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

Monitoring No. 18

Date: 4th – 13th April 2016

Monitoring carried out by:

National Fisheries Resources Research Institute (NaFIRRI)
P.O. Box 343, Jinja, Uganda
Tel: 256-43-120384
Fax: 256-43-120192
Email: firi@firi.go.ug, director@firi.go.ug

On behalf of :
Bujagali Energy Limited (BEL)

Date of Report: June 2016

1.0 BACKGROUND

Two 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 proceeded by eight ecological monitoring surveys (September 2007, April 2008, April 2009, October 2009, April 2010, September 2010, April 2011, September 2011) during construction period.

This ecological monitoring survey No. 18 (4th -13th April 2016) on the Upper Victoria Nile is the ninth one to be undertaken after completion of construction of 250 MW Bujagali hydropower plant in February 2012, which was commissioned seven months later. 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

For eighteen surveys including one during April 2016, Kalange-Makwanzi and Buyala-Kikubamutwe, upstream and downstream transects respectively have been sampled for water quality, fish abundance, diversity and distribution, fish biology, fish catch, sanitation conditions, bilharzia and river blindness vectors. Due to reservoir conditions created from the dam up to beyond Kalange-Makwanzi, a third transect was created in between, from which assessment of parameters as at the upstream and downstream transects was also undertaken including assessment of algae, zooplankton and benthic macro-invertebrates.

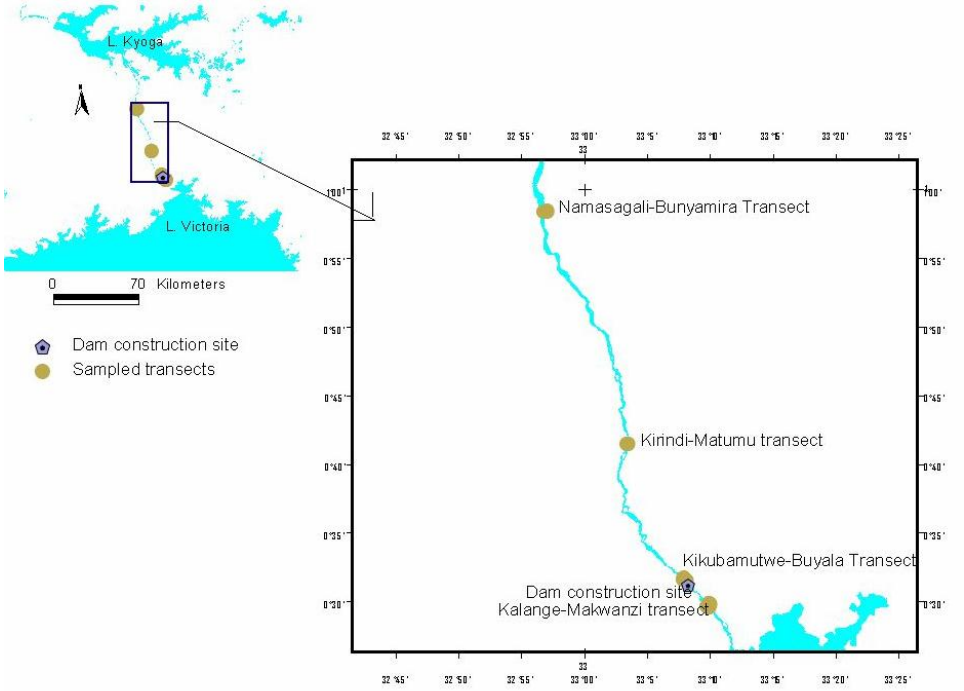

Figure 2.1a *A map showing the Upper Victoria Nile where the BHPP is located and river segments where baseline as well as monitoring samples were taken*

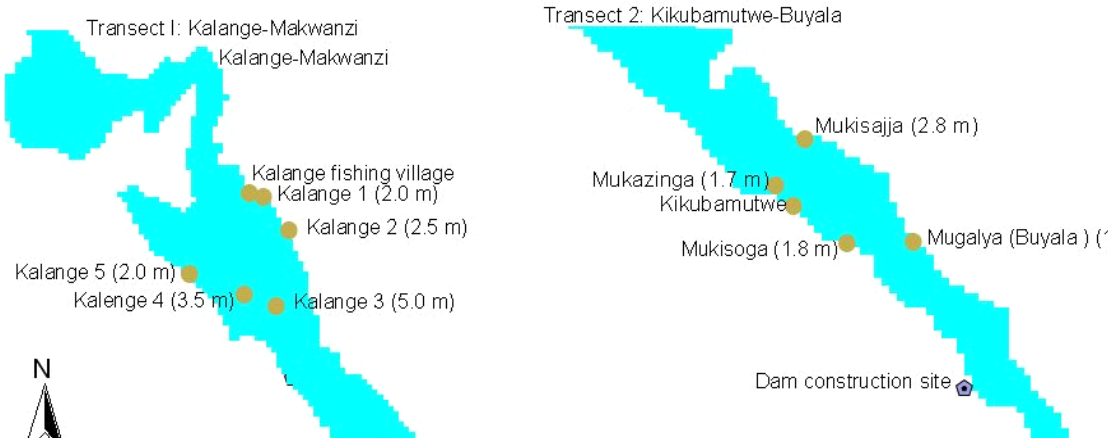

Figure 2.1b *Detailed maps of the two sampled transects: Transect 1 = Kalange-Makwanzi and Transect 2 = Buyala-Kikubamutwe and associated locations on the Upper Victoria Nile.*

Sampling, analytical procedures and techniques used in the previous surveys were followed. Sampling of zooplankton was 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 were combined to make a composite sample, preserved in 4% sugar-formalin in a clean, labelled, plastic sample bottle. Species identification was 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 were noted and areal density estimates calculated for each station in conjunction with the diameter of the sample net and depth of sampling. Benthic macro-invertebrates were identified and classified using keys from Merrit & Cummins 1997, Pennak 1989 and Mandahl-Barth 1954, and enumerated as mean numbers per square meter.

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																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		Apr-06	Sept. 07	Apr-08	Apr-09	Oct-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
Dissolved Oxygen (mg/L)	Kalange-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	4.88	5.88	5.75	6.18
	Mid section of the Reservoir										5.2	6.4	7.02	5.3	6.27	5.47	6.06	6.78	6.3
	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	6.11	5.69	6.29	7.03
	NEMA Std	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
pH	Kalange-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	7.45	7.12	7.46	6.87
	Mid section of the Reservoir										8.2	7.5	7.4	7.4	6.65	7.51	7.25	8.86	6.95
	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	7.71	7.24	8.01	7.32
	Upper NEMA Std	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
Temperature (°C)	Kalange-Makwanzi	26.7	26.1	26.2	26.4	25.7	25.6	24.8	26.4	24.9	25.3	25.9	26.85	25.2	26.56	24.64	26.24	25.91	24.44
	Mid section of the Reservoir										26.1	25.4	26.94	25.3	26.69	24.78	26.39	25.93	25.12
	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	27.22	24.88	26.47	26.05	26.03
	Upper NEMA Std	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
Conductivity (µS/cm)	Kalange-Makwanzi	103	112	81.1	95.5	96.9	87.3	100	128.6	105	92.3	90.0	101.4	110.0	100.7	98.0	99.7	101.0	100.0
	Mid section of the Reservoir										97.4	95.0	101.6	110.0	101.6	98.0	99.3	103.0	103.8
	Buyala-Kikubamutwe	88.5	114	82.8	97.6	97.7	86.1	102.4	N/D	113.7	94.8	100.0	101.5	112.0	111.9	98.6	99.4	106.7	108.0
Secchi Visibility (m)	Kalange-Makwanzi	1.9	1.6	1.9	2.2	2.2	2.3	2.2	2.2	N/D	1.5	2.1	1.72	2.03	1.71	2.37	1.26	1.83	0.83
	Mid section of the Reservoir										1.7	2.1	1.62	2.16	1.56	2.1	1.35	1.85	0.72
	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	1.59	2.34	1.25	1.9	1.14
Total Suspended Solids (mg/L)	Kalange-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	3.33	4.13	1.22	7.8
	Mid section of the Reservoir										3.6	3.3	1.5	3.6	4.67	5.43	3.4	2.67	5.8
	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	4.74	2.47	1.44	5.73
	NEMA Std	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Oil & Grease (mg/L)	Kalange-Makwanzi	0.6	0.1	0.003	0.02	0.08	0.04	0.06	0.07	0.1	0.17	0.18	0.12	0.13	0.19	0.15	0.06	0.16	0.01
	Mid section of the Reservoir										0.21	0.17	0.14	0.19	0.23	0.23	0.08	0.18	0.02
	Buyala-Kikubamutwe	0.9	0.8	0.002	0.06	0.52	0.08	0.08	0.08	0.13	0.22	0.18	0.1	0.16	0.21	0.21	0.11	0.18	0.02
	NEMA Std	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Over the monitoring period, temporal and spatial fluctuations in mean concentrations of dissolved oxygen at the three sites were negligible (Table 3.1.1). During this survey period-April 2016, dissolved oxygen concentration slightly increased along the stream flow from the upstream at Kalange-Makwanzi, through the mid-reservoir to the downstream at Buyala-Kikubamutwe. Mean concentrations at monitored sites were well above the permissible National Environment Management Authority (NEMA) limit of 3 mgL^{-1} which supports survival of most aquatic organisms including fish.

During the current survey period, mean pH at the monitored sites ranged from 6.85 to 7.24, indicating more or less circumneutral conditions but in September 2015 survey

period, it varied from 7.46 to 8.86, a range that showed slight alkaline conditions. However, the pH range continued to be in the NEMA permissible range of 6 to 8.

During the present survey period, average water temperature ranged between 24.41 and 26.07 °C at monitored sites and was within the NEMA permissible range of 20ºC to 35ºC. In the previous survey period-September 2015, average water temperature ranged from 25.91 to 26.05 °C.

During this survey period, average water electrical conductance ranged between 100.00 and 108.36 µS/cm but the September 2015 survey period, it varied within a narrow range of 101.00 and 102.95 µS/cm. The range values have continued to be close to those recorded in unpolluted sites of Lake Victoria waters (i.e. ≤ 120 µS/cm).

During this survey period, water clarity was lower than what was observed in April and September 2015 survey times and was attributed to the rain season that brought in inflows with more turbid waters from the surrounding landscape.

During this survey period, average concentration of Total Suspended Solids (TSS) was highest (7.80 mg/L) at the upstream transect and lowest (5.73 mg/L) at the downstream transect, hence reduced along the stream flow. The reducing trend in the concentration of TSS along the stream flow was attributed to high loads of TSS in the inflows as a result of erosion from the landscape, followed by settling in the reservoir before discharge at the downstream transect. Despite the observed variation, the concentration of TSS was far below the permissible NEMA standard of 100 mg/L. In the September 2015 period, mean concentration of TSS was highest (2.67 mg/L) in the mid- reservoir transect and lowest (1.22 mg/L) at the Kalange-Makwanzi transect.

The concentration of oil and grease at the monitored sites was relatively lower (range 0.01 to 0.02 mg/L) than that of April and September of 2015 (range 0.16 to 0.18 mg/L) at the three monitored zones, but remained far below the NEMA permissible upper limit of 10 mg/L.

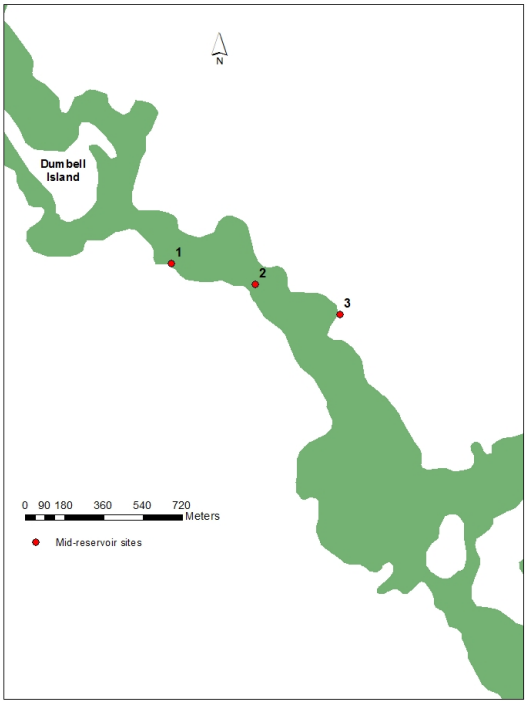

Figure 3.1.1 *Sampled points (1, 2, 3) on the section of the river where depth profiles of temperature, dissolved oxygen and conductivity were taken.* (*NB: Base map used was before dam construction*)

During this survey period, vertical profiles of water temperature, dissolved oxygen, pH and conductivity varied from 25.39 to 24.60 °C, from 6.54 to 5.15 mg/L, from 7.04 to 6.72 and from 107.14 to 100.00 µS/cm, respectively. During September 2015 survey, from surface to the reservoir bottom, water temperatures ranged between 25.89 and 25.96 °C, dissolved oxygen was from 6.53 to 9.21 mg/L, pH was from 8.82 to 8.89, while water conductance was in the range 99 to 110 µS/cm.

3.1.2 Nutrient (nitrogen, phosphorus and silica) concentrations in water

During this survey period, the concentration of ammonium-nitrogen (NH_4-N) was lowest (7.78 μg/L) at the upstream transect and highest (18.40 μg/L) in the mid-reservoir and was higher than that of a similar period in 2015 (Table 3.1.2). In the previous survey-September 2015, concentration was lowest (0.51 μg/L) in the mid-reservoir transect but highest (11.63 μg/L) in Buyala-Kikubamutwe transect. Despite the observed variations, ammonia concentration was far below the NEMA permissible upper limit of 10,000 μg/L.

Nitrite –nitrogen (NO_2-N) showed similar trend as NH_4-N, and so did nitrate-nitrogen (NO_3-N) with mean concentrations that were far below the NEMA permissible upper limit of 20,000 μg/L respectively.

During this survey period, narrow variations in mean concentration of Total Nitrogen (TN) were noted but increased along the stream flow, though this remained below the NEMA permissible upper limit of 10,000 µg/L.

During this survey period, the average concentration of soluble reactive phosphorus (SRP) was lowest (16.92 µg/L) at the upstream transect and highest (21.08 µg/L) in the mid-reservoir area. This trend is attributed to the long residence time that allowed accumulation as a result of inflows from upstream. During the September 2015 survey period, mean concentration of SRP increased along the river flow i.e. lowest concentration (9.64 μg/L) at the upstream (Kalange-Makwanzi) and highest (16.05 μg/L) downstream at Buyala-Kikubamutwe transect. Concentrations at all sites were below the permissible NEMA upper limit of 5,000 µg/L.

During this survey period, Total Phosphorus (TP) was lower than what was recorded in September 2015 (the highest since April 2006), and minimally varied. Though it was highest concentrations were recoreded at the upstream probably due to inflows from the catchment. Despite the observed trend, average TP concentration remained consistently below the NEMA permissible upper limit of 10,000 μg/L.

During this survey period, the concentration of Soluble Reactive Silica (SRSi) too varied minimally among the three transects. However, this was the highest ever recorded since 2006. This almost 2-fold increase in silica concentration was attributed to enhanced erosion of the catchment as a result of heavy rains that were characteristic of this season. The 2-fold increase in silica explains the very high wet algal biomass that is constituted of more than 50% diatoms whose main nutrient is silica, an important requirement for formation of diatom frustules.

During this survey period at the upstream and downstream transects, blue green algae constituted the second highest wet algal biomass after the diatoms, while green algae had the lowest biomass at all sites. In the mid- reservoir area however, blue green algae were the dominant constituents, while the green algae formed the least wet biomass.

During this survey period at the upstream and downstream transects, lowest algal biomass (Chlorophyll-a) was recorded since April 2012. This was attributed to the relatively low water clarity. In the mid-reservoir however, the relatively high algal biomass (Chlorophyll-a) was recorded attributed to very low water clarity and the longer residence time in the mid- reservoir which allowed and enhanced algal production.

Table 3.1.2 *Trends in mean concentrations of nutrients and algal biomass (chlorophyll-a) in water at monitored sites*

Parameter	Site	Monitoring Dates																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		Apr-06	Sept. 07	Apr-08	Apr-09	Oct-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-15
Ammonium Nitrogen, NH_4-N (μg/L)	Kalange-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
	Mid section of the Reservoir										10.5	4.9	7.4	81.74	45.17	36.11	13.44	0.51	18.4
	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
	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
Nitrite-Nitrogen, NO_2-N (μg/L)	Kalange-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
	Mid section of the Reservoir										6.3	2.8	10.6	5.35	12.75	7.34	14.37	1.37	6.64
	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
Nitrate-Nitrogen, NO_3-N (μg/L)	Kalange-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
	Mid section of the Reservoir										50.4	18.4	54.72	91.09	140.93	81.06	55.05	15.01	214.3
	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	197.57
	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
Total-Nitrogen, TN (μg/L)	Kalange-Makwanzi	1174	2094	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
	Mid section of the Reservoir										1,606.90	4,337.30	1,335.20	394.05	1,070.04	1,266.39	3,343.18	2,912.06	806.75
	Buyala-Kikubamutwe	1193	2139	2492	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
	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
Total Phosphorus, TP (μg/L)	Kalange-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	46.1	29.1	50.8	113.2	63.0
	Mid section of the Reservoir										41.8	107.6	33.9	57.0	52.7	31.5	59.1	156.2	58.8
	Buyala-Kikubamutwe	100.8	48.7	76.3	47.3	45	271.9	88.8	64.1	35.6	107.7	112.0	41.1	48.5	32.7	112.7	52.7	167.5	57.6
	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
Soluble Reactive Phosphorus, SRP (μg/L)	Kalange-Makwanzi	19	24.2	11.7	6.9	27	15.7	21.1	31.6	9.8	6.4	20.0	12.7	11.2	12.2	14.0	10.5	9.6	16.9
	Mid section of the Reservoir										7	17.6	12.7	10.6	18.9	15.8	11.4	11.4	21.1
	Buyala-Kikubamutwe	19.2	27.7	18.9	16.6	32	24.8	25.6	20	11.7	6.6	21.4	12.7	15.6	14.0	42.0	9.5	16.1	17.9
	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
Soluble Reactive Silica, SRSi (μg/L)	Kalange-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	1236.92
	Mid section of the Reservoir										268.1	268.5	256.8	458.77	396.38	803.5	379.63	588.96	1573.23
	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	369.38	239.73	401.65	645.77	1268.92
Chlorophyll-a (µg/L)	Kalange-Makwanzi										5.1	6.3	10.2	12.51	10.01	4.32	7.26	3.55	1.48
	Mid section of the Reservoir										5.6	10.1	5.6	13.44	4.26	5.1	8.03	1.44	1.76
	Buyala-Kikubamutwe										6	9.7	6	9.27	5.37	13.9	5.87	2.67	0.93

3.1.3 Algae and aquatic macrophytes/weeds

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

Broad taxa	English name	Site	Monitoring time							
			Sept.2012	Apr. 2013	Sept. 2013	Apr. 2014	Sept. 2013	Apr. 2015	Sept. 2015	Apr. 2016
Cyanopytes	Blue-greens	Kalange-Makwanzi	9	15	12	14	12	14	11	6
		Mid section of the Reservoir	20	14	14	16	9	19	11	11
		Buyala-Kikubamutwe	19	18	12	15	14	20	14	11
Chlorophytes	greens	Kalange-Makwanzi	4	8	6	4	6	6	9	4
		Mid section of the Reservoir	8	7	6	5	7	11	12	5
		Buyala-Kikubamutwe	7	7	7	5	3	5	8	7
Bacillariophytes	Diatoms	Kalange-Makwanzi	4	4	5	2	6	6	2	5
		Mid section of the Reservoir	3	2	3	4	2	6	3	2
		Buyala-Kikubamutwe	2	5	3	4	2	5	3	5
Euglenophytes	Uni-cellular flagelated algae	Kalange-Makwanzi	0	0	0	0	0	0	0	0
		Mid section of the Reservoir	0	1	0	0	0	0	1	0
		Buyala-Kikubamutwe	1	0	0	0	0	0	0	0
Dinoflagellates		Kalange-Makwanzi	0	0	0	0	0	0	0	0
		Mid section of the Reservoir	0	1	0	0	0	0	0	0
		Buyala-Kikubamutwe	1	0	0	0	0	0	0	0
Total number of species		Kalange-Makwanzi	**17**	**27**	**23**	**20**	**24**	**26**	**22**	**15**
		Mid section of the Reservoir	**25**	**30**	**23**	**25**	**18**	**36**	**18**	**27**
		Buyala-Kikubamutwe	**30**	**30**	**22**	**24**	**19**	**30**	**25**	**25**

As was in the previous two survey periods- April and September 2015, the major taxonomic groups encountered were Blue-greens, Greens and Diatoms (Table 3.1.3). Dinoflagellates and Euglenophytes were not absent at all sites. Blue-green algae remained the dominant taxa, constituting ≥ 40% at all sites, while Diatoms remained the least represented in diversity at the downstream transect and in the mid-reservoir (3.1.4 c). Species numbers per taxa generally reduced compared to the September 2015 survey records i.e. for blue-greens from 11 to 6 species at the upstream transect and from 14 to 11 at the downstream transect (Table 3.1.4a). Species numbers however, remained constant in the reservoir probably because of the lake-like conditions especially with regard to residence time. There was a general decline in number of species of Green Algae from 9 to 4 at the upstream transect; from 12 to 5 in the reservoir; and from 8 to 7 at the downstream transect (3.14b). For Diatoms, the number of species increased from 2 to 5 at the upstream transect; and from 3 to 5 at the downstream transect; but reduced from 3 to 2 in the reservoir probably due to settling to the sediment surface due to the heavy nature of diatoms (Table 3.14c). During this reporting period, no Dinoflagellates were encountered at all sites (Table 3.1.4c).

Overall, the total number of algal species reduced at all sites when compared with September 2015 data i.e. from 22 to 15 at the upstream transect; from 27 to 18 species in the reservoir; and from 25 to 23 species at the downstream transect (Table 3.1.3).

Table 3.1.4a *Species composition of the blue-greens at the three sites over the monitoring periods (P denotes presence).*

	Kalange-Makwanzi								Mid section of the Reservoir								Buyala-Kikubamutwe							
	Sept.2012	Apr. 2013	Sept. 2013	Apr. 2014	Sept. 2013	Apr. 2015	Sept. 2015	Apr. 2016	Sept.2012	Apr. 2013	Sept. 2013	Apr. 2014	Sept. 2013	Apr. 2015	Sept. 2014	Apr. 2016	Sept.2012	Apr. 2013	Sept. 2013	Apr. 2014	Sept. 2013	Apr. 2015	Sept. 2015	Apr. 2016
Bluegreen (Cyanopytes)																								
Planktolyngbya limnetica		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
P.tallingii			P	P		P	P		P	P	P	P	P	P			P		P	P		P		
P.undulata									P		P						P							
P.contotum									P	P														
P.circumreta		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Aphanocapsa sp	P								P				P	P	P		P				P	P	P	P
Aphanocapsa nubilium		P		P	P	P	P	P		P		P	P	P	P	P		P		P	P	P	P	P
Aphanocapsa holistica		P								P		P	P	P	P									P
Aphanocapsa elachista			P	P	P		P				P	P		P		P	P	P		P	P	P	P	
Aphanocapsa incerta			P	P	P	P				P	P		P	P			P		P		P	P		
Aphanocapsa holistica	P			P													P	P		P		P		
Aphanocapsa delicatissima	P	P	P	P	P	P	P		P	P	P	P		P			P	P	P	P	P	P	P	
Aphanocapsa disperses						P															P			
Cylindropermopsis africana		P	P						P	P				P			P					P		
Cylindropermopsis cuspis									P															
Cylindrospermopsis raciborskii									P															
Merismopedia teniussima	P	P	P	P		P	P		P	P	P	P	P	P	P	P	P		P	P	P	P	P	P
Merismopedia gluaca	P	P			P	P		P	P			P		P	P		P	P				P	P	P
Merismopedia elegans		P								P								P				P		
Microcystis flos-aquea														P									P	
Microcystis aeruginosa		P		P						P		P		P		P		P		p	p		P	
Pseudoanabeana					P				P			P						P		P				
Chroococcus sp						P																P		
Chroococcus limneticus	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P		P	P	P	P	P
Chroococcus minutes						P	P							P								P	P	
Chroococcus turgidus	P								P															
Chroococcus aphanocapsiodes			P								P						P							
Chroococcus dispersus				P		P	P							P	P	P	P		P				P	P
Cyanodyction spp		P								P								P						
Ceolosphaerium kuetzinganianum				P		P	P			P	P	P			P					P	P			P
Ceolomoron sp (tropicale)	P		P		P				P			P		P	P	P					P	P	P	
Anabeanopsis tanganyikae	P	P			P			P			P					P		P	P	P	P	P		
Anabeana compacta											P						P							
Anabaena floa-saque		P								P														
Anabeana circinalis		P	P	P	P				P	P	P	P						P	P	P				P
Romeria spp														P					P			P		
Pico Blues									P															

Table 3.1.4b *Species composition of the -greens at the three sites over the monitoring periods (P denotes presence).*

	Kalange-Makwanzi								Mid section of the Reservoir								Buyala-Kikubamutwe							
	Sept.2012	Apr. 2013	Sept. 2013	Apr. 2014	Sept. 2013	Apr. 2015	Sept. 2015	Apr. 2016	Sept.2012	Apr. 2013	Sept. 2013	Apr. 2014	Sept. 2013	Apr. 2015	Sept. 2014	Apr. 2016	Sept.2012	Apr. 2013	Sept. 2013	Apr. 2014	Sept. 2013	Apr. 2015	Sept. 2015	Apr. 2016
Green (Chlorophytes)																								
Actinastrum hantzschii										P					P					P	P			
Ankistrodesmus fusiformis		P				P			P				P	P										
Ankistrodesmus falcatus	P	P	P	P	P	P	P	P			P	P	P	P	P	P	P	P	P	P		P	P	P
Ankistrodesmus stegala									P					P	P									
Monoraphidium contortum			P	P	P	P			P		P			P		P	P		P	P		P	P	
Chodetella sp	P					P	P							P	P				P				P	
Crucigenia fenestrate (apiculata)							P	P								P		P						P
Kirchnriella obesa (subsolitaria) (contorta)		P	P	P	P	P	P			P	P	P		P	P			P	P			P	P	PP
Monorophidium contortum		P					P			P		P			P			P						P
Cosmorium sp							P		P								P							
Closterium spp (acerosum)			P	P			P			P	P							P	P		P		P	
Closterium acicularis					P																			
Closterium spp					P		P								P									P
Stuarastrum sp (cuspdatum) gracile, cingulum		P		P				P	P	P		P	P	PP		P	P							P
Pediastrum simplex		P	P											P				P	P					
Pediastrum duplex									P						P		P							
Scenedesmus acuminatus	P				P				P		P		P	P		P							P	
Scenedesmus perforatus		P				P				P	P			P	P			P	P	P	P	P		
Scenedesmus curvatus																	P							
Scenedesmus castato	P																P	P						
Selenestrum ganulata			P																					
Didymocystis tuberculata															P									
Dictyosphaeruim spp														P						P				
Oocysistis soltaria													P											
Oocysistis borgi (gigas)								P		P					P	P							P	
Coelastrum microporum (proboscideum)													P										P	
Tetraedrom trigonum							P			P			P		P									

Table 3.1.4c *Species composition of the diatoms, euglenophytes and dinoflagellates at the three sites over the monitoring periods (P denotes presence).*

	Kalange-Makwanzi								Mid section of the Reservoir								Buyala-Kikubamutwe							
	Sept.2012	Apr. 2013	Sept. 2013	Apr. 2014	Sept. 2013	Apr. 2015	Sept. 2015	Apr. 2016	Sept.2012	Apr. 2013	Sept. 2013	Apr. 2014	Sept. 2013	Apr. 2015	Sept. 2014	Apr. 2016	Sept.2012	Apr. 2013	Sept. 2013	Apr. 2014	Sept. 2013	Apr. 2015	Sept. 2015	Apr. 2016
Diatoms (Bacillariophytes)																								
Navicula gastrum, platycephala			P		P	PP		P		P	P			P			P	P	P		P	P	P	P
Nitzschia nyassae (gastrum)		P				P		P		P		P		P						P		P	P	
Nitzschia acicularis	P	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	P	P		P	P
Rhopalodia vermicularis																								P
Rhizosolenia victoriae	P																P							
Nitzschia fonticola		P	P		P	P			P	P		P		P	P	P	P	P				P		
Synedra cunnigtonii	P	P	P	P	P			P		P	P	P		P			P	P	P	P				P
Cyclostephanodiscus spp			P		P	P	P						P		P					P		P		
Aulacoseira granulata					P			P						P								P		
Cyclotella sp	P								P								P							P
Euglenophytes																								
Euglena acus									P															
Phacus sp																	P							
Dinoflagellates																								
Glenediniuim sp	P																							
Ceratium spp															P									

Algal wet biomass was dominated by diatoms at the upstream and downstream transects, with the highest at the downstream transect and lowest in the reservoir (Fig.3.1.1). Blue-green algal wet biomass was second in abundance, with the highest at the downstream transect and lowest at the upstream transect. The relatively higher wet biomass for diatoms was attributed to the relatively high (2-fold) concentration of silica which is a vital nutrient for diatoms. The increasing trend in Blue-green wet biomass was attributed mainly to the concentration of these algal types via the stream flow. The wet biomass for Green algae was however, not discernible

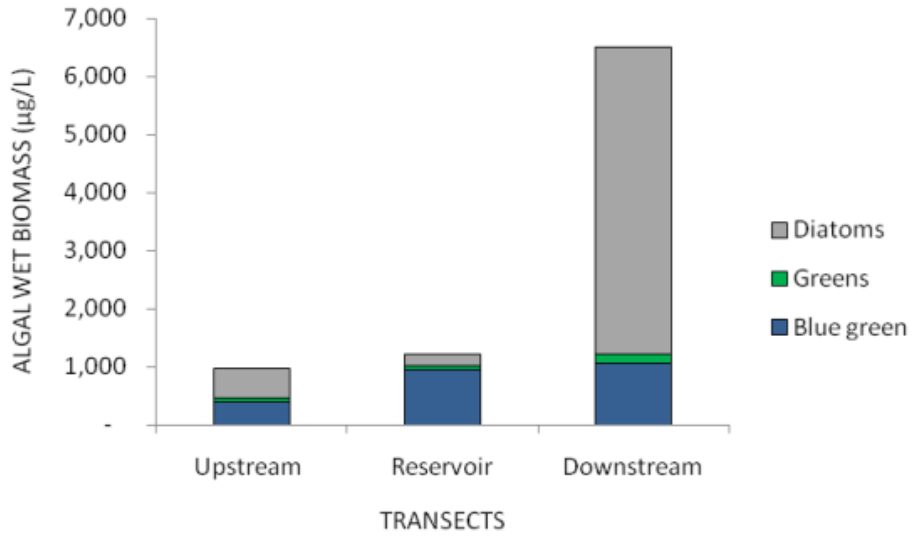

Figure 3.1.1: Algal wet biomass by major taxa in the transects

Aquatic macrophytes

During this survey period, the major aquatic macrophytes were water hyacinth (*Eichhornia crassipes*), Hippo grass (*Vossia cuspidata*), Duckweed (*Lemna minor*), Water primrose (*Ludwigia* spp.) and Cattail (*Typha* spp.). Other than water hyacinth whose cover abundance had increased to some extent, the rest of the macrophytes were still not well established along the banks of the reservoir.

At Kalange-Makwanzi (Upstream transect), water hyacinth dominated the shores and its cover abundance had increased from approximately 3.06 ha in September 2015 to approximately 5.03 ha, with Hudson Bay having > 62% during this survey period. Cover abundance of Cattail (*Typha* spp) had stagnated at approximately 0.2 ha since September 2015, while that of Hippo grass (*V. cuspidata*) had reduced from ~ 1.5 ha in September 2015 to 0.92 ha during this reporting period. Other macrophytes at this transect but with insignificant coverage (< 0.25 ha) were: Water primrose, Reeds (*Phragmites* spp), Nile Cabbage (*Pistia stratiotes*), sedges and Duck weeds (*Lemna* spp.).

At Buyala-Kikubamutwe (Downstream transect), much of the river bank (> 60%) had been cultivated down to the highest water level, and trees such as eucalyptus had been grown thus leaving little room for establishment of aquatic macrophytes. Cover abundance of dominant macrophytes had reduced further since 2015 i.e. for *V. cuspidata* from ~ 0.76 ha in September 2015 to 0.21ha; and for water hyacinth from ~0.75 ha in September 2015 to 0.21 during this survey. This trend in reduction of aquatic macrophytes cover abundance was attributed to harvesting by local people who feed some of these macrophytes on their domestic animals e.g. hippo grass on cattle and water hyacinth on pigs. The rest of the macrophytes were of insignificant (i.e. < 0.01 ha) occurrence and included: *Typha* spp, *Ludwigia* sp. and *Phragmites* spp.

The mid-reservoir was devoid of most of the common aquatic macrophytes, although water hyacinth dominated the shores but had reduced from 3.8 ha in September 2015 to 0.53 ha during this reporting period. Aquatic macrophytes that were rare included *Vossia cuspidata* that covered approximately 0.49 ha up from 0.3 ha in September 2015; and Ludwigia spp that covered approximately 0.2 ha. Buloba and Kyekidde had similar water hyacinth cover abundance of ~ 0.25 ha, while Kyabirwa remained clear of any aquatic macrophytes except some water hyacinths that covered ~0.21 ha. Thus until this survey, aquatic macrophytes were not yet well established in 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 was comparable with earlier observations with the three key groups represented by different species numbers in the three study sites (Table 3.2.1a, b,c). However, copepod species richness appeared to have improved from 4-5 species in September 2015 to 4-7 in April 2016 with the lowest species number recorded in the downstream site (Table 3.2.1a). Higher cladoceran species richness was observed at upstream and reservoir sites compared to the downstream site. Rotiferan species were highest at the upstream and reservoir sites decreasing to half the number at the downstream site; a trend which was comparable to those observed in April and September 2015 (Table 3.2.1c). Total species numbers across the study sites showed much higher numbers at the upstream and reservoir sites with half the numbers (10) recorded at the downstream site; exhibiting a similar trend to that in the April 2015 survey but quite different from that observed in September 2015 (Table 3.2.1c).

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

Taxa	Species name	Site	Monitoring time									
			Apr-06	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16
Copepoda		Kalange-Makwanzi		55		180		404		359		640
	Thermocyclops incisus	Mid section of the Reservoir		510				876	135	808	180	
		Buyala-Kikubamutwe	54	69			449	135		180	225	
		Kalange-Makwanzi	555	217	173	359	339	472		696		2,122
	Mesocyclops sp.	Mid section of the Reservoir		225	63	505	45	1,752	135	1,033		1,347
		Buyala-Kikubamutwe	77	361		55	90			539		
		Kalange-Makwanzi	1,213	222	94	1,123	229	606	404	449		2,560
	Thermocyclops emini	Mid section of the Reservoir			259	2,403	1,619	741		2,030		2,021
		Buyala-Kikubamutwe	22	208			180			90		
		Kalange-Makwanzi	2,458	402	582	3,440	1,702	9,791	741	2,448	2,246	5,201
	Tropocyclops confinnis	Mid section of the Reservoir		1,021	660	7,087	7,223	4,446	3,256	3,270	539	3,413
		Buyala-Kikubamutwe	177	985	356	1,600	1,412	1,038	404	472	292	813
		Kalange-Makwanzi	3,649	1,586	550	1,255	671	3,705	2,268	6,310	5,120	7,206
	Thermodiaptomus galeboid	Mid section of the Reservoir		827	1,218	4,087	3,288	4,514	3,166	9,508	3,862	14,574
		Buyala-Kikubamutwe	423	1,156	451	1,077	954	1,201		1,819	1,044	3,384
		Kalange-Makwanzi	6,086	3,648	1,258	7,204	5,259	9,364	2,829	7,523	9,342	10,521
	Thermocyclops neglectus	Mid section of the Reservoir		2,835	1,077	6,160	8,950	13,002	4,267	3,274	1,707	7,545
		Buyala-Kikubamutwe	197	1,216	906	343	1,392	1,324		90	1,875	959
		Kalange-Makwanzi						157				
	Harpacticoida	Mid section of the Reservoir					22					
		Buyala-Kikubamutwe						28				
		Kalange-Makwanzi	8,585	4,498	1,336	11,497	11,497	14,574	4,491	10,352	3,862	11,845
	Tropocyclops tenellus	Mid section of the Reservoir		4,871	762	11,147	12,279	8,892	7,163	8,560	3,773	14,574
		Buyala-Kikubamutwe	1,201	5,927	802	5,636	3,133	4,660	1,886	1,213	4,076	3,793
	Total copepod species abundance	Kalange-Makwanzi	**22,546**	**10,628**	**3,993**	**25,058**	**19,697**	**39,073**	**10,733**	**28,137**	**20,570**	**40,095**
		Mid section of the Reservoir	**0**	**10,289**	**4,039**	**31,389**	**33,426**	**34,223**	**18,122**	**28,483**	**10,061**	**43,474**
		Buyala-Kikubamutwe	**2,151**	**9,922**	**2,515**	**8,711**	**7,610**	**8,386**	**2,290**	**4,403**	**7,512**	**8,949**
	Cyclopoid copepodite	Kalange-Makwanzi	46,139	13,604	20,749	55,645	19,959	109,719	50,233	128,110	47,696	76,630
		Mid section of the Reservoir		17,786	14,194	72,754	72,754	49,111	73,183	132,471	36,019	109,067
		Buyala-Kikubamutwe	8,449	8,482	12,214	19,679	23,349	20,567	19,671	69,478	12,710	16,557
	Calanoid copepodites	Kalange-Makwanzi	6,808	1,401	1,808	4,436	1,305	10,038	4,267	6,018	4,671	17,329
		Mid section of the Reservoir		2,843	2,122	9,234	5,731	4,244	3,952	6,827	2,066	10,554
		Buyala-Kikubamutwe	531	1,724	859	2,487	595	2,964	741	2,897	2,178	3,375
	Nauplius larvae	Kalange-Makwanzi	109,016	56,689	17,165	110,662	73,062	354,935	96,515	148,859	166,621	206,202
		Mid section of the Reservoir		72,696	14,108	229,029	142,430	202,539	120,879	198,217	116,006	352,106
		Buyala-Kikubamutwe	27,844	25,701	12,670	99,546	48,792	161,277	48,459	85,062	69,321	79,004
	Total copepod develpmental stages abundance	Kalange-Makwanzi	**161,963**	**71,694**	**39,722**	**170,743**	**94,326**	**474,692**	**151,015**	**282,987**	**218,988**	**300,161**
		Mid section of the Reservoir		**93,325**	**30,424**	**311,017**	**220,915**	**255,894**	**198,014**	**337,515**	**154,091**	**471,727**
		Buyala-Kikubamutwe	**36,824**	**35,907**	**25,743**	**121,712**	**72,736**	**184,808**	**68,871**	**157,437**	**84,209**	**98,936**
	No of taxa	Kalange-Makwanzi	**6**	**7**	**6**	**7**	**6**	**8**	**5**	**7**	**4**	**7**
		Mid section of the Reservoir		**7**	**6**	**7**	**6**	**8**	**5**	**7**	**4**	**6**
		Buyala-Kikubamutwe	**7**	**7**	**4**	**5**	**7**	**6**	**2**	**7**	**5**	**4**

Abundance and distribution trends

Two copepod species: *Mesocyclops sp.* and *Thermocyclops emini* that were reported missing during the September 2015 survey reappeared in the April 2016 survey (Table 3.2.1a). Four copepod species (*Thermocyclops neglectus, Thermodiaptomus galeboides, Tropocyclops confinnis* and *T. tenellus*) were found in all the three study sites, two species (*Mesocyclops* sp. and *Thermocyclops emini*) occurred in two study sites while

one species (*Thermocyclops incisus*) was encountered only at one study site the three study sites. This species distribution trend did not differ much from those in most previous surveys. Copepoda numerical abundance was comparable at the upstream and mid-reservoir sites and lowest at the downstream site and with much higher densities compared to the 2015 surveys. Copepod developmental stages (copepodites and naupliar larvae) were highest at the mid-reservoir and lowest at the downstream site.

The maximum number of cladoceran species (5) recorded at the mid-reservoir while the lowest (2) was at the downstream site. Two species of Cladocera (*Bosmina longirostris* and *Moina micrura*) occurred at all three study sites while the rest exhibited an intermittent distribution pattern. Four species (*Chydorus* sp. *Macrothrix* sp., *Daphnia longispina* and *Dapnia lumholtzi*) were altogether not encountered at all the three study sites. Higher cladoceran densities and species numbers were recorded at the mid-reservoir and upstream sites while lower values were made at the downstream site (Table 3.2.1c). Records of the September 2015 survey indicate nearly similar trends although the values were much lower.

Table 3.2.1b. *Trends in numerical abundance (ind. m^{-2}) and diversity of Rotifer (wheel animalcules) species at the monitored sites*

Broad taxa	Species name	Site	Monitoring time									
			Apr-06	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16
Rotifera		Kalange-Makwanzi							135			
	Asplanchna sp.	Mid section of the Reservoir		22	55		55					
		Buyala-Kikubamutwe										
		Kalange-Makwanzi							674			
	Ascomorpha sp.	Mid section of the Reservoir		42	24							
		Buyala-Kikubamutwe					135					
		Kalange-Makwanzi	19		16		106				180	
	Euclanis sp.	Mid section of the Reservoir		28	24	225	247					
		Buyala-Kikubamutwe		14		90						
		Kalange-Makwanzi				45	584			90		359
	Brachionus falcatus	Mid section of the Reservoir		33		90				67		472
		Buyala-Kikubamutwe	11									
		Kalange-Makwanzi	116	23		264				449	629	269
	Filinia longiseta	Mid section of the Reservoir		42	16	797	269			472		2,785
		Buyala-Kikubamutwe				355						
		Kalange-Makwanzi	204						269			
	Polyarthra sp.	Mid section of the Reservoir			79		76		225	269		
		Buyala-Kikubamutwe							427	808		
		Kalange-Makwanzi	19	37		145		202	135	269	359	
	Filinia opoliensis	Mid section of the Reservoir		180	39	712		741				
		Buyala-Kikubamutwe			16	225		67				
		Kalange-Makwanzi										359
	Brachionus picatilis	Mid section of the Reservoir										
		Buyala-Kikubamutwe									124	
		Kalange-Makwanzi				135		90				
	Brachionus forticula	Mid section of the Reservoir					168					
		Buyala-Kikubamutwe										240
		Kalange-Makwanzi	173	74			269			1,055		7,343
	Keratella cochlearis	Mid section of the Reservoir		164	24	258	707	202	1,437	1,437		13,182
		Buyala-Kikubamutwe	30	83	16		404		314	2223	225	2,284
		Kalange-Makwanzi							269			
	Brachionus bidentatus	Mid section of the Reservoir				34						
		Buyala-Kikubamutwe										
		Kalange-Makwanzi	165	18	79			180			898	449
	Brachionus calyceforou	Mid section of the Reservoir		14	39		539		516		180	472
		Buyala-Kikubamutwe	68	37		135			269	584		
		Kalange-Makwanzi	105	92	267		204			539		
	Trichocerca cylindrica	Mid section of the Reservoir		333	487	292	1,219	606	3,705		269	
		Buyala-Kikubamutwe	13		168	262			674	629		
		Kalange-Makwanzi	213	46		90	494	719	898	674	898	2,111
	Brachionus angularis	Mid section of the Reservoir		164	55		319	404	2,268		1,527	
		Buyala-Kikubamutwe	95	97	131		79	1,078	1,280		618	
		Kalange-Makwanzi				45				67		
	Hexathra sp.	Mid section of the Reservoir				67				135		472
		Buyala-Kikubamutwe										
		Kalange-Makwanzi	289	379	534	835	1,763	1,033	3,436	2,785	539	
	Lecane bulla	Mid section of the Reservoir		732	409	2,439	2,550	2,088	2,133	5,223	1,168	786
		Buyala-Kikubamutwe	79	166	419	337	1,060		427	5,704		
		Kalange-Makwanzi					135	449	472	90		
	Lecane luna	Mid section of the Reservoir				1,880	657	404	741			
		Buyala-Kikubamutwe				269	808				168	
		Kalange-Makwanzi	617	587	550	853	649		943	4,963	359	4,700
	Synchaeta sp.	Mid section of the Reservoir	P	644	487	1,758	1,072	876		6,333	2,515	5,659
		Buyala-Kikubamutwe	42	291	634	748	865	935		4850	674	3,660
		Kalange-Makwanzi	565	240	346	1,506	849	5,142	988	4,738	3,503	4,161
	Keratella tropica	Mid section of the Reservoir		752	330	3,734	1,278	2,156		5,915	2,425	5,457
		Buyala-Kikubamutwe	659	647	346	1,054	638	2,457	449	4,087	898	3,335
		Kalange-Makwanzi	**2,485**	**1,496**	**1,792**	**3,918**	**5,053**	**7,815**	**8,219**	**15,719**	**7,365**	**19,751**
	Total abundance	Mid section of the Reservoir		**3,150**	**2,068**	**12,286**	**9,156**	**7,477**	**11,025**	**19,851**	**8,084**	**29,285**
		Buyala-Kikubamutwe	**997**	**1,335**	**1,730**	**3,475**	**3,989**	**4,537**	**3,840**	**18,885**	**2,707**	**9,519**
		Kalange-Makwanzi	**11**	**9**	**6**	**9**	**9**	**7**	**9**	**11**	**8**	**8**
	Number of species	Mid section of the Reservoir		**13**	**13**	**12**	**13**	**8**	**6**	**8**	**6**	**8**
		Buyala-Kikubamutwe	**8**	**7**	**7**	**9**	**7**	**4**	**6**	**7**	**6**	**4**

Rotiferan species richness in the present survey was still relatively low (4-8) compared to 6-8 species the September 2015 survey and 7-11 in April 2015 (Table 3.2.1b). Most of the rotiferan species were intermittently distributed except *Keratella tropica, Keratella cochlearis* and *Synchaeta* sp., which were recovered in all the study sites; a feature also observed in the September 2015 survey and in the April 2015 survey. As a general trend, rotifer total abundances were higher (9,519- 29,282 ind. m^{-2}**)** compared to (2,706-8,084 ind. m^{-2}) in the September 2015 and 15,719-19,851 ind. m^{-2} in April 2015.

Table 3.2.1c. *Trends in numerical abundance (ind. m^{-2}) and diversity of Cladocera (water fleas) species and overall zooplankton density at the monitored sites*

Broad taxa	Species name	Site	Monitoring time									
			Apr-06	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16
Cladocera	*Daphnia lumholtzi*	Kalange-Makwanzi										
		Mid section of the Reservoir							67			135
		Buyala-Kikubamutwe	9									
	Daphnia longispina	Kalange-Makwanzi		42								
		Mid section of the Reservoir										
		Buyala-Kikubamutwe										
	Macrothrix sp.	Kalange-Makwanzi										
		Mid section of the Reservoir										
		Buyala-Kikubamutwe	20									
	Chydorid sp.	Kalange-Makwanzi	29									
		Mid section of the Reservoir		42								
		Buyala-Kikubamutwe	7	37								
	Daphnia lumhortzi (helm.)	Kalange-Makwanzi	243	23		108			67			308
		Mid section of the Reservoir		14		36	56		67			
		Buyala-Kikubamutwe	17					67			112	
	Ceriodaphnia cornuta	Kalange-Makwanzi	58	23	63	1,118	808	2,223	449	2,290	1,886	6,422
		Mid section of the Reservoir		147	181	584	584	1,087	1,011	1,729	90	2,897
		Buyala-Kikubamutwe		203	89	45	79	83	427			
	Diaphanosoma excisum	Kalange-Makwanzi	287	462		1,292	382	135	112	1078	988	
		Mid section of the Reservoir		297	94	921	685	2,358	584	1,100	180	1,999
		Buyala-Kikubamutwe		190	73	674	557	337			112	
	Moina micrura	Kalange-Makwanzi	679	361	63	1,934	90	808	1,909	943	988	2,560
		Mid section of the Reservoir		497	118	932	659	606	1,055	1,037		2,290
		Buyala-Kikubamutwe	28	227	31	67	31				112	135
	Bosmina longirostris	Kalange-Makwanzi	859	254	31	444	606	180	1,549	427	1,347	1,206
		Mid section of the Reservoir		330	212	564	1,329	269	1,302	1,028	449	3,279
		Buyala-Kikubamutwe	213	319	110		528	28		516	112	501
	Total Calanoid abundance	Kalange-Makwanzi	**2155**	**1165**	**157**	**4896**	**1886**	**3346**	**4086**	**4738**	**5209**	**10496**
		Mid section of the Reservoir		**1327**	**605**	**3037**	**3313**	**4320**	**4086**	**4894**	**719**	**10600**
		Buyala-Kikubamutwe	**294**	**976**	**303**	**786**	**1195**	**515**	**427**	**516**	**448**	**636**
	No of cladoceran taxa	Kalange-Makwanzi	**6**	**6**	**3**	**5**	**4**	**4**	**4**	**4**	**4**	**4**
		Mid section of the Reservoir		**6**	**4**	**5**	**5**	**4**	**6**	**4**	**3**	**5**
		Buyala-Kikubamutwe	**6**	**5**	**4**	**3**	**4**	**4**	**1**	**1**	**4**	**2**
	overall zooplankton abundance	Kalange-Makwanzi	**189,149**	**84,983**	**45,664**	**204,615**	**120,962**	**524,926**	**174,053**	**331,581**	**252,132**	**370,503**
		Mid section of the Reservoir	-	**108,091**	**37,136**	**357,729**	**266,810**	**301,914**	**231,247**	**390,743**	**172,955**	**555,086**
		Buyala-Kikubamutwe	**40,266**	**48,140**	**30,291**	**134,684**	**85,530**	**198,246**	**75,428**	**181,241**	**94,876**	**118,040**

Discussion

The community composition data for April, September 2015 and April 2016 indicates occurrence of nearly the same zooplankton species in the three taxonomic groups (Copepoda, Cladocera and Rotifera). As observed in the previous survey, the species assemblage has not changed significantly for the last five years and there is close

resemblance of the assemblage with that of Lake Victoria, which is the ultimate source of the River Nile water. This observation suggests comparable environmental parameters between the two systems (i.e. Lake Victoria and the Upper Victoria Nile). The general similarity of the zooplankton assemblage over several past surveys including pre-and post-reservoir eras suggests that community composition has remained remarkably stable following and after creation of the hydropower dam and reservoir. Stability of biological communities especially those that include biological indicators of water quality, such as zooplankton, suggests corresponding stability of environment conditions over the different phases of the hydropower construction at Bujagali and probably minimal impacts of the dam on the zooplankton community. This is a crucial ecological attribute that ensures sustenance of the various ecological roles of the community in the River Nile ecosystem.

In Lake Victoria, the zooplankton assemblage has been shown to have changed since the 1960s when sizeable proportions of large-bodied members (calanoids and cladocerans) used to be the distinctive feature of the community. This status has now changed to give way to dominance of the community by medium-sized cyclopoid copepods (Mwebaza-Ndawula 1994). Such shift may be caused by a combination of environmental drivers including changes in water quality parameters and fish community probably favoring higher, size-selective planktivory. As zooplankton have been reported to provide over 70% of the diet of the pelagic *Rastrineobola argentea* in Lake Victoria (Mwebaza-Ndawula 1998), the consistent occurrence of these fish food organisms in relatively high abundance (118,039-555,128 ind. m^{-2}) at the investigated sites implies potential for the pelagic fishery in the study area, notwithstanding the lower density estimates during the April and September 2015 surveys. The latter may be due to possible seasonal variations of the community in this part of the river. The trend of lower zooplankton numerical abundance downstream of the dam (Table .3.2.1c) has been consistent since 2012 through 2013 and 2014 to 2015 up to the present time in April 2016. This observation is in contrast to the one reported by Zarfdiian *et al.* (2000) in River Aliakmon in Greece who observed much higher zooplankton abundance in a downstream site, probably due to different environmental conditions from those obtaining at BEL dam area. The consistency of this pattern of zooplankton abundance distribution over a period of four years suggests possible community response to different water flow dynamics at the downstream site of the dam compared to the reservoir and upstream sites.

The present data is in agreement with the September 2015 data indicating numerical co-dominance of four species: *Tropocyclops confinnis*, *Tropocyclops tenellus*, *Thermocyclops neglectus* and *Thermodiaptomus galboides* (Table 3.2.1a), suggesting a continuation of favorable conditions for these taxa in the study area. In addition, the present data confirms earlier observations of a rotifer-driven species richness (Table 3.2.1b) and numerical superiority of copepods (Table 3.2.1a). This observation explains the dominance of copepods in the diet of the pelagic and commercially important mukene (*Rastrineobola argentea*) in Lake Victoria (Mwebaza-Ndawula 1998). The higher

zooplankton abundance in the upstream sand reservoir areas (Table 3.2.1c) suggests higher potential of these sites for fish production relative to the downstream site.

It is clear that zooplankton community abundance is heavily dependent on copepods especially, Cyclopoid copepods. The most contributing copepod species and groups have remained the same over the survey years, namely *Tropocyclops tenellus, T. confinnis Thermocyclops neglectus* and to some extent, *Tropodiaptomus galboides*. The juvenile stages of Copepoda i.e. copepodites and nauplius larvae have remained the most abundant entities of the zooplankton community and this consistent pattern for the last five years defines their unsurpassed ecological importance in the upper Victoria Nile system.

3.3 Benthic macro-invertebrates

Three species of water snails were recorded in the benthos at Kalange-Makwanzi transect during the current survey, 1 in the mid-reservoir and 5 at Buyala-Kikubamutwe transect (Table 3.3.1a). Only 37 ind. m^{-2} of *Bellamya unicolor* at Buyala-Kikubamutwe transect. They were 579 ind. m^{-2} during April 2015 and 9 ind. m^{-2} during the September 2015. At the mid-reservoir transect, the density increased from 98 ind. m^{-2} during the September 2015 survey to 1097 ind. m^{-2} during the present one. Snail density was highest (1181 ind. m^{-2}) at the mid-reservoir transect and least (91 ind. m^{-2}) at the Kalange-Makwanzi transect.

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

Broad taxa	English name	Scientific Species name	Site	Monitoring time											
				Apr-06	Aug-07	Apr-08	Apr-12	Sep-12	May-13	Sep-13	Apr-14	Sep.14	Apr-15	Sep.15	Apr.16
Gastropoda	Water snail	*Bellamya unicolor*	Kalange-Makwanzi	33	173	5	33	-	-	299	-	-	-	-	35
			Mid section of the Reservoir				-	-	4	154	296	23	14	98	1,097
			Buyala-Kikubamutwe	37	126	11	42	65	285	14	23	47	579	9	37
		Melanoides tuberculata	Kalange-Makwanzi	28	107	257	14	19	5	19	-	-	14	-	56
			Mid section of the Reservoir				-	-	77	5	5	9	145	35	5
			Buyala-Kikubamutwe	33	224	100	121	33	33	9	33	-	42	14	-
		Biomphalaria choanomphala	Kalange-Makwanzi	-	14	5	-	-	-	9	-	-	5	-	-
			Mid section of the Reservoir				2	-	4	7	25	-	-	-	61
			Buyala-Kikubamutwe	-	19	11	-	5	9	5	9	5	23	5	5
		Anisus natalensis	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	-	-	-	-	-	-
			Buyala-Kikubamutwe	-	-	-	5	-	-	-	-	-	-	-	5
		Gyraulus sp.	Kalange-Makwanzi	-	-	-	5	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	-	-	-	-	-	-
			Buyala-Kikubamutwe	-	-	-	-	-	47	-	5	-	-	-	-
		Segmentorbis sp.	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	3	-	-	-	-	-	-	-
			Buyala-Kikubamutwe	-	-	-	47	9	23	-	-	-	-	-	-
		Gabbia humerosa	Kalange-Makwanzi	-	79	5	-	-	5	23	-	-	-	-	-
			Mid section of the Reservoir				-	-	4	5	33	-	-	-	5
			Buyala-Kikubamutwe	-	-	121	1,027	677	135	-	-	9	42	-	196
		Bulinus sp	Kalange-Makwanzi	5	9	5	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	12	-	-	-	-	14
			Buyala-Kikubamutwe	5	5	5	-	19	65	-	5	-	-	-	5
		Pila ovata	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				7	-	-	-	-	-	-	-	-
			Buyala-Kikubamutwe	-	-	5	-	-	5	-	-	-	-	-	-
		Total snail density	Kalange-Makwanzi	**65**	**383**	**275**	**51**	**19**	**9**	**350**	-	-	**19**	-	**91**
			Mid section of the Reservoir	-	-	-	**9**	**3**	**88**	**182**	**358**	**33**	**159**	**133**	**1,181**
			Buyala-Kikubamutwe	**70**	**369**	**247**	**1,242**	**789**	**537**	**28**	**70**	**61**	**686**	**28**	**243**
		No of snail species	Kalange-Makwanzi	**3**	**6**	**6**	**3**	**1**	**2**	**4**	**0**	**0**	**2**	**0**	**3**
			Mid section of the Reservoir				**1**	**2**	**2**	**3**	**2**	**1**	**2**	**1**	**1**
				3	**4**	**6**	**5**	**6**	**8**	**3**	**4**	**3**	**4**	**3**	**5**

The density of bivalves at Kalange-Makwanzi and mid-reservoir transects increased tremendously from 63 ind. m^{-2} during April 2015 to 686 ind. m^{-2} during the present survey period at the former and from 138 ind. m^{-2} to 677 ind. m^{-2} at the latter (Table 3.3.1 b). There was an increase in bivalval abundance at Buyala-Kikubamutwe transect from 331 ind. m^{-2} in the previous survey to 385 ind. m^{-2} during the current one. Six species of bivalves were encountered at Kalange-Makwanzi and 5 repesctively at mid-reservoiur and Buyala-Kikubamutwe transects.

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

Broad taxa	English name	Scientific Species name	Site	Monitoring time											
				Apr-06	Aug-07	Apr-08	Apr-12	Sep-12	May-13	Sep-13	Apr-14	Sep.14	Apr-15	Sep.15	Apr.16
Bivalvia	Clam/ mussels	*Byssanondota parasitica*	Kalange-Makwanzi	79	145	252	61	75	42	121	14	-	9	-	133
			Mid section of the Reservoir				23	95	686	380	801	28	79	58	42
			Buyala-Kikubamutwe	-	19	63	317	9	117	733	159	205	75	149	140
		Corbicula africana	Kalange-Makwanzi	56	126	182	47	219	514	98		19	145	9	413
			Mid section of the Reservoir				5	25	196	44	581	140	481	7	406
			Buyala-Kikubamutwe	65	131	205	65	28	79	56	47	126	126	93	175
		Caelatura spp	Kalange-Makwanzi	149	93	229	79	79	47	-	124	9	84	47	133
			Mid section of the Reservoir				9	20	28	23	44	33	5	58	135
			Buyala-Kikubamutwe	37	61	63	37	5	5	47	23	51	28	75	47
		Pisidium victoriae	Kalange-Makwanzi	-	5	-	-	9	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	-	-	-	-	-	47
			Buyala-Kikubamutwe	-	-	32	19	5	-	-	-	-	-	-	-
		Mutela sp	Kalange-Makwanzi	-	-	-	5	5	-	-	7	-	9	7	-
			Mid section of the Reservoir				-	-	-	-	-	-	-	-	19
			Buyala-Kikubamutwe	5	5	16	-	-	-	-	-	-	9	-	7
		Sphaerium victoriae	Kalange-Makwanzi	5	51	14	-	-	-	-	14	-	9	-	7
			Mid section of the Reservoir				2	-	-	2	14	5	14	-	9
			Buyala-Kikubamutwe	-	19	-	23	-	-	5	-	61	23	5	7
		Sphaerium stuhlman	Kalange-Makwanzi	-	-	-	9	-	-	9	-	-	-	-	-
			Mid section of the Reservoir				5	146	18	2	26	-	-	7	-
			Buyala-Kikubamutwe	-	-	-	9	5	-	-	-	-	-	9	-
		Aspantharia sp	Kalange-Makwanzi	9	9	5	5	5	5	-	5	-	14	-	-
			Mid section of the Reservoir				-	-	-	-	-	-	5	-	19
			Buyala-Kikubamutwe	5	-	-	-	-	-	-	5	-	5	-	-
		Etheria eliptica	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	-	-	-	14	7	-
			Buyala-Kikubamutwe	-	-	5	5	-	-	-	-	-	-	-	9
		Total bivalve density	Kalange-Makwanzi	**299**	**430**	**682**	**205**	**392**	**607**	**229**	**386**	**28**	**271**	**63**	**686**
			Mid section of the Reservoir	-	-	-	**44**	**286**	**928**	**453**	**1,466**	**205**	**598**	**138**	**677**
			Buyala-Kikubamutwe	**112**	**233**	**383**	**476**	**51**	**201**	**840**	**233**	**444**	**266**	**331**	**385**
		No. of species	Kalange-Makwanzi	**4**	**5**	**4**	**5**	**6**	**4**	**4**	**6**	**2**	**6**	**3**	**6**
			Mid section of the Reservoir				**4**	**4**	**4**	**5**	**4**	**4**	**6**	**5**	**5**
			Buyala-Kikubamutwe	**3**	**4**	**5**	**6**	**5**	**3**	**4**	**4**	**4**	**6**	**4**	**5**

During the current survey, only one species of may fly nymph, *Povilla adusta* was recorded in the benthos at Buyala-Kikubamutwe transects at density of 79 ind. m^{-2} (Table 3.3.1 c) .Odonata nymphys, *Hagenius sp* and Libellulidea were encountered at the mid-reservoir at densities of 33 and 84 ind. m^{-2} respectively. Of the true flies, Chaoborus sp, Chironominea Ceratopogonidea and Taniponidea were encountererd at densities ranfing from 5 to 126 ind. m^{-2} (Table3.3.1c).

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

Broad taxa	English name	Scientific Species name	Site	Monitoring time											
				Apr-06	Aug.07	Apr-08	Apr-12	Sep-12	May-13	Sep-13	Apr-14	Sep.14	Apr-15	Sep.15	Apr-16
Ephemeroptera	Mayfies	*Povilla adusta*	Kalange-Makwanzi	19	163	9	28	-	14	-	9	-	-	-	-
			Mid section of the Reservoir				5	3	144	245	5	-	70	12	-
			Buyala-Kikubamutwe	5	9	63	28	5	37	9	28	-	19	5	79
		Baetis sp.	Kalange-Makwanzi	5	9	-	-	-	-	-	-	5	-	-	-
			Mid section of the Reservoir				-	3	-	-	-	79	-	-	-
			Buyala-Kikubamutwe	23	5	-	-	5	-	-	-	19	-	-	-
		Caenis sp.	Kalange-Makwanzi	19	75	19	5	-	-	5	-	-	-	-	-
			Mid section of the Reservoir				-	-	7	-	-	-	9	-	-
			Buyala-Kikubamutwe	-	9	26	37	9	313	-	23	-	-	-	-
		Cloeon sp.	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	-	-	-	-	-	-
			Buyala-Kikubamutwe	37	-	-	-	9	9	-	-	-	-	-	-
		Leptophlebidae	Kalange-Makwanzi	-	14	-	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	5	-	-	-	-	-
			Buyala-Kikubamutwe	-	-	-	-	-	5	9	-	-	-	-	-
		Trichorythidae	Kalange-Makwanzi	-	89	-	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	19	-	-	-	-	-
			Buyala-Kikubamutwe	-	-	-	5	-	19	-	-	-	-	-	-
Odonata	Dragon flies/ damsels	*Hagenius* sp.	Kalange-Makwanzi	19	-	9	-	5	-	-	7	-	-	-	-
			Mid section of the Reservoir				-	3	-	-	-	-	-	7	33
			Buyala-Kikubamutwe	5	-	-	5	5	-	-	5	-	-	5	-
		Gomphoides sp.	Kalange-Makwanzi	5	-	5	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	-	-	-	-	-	-
			Buyala-Kikubamutwe	-	19	-	-	-	-	-	-	-	-	5	-
		Libellulidea	Kalange-Makwanzi	9	33	-	5	-	14	5	-	-	-	-	7
			Mid section of the Reservoir				2	-	18	2	2	-	-	-	84
			Buyala-Kikubamutwe	-	5	37	5	5	14	-	-	-	-	-	-
		Coenagrion sp.	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	-	-	-	-	-	-
			Buyala-Kikubamutwe	5	-	5	-	-	-	-	-	5	-	-	-
		Protoneuridae	Kalange-Makwanzi	-	9	9	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	-	-	-	-	-	-
			Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-
Trichoptera	Caddis flies	Hydropsychidae	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	5	-	-
			Mid section of the Reservoir				-	-	-	257	-	-	-	12	-
			Buyala-Kikubamutwe	-	19	16	5	-	9	-	5	-	-	5	14
		Brachycentridae	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	-	-	-	-	-	-
			Buyala-Kikubamutwe	-	-	-	2	-	-	-	-	-	-	-	-
		Psychomyiid	Kalange-Makwanzi	-	2	-	-	-	5	9	-	-	-	-	-
			Mid section of the Reservoir				-	3	4	7	-	-	-	-	-
			Buyala-Kikubamutwe	-	-	-	5	-	-	14	-	-	-	9	-
		Leptoceridae	Kalange-Makwanzi	-	-	-	-	-	5	-	-	5	-	-	-
			Mid section of the Reservoir				-	-	-	-	-	5	-	-	-
			Buyala-Kikubamutwe	-	2	3	-	-	5	-	-	-	-	-	-
Hemiptera	Water bugs	Nepidae	Kalange-Makwanzi	-	-	5	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	-	-	-	-	-	-
			Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-
Coleoptera	Beetles/ weevils	Elmidae	Kalange-Makwanzi	-	5	-	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	-	-	-	-	-	-
			Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-
Diptera	True flies	Chironominae	Kalange-Makwanzi	271	331	238	201	47	117	191	5	-	9	208	56
			Mid section of the Reservoir				201	73	98	26	27	-	-	63	51
			Buyala-Kikubamutwe	84	56	58	84	9	75	37	19	-	14	84	12
		Tanipodinae	Kalange-Makwanzi	19	33	23	5	14	33	37	19	61	5	63	21
			Mid section of the Reservoir				-	8	42	42	56	47	-	-	56
			Buyala-Kikubamutwe	23	42	5	26	-	14	56	-	28	42	75	7
		Chaoborus sp	Kalange-Makwanzi	9	23	9	9	42	28	70	196	-	37	96	126
			Mid section of the Reservoir				-	8	53	47	40	5	5	14	5
			Buyala-Kikubamutwe	5	5	-	65	-	-	23	5	23	14	14	-
		Ceratopogonidae	Kalange-Makwanzi	5	14	-	9	-	-	-	5	84	-	-	-
			Mid section of the Reservoir				-	-	-	-	-	-	5	-	14
			Buyala-Kikubamutwe	-	5	-	-	-	-	-	-	5	-	-	-
		Psychodidae	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	5	-	-	-	-	-
			Buyala-Kikubamutwe	-	-	-	-	-	-	-	-	-	-	-	-

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

Broad taxa	English name	Scientific Species name	Site	Monitoring time											
				Apr-06	Aug-07	Apr-08	Apr-12	Sep-12	May-13	Sep-13	Apr-14	Sep.14	Apr-15	Sep.15	Apr.16
Decapoda	Shrimps	*Caridina nilotica*	Kalange-Makwanzi	-	5	-	5	-	-	5	-	-	9	-	-
			Mid section of the Reservoir				7	3	-	5	14	-	5	-	70
			Buyala-Kikubamutwe	-	5	32	-	-	-	5	-	-	126	5	-
Oligochaeta	Earthworms	*Nais* sp.	Kalange-Makwanzi	-	5	5	14	5	-	28	-	9	5	14	21
			Mid section of the Reservoir				-	-	11	16	56	5	9	49	191
			Buyala-Kikubamutwe	-	33	11	9	5	-	19	-	9	28	42	-
Hirudinea	Leeches	Glosophomidae	Kalange-Makwanzi	-	-	-	-	-	-	-	-	-	-	-	-
			Mid section of the Reservoir				-	-	-	-	-	-	-	-	-
			Buyala-Kikubamutwe	-	-	5	-	-	-	-	-	-	-	-	-
Ostracods	Seed shrimps	Ostracods	Kalange-Makwanzi	-	-	-	-	5	-	9	-	-	-	-	-
			Mid section of the Reservoir				229	11	-	7	2	-	-	-	-
			Buyala-Kikubamutwe	-	-	-	-	-	-	5	-	-	-	-	-

During this survey period, nile shrimps (*Caridina nilotica*) were recorded only at the mid-reservoir transect at a density of 70 ind. m^{-2} (Table 3.3.1 d). The earthworms (Oligocheata) density at the mid-reservoir rose from 49 ind. m^{-2} during the previous survey period to 191 ind. m^{-2} during the current one. The leeches and seed shrimps have remained unseen in the benthos for the last 4 previous surveys.

3.4 Fish Species Composition and Relative Abundance

3.4.1 Catch composition

With haplochromines taken as a single species group, a total of 5 fish species were recorded at the three transects along River Nile in April 2016 compared to 10 in September 2015 and 10 in April 2015 (Table 3.4.1). Four species were recorded from the upstream station (Kalange-Makwanzi), 5 from the mid-reservoir and 2 from the downstream (Buyala-Kikubamutwe).

Keystone species: Nile perch (*Lates niloticus*), catfishes (*Bagrus docmak*, *Synodontis afrofischeri*), Elephant snout fish (*Mormyrus kannume*) and the haplochromines were recovered during this survey. Nile perch and haplochromines were recovered from all the three transects, while *Bagrus docmak* was recovered from the mid-reservoir transect only. *Mormyrus kannume* and *S. afrofischeri* were recovered from the upstream and mid-reservoir transects and absent downstream.

The highest densities of fish by numbers was at the mid-reservoir transect (71.2%), followed by the upstream transect (15.2%) and least from the downstream transect (13.6%). The dominance by numbers was *M. kannume* at the upstream transect (40%), while Nile perch dominated at both the mid-reservoir (48.9%) and downstream (55.6%) transects. In terms of weight, Nile perch dominated with 83%, 47% and 83.8% at the upstream, reservoir and downstream transects respectively.

The total number of fish species recovered from all gears at different transects has declined over time (Figure 3.4.1)

Table 3.4.1 *Fish species recorded overtime at the monitored sites.*

Family names	Scientific names	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
				Apr. 2006	Sep. 2007	Apr. 2008	Apr. 2009	Oct. 2009	Apr. 2010	Sep. 2010	Apr. 2011	Sep. 2011	Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016
Bagridae	*Bagrus docmak*	Catfish/(Semutundu)	Kalange-Makwanzi		P			P													
			Mid section of the Reservoir										P	P	P	P	P	P	P	P	P
			Buyala-Kikubamutwe		P		P								P	P					
Centropomidae	*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
			Mid section of the Reservoir										P	P	P	P	P	P	P	P	P
			Buyala-Kikubamutwe	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Characidae	*Brycinus jackzonii*	(Nsoga)	Kalange-Makwanzi																		
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe	P																	
	B. sadleri	(Nsoga)	Kalange-Makwanzi	P																P	
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe																		
Cichlidae	*Oreochromis niloticus*	Nile tilapia/(Ngege -kibati)	Kalange-Makwanzi	P	P	P		P			P	P	P					P	P	P	
			Mid section of the Reservoir												P						
			Buyala-Kikubamutwe	P	P	P	P	P		P			P	P	P	P	P				
	O. leucostictus	Black tilapia/(Ngege)	Kalange-Makwanzi	P	P																
			Mid section of the 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	
			Mid section of the 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	
			Mid section of the Reservoir										P		P	P					
			Buyala-Kikubamutwe	P	P	P	P	P		P			P	P			P		P	P	
	Haplochromines	(Nkejje)	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
			Mid section of the 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
Clariidae	*Clarias gariepinus*	Mudfish/ (Male)	Kalange-Makwanzi			P	P							P	P						
			Mid section of the Reservoir										P	P							
			Buyala-Kikubamutwe			P	P		P			P				P					
Cyprinidae	*Barbus altianalis*	Barbel fish/ (Kisinja)	Kalange-Makwanzi	P	P	P	P		P				P								
			Mid section of the Reservoir										P	P	P						
			Buyala-Kikubamutwe	P	P	P	P		P	P		P	P		P		P				
	B. paludinosus	Barbel fish/ (Kisinja)	Kalange-Makwanzi																		
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe	P																	
	Labeo victorianus	(Ningu)	Kalange-Makwanzi																		
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe		P					P											
	Rastrineobola argentea	Silver fish/(Mukene)	Kalange-Makwanzi							P											
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe	P	P		P			P											
Cyprinodontidae	*Aplocheilichthys pumilus*	Gambusia	Kalange-Makwanzi																		
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe		P																
Lepidosirenidae	*Protopterus aethiopicus*	Lung fish (Mamba)	Kalange-Makwanzi						P												
			Mid section of the 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
			Mid section of the Reservoir										P		P	P			P		P
			Buyala-Kikubamutwe		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 section of the Reservoir										P	P		P		P	P	P	
			Buyala-Kikubamutwe											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
			Mid section of the 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	
Mormyridae	*Gnathonemus longibarbis*	Elephant snout fish (Kasulubana)	Kalange-Makwanzi																		
			Mid section of the 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	
			Mid section of the Reservoir										10	7	8	7	6	5	7	5	
			Buyala-Kikubamutwe	11	13	8	12	6	6	10	4	7	8	7	7	7	7	3	7	7	

3.4.2 The Haplochromines

At least 5 species belonging to 5 genera of haplochromines were recovered during this survey (Table 3.4.2a & b). The mid-reservoir transect yielded the highest haplochromine species diversity (3 species) followed by the upstream and downstream transects with 2 haplochromine species each. The most dominant genera by number and weight were *Astatotilapia* (44.4%) and *Mpibia* (33.6%) respectively.

Table 3.4.2a *Haplochromine species recorded over time at the monitored sites*

Genus	Species name	Site	Monitoring dates																	
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			Apr. 2006	Sep. 2007	Apr. 2008	Apr. 2009	Sep. 2009	Apr. 2010	Sep. 2010	Apr. 2011	Sep. 2011	Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016
Astatoreochromis	*A. alluaudi*	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P	P	P	P				
		Mid section of the 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
		Mid section of the Reservoir										P				P				
		Buyala-Kikubamutwe		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	A. "cylindrical"	Kalange-Makwanzi			P															
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe																		
	A. "elongate"	Kalange-Makwanzi	P	P	P	P	P	P	P											
		Mid section of the Reservoir										P								
		Buyala-Kikubamutwe			P		P			P										
	A. "purple dorsum"	Kalange-Makwanzi		P								P				P	P			
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe												P	P					
	A. "red dorsum"	Kalange-Makwanzi				P	P		P		P		P							
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe					P	P	P							P				
	Astatotilapia sp.	Kalange-Makwanzi			P	P	P			P				P	P		P	P		
		Mid section of the Reservoir												P	P			P		
		Buyala-Kikubamutwe		P	P	P	P				P			P	P	P		P		
	A. nubila	Kalange-Makwanzi															P			
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe																P		
Gaurochromis	*Gaurochromis sp*	Kalange-Makwanzi		P																
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe																		
Haplochromis	*H. lividus*	Kalange-Makwanzi									P									
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe																		
Harpagochromis	*H. guiarti*	Kalange-Makwanzi	P	P	P	P	P		P	P	P	P						P	P	
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe	P		P	P	P		P			P	P			P		P		
	H. serranus	Kalange-Makwanzi																		
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe	P																	
Labrochromis	*L. humilior*	Kalange-Makwanzi		P																
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe																		
Lithochromis	*Lithochromis sp*	Kalange-Makwanzi		P		P	P												P	
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe					P												P	
Lipochromis	*L. microdon*	Kalange-Makwanzi					P													
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe																		
	L. parvidens	Kalange-Makwanzi			P			P												
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe							P			P								
Mbipia	*M. mbipi*	Kalange-Makwanzi	P	P	P	P	P	P	P	P	P	P	P							
		Mid section of the Reservoir										P			P		P	P		P
		Buyala-Kikubamutwe	P	P	P	P	P	P	P	P	P	P	P		P	P		P		
Neochromis	*N. "elongate"*	Kalange-Makwanzi										P								
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe						P												
	N. greenwoodi	Kalange-Makwanzi	P							P										
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe		P																
	N. rufocaudalis *(Neochromis spp.)*	Kalange-Makwanzi		P	P	P	P	P	P	P		P								
		Mid section of the Reservoir										P			P	P			P	
		Buyala-Kikubamutwe		P														P		
Paralabidochromis	*P. "black para"*	Kalange-Makwanzi				P			P			P								
		Mid section of the Reservoir														P				
		Buyala-Kikubamutwe			P						P									
	P. cyaneus	Kalange-Makwanzi																		
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe	P																	
	P. "earthquake"	Kalange-Makwanzi	P				P			P										
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe	P																	
	P. flavus	Kalange-Makwanzi																		
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe					P				P									
	P. rock kribensis	Kalange-Makwanzi					P				P									
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe																		
	P. "scarlet anal"	Kalange-Makwanzi	P						P	P	P	P				P			P	
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe					P										P			
	P. "yellow"	Kalange-Makwanzi																		
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe	P																	
	Paralabidochromis sp *(P. crassilabris)*	Kalange-Makwanzi	P															P		
		Mid section of the Reservoir														P				
		Buyala-Kikubamutwe	P	P	P															

Table 3.4.2b *Haplochromine species recorded over time at the monitored sites*

Genus	Species name	Site	Monitoring dates																
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			Apr. 2006	Sep. 2007	Apr. 2008	Apr. 2009	Sep. 2009	Apr. 2010	Sep. 2010	Apr. 2011	Sep. 2011	Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016
Prognathochromis	*P. "shovel mouth"*	Kalange-Makwanzi	P	P			P	P	P	P	P									
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe				P			P			P	P							
Psammochromis	*P. aelocephalus*	Kalange-Makwanzi		P					P											
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe		P					P											
	P. riponianus	Kalange-Makwanzi	P	P	P	P	P		P	P		P	P					P		
		Mid section of the Reservoir												P						P
		Buyala-Kikubamutwe	P		P		P		P				P	P	P			P		
Ptyochromis	*P. sauvagei (P. xenognathus)*	Kalange-Makwanzi	P		P		P			P	P	P					P			
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe	P		P				P					P			P	P		
Pundamilia	*P. "black"*	Kalange-Makwanzi		P	P	P	P	P	P	P	P									
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe					P	P												
	P. "orange anal"	Kalange-Makwanzi		P																
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe																		
	P. igneopinnis	Kalange-Makwanzi										P								
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe																		
	P. macrocephala	Kalange-Makwanzi										P								
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe																		
	P. "orange tail"	Kalange-Makwanzi		P						P										
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe																		
	P. pundamilia	Kalange-Makwanzi										P								
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe																		
	P. "red tail"	Kalange-Makwanzi	P			P														
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe				P														
	Pundamilia sp	Kalange-Makwanzi		P																P
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe																		P
Xystichromis	*X. phytophagus*	Kalange-Makwanzi	P			P		P	P											
		Mid section of the Reservoir																		P
		Buyala-Kikubamutwe									P									
Unindentified	Haplochromines	Kalange-Makwanzi				P														
		Mid section of the Reservoir																		
		Buyala-Kikubamutwe																		
Total Number of Species		Kalange-Makwanzi	15	16	12	14	16	9	14	15	11	14	4	3	3	4	6	7	9	4
		Mid section of the Reservoir										4		2	3	5	1	2	5	5
		Buyala-Kikubamutwe	11	8	10	9	12	5	9	3	6	4	8	5	5	7	3	8	7	2
		Total									14	17	8	6	7	7				

3.2.3 Catch rates / biomass estimates

As a measure of standing biomass, catch rates i.e. catch per net per night was used to indicate relative abundance of fish species from the transects. To analyse for catch per net, gillnets were grouped into three size categories: small (1 to 2 ½ inches stretched mesh), medium (3 to 4 ½) and large (5 to 8 inches). Overall catch rates (by numbers were highest at the mid-reservoir (0.60 fish per net per night) and lowest at the downstream transect (0.12 fish per net per night) (Table 3.4.3). Similarly, by weight, catch rates were

highest at the reservoir (182.6g) and lowest at Buyala (2.55g) (Table 3.4.4). At Kalange, haplochromines recorded the highest catch rates by number (0.08 fish per net per night) and Nile perch with the highest catch rate by weight (30.2g). At Buyala-Kikubamutwe, haplochromines and Nile perch recorded the highest catch rate by number (0.17 fish per net per night) and weight (2.14g) respectively. At the reservoir, Nile perch recorded the highest rate by number (0.29 fish per net per night) and weight (85.8 g). The overall catch rates by numbers and weights reduced from those recorded in the previous survey for all the transects.

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*

Family name	entific Species n	English names/local names (Luganda)	Site	Monitoring dates																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
				Apr. 2006	Sep. 2007	Apr. 2008	Apr. 2009	Sep. 2009	Apr. 2010	Sep. 2010	Apr. 2011	Sep. 2011	Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016
Bagridae	*Bagrus docmak*	Catfish/(Semutundu)	Kalange-Makwanzi		0.03			0.08													
			Mid section of the Reservoir										0.03	0.1	0.38	0.4	0.1	0.01	0.15	0.2	0.01
			Buyala-Kikubamutwe		0.07		0.04								0.08	0.1					
Centropomidae	*Lates niloticus*	Nile perch/Mputa	Kalange-Makwanzi	0.19	3.1	3.32	2.3	9.76	0.32	0.58	1.1	0.15	2.83	0.5	1.62	0.7	0.1	0.14	0.32	0.26	0.04
			Mid section of the Reservoir										3.06	0.7	1.08	4.2	0.3	0.16	0.66	1	0.29
			Buyala-Kikubamutwe	1.12	1.68	1.86	2.29	2.57	0.35	0.4	0.2	0.72	0.83	0.2	0.85	1.5	0.6	0.13	0.32	0.08	0.06
Characidae	*Brycinus jacksonii*	(Nsoga)	Kalange-Makwanzi																		
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe	0.04																	
	B. sadleri	(Nsoga)	Kalange-Makwanzi	0.04																0.04	
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe																		
Cichlidae	*Oreochromis niloticus*	Nile tilapia/(Ngege - kibati)	Kalange-Makwanzi	0.04	0.33	0.1		0.2			0	0.01	0.02					0.01	0.01	0.03	
			Mid section of the Reservoir												0.08						
			Buyala-Kikubamutwe	0.07	0.41	0.04	0.04	0.1		0.1			0.19	0.04	0.38	0.2	0.3				
	O. leucostictus	Black tilapia/(Ngege)	Kalange-Makwanzi	0.04	0.09																
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe	0.06	0.08																
	O. variabilis	Tilapia/(Ngege)	Kalange-Makwanzi	0.17	0.91	0.43	0.45	1.52	0.06	0.17	0.2		0.09	0.04	0.31	0.2			0.04	0.06	
			Mid section of the Reservoir										0.03				0.01				
			Buyala-Kikubamutwe	0.13	0.08		0.17			0.02	0	0.03	0.03						0.09	0.03	
	Tilapia zillii	Red-belly tilapia/(Ngege)	Kalange-Makwanzi	0.1	0.17	0.17		0.17	0.04	0.1	0.1		0.09	0.09	0.13	0.1				0.06	
			Mid section of the 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	
	Haplochromines	(Nkejje)	Kalange-Makwanzi	9	10.5	6.63	19.04	15.5	5.83	4.5	13	10.6	11.1	0.4	11.8	2.5		2.54	2.75	2.04	0.08
			Mid section of the Reservoir										0.25		0.5	5.8		0.13	0.15	0.1	0.13
			Buyala-Kikubamutwe	16.8	4.27	6.36	8.32	6.47	0.78	1.62	2.1	1.36	6.13	2.3	13.8	47.2		0.79	13.74	0.44	0.17
Clariidae	*Clarias gariepinus*	Mudfish/ (Male)	Kalange-Makwanzi			0.03	0.17							0.01	0.08						
			Mid section of the Reservoir										0.02	0.03							
			Buyala-Kikubamutwe	0.01		0.25	0.07		0.03			0.02				0.1					
Cyprinidae	*Barbus altianalis*	Barbel fish/ (Kisinja)	Kalange-Makwanzi	0.02	0.1	0.17	0.03		0.01				0.02								
			Mid section of the 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				
	Barbus paludinosus	Barbel fish/ (Kisinja)	Kalange-Makwanzi																		
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe	0.04																	
	Labeo victorianus	(Ningu)	Kalange-Makwanzi																		
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe		0.09					0.02											
Lepidosirenidae	*Protopterus aethiopicus*	Lung fish (Mamba)	Kalange-Makwanzi						0.01												
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe				0.04														
Mochokidae	*Synodontis afrofischeri*	Tiger fish (Nkolongo)	Kalange-Makwanzi	0.21	0.63	0.08	0.42	1.46	0.46	0.33	0.1	0.38	4.75	1.8	53.8	79.5	1.5	4.42	0.58	1.08	0.04
			Mid section of the Reservoir										0.75		1.5	1.5			0.15		0.17
			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	
	S. victoriae	Tiger fish (Nkolongo)	Kalange-Makwanzi			0.08		0.21	0.29		0.2			0.1	3.25	1.3	0.1	0.16		0.08	
			Mid section of the Reservoir										0.05	0.04		1.8		0.08	0.05	0.8	
			Buyala-Kikubamutwe											0.1					0.04	0.06	
Mormyridae	*Gnathonemus longibarbis*	Kasulubana	Kalange-Makwanzi																		
			Mid section of the Reservoir											0.04			0.1		0.15		
			Buyala-Kikubamutwe																		
	Mormyrus kannume	Elephant snout fish (Kasulubana)	Kalange-Makwanzi	0.32	0.8	1.83	0.7	0.08	0.23	0.18	0.2	0.04	0.33	0.1	0.46	0.5	0.01	0.04	0.23	0.1	0.05
			Mid section of the Reservoir										0.82	0.9	1.46	2.7	0.3	0.23	0.48	0.6	0.21
			Buyala-Kikubamutwe	0.68	0.86	2.25	0.39	0.38	0.15	0.25	0.2	0.17	0.02	0.1	0.15				0.01	0.02	
OVERALL RATES			Kalange-Makwanzi	2.89	5.48	4.39	7.54	10	2.87	2.41	4.5	3.36	8.2	1.3	23.6	26.9	1.5	2.38	1.62	1.46	0.13
			Mid section of the Reservoir										4.4	1.8	4.2	10.2	0.9	2.11	1.45	1.98	0.6
			Buyala-Kikubamutwe	6.45	3.28	3.91	3.71	4.28	0.81	1.21	1	1.5	3.1	2.3	6.6	16.8	6.8	0.41	4.86	0.48	0.12

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

Family name	Scientific Species n	English names/local names (Luganda)	Site	Monitoring dates																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
				Apr. 2006	Sep. 2007	Apr. 2008	Apr. 2009	Sep. 2009	Apr. 2010	Sep. 2010	Apr. 2011	Sep. 2011	Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016
Bagridae	*Bagrus docmak*	Catfish/(Semutundu	Kalange-Makwanzi		37.53			28.58													
			Mid section of the Reservoir										14.1	27.7	834.6	135.6		0.51	32.5	73.6	11.38
			Buyala-Kikubamutwe		22.50		0.6.93								13.8	19.1	4				
Centropomi	*Lates niloticus*	Nile perch/Mputa	Kalange-Makwanzi	15.75	271.27	371.00	114.13	250.84	49.44	35.86	11.6	8.6	156.2	63.3	141.2	77.7	9.3	25.41	13.9	53.8	30.22
			Mid section of the Reservoir										197.6	139.8	532.3	537.6	17.8	42.8	104.4	81.4	85.82
			Buyala-Kikubamutwe	108.21	107.79	159.07	111.00	171.43	28.81	39.28	16.4	44.5	30.2	18	36.8	94.8	22.7	4.27	13.4	3.2	2.14
Characidae	*Brycinus jacksonii*	(Nsoga)	Kalange-Makwanzi																		
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe	3.25																	
	B. sadleri	(Nsoga)	Kalange-Makwanzi	0.75																0.58	
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe																		
Cichlidae	*Oreochromis niloticus*	Nile tilapia/(Ngege kibati)	Kalange-Makwanzi	1.80	7.42	28.93		20.08			0.5	6.7	1.2					9.68	0.05	2.24	
			Mid section of the Reservoir												9.2						
			Buyala-Kikubamutwe	4.53	0.18	3.93	0.93	5.05		0.83			5.8	1.7	204.6	7.4	29.9				
	O. leucostictus	Black tilapia/(Ngege)	Kalange-Makwanzi	3.67	6.61																
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe	5.75	6.75																
	O. variabilis	Tilapia/(Ngege)	Kalange-Makwanzi	33.54	49.04	63.30	44.73	82.76	14.87	19.54	26.1		18.4	8.7	122.3				1.02	18.1	
			Mid section of the Reservoir										1.7				5.4				
			Buyala-Kikubamutwe	11.58	12.08		8.17			4.04	11.5	13.6	8.1				20.3		9.2	15.5	
	Tilapia zillii	Red-belly tilapia/(Ngege)	Kalange-Makwanzi	6.92	15.65	21.65		7.92	7.71	32.17	21		10.1	2.8	18.8					3.6	
			Mid section of the Reservoir										7.2		21.3	10.5					
			Buyala-Kikubamutwe	81.85	19.08	7.33	42.26	7.90		2.71			6.1	2.1		32	38.9		1.3	1.3	
	Haplochromines	(Nkejje)	Kalange-Makwanzi	303.92	191.92	168.08	534.33	383.24	167.67	113.11	160	246	167.5	8.5	218.8	33.8	15.5	26.2	26.6	20.4	1.21
			Mid section of the Reservoir										4.1		22.5	112.5	112.5	2.92	4.05	2.6	0.13
			Buyala-Kikubamutwe	284.88	51.27	206.00	187.05	167.90	15.78	40.38	37.7	15.3	86.9	32.3	226.3	696.7	299.2	9.63	143.9	5.3	1.33
Clariidae	*Clarias gariepinus*	Mudfish/ (Male)	Kalange-Makwanzi			6.27	69.33							8.9	100						
			Mid section of the Reservoir										9.4	48.7							
			Buyala-Kikubamutwe	9.20		52.93	89.36		33.58			3.1				138.5					
Cyprinidae	*Barbus altianalis*	Barbel fish/ (Kisinja)	Kalange-Makwanzi	19.27	403.33	501.13	7.27		2.31				0.6								
			Mid section of the Reservoir										51.3	198.7	266.2						
			Buyala-Kikubamutwe	48.88	22.93	95.57	9.36		4.03	5.73		12.8	0.3		407.7		8.2				
	Barbus paludinosus	Barbel fish/ (Kisinja)	Kalange-Makwanzi																		
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe	0.50																	
	Labeo victorianus	(Ningu)	Kalange-Makwanzi																		
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe		38.91					14.80											
Lepidosiren	*Protopterus aethiopicus*	Lung fish (Mamba)	Kalange-Makwanzi						15.92												
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe				26.21														
Mochokida	*Synodontis afrofischeri*	Tiger fish (Nkolongo)	Kalange-Makwanzi	10.92	49.50	4.58	14.92	56.79	59.63	18.75	7.2	28.8	61.1	64.2	1542.5	2668	46.3	151	22.13	50.4	2.13
			Mid section of the Reservoir										15.6		62.5	61			8.75		8.25
			Buyala-Kikubamutwe		19.09	30.64	10.42	111.58	12.89	2.38		17.4	1.3	87.3	45	18	3.8	1.67	34.4	15.4	
	S. victoriae	Tiger fish (Nkolongo)	Kalange-Makwanzi			12.50		17.92	39.33		28.1			7.3	277.5	108.3	5.2	18.29		5.3	
			Mid section of the Reservoir										6.8	3.6		236		7.63	10.1	69.5	
			Buyala-Kikubamutwe											9.6					4.39	10.3	
Mormyridae	*Gnathonemus longibarbis*	Elephant snout fish (Kasulubana)	Kalange-Makwanzi																		
			Mid section of the Reservoir														8		9.15		
			Buyala-Kikubamutwe																		
	Mormyrus kannume	Elephant snout fish (Kasulubana)	Kalange-Makwanzi	110.16	250.47	511.47	95.75	14.72	49.01	77.49	39.7	7.5	44.5	27.7	113.8	57.6	9.5	16.9	15.5	61.9	5.18
			Mid section of the Reservoir										157.5	155.7	238.3	643.3	80.1	119	108	111.3	81.74
			Buyala-Kikubamutwe	217.37	89.54	175.64	185.00	51.62	9.22	33.36	15.6	15.9	1.3	7.8	208.5				25.2	2.66	
OVERALL RATES			Kalange-Makwanzi	242.00	473.90	635.87	299.47	296.77	212.59	185.74	141	102	290	131.5	1116.2	1076	55.3	112.1	86.3	155.1	36.42
			Mid section of the Reservoir										443	572.8	1919.8	1449	114.5	165.7	254.7	288.4	182.6
			Buyala-Kikubamutwe	502.77	137.22	257.05	241.69	170.83	82.81	104.11	49.9	102	73	68.6	954.8	499.3	199.5	8.16	100.2	25.9	2.55

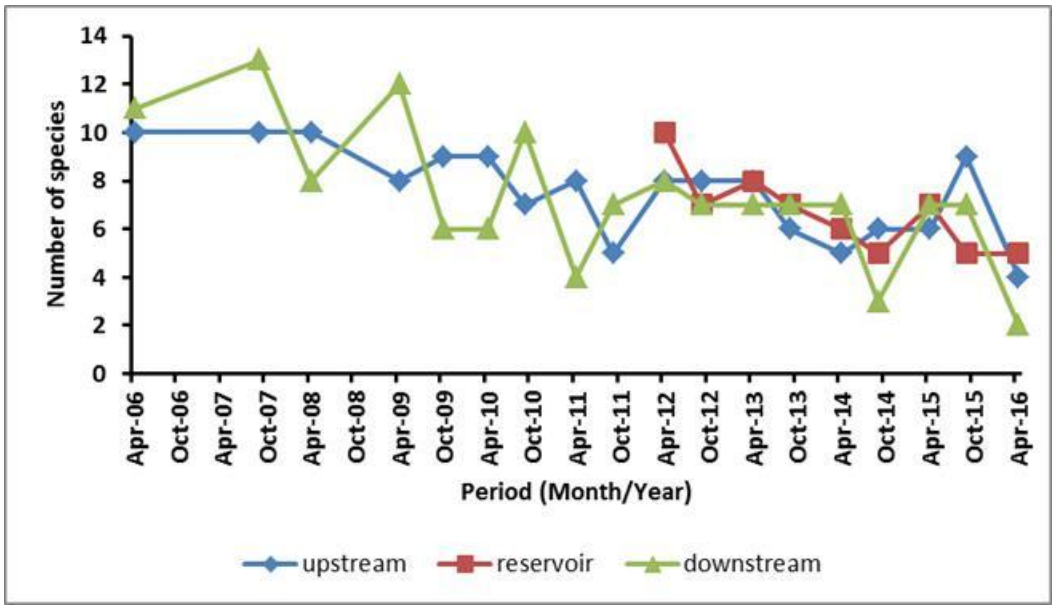

Figure 3.4.1 Cumulative *number of fish species recovered from the study transects on the Upper Victoria Nile over the sampling period.*

3.5 The Food and Trophic Ecology of the Fishes

In the survey of April 2016, *L. niloticus* was recorded from all the three transects. In Kalange-Makwanzi transect, the diet of the species comprised of fish (98.6%) and odonata nymphs (1.4%). The fish prey was dominated by *Lates* (55.7%) followed by haplochromine cichlids (28.6%) and *R. argentea* (14.3%). However, in the previous surveys of April and September 2015, *Caridina* was the dominant prey for Nile perch.

Fish (86.7%) and *Caridina* (33.3%) were the prey of Nile perch in the mid-reservoir area in the survey of April 2016. The fish prey comprised of *R. argentea* (53.3%) and unidentifiable fish material (13.4%). However, in the previous surveys of April and September 2015, *Caridina* was the dominant prey for Nile perch in the mid-reservoir.

At Buyala-kikubamutwe tansect, *R. argentea* was the only prey ingested by *L. niloticus* in April 2016 although in the previous surveys of September and April 2015 Nile perch from the same transect had ingested a variety of prey items dominated by haplochromine cichlids.

In April 2016, the elephant snout fish, *Mormyrus kannume* was only recorded from Kalange-Makwanzi and the mid-reservoir. At this transect, the diet of the species comprised of insect larvae (99.6%) and mollusk (0.4%). The insect prey included: chironomids (92.3%) and Ephemeroptera (7.3%). In the mid-reservoir, the diet of *M. kannume* was dominated by Ephemeroptera nymphs (67.1) followed by Odonata nymphs

(14.6%), *Caridina* (8.5%), chironomids (7.3%) and unidentifiable insect material. Dominance of insects in the diet of *M. kannume* in the two transects was also observed in the previous surveys of September and April 2015

In the survey of April 2016, *S. afrofischeri* was only recorded from two transects ie. Kalange-Makwanzi and the mid-reservoir. In Kalange-Makwanzi, the diet of the species comprised of chironomid larvae. Dominance of chironomids in the diet of *S. afrofischeri* in Kalange-Makwanzi was also observed in the previous survey of September 2015. In the mid-reservoir, the diet *S. afrofischeri was* dominated by Ephemeroptera nymphs (45.2%) followed by *R.argentea* (40.5%) and *Caridina* (14.3%).

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

Family name	Secientific Species name	English/local (Luganda) name	Site	Monitoring dates																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
				Apr. 2006	Sep. 2007	Apr. 2008	Apr. 2009	Sep. 2009	Apr. 2010	Sep. 2010	Apr. 2011	Sep. 2011	Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016
Bagridae	*Bagrus docmac*	Semutundu	Kalange-Makwanzi (upstream of the reservoir)										FR		E	E					
			Mid section of the Reservoir										SYN	CAR	SYN	CAR	FR	HAP	CAR	LN	RAS
			Buyala-Kikubamutwe (downstream)													FR					
Centropomidae	*Lates niloticus*	Nile perch/ (Mputa)	Kalange-Makwanzi (upstream of the reservoir)	FR	HAP	HAP	HAP	FR	HAP	HAP	HAP	HAP	HAP	ODT	LN	HAP	HAP	RAS	HAP	CAR	LK
			Mid section of the Reservoir										RAS	CAR	RAS	CAR	CAR	CAR	CAR	CAR	RAS
			Buyala-Kikubamutwe (downstream)	FR	CAR	FR	CAR	ODT	RAS	RAS	CHR	HAP	FR	CRB	HAP	HAP	HAP	RAS	HAP	HAP	RAS
Cichlidae	*Oreochromis niloticus*	Nile tilapia/ (Ngege-Kibati)	Kalange-Makwanzi (upstream of the reservoir)	E	HPM	BGA	HPM	E	E	DTR	IR	DETR	MOL				HPM	E	E	E	
			Mid section of the Reservoir												CHAO						
			Buyala-Kikubamutwe (downstream)	E				E	DTR	E	DETR		INS	EPH	EPH	HPM	BGA				
	O. variabilis	(Ngege)	Kalange-Makwanzi (upstream of the reservoir)	BGA	GRA	BGA	HPM	GRA	BGA	BGA	BGA	EPH	BGA	BGA	BGA	DETR	BGA		DETR	BGA	
			Mid section of the Reservoir														BGA				
			Buyala-Kikubamutwe (downstream)	BGA	E		HPM				E	E	BGA				BGA		E	DETR	
	Tilapia zillii	Red-belly tilapia /(Ngege)	Kalange-Makwanzi (upstream of the reservoir)	MOL	HPM	E		E	IR	HPM	IR		EPH	E	HPM		ODT			DETR	
			Mid section of the Reservoir										INS		E	E					
			Buyala-Kikubamutwe (downstream)	HPM	CAR	E	HPM	E	HPM	HPM			EPH	HPM		HPM	HPM		HPM	HPM	
Clariidae	*Clarias gariepinus*	Mudfish/(Male)	Kalange-Makwanzi (upstream of the reservoir)			FR	FR				EPH			E	MOL	MOL					
			Mid section of the Reservoir										EPH	EPH							
			Buyala-Kikubamutwe (downstream)			HAP	EPH		E			CHR				EPH					
Cyprinidae	*Barbus altianalis*	Barbelfish/(Kisinja)	Kalange-Makwanzi (upstream of the reservoir)	E	INS	INS	INS		MOL	E	IR	CHR	DETR								
			Mid section of the Reservoir										INS	MOL	MOL						
			Buyala-Kikubamutwe (downstream)	E	INS	INS			E	MOL		CHR			MOL		E				
Mochokidae	*Synodontis afrofischeri*	Tigerfish/(Nkolongo)	Kalange-Makwanzi (upstream of the reservoir)	CHR	EPH		CAR	CHR	EPH	CHR	EPH	INS	MOL	EPH	EPH	CHR	CHR	CHR	EPH	CHR	CHR
			Mid section of the Reservoir										INS		CHR	EPH			CHR		EPH
			Buyala-Kikubamutwe (downstream)		CHR	CHR	INS	CHR	INS	CHR		INS		EPH	INS	EPH	CHR	E	EPH	ODT	
Mormyridae	*Mormyrus kannume*	Elephant Snoutfish/(Kasulubana)	Kalange-Makwanzi (upstream of the reservoir)	INS	EPH	EPH	INS	EPH	EPH	EPH		CHR	EPH	CHR		EPH	CHR	EPH	CHR	EPH	CHR
			Mid section of the Reservoir										EPH	EPH		EPH	CHR	CHR	MOL	CHR	EPH
			Buyala-Kikubamutwe (downstream)	INS	EPH	INS	EPH	CHR	CHR	INS	EPH	INS	E	ODT					E	E	

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

In the survey of April 2016, signs of breeding were observed in all the four species examined (Table3.5.2). The highest breeding intensity (3 species) was recorded from the mid Reservoir, followed by Kalange-Makwanzi (2 species). All the fish species recorded from Buyala-kikubamutwe were immature. The species that indicated signs of breeding in the Reservoir included: *L. niloticus, M. kannume* and *S. afrofischeri*. At Kalange-Makwanzi, the species found breeding included: *M. kannume* and *S. afrofischeri*. Fish breeding intensity was lower in April 2016 compared to that recorded in the previous survey of September 2015.

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

Family name	Scientific Species name	English/local (Luganda) name	Site	Monitoring dates																
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
				Apr. 2006	Sep. 2007	Apr. 2008	Apr. 2009	Sep. 2009	Apr. 2010	Sep. 2010	Apr. 2011	Sep. 2012	Apr. 2012	Sept. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016
Bagridae	*Bagrus docmak*	Semutundu	Kalange-Makwanzi (upstream of the reservoir)												0						
			Mid section of the Reservoir										50	25	40	14.3			20	30	0
			Buyala-Kikubamutwe (downstream)												0						
Centropomidae	*Lates niloticus*	Nile perch/ (Mputa)	Kalange-Makwanzi (upstream of the reservoir)												0				4.3	5.6	0
			Mid section of the Reservoir										1		7.1			8.3	2.4	0	8
			Buyala-Kikubamutwe (downstream)												0					0	
Cichlidae	*Oreochromis niloticus*	Nile tilapia/ (Ngege-Kibati)	Kalange-Makwanzi (upstream of the reservoir)			71.4			50	54.5	38.5	70					6.7	100		0	
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe (downstream)												60		10.5				
	O. variabilis	(Ngege)	Kalange-Makwanzi (upstream of the reservoir)	12.5		22.2	55.2		50	38.1	46.3	50			14.3	45.5	46.2		0	33.3	
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe (downstream)									100					11.1			100	
	Tilapia zillii	Red-belly tilapia /(Ngege)	Kalange-Makwanzi (upstream of the reservoir)							83.3	42.9		33.3	33.3	0		57.1			0	
			Mid section of the Reservoir												0						
			Buyala-Kikubamutwe (downstream)	7.1	25	100										75	6.1			50	
Clariidae	*Clarias gariepinus*	Mudfish/(Male)	Kalange-Makwanzi (upstream of the reservoir)								100					50					
			Mid section of the Reservoir																		
			Buyala-Kikubamutwe (downstream)																		
Cyprinidae	*Barbus altianalis*	Barbelfish/(Kisinja)	Kalange-Makwanzi (upstream of the reservoir)	100	100	80	100		64.7		64.3	100									
			Mid section of the Reservoir										50	50							
			Buyala-Kikubamutwe (downstream)	12.5	100	100				100		100			50						
Mochokidae	*Synodontis afrofischeri*	Tigerfish/(Nkolongo)	Kalange-Makwanzi (upstream of the reservoir)	20	100		70	91.7	90	88.9	100	87.5	7.9	35.3	34	68	54.8	98.8	100	96.4	100
			Mid section of the Reservoir										6.7	12.5	16.7	25			33.3		25
			Buyala-Kikubamutwe (downstream)		75	36.4	50	100	100	100		100			70	100	16.7	100	100	87.5	
Mormyridae	*Mormyrus kannume*	Elephant Snoutfish/(Kasulubana)	Kalange-Makwanzi (upstream of the reservoir)	44.1	58.3	43.5	23.8	50	56.7	72.2	59.3	50	17.6	33.3	45.5	28.6	25		38.5	25	25
			Mid section of the Reservoir										25	44.2	42.1	44.4	61.9	88.9	25.8	18.9	56.3
			Buyala-Kikubamutwe (downstream)	37.5	41.7	27.1	54.5	33.3		33.3	18.8	20		33.3	100				100	100	

Major observations

In the survey of April 2016, fish dominated by juvenile Nile perch, was the major prey for *Lates niloticus* from Kalange-Makwanzi whereas in the mid-reservoir and in Buyala-Kikubamutwe, *R. argentea* was the main prey for the species. Dominance of fish in the diet of Nile perch Kalange-Makwanzi and Buyala-Kikubamutwe was also observed in the

previous survey of September 2015 although; the fish prey then was mainly haplochromine cichlids. However in the mid-reservoir, *Caridina* was the dominant prey for *L. niloticus* in the previous survey of September 2015. The change in the diet of Nile perch from dominance of Caridina in September 2015 to R. argentea in April 2016 in the mid-reservoir is attributed to seasonal variation in availability of the prey species. *Bagrus docmac* was only recorded from the mid-reservoir and its diet was dominated by *R. argentea* as opposed to Nile perch in September 2015 and *Caridina* in April 2015. The diets of *S. afrofischeri* and *M. kannume* were dominated by insect prey as in the previous survey of September 2015. However, some of the keystone fish species especially *Oreochromis niloticus* and *Oreochromis variabilis* were not recorded in the experimental gillnets in the survey of April 2016.

Breeding intensity of keystone fish species at all the Transects was lower (4 species as compared to six species recorded in September 2015 but similar to that recorded in the survey of April 2015 (4 species). This is attributed to the low number of fish species diversity recorded in the recent survey.

3.6. THE COMMERCIAL FISHERY

3.6.1 Fishing effort in the fishery

Fishing effort and catchability coefficients 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 because fishing is an important socio-economic activity for the riparian communities. Besides estimation of fishery yields, information that guides formulation of sustainable management advice alongside development projects such as dam construction is provided. For example, Tolmazin (1979) attributed reduced fish yields in the Black Sea and the Sea of Azov to impoundments on the Danube, Dnieper and Dniester rivers in Europe. 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.

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

Number of common gears in use	Transect	Monitoring dates																	
		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
Number of fishing boats	Kalange-Makwanzi	9	10	7	22	18	23	23	18	32	15	20	19	24	27	27	32	25	40
	Mid section of the Reservoir										16	13	18	27	44	60	38	51	46
	Buyala-Kikubamutwe	13	17	23	26	32	23	15	12	15	34	19	28	40	20	32	25	21	18
Number of boats using gillnets	Kalange-Makwanzi		9	7	10	6	7	13	6	8	9	9	7	12	15	9	6	10	3
	Mid section of the Reservoir										13	3	4	12	20	21	13	12	11
	Buyala-Kikubamutwe		7	18	7	6	1	2		1	4	2	7	3	1	10	1	4	7
Number of boats using long line hooks	Kalange-Makwanzi		1	2	3	1	2	2	0	2	1	4	6	5	8	5	3	4	3
	Mid section of the Reservoir										1	0	0	5		6	6	2	7
	Buyala-Kikubamutwe		10	8	6	6	13	6	3	7	10	7	0	5			6		4
Number of boats using cast nets	Kalange-Makwanzi					5	4	1	1	5	1	0	3	3	2	6	5	2	5
	Mid section of the Reservoir										0	0	0	2			2	7	3
	Buyala-Kikubamutwe			1	6	3	1	1	3	0	7	2	0	2			7		1
Number of boats using Hand line hooks	Kalange-Makwanzi			7	9	5	4	2	6	8	3	3	1	3	1	1	4		6
	Mid section of the Reservoir										1	7	3	0	16	23	9	14	9
	Buyala-Kikubamutwe			15	9	14	9	2	2	3	12	5	2	5	5	7	3	17	3
Number of boats using traps	Kalange-Makwanzi															5	7	7	7
	Mid section of the Reservoir																	1	6
	Buyala-Kikubamutwe														14	15	8		21
Number of boats using small seines	Kalange-Makwanzi															1	3	2	2
	Mid section of the Reservoir															2			
	Buyala-Kikubamutwe																		
Number of boats using scoop nets	Kalange-Makwanzi					1	6	4	4	4	1	2	3	2			4		
	Mid section of the Reservoir										6	3	12	8	8	8	8		
	Buyala-Kikubamutwe			2	1	1		1	2	1	1	0	0						

During the April 2016 survey, 46 boats were registered at the mid-reservoir transect and 18 boats at the downstream transect (Table 3.6.1a). Compared to previous four surveys between September 2014 and April 2016, the number of boats at the mid-reservoir and downstream transects has declined by 23% and 44% respectively. On the other hand, the number of fishing boats increased by 48% at the upstream transect over the same period. Comparing September 2015 and April 2016 surveys, the downstream and mid-reservoir recorded 14% and 10% decline in numbers of fishing boats respectively. A 60% increase was noted at the upstream over the same period. The least number of fishing boats (12) ever recorded have been at the downstream transect during April 2011 survey period. The fluctuation in the number of fishing boats at the three sites over the monitoring times reflects migratory trends of fishers to and between the sites. This observation thus supports the notion that the migratory pattern of fishers tend to coincide with fish migrations. The growing number of fishing boats at the mid-reservoir area could be attributed to the developing bait fishery of *Mormyrus kanume* and the high value fish catches of *Rastrineobola argentae*. The decrease in numbers of fishing boats at the downstream station could be attributed to the reduced fish catches or some fishers engage in alternative livelihood options particularly farming during this period when the rains are

heavy. It is therefore more likely that some fishers could have resorted to farming while others could have migrated to areas (Upstream and Mid-Reservoir) with relatively better catches.

Studies (Fry, 1965) in the Table Rock and Taneycomo dams on the White River (Missouri, USA) and Clearwater Dam on the Black River (Missouri, USA) showed that fisheries registered more fishing effort per unit area at the downstream sites (tail waters), a scenario that has been observed with the downstream site (Buyala-Kikubamutwe) in the recent past. On the other hand, dams can enhance riverine fisheries particularly with respect to tail waters (downstream) where fish tend to concentrate as a result of the attractive foraging opportunities there, as well as seasonal congregations of migratory fishes (Jackson, 1985).

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

Number of gill nets by mesh size	Transect	Monitoring dates																	
		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
Gillnets - ≤2½"	Kalange-Makwanzi		3			1			4		2	0	0	1	11	2	8	1	6
	Mid section of the Reservoir										0	0	0		8	3	9		3
	Buyala-Kikubamutwe			1		10		2			0	0	12			38		11	
Gillnets 3"	Kalange-Makwanzi					3	1	6			8	0	0	10	4	15	6		13
	Mid section of the Reservoir										0	4	0	16	5	39	35	9	12
	Buyala-Kikubamutwe			1	4			9			10	0	0	0	0	0	15		7
Gillnets 3½"	Kalange-Makwanzi		3			1	1	4		5	16	0	0	0	1	3	1	8	
	Mid section of the Reservoir										0	3	0	12	7	16	5		16
	Buyala-Kikubamutwe			25							3	11	3	0	0	0			
Gillnets 4"	Kalange-Makwanzi		30		21	8	2	26	20	20	10	0	0	18	35	17	1		
	Mid section of the Reservoir										0	0	0	5	98	16	1		
	Buyala-Kikubamutwe		20	4			1			13	0	0	0	0	10				
Gillnets 4½"	Kalange-Makwanzi			21	5			2	2	12	4	0	0	0	3				
	Mid section of the Reservoir										0	0	0	0	0	8	1		
	Buyala-Kikubamutwe		3	12		6	1				0	0	0	12					
Gillnets 5"	Kalange-Makwanzi		2	25	12	1					1	0	0	0	3				
	Mid section of the Reservoir										14	0	0	0	0	1			
	Buyala-Kikubamutwe		5	47						5	0	0	0	0	0	0			
Gillnets 5½"	Kalange-Makwanzi											0	0	0	0	0			
	Mid section of the Reservoir											0	0	0	0	0			
	Buyala-Kikubamutwe											0	0	0	0	0			
Gillnets 6"	Kalange-Makwanzi							4		8		2	2	8	0	0			
	Mid section of the Reservoir										22	0	0	0	0	0		32	
	Buyala-Kikubamutwe			5	18	15						0	9	0	0	0			
Total gillnets	Kalange-Makwanzi		38	46	38	20	24	42	28	43	41	2	8	37	57	37	16	18	25
	Mid section of the Reservoir										36	7	0	33	118	87	51	32	31
	Buyala-Kikubamutwe		28	99	22	37	4	11		18	13	11	24	12	10	38	15	11	7

During this survey period, the highest number of gillnets (31) was registered at the mid-reservoir transect, followed by the Upstream transect with 25 and Downstream stations with 7 gillnets (Table 3.6.1 b). A similar trend was observed in the previous survey-September 2015 but numbers declined by 36% and 3% at the Downstream and mid-reservoir sites and increased by 39% at the upstream site. The monofilament gillnets

constituted the largest component (97%) of the total gillnets with the remaining 3% multifilament nets encountered at the mid-reservoir (Table 3.6.1c). The general increase in monofilament gillnets at the study sites is possibly due to reductions in catch rates of *L. niloticus* and the tilapia species which previously were targeted passively using the multifilament gillnets. Fishermen tend to resort to active fishing methods whenever catch rates of the target species go down. Monofilament gillnets are usually operated actively in order to improve catch rates.

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

No of fishing gears per boat	Transect	Monitoring dates																	
		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
Long line hooks	Kalange-Makwanzi		300	330	550	200	650	280		500	70	800	687	860	1360	950	230	626	250
	Mid section of the Reservoir										50	0	0	70		580	378	200	140
	Buyala-Kikubamutwe		510	445	277	180	380	142	110	482	525	420	0				1100	420	56
Beach seines	Kalange-Makwanzi																		
	Mid section of the Reservoir																		
	Buyala-Kikubamutwe			1															
Cast nets	Kalange-Makwanzi					5	4	1	1	5	1	0		3	2	6	5	2	5
	Mid section of the Reservoir										0	0		2			2	7	3
	Buyala-Kikubamutwe			1	6	3	1	1	3		7	2		2			7		1
Hand line hooks	Kalange-Makwanzi			91	105	124	26	3	18	88	35	4		26	2	10	35		30
	Mid section of the Reservoir										6	14			69	276	65	218	50
	Buyala-Kikubamutwe			394	97	152	32	16	8	5	51	24	2					63	18
Scoop nets	Kalange-Makwanzi					1	6	4	4	4	1	2	3	5	5	39	4		
	Mid section of the Reservoir										6	3	12	8	8	8	8	15	10
	Buyala-Kikubamutwe			2	1	1		1	2	1	1	0	0	2					
Small seines	Kalange-Makwanzi															3	3	2	2
	Mid section of the Reservoir															2			
	Buyala-Kikubamutwe																		
Monofilament nets	Kalange-Makwanzi										0	29	15		38		16		25
	Mid section of the Reservoir										21	0	13	3	113	56	47	43	28
	Buyala-Kikubamutwe										0	0	0		4				7
Traps	Kalange-Makwanzi											0	0			43	48	1	124
	Mid section of the Reservoir											0	0					10	105
	Buyala-Kikubamutwe											56	151	461	460	190	97	55	39

Considering the number of fishing units recorded, the most common gears used at all sites included; longline hooks, basket traps, hand line hooks, monofilament nets and cast nets (Table 3.6.1c). Generally, long line hooks recorded the highest number of fishing units but when compared between September 2015 and April 2016 surveys, a decrease in the numbers of 87% at the downstream transect, 60% at the upstream and 30% at the mid-reservoir was recorded. Ten Scoop nets were recorded only at the mid-reservoir area while 2 small seine nets were recorded at the upstream site. The two gears are used to harvest *Rastrineobola argentae* (Mukene). Overall, the number of basket traps at all the three sites increased by a 306% between September 2015 and April 2016. The Upstream site which had only one basket trap during the September 2015 survey registered 124 units during the April 2016 survey while the mid-reservoir transect recorded 105 traps

from 10 in September 2015. The only decline (29%) was observed at the downstream transect (Table 3.6.1c).

Basket traps are mainly used to harvest the young *Mormyrus kannume*, marketed live for use as bait to target the large high value species e.g. *Lates niloticus* (Nile perch), *Clarias gariepinus* and *Protopterus aethiopicus* on Lakes Victoria and Kyoga. Fishers tend to target fish species with high demand and market value. The increasing demand for bait on the large lakes to target the high value large species will probably lead to an increase in the harvest of juvenile *M. kannume*. This unsustainable harvest if left to continue with no management and conservation measures to protect the species may result to the collapse of its fishery at the study sites.

The total number of cast nets at all the three study sites remained constant at 9 units for the periods between September 2015 and April 2016. Five cast nets were recorded at the upstream transect and one at the downstream transect. Increases were registered at the Upstream and a decline at the mid- reservoir transect. It is most likely that the cast net fishers at the mid-reservoir station migrated upstream during the current survey in search for high catches.

There was a general decline in the number of Hand line hooks recorded between September 2015 and April 2016 (Table 3.6.1 c). Major declines of 77% and 71% were recorded at the mid-reservoir and downstream transects. The upstream transect where no hand line hook was recorded in September 2015 registered 30 units in the current survey. It is most likely that the hand line hook fishers could have migrated from the other two transects to the upstream station, hence the observed declines. The overall decline in number of hooks however, could be attributed to general the reduction in species targeted by hand line hooks such as tilapia species.

The choice of fishing gear at a particular fishing ground is influenced by the target fish species, the cost of fishing gear, the catch per unit of effort (CPUE), the habitat and the suitability of the gear with respect to that particular site (Hovgêrd & Lassen, 2008). The fishing gears encountered at the three study sites during the April 2016 survey could therefore be an indicator of possible target fish species at those sites. Fishermen have a tendency to shift between fishing gears in response to seasonal variations in catches of the target species, thus, they can use a particular fishing gear when catches of the target species are high and can abandon it when catches go down. The noticeable increase in basket traps at the upstream and mid-reservoir transects, and their continued use at the downstream transect suggests three possible scenarios: (i) improved catch rates of *Mormyrus kannume*, (ii) increased demand for the species as bait and (iii) improved prices for the species. The high demand for bait to support exploitation of the high valued- large size *Lates niloticus*, *Protopterus aethiopicus* and *Clarias gariepinus* on Lakes Victoria and Kyoga as pointed out earlier is the most probable factor responsible for increased investment in the basket trap/ *Mormyrus kannume* fishery.

3.6.2. Fish catch composition and catch rates

Fish catch composition

Ten fish species belonging to six families were recorded at the three transects during the April 2016 survey compared to the 12 species in September 2015 (Table 3.6.2)**.** They included; *L. niloticus, Oreochromis niloticus, Oreochromis variabilis, Tilapia zillii, Bagrus docmak, M. kannume, Synodontis victoriae, Synodontis afrofischeri, R. argentea*, and haplochromine species taken as a single group. Like during the previous surveys, *Cichlidae* had the highest (four) number of species followed by *Mochocidae* (two). The other families encountered were represented by only a species. The black tilapia, *O. variabilis* was recorded only at the upstream transect which also had the highest number of species (10). At the downstream transect, 5 species were recorded. Fish species i.e. *L. niloticus, B. docmak, M. kannume, S. afrofischeri and T. zilli*, were recorded at all transects while *O. niloticus, S. afrofischeri, R. argentea* (Mukene), and haplochromine species were encountered at the upstream and mid-reservoir transects.

The number of fish species recorded in the commercial catch at all the three transects declined from 14 in April 2014 to 10 species in the current survey. Only six species (*B. docmak, L. niloticus, O. niloticus, O. variabilis, T. zilli and M. kanume*) have shown consistent appearance at the Upstream transect since April 2009 (Table 3.6.2). The lung fish, *Protopterus aethiopicus* has been recorded six times at this transect over the same period and since September 2013 it has been absent in the commercial catch. Since its disappeared from the commercial at the downstream transect in September 2011, *R. argentea* became a major fishery at the mid-reservoir and is occasionally encountered upstream.

The presence of more species consistently at the upstream transect (Kalange-Makwanzi) is an indicator of its ecological importance in supporting a high species diversity including those considered rare at the other two transects e.g. *Protopterus aethiopicus, B. altianalis and Oreochromis leucostictus*. Any negative post effects of the Bujagali hydropower project upstream would therefore not only alter the fish species diversity but also impact negatively on the riparian fisher communities whose livelihoods are either directly or indirectly derived from the diverse fish species.

Fish catch rates (kg/boat/day)

Comparing September 2015 survey withthe current one, a general decline in catch rates of the commercial fish species was noted in the study area (Table 3.6.2). *Mormyrus kannume* is the only fish species that registered increased catch rates at the mid-reservoir and upstream transects. The species registered the highest catch rate (9.1 kg/boat/day) at the downstream transect and the lowest (2.1 kg/boat/day) at the upstream transect (Table 3.6.2). The high CPUE of *M. kannume* at the downstream transect could be attributed the fewer boats and fishing units (Basket traps) targeting the species at the site (Table 3.6.1c). While some species registered increases in catch rates, others either remained

constant or recorded reductions. At the mid-reservoir, *R. argentae* and *S. victoriae* increased from 51 kg/boat/day to 73 kg/boat/day and from 0.3 kg/boat/day to 0.5kg/boat/day respectively while *L. niloticus* increased slightly from 2.7 kg/boat/day to 2.8 kg/boat/day upstream. The catch rates for haplochromine fishes at upstream and mid-reservoir, *S. afrofischeri* at downstream and *M. Kanume* at the mid-reservoir remained unchanged between September 2015 and April 2016. All other species encountered at the different transects recorded a decline in their catch rates.

Hydro-power dam projects have been reported to reduce fish species and population numbers (Agostinho, et al , 2008; Lin , 2011) because they 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). Dam barriers thus hinder migration of fish migration which may be in search of suitable breeding and feeding habitats, negatively affecting recruitment and growth and ultimately lead to changes in fish species composition, abundance and diversity. Species that are able to adapt the new habitat conditions will servive while others will reduce or even be eliminated thereby lowering the overall fish populations (Agostinho, et al., 2008). The persistent absence of the previously common species like *Protopterus aethiopicus, B. altianalis and Oreochromis leucostictus* and the general reduction in catch rates of most species at almost all the transects should be treated with caution from the conservation point of view. If such a trend continues in the subsequent monitoring surveys, corrective measures may be required to avert it.

Since the creation of the reservoir, there has been a continuous decline in species richness at mid-reservoir transect from 11 species in April 2012 to nine currently. This observation is similar to Agostinho et al. (2007) studies in which species richness increased during the initial stages of the reservoir establishment due to the mixture of local assemblages distributing over a range of fluvial environments that later flooded and homogenized. After establishment of the reservoir, environmental quality may deteriorate and fish begin to search for favourable environments nearby including the free flowing stretches to the upstream or shoreline areas. Agostinho et al. (2008) and Lin (2011) report that damming alters the physiography of river basins by creating distinctive zones i.e. the lentic or semi lentic (reservoirs) and riverine/lotic (Upstream and downstream) zones. This could be the possible explanation for the presence of more fish species at the upstream. The upstream transect had the highest number with 10 fish species recorded, 9 at the mid-reservoir and only 5 recorded downstream during the April 2016 survey. The decline in number of species downstream could also be attributed to the barrier created by the dam there by hindering fish migration from uptream to downstream.

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

Familiy	Species/taxa	Transect	Monitoring Period																
			Sep. 2007	Apr. 2008	Apr. 2009	Oct. 2009	Apr. 2010	Sep. 2010	Apr. 2011	Sep. 2011	Apr. 2012	Sep. 2012	Apr. 2013	Sep. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016
Bagridae	*Bagrus docmac*	Kalange-Makwanzi	0.05	0.21	0.4	0.27	0.08	0.15	0.09	0.5	0.53	0.9	0.46	0.8	1	0.7	0.2	1	0.9
		Mid section of the Reservoir									0.18	6	0.2	1.1	0.9	1.2	0.3	1.6	1.1
		Buyala-Kikubamutwe	0.39	0.1	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
Centropomidae	*Lates niloticus*	Kalange-Makwanzi	1.11	1.36	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
		Mid section of the Reservoir									0.43	3.5	0.81	1.9	2.5	2.6	1.6	2.5	1.6
		Buyala-Kikubamutwe	0.52	0.15	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
Characidae	*Brycinus jacksonii*	Kalange-Makwanzi																	
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe																	
	Brycinus sadleri	Kalange-Makwanzi																	
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe																	
Cichlidae	*Oreochromis niloticus*	Kalange-Makwanzi	1.5	1.03	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
		Mid section of the Reservoir									0.3	0.3	0	0.6	1.9	0.3	0.2	1.5	0.3
		Buyala-Kikubamutwe	0.18	0.64	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	Kalange-Makwanzi			0.01	0.13	0.01								0.2	0.01	0.1	0.2	
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe																	
	Oreochromis variabilis	Kalange-Makwanzi	1.25	1.43	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
		Mid section of the Reservoir									0.48	0.1	0		0.3	0.3		0.3	
		Buyala-Kikubamutwe				0.06	0.25	0.1	1.67										
	Tilapia zillii	Kalange-Makwanzi	0.88	0.9	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
		Mid section of the Reservoir									1.13	0.1		0.8	0.5	0.2	0.02	0.5	0.2
		Buyala-Kikubamutwe	0.06	0.38		0.01	0.15	0.04					0.02	0.5				0.6	0.2
	Haplochromines	Kalange-Makwanzi	0.22		0.02	0.04	0.01	0.01	0.01	0.15	0.03			0.1		0.02	0.01	0.1	0.1
		Mid section of the Reservoir									0.01				0.1			0.1	0.1
		Buyala-Kikubamutwe		0.1		0.01		0.02	0.1	0.01				0.6	0.2	0.04	0.2	0.8	
Clariidae	*Clarias gariepinus*	Kalange-Makwanzi	0.08	1.22	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 section of the Reservoir									1.35							3.1	
		Buyala-Kikubamutwe		0.83	0.18								0.03			0.3	0.1		
Cyprinidae	*Barbus altianalis*	Kalange-Makwanzi	2.88	6.72	3.98	5.11	2.27	2.87	1.66	0.28	6.05	0.1	0.24	1.2	9.8			9.8	
		Mid section of the Reservoir									0.95			0.5		0.7			
		Buyala-Kikubamutwe	2.72	0.35	1.17	0.54	2.1	1.58	1.13	2.98	1.4	1.5				9.4			
	Barbus paludinosus	Kalange-Makwanzi																	
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe																	
	Labeo victorianus	Kalange-Makwanzi																	
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe																	
	Rastrineobola argentea	Kalange-Makwanzi					11.4	2.96	34.5			43	43		24	21			5
		Mid section of the Reservoir									115	23.5	4.29		22		7.2	51	73.3
		Buyala-Kikubamutwe		1.92	5.3			3.05	50										
Cyprinodontidae	*Aplocheilichthys pumilus*	Kalange-Makwanzi																	
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe																	
Lepidosirenidae	*Protopterus aethiopicus*	Kalange-Makwanzi		0.19	0.06		0.05	0.48			0.05		0.05			12			
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe											0.04						
Mochochidae	*Synodontis victoriae*	Kalange-Makwanzi														0.3			0.2
		Mid section of the Reservoir														0.4		0.3	0.5
		Buyala-Kikubamutwe															0.2		
	Synodontis afrofischeri	Kalange-Makwanzi	0.04		0		0.02	0.01		0.01	0.2				0.3	0.4	0.4	0.7	0.3
		Mid section of the Reservoir									0.06			0.5	0.1	0.2		0.5	0.2
		Buyala-Kikubamutwe	0				0.01							0.1		1		0.4	0.4
Mormyridae	*Mormyrus kannume*	Kalange-Makwanzi	2.21	6.77	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
		Mid section of the Reservoir									1	4.7	0.96	3.4	3.3	4.8	0.4	2.7	2.7
		Buyala-Kikubamutwe	0.28	0.31	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

3.63. Estimates of total fish catches

The period between September 2015 and April 2016 registered a general increase in the total monthly catch across all the study transects, the highest increase (203%) being at the downstream transect and the lowest (3%) at the mid-reservoir (Table 3.6.3). Variations in the total monthly catches of individual fish species at the transects were also observed in the study area. *Lates niloticus* increased at the upstream from 1.25t to 6.90 t and from 2.47 t to 3.50 t at mid-reservoir sites but declined from 1.07 t to 0.06 t at the downstream; *B. docmak* only increased at the upstream site from 0.34 t to 1.49 t but declined from 1.72 t to 1.01 t at the mid-reservoir and from 0.74 t to 0.16 t at downstream transects. Noticeable increases were also recorded for *Tilapia zilli, Haplochromines and Synodontis Victoriae* at the upstream and mid-reservoir transects. *Tilapia zilli* registered declines in catches at the downstream transect form 0.15 t to 0.09 t. No catches for Haplochromines and *Synodontis Victoriae* were recorded at the transect. *Mormyrus kannume* was the only species whose monthly catches recorded increases at all transects between September 2015 and April 2016. The 8.8 t of *M. kannume* recorded at the downstream site is the highest recorded monthly catch of a single species since the onset of aquatic ecological monitoring surveys in the study area. In the current survey, no catches were recorded for *B. altinalis, C. gariepinus, O. leucostictus* and *P aethiopicus* at all transects.

Fishery yields have been found to increase with increase in fishing inputs up to a point of maximum sustainable yield (MSY) beyond which further increase in fishing inputs results into diminishing returns. Similar studies on effects of fishing effort on fish stock biomass (Jennings & Polinin, 1996) have shown that biomass decreases with increase in fishing intensity. The interactions between fishing effort and catch per unit effort show that high fishing effort leads to a slight increase in CPUE, while high CPUE attracts additional fishing effort, which in the long term leads to reductions in CPUE. 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).

In this study, the continual increase in numbers of traps targeting *M. kannume* for bait greatly is responsible for its increased total monthly catch at all transects in the study area. The long term sustainability of this fishery however, should be a major concern for the fisheries conservationists, managers and researchers given that traps target and harvest mainly the live juvenile mormyrids for bait which have tended to attract more demand and fetch higher market prices. Although live fish fetch high prices in a short term, harvesting juveniles leads to heavy ecological losses 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 bait away (Lakes Victoria and Kyoga) from the study area deprives the riparian communities of the rich fish protein hence may lead to prevalence of malnutrition among the fisher communities.

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

Family	Species/Taxa	Transect	Monitoring dates															
			Sep.2007	Apr. 2008	Apr. 2009	Oct. 2009	Apr 2010	Sept. 2010	Apr. 2011	Sept. 2011	Apr. 2012	Sept. 2012	Apr. 2013	Sept. 2013	Apr. 2014	Sep. 2014	Apr. 2015	Sep. 2015	Apr. 2016
Bagridae	*Bagrus docmac*	Kalange-Makwanzi	11.3	33.1	182.5	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	1,448.3
		Mid section of the Reservoir									68.4	481.5	74.5	187.1	1,133.4	2,068.4	283.8	1,724.0	1,041.8
		Buyala-Kikubamutwe	198.3	67.6	24.4	191.6	109.9	25.8	195.3	73.5	396.7	128.6	397.0	360.8		7,200.0	116.9	741.0	1,014.8
Centropomidae	*Lates niloticus*	Kalange-Makwanzi	232.6	212.4	361.5	532.2	422.1	303.1	193.1	78.3	473.6	870.7	948.7	3,940.2	1,950.1	4,418.1	375.6	1,252.0	6,865.8
		Mid section of the Reservoir									163.1	248.7	305.7	347.1	3,183.1	4,689.0	1,536.3	2,470.0	3,502.1
		Buyala-Kikubamutwe	263.5	89.2	741.2	707.8	840.6	163.5	463.5	1612.5	592.7	117.1	449.6	452.3	1,200.0		151.9	1,074.0	63.0
Characidae	*Brycinus jacksonii*	Kalange-Makwanzi					-	-											
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe					-	-											
	Brycinus sadleri	Kalange-Makwanzi					-	-											
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe					-	-											
Cichlidae	*Oreochromis niloticus*	Kalange-Makwanzi	315	162.1	395.6	705.7	765.1	39.9	179	7.5	14.6			96.6	950.0	842.4	376.3	1,318.0	875.6
		Mid section of the Reservoir									112.8	25.5	0.0	102.3	2,392.8	453.6	177.2	70.9	220.5
		Buyala-Kikubamutwe	93.5	378.5	696.7	124.4	-	60.2	197	907.8	70	10.3	161.6	1,069.2	120.0		888.3	24.0	
	Oreochromis leucostictus	Kalange-Makwanzi			3.5	32.4	6.6	-							153.0	90.3	8.5		
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe			-		-	-											
	Oreochromis variabilis	Kalange-Makwanzi	261.7	224.1	665.3	221.8	679.4	271.2	623.6	434.9	172.6	352.0	380.4	273.2	1,515.7	1,278.6	227.7	392.0	912.0
		Mid section of the Reservoir									184.2	8.0			314.8	468.0	12.3		
		Buyala-Kikubamutwe			-	52.3	161.7	43	53.9										
	Tilapia zillii	Kalange-Makwanzi	185.8	140.6	107.4	261.5	138.5	87.7	88.9	87.7	103.5	96.2	62.4	146.9	803.8	240.7	15.7	174.0	298.7
		Mid section of the Reservoir									429.5	6.4	0.0	13.9	650.7	288.0	22.7		140.0
		Buyala-Kikubamutwe	28.3	227.1	-	5	97	17.2	52.9	2.1			16.8	13.9					
	Haplochromines	Kalange-Makwanzi	46.8		7.9	9.8	6.6	4	4.68	108.3	6.7		0.2	7.9		15.0	4.6	32.0	215.1
		Mid section of the Reservoir									3.5				88.2				84.0
		Buyala-Kikubamutwe		62.2	-	7.5	-	8.6	24.5	3				166.3	93.0	27.0	131.5	120.0	
Clariidae	*Clarias gariepinus*	Kalange-Makwanzi	17.8	191.5	80.9	17	-	16			467	109.2	102.8	554.4	2,870.6	1,147.0	85.1	210.0	
		Mid section of the Reservoir									515.5							1,098.0	
		Buyala-Kikubamutwe		538.1	135.5		-	-		159	-	-	23.9			270.0	52.6		
Cyprinidae	*Barbus altianalis*	Kalange-Makwanzi	605.8	1,053.10	1,837.60	1,282.50	1,497.20	1,144.50	436.4	200.6	1,597.80	30.0	141.7						
		Mid section of the Reservoir									362.7			190.1	7,501.8				
		Buyala-Kikubamutwe	1388.3	210.9	863.2	482.8	1,357.90	679.7	266.6	1341	515.5	209.4		89.1		1,200.0			
	Barbus paludinosus	Kalange-Makwanzi					-	-								8,460.0			
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe					-	-											
	Labeo victorianus	Kalange-Makwanzi					-	-											
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe					-	-											
	Rastrineobola argentea	Kalange-Makwanzi		1,243.80	-		6,463.80	2,109.50	2,152.80			1,105.7			18,371.9	15,795.0			428.6
		Mid section of the Reservoir									13,128	1,480.5	1,627.6		27,706.5		7,057.1	23,000.0	22,000.0
		Buyala-Kikubamutwe			2,873.70		-	980.4	1,960.00										
Cyprinodontidae	*Aplocheilichthys pumilus*	Kalange-Makwanzi					-	-											
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe					-	-								9,025.7			
Lepidosirenidae	*Protopterus aethiopicus*	Kalange-Makwanzi		30.5	25.4		33	191.4			12		26.4						
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe			-		-	-											
Mochochidae	*Synodontis victoriea*	Kalange-Makwanzi																	
		Mid section of the Reservoir													251.9	729	7.9	108.9	441
		Buyala-Kikubamutwe												26.4					
Mochochidae	*Synodontis afrofischeri*	Kalange-Makwanzi	8.1		1.8		13.2	4		10.4	52.8		31.9		229.6	305.9	409.0	426.1	245.4
		Mid section of the Reservoir									22.9			89.1	125.9	324.0		124.9	154.0
		Buyala-Kikubamutwe	0.6		-		6.5	-						13.2	300.0	900.0		158.5	292.5
Mormyridae	*Mormyrus kannume*	Kalange-Makwanzi	463.6	1,060.10	1,352.50	106.9	1,213.60	809.5	389.6	500.1	1,444.10	357.6	783.2	214.1	562.6	1,753.3	1,986.0	831.7	2,733.3
		Mid section of the Reservoir									381.8	374.7	365.5	605.2	4,156.0	8,568.0			
		Buyala-Kikubamutwe	141.7	183.9	170.3	169.2	252.2	25.8	57.8	276		842.1	3,248.0	1,135.2	1,900.0	3,465.0	1,607.1	834.8	8,821.9
TOTAL		Kalange-Makwanzi	2148.5	3,107.40	5,021.80	3,238.30	11,291.90	5,040.40	4,097.30	2842	4,484.50	3,308.1	3,141.0	2,066.0	36,626.2	35,651.7	3,383.8	4,940.9	14,166.8
		Mid section of the Reservoir									15,417.20	2,625.2	2,400.4	1,559.0	40,633.1	21,245.0	9,507.9	30,008.9	30,839.4
		Buyala-Kikubamutwe	2114.2	3,001.30	5,505.00	1,740.70	2,825.80	2,004.20	3,247.00	3315.6	1,647.30	1,309.3	4,468.7	6,850.0	3,613.0	20,322.0	3,830.0	3,110.9	9,427.5

3.6.4. Estimates of total beach value of the catch

The April 2016 survey indicated a considerable increase in the beach revenue generated from the commercial catch landed at the study sites compared to the September 2015 survey (Table 3.6.4). Beach revenue of 167.4 million Uganda shillings was registered representing a 101% increment from the 54.4 t of fish landed in the commercial fishery at the three study sites (Table 3.6.4). The highest increase in beach revenue from catches was at the upstream site (284%) from 4.2 m in September 2015 to 48.3 m in April 2016, followed by the downstream transect (123%) from 22.2 m to 49.5 m and a slight increase (17%) at the mid-reservoir from 43.9 m to 51.4 m. *Mormyrus kannume, L. niloticus* and *R. argentae* contributed the highest value of the total beach revenue from the landed commercial fish catch. The high revenue recorded at the upstream transect (66.3 m) can be attributed to the high catches of *L. niloticus* (6.9 t) and its high value per unit kilogram in addition to the booming bait fishery of *M. kannume.* Compared to the adult *Mormyrus kannume* sold for direct human consumption, the juveniles used for bait fetch more market prices per kilogram. The high values of beach revenue from the commercial fish species in the study area highlights their contribution to supporting livelihoods of the riparian communities particularly the women who are involved in the downstream fishing activities like processing and marketing. Deliberate efforts need to be put in place 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. *Trend of monthly gross value of fish catches (shs) at monitored sites*

Family	Species/Taxa	Transect	Monitoring dates																
			Sep. 2007	Apr. 2008	Apr. 2009	Oct. 2009	Apr. 2010	Sep.2010	Apr.2011	Sep.2011	Apr.2012	Sep.2012	Apr.2013	Sep.2013	Apr.2014	Sep.2014	Apr.2015	Sep.2015	Apr.2016
Bagridae	*Bagrus docmac*	Kalange-Makwanzi	10,313	74,417	912,450	136,800	158,400	104,676	101,790	1,065,257	462,400	1,365,321	802,998	349,184	2,548,060	57,600,000	193,000	1,055,000	5,122,000
		Mid section of the Reservoir									226,200	1,564,791	230,418	966,735	2,455,806	8,029,000	248,000	5,251,000	3,653,000
		Buyala-Kikubamutwe	180,880	152,093	97,541	431,200	109,900	45,173	585,942	661,500	1,312,000	450,000	1,488,853	1,443,200		983,000	27,000	7,406,000	494,000
Centropomidae	*Lates niloticus*	Kalange-Makwanzi	66,602	336,182	644,702	997,785	759,780	549,553	868,725	274,040	1,299,000	3,294,523	2,189,276	1,771,868	9,165,457	16,568,000	369,000	6,053,000	34,166,000
		Mid section of the Reservoir									447,400	746,126	1,089,138	1,239,445	12,398,184	23,575,000	3,929,000	10,957,000	14,592,000
		Buyala-Kikubamutwe	415,276	141,247	2,223,704	1,887,573	1,821,328	296,450	1,100,908	12,255,000	1,625,400	385,714	2,248,492	15,760,800	8,400,000		69,000	9,559,000	410,000
Characidae	*Brycinus jacksonii*	Kalange-Makwanzi																	
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe																	
	Brycinus sadleri	Kalange-Makwanzi																	
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe																	
Cichlidae	*Oreochromis niloticus*	Kalange-Makwanzi	374,535	240,015	553,823	776,226	1,530,200	83,741	179,010	2,269.43	33,200			117,144	3,606,416	3,791,000	168,000	5,534,000	2,773,000
		Mid section of the Reservoir									256,300	76,526		307,395	7,178,510	1,524,000	106,000	213,000	551,000
		Buyala-Kikubamutwe	111,172	560,620	1,045,083	186,667		126,485	196,980	18,750	159,000	30,857	323,208	2,138,400	360,000		808,000	56,000	
	Oreochromis leucostictus	Kalange-Makwanzi			5,198	32,376	13,200								535,846	181,000	1,000		
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe			-														
	Oreochromis variabilis	Kalange-Makwanzi	245,206	378,091	964,656	277,305	1,358,800	650,786	623,610	1,159,794	376,400	1,048,522	1,024,216	724,086	6,365,852	4,560,000	153,000	1,735,000	1,824,000
		Mid section of the Reservoir									402,000	23,914			787,117	1,544,000	2,000		
		Buyala-Kikubamutwe		-	-	78,400	161,700	103,253	53,900										
	Tilapia zillii	Kalange-Makwanzi	170,908	161,368	161,123	167370	277,000	175,457	88,920	175,314	241,000	265,586	149,851	365,310	2,712,721	409,000	4,000	558,000	597,000
		Mid section of the Reservoir									1,000,000	19,131		277,992	1,626,709	950,000	5,000		233,000
		Buyala-Kikubamutwe	26,067	260,740	-	7,467	97,000	34,418	52,920	4,200				278,080				67,611,300	171,000
	Haplochromines	Kalange-Makwanzi	46,846	-	2,356	4,902	3,300	2,991	3,744	54,154				3,960					215,000
		Mid section of the Reservoir													44,079				84,000
		Buyala-Kikubamutwe		62,189	-			6,453	19,600	1,500					46,500	11,000	60,000	60,000	
Clariidae	*Clarias gariepinus*	Kalange-Makwanzi	17,769	284,350	86,240	17,100		31,901		635,886	1,131,500	327,600	256,865	2,772,000	8,611,813	4,588,000	15,000	560,000	
		Mid section of the Reservoir									1,248,900							3,844,000	
		Buyala-Kikubamutwe		799,034	270,947			-								1,350,000	17,000		
Cyprinidae	*Barbus altianalis*	Kalange-Makwanzi	674,221	1,660,815	3,215,809	1,923,750	2,245,800	1,823,982	872,820	501,429	4,411,000	75,056	481,904	855,360	22,505,538				
		Mid section of the Reservoir									1,001,000	633,000		267,300		3,600,000			
		Buyala-Kikubamutwe	1,545,215	332,592	1,366,671	801,522	2,580,010	1,083,347	799,680	6,705,000	1,623,300					38,070,000			
	Barbus paludinosus	Kalange-Makwanzi																	
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe																	
	Labeo victorianus	Kalange-Makwanzi																	
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe																	
	Rastrineobola argentea	Kalange-Makwanzi		-	-		2,352,823	894,417	1,722,240			514,286			12,247,912	15,043,000			171,000
		Mid section of the Reservoir									2,863,600	945,000	813,815		18,891,000		834,000	21,956,000	22,000,000
		Buyala-Kikubamutwe		216,418	1,436,842			415,671	1,568,000										
Cyprinodontida	*Aplocheilichthys pumilus*	Kalange-Makwanzi														27,077,000			
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe																	
Lepidosirenidae	*Protopterus aethiopicus*	Kalange-Makwanzi		15,231	38,115		23,100	350,914			36,000		52,690						
		Mid section of the Reservoir																	
		Buyala-Kikubamutwe		-	-			-					63,844						
	Synodontis victoriae														440,786	1,750,000	2,000	218,000	441,000
																	11,000		
	Synodontis afrofischeri	Kalange-Makwanzi	1,615	-	554		9,900	1,994		10,400	52,000	4,992			344,473	336,000	191,000	481,000	245,000
		Mid section of the Reservoir									22,900				251,878	567,000		219,000	159,000
		Buyala-Kikubamutwe	113	-	-		-	-							600,000	90,000		206,000	146,000
Mormyridae	*Mormyrus kannume*	Kalange-Makwanzi	328,240	977,422	1,327,914	89,110	1,743,943	1,160,277	389,610	450,082	1,959,800	572,083	1,391,402	415,900	1,153,409	7,013,000	11,207,000	1,291,000	21,121,000
		Mid section of the Reservoir									518,000	374,657	749,354	1,149,000	5,699,629	17,933,000	174,000	1,201,000	9,723,000
		Buyala-Kikubamutwe	100,300	169,522	170,310	338,488	201,760	36,999	14.4	331,200		2,105,357	24,360,327	11,352,000	9,658,333	15,593,000	5,260,000	4,202,000	48,288,000
TOTAL		Kalange-Makwanzi	2,236,254	4,127,892	7,912,939	4,422,724	10,476,246	5,830,689	4,850,469	6,595,785	10,003,000	7,467,968	7,162,475	7,434,812	69,797,498	80,935,000	12,649,000	17,267,000	66,378,000
		Mid section of the Reservoir									7,987,000	3,750,146	2,882,725	4,208,684	49,064,515	59,533,000	5,300,000	43,858,000	51,437,000
		Buyala-Kikubamutwe	2,379,023	2,694,454	6,611,098	3,731,317	4,971,698	2,148,249	4,377,944	19,977,150	4,720,000	3,604,929	28,484,724	46,733,280	19,064,833	112,713,000	6,251,000	22,164,000	49,509,000

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.*

Species/Taxa	Monitring Dates																	
	Apr-06	Sep-07	Apr-08	Apr-09	Oct-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
Lates niloticus	900	1576	1583	2188	2423	2000	1813	3286	6429	2750	2785	3063	3830	4363	4571	5198	4945	4689
Oreochromis niloticus	750	1189	1481	1409	1189	2000	2100	1000	2500	2300	3000	2250	2278	3429	3686	3286	3526	2900
Barbus altianalis	800	1113	1577	1666	2250	1722	1594	2250	4000	2760	3370	3400	3750	3000	3375	3000		
Mormyrus kannume	786	708	922	983	1416	1310	1433	667	986	1400	1825	3886	4600	2635	3444	2709	2877	5787
Oreochromis variabilis	550	937	1687	1450	1357	1929	2400	1000	2667	2200	2860	2692	2650	4045	3500	3350	4300	2000
Bagras docmak													3950	3028	3780	2813	3542	3540
Clarias gariepinus													5000	3000	4333	3000	2875	

3.6.5 Estimated total catches and revenue of individual fishing units

Compared to the September 2015 survey, there was an overall increase in both the total monthly catch and beach revenue from catch in April, 2016 (Tables 3.6.5 and 3.6.6). Mid-reservoir registered 30.8 t, which was the highest mean monthly catches, upstream transect recorded 14.2 t and the downstream one 9.4 t. Beach revenue of 66.4 million UGX was realised at the upstream transect, representing a 284% increase in the value between September 2015 and April 2016. Mid-reservoir and downstream transects similarly registered increases in the mean monthly catches and beach revenue from catch (Table 3.6.6). Although the mid-reservoir registered the highest monthly catch, the beach value generated from the catch was lower compared to that at the upstream and downstream transects (Table 3.6.3 & 3.6.4). The increase in beach values of catch at the upstream and downstream transects are attributed to the booming and highly prized bait fishery. Thus, incentives for most fishers to invest in traps for bait harvesting grew up. High fish catches are good for the riparian communities due to the associated economic benefits (beach revenues). This calls for 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*

Parameter rate	Site	Monitoring Dates																
		Sep-07	Apr-08	Apr-09	Oct-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
Total catch (Kg/boat/month)	Kalange-Makwanzi	215	444	228	180	418	219	467	89	47	144	158	103	1,356	1,320	3,384	4,941	14,167
	Mid section of the Reservoir									307	389	150	79	924	354	9,508	30,009	30.839.4
	Buyala-Kikubamutwe	124	130	212	55	123	134	329	221	275	66	154	343	181	677	3,830	3,111	9,428
Total revenue (Shs/boat/month)	Kalange-Makwanzi	223,625	589,698	359,679	245,707	388,009	253,508	298,445	206,118	188,500	418,986	7,162,475	7,434,812	2,585,093	2,997,586	12,649,000	17,267,000	66,378,000
	Mid section of the Reservoir									1,227,000	883,296	2,882,725	4,208,684	1,131,216	992,209	5,300,000	43,858,000	51,437,000
	Buyala-Kikubamutwe	139,943	117,150	254,273	116,604	216,161	143,217	410,225	1,331,810	1,098,000	187,657	28,484,724	46,733,280	953,242	3,757,110	62,251,000	22,164,000	49,509,000

3.6.6 Socio-economic aspects of the fishery

Non-commercial uses of fish

The fish consumption culture by fishers improved slightly at the downstream (0.3 kg/boat/day) and mid-reservoir (0.9 kg/boat/day) transects during the April 2016 survey (Table 3.6.7). The quantity of fish retained at the two stations can be attributed to the improved monthly catch landings during the survey (Table 3.6.3). There was no fish retained at the upstream station despite the relatively high catches from the station. The retention of relatively small proportions of catch for domestic consumption at the mid-reservoir and downstream and none at the upstream sites is linked to large quantities of juvenile *M. kannume* sold live as bait for exploitation of other species on Lakes Victoria and Kyoga. Besides, fishers prioritize income over nutrition. Some quantities of Mukene were landed at the mid-reservoir and upstream transects. However, the species is regarded as food for animals and the lower class of people hence less preferred for human consumption. It is also difficult to quantify amounts retained for human consumption when it is fresh. Absence of fish for domestic consumption at the upstream transect exposes the riparian communities, especially the children to risks of malnutrition given that fish is the source of animal protein. There is need to improve the post-harvest handling and value addition besides sensitizing fisher communities about the nutritive values of Mukene to promote its consumption.

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

Sites	Monitoring dates																
	Sep-07	Apr-08	Apr-09	Oct-09	Apr-10	Sep-10	Apr-11	Sep-10	Apr-12	Sep-12	Apr-13	Sep-13	Apr-14	Sep-14	Apr-15	Sep-15	Apr-16
Kalange-Makwanzi	0.3 (2.9%)	1.1 (5.5%)	0.4 (3.7%)	3.5 (27.1%)	2.2 (11.8%)	1.5 (16.8%)	1.4 (30.7%)	2.1 (60.0%)	1.2 (12.8%)	1.2 (20.4%)	0.1 (2.58%)		1.3 (2.72%)		0.5 (9.2%)	1.3 (1.8%)	
Mid section of the Reservoir									1.5 (50 %)		0.1 (1.1%)	5.4 (3.3 %)	0.5 (1.55 %)	1.4 (6 %)	0.1 (0.65)	0.5 (0.8%)	0.9 (0.3%)
Buyala-Kikubamutwe	0.7 (16.9%)	0.1 (2.1%)	0 (0%)	1.4 (71.8%)	1.3 (29.7%)	0.8 (16.5%)	1.2 (23.8 %)	3.0 (45.8%)	0.8 (14.4%)		0.2 (3.2%)				0.1 (3%)		0.3 (0.2%)

Fishery related jobs

The current survey recorded 218 people employed by the fisheries sector (i.e. fishing and other related activities) in the study area representing a 32% increase since September 2015 (Table 3.6.8). Fishing was the most prominent job engaging 125 people (57.3%) who predominantly male. In previous surveys between September 2013 and September 2015, some women were featured as fishers mainly at the upstream transect but during the April 2016 survey, no women fishers were registered. Fifty two fishers were recorded at the upstream transect, 37 at mid-reservoir transect and 21 at the downstream transect. There was a 30% increase in the number of fishers at all transects in the study area (Table 3.6.8). Besides fishing, fish trade was another fishery related activity that employed a high number of people in the study area, engaging 33 people dominated by women (82%) with the highest number registered at the mid-reservoir. There were 19 fish traders at mid-reservoir, 11 at the upstream and 3 at the downstream area. The dominance of women in fish trade business shows that riverine fisheries can economically empower women.

In other job descriptions, food vending employed six people (5 women and 1 man) all situated at the upstream transect (Table 3.6.8). Five people were involved in boat building and repairs compared to the six recorded in September 2015. As observed in the previous six monitoring surveys, there was no boat repairer at the downstream transect and the relatively old canoes were still in use. Absence of boat builders/repairers and the continued use of old leaking canoes by fishers at the downstream transect puts their safety on water at risk and this could also be an indication of low returns from fishing.

In terms of BMU membership, there was a fairly good proportion of women (44%) representation on the executive committee but only at the upstream transect. The mid-reservoir and downstream transects registered no women involvement in the BMU committee. This could be an indication of a reduction in fish supply especially the major commercial species of *L. niloticus* and *O. niloticus* since women are involved in post-harvest-handling and marketing hence are most likely to be active in areas where they trade species in large supply. The general increase in the number of fishers at all the three transects could be attributed to the growing bait fishery of *M. kannume* claiming high economic returns to the fishers. In general, any economic activity with high returns attracts more investment; therefore, fishing as an economic activity causes fishers to respond to both high catches and economic returns by investing in gears that harvest the target species with the highest economic returns. This causes other community members to join the fishery thus accounting for the increase in the number for fishers across all transects given the open access nature of the fishery. This should be a point of concern given that increased fishing effort exerts more pressure on the target species that in turn compromises sustainability of their fisheries.

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

Job description	Transect	Sex	Monitoring Dates																	
			Apr-06	Sep-07	Apr-08	Apr-09	Oct. 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
Boat builders/repairers	Kalange-Makwanzi	M	2	1	3	3	3	1	2	3	3	2	2	3	3	3	2	2	4	3
		F																		
	Mid section of the Reservoir	M														1	5		2	2
		F																		
	Buyala-Kikubamutwe	M	5	2	4	2	2	3		1	1	3	3							
		F																		
Food vendors	Kalange-Makwanzi	M				1	1	2	4	1	1	1	1		1	2		1		1
		F	4	3	5	4	2	4		3	3	3	3	2	5	2	5	4	5	5
	Mid section of the Reservoir	M												1	1			1		
		F											2	4	3	3	1	1		1
	Buyala-Kikubamutwe	M										3	3		2					
		F		2														4		
Net repair(s)	Kalange-Makwanzi	M			5	4	4		3	5	5	3	3	7	5	6	4	6	4	5
		F																		
	Mid section of the Reservoir	M																		
		F																		
	Buyala-Kikubamutwe	M		2		1			3			6	6		3		11		3	
		F																		
Cleaner fish landing	Kalange-Makwanzi	M																		
		F																		
	Mid section of the Reservoir	M																		
		F																		
	Buyala-Kikubamutwe	M																		
		F																		
Fisher(s)	Kalange-Makwanzi	M	57	20	32	43	37	30	38	25	25	25	25	25	42	39	39	54	36	52
		F													1	1	1	1	2	
	Mid section of the Reservoir	M											13	24	49	51	55	74	37	49
		F																		
	Buyala-Kikubamutwe	M	26	30	42	47	46	30	34	30	30	15	9	28	72	15	11	42	21	24
		F																		
Fish trader(s)	Kalange-Makwanzi	M	11	3	2	3	6	4	4	6	6		2	1	1	2	6	1	1	3
		F	12	9	13	10	20	16	16	30	30		16	9	16	13	2	4	7	8
	Mid section of the Reservoir	M											2	1	1	3	1		2	3
		F											5	1	1	12	12	16	9	16
	Buyala-Kikubamutwe	M	5	2		2	2	2	2				1		1	1		2	1	
		F	8	2		4	3	5	5	5	5		3	6	5		1	3		3
Fish processor(s)	Kalange-Makwanzi	M																		
		F													3	3				
	Mid section of the Reservoir	M																		
		F														2			2	6
	Buyala-Kikubamutwe	M			3							1	1							
		F			5							5	5							
Fish cleaner	Kalange-Makwanzi	M																		
		F																		
	Mid section of the Reservoir	M																		
		F												1	1					
	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 section of the Reservoir	M												1	1	1	1	1	1	1
		F																		
	Buyala-Kikubamutwe	M		1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1
		F																		
BMU committee member(s)	Kalange-Makwanzi	M				6		4	5			7	7	5	5	7	4	5	6	5
		F				3		5	4			2	2	1	3	2	2	1	3	4
	Mid section of the Reservoir	M												5	3	3	2	4	3	18
		F												3	1			1	10	
	Buyala-Kikubamutwe	M				4	2	2	3	3	3	4	4	4	4	10	4	8	2	3
		F				2	1					1	1	1	3	2		4		
Fisheries Officer	Kalange-Makwanzi	M										1	1	1						
		F																1	1	
	Mid section of the Reservoir	M										1	1	1						
		F																1	1	
	Buyala-Kikubamutwe	M																		
		F																1	1	
Landing site askali	Kalange-Makwanzi	M	1										1	1	1					
		F																		
	Mid section of the Reservoir	M																	1	
		F																		
	Buyala-Kikubamutwe	M											1	1	1					
		F																		

Considering fishing effort, fish composition, beach revenue and fishery related jobs of the monitoring surveys; the downstream river-dependent communities seem to be more vulnerable to the likely negative consequences of the dam. This is shown through the reductions in fish species composition, CPUE of the regular commercial species except *M. kannume*, fish catches, beach revenue and fishery related jobs. Although the downstream river-dependent communities may benefit from some degree of flood protection and enhanced irrigation opportunities provided by dams (Richter , et al., 2010), studies by Richter, et al., 2010 and Adams, 1985 have demonstrated the adverse effects of dams to the downstream areas as decline in fish populations (fish species, abundance and composition) thus decline in fishing opportunities and income. The negative impacts outweigh the benefits thus result in reduction of their incomes and livelihoods. There is need to quantify and account for these impacts thus recommending mitigation measures to improve community's livelihoods prior to the existence of the dam.

3.7 SCHISTOSOMIASIS, RIVERBLINDNESS AND SANITATION STUDIES

3.7.1 Parasitological analysis of bilharzias in humans

Sampling for parasitological prevalence and intensity of Bilharziasis infection were maintained at Kalange-Makwanzi (an upstream transect), mid-reservoir and downstream (Buyala-Kikubamutwe).

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

Parameter	Variety	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
Schistosomiasis Prevalence	*Mansonii*	Kalange-Makwanzi	53	46	56	28	49	21	21.8	16	18	18.6	17	25	20	19.6	20	22	16	17
		Mid section of the Reservoir										20.5	16.7	18.5	20	13	14.2	20	10	12
		Buyala-Kikubamutwe	48	43	40	22	33	19	16.7	18.6	21.8	19.6	20	17.5	18.6	16.4	20	15	20	14
	Haematobium	Kalange-Makwanzi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Mid section of the Reservoir										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
Schistosomiasis Intensity	*Mansonii*	Light	32	60.8	59	35	77	83	86	87	86.3	75	67	79.2	83.3	90.5	70	81.2	76	57.8
		Moderate	50	27.5	32	12	4	17	13.6	15	13.7	18.1	33	16.7	16.6	9.5	20.5	12.8	23.5	21
		Heavy	18	11.8	10	3	4	0	0	0	0	6.2	0	4.1	0	0	8.3	6.1	0	10.5
Prevalence by water contact	*Mansonii*	Fishing	71.4	94.4	60	68	79	62	31.4	21.9	24	28	27.8	25.8	32	38.9	37.2	32.7	20	28.5
		Fetching water	18.1	38.4	36.6	30.9	48	0	6.5	14.3	20	20.5	18	17.6	16.6	9.1	13.3	15.3	16.6	16
		Bathing/swimming	70	93.4	54.5	54.8	63	15	18.6	20	46	20.4	23	34	20	42	20	20.5	30.1	17
		Fish mongers	60	42.8	16.6	15	33	8	14.3	5	14	13.3	11	18	14.2	10	18.1	16.6	0	9
Snail Species abundance	*Bulinus sp.*	Kalange-Makwanzi	10	21	14	8	23		19	37	85	17	251	20	8	6	20	44	118	64
		Mid section of the Reservoir										11	30	10	7	4	55	54	20	42
		Buyala-Kikubamutwe	13	11	50	8	83		9	51	18	3	5	7	21	8	37	7	74	10
	Biomphalaria sp.	Kalange-Makwanzi	22	31	26	25	20		63	182	33	26	26	47	16	20	16	16	32	79
		Mid section of the Reservoir										68	67	67	46	45	31	27	24	40
		Buyala-Kikubamutwe	11	9	65	74	122		62	80	60	200	167	22	51	44	47	18	28	40
	Others	Kalange-Makwanzi	127	39	51	135	67		101	455	81	8	72	39	68	222	28	4	39	185
		Mid section of the Reservoir										13	15	63	131	100	42	58	102	104
		Buyala-Kikubamutwe	50	37	52	188	91		118	96	57	71	105	87	84	42	37	70	36	
Coliforms in water	Shallow	Kalange-Makwanzi	200	73	63	105	15	50	50	48	70	57	60	60	96	92	105	99	104	97
		Mid section of the Reservoir										79	80	94	80	80	133	130	131	131
		Buyala-Kikubamutwe	50	87	73	100	10	87	80	82	81	82	76	80	94	90	91	89	90	104
	Deep	Kalange-Makwanzi	40	10	43	15	1	1	1	1	2	79	80	80	80	80	133	130	131	152
		Mid section of the Reservoir										1	1	5	5	3.1	5	3.1	2	6.5
		Buyala-Kikubamutwe	10	21	70	22	1	1	1	1	1	6	1	1	1	4	10	7	7	2

Out of 128 stool samples collected from 500 people, 19 people (16.1 %) were infected with Schistosomiasis. The infection rate has remained the same as in the previous survey-September 2015. Only intestinal type of Schistosomiasis (*Schistosoma mansoni*) has continued to be prevalent; the urinary type, *Schistosoma haematobium*, has never been detected at all. The infection rate at Kalange-Makwanzi slightly increased to 17% during this survey period from 16% during the previous survey period-September 2015. Similarly, the infection rate at the mid-resevoir transect increased from 10 % during September 2015 to 12% during the present survey period. At Buyala-Kikubamutwe, the

rate of infection declined from 20% during September 2015 survey to 16 % during the current survey period (Table. 3.7.1).

A decreasing trend of light intensity infection has been observed in the last three survey periods i.e. from 81.2 % during April 2015 to 76% during September 2015 and to 57.8% during the current survey period (Table 3.7.1). While moderate infection intensity has varied from 12.8 % during April 2015 to 23.5% during September 2015 and to 21% during the present survey period. Heavy infection intensity was 6.1% during April 2015, nil during the previous survey period and rose to 10.5 % during the current survey. The results indicate a decline in rate of transmission of the disease and perhaps praziquatal treatment given to those infected was effectively working.

During this survey period, fishing became biggest predisposing factor to Schistosomiasis infection by 28.5%, increasing from 20% during September 2015 and overtaking bathing and swimming which were the major swaying factors to Schistosomiasis infection by 30.1% during the same survey period (Table 3.7.1). During this survey period, bathing and swimming predisposed people to Schistosomiasis by 17% and predisposal to fish monger registered 9%, having had no infection among this group of people during September 2015. In previous surveys, health and sanitation messages excluded fish mongers because none had been found infected but during the next survey period, fish mongers will also be included for the behaviour change communication (BCC) efforts. Positive Schistosomiasis- infected people were treated under directly observed treatment (DOTs) by the sanitation team.

Status of snail vectors

Schistosomiasis, *Bulinus sp.* vector load numbers at the upstream transect (Nkalange-Makwanzi) was 44 during April 2015 period, increased to 118 during September 2015 and then decreased to 64 during the present survey period (Table 3.7.1). Similarly, at the downstream transect (Buyala-Kikubamutwe), *Bulinus sp* numbers were 7 in April 2015 spiked to 74 during the September 2015 survey and dropped to 10 during the current survey period. At the mid-reservoir transect, the vector number were 54 during April 2015, decreased to 20 during September and went up to 42 during the current survey.
Like for *Bulinus sp* snail vectors, the *Biomphalaria sp* vector snail also remarkbly increased at thee upstream transect from 16 April 2015 survey to 32 during September 2015 to 79 during the current survey period. At the downstream transect, the numbers rose from 28 during September 2015 to 40 during the current survey period and similarly at mid-reservoir transect during the same peiods, the numbers increased from 24 to 40.

Six *Biomphalaria* and four *Bulinus sp* collected from the mid-reservoir transect shed Cercaria. At the downstream transect, two *Biomphalaria sp* snails produced Cerceria. These results indicate that transmission at the downstream transect as well as the mid reservoir area is possible.

Faecal coli forms

Colonies of faecal coliforms at shallow human-water contact points upstream were 104 colonies per ml during September 2015 up from 99 colonies per ml during the April 2015 (Table 3.7.1). During the current survey period, 97 colonies per ml were recorded. At the downstream transect, similar counts of faecal coliform colonies have been registered during the April and September 2015 surveys respectively (i.e. .90 Colonies per ml).This however increased to 104 colonies per ml during the present survey period. At the mid-reservoir transect, 131 colonies per ml were recorded during September 2015 and these increased to 152 during the current survey period. This heavy contamination portends high risk level for water borne diseases like cholera and diarrhoea.
Water from the deep middle part of the river recorded coliform counts of 2 colonies per 10 mls during this survey perios at the downstream transect and 7 colonies at the upstream transect. The micro-organisms of medical importance were predominantly *Salmonella sp* and *Shigell*a *sp.* Water from the deep middle part of the river had a lower coli form count of 2 colonies per 10 mls of water downstream and 6.5 colonies upstream, showing a slight increase from previous sampling, this is a case of moderate risk level (1-10 colonies per 10 ml of water).
All shallow human/water contact points at all three transects had above 10 colonies 10mls, which is high contamination. The increase in contamination at the reservoir needs some attention with regard to improving sanitation.

Blackfly/*Mbwa Fly* Sampling
Medically important species of *Simulium* flies mostly live in sheltered areas of the river/stream in fast moving waters where they breed on crabs and Twigs depending on their species and sub species. During this sampling, none were detected either by human landing catches, foot patrol or of 99 crabs examined.

3.8. CONCLUSIONS AND RECOMMENDATIONS

3.8.1 Conclusions

1. Data 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 suggests 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. In the mid-reservoir, the biomass of keystone species (*L. niloticus, B. docmak* and *M. kannume*) has reduced when compared to previous surveys of April and September 2013. This is attributed to increase in fishing activities' in the main reservoir by the local fishers

6. In the September 2015 survey, *Caridina* was the dominant prey for *L. niloticus* at the mid-reservoir and Kalange-Makwanzi transets whereas at Buyala-Kikubamutwe transect, haplochromines were the major prey for the species. The diet of *L. niloticus* in September 2015 at the mid-reservoir and Buyala-Kikubamutwe transects was similar to observation made in the previous survey of April 2015. The change in the diet of L, niloticus from dominance of haplochromines in April 2015 to *Caridina* in September 2015 at Kalange-Makwanzi is attributed to seasonal variation in availability of the prey species.

7. Breeding intensity of keystone fish species in all transects was higher in September 2015 (6 species) when compared to the previous survey of April 2015 (4 species). This is attributed to the higher fish species diversity recorded in the recent surveys.

8. An increase in *Biomphalaria sp* vector abundance at all transects was noted. This was coupled with a 10% increase in heavy intensity of Schistosomiasis infection. An increase in faecal coliform contamination at the mid-reservoir was noted. Though these scenarios may not currently be attributable to the construction of the dam, it merits closer monitoring during subsequent sampling.

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 in order to interrupt transmission of Schistosomiasis especially at the downstream transect where infection increased. Health education should be intensified especially among the new settlers and cultivators at the reservoir.

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