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

Monitoring No. 22

Date: 4th – 10th April 2018

Monitoring carried out by:

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On behalf of :
Bujagali Energy Limited (BEL)

Date of Report: June 2018

1.0 BACKGROUND

Pre-construction ecological baseline surveys, 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 studies (bilharzias and river blindness). These baseline assessments were preceded 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. 22 (4th -10th April 2018) on the Upper Victoria Nile is the thirteenth one to be undertaken after completion of the 250 MW Bujagali hydropower plant that was commissioned in September 2012. During the post construction period, ecological monitoring surveys 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. 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 surveys at the three transects.

2.0 GENERAL METHODOLOGY AND DATA COLLECTION

2.1. Materials and Methods

This is the twenty second 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.

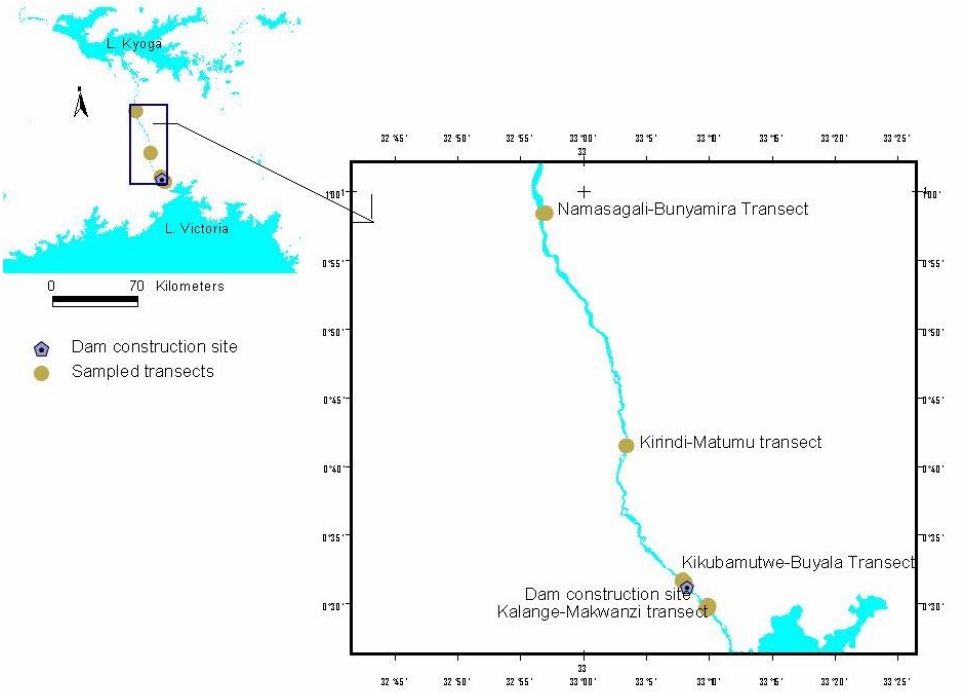

Figure 2.1a *A map showing the Upper Victoria Nile where the BHPP is located and river segments where baseline as well as monitoring samples were taken*

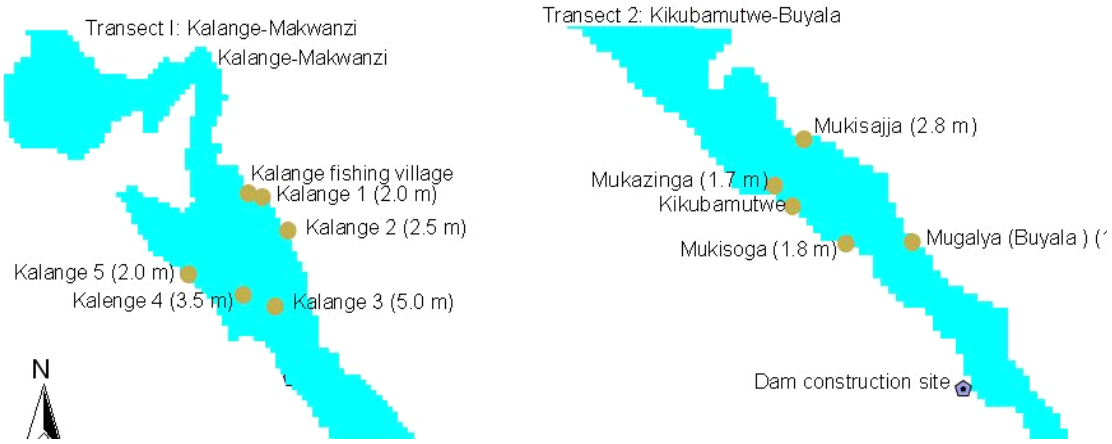

Figure 2.1b *Detailed maps of the two sampled transects: Transect 1 = Kalange-Makwanzi and Transect 2 = Buyala-Kikubamutwe and associated locations on the Upper Victoria Nile.*

Sampling, analytical procedures and techniques used right from the baseline surveys are followed.

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, two transects 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* aree 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 are indicative of relative abundance of fish species from the transects under survey. Catch rates are used to estimate standing biomass. To analyse for catch per net, gillnets are grouped into three size categories: small (1 to 2 ½ inches stretched mesh), medium (3 to 4 ½) and large (5 to 8 inches).

Fishing effort estimation

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) have been 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 *Biompharalia 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 competely 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 water physico-chemical parameters at the monitored sites*

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
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
	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
	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
	NEMA Std	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
	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
	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
	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
	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
Temperature (ºC)	Kalanga-Makwanzi	26.7	26.1	26.2	26.4	25.7	25.6	24.8	26.4	24.9	25.9	25.3	26.85	25.2	26.6	25	26.2	25.9	24.4	26.1	27.5	25.4	26
	Mid-reservoir										26.1	25.4	26.94	25.3	26.7	25	26.4	25.9	25.1	26.1	27.3	25.4	26.2
	Buyala-kikubamutwe	26.4	25.7	26.9	26.8	25	25.8	25.4	26.9	26.5	26.1	25.3	27.14	25.6	27.2	25	26.5	26.1	26	26.2	27.5	26	25.8
	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
	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
Conductivity (µS/cm)	Kalanga-Makwanzi	103	112	81.1	95.5	96.9	87.3	100	129	105	92.3	90	101.4	110	101	98	99.7	101	100	102	96.1	103	101
	Mid-reservoir										97.4	95	101.6	110	102	98	99.3	103	104	102	96.2	103	101.1
	Buyala-kikubamutwe	88.5	114	82.8	97.6	97.7	86.1	102		114	94.8	100	101.5	112	112	99	99.4	102	108	103	96.1	102	101
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
	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
	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
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
	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
	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
	NEMA Std	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
	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
	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
	NEMA Std	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, spatial variations in mean dissolved oxygen concentration along the stream flow from Kalange-Mkwanzi, the upstream transect, through the mid-reservoir to Buyala-Kikubamutwe, the downstream transect were minor, just like it was during the previous monitoring period (Table 3.1.1). These concentrations at all sites were well above the permissible National Environment Management Authority (NEMA) lower limit of 3 mg/L, which is the minimum concentration required for survival of most aquatic organisms including fish.

The mean pH at the monitored sites was slightly alkaline and varied within a narrow range i.e. 8.1 at the upstream and 8.4 in the mid-reservoir (Table 3.1.1). This pH range was comparable to that of April 2012 (range: 8.2 to 8.5) and September 2015 (range: 7.5 to 8.9) and was slightly beyond the permissible NEMA range of 6 to 8.

At all monitored sites, average water temperatures ranged between 25.8°C at the downstream transect and 26.2°Cin the mid-reservoir, a range that was within the NEMA permissible range of 20°C to 35°C.

Average water electrical conductance ranged between 101 µS/cm at the upstream and downstream transects and 101.1 µS/cm in the mid-reservoir, hence showed slight spatial variations that were within acceptable ranges when compared with those recorded at unpolluted sites of Lake Victoria waters that show values of ≤ 120 µS/cm. These ranges in water conductance were however; lower than what was recorded in September 2016.

Water clarity was lower (1.6 m) at the upstream transect compared to 2.1 m both in the mid-reservoir and at the downstream transects. This spatial variation in water clarity was attributed to the long residence time in the mid-reservoir that allowed settling of particulate matter hence making the water column clearer.

Average concentration of TSS was highest in the mid-reservoir (4.1 mg/l) and lowest at the downstream transect (0.8 mg/l). Despite the observed spatial variations, the concentration of TSS was far below the permissible NEMA upper limit of 100 mg/L.

During this reporting period, the concentration of oil and grease at all sites was 2 to 6 times lower than the NEMA permissible upper limit of 10 mg/L i.e. 0.3 mg/L at the upstream transect, 0.6 mg/L in the mid-reservoir; and 0.2 mg/L at the downstream transect. The observed situation was an improvement from the very high figures of September 2016 and remained far below the permissible NEMA upper limit of 10 mg/L.

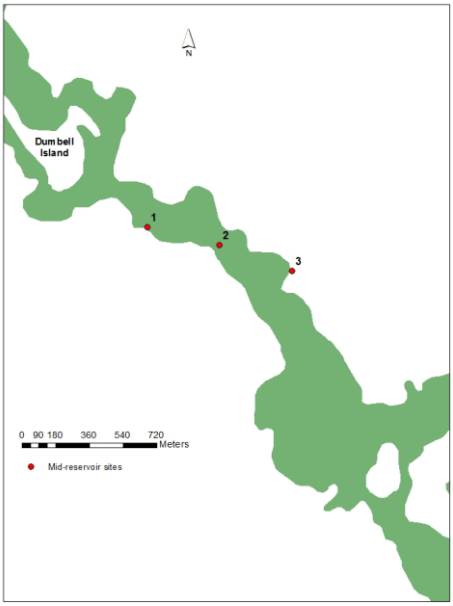

Figure 3.1.1 *Sampled points (1, 2, 3) on the section of the river where depth profiles of temperature, dissolved oxygen and conductivity were taken.* (*NB: Base map used was before dam construction*)

Vertical profiles for major physico-chemical parameters were not taken due to failure of the CTD Profiler. However, physic-chemical parameters determined from samples drawn from the sub-surface, 1m, 5m, 8m, 10m and 20m showed dissolved oxygen to be in the range of 5.2 to 5.8 mg/l; pH ranged between 8.4 and 8.5 hence slightly alkaline; temperature ranged between 26.0 and 26.7°C; while water conductance was in the range of 100.9 and 100.9µS/cm. These observations were similar to those noted in April 2017.

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

The concentration of ammonium-nitrogen (NH_4-N) in the surface waters (i.e. 0 to 2 m) was highest (9.2μg/L) in the mid-reservoir and lowest (7.6μg/L) at the upstream transect (Table 3.1.2). Despite the observed variations, ammonia concentration was far below the NEMA permissible upper limit of 10,000μg/L.

The concentration of nitrite-nitrogen (NO_2-N) negligibly ranged between 6.1μg/L at the upstream transect and 6.4μg/L at the downstream transect. Despite these observations, the low levels of both NH_4-N and NO_2-N indicated a healthy system since conversion of the former into the latter, a process known as nitrification or oxidation of ammonia was at its best. It was also noted, like in previous assessments that the mean concentrations of NO_2-N were far below the NEMA permissible upper limit of 20,000 μg/L.

The mean concentration of nitrate-nitrogen (NO_3-N) was highest (55.3μg/L) in the mid-reservoir and lowest (25.8μg/L) at the downstream transect. Despite the observed

variations, the concentration of NO_3-N remained lower than the permissible NEMA upper limit of 20,000μg/L.

Mean concentration of Total Nitrogen (TN) reduced along the stream flow though this remained below the NEMA permissible upper limit of 10,000 μg/L.

During this reporting period, the average concentration of soluble reactive phosphorus (SRP) was lowest (31.7μg/L) in the reservoir and highest (33.9μg/L) at the downstream transect. Despite this observation, average concentrations of SRP were below the permissible NEMA upper limit of 5,000µg/L.

Total Phosphorus (TP) was within a narrow range (59.6 to 63.1 μg/L) at all sites, with the highest in the mid-reservoir and lowest at the downstream transect. In spite of the observed trend, average TP concentration remained consistently below the NEMA permissible upper limit of 10,000 μg/L.

The concentration of Soluble Reactive Silica (SRSi) decreased along the stream flow and was attributed to enhanced uptake by diatoms and sedimentation in the reservoir.

Algal biomass was highest at the upstream transect (~10.3μg/L) and was attributed to the direct inflow from the lake in addition to the ample nutrient base. Algal biomass was however, lowest in the mid-reservoir due probably to light limitation as a result of the high concentration of TSS (~4.1 mg/l) compared what was noted at the upstream and downstream transects.

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

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
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
	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
	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
	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
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
	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
	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
	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
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	48.8
	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
	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
	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
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
	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
	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
	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
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
	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
	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
	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
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
	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
	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
	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
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
	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
	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
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
	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
	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

3.1.3 Algae and aquatic macrophytes/weeds

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

Broad taxa	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
Cyanophtes	Blue-greens	Kalange-Makwanzi	9	15	12	14	12	14	11	6	25	16	14	16
		Mid-Reservoir	20	14	14	16	9	19	11	11	28	17	11	18
		Buyala-Kikubamutwe	19	18	12	15	14	20	14	11	27	16	16	15
Chlorophytes	Greens	Kalange-Makwanzi	4	8	6	4	6	6	9	4	23	7	7	14
		Mid-Reservoir	8	7	6	5	7	11	12	5	17	12	12	10
		Buyala-Kikubamutwe	7	7	7	5	3	5	8	7	14	7	7	9
Bacillariophytes	Diatoms	Kalange-Makwanzi	4	4	5	2	6	6	2	5	10	4	4	8
		Mid-Reservoir	3	2	3	4	2	6	3	2	9	4	4	5
		Buyala-Kikubamutwe	2	5	3	4	2	5	3	5	12	5	5	6
Euglenophytes	Uni-cellular flagellated algae	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-Reservoir	0	1	0	0	0	0	1	0	1	0	0	0
		Buyala-Kikubamutwe	1	0	0	0	0	0	0	0	0	0	0	0
Dinoflagellates		Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	1	0	0
		Mid-Reservoir	0	1	0	0	0	0	0	0	0	0	0	1
		Buyala-Kikubamutwe	1	0	0	0	0	0	0	0	0	0	0	1
Total number of species		Kalange-Makwanzi	17	27	23	20	24	26	22	15	58	28	28	38
		Mid-Reservoir	25	30	23	25	18	36	18	27	55	33	33	34
		Buyala-Kikubamutwe	30	30	22	24	19	30	25	25	54	28	38	31

The algae community comprised four taxonomic groups dominated by blue-green algae by 58% (Table 3.1.3) especially in the mid-reservoir area. Blue-green algae were followed by green algae and diatoms in that order. This trend was similar to species occurrence during September 2016 and April 2017. During September 2017, 45 species were recorded compared to 55 recorded during the current monitoring period, April 2018. Of the 45 species recorded, 22 belonged to blue-green algae, nine to diatoms, 14 to green algae and only one species from the cryptophytes group (Tables 3.1.4 a-c).

Blue-green algae dominated at all sites however, green algae made a significant contribution upstream and downstream. Comparably, *Anabaena circinalis, Scenedesmus perfolatus* and *Nitzschia acicularis* were most abundant algal species among blue-greens, greens and diatoms respectively (Table 3.1.4 a-c).

Table 3.1.4a *Species composition of the blue-greens at the three sites during April 2018 monitoring period (* denotes presence).*

Broad Taxa	Species	Kalange-Makwanzi	Mid-Reservoir	Buyala-Kikubamutwe
Blue-greens	*Anabaena circinalis*	*	*	
	Anabaena sp.			*
	Aphanocapsa delicatissima	*	*	
	Aphanocapsa elachista	*	*	*
	Aphanocapsa holistica	*	*	*
	Aphanocapsa incerta	*	*	*
	Aphanocapsa nubilium	*	*	*
	Aphanocapsa sp.	*	*	*
	Chroococcus dispersus		*	
	Chroococcus limnetica	*	*	*
	Chroococcus minutus	*		*
	Chroococcus turgidus	*	*	
	Coelomoron pusila		*	*
	Coelosphaerium kuetzingianum			*
	Merismopedia elegans		*	
	Merismopedia tenuissima	*	*	*
	Microcystis aeruginosa		*	*
	Microcystis flos-aqaue		*	
	Planktolyngbya circumreta	*	*	*
	Planktolyngbya limnetica	*	*	*
	Planktolyngbya tallingii	*	*	
	Psuedonabaena limnetica	*		*
	Psuedonabaena sp.	*		
Number of species		**16**	**18**	**15**

Table 3.1.4b *Species composition of the greens at the three sites during April 2018 monitoring period (* denotes presence).*

Broad Taxa	Species	Kalange-Makwanzi	Mid-Reservoir	Buyala-Kikubamutwe
Greens	*Actinastrum sp.*	*		
	Ankistrodesmus falactus	*	*	*
	Ankistrodesmus stegera	*		
	Closterium sp.	*		*
	Coelastrum sp.	*	*	*
	Cosmarium sp.	*	*	
	Crucigenia tetrapoda			*
	Didymocystis tuberculata	*		
	Kirchneriella obesa			*
	Kirchneriella sp.	*		
	Monoraphidium contortum	*	*	*
	Oocystis gigas		*	
	Oocystis sp.	*		
	Pediastrum simplex	*		*
	Scenedesmus acuminatus	*	*	
	Scenedesmus apiculatus		*	*
	Scenedesmus perfolatus	*	*	
	Scenedesmus sp.	*	*	
	Staurastrum gracile		*	*
Number of species		**14**	**10**	**9**

Table 3.1.4c *Species composition of the diatoms and crytophytes at the three sites during April 2018 monitoring period (* denotes presence).*

Broad Taxa	Species	Kalange-Makwanzi	Mid-Reservoir	Buyala-Kikubamutwe
Diatoms	Centric Diatom	*	*	*
	Cyclotella sp.		*	
	Cymbella sp.	*		
	Epithemia argus	*		
	Navicula gastrum	*		*
	Navicula radiosa	*		*
	Nitzschia acicularis	*	*	*
	Stephanodiscus astrea	*	*	*
	Synedra cunningtonii	*	*	*
Number of species		**8**	**5**	**6**
Cryptophytes	*Cryptomonas erosa*			*
	Cryptomonas sp.		*	
Number of species			**1**	**1**

Algal bio-volume among the sites slightly varied. At the mid-reservoir, algal bio volume was dominated by blue-greens whereas at Kalange-Makwanzi and Buyala-Kikubamutwe, bio-volume was dominated by diatoms. The water environment in the mid-reservoir favoured blue-green algae known to be K-strategists probably due to higher water retention conditions and relatively higher availability of nitrates and ammonium ions compared to the other two sites (Dokuli and Teubner 2000). On the other hand, relatively high silica concentrations (> 160 µg/l) at the upstream and downstream sites could have favoured diatoms growth, hence high algal bio volume of diatoms at those sites. Additionally, river flow was more turbulent at the upstream and downstream sites, conditions that can be bore up by diatoms (Kilham 1971). Even in September 2017 monitoring period, diatoms contributed significantly to the total bio-volume. Although blue-green algae had higher number of species than other groups, their bio-volume at the sites was comparably lower. Green algae were third in importance at all sites. Cryptophytes were only recorded downstream and at the mid-reservoir with negligible contribution to the total bio-volume.

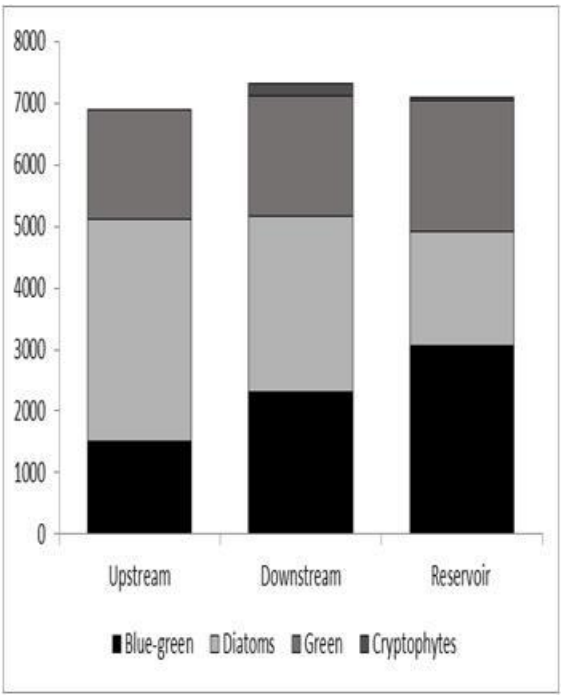

Figure 3.1.2a *Algal bio volume (μm^3L^{-1}) by taxa at the three transects (Upstream, mid-Reservoir & Downstream)*

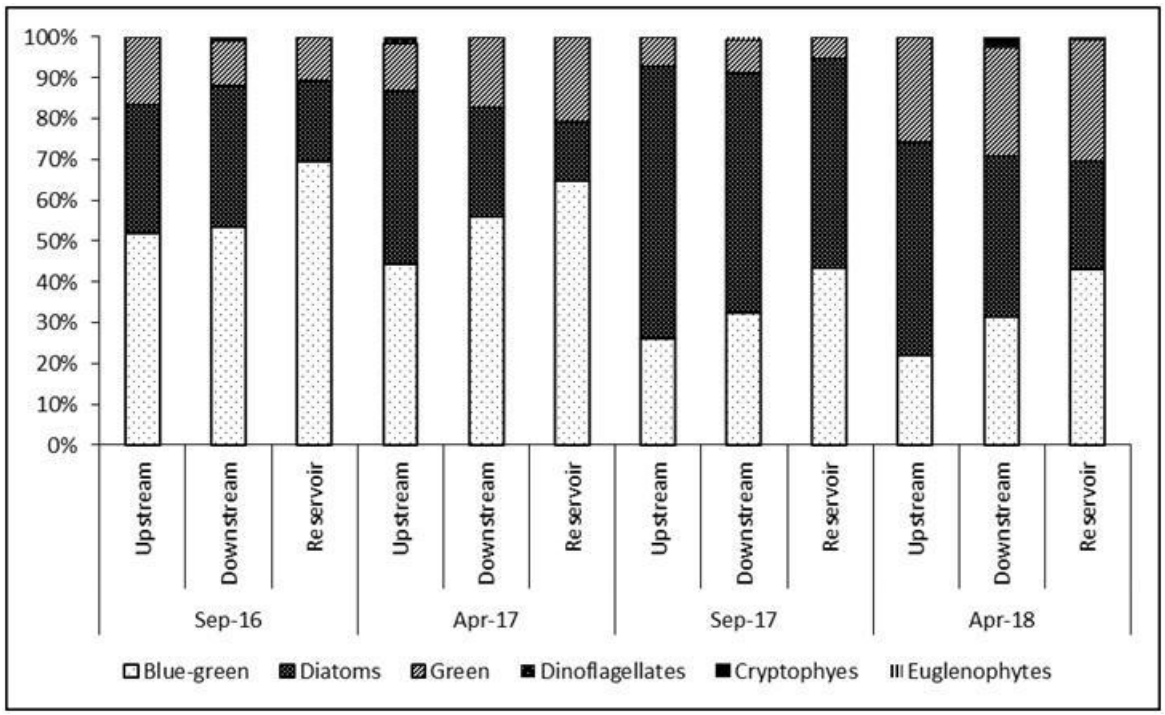

Figure 3.1.3 *Algal bio volume (μm^3ml^{-1}) of Sep-16, Apr-17, Sep-17 and Apr-2018 by taxa at the three transects (Upstream, mid-Reservoir & Downstream)*

Compared to the previous monitoring surveys, there has been a general decline in bio-volume of blue-green algae and an increment in diatoms at all sites (Figure 3.1.3) except

at the mid-reservoir. Nitrogen and Phosphorus are known to significantly influence the growth and abundance of greens and blue-greens (Wetzel 2001) whereas Silica has been reported to majorly influence diatoms growth. Thus, changes in diatom assemblages may indicate a variations in resource ratios of Silica: Phosphorus (Si:P) (Kilham 1971), mixing and nutrient uptake by phytoplankton (Padisak *et al.* 1993). The common *Stephanodiscus astrea* has been found in other African Great Lakes such as Lake Albert where conditions of Silica limitation 0.01-1.1 mg/l thrive (Talling 1963). *Nitzschia* has lower silica requirements than *Stephanodiscus* hence it can occur under low silica conditions and attain faster growth. The dominance of *Nitzschia* during this survey period could mostly be attributed to its being lightly silicified, thus being able to occur in suspense even when water conditions are turbulent. Increase in silica concentrations, therefore does not account for dominance of *Nitzschia*. Contrary to the previous surveys, *Stephanodiscus astrea* species did not co-occur with *Nitzchia acicularis* during September 2017 and April 2018 monitoring periods.

Aquatic macrophytes

The major aquatic macrophytes were water hyacinth (*Eichhornia crassipes*), Hippo grass (*Vossia cuspidata*), Water primrose (*Ludwigia sp.*), Cat tail (*Typha latifolia*) and Nile cabbage (*Pistia stratiotes*). Cover abundance of most aquatic macrophytes during April 2018, reduced compared to what was recorded in September 2017. Still, most aquatic macrophytes were not well established along the banks of the reservoir and the river.

At the Kalange-Makwanzi- upstream transect, water hyacinth dominated the shores but its cover abundance reduced from 1.02 in September 2017 to 0.80 ha during this monitoring period. Cover abundance of the Water Primrose (*Ludwigia* sp.) also reduced from 0.3 ha in September 2017 to 0.06 ha during this reporting period; while Hippo grass (*V. cuspidata*) reduced from 1.1 ha in September 2017 to 0.02 ha during this reporting period. Other aquatic macrophytes (*Phragmites sp* and *Typha sp*) still remained rare and their cover abundance decreased, each covering less than 0.01 ha. Of the 0.8 ha of water hyacinth cover abundance, 0.28 ha occurred at Hudson, 0.16 ha were recorded at Kalange and Kasenyanku respectively. Additionally, 0.45 ha *of V. cuspidata* was recorded at Muluwanvu compared to 0.68 ha in September 2017, while the rest of the macrophytes were of minor occurrence (< 0.2 ha).

At Buyala-Kikubamutwe-downstream transect, much of the river bank (> 60%) was cultivated down to the highest water level, and trees such as Eucalyptus were grown, thus leaving little room for establishment of aquatic macrophytes. Cover abundance of dominant macrophytes have decreased since September 2017 e.g. that of water hyacinth decreased from 0.24 ha in September 2017 to 0.08 ha during this reporting period, and *Vossia cuspidate* decreased during the same periods from 0.54 ha to 0.43 ha. Other macrophytes (*Ludwigia* sp and *Pistia stratiotes)* occurred in insignificant

abundance (0.01-0.02 ha) only at Ofwono site. The reduction in cover abundance of aquatic macrophytes compared to what was noted in September 2017 was attributed to current rains that led to a rise in water levels that resulted in submerging and dislodging of rooted littoral macrophytes.

At mid-reservoir, the banks were devoid of the common aquatic macrophytes, although water hyacinth dominated the shores but with a slight increase in cover abundance from 0.63 ha in September 2017 to 1.08 ha during this reporting period. Buloba and Kyekidde had water hyacinth cover abundance of approximately 0.33 ha (31%) and 0.70 ha (65%), respectively, while Kyabirwa had a paltry 0.05 ha (4%) of this waterweed. Aquatic macrophytes that were very rare (< 0.01 ha) included *Ludwigia* sp and *T. latifolia*. Thus to date, aquatic macrophytes had not yet established around the reservoir and at much of the shores of the two transects.

3.2 Zooplankton (Water column micro-invertebrates)

Species diversity and distribution trends

The zooplankton community composition has continued to be comparable with earlier observations with the three key groups: Copepods, Cladocerans and Rotifers represented by different species numbers in the three study sites (Tables 3.2.1a, b,c). Compared to the previous surveys (Table 3.2.1 c), the number of zooplankton species during April 2018 dropped especially at Kalange-Makwanzi and Buyala-Kikubamutwe sites. For instance, there were just 7 species recorded at Buyala-Kikubamutwe during this period, down from 18 species recorded during September 2017. There were 20 species recorded at the mid-reservoir during this survey. During the previous monitoring period, 22 species were registered at this site (Table 3.2.1 c). During this period, rotifers were the dominant zooplankton at the mid- reservoir and downstream sites while at the upstream site, copepods were the most abundant (Table 3.2.1 a-c). The number of copepod species recorded at the sites especially at the upstream and mid-reservoir has not changed. At the downstream, only 3 species of copepods were recorded. This scenario is similar to what was observed during April 2016, when only 4 species were recorded. During the current survey of April 2018, cladoceran species were completely absent at the downstream site but at the mid-reservoir site, 6 species were registered. The highest number of rotifer species (8 species) was recorded at the mid-reservoir during this monitoring period but this species richness was lower than that recorded in April and September 2017. It was however similar to that recorded in April 2016.

Abundance and distribution trends

Total zooplankton abundance was highest (403,059 ind.m^{-2}) at the mid-reservoir and lowest (159,256 ind.m^{-2}) at the downstream site (Table 3.2.1 c). This trend in abundance of zooplankton among sites is comparable to previous surveys conducted in 2017.

Copepods were the most abundant zooplankton followed by rotifers. The high abundance of copepods was mainly accounted for by the juveniles (copepodites and nauplius larvae) that made up 82% of the abundance. Among copepod developmental stages, the order of abundance at all sites was nauplii > cyclopoid copepodites > calanoid copepodites. Like previously recorded, cladocerans were the least abundant group of zooplankton at all sites (Table 3.2.1 b).

The copepods: *Tropocyclops confinnis*, *Tropocyclops tenellus* and *Thermocyclops neglectus* were recorded at all sites, as observed in previous surveys (Table 3.2.1 a). *Mesoclops sp.*, *Thermocyclops emini* and *Thermodiaptomus galeboides* were recorded at upstream and mid-reservoir but not at the downstream site. However, they were present at all sites during the previous surveys. *Thermocyclops incisus* was only encountered at the upstream site during April 2018 monitoring period (Table 3.2.1 a). This species has been rare at the mid-reservoir where it was last recorded in September 2016, while at the downstream site, it was absent during this survey of April 2018. Among the Cladocera, *Moina micrula*, *Bosmina longirostris* and *Daphnia lumholtz* (helm) were encountered at the upstream and mid reservoir sites while *Chydorus* sp., *Ceriodaphnia cornuta* and *Diaphanosoma excisum* were only encountered at the mid-reservoir during the current survey (Table 3.2.1 b). Only two rotifer species, *Lecane bulla* and *Synchaeta sp.* have been consistently encountered at all sites. *Cephallodella sp.*, *Brachionus bidentatus* and *B. angularis* were only recorded at the mid-reservoir while *Polyarthra vulgaris* was only recorded at the downstream site (Table 3.2.1 c).

Table 3.2.1a. *Trends in numerical abundance (ind. m^{-2}) and diversity of Copepod species at the monitored sites, April 2016 to April 2018.*

Broad taxa	Species name	Upstream-Kalange-Mawkanzi				Mid-reservour				Downstream-Buyala-Kikubamutwe			
		16-Sep	17-Apr	17-Sep	18-Apr	16-Sep	17-Apr	17-Sep	18-Apr	16-Sep	17-Apr	17-Sep	18-Apr
Copepods	*Thermocyclops incisus*	696	606	236	472	898				1,482	202	494	
	Mesocyclops sp.	1,100	808	314	269	449	404	236	943	1,752	180	180	
	Thermocyclops emini	4,289	1,145	393	1,617	5,389		5,541	1,179	15,494		157	
	Tropocyclops confinnis	38,197	7,410	6,130	3,503	21,108	4,244	10,807	4,884	55,511	1,752	3,234	674
	Thermodiaptomus galeboides	6,490	6,130	707	808	4,222	6,198	2,043	5,053	15,764	1,482	831	
	Thermocyclops neglectus	25,353	7,276	3,851	10,846	2,066	14,259	4,283	8,758	19,536	472	550	606
	Tropocyclops tenellus	27733	7,747	6,602	4,244	10,060	25,465	9,038	7,444	19,267	6,086	7,388	4,379
	Total copepod species abundance	**103,858**	**31,124**	**18,234**	**21,759**	**44,193**	**50,570**	**31,949**	**28,261**	**128,806**	**10,172**	**12,833**	**5,659**
	Cyclopoid copepodite	94,471	56,386	70,225	28,395	90,541	67,390	88,812	59,283	254,648	21,849	49,829	10,779
	Calanoid copepodites	18,885	8,286	4,323	7,579	9,072	6,804	4,205	3,267	31,797	2,111	1,707	404
	Nauplius larvae	507,724	139,585	150,195	141,842	315,009	171,023	196,959	295,675	654,539	113,648	112,155	138,035
	Total copepod developmental stages	**621,080**	**204,257**	**224,742**	**177,816**	**414,622**	**245,217**	**289,976**	**358,225**	**940,985**	**137,609**	**163,691**	**149,218**

Table 3.2.1b. *Trends in numerical abundance (ind. m^{-2}) and diversity of Cladocera (water fleas) species and overall zooplankton density at the monitored sites, April 2016 to September 2017*

Broad taxa	Species name	Upstream-Kalange-Mawkanzi				Mid-reservour				Downstream-Buyala-Kikubamutwe			
		16-Sep	17-Apr	17-Sep	18-Apr	16-Sep	17-Apr	17-Sep	18-Apr	16-Sep	17-Apr	17-Sep	18-Apr
Cladocerans	*Daphnia lumholtzi*		135										
	Chydorus sp.					90			472	269			
	Daphnia lumholtzi (helm)				135	90			236	269			
	Ceriodaphnia cornuta	1999	1,886	79		629	808	1,100	269	2,425		236	
	Diaphanosoma excisum	1347	606	1,022		90	2,313	354	707	3,773	67		
	Moina micrura	2448	1,347	1,415	2,425	1,617	202	1,690	2,122	5,120	337	1,033	
	Bosmina longirostris	2,740	876	2,436	1,684	1,437	629	4,598	1,179	2,695	516	685	
	Total Cladocera abundance	**8,533**	**4,850**	**4,951**	**4,244**	**3,952**	**3,952**	**7,742**	**4,985**	**14,551**	**921**	**1,954**	

Of all the rotifer species encountered, four (*Synchaeta* sp., *Keratella tropica*, *Lecane bulla*, *Brachionus angularis* and *Brachionus calyciflorus*) were recorded at all the sites. However, in comparison with records of 2016, only *Synchaeta* sp. and *Keratella tropica* were consistently recorded at all sites. The rest of rotifer species were intermittently distributed (Table 3.2.1 c).

Table 3.2.1c. *Trends in numerical abundance (ind. m^{-2}) and diversity of Rotifer (wheel animalcules) species and overall zooplankton density at the monitored sites at the monitored sites, April 2016 to September 2017*

Broad taxa	Species name	Upstream-Kalange-Mawkanzi				Mid-reservour				Downstream-Buyala-Kikubamutwe			
		16-Sep	17-Apr	17-Sep	18-Apr	16-Sep	17-Apr	17-Sep	18-Apr	16-Sep	17-Apr	17-Sep	18-Apr
Rotifers	*Asplanchna* sp.							157		674			
	Ascomorpha sp.							79					
	Euclanis sp.	2246	269			719		472		1,213			
	Brachionusfalcatus		269					79		135			
	Filinia longiseta												
	Polyarthra sp.	180		157						269	225		
	Filinia opoliensis	135	337	707		180	180	550		1,347			
	Brachionus picatilis												
	Brachionus forticula			157									
	Keratella cochlearis	90		2,279		180		1,336	2,964	269	898	1,729	539
	Brachionus calyciflorus		337	314			606	236			135	427	
	Trichocerca cylindrica	808		1,415	135	1,976	180	1,926	2,863	1,482	404	707	
	Brachionus angularis	180	472	236		898	786	2,161	404	3,234	225	427	
	Brachionus bidentatus								135				
	Hexathra sp.												
	Lecane bulla	5,771	1,415	4,480	674	10,869	3,570	4,834	674	31932	1,482	1,134	1,617
	Lecane luna						629	275					
	Synchaeta sp.	2,852	1,617	629	3,032	3,683	3,840	786	2,594	5,255	853	786	1,886
	Keratella tropica	4,222	4,783	314	2,796	3,054	4,222		1,718	8,219	4,087	516	
	Brachionus patulus									135			
	Cephalodella sp.						2,380		236		2,156	79	
	Polyarthra vulgaris												337
	Total Rotifer abundance	**16,483**	**9,499**	**10,689**	**6,637**	**21,557**	**16,393**	**12,890**	**11,588**	**54,163**	**10,464**	**5,805**	**4,379**
Overall zooplankton abundance		**749,954**	**249,730**	**258,617**	**210,455**	**484,325**	**316,132**	**342,556**	**403,059**	**1,138,505**	**159,166**	**184,283**	**159,256**

Discussion

The abundance of zooplankton was highest at the mid-reservoir, followed by upstream and least at the downstream site. Zooplankton abundance at the downstream site has been consistently low compared to the other two sites since 2012. According to Basu and Pick, 1996, the abundance of zooplankton is positively related to water residence time, probably that is why at the mid-reservoir, zooplankton abundance is high due to high residence time there and very low at the downstream of the dam where Residence time is lower. Moreover, zooplankton groups (copepods, cladocerans and rotifers) respond differently to water residence time. For instance, when water residence time is short, rotifers dominate the zooplankton and when the residence time is long the community is dominated by crustaceans (Baranyi *et al.*, 2002; Shiel and McEvoy, 2015).

Among zooplankton groups, copepods were the most abundant group, dominated by developmental stages especially nauplii, a common pattern observed in Lake Victoria and other freshwater habitats (Vasquez and Rey 1992, Sampaio and Lopea 2000). The high density of juvenile copepods is a result of continuous reproduction (Neves *et al.* 2003) which is important for zooplankton population dynamics and trophic aspects. The immature forms of copepods occupy trophic niches different from those of the adult forms e.g. the nauplii and first copepodite instars of the cyclopoids have a filtration feeding habit and are predominantly herbivorous, while the later copepodite stages and the adults have raptorial feeding habits and are predominantly carnivorous (An *et al.* 2012). Rotifer genera such as *Brachionus*, *Filinia* and *Lecane* have been used as indicators of eutrophy. Although two species belonging to the genus *Brachionus*, *B.angularis* and *B. bidentatus* were recorded at the mid reservoir only, they occurred in low abundance (135 to 404 ind.m^{-2}). On the other hand, the genus *Lecane* was represented by *Lecane bulla* which was more abundant at the downstream site (1617 ind.m^{-2}). At the upstream and mid-reservoir sites up to 674 ind.m^{-2} of *L. bulla* were recorded. As observed in the previous surveys, the species assemblage has not changed significantly over the years of operation of the dam. Stability of zooplankton communities suggests that the environment conditions at the sites are correspondingly approaching level of stability.

3.3 Benthic macro-invertebrates

During this survey period, benthic water snail density increased at all sites, from 19 ind. m^{-2} during September 2017 to 140 ind. m^{-2} at Kalange-Makwanzi, from 28 to 119 ind. m^{-2}at mid-reservoir and 47 to 51 ind. m^{-2}at Buyala-Kikubamutwe transect (Table 3.3.1a). Like in the April 2017 survey period, *Melanoides tuberculata* was the highest contributor to overall water snail density, registering 140 at Kalange-Makwanzi, 119 at the mid-reservoir transect and 51 ind. m^{-2} at Buyala-Kikubamutwe site. At the mid reservoir, *Bellamya unicolor* and *Gabbia humerosa* weres encountered but not at Kalange-Makwanzi and Buyala-Kikubamutwe transects at very low densities of ≤ 7 ind. m^{-2}).

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

Broad taxa	Species name	Site	Monitoring periods															
			Apr-06	Sep-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
Gastropoda (Water snails)	*Bellamya unicolor*	Kalange-Mankwanzi	33	173	5	33	0	0	299	0	0	0	0	35	0	0	0	0
		Mid-reservour				0	0	4	154	296	23	14	98	1097	61	42	21	7
		Buyala-Kikubamutwe	98	126	11	42	65	285	14	23	47	579	9	37	5	33	0	0
	Melanoides tuberculata	Kalange-Mankwanzi	28	107	257	14	19	5	19	0	0	14	0	56	177	79	19	140
		Mid-reservour				0	0	77	5	5	9	145	35	5	107	133	28	119
		Buyala-Kikubamutwe	33	224	100	121	33	33	9	33	0	42	14	0	56	196	47	51
	Biomphalaria choanomphala	Kalange-Mankwanzi	0	14	5	0	0	0	9	0	0	5	0	0	0	0	0	0
		Mid-reservour				2	0	4	7	25	0	0	0	61	9	0	0	0
		Buyala-Kikubamutwe	0	19	11	0	5	9	5	9	5	23	5	5	0	0	0	0
	Anisus natalensis	Kalange-Mankwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour				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
	Gyraulus sp.	Kalange-Mankwanzi	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour				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
	Segmentorbis sp.	Kalange-Mankwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour				0	3	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
	Gabbia humerosa	Kalange-Mankwanzi	0	79	5	0	0	5	23	0	0	0	0	0	0	0	5	0
		Mid-reservour				0	0	4	5	33	0	0	0	5	14	0	0	7
		Buyala-Kikubamutwe	0	0	121	1027	677	135	0	0	9	42	0	196	23	9	0	0
	Bulinus sp	Kalange-Mankwanzi	5	9	5	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour				0	0	0	12	0	0	0	0	14	0	0	0	0
		Buyala-Kikubamutwe	5	5	5	0	19	65	0	5	0	0	0	5	0	0	0	0
	Pila ovata	Kalange-Mankwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour				7	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
Total Gastropod density		Kalange-Mankwanzi	65	383	275	51	19	9	350	0	0	19	0	91	177	79	23	140
		Mid-reservour	0	0	0	9	3	88	182	358	33	159	133	1181	191	175	49	133
		Buyala-Kikubamutwe	135	373	252	1242	808	602	28	75	61	686	28	247	84	238	51	51

Like for benthic water snails, the density of bivalves too increased from the previous survey to the current one i.e. from 84 to 467 ind. m^{-2}at Kalange-Makwanzi, from 189 to 742 ind. m^{-2}at the mid-reservoir transect and decreased from 565 to 70 ind. m^{-2}at Buyala-Kikubamutwe (Table 3.3.1 b). During this monitoring period- April 2018, overall bivalval abundance was most abound at mid-reservour site but during the previous two monitoring periods, this abundance was prominent at Buyala-Kikubamutwe. The most common bivalves at the sites remained *Byssanodonta parastica* and *Corbicular Africana*. The density of the former increased from 9 during September 2017 to 159 ind. m^{-2} during the current monitoring period at Kalange-Makwanzi, 56 to 182 ind. m^{-2} at the mid-reservoir and decreased from 79 to 47 ind. m^{-2}at Buyala-Kikubamutwe. That of the latter too increased from 37 to 154 ind. m^{-2} at Kalange-Makwanzi and from 77 to 448 ind. m^{-2} at the mid-reservoir. It was absent at Buyala-Kikubamutwe. The density of *Ceratula sp*. increased from 28 to 131 ind. m^{-2} at Kalange-Makwanzi and from 42 to 105 ind. m^{-2} at the mid-reservoir and decreased at Buyala-Kikubamutwe from 145 during September 2017 to 9 ind. m^{-2}during the current period. During September 2017, *Mutela*

sp was encountered at Kalange-Makwanzi and mid-reservoir sites at low density (7-14 ind. m^{-2}) and none was recorded at Buyala-Kikubamutwe. During this monitoring period-April 2018, this snail was not recorded at Kalange-Makwanzi and mid-reservoir sites but was at Buyala-Kikubamutwe, registering just 19 ind. m^{-2}).

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

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

During this April 2018 survey, no may fly species was encountered at Kalange-Makwanzi and mid-reservoir sites but they were present during the previous period at the densities of 23 ind. $m^{-2}$and 49 ind. m^{-2} at the former and latter respectively (Table 3.3.1 c). At Buyala-Kikubamutwe, their density increased from 5 ind. m^{-2} during September 2017 to 56 ind. m^{-2} during April 2018. No odonates were found at all sites. Caddis flies were found at the mid-reservoir both during the previous and current surveys at densities of 77 and 28 ind. m^{-2} respectively. Dipteran density decreased at all sites during the current survey i.e. from 1050 to 150 ind. m^{-2} at Kalange-Makwanzi, 315 to 28 ind. m^{-2} at the mid-reservoir and 145 to 47 ind. m^{-2} at Buyala-Kikubamutwe. Chironominea density was the most abound dipteran abundance at all transects; during

the previous monitoring period, registering 962 ind. m^{-2} at Kalange-Makwanzi, 259 ind. m^{-2} at mid-reservoir 145 ind. m^{-2} at Buyala-Kikubamutwe (Table3.3.1c). During April 2018, chiromids were absent at Kalange-Makwanzi and mid-reservoir sites and only 9 ind. m^{-2} were recorded at Buyala-Kikubamutwe. Hemiptera and Coleoptera were absent.

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	Monitoring periods															
			Apr-06	Sep-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
Ephemeroptera (May flies)	*Povilla adusta*	Kalange-Mankwanzi	19	163	9	28	0	14	0	9	0	0	0	0	0	0	14	0
		Mid-reservour				5	3	144	245	5	0	70	12	0	5	0	35	0
		Buyala-Kikubamutwe	5	9	63	28	5	37	9	28	0	19	5	79	5	0	5	23
	Baetis sp.	Kalange-Mankwanzi	5	9	0	0	0	0	0	0	5	0	0	0	0	0	5	0
		Mid-reservour				0	3	0	0	0	79	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
	Caenis sp.	Kalange-Mankwanzi	19	75	19	5	0	0	5	0	0	0	0	0	0	0	0	0
		Mid-reservour				0	0	7	0	0	0	9	0	0	0	0	14	0
		Buyala-Kikubamutwe	0	9	26	37	9	313	0	23	0	0	0	0	0	0	0	28
	Cloeon sp.	Kalange-Mankwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour				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
	Leptophlebidae	Kalange-Mankwanzi	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour				0	0	0	5	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
	Trichorythidae	Kalange-Mankwanzi	0	89	0	0	0	0	0	0	0	0	0	0	0	0	5	0
		Mid-reservour				0	0	0	19	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
Total may fly density		Kalange-Mankwanzi	42	350	28	33	0	14	5	9	5	0	0	0	0	0	23	0
		Mid-reservour	0	0	0	5	6	151	268	5	79	79	12	0	5	0	49	0
		Buyala-Kikubamutwe	65	23	89	70	28	383	19	51	19	19	5	79	5	0	5	56
Odonata (dragon and damsel flies)	*Hagenius* sp.	Kalange-Mankwanzi	19	0	9	0	5	0	0	7	0	0	0	0	0	0	0	0
		Mid-reservour				0	3	0	0	0	0	0	7	33	0	0	0	0
		Buyala-Kikubamutwe	5	0	0	5	5	0	0	5	0	0	5	0	5	0	5	0
	Gomphoides sp.	Kalange-Mankwanzi	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour				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
	Libellulidea	Kalange-Mankwanzi	9	33	0	5	0	14	5	0	0	0	0	7	0	5	0	0
		Mid-reservour				2	0	18	2	2	0	0	0	84	0	14	7	0
		Buyala-Kikubamutwe	0	5	37	5	5	14	0	0	0	0	0	0	0	0	0	0
	Cordulidae	Kalange-Mankwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
		Mid-reservour				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
	Coenagrion sp.	Kalange-Mankwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour				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
	Protoneuridae	Kalange-Mankwanzi	0	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour				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
Total Odonata density		Kalange-Mankwanzi	33	42	23	5	5	14	5	7	0	0	0	7	0	5	5	0
		Mid-reservour	0	0	0	2	3	18	2	2	0	0	7	117	0	14	7	0
		Buyala-Kikubamutwe	9	23	42	9	9	14	0	5	5	0	9	0	9	0	5	0

Broad taxa	Species/family name	Site	Monitoring periods															
			Apr-06	Sep-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
Trichoptera (Caddis flies)	Hydropsychidae	Kalange-Mankwanzi	0	0	0	0	0	0	0	0	0	5	0	0	0	0	5	0
		Mid-reservour				0	0	0	257	0	0	0	12	0	56	0	0	0
		Buyala-Kikubamutwe	0	19	16	5	0	9	0	5	0	0	5	14	0	0	0	0
	Brachycentridae	Kalange-Mankwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour				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
	Psychomyiid	Kalange-Mankwanzi	0	2	0	0	0	5	9	0	0	0	0	0	0	0	0	0
		Mid-reservour				0	3	4	7	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
	Polycentropodidae	Kalange-Mankwanzi				0	0	0	0	0	0	0	0	0	14	0	0	0
		Mid-reservour	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	56	0	0	0
	Leptoceridae	Kalange-Mankwanzi	0	0	0	0	0	5	0	0	5	0	0	0	0	0	0	0
		Mid-reservour				0	0	0	0	0	5	0	0	0	0	42	0	28
		Buyala-Kikubamutwe	0	2	3	0	0	5	0	0	0	0	0	0	0	0	0	5
	Economidae	Kalange-Mankwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
		Mid-reservour				0	0	0	0	0	0	0	0	0	0	0	77	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total caddis fly density		Kalange-Mankwanzi	0	2	0	0	0	9	9	0	5	5	0	0	14	0	9	0
		Mid-reservour	0	0	0	0	3	4	264	0	5	0	12	0	61	42	77	28
		Buyala-Kikubamutwe	0	21	18	7	0	14	0	5	0	0	5	14	56	0	0	5
Hemiptera (water bugs)	Nepidae	Kalange-Mankwanzi	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour				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
	Aphelocheiridae (*Aphelocheirus* sp.)	Kalange-Mankwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour	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
Total water bug density		Kalange-Mankwanzi	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour	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
Coleoptera (Beetles/weevils)	Elmidae	Kalange-Mankwanzi	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour				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
Diptera (True flies)	Chironominae	Kalange-Mankwanzi	271	331	238	201	47	117	191	5	0	9	208	56	490	9	962	0
		Mid-reservour				201	73	98	26	27	0	0	63	51	182	21	259	0
		Buyala-Kikubamutwe	84	56	58	84	9	75	37	19	0	14	84	12	182	33	145	19
	Tanypodinae	Kalange-Mankwanzi	19	33	23	5	14	33	37	19	61	5	63	21	9	56	0	5
		Mid-reservour				0	8	42	42	56	47	0	0	56	42	0	28	28
		Buyala-Kikubamutwe	23	42	5	26	0	14	56	0	28	42	75	7	9	14	0	28
	Chaoborus sp	Kalange-Mankwanzi	9	23	9	9	42	28	70	196	0	37	96	126	7	0	84	175
		Mid-reservour				0	8	53	47	40	5	5	14	5	14	0	21	0
		Buyala-Kikubamutwe	5	5	0	65	0	0	23	5	23	14	14	0	28	0	0	0
	Ceratopogonidae	Kalange-Mankwanzi	5	14	0	9	0	0	0	5	84	0	0	0	0	0	0	0
		Mid-reservour				0	0	0	0	0	0	5	0	14	5	0	0	0
		Buyala-Kikubamutwe	0	5	0	0	0	0	0	0	5	0	0	0	0	0	0	0
	Psychodidae	Kalange-Mankwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
		Mid-reservour				0	0	0	5	0	0	0	0	0	0	0	7	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total dipteran density		Kalange-Mankwanzi	303	401	271	224	103	177	299	224	145	51	366	203	507	65	1050	180
		Mid-reservour	0	0	0	201	90	193	119	123	51	9	77	126	243	21	315	28
		Buyala-Kikubamutwe	112	107	63	175	9	89	117	23	56	70	173	19	219	47	145	47

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

Broad taxa	Species/family name	Site	Monitoring periods															
			Apr-06	Sep-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
Oligochaeta (earth worms)	*Nais* sp.	Kalange-Mankwanzi	0	5	5	14	5	0	28	0	9	5	14	21	23	5	5	19
		Mid-reservour				0	0	11	16	56	5	9	49	191	42	49	7	7
		Buyala-Kikubamutwe	0	33	11	9	5	0	19	0	9	28	42	0	19	9	0	5
Hirudinea (leeches)	Glosophomidae	Kalange-Mankwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid-reservour				0	0	0	0	0	0	0	0	0	0	0	0	0
		Buyala-Kikubamutwe	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Ostracods (seed shrimps)		Kalange-Mankwanzi	0	0	0	0	5	0	9	0	0	0	0	0	0	0	0	0
		Mid-reservour				229	11	0	7	2	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
Decapoda (Shrimps)	*Caridina nilotica*	Kalange-Mankwanzi	0	5	0	5	0	0	5	0	0	9	0	0	0	0	0	0
		Mid-reservour				7	3	0	5	14	0	5	0	70	0	0	0	0
		Buyala-Kikubamutwe	0	5	32	0	0	0	5	0	0	126	5	0	0	0	0	0
Total 0ther benthic macro-jnvertebrates density		Kalange-Mankwanzi	0	9	5	19	9	0	42	0	9	14	14	21	23	5	5	19
		Mid-reservour	0	0	0	236	14	11	28	72	5	14	49	261	42	49	7	7
		Buyala-Kikubamutwe	0	37	47	9	5	0	28	0	9	154	47	0	19	9	0	5

For four consecutive monitoring periods since April 2016, Nile shrimps (*Caridina nilotica*) have been absent at all sites (Table 3.3.1 d). The waterworms (Oligocheata) occurred at the three sites, albeit at very abundance (≤ 19 ind. m^{-2}). Since April 2014, seed shrimps have not been encountered and leeches were last seen in September 2013 at Buyala-Kikubamutwe.

3.4 Fish Species Composition and Relative Abundance

3.4.1 Catch composition

Haplochromines taken as a single species group, 9 fish species were recorded at the three sites along River Nile in April 2018 compared to 11 in September 2017 and 10 in April 2017 (Tables 3.4.1 a & b). At Kalange-Makwanzi site, 7 species were recorded, 6 were registered at the mid- reservoir site and 5 at Buyala-Kikubamutwe.
Keystone species which included: Nile perch (*Lates niloticus*), tilapiines (*Oreochromis niloticus*, *O. variabilis*, *Tilapia zillii*), catfishes (*Bagrus docmak*, *Synodontis afrofischeri, S. victoriae*), Elephant snout fish (*Mormyrus kannume*), and the haplochromines were recovered during this survey. Nile perch, haplochromines, and *S. afrofischeri* were recovered from all the three transects. *Oreochromis variabilis* was recovered from Kalange-Makwanzi site only, *B. docmak* and *S. victoriae* were recovered at the mid-reservoir site only, *M. kannume* was got at Kalange-Makwanzi and mid-reservoir sites,

O. niloticus and *T. zillii* were recovered at Kalange-Makwanzi and Buyala-Kikubamutwe sites.

The highest density of fish by numbers (64.1%) was at Kalange-Makwanzi, 28.2 % at mid-reservoir and 7.8% at Buyala-Kikubamutwe. Nile perch, *Lates niloticus* dominated abundance by numbers and weight at the mid-reservoir by 56.9% and 47.2% and at Buyala-Kikubamutwe by 60.0% and 62.7% respectively. The haplochromines were dominant at Kalange-Makwanzi in terms of numbers by 80.6% and weight by 37.2%.

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

a)

Family name	Scientific name	English names/local names (Luganda)	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
				6-Apr	7-Sep	8-Apr	9-Apr	9-Oct	10-Apr	10-Sep	11-Apr	11-Sep	12-Apr	12-Sep	13-Apr	13-Sep	14-Apr	14-Sep	15-Apr	15-Sep	16-Apr	16-Sep	17-Apr	17-Sep	18-Apr
Bagridae	*Bagrus docmak*	Catfish (Semutundu)	Kalange-Makwanzi		P			P																
			Mid-Reservoir										P	P	P	P	P	P	P	P	P	P	P	P
			Buyala-Kikubamutwe		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
			Mid-Reservoir										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
Characidae	*Brycinus jacksoni*	(Nsoga)	Kalange-Makwanzi																					
			Mid-Reservoir																					
			Buyala-Kikubamutwe	P																				
	B. sadleri	(Nsoga)	Kalange-Makwanzi	P																P				P	
			Mid-Reservoir																						
			Buyala-Kikubamutwe																						
Cichlidae	*Oreochromis niloticus*	Nile tilapia (Ngege-kibati)	Kalange-Makwanzi	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
	O. leucostictus	Black tilapia (Ngege)	Kalange-Makwanzi	P	P																			P	
			Mid-Reservoir																						
			Buyala-Kikubamutwe	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
			Mid-Reservoir										P				P								
			Buyala-Kikubamutwe	P	P		P			P	P	P	P				P		P	P					
	Tilapia zillii	Red-belly tilapia (Ngege)	Kalange-Makwanzi	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
	Haplochromine	(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
			Mid-Reservoir										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

b)

Family name	Scientific name	English names/local names (Luganda)	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
				6-Apr	7-Sep	8-Apr	9-Apr	9-Oct	10-Apr	10-Sep	11-Apr	11-Sep	12-Apr	12-Sep	13-Apr	13-Sep	14-Apr	14-Sep	15-Apr	15-Sep	16-Apr	16-Sep	17-Apr	17-Sep	18-Apr
Clariidae	*Clarias gariepinu*	Mudfish (Male)	Kalange-Makwanzi			P	P							P	P								P		
			Mid-Reservoir										P	P											
			Buyala-Kikubamutwe			P	P		P			P				P						P			
Cyprinidae	*Barbus 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			
	B. 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
			Mid-Reservoir										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
	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
			Buyala-Kikubamutwe											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
			Mid-Reservoir										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					
	Gnathonemus longibarbis		Kalange-Makwanzi																						
			Mid-Reservoir														P		P						
			Buyala-Kikubamutwe																						
Total No. of Species			Kalange-Makwanzi	10	10	10	8	9	9	7	8	5	8	8	8	6	5	6	6	9		7	8	9	7
			Mid-Reservoir										10	7	8	7	6	5	7	5		6	5	6	6
			Buyala-Kikubamutwe	11	13	8	12	6	6	10	4	7	8	7	7	7	7	3	7	7		6	4	3	5

3.4.2 The Haplochromines

At least 13 species belonging to 9 genera of haplochromines were recovered during this survey April 2018 (Tables 3.4.2 a, b & c). At Kalange-Makwanzi site, 11 haplochromine species were recorded, 6 were got at the mid- reservoir and just 2 at Buyala-Kikubamutwe. The most dominant genus by number was Astatotilapia by 40.4%, while Psamochromis dominated in terms of weight by 31.6%.

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

a)

Genus	Species name	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
			6-Apr	7-Sep	8-Apr	9-Apr	9-Oct	10-Apr	10-Sep	11-Apr	11-Sep	12-Apr	12-Sep	13-Apr	13-Sep	14-Apr	14-Sep	15-Apr	15-Sep	16-Apr	16-Sep	17-Apr	17-Sep	18-Apr
Astatoreochromis	*A. alluaudi*	Kalange-Makwanzi	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
		Mid-Reservoir										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	
	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
		Mid-Reservoir																						
		Buyala-Kikubamutwe					P	P	P							P								
	Astatotilapia sp	Kalange-Makwanzi			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
	A. nubila	Kalange-Makwanzi															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
		Mid-Reservoir																						
		Buyala-Kikubamutwe	P		P	P	P		P			P	P			P		P					P	
	H. serranus	Kalange-Makwanzi																						
		Mid-Reservoir																						
		Buyala-Kikubamutwe	P																					

b)

Genus	Species name	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
			6-Apr	7-Sep	8-Apr	9-Apr	9-Oct	10-Apr	10-Sep	11-Apr	11-Sep	12-Apr	12-Sep	13-Apr	13-Sep	14-Apr	14-Sep	15-Apr	15-Sep	16-Apr	16-Sep	17-Apr	17-Sep	18-Apr
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
		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	
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. crassilabris	Kalange-Makwanzi																P						
		Mid-Reservoir																						
		Buyala-Kikubamutwe																						

c)

Genus	Species name	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
			6-Apr	7-Sep	8-Apr	9-Apr	9-Oct	10-Apr	10-Sep	11-Apr	11-Sep	12-Apr	12-Sep	13-Apr	13-Sep	14-Apr	14-Sep	15-Apr	15-Sep	16-Apr	16-Sep	17-Apr	17-Sep	18-Apr
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
		Mid-Reservoir												P		P				P			P	P
		Buyala-Kikubamutwe	P		P		P		P				P	P	P	P		p					P	
	Psammochromis sp	Kalange-Makwanzi															P				P	P		
		Mid-Reservoir																						
		Buyala-Kikubamutwe															P							
Ptyochromis	*P. sauvagei*	Kalange-Makwanzi	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
		Mid-Reservoir																						
		Buyala-Kikubamutwe																		P			P	P
Xystichromis	*X. phytophagus*	Kalange-Makwanzi	P			P		P	P												P			
		Mid-Reservoir																		P				
		Buyala-Kikubamutwe									P													
Unidentified	Haplochromines	Kalange-Makwanzi				P																		
		Mid-Reservoir																						
		Buyala-Kikubamutwe																						
Total number of species		Kalange-Makwanzi	14	17	12	15	16	9	14	14	11	14	5	3	3	4	6	7	9	4	7	7	8	11
		Mid-Reservoir										4		2	3	5	1	2	5	5	1	3	3	6
		Buyala-Kikubamutwe	10	8	10	7	12	5	9	4	6	5	8	5	5	7	3	8	7	2	1	2	7	2

3.2.3 Catch rates / biomass estimates

Overall catch rates by numbers and weight were highest at Kalange-Makwanzi - 3.18 fish per net per night and 139.2g and lowest at Buyala-Kikubamutwe 0.39 fish per net per night and 7.2 g respectively (Tables 3.4.3 and 3.4.4). At Kalange-Makwanzi, haplochromines recorded the highest catch rates by number of 8.3 fish per net per night and weight of 168.0 g. Even at the mid-reservoir and Buyala-Kikubamutwe sites, haplochromines recorded the highest catch rates by number of 1.29 and 0.41 fish per net per night but *L. niloticus* dominated the catch by weight at both sites by 52.3 g and 4.5 g respectively. Although the overall catch rates by numbers reduced from those recorded in the previous survey at the mid-reservoir and Buyala-Kikubamutwe sites, an increase in overall catch rates by weight was realised at Kalange-Makwanzi and mid-reservoir sites.

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 resurgence of the haplochromines in the mid-reservoir has been noted. All keystone fish species expected at these transects have been recovered. Further colonisation of this reservoir by new species is to be monitored.

Table 3.4.3 *Catch rates (numbers) of fish species caught by gillnets over time at the monitored sites*

Species	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
		6-Apr	7-Sep	8-Apr	9-Apr	9-Oct	10-Apr	10-Sep	11-Apr	11-Sep	12-Apr	12-Sep	13-Apr	13-Sep	14-Apr	14-Sep	15-Apr	15-Sep	16-Apr	16-Sep	17-Apr	17-Sep	18-Apr
Bagrus docmak	Kalange-Makwanzi		0.03			0.08																	
	Mid-Reservoir										0.03	0.1	0.38	0.4	0.1	0.01	0.15	0.2	0.01		0.03	0.01	0.03
	Buyala-Kikubamutwe		0.07		0.04								0.08	0.1						0.01			
Lates niloticus	Kalange-Makwanzi	0.19	3.1	3.32	2.3	9.76	0.32	0.58	1.13	0.15	2.83	0.5	1.62	0.7	0.1	0.14	0.32	0.26	0.04	0.19	0.4	0.19	0.19
	Mid-Reservoir										3.06	0.7	1.08	4.2	0.3	0.16	0.66	1	0.29	0.13	0.72	11.3	0.79
	Buyala-Kikubamutwe	1.12	1.68	1.86	2.29	2.57	0.35	0.4	0.16	0.72	0.83	0.2	0.85	1.5	0.6	0.13	0.32	0.08	0.06	0.23	0.07		0.24
Brycinus jacksonii	Kalange-Makwanzi																						
	Mid-Reservoir																						
	Buyala-Kikubamutwe	0.04																					
B. sadleri	Kalange-Makwanzi	0.04																0.04				0.13	
	Mid-Reservoir																						
	Buyala-Kikubamutwe																						
Oreochromis niloticus	Kalange-Makwanzi	0.04	0.33	0.1		0.2			0.01	0.01	0.02					0.01	0.01	0.03		0.01	0.37	0.15	0.06
	Mid-Reservoir												0.08							0.01			
	Buyala-Kikubamutwe	0.07	0.41	0.04	0.04	0.1		0.1			0.19	0.04	0.38	0.2	0.3								0.01
O. leucostictus	Kalange-Makwanzi	0.04	0.09																			0.02	
	Mid-Reservoir																						
	Buyala-Kikubamutwe	0.06	0.08																				
O. variabilis	Kalange-Makwanzi	0.17	0.91	0.43	0.45	1.52	0.06	0.17	0.19		0.09	0.04	0.31	0.2			0.04	0.06		0.06	0.38	0.15	0.04
	Mid-Reservoir										0.03				0.01								
	Buyala-Kikubamutwe	0.13	0.08		0.17			0.02	0.02	0.03	0.03						0.09	0.03					
Tilapia zilli	Kalange-Makwanzi	0.1	0.17	0.17		0.17	0.04	0.1	0.13		0.09	0.09	0.13	0.1				0.06		0.08	1.44	0.23	0.42
	Mid-Reservoir										0.05	0.05	0.25	0.5									
	Buyala-Kikubamutwe	0.88	0.46	0.04	0.43	0.1		0.04			0.16	0.16			1		0.07	0.07			0.02	0.04	0.02
Haplochromines	Kalange-Makwanzi	9	10.5	6.63	19	15.5	5.83	4.5	12.7	10.6	11.1	0.4	11.8	2.5		2.54	2.75	2.04	0.08	2.92	7.96	7.63	8.33
	Mid-Reservoir										0.25		0.5	5.8		0.13	0.15	0.1	0.13	0.08	0.29	0.42	1.29
	Buyala-Kikubamutwe	16.8	4.27	6.36	8.32	6.47	0.78	1.62	2.05	1.36	6.13	2.3	13.8	47.2		0.79	13.7	0.44	0.17	0.27	0.59	2.63	0.41
Clarias gariepinus	Kalange-Makwanzi			0.03	0.17							0.01	0.08								0.01		
	Mid-Reservoir										0.02	0.03											
	Buyala-Kikubamutwe	0.01		0.25	0.07		0.03			0.02				0.1						0.01			
Barbus altianalis	Kalange-Makwanzi	0.02	0.1	0.17	0.03		0.01				0.02												
	Mid-Reservoir										0.06	0.1	0.38										
	Buyala-Kikubamutwe	0.1	0.11	0.04	0.04		0.01	0.01		0.02	0.02		0.15		0.01					0.01			
B. paludinosus	Kalange-Makwanzi																						
	Mid-Reservoir																						
	Buyala-Kikubamutwe	0.04																					
Labeo victorianus	Kalange-Makwanzi																						
	Mid-Reservoir																						
	Buyala-Kikubamutwe		0.09					0.02															
Protopterus aethiopicus	Kalange-Makwanzi						0.01																
	Mid-Reservoir																						
	Buyala-Kikubamutwe				0.04																		
Synodontis afrofischeri	Kalange-Makwanzi	0.21	0.63	0.08	0.42	1.46	0.46	0.33	0.13	0.38	4.75	1.8	53.8	79.5	1.5	4.42	0.58	1.08	0.04	7.75	0.13	0.25	0.13
	Mid-Reservoir										0.75		1.5	1.5			0.15		0.17	0.08		0.25	0.21
	Buyala-Kikubamutwe		0.27	1.09	0.37	3.58	0.28	0.1		1.07	0.06	3.7	2.5	0.5	0.1	0.04	0.87	0.5		1.73		0.04	0.05
S. victoriae	Kalange-Makwanzi			0.08		0.21	0.29		0.17			0.1	3.25	1.3	0.1	0.16		0.08					
	Mid-Reservoir										0.05	0.04		1.8		0.08	0.05	0.8		0.21	0.08	0.17	0.04
	Buyala-Kikubamutwe											0.1					0.04	0.06			0.09		
Mormyrus kannume	Kalange-Makwanzi	0.32	0.8	1.83	0.7	0.08	0.23	0.18	0.22	0.04	0.33	0.1	0.46	0.5	0.01	0.04	0.23	0.1	0.05	0.05	0.03	0.01	0.04
	Mid-Reservoir										0.82	0.9	1.46	2.7	0.3	0.23	0.48	0.6	0.21	0.21	0.14	0.08	0.09
	Buyala-Kikubamutwe	0.68	0.86	2.25	0.39	0.38	0.15	0.25	0.18	0.17	0.02	0.1	0.15				0.01	0.02					
Gnathonemus longibarbis	Kalange-Makwanzi																						
	Mid-Reservoir											0.04			0.1		0.15						
	Buyala-Kikubamutwe																						
OVERALL RATES	Kalange-Makwanzi	2.89	5.48	4.39	7.54	10	2.87	2.41	4.54	3.36	8.2	1.3	23.6	26.9	1.5	2.38	1.62	1.46	0.13	3.63	4.41	3.06	3.18
	Mid-Reservoir										4.4	1.8	4.2	10.2	0.9	2.11	1.45	1.98	0.6	0.46	1	11.6	1.4
	Buyala-Kikubamutwe	6.45	3.28	3.91	3.71	4.28	0.81	1.21	0.95	1.5	3.1	2.3	6.6	16.8	6.8	0.41	4.86	0.48	0.12	0.71	0.28	0.85	0.39

Table 3.4.4 *Catch rates (weight (g) of fish species caught by gillnets over time at the monitored sites*

Species	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
		6-Apr	7-Sep	8-Apr	9-Apr	9-Oct	10-Apr	10-Sep	11-Apr	11-Sep	12-Apr	12-Sep	13-Apr	13-Sep	14-Apr	14-Sep	Apr_15	15-Sep	16-Apr	16-Sep	17-Apr	17-Sep	18-Apr
Bagrus docmak	Kalange-Makwanzi		37.5			28.6																	
	Mid-Reservoir										14.1	27.7	835	136		0.51	32.5	73.6	11.4		17.1	3.88	3.31
	Buyala-Kikubamutwe		22.5		6.93								13.8	19.1	4					2.8			
Lates niloticus	Kalange-Makwanzi	15.8	271	371	114.1	251	49.4	35.9	11.6	8.6	156	63.3	141	77.7	9.3	25.41	13.9	53.8	30.2	21.3	25.8	8.12	48.7
	Mid-Reservoir										198	140	532	538	17.8	42.8	104.4	81.4	85.8	19.1	65	28.01	52.3
	Buyala-Kikubamutwe	108	108	159	111	171	28.8	39.3	16.4	44.5	30.2	18	36.8	94.8	22.7	4.29	13.4	3.2	2.14	10.4	4.9		4.51
Brycinus jacksonii	Kalange-Makwanzi																						
	Mid-Reservoir																						
	Buyala-Kikubamutwe	3.25																					
B. sadleri	Kalange-Makwanzi	0.75																0.58				1.38	
	Mid-Reservoir																						
	Buyala-Kikubamutwe																						
Oreochromis niloticus	Kalange-Makwanzi	1.8	7.42	28.9		20.1			0.5	6.7	1.2					9.68	0.05	2.24		5.1	35.6	9.04	11.8
	Mid-Reservoir												9.2							2.9			
	Buyala-Kikubamutwe	4.53	0.18	3.93	0.93	5.05		0.83			5.8	1.7	205	7.4	29.9								0.14
O. leucostictus	Kalange-Makwanzi	3.67	6.61																			1.06	
	Mid-Reservoir																						
	Buyala-Kikubamutwe	5.75	6.75																				
O. variabilis	Kalange-Makwanzi	33.5	49	63.3	44.73	82.8	14.9	19.5	26.1		18.4	8.7	122				1.02	18.1		24.8	34.5	20.63	7.9
	Mid-Reservoir										1.7				5.4								
	Buyala-Kikubamutwe	11.6	12.1		8.17			4.04	11.5	13.6	8.1				20.3		9.2	15.5					
Tilapia zillii	Kalange-Makwanzi	6.92	15.7	21.7		7.92	7.71	32.2	21		10.1	2.8	18.8					3.6			69.9	11.38	19.8
	Mid-Reservoir										7.2		21.3	10.5									
	Buyala-Kikubamutwe	81.9	19.1	7.33	42.26	7.9		2.71			6.1	2.1		32	38.9		1.3	1.3			2.7	2.3	
Haplochromines	Kalange-Makwanzi	304	192	168	534.3	383	168	113	160	246	168	8.5	219	33.8	15.5	26.2	26.6	20.4	1.21	38.6	180.7	97.5	168
	Mid-Reservoir										4.1		22.5	113	113	2.92	4.05	2.6	0.13	1.9	6.3	4.08	32.4
	Buyala-Kikubamutwe	285	51.3	206	187.1	168	15.8	40.4	37.7	15.3	86.9	32.3	226	697	229	9.63	143.9	5.3	1.33	2.4	10.8	44.5	3.82
Clarias gariepinus	Kalange-Makwanzi			6.27	69.33							8.9	100								33		
	Mid-Reservoir										9.4	48.7											
	Buyala-Kikubamutwe	9.2		52.9	89.36		33.6			3.1				139						9			
Barbus altianalis	Kalange-Makwanzi	19.3	403	501	7.27		2.31				0.6												
	Mid-Reservoir										51.3	199	266										
	Buyala-Kikubamutwe	48.9	22.9	95.6	9.36		4.03	5.73		12.8	0.3		408		8.2					4			
B. paludinosus	Kalange-Makwanzi																						
	Mid-Reservoir																						
	Buyala-Kikubamutwe	0.5																					
Labeo victorianus	Kalange-Makwanzi																						
	Mid-Reservoir																						
	Buyala-Kikubamutwe		38.9					14.8															
Protopterus aethiopicus	Kalange-Makwanzi						15.9																
	Mid-Reservoir																						
	Buyala-Kikubamutwe				26.21																		
Synodontis afrofischeri	Kalange-Makwanzi	10.9	49.5	4.58	14.92	56.8	59.6	18.8	7.2	28.8	61.1	64.2	1543	2668	46.3	151	22.13	50.4	2.13	310	5.2	10.83	5.92
	Mid-Reservoir										15.6		62.5	61			8.75		8.25	3.3		11.21	14.6
	Buyala-Kikubamutwe		19.1	30.6	10.42	112	12.9	2.38		17.4	1.3	87.3	45	18	3.8	1.67	34.4	15.4		67.8		1.13	0.41
S. victoriae	Kalange-Makwanzi			12.5		17.9	39.3		28.1			7.3	278	108	5.2	18.29		5.3					
	Mid-Reservoir										6.8	3.6		236		7.63	10.1	69.5		27.4	9.2	16.17	6.15
	Buyala-Kikubamutwe											9.6					4.39	10.3			7.8		
Mormyrus kannume	Kalange-Makwanzi	111	251	511	95.75	14.7	49	77.5	39.7	7.5	44.5	27.7	114	57.6	9.5	16.9	15.5	61.9	5.18	31.2	2.6	2.08	8.05
	Mid-Reservoir										158	156	238	643	80.1	119	108	111.3	81.7	68.8	29.5	25.41	37.1
	Buyala-Kikubamutwe	217	89.5	176	185	51.6	9.22	33.4	15.6	15.9	1.3	7.8	209				25.2	2.66					
Gnathonemus longibarbis	Kalange-Makwanzi																						
	Mid-Reservoir														8		9.15						
	Buyala-Kikubamutwe																						
OVERALL RATE	Kalange-Makwanzi	242	474	636	299.5	297	213	186	141	102	290	132	1116	1076	55.3	112.1	86.3	155.1	36.4	182	218.4	73.3	139
	Mid-Reservoir										443	573	1920	1449	115	165.7	254.7	288.4	183	101	116.5	67	111
	Buyala-Kikubamutwe	503	137	257	241.7	171	82.8	104	49.9	102	73	68.6	955	499	200	8.16	100.2	25.9	2.55	41.6	11.9	15.5	7.2

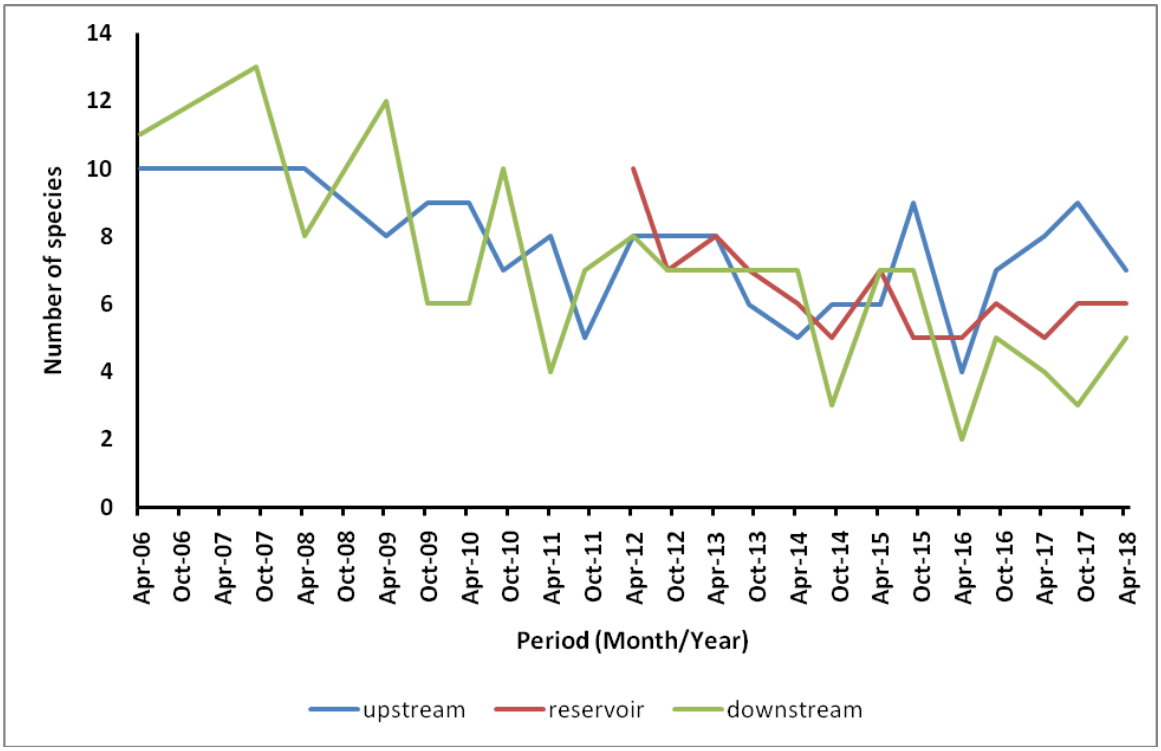

Figure 3.4.1 Cumulative *number of fish species recovered from the study transects on the Upper Victoria Nile over the sampling period.*

3.5 The Food and Trophic Ecology of the Fishes

During this survey of April 2018, *L. niloticus* was recorded from all the three sites (Table 3.5.1). At Kalange-Makwanzi, the diet of the species comprised of fish (94.7%) and *Caridina nilotica* (5.3%). The fish prey included haplochromine cichlids (68.4%) and unidentifiable fish remains (26.3%). Dominance of fish prey, especially haplochromine cichlids, in the diet of *L. niloticus* from Kalange-Makwanzi was also observed in the previous survey of September 2017. At the mid-reservoir site, the diet of *L. niloticus* comprised of *Caridina nilotica* (63.5%) and fish (36.5%) during this monitoring of April 2018. Dominance of *C. nilotica* in the diet of *L. niloticus* in the mid-reservoir was also observed in the previous survey of September 2017. From Buyala-Kukubamutwe site, *L. Niloticus* ingested only fish prey that comprised of haplochromine cichlids (67.1%) and *Rastrineobola argentea* (42.9%) during the recent survey of April 2018. In the previous survey of September 2017, *L. niloticus* was absent in the catch at this site.

In the survey of April 2018, *Mormyrus kannume* was recorded from all the three sites (Table 3.5.1). At Kalange-Makwanzi and Buyala-Kukubamutwe sites, *M.*

kannume ingested ephemeropteran nymphs whereas in the mid-reservoir the diet of the species comprised of chironomid larvae. Dominance of insect prey in diet of *M. kannume* was also observed in the previous survey of September 2017,

During the survey of April 2018, *Synodontis afrofischeri* was only recorded from Kalange-Makwanzi and Buyala-Kukubamutwe sites (Table 3.5.1). The diet of *S. afrofischeri* from both sites comprised of only ephemeropteran nymphs. Dominance of insect prey in the diet of the species in the same sites was also observed in the previous survey of September 2017.

In the survey of April 2018, *Oreochromis variabilis* was only recorded from Kalange-Makwanzi but its gut was empty (Table 3.5.1). In the previous survey of September 2017, the diet of the species from Kalange-Makwanzi comprised of blue-green algae (32%), diatoms (28%), detritus (26%), water plants (10%) and green algae (9%).

During April 2018 monitoring period, *Oreochromis niloticus* was recorded from Kalange-Makwanzi and Buyala-Kukubamutwe (Table 3.5.1). At Kalange-Makwanzi, the diet of *O.niloticus* comprised of blue-green algae (28.0%), high plant material (26.7%), detritus (18.3%) and insect material (4.3%). However, in the previous survey of, September 2017, the diet of the species from the same transect was dominated by detritus. Variation in the diet of *O.niloticus* is attributed to seasonal changes in availability of food items of the species in the environment. The specimen from Buyala-Kukubamutwe had an empty gut.

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

Family	Species	site	Monitoring dates												
			10	11	12	13	14	15	16	17	18	19	20	21	22
			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
Bagridae	*Bagrus docmak*	Kalange-Makwanzi			E	E						CRB		CG	
		Mid-Reservoir	SYN	CAR	SYN	CAR	FR	Hap	CAR	LN	RAS	E	ODT	CG	CAR
		Buyala-Kikubamutwe				FR						FR			
Centropomidae	*Lates niloticus*	Kalange-Makwanzi	HAP	ODT	LN	HAP	HAP	RAS	HAP	CAR	LN	HAP	CAR	HAP	HAP
		Mid-Reservoir	RAS	CAR	RAS	CAR	CAR	CAR	CAR	CAR	RAS	CAR	CAR	CAR	CAR
		Buyala-Kikubamutwe	FR	CRB	HAP	HAP	HAP	RAS	HAP	HAP	RAS	HAP	RAS	E	RAS
Cichlidae	*Oreochromis niloticus*	Kalange-Makwanzi	MOL				HPM	E	E	E		HPM	DETR	DETR	BGA
		Mid-Reservoir			CHA							IR			
		Buyala-Kikubamutwe	INS	EPH	EPH	HPM	BGA								E
	O. variabilis	Kalange-Makwanzi	BGA	BGA	INS	DETR	BGA		DETR	BGA		DETR	DETR	BGA	E
		Mid-Reservoir					BGA								
		Buyala-Kikubamutwe	BGA				BGA		E	DETR					
	Tilapia zillii	Kalange-Makwanzi	EPH	E	HPM		ODT			DETR		HPM	HPM	HPM	HPM
		Mid-Reservoir	E		E	E									
		Buyala-Kikubamutwe	EPH	HPM		HPM	HPM		HPM	HPM			E	HPM	HPM
Claridae	*Clarias gariepinus*	Kalange-Makwanzi		E	MOL	MOL							CRAB		
		Mid-Reservoir	EPH	EPH								E			
		Buyala-Kikubamutwe				EPH						E			
Cyprinidae	*Barbus altianalis*	Kalange-Makwanzi	DETR												
		Mid-Reservoir	MOL	MOL	MOL										
		Buyala-Kikubamutwe			MOL		E					E			
Mochokidae	*Synodontis afrofischeri*	Kalange-Makwanzi	MOL	EPH	EPH	CHR	CHR	CHR	EPH	CHR	CHR	EPH	CHR	CHR	EPH
		Mid-Reservoir	CHR		EPH	EPH			CHR		EPH	EPH		EPH	
		Buyala-Kikubamutwe		EPH	EPH	EPH	CHR	E	EPH	ODT		EPH		E	EPH
Momyridae	*Mormyrus kannume*	Kalange-Makwanzi	EPH	CHR	EPH	EPH	CHR	EPH	CHR	EPH	CHR	CHR	CHR	E	EPH
		Mid-Reservoir	EPH	EPH	CHR	EPH	CHR	CHR	MOL	CHR	EPH	EPH	CHR	MOL	CHR
		Buyala-Kikubamutwe	E	ODT	INS				E	CHR					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 the recent survey of April 2018, signs of breeding activity were observed in all fish species examined, except L*ates niloticus,* in which only 1 specimen was mature but not in breeding condition (Table 3.5.2). The highest breeding intensity was recorded from Kalange-Makwanzi in 5 species, followed by the mid-reservoir in 3 species. **At** Kalange-Makwanzi, the species that indicated signs of breeding activity included: *M. kannume*, *O. variabilis*, *Tilapia zillii, O. niloticus* and

S. afrofischeri. The species that showed signs of breeding in the mid-reservoir included: *M. kannume, Bagrus docmac,* and *S. afrofischeri.* At Buyala-Kukubamutwe, all the fish species recorded and examined were immature.

Fish breeding intensity at Kalange-Makwanzi during April 2018 was observed in 5 species and six species during the previous survey of September 2017. At the mid-reservoir, 3 fish species were in breeding condition during April 2018 while during September 2017, they were 4 species (Table 3.5.2). The breeding status of fish species recorded at Kalange-Makwanzi during this recent survey of April 2018 was similar to those in the previous survey of September 2017.

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

Family	Species	site	Monitoring date												
			10	11	12	13	14	15	16	17	18	19	20	21	22
			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
Bagridae	*Bagrus docmak*	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*	Kalange-Makwanzi	0	0	0	0	0	0	4.3	5.6	0	0	0	0	15
		Mid-Reservoir	1	0	7.1	0	0	8.3	2.4	0	8	8	0	4	0
		Buyala-Kikubamutwe	0	0	0	0	0	0	0	0	0	0	0	0	0
Cichlidae	*Oreochromis niloticus*	Kalange-Makwanzi	0				6.7	100	0	0		100	40	0	48.5
		Mid-Reservoir			0	0						0			
		Buyala-Kikubamutwe	0	0	60	0	10.5								0
	O. variabilis	Kalange-Makwanzi	0	0	14.3	45.5	46.2		0	33.3		75	30	25	50
		Mid-Reservoir					0								
		Buyala-Kikubamutwe	0				11.1		0	100					
	Tilapia zillii	Kalange-Makwanzi	33.3		0	0	57.1			0		0	37	25	29
		Mid-Reservoir			0	0									
		Buyala-Kikubamutwe	0			75	6.1		0	50			50	0	0
Claridae	*Clarias gariepinus*	Kalange-Makwanzi		0	0	50							50		
		Mid-Reservoir	0	0								50			
		Buyala-Kikubamutwe				0						0			
Cyprinidae	*Barbus altianalis*	Kalange-Makwanzi	0												
		Mid-Reservoir	50	50	0										
		Buyala-Kikubamutwe			50		0					50			
Mochokidae	*Synodontis afrofischeri*	Kalange-Makwanzi	7.9	35.3	34	68	54.8	98.8	100	96.4	100	92.6	40.2	83.3	100
		Mid-Reservoir	6.7	12.5	16.7	25			33.3		25	0	0	60	75
		Buyala-Kikubamutwe	0		70	100	16.7	100	100	87.5		100	0	0	0
Momyridae	*Mormyrus kannume*	Kalange-Makwanzi	17.6	33.3	45.5	28.6	25	0	38.9	25	25	100	50	100	30
		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
		Buyala-Kikubamutwe	0	33.3	100				100	100					

Major observations

During this survey of April 2018, fish dominated by Haplochromine cichlids was the major prey for *Lates niloticus* at Kalange-Makwanzi site, although *Caridina nilotica* also contributed significantly to the diet of the species as was during the previous survey of September 2017.

At the mid-reservoir site, *Caridina* was the major prey for Nile perch during April 2018 as was during the previous survey of September 2017. At Buyala-Kikubamutwe site, the species had ingested haplochromine cichlids and *R. argentea* during the recent survey of April 2018 whereas in the previous survey of September 2017, the species had ingested only *R. argentea.*

B*agrus docmac* was only recorded from the mid-reservoir during this monitoring period of April 2018 and its diet comprised of only *Caridina.* During the previous survey of September 2017, the species had ingested fish prey. The diets of *S. afrofischeri* and *M. kannume* were dominated by insect prey as was during the previous survey of September 2017.

The diet of O.niloticus during the survey of April 2018 was dominated by blue-green algae whereas during September 2017, the diet of the species was dominated by detritus. *T. zillii* had ingested mostly water plants as in the previous survey of September 2017.

During April 2018 monitoring period, breeding intensity and condition of keystone fish species in all the sites were similar to that recorded in the previous survey of September 2017.

3.6. THE COMMERCIAL FISHERY

3.6.1 Fishing effort in the fishery

In April 2014, there were 117 fishing boats at the three sites. Currently (April 2018), the number of fishing boats across the three transects has reduced to 67 boats (Tables 3.6.1 a-c). Of the 67 fishing boats counted during this monitoring period, 43 % were registered at the mid-reservoir site, 37 % at Kalange-Makwanzi and 20 % at Buyala-Kikubamutwe. Both the Upstream and Downstream transects registered declines in the number of fishing boats, while

the mid-reservoir recorded an increase from 22 boats during September 2017 to 29 boats during April 2018. The number of fishing boats among the three sites has continued to fluctuate over the monitoring periods probably due to the migratory nature of fishers. Fishers occasionally migrate to sites suspected to have better fish catches and prices as a fishing strategy (Lwenya et al., 2009; Binet et al., 2012). As fish migrates, so do the fishers (Njock & Westlund, 2008). Such migrations help fishers to keep up with their livelihoods in forms of employment, food and nutritional security. Some fishers opt out completely from fishing for alternative livelihood sources.

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

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
Number fishing boats	Kalange-Makwanzi	22	18	23	23	18	32	15	20	19	24	27	27	32	25	40	31	37	45	25
	Mid-Reservoir	-	-	-	-	-	-	16	13	18	27	44	60	38	51	46	48	41	22	29
	Buyala-Kikubamutwe	26	32	23	15	12	15	34	19	28	40	20	32	25	21	18	14	21	11	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
	Mid-Reservoir	-	-	-	-	-	-	13	3	4	12	20	21	13	12	11	9	10	6	5
	Buyala-Kikubamutwe	7	6	1	2		1	4	2	7	3	1	10	1	4	7	3	-	1	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
	Mid-Reservoir	-	-	-	-	-	-	1	0	-	5	-	6	6	2	7	6	3	-	3
	Buyala-Kikubamutwe	6	6	13	6	3	7	10	7	-	-	-	-	6	-	4	3	3	-	-
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
	Mid-Reservoir	-	-	-	-	-	-	0	0	-	2	-	-	2	7	3	2	10	-	-
	Buyala-Kikubamutwe	6	3	1	1	3	0	7	2	-	2	-	-	7	-	1	3	1	-	-
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
	Mid-Reservoir	-	-	-	-	-	-	1	7	3	0	16	23	9	14	9	13	13	12	11
	Buyala-Kikubamutwe	9	14	9	2	2	3	12	5	2	5	5	7	3	17	3	2	2	5	1
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	-	-
	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
	Mid-Reservoir	-	-	-	-	-	-	-	0	-	0	-	-	-	1	6	2	3	3	6
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	11	20	30	14	15	8		21	6	15	5	12
Number of boats using Small seine.	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	1	3	2	2	4	2	2	3
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	3	-	-
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Both April and September monitoring surveys coincide with the rainy spells, which are associated with variations in the physical and biotic environments ranging from food availability to better conditions for fish to spawn, thus during these periods fish catches are generally expected to be high. Fish assemblages correlates with seasonality, with the rainy seasons registering higher catches and therefore fishing activities in terms of fishing inputs (boats, gears and crew) tend to be more during the wet season than during the dry periods. Mansor *et al*

(2012) found the primary and secondary wet seasons in March–June and August–November respectively influenced water chemistry and fish assemblages in Merbok Estuary. During dry months of the year, returns from the fisheries go down-as such fishers tend to withdraw their fishing inputs (boats and gears) from the fishery and switch to more productive alternative livelihood sources. Despite this monitoring period being a rainy one, the overall number of boats recorded in the study area reduced. This reduction therefore could be an indication of declining stocks of the commercially exploited fish species and low economic returns from the existing fishery. The increase in number of fishing boats at the mid-reservoir site could be due to better catch yields at this site compared to the other two monitored sites.

There were 16 fishing boats using gillnets in the study area in April 2017. These have reduced to 13 during the April 2018 survey (Table 3.6.1 b). There were 7 boats using gillnets at the upstream site and just one at the downstream one. What determines the choice of fishing gear(s) in exploitation of the fisheries is the target fish species. At the downstream site, species that require gillnets for their harvest were absent, that is why the boats using gillnets in this area were very few. Most fishing boats at the downstream site had basket traps and long-line hooks, which they used to harvest *Mormyrus kannume* as live bait (Table 3.6.1 c). Hovgêrd & Lassen (2008) showed that the choice of fishing gear at a particular fishing ground was 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.

The number of boats using longline hooks at the upstream and mid-reservoir transects increased between September 2017 and April 2018 (Table 3.6.1 c). Boats using hand line hooks were encountered at all the three transects, with the mid-reservoir recording 11 boats, which was the highest number. Both the number of boats using basket traps and the number of basket traps increased across the three transects between April 2017 and April 2018. This increase is attributed to the increasing significance of the *M. kannume* bait fishery. The species has recently gained importance as bait for the large size high valued *Lates niloticus*, *Protopterus aethiopicus* and *Clarias gariepinus* on lakes Victoria and Kyoga-that why it is currently faced with heavy exploitation. The species appears to be experiencing growth overfishing thus the sustainability implications of its exploitation require urgent attention.

As was in the previous surveys, basket traps, long-line hooks, hand-line hooks, and monofilament gill-nets have remained the most common gears used at all

sites even during this monitoring period. The majority of gillnets recorded at all sites (Table 3.6.1 b) were below the legal size limit of 127 mm (5 inches) and are dominated by 76.2 mm and 63.5 mm mesh sizes. The number of legal gillnets in the study area was low probably because the target species (e.g. *Lates niloticus*, *Tilapia sp* and *Barbus sp*) that mature at large sizes were scarce or low. This is further reflected in the low catch rates of the landed catch for these species (Table 3.6.2) and the common gillnets being used, the monofilaments. Whenever catch rates of the target species go down, fishermen resort to active fishing methods. Monofilament gillnets are usually operated actively in order to improve catch rates. There were no boats using scoop nets encountered at all sites during the April 2018 survey. There were 3 boats that had small seine boats at the downstream transect. The number of cast-nets remained relatively stable between September 2013 and April 2018 despite migratory shifts amongst transects.

The composition and distribution of fishing effort (boats, gears and size) at the three sites during the April 2018 survey provides an insight of the possible target fish species at those sites. Do fishermen budge between fishing gears in response to seasonal variations in catches of the target species? They do, particularly when catches of the target species are high, they use a particular fishing gear and abandon it when catches go down (Lwenya *et al*., 2009; Binet et al., 2012; Njock & Westlund, 2008).

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

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
Gillnets - ?2½"	Kalange-Makwanzi	-	1			4		2	0		1	11	2	8	1	6	19	5	14	10
	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
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
	Buyala-Kikubamutwe	4	-	-	9	-	-	10	0		0			15		7	6	-	-	-
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	-	-	-	-	-	-	-	-	-
Gillnets 4"	Kalange-Makwanzi	21	8	2	26	20	20	10	0	-	18	35	17	1	-	6	3	-	3	-
	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	-	-	-	-	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	0	0	-	0	-	8	1	-	-	3	5	-	-
	Buyala-Kikubamutwe		6	1	-	-	-	0	0	-	12	-	-	-	-	-	-	-	-	-
Gillnets 5"	Kalange-Makwanzi	12	1		-	-	-	1	0	-	0	3	-	-	-	-	-	-	-	-
	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	-	-	-	-	-
	Buyala-Kikubamutwe	18	15	-	-	-	-	-	0	9	0	-	-	-	-	-	-	-	-	-
Gillnets 6½"	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gillnets 7"	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
	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
	Mid-Reservoir	-	-	-	-	-	-	36	7	0	33	118	87	51	32	31	40	63	34	13
	Buyala-Kikubamutwe	22	37	4	11	-	18	13	11	24	12	10	38	15	11	7	6	-	3	3

***Table 3.6.1 b**. The 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
Long line hooks	Kalange-Makwanzi	550	200	650	280	-	500	70	800	687	860	1360	950	230	626	250	1060	910	440	650
	Mid-Reservoir	-	-	-	-	-	-	50	-	-	70	-	580	378	200	140	154	112	-	55
	Buyala-Kikubamutwe	277	180	380	142	110	482	525	420	-	-	-	-	1100	420	56	420	300	-	-
Cast nets	Kalange-Makwanzi	-	5	4	1	1	5	1	0	-	3	2	6	5	2	5	3	6	6	5
	Mid-Reservoir	-	-	-	-	-	-	0	0	-	2	-	-	2	7	3	2	-	-	-
	Buyala-Kikubamutwe	6	3	1	1	3		7	2	2	2	-	-	7		1	3	1	-	-
Hand line hooks	Kalange-Makwanzi	105	124	26	3	18	88	35	4		26	2	10	35		30	1	10	12	15
	Mid-Reservoir	-	-	-	-	-	-	6	14			69	276	65	218	50	73	61	36	85
	Buyala-Kikubamutwe	97	152	32	16	8	5	51	24	2	5	5	39	18	63	18	-	4	15	10
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	-	-
	Buyala-Kikubamutwe	1	1		1	2	1	1	0	-	-	-	-	-	-	-	-	-	-	-
Small seine nets	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	3	3	2	2	4	2	2	3
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	3	-	-
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Monofilament nets	Kalange-Makwanzi	-	-	-	-	-	-	0	29	15		38		16		25	24	23	18	15
	Mid-Reservoir	-	-	-	-	-	-	21	0	13	3	113	56	47	43	28	34	30	34	30
	Buyala-Kikubamutwe	-	-	-	-	-	-	0	0	-	-	4				7	10	12	3	2
Number of Traps	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	43	48	1	124	41	189	110	164
	Mid-Reservoir	-	-	-	-	-	-	-	-	-	-	-	-	-	10	105	22	44	36	59
	Buyala-Kikubamutwe	-	-	-	-	-	-	-	56	151	461	460	190	97	55	39	53	127	29	62

3.6.2. Fish catch composition and catch rates

Fish catch composition

During the April 2018 survey, 8 fish species which included: *Lates niloticus, Oreochromis niloticus, Oreochromis niloticus, Tilapia zillii, Bagrus docmak, Mormyrus kannume, Synodontis afrofischeri,* and haplochromine species grouped as a single species group), belonging to six families were recorded at the three sites (Table 3.6.2). This observation reflects a 38% reduction in the number of commercial species recorded in April 2014 and a 20% reduction in those recorded in September 2017. All the species encountered during the current survey were also recorded in September 2017. Similar to the previous surveys, Family *Cichlidae* recorded the highest number of species (three) while the other families were each represented by a single species. The mid-reservoir and downstream sites recorded the highest (seven) and lowest number of species respectively. Mukene, *Rastrineobola argentea* and *Oreochromis niloticus* were exclusively recorded in the mid-reservoir while and *Tilapia zillii* was encountered at only Kalange-Makwanzi transect. Three fish species, *M. kannume*, *L. niloticus* and *B. docmak* were encountered at all the three sites (Table 3.6.2). Two fish species, *Oreochromis variabilis* and *Barbus altianalis* recorded during the September 2017 survey were absent during the current monitoring survey.

The number of fish species recorded in the commercial catch at all the three transects declined from 14 during April 2014 to 8 during this survey period. Since April 2009, commercial fisheries have been fluctuating, with some species absent in some surveys but reappear in the subsequent ones. Six species, *B. docmak, L. niloticus, O. niloticus, T. zilli and M. kanume* have consistently occurred in the commercial catches at the upstream site since April 2009 (Table 3.6.2). The lung fish, *Protopterus aethiopicus* was recorded six times at this transect over the same period, however, it has not been recorded at any of the three transects since September 2013. Likewise, *Oreochromis leucostictus* has not been encountered at the monitored sites since April 2014.

Fish catch rates (kg/boat/day)

Catch-per-unit-effort (CPUE) for majority of the species during April 2018 substantially reduced across the three sites compared to September 2017 record, with *M. kannume, L.niloticus,* and *B. docmak* registering the greatest declines (Table 3.6.2). However, three species; *L. niloticus*, *O. niloticus* and *R. argentea* showed improvements in daily catch rates (Table 3.6.2).

Current monitoring trends reveal that a change in the composition and spatial/temporal distribution of fish species amongst the three monitored sites has been manifested. Now, there are more species at the mid-reservoir transect than at the upstream site where previously more species were abound. This change could be an attribution of the ecological habitat alterations, evidence by the creation of lentic-like environment in the reservoir. Dams have been reported to lower fish species and population numbers (Agostinho *et al* , 2008; Lin , 2011), which is a concern to fisheries biologists, conservationists and managers. In this study, the persistent absence of the previously common species like *Protopterus aethiopicus* and *Oreochromis leucostictus* is of concern. If in the subsequent monitoring surveys, this trend continues, corrective measures may be required to avert it. Dam barriers obstruct the migratory patterns of aquatic organisms including fish between the upstream and downstream sites (Hafiz *et al*., 2014; Hall, Jordan, & Frisk, 2011; and Roberts, 2001). The hindrance to fish migration in search for suitable breeding and feeding habitats negatively affects recruitment and growth. It is only those species that are able to adapt the new habitat conditions that will servive while the rest will be completely wiped out, thereby lowering the overall fish populations.

Damming creates distinctive zones i.e. the lentic or semi lentic (reservoirs) and riverine/lotic (Upstream and downstream) zones (Agostinho *et al*., 2008; Lin, 2011). In the study area, a reservoir was created in April 2012 after completion of the dam construction. Since the creation of the reservoir, there has been a continuous decline in species composition at the downstream site from 11 in April 2012 to six currently. The total number of fish species at the three sites has since reduced from 14 to only 10 species. This observation is in agreement with earlier studies of Agostinho *et al*., 2007 who showed species composition to increase during the initial stages of the reservoir development due to the mixture of local assemblages formerly distributed over a range of fluvial environments which later become flooded and homogenized. After the complete filling of the reservoir, environmental quality may deteriorate and fish begin to search for favourable environments nearby including the free flowing stretches to upstream, or shoreline areas. This could be the possible explanation for the presence of more fish species at the upstream. The decline in number of species downstream could also be attributed to the barrier created by the dam, which hinders fish migration from uptream and the reservoir to downstream. This hinderance could be mitigated by providing for fish migration ladders.

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 r	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
BAGRIDAE	*Bagrus docmak* (Semutundu)	Kalange-Makwanzi	0.4	0.27	0.08	0.15	0.09	0.5	0.53	0.09	0.46	0.8	1	0.7	0.2	1	0.9	1	1.7	2	0.3
		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
		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
CENTROPOMIDAE	*Lates niloticus* (Mputa)	Kalange-Makwanzi	0.78	2.12	0.64	0.76	0.52	0.11	1.79	1.8	1.56	2.9	2.5	5.9	0.4	2.7	2.8	1.9	2.6	2	3.3
		Mid-Reservoir	-	-	-	-	-	-	0.43	3.5	0.81	1.9	2.5	2.6	1.6	2.5	1.6	2.8	2.3	3.3	3.9
		Buyala-Kikubamutwe	1.01	0.79	1.3	0.38	1.97	3.58	1.41	1.5	0.56	4.9	2	-	0.2	1.8	0.1	8	-	1.4	-
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	-
		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
		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	-	-	-	-	-
	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	0.66	1.7	2	1.7	0.2	1.6	1	1.2	0.4	0.4	-
		Mid-Reservoir	-	-	-	-	-	-	0.48	0.1	-	-	0.3	0.3	-	0.3	-	-	-	0.1	-
		Buyala-Kikubamutwe	-	0.06	0.25	0.1	1.67	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tilapia zillii (Ngege)	Kalange-Makwanzi	0.23	1.04	0.21	0.22	-	0.12	0.39	0.1	0.11	0.9	1.1	0.3	0.02	1	0.2	0.8	1	0.7	0.1
		Mid-Reservoir	-	-	-	-	-	-	1.13	0.1		0.8	0.5	0.2	0.02	0.5	0.2	-	-	-	-
		Buyala-Kikubamutwe	-	0.01	0.15	0.04	-	-	-	-	0.02	0.5	-	-	-	0.6	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	-
		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	-	-
CLARIIDAE	*Clarias gariepinus* (Male)	Kalange-Makwanzi	0.18	0.07	-	0.04		0.22	1.77	0.5	0.18	3.5	3.8	1.5	0.1	2.8	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	1.35	-	-	-	-	-	-	3.1	-	4.5	8	4.8	-
		Buyala-Kikubamutwe	0.18	-	-	-	-	-		-	0.03	-	-	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	0.24	1.2	9.8	-	-	9.8	-	-	-	2.1	-
		Mid-Reservoir	-	-	-	-	-	-	0.95	-	-	0.5	-	0.7	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	1.17	0.54	2.1	1.58	1.13	2.98	1.4	1.5	-	-	-	9.4	-	-	-	3	-	15	-
	Rastrineobola argentea (Mukene)	Kalange-Makwanzi	-	-	11.4	2.96	34.5	-		43	-	-	24	21	-	-	5	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	115	23.5	4.29	-	22	-	7.2	51	73.3	23	25	-	26
		Buyala-Kikubamutwe	5.3	-	-	3.05	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PROTOPTERIDAE	*Protopterus aethiopicus* (Mamba)	Kalange-Makwanzi	0.06	-	0.05	0.48	-	-	0.05	-	0.05	-	-	12	-	-	-	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	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
		Mid-Reservoir	-	-	-	-	-		0.06		-	0.5	0.1	0.2	-	0.5	0.2	0	-	0.5	0.3
		Buyala-Kikubamutwe	-	-	0.01	-	-	-	-	-	-	0.5	0.5	1	-	0.4	0.4	-	-	1.7	-
	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	1.35	1.4	0.7	2.3	2.2	1.1	2.1	0.3	0.3	2.2	0.5
		Mid-Reservoir	-	-	-	-	-	-	1	4.7	0.96	3.4	3.3	4.8	0.4	2.7	2.7	0.8	0.6	5.8	1.1
		Buyala-Kikubamutwe	0.23	0.19	0.39	0.06	1.04	0.61		2.3	4.07	4.3	3.2	3.9	2.5	2.3	9.7	2.3	1.6	7.5	1

3.63. Estimates of total fish catches

The monthly catch for majority of the species recorded in April 2018 at all sites decreased (Table 3.6.3), except for *R. argentea* at the mid-reservoir site. The reduction in monthly catches across sites could be attributed to the decline in the number of fishing boats, fishing gears and the CPUE for the exploited species. The mid-reservoir transect had a fairly high number of fishing boats, registering high number of species landed in the commercial catches (Table 3.6.4).

Studies on effects of fishing effort on fish stock biomass (Jennings & Polinin, 1996) have shown that biomass decreases with increase in fishing intensity.

Fishery yields can increase with rise in fishing inputs up to a point of maximum sustainable yield (MSY) beyond which further increase in fishing inputs results into diminishing returns. In an unexploited fishery, introduction of small amount of fishing effort will result into high catch rates (catch-per-unit-effort) but further increase beyond the maximum sustainable yield (MSY) will result into a decrease in CPUE thus a decrease in stock biomass since CPUE is at times used as a measure of biomass index (stock size of the species).

The number of fishing boats and gears targeting the different exploitable fish species across all the study sites has fluctuated since the onset of the monitoring surveys (Table 3.6.1). The fluctuations in effort (fishing crafts and gears) have also been reflected by the fluctuations in daily mean catch rates, monthly catches and revenue of total catch at beach level (Tables 3.6.2 and 3.6.3). Reductions in both catch rates and biomass are thus signals of over-exploitation and unsustainable selective fishing for species which if not checked could lead to the collapse of the fisheries. The observed impacts may not solely be attributed to the dam construction but also a failure in management and regulation of fishing effort to sustainable levels. For instance, the *M. kannume* bait fishery has not been regulated since its emergency and has now led to the near collapse of the species in the study area. *M. kannume* has dominated the commercial fisheries across all transects since April 2013, but drastically reduced during the April 2018 survey. The basket traps used to harvest *M. kannume*, target mainly the live juvenile individuals for bait for the Nile perch fishery on lakes Victoria and Kyoga. The price for bait fetches high market prices than the mature individuals and this has been the main incentive for harvesting of large quantities of the juveniles. 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 affects recruitment and may lead to reductions in fish stocks. Similarly, harvesting juvenile species for use as bait away from the study area (on Lakes Victoria and Kyoga) deprives the riparian communities of the rich fish protein hence may lead to prevalence of malnutrition among the fisher communities. There is need for consorted efforts from particularly the fisheries managers to protect *M. kannume* by prohibiting the use of basket traps since they are already declared illegal fishing gears under the Uganda fishing regulations.

The development of *M. kannume* bait fishery evolved in response to decline in catches of the large sized species *L. niloticus*, *Tilapia spp*, *C. gariepinus*, *Bagras spp* and *Barbus spp*. The decline in catch landing has resulted into substantial increases in the unit cost of fish across the three transects. The observed declines

in both the catch rates and total monthly catch of the species at some transects should be of concerns to the resources users, fisheries conservationists, managers and researchers as far as the long term sustainability of exploited species is concerned.

Table 3.6.3 *Trends of total fish catch estimates (kg) 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
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
		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
		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
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
		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
		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	-
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	-
		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
		Buyala-Kikubamutwe	124.4	-	60.2	197.0	907.8	70.0	10.3	161.6	1069.2	120.0	-	888.3	24.0	-	-	-	-	-
	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	-
		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
		Mid-Reservoir	-	-	-	-	-	429.5	6.4		13.9	650.7	288.0	22.7	-	140.0	-	-	-	-
		Buyala-Kikubamutwe	5.0	97.0	17.2	52.9	2.1	-	-	16.8	13.9	-	-	0.0	159.1	85.5	-	-	-	-
	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	-
		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	-	-
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	-
		Mid-Reservoir	-	-	-	-	-	362.7	-	-	89.1	-	1200.0	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	482.8	1357.9	679.7	266.6	1341.0	515.3	209.4	-	-	-	8460.0	-	-	-	90.0	-	4620.0	-
	Rastrineobola argentea (Mukene)	Kalange-Makwanzi	-	6463.8	2109.5	2152.8	-		1105.7		-	18371.9	15795.0	-	-	428.6	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	13128.0	1480.5	1627.6	-	27706.5	-	7057.1	23000.0	22000.0	4731.4	1500.0	-	2340.0
		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
		Mid-Reservoir	-	-	-	-	-	22.9	-		89.1	125.9	324.0		124.9	154.0	8.6	-	308.0	67.5
		Buyala-Kikubamutwe	-	6.5	-	-	-		-		13.2	300.0	900.0		158.5	292.5	-	-	524.0	-
	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
		Mid-Reservoir	-	-	-	-	-	381.8	374.7	365.5	605.2	4156.0	8568.0	348.9	508.1	3283.0	172.3	1296.1	3581.0	397.5
		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
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
		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
		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

3.6.4. Estimates of total beach value of the catch

The total value of catch (revenue at beach level) greatly reduced for all the species recorded and transects monitored except for *S. afrofischeri* and the Reservoir (Table 3.6.4). A total beach revenue of 111.7 million (UGX) was generated from the 6.8 t compared to the 174.4 million (UGX) from the 33.1 t and the 136.5 million obtained from 23.4 t during September 2017 and April 2017

respectively. Similar to the monthly catch landings, the highest revenue of catch at beach level was observed the mid-reservoir (86 million) and the lowest at the Downstream transect (3.6 million). Five species; *M. kannume*, *O. niloticus, L. niloticus, R. argentea,* and *B. docmak* contributed highest to the total monthly beach revenue of the landed fish catch in the study area (Table 3.6.4). Compared to the adult *Mormyrus kannume* sold for direct human consumption, the juveniles used for bait fetched more market prices per kilogram. The juvenile *M. kannume* is currently sold as individual pieces, with an average juvenile of 50-100 grams costing between 2000 to 2500 Uganda shillings. The high value of catch signifies the importance of the river fishers to the riparian communities who depend on the river water, employment, income, food and nutritional security. There is need for strategic intervention to minimize the potential negative impacts of the dam to the fisheries and their habitats in order to sustain their benefits to the riparian communities who directly derive their livelihood from fishing activities.

Table 3.6.4. **M***onthly 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
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
		Mid-Reservoir	-	-	-	-	-	226	1,565	230	967	2,456	8,029	248	5,251	3,653	360	10,565	10,108	3,705
		Buyala-Kikubamutwe	431	110	45	586	662	1,312	450	1,489	1,443	-	983	27	7,406	494	270	-	4,928	368
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
		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
		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	-
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	-
		Mid-Reservoir	-	-	-	-	-	256	77	-	307	7,179	1,524	106	213	551	428	30,143	-	2,700
		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	-
		Mid-Reservoir	-	-	-	-	-	402	24	-	-	787	1,544	2	-	-	-	-	26	-
		Buyala-Kikubamutwe	78	162	103	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Tilapia zilli (Ngege)	Kalange-Makwanzi	167	277	175	89	175	241	266	150	365	2,713	409	4	558	597	300	3,321	2,387	17
		Mid-Reservoir	-	-	-	-	-	1,000	19	-	278	1,627	950	5	-	233	-	-	-	-
		Buyala-Kikubamutwe	7	97	34	53	4	-	-	-	278	-	-	-	676,113	171	-	-	-	-
	Haplochromines (Nkejje)	Kalange-Makwanzi	5	3	3	4	54	-	-	-	4	-	-	0	-	215	122	233	557	-
		Mid-Reservoir	-	-	-	-	-	-	-	-	-	44	-	-	-	84	-	-	-	22
		Buyala-Kikubamutwe	-	-	6	20	2	-	-	-	-	47	11	60	60	-	-	143	-	-
CLARIIDAE	*Clarias gariepinus* (Male)	Kalange-Makwanzi	17	-	32	-	636	1,132	328	257	2,772	8,612	4,588	15	560,000	-	-	21,600	-	-
		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	-
		Mid-Reservoir	-	-	-	-	-	1,001	633	-	267	-	3,600	-	-	-	-	-	-	-
		Buyala-Kikubamutwe	802	2,580	1,083	800	6,705	1,623	-	-	-	-	38,070	-	-	-	450	-	32,340	-
	Rastrineobola argentea (Mukene)	Kalange-Makwanzi	-	2,353	894	1,722	-	-	514	-	-	12,248	15,043	-	-	171	-	-	-	-
		Mid-Reservoir	-	-	-	-	-	2,864	945	814	-	18,891	-	834	21,956	22,000	1,800	4,500	-	58,500
		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
		Mid-Reservoir	-	-	-	-	-	23	-	-	-	252	567	-	219	159	45	-	154	2,109
		Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	600	90	-	206	146	-	-	524	-
	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
		Mid-Reservoir	-	-	-	-	-	518	375	749	1,149	5,700	17,993	174	1,201	9,723	180	5,647	14,921	11,717
		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
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
		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
		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

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	-

Overall, the mean price per kilogram weight of fish landed in the commercial catches has been fluctuating since April 2009 for seven fish species whose mean prices have been monitored over the period (Table 3.6.5). The April 2018 survey saw an increase in the unit price for all the species encountered at all the monitored transects. Three of the monitored species (Table 3.6.5) did not appear in the commercial catch during the April 2018 survey. The most highly priced species was *M. kannume*, currently sold live per individual piece, thus the unit price was calculated based on the number of individuals contained in a kilogram. The monetary value (measured as mean price per kilogram weight) of fish is very important in commercial catch monitoring since it reflects the dynamic nature of fisheries and is dependent on seasonality, demand, size and quantities of catch landed. The observed fluctuations in the unit cost of fish for the majority of the exploited species during the current survey could be linked to a reduction in catches and increased demand for fish. Many factors determine the market value of fish, the major ones being type of species, size of fish and supply at a

given time as well as the relationships between demand and supply, where by scarcity of a fish commodity results into a corresponding increase in its cost while surplus may cause a reduction in its value. Generally, the larger the size of fish harvested (except for *M. kanume)*, the higher the price and the smaller the size the lower the price. The total catch of all the harvestable fish species across the three monitored transects substantially declined, thereby creating scarcity and demand. During scarcity, the demand for fish irrespective of the individual sizes is high thus forcing the prices to rise. Due to the high demand for bait in the long-line fishery on large lakes Victoria and Kyoga, the live juvenile *M. kannume* has progressively gained economic value than the large sized, becoming the most highly valued fish species in the study area.

3.6.5 Estimated total catches and revenue of individual fishing units

As discussed in the sections above, the current survey registered significant increases in both the total monthly catch landings and beach revenue of catch for all the monitored transects (Tables 3.6.3 & 3.6.4). Similar to the September 2016 survey, the reservoir transect registered the highest mean monthly catches and beach revenue (12.7 t, 80.9 million UGX) followed by upstream (10.4 t, 50.5 million UGX) and the downstream (0.9 t, 5.0 million UGX). The high beach values of catch at the Reservoir transect could be explained by the high number of fish species landed, high catch rates (Kg/boat/day) and number of fishing boats at the transect while the lower beach values at both the Downstream and Upstream transects correspond to the low catch rates, number of landed species and fishing boats. During the previous surveys, the high catches and beach value for *M. kanume* were the main incentives for investment in the illegal basket trap bait fishery. The species has however started to show signs of decline as evidenced in the two recent surveys of September 2016 and April 2017, where the species has registered reductions of about 95% in monthly catch at all the three transects. Although high fish catches are good for the riparian communities due to the associated economic benefits (beach revenues), unattainable selective exploitation of a species may yield only short term benefits with severe long term impact that may range from loss of income, employment and livelihood sources. Alongside the formulation of mitigation measures for the likely negative impacts resulting from the, should be management measures aimed at sustaining fish catches in the study area. This can be achieved through use of sustainable harvesting technologies and mitigation of negative environmental impacts associated with dam construction.

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

Monitoring period		Upstream-Kalange-Makwanzi		Mid-reservoir		Downstream-Buyala-Kikubamutwe	
Year	Month	Catch	Beach revenue	Catch	Beach revenue	Catch	Beach revenue
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

3.6.6 Socio-economic aspects of the fishery

Non-commercial uses of fish

The quantities of fish retained by fishers for domestic consumption at the Kalange-Makwanzi and mid-reservoir sites greatly improved to 0.8 kg/boat/day and 0.7 kg/boat/day respectively but at Buyala-Kikubamutwe, the fish retention for domestic consumption has remained constant ie.0.3 kg/boat/day since April 2016 (Table 3.6.7). The increase in fish retained for domestic consumption could be attributed to declines in total catches, particularly the large sized species *Oreochromis niloticus, Bagras docmak, Lates niloticus*, and *Clarias gariepinus* across all sites (Table 3.6.3), thus the little caught is reserved for home nutrition.

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	
Year	Month	average weight of fish retained (kg/boat/day) for consumption	% weight of fish retained (kg/boat/day)for consumption of the overall boat catch	average weight of fish retained (kg/boat/day) for consumption	% weight of fish retained (kg/boat/day)for consumption of the overall boat catch	average weight of fish retained (kg/boat/day) for consumption	% weight of fish retained (kg/boat/day)for consumption of the overall boat catch
2009	April	0.4	3.7	-	0	0	0
	October	3.5	27.1	-	0	1.4	71.8
2010	April	2.2	11.8	-	0	1.3	29.7
	September	1.5	16.8	-	0	0.8	16.5
2011	April	1.4	30.7	-	0	1.2	23.8
	September	2.1	60	-	0	3	45.8
2012	April	1.2	12.8	1.5	50	0.8	14.4
	September	1.2	20.4	-	0	-	0
2013	April	0.1	2.6	0.1	1.1	0.2	3.2
	September	-	0	5.4	3.3	-	0
2014	April	1.3	2.7	0.5	1.6	-	0
	September	-	0	1.4	6	-	0
2015	April	0.5	9.2	0.1	0.6	0.1	3
	September	1.3	1.8	0.5	0.8	-	0
2016	April	-	0	0.9	0.3	0.3	0.2
	September	0.6	43	-	-	-	0
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

Fishery related jobs

The number of people employed by the fisheries sector (i.e. fishing and other related activities) in the study area reduced from 152 recorded during September 2017 to 148 during this monitoring period. During April 2017, 202 people were employed in the sector-the number recorded during this monitoring period indicates a reduction of 27% (Table 3.6.8 a). Fishing employed most people-

exclusively males, 81 people of them (55%). Since September 2015, there has been no female fisher registered during at all the three transects. For this monitoring period and two previous surveys, the highest number of fishers (37, 46%) was recorded at the upstream transect, followed by the mid-reservoir (28, 35%) and then downstream (16, 20%).

Besides fishing, fish trade employed 25 people who were mostly men (56%).This was a shift. During April 2017 monitoring period, women dominated the fish trade business by 60.9%. Majority of fish traders (42.9%) were encountered at the upstream transect while the downstream transect recorded the least (14.3%). The scarcity and high prices for fish could have been the factors that pushed women out of business, hence a shift in dominance of the fish trade business from women to men.

Food vending has remained a domain of women. During the current monitoring period, four women were engaged in the activity (Table 3.6.8 b). The food vending activity was only recorded at upstream (four) and mid-reservoir transects (one).

Boat building was an exclusively male activity that happened only at the Upstream transect, employing three men. Absence of boat builders/repairers and the continued use of old leaking canoes by fishers at the mid-reservoir and downstream transects is a safety risk, but also an indication of low returns from fishing.

The BMU leadership was recorded at upstream and mid-reservoir transects and absent downstream (Table 3.6.8 b). At both transects, the men and women were represented but the men dominated (68%). Absence of BMU leadership at the downstream transect could be due to the continued low fish supply; especially the large sized commercial species e.g. *L. niloticus* and *O. niloticus* at this site.

Women are involved in post-harvest handling and marketing hence are most likely to be active in areas with high supply of their traded fish commodities. Since April 2012, the downstream transect has been dominated by bait fishery of *Mormyrus kannume* transported by men to the distant markets on lakes Victoria and Kyoga.

The relatively high number of people employed in the fisheries sector in the study sites (148), with the majority (55%) being fishers underpins the significance of fisheries and fishing in sustaining the livelihoods of the river-dependent

communities. This dependence also indicates the lack of genuine alternative livelihood options and therefore means that 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 their livelihoods. There is hence a need for a clear strategic mitigation plan for such impacts. In general, any economic activity with high returns attracts more investment. Fishers also respond in a similar manner by investing substantially in gears and species with better economic returns.

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
Boat builders/	**Kalange-Makwanzi**	**M**	3	1	2	3	3	2	2	3	3	3	2	2	4	3	3	5	4	3
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	1	5	-	2	2	2	2	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	**M**	2	3		1	1	3	3	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Food vendors	**Kalange-Makwanzi**	**M**	1	2	4	1	1	1	1		1	2	-	1	-	1	-	1	1	3
		F	2	4		3	3	3	3	2	5	2	5	4	5	5	6	3	4	1
	Mid-reservoir	M	-	-	-	-	-	-	-	1	1		-	1	-	-	-	-	-	-
		F	-	-	-	-	-	-	2	4	3	3	1	1	-	-	-	2	2	-
	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
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	-	11	-	-	-	3	15	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	**M**	-	-	3	-	-	6	6	-	3		-	-	3	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cleaner fish landing	**Kalange-Makwanzi**	**M**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	**M**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3.6.8b *Number 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
Fisher(s)	Kalange-Makwanzi	M	37	30	38	25	25	25	25	25	42	39	39	54	36	52	45	42	45	37
		F	-	-	-	-	-	-	-	-	1	1	1	1	2	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	13	24	49	51	55	74	37	49	30	52	27	16
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	46	30	34	30	30	15	9	28	72	15	11	42	21	24	51	20	18	28
		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
		F	20	16	16	30	30	16	16	9	16	13	2	4	7	8	10	6	6	6
	Mid-reservoir	M	-	-	-	-	-	-	2	1	1	3	1	-	2	3	3	3	4	4
		F	-	-	-	-	-	-	5	1	1	12	12	16	9	16	6	7	4	-
	Buyala-Kikubamutwe	M	2	2	2			1	1		1	1	-	2	1	-	4	3	3	6
		F	3	5	5	5	5	5	3	6	5	-	1	3	-	3	1	1	-	5
Fish processor(s)	Kalange-Makwanzi	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	3	3		-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-		2		2	-	6	-	-	-	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fish cleaner	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
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
		F	-	-	-	-	-	-	-				-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	1	1	2	2	2	1	1	2	2	1	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BMU committee member (s)	Kalange-Makwanzi	M		4	5			7	7	5	5	7	4	5	6	5	5	5	2	5
		F		5	4			2	2	1	3	2	2	1	3	4	3	3	-	4
	Mid-reservoir	M	2	2	3	3	3	4	4	4	3	3	2	4	3	18	8	11	12	12
		F	1	-	-	-	-	1	1	1	1		-	1	10		3	4	4	4
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	5	4	10	4	8	2	3	3	3	3	-
		F	-	-	-	-	-	-	-	3	3	2	-	4	-	-	-	3	-	-
Landing site Guard	Kalange-Makwanzi	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mid-reservoir	M	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Fisheries officer	Kalange-Makwanzi	M	-	-	-	-	-	-	1	1	1	-	-		-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	-	-
	Mid-reservoir	M	-	-	-	-	-		1	1	1				-	-	-	-	-	-
		F	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	1	-	-
	Buyala-Kikubamutwe	M	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	1
		F	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-		-	-

Monitored indicators such as fishing effort, fish composition, beach revenue and fishery related jobs in the study area indicate negative impacts (e.g. decline of

incomes and deterioration of livelihood) of dam construction especially for the downstream river-dependent communities. A decline in landed catch of exploitable fish species, beach revenue of catch, CPUE of the regular commercial species and fishery related jobs has been note over the monitoring period. Richter *et al*. (2010) and Adams (1985) have demonstrated that downstream river-dependent communities can benefit from some degree of flood protection and irrigation opportunities provided by dams. However, adverse effects of dams to the downstream areas such as decline in fish populations (fish species, abundance and composition), fishing opportunities and income have been noted. The negative impacts outweigh the benefits thus result in reduction of their incomes and livelihoods.

3.7 SCHISTOSOMIASIS, RIVERBLINDNESS AND SANITATION STUDIES

3.7.1 Parasitological analysis of bilharzias in humans

Table 3.7.1 *Trend of Schistomiasis infection prevalence, intensity and vector numbers; coliform counts among sampled people at monitored sites*

a

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
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
		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
		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
	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
		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
		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

b)

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
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
	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
	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

c)

Prevalence of Schistosomiasis by water contact		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
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
	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
	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
	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

d)

Parameter considered		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
Snail Species abundance	*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
		Mid-Reservoir										11	30	10	7	4	55	54	20	42	20	35	75	24
		Buyala-Kikubamutwe	13	11	50	8	83	81	9	51	18	3	5	7	21	8	37	7	74	10	12	58	93	12
	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
		Mid-Reservoir										68	67	27	46	45	31	27	24	40	82	21	88	33
		Buyala-Kikubamutwe	11	9	65	74	122	60	62	80	60	200	167	22	51	44	47	18	28	40	54	18	68	24
	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
		Mid-Reservoir										13	15	63	131	100	42	58	102	104	186	52	97	45
		Buyala-Kikubamutwe	50	37	52	188	91	98	118	96	57	71	105	87	84	42	37	70	36	39	74	78	125	61
Coliforms in water	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
		Mid-Reservoir	0	0	0	0	0	0	0	0	0	79	80	94	80	80	133	130	131	152	144	213	212	231
		Buyala-Kikubamutwe	50	87	73	100	10	87	80	82	81	82	76	80	94	90	91	89	90	104	109	104	109	115
	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
		Buyala-Kikubamutwe	10	21	70	22	1	1	1	1	1	1	1	5	5	4	10	7	7	2	3	4	20	19

Out of 128 stool samples collected from 545 people, 19 (14.8%) were infected with Schistosomiasis. This marked an increase in rate of infection from 8.9% during the previous monitoring period- September 2017. Infection rate during the recent past were 16.1% in April 2016, 15.7 % in September 2016 and 14.1% in April 2017. Schistosomiasis (*Schistosoma mansonii*) has continued to be prevalent while the urinary type, *Schistosoma haematobium,* has remained undetected (Table 3.7.1 a). Infection rates were highest (17.0%) at the upstream transect and lowest (12.0%) at the mid-reservoir transect. The increase in prevalence of infection at the upstream transect corresponded with the increase in snail vector abundance and number of infective snails at the upstream transect (Table 3.7.1 d).

During this monitoring period, majority of infected persons at all sites presented with light intensity of 73.6% down from 75.0% during September 2017 (Table

3.7.1 b). Moderate intensity presentation decreased to 21.0% during this monitoring period from 25.0% during September 2017. During the previous monitoring period, heavy infestation presentation was not detected i.e. 0%. During this period, 5.2% of heavy infestation was recorded. This corresponded with increase in snail vector abundance and cercaria shedding.

Bathing/Swimming was the biggest predisposing factor to Schistosomiasis infection (Table 3.7.1 c) contributing to 52.6% during this monitoring period, up from 41.6% during the previous survey period. Fishing predisposed people to the disease by 31.6%. Fishmongers were least predisposed by 5.3%. There was a decline in the predisposing factors from fishing and fishmongers to fetching water, bathing/ swimming which showed a marked increase. Going forward, we will focus current behaviour change communication (BCC) efforts towards the swimming/bathing in order to bring down prevalence and intensity of infection among the riparian community

All residents found to be positive for Schistosomiasis infection were treated by the sanitation/Vector team under directly observed treatment (DOTs) using Praziquantal and Albendazole medicines.

Status of snail vectors

During this monitoring period, *Bulinus sp.* decreased at all the three transects, doing so markedly at the downstream transect ie from 93 during the previous monitring period to just 12 during the current survey (Table 3.7.1 d). The reduction at the upstream transect was negligible, however, *Biomphalaria sp* abundance slightly increased at this site from 17 during September 2017 to 26 during the current monitoring period. At the downstream and nid-reservoir transects, abundance of *Biomphalaria sp* decreased significantly from 68 to 24 and from 88 to 33 during September 2017 and April 2018 monitoring periods respectively. Over the same monitoring periods, the numbers of non-medically important species increased at the upstream transect from 94 to 147 while at the downstream and reservoir transects abundance decreased from 125 to 61 and 97 to 45 respectively.

Faecal coli forms

Shallow human-water contact points upstream registered 174 colonies per ml of faecal coliforma, 231 up from 215 colonies per ml during September 2017 at the

mid-reservoir and 115 up from 109 colonies per ml at the downstream (Table 3.7.1 d). This status-quo still presents a high risk contamination of faecal coliforms. Water from the deep middle part of the river had a lower coli form count of 7.0 colonies per 10mls of water upstream while downstream readings were stable at 19 colonies per 10mls from only 20 colonies during the previous sampling period. Faecal coliform counts of 1-10 colonies per 10 ml of water is considered risk free in terms of health. The microorganisms of medical importance were predominantly *Salmonella sp* and *Shigella sp.*
Level of faecal coliform contamination at shallow human-water contact points along

Blackfly/*Mbwa Fly* Sampling

During this sampling period, no medically important species of *Simulium* flies were detected either by human landing catches, foot patrol or by physical examination of 188 crabs.

3.8. CONCLUSIONS AND RECOMMENDATIONS

3.8.1 Conclusions

1. Trends of zooplankton composition, species richness and abundance estimates show that the construction of the hydropower dam and creation of the reservoir have not disrupted the stability of the zooplankton community (characterized by rotifer-driven species richness and copepod dominated numerical abundance).
2. The high dominance values of copepods especially in the reservoir and upstream reaches of the dam suggest high potential for fish production, especially pelagic fishes in these areas relative to the downstream site.
3. The consistent occurrence of lower abundance of zooplankton in the downstream part of the study area is likely a reflection of community response to prevailing water flow dynamics in this area probably created by the dam operations for instance periodic opening and shutting of the sluice gates
4. 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.
5. Transmission of Schistosomiasis is still occurring among the riparian population despite drugs being administered to infected people during

the survey periods. Moreover, heavy intensity of Schistosomiasis infection (five cases recorded) re-emerged at Kalange-Makwanzi site during the current monitoring period. For the last three survey periods, levels of infection had remained at light to moderate levels and no heavy intensity levels had been seen. The shedding of cercaria confirms that the transmission loop has been broken yet.

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 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. Mass drug administration and health education should be intensified at Kalange-Makwanzi targeting fisherfolk and swimmers in order to interrupt transmission of Schistosomiasis because here infection increased. Health education should be intensified especially among the new settlers and cultivators at the mid-reservoir. Ministry of Health Bilharzia monitoring/response team should be notified about the status qua of bilharzias at Kalange-Makwanzi.

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