend of monthly total catches and revenue of individual fishing units at the monitored sites*

Monitoring period		Upstream-Kalange-		Mid-reservoir		Downstream-Buyala-	
Year	Month	Catch (Kes)	Beach	Catch (Kes)	Beach	Catch (Kes)	Beach
2009	April	228	360	-	-	212	254
	September	180	246	-	-	55	117
2010	April	418	388	-	-	123	216
	September	219	254	-	-	134	143
2011	April	467	298	-	-	329	410
	September	89	206	-	-	221	1,332
2012	April	47	189	307	1,227	275	1,098
	September	144	419	389	883	66	188
2013	April	158	7,162	150	2,883	154	28,485
	September	103	7,435	79	4,209	343	46,733
2014	April	1,356.50	2,585	923.5	1,131	180.7	953
	September	1,320.40	2,998	354.1	992	677.4	3,757
2015	April	3,383.80	12,649	9,507.90	5,300	3,830.00	6,251
	September	4,940.90	17,267	30,008.90	43,858	3,110.90	22,164
2016	April	14,166.80	66,378	30,839.40	51,437	9,427.50	49,509
	September	3,671.70	2,309.60	9,335.10	3,761.30	1,523.20	2,166.40
2017	April	10,368.20	50,533	12,688.30	80,931	892.4	5,038
	September	12,675	50,487	11,365	74,847	9,086	48,726
2018	April	1,687	22,050	4,800	86,050	403	3,579
	September	1,847	13,979	16,259	286,659	5,704	115,440
2019	April	74,182	357,186	16,812	279,265	16,928	171,666
	September	4,665	43,658	35,729	489,360	4,476	44,617
2020	June	6,107	37,716	17,771	209,855	839	95,517

3.6.6 Socio-economic aspects of the fishery

Non-commercial uses of fish

During the June 2020 monitoring, fishers did not retain from their catches any fish for house-hold consumption at the monitored transects. This could be explained by the low catches landed in the few fishing boats that were operating on the UVN during moinitoring. The little catch obtained was sold directly to traders with no fish retained for home. This shows that fishers prioritize income to food nutrition. Even the low-value species such as *S. afrofischeri* and Haplochromines that were were previously retained for home consumption were this time round offered for money, thus emphasizing the role of fisheries to employment and income generation (Odongkara *et al.*, 2018). The lack of fish retained for home consumption limits the attainments of the FAO's per capita fish

consumption targets of 19.2 kg/person/year and WHO targets of 25 kg/person/year. Studies around fishing communities reveal high prevalence of malnutrition cases, poverty levels and low standards of living. There is need for sensitization of the riparian communities about the importance of sustainable fisheries resource use and the contribution of fish to food security and nutrition. The communities should be encouraged to consider fish in their daily food intakes.

Table 3.6.7 *Trends of the average weight of fish (kg/boat/day) retained by fishers for domestic use and weight of fish retained as a percentage of the overall average weight of fish caught per boat.*

Monitoring period		**Sites**					
		Upstream-Kalange-Makwanzi		Mid-reservoir-Malindi-Namizi		Downstream-Buyala-Kikubamutwe	
2009	April	0.4	3.7	-	-	-	-
	October	3.5	27.1	-	-	1.4	71.8
2010	April	2.2	11.8	-	-	1.3	29.7
	September	1.5	16.8	-	-	0.8	16.5
2011	April	1.4	30.7	-	-	1.2	23.8
	September	2.1	60	-	-	3	45.8
2012	April	1.2	12.8	1.5	50	0.8	14.4
	September	1.2	20.4	-	-	-	-
2013	April	0.1	2.6	0.1	1.1	0.2	3.2
	September	-	0	5.4	3.3	-	-
2014	April	1.3	2.7	0.5	1.6	-	-
	September	-	0	1.4	6	-	-
2015	April	0.5	9.2	0.1	0.6	0.1	3
	September	1.3	1.8	0.5	0.8	-	-
2016	April	-	0	0.9	0.3	0.3	0.2
	September	0.6	43	-	-	-	-
2017	April	0.9	59	-	0	0.3	18
	September	0.3	26	0.1	0	0.3	5
2018	April	0.8	50	0.7	17.2	0.3	5.5
	September	-	0	1.2	17.1	-	0
2019	April	-	-	0.4	6.7	0.8	38.1
	September	0.4	5	-	-	-	-
2020	June	-	-	-	-	-	-

Fishery related jobs

A total of 273 people were employed by the fisheries sector at monitored landings on the UVN by June 2020. This observation shows an 18% decline in fishery related job opportunities compared to the September 2019 monitoring (Tables 3.6.8 a & b). Fishing remained the main fishery economic activity, accounting for 42% of all jobs and was exclusively at 100% a male activity. During current monitoring-June 2020, women were not get involved in any fishery jobs probably due to difficulties they could have faced to navigate the fast-flowing waters of the River due to the increased water levels. At Kalange-Makwanzi and mid-reservoir transects 50 fishers were registered respectively. The number of fishers at Buyala-Kikubamutwe was few.

Fish trading employed 37 people, accounting for 15% of all people involved in the fishery related jobs along the UVN. The fish trade activity was dominated by women, constituting over 90% at each landing site. Majority of the fish traders were encountered at the mid-reservoir (70%), followed by Kalange-Makwanzi (27%) and no single fish trader was registered at Buyala-Kikubamutwe. Dominance of women in fish trade and men in fishing is not a new phenomenon in the fisheries sector and on the UVN. In most fisheries, fishing is regarded a risky job excluding women who are considered unfit for harsh conditions and weak to undertake fishing, a night dominated activity (Lina, 2007; Kim et al., 2008). Gender issues in most fishing communities bring inequality associated to customary beliefs and cultural settings that favour men than women in most work places. This trend has widely been documented in the fisheries (Medard*et al*, 2002; FAO, 2014), an indication of labour division in fisheries sector.

Table 3.6.8a *The numbers of people by gender engaged in different jobs at monitored landing sites*

Job type	Sites	Sex	Monitoring periods																						
			Sep-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18	Apr-19	Sep-19	Jun-20
Boat builders/	Kalange-Makwanzi	M	3	1	2	3	3	2	2	3	3	3	2	2	4	3	3	5	4	3	3	2	2	3
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	1	5	-	2	2	2	2	-	-	6	10	5	3
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	2	3		1	1	3	3	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Food vendors	Kalange-Makwanzi	M	1	2	4	1	1	1	1		1	2	-	1	-	1	-	1	1	3	1	1	1	1
		F	2	4		3	3	3	3	2	5	2	5	4	5	5	6	3	4	1	2	3	3	6
	Mid-reservoir	M	-	-	-	-	-	-	-	1	1		-	1	-	-	-	-	-	-	-	1	-	-
		F	-	-	-	-	-	-	2	4	3	3	1	1	-	-	-	2	2	-	2	2	2	5
	Buyala-Kikubamutwe	M	-	-	-	-	-	3	3	-	2	-	-		-	-	-	-	-	1	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-
Net repair(s)	Kalange-Makwanzi	M	4		3	5	5	3	3	7	5	6	4	6	4	5	5	-	6	5	4	-	-	4
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	-	11	-	-	-	3	15	-	-	5	-	5	12
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	-	-	3	-	-	6	6	-	3		-	-	3	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cleaner fish landing	Kalange-Makwanzi	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.6.8b *Number of people by gender engaged in different jobs at landing sites*

Job type	Sites	Sex	Monitoring periods																					
			Sep-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18	Apr-19	Sep-19	Jun-20
Fisher(s)	Kalange-Makwanzi	M	37	30	38	25	25	25	25	25	42	39	39	54	36	52	45	42	45	37	51	60	53	55
		F	-	-	-	-	-	-	-	-	1	1	1	1	2	-	-	-	-	-	1	1	2	-
	Mid-reservoir	M	-	-	-	-	-	-	13	24	49	51	55	74	37	49	30	52	27	16	73	153	92	50
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
	Buyala-Kikubamutwe	M	46	30	34	30	30	15	9	28	72	15	11	42	21	24	51	20	18	28	20	98	57	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Fish trader(s)	Kalange-Makwanzi	M	6	4	4	6	6	2	2	1	1	2	6	1	1	3	14	3	4	4	6	6	3	1
		F	20	16	16	30	30	16	16	9	16	13	2	4	7	8	10	6	6	6	8	4	6	8
	Mid-reservoir	M	-	-	-	-	-	-	2	1	1	3	1	-	2	3	3	3	4	4	4	2	6	2
		F	-	-	-	-	-	-	5	1	1	12	12	16	9	16	6	7	4	-	7	13	17	26
	Buyala-Kikubamutwe	M	2	2	2			1	1		1	1	-	2	1	-	4	3	3	6	2	1	2	-
		F	3	5	5	5	5	5	3	6	5	-	1	3	-	3	1	1	-	5	-	-	10	-
Fish processor(s)	Kalange-Makwanzi	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	3	3		-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
		F	-	-	-	-	-	-	-	-		2		2	-	6	-	-	-	-	-	-	11	15
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fish cleaners	Kalange-Makwanzi	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chairperson landing	Kalange-Makwanzi	M	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1
		F	-	-	-	-	-	-	-				-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	1	1	2	2	2	1	1	2	2	1	-	1	1	1	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMU committee member (s)	Kalange-Makwanzi	M		4	5			7	7	5	5	7	4	5	6	5	5	5	2	5	4	5	6	6
		F		5	4			2	2	1	3	2	2	1	3	4	3	3	-	4	5	1	2	3
	Mid-reservoir	M	2	2	3	3	3	4	4	4	3	3	2	4	3	18	8	11	12	12	7	3	10	-
		F	1	-	-	-	-	1	1	1	1		-	1	10		3	4	4	4	-	2	3	4
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	5	4	10	4	8	2	3	3	3	3	-	4	-	5	-
		F	-	-	-	-	-	-	-	3	3	2	-	4	-	-	-	3	-	-	-	-	3	-
Landing site Guards	Kalange-Makwanzi	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	3
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	3	3
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Fisheries officers	Kalange-Makwanzi	M	-	-	-	-	-	-	1	1	1	-	-		-	-	-	-	-	-	-	-	1	-
		F	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-		1	1	1				-	-	-	-	-	-	-	-	-	1
		F	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	1	1	1	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-		-	-	-	-	-	-

Boat building and food vending as related to fishery job activities provided 2% and 5% respectively the riparian communities' engagement. Unlike during the 2019 monitoring surveys, there were five landing site cleaners recorded at mid-reservoir transect. The rising water levels in the River came along with sedimentation, siltation and deposit of tree trunks and debris on the river banks that necessitated regular cleaning to maintain the landing sites clean. The fisheries of the UVN are still artisanal in nature, public healthy and sanitation is of paramount importance at any fish handling or processing point to reduce on post-harvest losses (Qicai Lin (2010), hence the need to maintain the landing points in acceptable hygienic conditions.

The net repairers were encountered at mid-reservoir and Kalange-Makwanzi transects, where the fishers involved in Mukene fishing and processing also undertook the repair of torn nets to earn a living. Boat building and net repairing activities were fully performed by men, whereas food vending was dominated by women; one male was found dealing in business at the upstream transect. At Upstream, fire wood collection (Plate.5) was observed as an alternative income generating activity.



Plate 3.6.5. *Tree logs (**a**) and stems (**b**) heaped for selling as firewood at Kalange landing site*

Landing sites management is represented by the presence of the BMU leadership involving both women and men who were recorded at the monitored transects. The chairpersons of landing sites were exclusively males (Tables 3.6.8 b). The Upstream transect recorded the highest number of members (64%), with a BMU committee consisting of six males and three females. The mid-reservoir had 5 BMU members consisting of 1 man and 4 women (Table 3.6.8 b). Generally, the BMU committees at the monitored transects are ineffective and are not empowered to enforce fisheries regulations. The women continued to dominate the post-harvest handling and marketing jobs since fishing activity mostly takes place at night and has related challenges only endured by men (Plate 3.6.6). Across the monitored transects, the bait fishery of juvenile

M. kannume was exclusively practiced by men who fish and transport the live bait to distant markets on lakes Victoria and Kyoga.



Plate 3.6.6. *Women off-loading mukene catch for drying at Malindi landing site on the Mid-reservoir transect*

This number of people employed in the fishery at the study transects indicates a high dependence of riparian communities to the fisheries but also lack of genuine alternative livelihood options in these communities. Subsequently, any negative effects from the dam that may alter the ecological functioning of the monitored aquatic habitats and cause shifts in fish species composition, distribution and abundance may severely impact on the livelihoods of these communities. Therefore, a clear strategic mitigation plan is needed for such impacts to enable people derive viable livelihoods given fish stocks can decline or even disappear.

Conclusion

Fishing effort, fishery yield, beach revenue and fishery related jobs at the three transects monitored along the UVN declined during this monitoring period-June 2020 compared to the indicators observed in the previous monitoring periods.

Despite registering decline in catches, *M. kannume* remained a highly priced species, especially at the Downstream transect.

The current changes in water levels and speed due to the increases in the Lake Victoria have disrupted fishing operations and navigation on the river, with some fishers abandoning fishing for alternative activities including fire wood selling.

3.7 SCHISTOSOMIASIS, RIVERBLINDNESS AND SANITATION STUDIES

3.7.1 Parasitological analysis of bilharzias in humans

During this June 2020 monitoring, 98 stool samples were collected from a population of 537 people, 13 (13.9%) of whom were infected with Schistosomiasis, increasing by 8.9% from the previous monitoring period-September 2019 (Table 3.7.1 a). The infection rate however, has been reducing since April 2016. The intestinal type of Schistosomiasis (*Schistosoma mansonii*) has continued to be prevalent while the urinary type, *Schistosoma haematobium,* has remained undetected (Table 3.7.1 a). Infection with Schistosomiasis was higher at Buyala-Kikubamutwe transect (17%)-up from 11.6% during the previous monitoring period and lowest at the mid-reservoir transect at 5.5%. All three transects showed a slight increase in schistosomiasis prevalence during this monitoring period.

Table 3.7.1 a *Trend of Schistomiasis infection prevalence among riparian residents at the monitored sites*

Type of Schistosomiasis		Transect/sites	Monitoring periods																												
			Apr-06	Sep-07	Apr-08	Apr-09	Sep-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18	Apr-19	Sep-19	Jun-20
Prevalence rate (%)	Schistosomiasis mansonii	Kalange-Makwanzi	53.0	46.0	56.0	28.0	49.0	21.0	21.8	16.0	18.0	18.6	17.0	25.0	20.0	19.6	20.0	22.0	16.0	17.0	15.3	17.5	9.1	17.0	12.5	10.6	9.1	12.8
		Mid-Reservoir										20.5	16.7	18.7	20.0	13.0	14.2	20.0	10.0	12.0	3.3	5.2	5.0	12.0	11.0	10.0	5.0	5.5
		Buyala-Kikubamutwe	48.0	43.0	40.0	22.0	33.0	19.0	16.7	18.6	21.8	19.6	20.0	17.5	18.6	16.4	20.0	15.0	20.0	14.0	18.4	15.0	11.6	13.0	9.9	12.7	11.6	17.0
	S. Haematobium	Kalange-Makwanzi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Mid-Reservoir										0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Buyala-Kikubamutwe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

People at all sites with light intensity of infection reduced to 69.2% during this monitoring period from 75% during the previous monitoring period-September 2019 (Table 3.7.1b), those with moderate intensity increased to 30.8% from 20% and heavy infestation intensity remained nil. The nix of heavy intensity infection is indicative of recovery from the disease due to medication that has been administered to patients during the previous monitoring periods. However, the increase in moderate intensity indicate that some riparian residents have lazed taking their medication as prescribed or re-infection is occurring somehow.

Table 3.7.1 b *Trend of Schistomiasis infection intensity among riparian residents at the monitored sites.*

Schistosomiasis Intensity of *S. mansonii*		Monitoring periods																											
		Apr-06	Sep-07	Apr-08	Apr-09	Sep-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18	Apr-19	Sep-19	Jun-20
Intensity levels (%)	Light	32.0	60.8	59.0	35.0	77.0	83.0	86.0	87.0	86.3	75.0	67.0	79.2	83.3	90.5	70.0	81.2	76.0	57.8	80.0	85.7	75.0	73.6	76.0	80.0	75.0	69.2
	Moderate	50.0	27.5	32.0	12.0	4.0	17.0	13.6	15.0	13.7	18.1	33.0	16.7	16.6	9.5	20.5	12.8	23.5	21.0	20.0	14.3	25.0	21.2	24.0	20.0	25.0	30.8
	Heavy	18.0	11.8	10.0	3.0	4.0	0.0	0.0	0.0	0.0	6.2	0.0	4.1	0.0	0.0	8.3	6.1	0.0	10.5	0.0	0.0	0.0	5.2	0.0	0.0	0.0	0.0

Fishing and Bathing/Swimming remained the main predisposing factors to Schistosomiasis infection contributing to 38.5% each to schistosomiasis prevalence (Table 3.7.1 c and Plate 3.7.1). People who fetch water from the river were the least susceptible to the disease because their predisposing prevalence rate reduced to 7.6% during this monitoring from 8.3% during the previous monitoring period-September 2019. If people, especially those involved in Fishing and bathing and swimming activities take basic sanitation and hygienic tendencies, they could reduce their risk of being predisposed to bilharzias. Even though fish mongers (Plate 3.7.2) and water fetchers were least predisposed to the disease, we involved them in our Behaviour Change Communication (BCC) efforts. Subsequently, we are going to focus out mitigating intervention efforts towards the fishermen and those swimming, bathing in order to bring down prevalence and intensity of infection among this riparian community. One of our mitigation measure is that all residents found to be positive for Schistosomiasis infection are treated under directly observed treatment (DOTs) using Praziquantal and Albendazole medicines every the other monitoring period.

Table 3.7.1 c *Trend of Schistomiasis infection prevalence rates according to predisposing factors among riparian residents at the monitored sites.*

Prevalence of Schistosomiasis and water contact predisposing factors		Monitoring periods																											
		Apr-06	Sep-07	Apr-08	Apr-09	Sep-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18	Apr-19	Sep-19	Jun-20
Prevalence rates (%)	Fishing	71.4	94.4	60.0	68.0	79.0	62.0	31.4	21.9	24.0	28.0	27.8	25.8	32.0	38.9	37.2	32.7	20.0	28.5	46.8	42.8	41.6	31.6	40.0	40.0	41.6	38.5
	Fetching water	18.1	38.4	36.6	30.9	48.0	0.0	6.5	14.3	20.0	20.5	18.0	17.6	16.6	9.1	13.3	15.3	16.6	16.0	13.3	21.6	8,3	10.5	10.0	13.4	8.3	7.6
	Bathing/Swimming	70.0	93.4	54.5	54.8	63.0	15.0	18.6	20.0	46.0	20.4	23.0	34.0	20.0	42.0	20.0	20.5	30.1	17.0	33.3	28.5	41.6	52.6	37.0	39.9	41.6	38.5
	Fish mongers	60.0	42.8	16.6	15.0	33.0	8.0	14.3	5.0	14.0	13.3	11.0	18.0	14.2	10.0	18.1	16.6	0.0	9.0	6.6	7.1	8.5	5.3	13.0	0.0	8.3	15.4



Plate 3.7.1 *Fishing at Buyala-Kikubamutwe transect is a major predisposing factor to Schistomiasis*



Plate 3.7.2 *Fish mongers least predisposed Schistomiasis dry their silverfish at Buyala-Kikubamutwe transect*

Status of snail vectors

Table 3.7.1 d *Absolute abundance of Schistomiasis vector snails and non-vector snails at the monitored sites.*

Abundance of schistosomiasis vector water snails and non-vector snails		Transect/sites	Monitoring periods																										
			Apr-06	Sep-07	Apr-08	Apr-09	Sep-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18	Apr-19	Sep-19	Jun-20
Snail Species abundance (absolute numbers)	*Bulinus sp.*	Kalange-Makwanzi	10	21	14	8	23	20	19	37	85	17	251	20	8	6	20	44	118	64	111	66	119	111	26	140	68	50
		Mid-Reservoir										11	30	10	7	4	55	54	20	42	20	35	75	24	52	67	17	63
		Buyala-Kikubamutwe	13	11	50	8	83	81	9	51	18	3	5	7	21	8	37	7	74	10	12	58	93	12	18	1	2	0
	Biomphalaria sp.	Kalange-Makwanzi	22	31	26	25	20	28	63	182	33	26	26	47	16	20	16	16	32	79	32	15	17	26	24	2	3	3
		Mid-Reservoir										68	67	27	46	45	31	27	24	40	82	21	88	33	52	8	6	6
		Buyala-Kikubamutwe	11	9	65	74	122	60	62	80	60	200	167	22	51	44	47	18	28	40	54	18	68	24	18	10	10	0
	Others	Kalange-Makwanzi	127	39	51	135	67	100	101	455	81	8	72	39	68	222	28	4	39	185	15	36	94	147	10	64	25	41
		Mid-Reservoir										13	15	63	131	100	42	58	102	104	186	52	97	45	80	52	69	44
		Buyala-Kikubamutwe	50	37	52	188	91	98	118	96	57	71	105	87	84	42	37	70	36	39	74	78	125	61	138	26	76	0

During this monitoring period, *Bulinus sp* vectors slightly decreased at Kalange-Makwanzi transect to 50 from 68 ind. during the previous monitoring period (Table 3.7.1d). These vectors increased from 17 to63 ind. at the mid-reservoir (Table 3.7.1c). Sampling at Buyala-Kikubamutwe transect was not done as the snail habitat had been washed away by a flood release at the Bujagali dam.

Compared to previous monitoring, the vector numbers of *Biomphalaria sp* at the mid-reservoir transect during the current period remained the same i.e. 6 ind. At Kalange-Makwanzi, 3 ind. were encounterd and 6 at Buyala-Kikubamutwe.

The numbers of non-medically important water snail species increased from 25 to 41 at Kalange-Makwanzi. They decreases at the mid-reservoir transect from 69 to 44. Sampling for snail species abundance at the downstream transect could not be conducted as the habitat had been washed away by the flood release at the dam.

Of the vector snails, *Bulinus sp* was the more abundant, accounting for 54.5% of the total snail abundance while *Biomphalaria sp* was contributed merely 4.3%. This time, no vector snails collected shed any cercaria.

Faecal coli forms

Table 3.7.1 f *Feacal coliform counts in shallow and deep areas of the river at the monitored sites.*

Coliforms in water (number of colonies per ml)	Transect/sites	Monitoring periods																								
		Apr-06	Sep-07	Apr-08	Apr-09	Sep-09	Apr-10	Sep-10	Apr-11	Sep-11	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16	Sep-16	Apr-17	Sep-17	Apr-18	Sep-18	Apr-19	Sep-19	Jun-20
Shallow	Kalange-Makwanzi	200	73	63	105	15	50	50	48	70	57	60	72	96	92	105	99	104	97	99	163	163	174	85	100	104	96
	Mid-Reservoir										79	80	94	80	80	133	130	131	152	144	213	212	231	115	152	166	152
	Buyala-Kikubamutwe	50	87	73	100	10	87	80	82	81	82	76	80	94	90	91	89	90	104	109	104	109	115	83	104	110	104
Deep	Kalange-Makwanzi	40	10	43	15	1	1	1	1	2	6	1	3.5	3.5	3.1	5	3	2	6.5	5	6.5	6.4	7	6.5	6.5	7.5	6.5
	Buyala-Kikubamutwe	10	21	70	22	1	1	1	1	1	1	1	5	5	4	10	7	7	2	3	4	20	19	9	6.5	7	1

The level of faecal coliform contamination at shallow human-water contact points decreased at Kalange-Makwanzi to 96 colonies per ml from 104 colonies per ml during the previous monitoring-September 2019 (Table 3.7.1f). Reduction was experienced at the mid-reservoir too, decreasing to 152 during the current monitoring-June 2020 from 166 per ml during September 2019. So did the decrease happen at the downstream transect 104 during this period-June 2020 from 110 per ml during September 2019. This decline may be due to reduced human water contact activity during the COVID 19 lockdown and the increased water flow rate occasioned by increased release from upstream dams, Nalubale and Kiira. Contamination of more than 10 colonies per ml at all shallow human-water contact points shows a persistent risk to those who use the water for domestic purposes like drinking. Contamination was still highest at the mid-reservoir transect during this sampling period. Water from the deep middle part of the river at Kalange-Makwanzi had a slight decrease in coliform count of 6.5 colonies per 10 mls from 7.5 during the last monitoring period of water. At Buyala-Kikubamutwe, faecal coliform countss dropped to 1 colony from 6.5 colonies per 10 mls during the previous monitoring period. The micro-organisms of medical importance were mainly *Salmonella sp* and *Shigell*a *sp.* Faecal coliform counts of 1-10 colonies per 10 ml of water are considered risk free in terms of health.



Plate 3.7. 1*: The sanitation and vector team (in life jackets and boots) prepare to collect samples, the approach that should be adapted by fishers*

Blackfly/*Mbwa Fly* Sampling

During this monitoring period, no medically important species of *Simulium* flies were detected either by human landing catches, foot patrol or by physical examination of 87 crabs.

Major observations

Generally, snail vector abundance reduced during the current monitoring-June 2020 except at the mid-reservoir transect where numbers *Bulinus sp* were significant.

Counts of fecal coliforms reduced at the three transect.

The increase in schistosomiasis prevalence despite reduced populations at the transects during a partial COVID 19 lockdown is suggestive of a reduced uptake of medication.

There was a slight increase in moderate intensity of infection with schistosomisasis during this sampling period.

3.8. CONCLUSIONS AND RECOMMENDATIONS

3.8.1 Conclusions

1. Trends of zooplankton composition, species richness and abundance estimates show that this assemblage is characterized by rotifer-driven species richness and copepod-dominated numerical abundance and has been stable over the monitoring periods.

2. The high dominance values of copepods especially in the reservoir reaches of the dam suggests high potential for fish production, especially pelagic fishes in these areas relative to the downstream site. The abundance of zooplankton at the downstream part of the study area is consistently lower compared to what is picked up in reservoir reaches. This could be a community response to prevailing water flow dynamics in this area probably created by the dam operations due to periodic opening and shutting of the sluice gates

3. No new species recoveries on the list were recorded. The list of fish species expected from this section of the river (Upper Victoria Nile) seems to have been exhausted.

4. During this monitoring-June 2020, bait fishery of *M. kannume U*VN using basket traps was curtailed due risen water levels and flows.

5. The *Bulinus sp.* vector snail did not shed cercaria transects however, light and moderate infection burdens in the population were still there, bearing out that the transmission loop has not been broken yet. Therefore, transmission of Schistosomiasis is still occurring among the riparian population despite drugs being administered to infected people during the monitoring periods.

3.8.2 Recommendations

1. Given the observed stability and ecological roles of the zooplankton community, protective management needs to be maintained to preserve the community for continued ecological benefits with respect to the water environment quality, fish production as well as biodiversity concerns.

2. Fishing and other activities of the communities around the dam-reservoir areas need to be properly monitored and regulated especially for *M. kannume* bait fishery for a sustainable future fishery in this structurally changed section of the river.

3. Regular environment monitoring of the dam/reservoir areas is useful for early detection of water quality and biotic changes for timely institution of necessary remedial measures.

4. To keep fishers who depend on the *M. kannume bait* fishery afloat in their business, sustainable fishing practices must be enforced to avoid harvesting of immature fish and encourage those who can to culture the fish species for commercial[bait business.

5. Health, hygienic and sanitation education should be continued especially among the new settlers and cultivators at the mid-reservoir vicinity because faecal coliform counts increase that was encountered, could be coming from a new source of contamination. Mass drug administration and health education will continue targeting fisherfolk and swimmers in order to break up transmission of Schistosomiasis from progressing.

3.9 References

Adams, W. M. (1985). "The downstream impacts of dam construction: a case study from Nigeria." Transactions of the Institute of British Geographers: 292-302.

Allan J. D. (1995) Stream ecology, structure and function of running waters. Kluwer Academic Publishers, 388pp.

Arreguín-Sánchez, F. (1996). "Catchability: a key parameter for fish stock assessment." Reviews in fish biology and fisheries **6**(2): 221-242.

Baxter, R. (1977). "Environmental effects of dams and impoundments." Annual Review of Ecology and Systematics **8**: 255-283.

Boxshall, G.A., and E. L. Braide. (1991). The freshwater Cyclopoid Copepods of Nigeria, with illustrated key to all species. *Bull. Br. Mus. Nat. Hist*. (zool) 57, 185–212.

Grabowska, M., Ejsmont-Karabin, J., & Karpowicz, M. (2013). Reservoir-river relationships in lowland, shallow, eutrophic systems: an impact of zooplankton from hypertrophic. *Pol. J. Ecol*, 759–768. Retrieved from http://www.pje.miiz.waw.pl/article/ar61_4_13.pdf

Hillebrand, H., Durselen, C.D., Kirschtel, D., Pollingher, U., Zohary, T., 1999. Biovolume calculation for pelagic and benthic microalgae. *J. Phycol*. **35**, 403–424.

Hovgard, H.; and Lassen, H. (2000). Manual on estimation of selectivity of gillnets and longline gears in abundance surveys. *FAO Fisheries Technical Paper*. No. 397. Rome, FAO. 2000. 84p.

John, M.D., Whitton, A.B. & Brook, J.A. eds., 2002. The freshwater algal flora of the British Isles. An identification guide to freshwater and terrestrial algae., London: Cambrige University Press

Kiggundu, V., L. Mwebaza-Ndawula, B. Makanga, & S. Nachuha (2012). Variation in zooplankton community structure and water quality conditions in three habitat types in northern Lake Victoria. *Lakes and Reservoirs: Research and Management*. xx xx.

Kilham, P., 1971. A hypothesis concerning Silica and the freshwater planktonic diatoms. *Limnology and Oceanography*, **16**(January), pp.10–18.

Korinek V. (1999). A guide to limnetic species of Cladocera of Africa Inland Waters. (Cladocera Branchiopoda). Occasional publication No. 1. The International publication of theoretical and Applied limnology. SIL.

Komarek, J. and Anagnostidis,K., 1999: Süâwasserflora von Mitteleuropa. Band 19/1. Cyanobacteria 1. Teil: Chroococcales. Gustav Fischer. Jena/Stuttgart.

Korovchinsky N. M. (1992). Guides to the identification of the Micro-invertebrates of continental waters of the world. Dididae and Holopedidae (Crustacea, Daphniiformes). SPB Academic Publishing. The Hague. The Netherlands

Koste W. (1978). Rotetria Die Radertiere Mitteleuropas Ein Bestmmungwerk, begrandet vo Max Volg. Uberrordnung Monogmonta. Geburuder Borntraeger, Berlin, Stuttgart.

Mwebaza-Ndawula, L. (1998) Distribution and abundance of zooplankton and *Rastrineobola argentea* (Pisces: Cyprinidae) and their trophic interactions in northern Lake Victoria. *Ph.D. Thesis, University of Vienna, Austria. 162pp.*

Mwebaza-Ndawula L, V. Kiggundu and W. Pabire Gandhi 2003. Diversity and abundance if invertebrates in the Victoria basin lakes and their role in fishery production. Uganda Journal of Agricultural Sciences 8: 209-220

Mwebaza-Ndawula L, S.B.K. Sekiranda and V. Kiggundu 2005. Variability of zooplankton community along a section of the upper Victoria Nile, Uganda. *African Journal of Ecology 43:251-257*

NEMA (1999) State of the environment report for Uganda. Standards for

discharge of effluent into water or on land, Statutory instruments No. 5 of Government of Uganda, 1999.

NaFIRRI, 2008. Environmental and Social Impact Monitoring of the Bujagali Hydropower Project (BHPP), Uganda Fisheries Component. A Report prepared for Bujagali Energy Limited (BEL) April 2008. 119p.

FIRRI-National Agricultural research Organization (NARO).2000 Aquatic and Fisheries Survey of the Upper Victoria Nile. A report prepared for AES Nile Power, Bujagali Hydropower Project. Second Quarter Survey 5-14 April 2000

NaFIRRI (2006). Environmental and Social Impact Assessment (ASIA) of the Bujagali Hydropower Project (BHPP), Uganda. A report prepared for R.J. Burnside International Limited. The First Quarter Survey 6th -13th April 2006

NaFIRRI (2007). Environmental and Social Impact Assessment (ASIA) of the Bujagali Hydropower Project (BHPP), Uganda. A report prepared for Bujagali Energy Limited (BEL). 27th September to 3rd October 2007.

World Health Organisation, January 2000, Human health and dams, The World Health Organization's submission to the World Commission on Dams Geneva, January 1999

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Padisak, J., Reynolds, C.S. & Sommer, U., 1993. Intermediate disturbance in the ecology of phytoplankton and the maintenance of species diversity : a synthesis. *Hydrobiologia*, 249, pp.183–188.

Rutner-Kolisko, A., 1974. Plankton rotifers: Biology and taxonomy. E. Schweizerbart'sche Veriagsbuchhandlung. Nagelen Obermiller.

Shiel, R. J., & Mcevoy, P. (2015). Conceptual Understanding of CLLMM Zooplankton Structure and Function.

Stainton M. P., Capel M. J. and Armstrong F. A. J. (1977) The Chemical Analysis of Fresh Waters, 2nd Edition. Misc. Spec. Publ. Environnent Canada 25,166pp.

Tallling, G. F., 1963. 1963. Origin of stratification in an African rift lake. *Limnology and Oceanography*. 8: 68-78.

Utermöhl, H., 1958. Vervollkommnung der quantitativen Phytoplankton-Methodik. Verhandlungen des Internationalen Verein Limnologie, 9, pp.1–38.

Wetzel, G.R., 2001. Limnology. Lake and River Ecosystems. Third Edition. Academic Press. San Diego.

Wetzel, R. G. and Likens G. E. 2000. Limnological Analyses, 3rd edn. Springer, New York: p. 429.

Zarfdiian, M., E. Michaloudi, D.C. Bobori and S. Mourelatos (2000). Zooplankton abundance in the Alkaiamon river, Greece. Belg. J. Zool. 130 (1): 29-33.

Zhou, S., Tang, T., Wu, N., Fu, X., & Cai, Q. (2008). Impacts of a small dam on riverine zooplankton. *International Review of Hydrobiology*, *93*(3), 297–311. http://doi.org/10.1002/iroh.200711038

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