



## Spatio-Temporal Variations in Water Quality and Fish Assemblages in Odoponyi Seasonal Stream as a response to disturbance from Selected Agricultural Landscapes in Tororo, Uganda

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**ABSTRACT:** This study investigated the Spatio-Temporal Variations in Water Quality and Fish Assemblages in Odoponyi Seasonal Stream as a response to disturbance from Selected Agricultural Landscapes. Six sampling campaigns were launched at three different landscape sampling sites (grazing, rice plantation and sugarcane plantation) for 12 months from January to December of 2022. There was a general trend of increase in Dissolved Oxygen from upstream to downstream in sites in the catchment during both dry (from  $7.13 \pm 1.9$  to  $8.9 \pm 2.1$  ppm) and wet seasons (from  $11.2 \pm 2$  to  $12.3 \pm 0.1$  ppm). Plantation landscape of sugarcane registered the highest concentrations of nitrates during both dry and wet seasons ( $8 \pm 0.9$  Mg/l and  $11 \pm 1$  Mg/l) respectively. There was higher water transparency during dry season than wet season. A total of 568 fish individuals belonging to 7 species including *Clarias leiocephalus*, *Pamphals promelas*, *Notemigonus crysoleucus*, *Anchoa mitchili*, *Poecilia reticulata*, *Barbodes binotatus* and *Pseudorasbora parva* were captured using hand line and seine nets. Fish species diversity, richness and abundance were higher during the wet season than dry season. Sugarcane plantation landscape registered the highest fish catch during both dry and wet season while grazing landscape registered the lowest catch at all times. This study recorded presence of a rare migratory fish species *Notemigonus crysoleucus* in wet season. We concluded that Odoponyi stream has migratory fish species that require protection especially during wet season. We recommended that land users in the catchment should leave a buffer strip of about 10m from the stream bank to reduce on the effect of erosion deposition directly into the stream.

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According to Brown(2000), and Van Butsel *et al.*,(2017), land use cover and land use changes in the tropics increases nitrate , phosphates, electrical conductivity , ammonia, suspended solids and which reduces the dissolved oxygen in the stream and therefore this has impact on fish distribution. In some situations opposite trends have been found for example river nitrate concentration were found to decrease where primary forests were converted in to pastures (Turyahabwe *et al.*, 2021). Land use impacts

on water quality and fish distribution became evident in the early 1990s when traces of chemicals were found in the shellfish, moreover a water quality and biological study report of Apia sewage project in Samoa conducted in 1993 to investigate fresh water contamination habitats (Matthews *et al.*, 1994). This was viewed as a serious environmental problem with potential high risks and the Samoa government at the time therefore considered immediate need for protecting of catchment areas. In East African streams,

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riparian anthropogenic activities/disturbances in head waters of most tropical stream systems pause profound effects on trophic structures and stability of fish assemblages throughout river system (Niels *et al.*, 2016). Changes in land use patterns in a catchment area causes changes in Physico-chemical water quality which in turn causes immense changes in the aquatic organism communities such as fish and macroinvertebrates. In-stream sedimentation is by category the largest stream pollutants in most East African streams (VanButsel *et al.*, 2017). According to Turyahabwe *et al.*, (2020), in a riparian agricultural landscape, improper use of fertilizers and pesticides is the major source of nutrients in streams. This causes eutrophication in the adjacent stream and well as recipient lakes. Previous studies about the effects of land use on stream fish and water quality have focused on mountain and permanent streams (Turyahabwe *et al.*, 2020, 2021 and 2022, Vanbutsel *et al.*, 2017, Niels *et al.*, 2016, Kobingi *et al.*, 2009, Bagalwa *et al.*, 2014 and Filgueira *et al.* 2016). None has considered effect of land use in a lowland intermittent stream that crosses an entirely agriculture-dominated landscape. Intermittent streams have unique characteristics such as pollution and temperature - resilient aquatic organisms like fish and macroinvertebrates. It should also be noted that these streams also have migratory characteristic of some fish species living in warm remnant pools while others migrate to recipient lakes during dry season but also usually migrate back to the streams in times of heavy rains. This has left a knowledge gap about spatio-temporal migration patterns of these fish. Hence the objective of this paper was to examine the effect of selected agricultural land uses on the spatio-temporal variations in water quality and fish assemblage in Odoponyi seasonal stream crossing agricultural landscapes in Tororo, Uganda.

## MATERIALS AND METHODS

**Study area:** River Odoponyi drains the lowland areas of eastern Tororo district and is located between Latitude: 0° 46' 7.19" N and Longitude: 34° 01' 20.40" E. It flows into River Manafwa in Butaleja district which is part of the larger R. Mpologoma catchment draining into L.Kyoga basin. The river flows over a distance of 39km with its head waters originating from the high elevated areas with channels such as Rukuli, Morikiswa\_Rutengo channel, Pajagoti channel, Abongiti\_Kisoko channel which all connect to the stream. The biggest part of the relief is dominated by plateau intercepted by gentle slopes and dombo

lowlands. River Odoponyi traverses arable farms with a few grazing farms and planted eucalyptus woodlots in the upper through the middle section while the lower reaches of the river crosses papyrus swamp vegetation before draining into R. Manafwa. The catchment area experiences pronounced alternating wet and dry seasons between January to February (dry season) March-May (wet season), June-July (dry season) and August – December wet season. Although these pattern may change due to the current prevailing climate change effects. The study considered 3 agricultural land uses on the basis of dominance, proximity to the stream and accessibility to the stream. The land uses considered were those that had identifiable clear-cut boundaries of the start and end of a land use (where the stream would be seen entering a land use and leave a land use) and these included; animal grazing land in the upper reaches, rice plantation in the middle reaches and sugarcane plantation in the lower reaches (table1).

**Water quality sampling:** On each sampling occasion, physicochemical water quality variables were measured in triplicate at randomly selected points at each of the 100 m stretch sampling sites prior to fish sampling. Conductivity, temperature, pH, and total dissolved solids (TDS) were measured *in situ* using a combined Conductivity/TDS/pH/Temperature Meter (HANNA Hi 991300 Model). Dissolved oxygen was measured using a multi-parameter analyser (Consort C3010/C3030 Model) and turbidity by a Turbidity Meter (AL 450T-IR Model). To avoid contamination, the respective equipment probes were rinsed after taking each reading for each parameter. Nutrients (nitrates and phosphates) were analysed in the laboratory following APHA (1998) protocols.

**Fish sampling:** Fish sampling was carried out in Odoponyi seasonal stream for 12 months from January- February/ June –September 2022 dry season (twice during the dry season) and March -May/ October-December 2022 (twice in the wet season). The sampling was carried out at the three selected agricultural landscape sites (Table1) in the catchment. The fish were sampled using a combination of two methods to reduce on the chances of missing some species by using one method. These included seine net and hand line (Hook method) as described by Greenwood (1966). Fish sampling each sampling time at each site was done during day time morning hours from 8am to 11am when it was still cool.

**Table 1.** Land use types/site, location and elevation along Odoponyi catchment area

Land use/site	Symbol	Easting	Northing	Elevation
Animal grazing	B1	0082604	0618966	1129m
Rice plantation	B2	0083275	0618197	1116m
Sugarcane plantation	B3	0084042	0615930	1106m

At each site, fish sampling started with use of hook method and then seine nets were employed next. Baits were fixed on five hooks and the five hooks were fixed on five nylon threads and all the nylon threads tied on one rod. The hooks together with the threads were then released into one stream habitat at ago (first in pool, later into a run and riffle last). We ensured silence at sites while using this method to avoid scaring away the fish in the stream. Fish coming to eat the baits were hooked on the hooks and got stuck. Each time the researcher noticed a struggle of fish wanting to get off the hook, pulled the hook out of the water to remove the fish caught. All the fish caught from the hooks were removed using hands and put in a bucket half-filled with water. While using the seine net, at each site, a 100 m reach of the stream in an agricultural site was identified, blocked on both sides (the up and downstream) using block nets of 10mm mesh size. A seine net of 1.5mx1m opening with 3m long seine net bag made of 0.5cm mesh size was used. The seine net bag was held by two people who dragged it on the stream bed in a direction against the flow of stream water (from down to upstream) to let the flowing water go through but trap the fish into the net. In each of the 100m stretch, this was repeated five times. All the fish harvested in this bag for each drag time were put in the bucket half-filled with water. At each site and each day, the fish samples collected using both the seine net and the hooks were pooled together to make one sample for that site which were later taken to the Busitema university Biology laboratory and were identified up to the species level on the basis of external morphological characteristics, following protocols set by Greenwood, (1996). The individual fish were grouped according to their taxonomical groups, weighed and counted. The fish biometrics indicating assemblage such as Relative abundance, Diversity, Richness and Evenness, Density and Biomass were determined to compare assemblage among the three agricultural landscapes. The Relative Abundance (R.A.) of fish species was calculated using the formula:

$$\text{Fish density} = \frac{\text{No. Fish taxon}}{\text{Total No. per site}}$$

Where No. Fish Taxon = number of fish individuals of one taxon; Total .No. Per Site = Total number of individual per site

Fish species diversity, richness and evenness were determined using the Shannon Weaver's Diversity Index to compare fish diversity in different land use types using the following formula:

$$H = \sum_{i=1}^n \left( \frac{n_i}{N} [\log 2] \left( \frac{n_i}{N} \right) \right)$$

Where, H= Shannon Wiener index of diversity;  $n_i$  = Total no. of individuals of a species; and N= Total number of individuals of all species. Biomass and density were also determined using respective formulae by Froese (2006) and Ricker (1975) as follows;

$$\text{Fish density} = \frac{\text{No. fish caught per site}}{\text{Size Area Fish Caught}}$$

$$\text{Fish Biomass} = \frac{\text{Total wt. fish caught}}{\text{Size Area Fish Caught}}$$

Where No. Fish Caught Site = Number of fish individuals caught per site; Total Wt. Fish Caught = Total weight of the fish caught on a site; Size Area Fish Caught = Size of the area from which the fish was caught;

*Data analysis:* Parametric (ANOVA) statistics were used to compare physicochemical water quality, and fish assemblage across sampling sites. Before the comparison, a normality test using Shapiro-Wilk was applied to fish assemblage, and physicochemical water quality variables. Data having passed the normality test, one-way ANOVA was performed to assess the differences between means of dependent variables from the different landscape sites. A post hoc test using Tukey's Honestly Significant Difference (HSD) test was performed to find the Least Significant Differences (LSD). These were generated from STATA statistical program (Version 14).

## RESULTS AND DISCUSSION

*Spatio-Temporal Variations in Physicochemical Water Quality in Agricultural Landscapes in Odoponyi Catchment:* The spatio-temporal variations in physico-chemical water quality parameters is shown in table 2. During the dry season, the average temperature range was  $2.4 \pm 0.05^\circ\text{C}$  but was highest in the rice plantation landscape and lowest in the sugarcane plantation landscape. During the wet season temperature reduced to a range of  $1.2 \pm 1^\circ\text{C}$ . Generally, sugarcane plantation landscape maintained the lowest temperature while rice plantation maintained the highest temperature in both wet and dry seasons. It should also be noted that temperature distribution in the catchment varied significantly from site to site and from season to season (at  $p \leq 0.05$ ). This is because sugarcanes provided riparian shade that shielded the water from direct sun heat while rice plantation which was shorter with less vegetation cover exposed the

stream water to direct sun heat for longtime and thus higher temperatures. This agrees with study by Turyahabwe et al., (2020) who also found out that

sugarcane plantation in River Sironko catchment registered low temperature comparable to the pristine stage of the river.

**Table2:** Spatio-temporal variations of Physico-chemical water quality in agricultural landscapes in Odoponyi stream catchment during wet and dry seasons.

Landscape sampling sites	Temp. °C	TDS Ppm	EC µS/cm	D.O Ppm	Turbidity NTUs	pH	Nitrate Mg l <sup>-1</sup>	Transparency Cm	Discharge M <sup>3</sup> /S <sup>-1</sup>
<b>DRY SEASON</b>									
Grazing	25.5±1a	100±3.1a	186±1a	7.13±1.9a	59±02a	7.05±0.1a	2±0.2a	26±2c	0.24±0.1b
Rice plantation	25.6±23a	93±0.6b	124±1.2c	7.8±0.5b	130±12b	7.6±0.4a	6±1b	20.5±1.9b	0.6±0.4a
Sugarcane plantation	23.2±18b	89±1.2c	198±0.1a	8.9±2.1b	44±3a	7.9±0.7a	8±0.9 ab	21±2b	0.72±0.1a
<b>WET SEASON</b>									
Grazing landscape	22±2c	142±2.1a	200±2abc	11.2±2bc	67±7a	6.8±0.1a	10±1a	23±3b	0.8±0.0a
Rice plantation	23.4±0.1b	106±0.9a	100±7b	10.1±1bc	198±0.2ab	7.4±00a	10±1.6ab	14±2.6a	1.1±0.2c
Sugarcane plantation	21.2±1.1a bc	94±1b	99±1b	12.3±01d	206±8.3bc	7.5±1a	11±1b	29±3.1c	2.6±0.1d

\*Different sampling plots with different letters (a, b, c and d) in the same column per site indicate significant differences (ANOVA) (at  $p \leq 0.05$ ).

Total dissolved solids (TDS) increased during the wet season compared to the dry season. This is probably because the runoff during the wet season which carried dissolved salts from farm lands to the stream channel. This explains why during data collection, we observed that, the concentration of the dissolved solids increased with increase in discharge. Grazing landscape was associated with the highest TDS concentrations while sugarcane plantation landscape scored the lowest concentrations of the TDS in both dry and wet seasons. This is because riparian vegetation cover provided by the sugarcane encouraged more filtration of materials in the sugarcane plantation landscape as opposed to grazing landscape where riparian pasture had been overgrazed, banks had been trampled on and thus degraded by livestock animals leading to soil slump/slides directly entering into the stream as described by Niels *et al.*, (2016). The range of concentration of TDS between dry and wet season in Odoponyi catchment was 42±1ppm. TDS values in all sites during the dry season varied significantly from site to site (at  $p \leq 0.05$ ) reserving some similarity in distribution during the wet season. A similar finding was noted by Bagalwa *et al.*, (2014) in the tributary river flowing into Lake Edward on the Democratic Republic of Congo side. Electrical Conductivity (EC) followed the same pattern as TDS and was higher during the wet season compared to dry season. The highest EC was recorded from grazing landscape in both wet and dry season. The distribution of EC varied significantly from site to site and season to season (at  $p \leq 0.05$ ). The range of EC during dry season was 73±0.9 µS/cm while that of wet season was 101±1.0 µS/cm. There was a general trend of increase in Dissolved Oxygen (D.O) from upstream to downstream during both dry and wet season. This trend may be attributed to differences in riparian vegetation cover, where the denser the cover the lower

the water temperature which accommodate more dissolved oxygen. Thus D.O remained highest in the sugar cane plantation landscape and lowest in the grazing landscape. Therefore the dense riparian vegetation cover appears to play key role providing cool temperatures suitable to facilitate dissolving of oxygen through gaseous exchange directly into water. This explains why D.O remained highest in the sugar cane plantation landscape. This concurs with study by Turyahabwe *et al.*, (2022) who observed that sugarcane plantation similarly registered higher D.O than some sites upstream Sironko river in Eastern Uganda. There was a significant variation in D.O from season to season (at  $p \leq 0.05$ ). The range of D.O in both wet and dry season was 1.8±0.8ppm and 1.1±0.1ppm respectively while that between dry season and wet season was 5.2±0.9ppm. D.O varied significantly from season to season and from site to site (at  $p \leq 0.05$ ). Turbidity was generally lower during dry season compared to wet season. The high turbidity levels during wet season are directly attributed to the runoff that carried loads of different sizes, erosion and deposition into the stream. While during dry season, the water levels dropped, and there was limited or no bank and valley erosion hence water appeared clearer at this time of the season. A similar result was recorded in the Kisian and Kisati rivers in Lake Victoria drainage, basin Kenya (Kobingi *et al.*, 2009). The highest turbidity levels during wet season was recorded from the sugarcane plantation while the lowest was recorded from the grazing landscape during the dry season probably because, pasture vegetation filtered runoff water before reaching the stream more than cultivated agricultural landscapes.. Generally, grazing landscape recorded the lowest turbidity in the whole catchment during the study period in both seasons. Turbidity varied significantly among the rice plantation and sugarcane plantation

landscapes at  $p \leq 0.05$ . pH remained fairly within neutral ranges ( $6.8 \pm 0.1$  and  $7.9 \pm 0.7$ ) throughout the sampling period at all the sampling sites (Table 2). Dissolved Nitrates increased from upstream to downstream sites in both dry and wet season. During wet season landscape sites registered higher nitrate (Nutrient) concentrations as compared to during dry season. Plantation landscapes of both sugarcane and rice registered the highest concentrations of nitrates during both dry and wet seasons. This is as a result of the fertilizers that was applied in these plantation fields that find their ways into the stream through leaching and runoff during the wet season. Ratemo (2018) had earlier reported a similar result from a plantation farm on River Athi in Machakos district, Kenya. Nitrate concentration varied from site to site and season to season save for the grazing landscape where it was fairly consistent. Comparing wet and dry seasons, there was higher water transparency during dry season than wet season. Table 2 shows that there was a significant variation in discharge and transparency from site to site and from season to season (at  $p \leq 0.05$ ).

During long drought spells, some parts of the river dried up completely, leaving pockets of pools but with clearer water. At this time some of the points in the river recorded zero discharge. A similar condition was reported by VanButsel *et al.*, (2017) in River Mpanga catchment in Western Uganda. The low transparency levels during wet season are directly attributed to the runoff that carried loads of different sizes, erosion and deposition into the stream. While during dry season, the water levels dropped, there was limited or no bank and valley erosion hence water appeared clearer at this time of the season hence higher transparency.

*Spatio-Temporal Variations in Fish Community Assemblage in Different Agricultural Landscapes:* The Spatio-temporal variations in fish community assemblage in different agricultural landscapes in Odoponyi stream catchment is shown in table 3. Total of 568 individual fish were harvested from River Odoponyi catchment throughout the sampling period. Fig 2 shows images of the species sampled from different agricultural landscapes.

**Table 3:** Spatio-temporal variations in fish community assemblage in different agricultural landscapes in Odoponyi stream catchment

Fish species harvested	Variations in fish community assemblage obtained from different agricultural landscapes during wet and dry seasons						Total
	During Dry Season			During Wet Season			
	Grazing Landscape	Rice plantation landscape	Sugarcane plantation landscape	Grazing Landscape	Rice plantation landscape	Sugarcane plantation landscape	
<i>Barbodes binotatus</i>	-	2	3	-	66	51	122
<i>Pimephals promelas (Cyprinids)</i>	6	2	16	17	32	57	130
<i>Poecilia reticulata</i>	-	-	-	6	39	44	89
<i>Clarias leiocephalus</i>	17	27	31	19	35	33	161
<i>Pseudorasbora parva</i>	-	1	6	4	13	11	35
<i>Anchoa mitchli</i>	-	-	-	-	5	16	19
<i>Notemigonus crysoleucus</i>	-	-	-	-	-	9	12
<b>Total per site</b>	23	32	57	46	190	221	568
<b>Total per season</b>	111			457			



**Fig 2:** Shows images of the samples of species trapped from different agricultural landscapes

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The 7 species captured were dominated by *Clarias leiocephalus* and *Pamiphals promelas* accounting for 28% and 23% respectively of the total catch. These two fish species constitute over 50% of the fish catch and this may be because these species are herbivorous in nature and the study site was dominated by leafy hanging riparian vegetation touching stream water at the river banks that provided abundant food, and hence large numbers. Similar result was recorded by Turyahabwe et al., (2022) who reported that herbivorous fish species were habitat-generalists but tend to colonise more areas that had a dense riparian vegetation. While the least species caught were *Notemigonus crysoleucus* and *Anchoa mitchili* both accounting for 2% and 3% respectively of the total fish catch. These species were habitat-specific and pollution-sensitive. Since the study site water was polluted in most parts of the stream, this limited survival of these species and hence fewer numbers recorded. Unlike most tropical fish species that can survive in sites with lower D.O of up to 6ppm, *Anchoa mitchili* cannot survive in D.O levels of less than 11.5ppm (Diana et al., 2006). This explains why *Anchoa mitchilli* species was only found in the sugarcane plantation and rice plantation landscapes in both wet and dry season where D.O level were favourable. This is unlike the *Clarias leiocephalus* that was found in all landscape sites. *Anchoa mitchili*, *Notemigonus crysoleucus* and *Poecilia reticulata* species were not recorded in dry season. In general the majority of the fish species were recorded during the wet season than dry season. This is because increased water discharge during wet season encouraged migrate from one point to another with in the stream hence the number increasing as explained by Walser et al., (2006). There was a generally trend of increase in the number of fish individuals during wet season among all the fish species from up to downstream sites in the catchment. Wet season generally recorded higher catch than dry season. This is indicative that fish were migrating from mouth of the river to upstream

probably for spouting. In this study we recorded presence of a rare fish species *Notemigonus cryseleucus* which only appeared during wet season in downstream but did not occur in the upstream sites of rice and grazing landscapes. Turyahabwe et al., (2022) reported that migratory rare fish species called *Amphilius uranoscopus* similarly appeared only in sampling sites during wet season. Sugarcane plantation landscape registered the highest fish catch during both dry and wet season while grazing landscape registered the lowest catch at all times. This can be attributed to the shading effect of the riparian cover provided by sugarcane plantation hence higher D.O, more nutrients from the plantation resulting from fertilizer and other chemical application. While evaluating detectability of freshwater fish assemblages in tropical streams, Deacon et al., (2017) observed that, D.O was a lifeline for the survival of fish and macroinvertebrates. And this may support the observations recorded in this study.

*Spatio-Temporal Variations of Some Fish Assemblage Metrics from Different Agricultural Landscapes:* Table 4. Shows Spatio-temporal variations of some fish metrics in different agricultural landscapes in Odoponyi catchment. Majority of the fish species were more abundant during the wet season than dry season. There was generally a trend of increase in number of fish numbers caught during wet season among all the fish species from up to downstream sites in the catchment. Wet season generally recorded higher catch than dry season. The highest species abundance was registered in the sugarcane plantation landscape followed by rice plantation landscape while the lowest was registered in the grazing landscape throughout the sampling period. The distribution and abundance of fish species varied significantly from site to site during wet season (at  $p \leq .05$ ). The relative abundance of species during wet season was more than three times that of dry season.

**Table4:** Spatio-temporal variations of some fish metrics in different agricultural landscapes in Odoponyi catchment

Sampling sites	Variations in mean metrics of fish community assemblage obtained from different agricultural landscapes during wet and dry seasons					
	Relative abundance (%)	Species diversity	Species richness	Fish biomass (g/m <sup>2</sup> )	Wet weight(g)	Fish density (Number/ m <sup>2</sup> )
<b>DURING DRY SEASON</b>						
Grazing land scape	4.04±1.1a	0.46±0.0b	2±0a	0.79±0.1c	6.9±1.2a	0.11±0.0a
Rice plantation landscape	5.5±0.3a	0.29±0.4a	4±1b	1.15±0.6a	7.2±0.2b	0.16±0.0a
Sugarcane plantation land scape	10.03±1.0b	0.42±0.1b	5±0.1b	2.81±0.0d	8.4±1.1a	0.29±0.1a
<b>DURING WET SEASON</b>						
Grazing land scape	8.1±2.3b	0.51±0.3b	4±1.2b	0.520±0.2c	5.9±0.9c	0.23±0.0a
Rice plantation landscape	33.5±1.9cd	1.19±0.0c	7±2.1c	1.10±0.1a	6.3±0.2b	0.95±0.2b
Sugarcane plantation land scape	38.9±5.8d	1.22±0.1c	7±2.2c	1.7±0.0b	6.5±0.4c	1.11±0.3b

\*Different sampling plots with different letters (a, b, c and d) in the same column per site indicate significant differences (ANOVA) at  $p \leq .05$ .

Sugarcane plantation landscape registered the highest fish catch during both dry and wet seasons, followed by rice plantation landscape. While grazing landscape registered the lowest catch during both dry and wet seasons. This was due to the higher concentrations of both D.O and nutrients that were associated with these plantation landscapes. The nutrients mainly nitrate that had been applied in the plantation gardens of sugarcane and rice at the start of the respective growing seasons. A similar observation was recorded by a study by Aazami *et al.*, (2015) during aquatic ecosystem monitoring. It was observed that during the dry season, most of the fish were held back in pool water, during which only resilient species such as *Clarias leiocephalus* could survive in the shallow water pools with limited D.O. Species diversity increased during the wet season as compared to that during the dry season. The highest diversity was recorded in the sugarcane plantation landscape while the lowest was recorded in the grazing landscape in both wet and dry season. Species diversity varied significantly from site to site and season to season (at  $p \leq 0.05$ ). This is attributed to differences in micro habitats quality for the fish. There were bigger and deeper pools that accommodated variety of species downstream sites like sugarcane plantation than was in upstream with limited discharge that was shallow thereby prone to high temperature and reduced D.O, a habitat that could favor only temperature tolerant species like *Clarias leiocephalus*.

Similar finding was reported by Turyahabwe *et al.*, (2022) where they observed that at the pool site where D.O was higher, in the deeper pool, this was associated with the highest species density. Wet season registered almost as twice higher species richness as dry season. The wet season resulted in wider stream width with a low velocity, a condition that allowed more fish habitation (Allan, 2004). This was because downstream channels occasionally flooded up to the plantation farms of sugarcane and rice, thereby connecting with overbank pools where nurseries of fish were leading to free movement and migration of the young fish species from nurseries to the streams (Brown, 2000). There was a general increase in species richness from upstream sites to downstream sites both during dry and wet seasons. Wet season registered almost twice higher species richness compared to the dry season. Species richness in the sugarcane plantation and rice plantation was almost uniform in both seasons. Unlike species relative abundance, richness and diversity, the fish biomass was higher in dry season than in the wet season. The highest biomass was registered in the sugarcane plantation followed by rice plantation landscapes. Biomass varied significantly from site to site and from

season to season (at  $p \leq 0.05$ ) and consequently, the general average wet weight of fish was higher during the dry season than in wet season. Wet weight was highest in sugarcane plantation during dry season and was lowest in the rice plantation during wet season. Wet weight varied significantly (at  $p \leq 0.05$ ) from season to season. The average wet weight and biomass of fish was higher in dry season than in the wet season. This is probably because mature fish were the ones that could withstand the harsh environmental conditions of lower D.O, pollution which prevails during dry season. So due to maturity, they were fat and heavier hence higher biomass as compared to those caught during wet season where the majority were young and light. Turyahabwe *et al.*, (2022). The average fish density was higher during wet season than dry season. This is attributed to a number of factors including but not limited to; migration of fish from lower reaches of the stream upwards, migration of fish from overbank ponds that joined the main stream, maximum concentrations of D.O and Nitrates from overbank sources to the stream through runoff and the larger discharge that increased the carrying capacity of the stream for a variety and number of fish species (Matthews *et al.*, 1994, Wang *et al.*, 2003). Unlike wet weight and biomass, the average fish density was higher during wet season than dry season. The highest fish density was recorded in the sugarcane plantation landscape during the wet season while the lowest density was recorded in the grazing landscape during the dry season. Spatio-temporal variation in fish species indicated that some fish species were migrating from mouth of the river to upstream probably for spawning that would eventually increase their number in the recipient lake Kyoga in the dry season.

**Conclusion:** The various agricultural activities in the landscapes of the Odoponyi stream watershed led to changes in spatio-temporal variations in water quality which in turn negatively affects fish assemblages in the catchment. There was generally increase in the number of fish individuals during wet season among all the fish species indicating that the stream was an important habitat for various fish species. We recommend establishing a buffer zone by designating a strip of about 10m from the stream bank which will reduce the effect of erosion and water pollution in the stream.

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