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Factors influencing rice production in the Lwafi-katongolo irrigation scheme: Nkasi District, Tanzania

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Abstract

This study was conducted to assess factors influencing rice production in the Lwafi-Katongolo Irrigation Scheme. A sample of 120 farmers from 4 villages of Katongolo, Masolo, Kamwanda and Mpata were purposively selected for the assessment of factors influencing crop yields and water delivery (flow). Data was collected through a questionnaire administered to households to generate information on factors influencing water delivery and how the influence affects rice production. The data were subjected to analysis of trends in crop production and water flows using Microsoft Excel. Multivariate regression analysis was used to assess factors influencing production during the wet and dry seasons while Descriptive analysis was used to determine the level of farmer satisfaction on irrigation services. Qualitative data were analyzed by content analysis. The findings show that Cropped land size, condition of secondary canals, relative position of irrigated area and Government facilitation for maintenance significantly and positively influenced productivity in the scheme. Experience of farmers in irrigation practices influenced negatively the productivity in the scheme. The annual rainfall increased 1.58mm in the period 1981-2020 causing destruction of canal walls and soil erosion in the scheme. Water discharge in the irrigation scheme decreased by 40.36m^3/s between 2019 and 2021 implying poor water supply hence negatively influencing productivity. The finding also explained farmers satisfaction for water delivery in the scheme as the response was 61.57% Neutral, 33.75% Dissatisfied, 3.64% Satisfied, 1.04 Strong Dissatisfied and 0% Strong Satisfied. The study recommends, the government and other stake holder of agriculture should continue planning for rehabilitating the infrastructure destructed and constructing other structure as per design, construction of water dam, and rescheduling of the maintenance and operation for Water user association in the scheme.

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Introduction

The accessibility of water is a main factor in irrigation performance, while allocation of the available water is an inherent component of an irrigation system that reflects the proper management of irrigation supplies for crop production (Rowshon *et al.*, 2014). Allocation of water for a large-scale irrigation system is always difficult, especially when the water supply is inadequate during crop season (Rowshon *et al.*, 2014). Globally, irrigation schemes are considered to exhibit with a low degree of management performance, this can include the low-cost recovery and low water use efficiencies as induced by water allocation and poor water delivery performance (Vos, 2005). The allocation and distribution of water in an irrigation system are most scheduling activities that influence productivity of rice in the scheme as interact with complex factor like physical, technical, socio-economical and organizational factors (Sarwar *et al.,* 2001).

Irrigation development in Tanzania as in other countries in Sub Saharan Africa, has taken place in stage and has been associated with large challenges (Mdemu *et al.*, 2017). Among of the challenges are inadequate investments in water abstraction and storage infrastructure, lack of enough funding from Government for irrigation investments, low capacity of beneficiaries to invest in the infrastructure for their irrigation systems, inadequate of private sector for investment in irrigated agriculture and failure of technology integration (Mfinanga & Musa, 2021). However, water scarcity has been experienced in many places and sectors of Tanzania due to unreliable rainfall, thus cause multiplicity of competing uses as the climatic variability cause low flow rate of river (Mahoo *et al.,* 2015). There are also increasing challenges in managing the water resources, and strengthening water management policy as well as the legal institutional frame work that deals with water management (Mahoo *et al.,* 2015).

Tanzania being a country that has invested in irrigation scheme to increase agricultural productivity, Lwafi-Katongolo irrigation scheme is among (FAO, 2015). Lwafi-Katongolo scheme as has being implemented in stage of its construction since 2011/2012 as phase I of its construction and 2016/2017 as phase II of its construction, during those phases of construction various resource including manpower and financial resources has been used to harness the scheme, although currently farmers are experiencing poor water delivery in their farm plot during rice production, however the water source is perennial river. The extent of water delivery problem and its influence on production has not been quantified. Regardless a number of studies on irrigation schemes found in Tanzania (January & Kim, 2019, Mdemu *et al.*, 2017, Oates *et al.*, 2017 and Mdee *et al.*, 2014). There was still a knowledge gap on the factors which influence rice production in the Lwafi-Katongolo irrigation scheme. The finding from the present research was motivated by increasing awareness among farmers and stakeholder actions by understanding factors that influence positively and negatively for rice production in the irrigation scheme, not only that, but also the result adds knowledge by understanding trend of temperature, rainfall and water discharge distribution for rice production in the scheme. This paper uses Lwafi-Katongolo irrigation scheme as a case to answer the questions: are there any factors that contribute to poor water delivery in the irrigation scheme, what are they and how does it influence production in the scheme. How is the seasonal availability of rainfall, water discharge from the river and temperature and how does it favor or constrain productivity in the scheme. What are the farmer satisfactions on rice production in the scheme?

Materials and methods

Description of the study area

The study was done in Nkasi District, Rukwa Region, in South Western Tanzania between Lake Tanganyika and Lake Rukwa. It lies between longitude 30^0 20'and 31^0 30' East and Latitude 6^0 58'and 8^0 17" South (Fig. 1). The Lwafi-Katongolo Irrigation Scheme is located in Masolo and Katongolo villages bounded by Kipili, Kirando and Itete wards about 60Km from Namanyere Town which lies at Latitude $07^0$26' S and Longitude 30^0 43' E. The soil of the irrigation scheme is sandy clay loam with a bulk density of 1.28g/cc, while the average rainfall distribution in the entire district ranges from 800-1400mm.

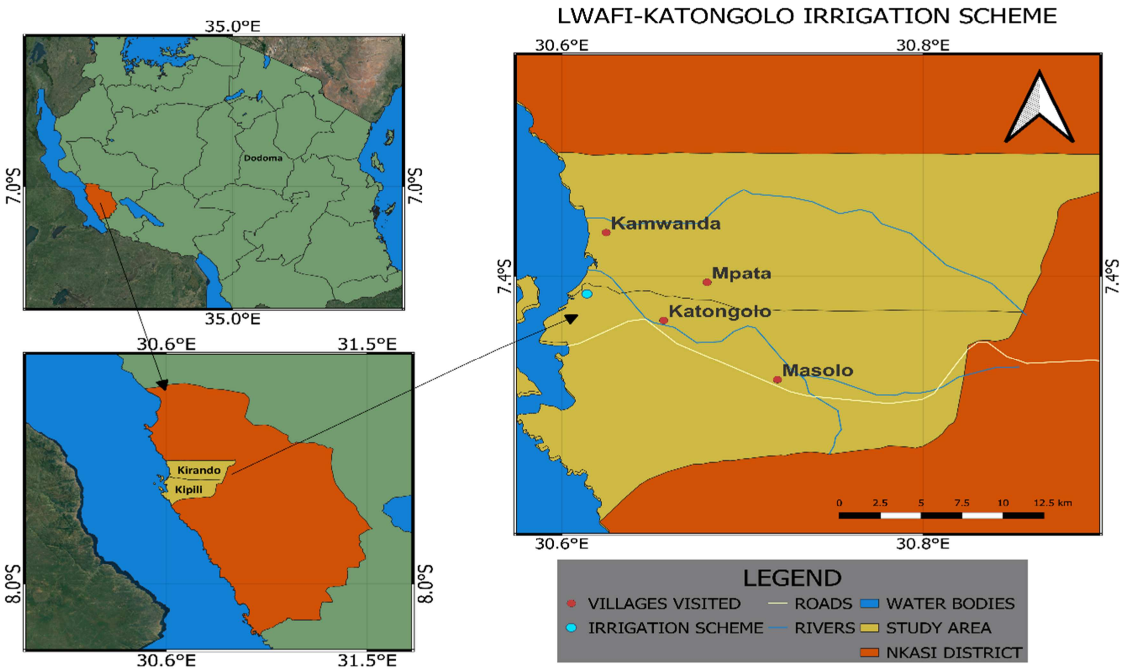

Fig. 1. Location of study area for Lwafi-Katongolo irrigation scheme.

Research Design

The study used cross-section design for socioeconomic data under which data were collected at one point in time. Biophysical data were collected through field surveys and observations. Using the list of household undertaking irrigation, 30 households were selected randomly from each of the 4 villages of Katongolo, Masolo, Kamwanda and Mpata, making a total sample of 120 respondent households.

Data collection

The structured questionnaire followed with focus group and key informant were used to collect primary data using multistage sampling technique where two wards, kipili and kirando were purposively selected, however the four village with highly practicing irrigation were selected randomly for the survey at which two village from each ward were selected. Secondary data on temperature, rainfall and water discharge seasonality were collected followed with data on existence of distribution box, condition of main canal, condition of secondary canal, land degradation in the scheme, occurrence of floods in the scheme, source of water, relative position of irrigated area, soil type in farm plots, maintenance and operation, institutional leader, source of financial support, livestock in scheme, land size cropped, use of available water in canals , experience of farmers in irrigation practices and Government facilitation in maintenance. On the other hand, data for farmer satisfaction on irrigation services was also collected. Though research was conducted from November 2021 up to February 2022.

Data analysis

Multivariate regression model was used to assess factors associated with water delivery and its influence on production in the scheme. Trend analysis on rainfall seasonality, water discharge seasonality and temperature were used to assess the influence of productivity in the scheme. Descriptive analysis on farmer satisfaction for irrigation services was used, however Microsoft excel, and Stata computer programs were used for data analysis

Regression model

A multivariate regression model was used in the analysis to assess the factors that influenced production during dry season and wet season (Uyanık & Güler, 2013).

$Y=\alpha+\beta_1 X_1+\beta_2 X_2+\cdots+\beta_k X_k+\varepsilon$

Where;

Y are the two dependent variables bags of rice in wet season (yield) and bags of rice in dry season (yield).

α ……Is the intercept

X_1, X_2……. X_k are 16 explanatory independent variables described above

β_1, β_2………βk are known as the model parameters (Beta coefficients), and "k" is the number of observations which is equivalent to the number of independent variables.

ε is the random error, assumed to be constant for this study

Result and discussion

Factors associated with water delivery and its influences on rice production

The identified multivariate model fits well the data as measured by R^2 (0.5314). These values suggest a good predictive ability of the model implying that explanatory/independent variables included in the model explain well the variation in the dependent variable and goodness of model fitness.

There are several factors that significantly influence productivity of the Lwafi-Katongolo irrigation scheme. These include size of cropped land, condition of the secondary canals, relative position of irrigated area, experience of farmers in irrigation practices- and government facilitation in maintenance of the system. Only one factor; the size of the cropped land significantly influence production during the wet season. During the dry season four factors influence production. The factors include condition of the secondary canals, relative position of irrigated area, experience of farmers in irrigation practices, and government facilitation in maintenance of the system.

Cropped land size

The size of the cropped land had a positive influence on productivity in Lwafi-Katongolo irrigation scheme and was statistically significant at the 99% and 90% level of significance respectively ($p<0.01$, $p<0.1$) (Table 1a, Table 1b). During wet season, one unit change in the cropped land will lead to 0 .9181199 unit increase in productivity on average (Table 1a). This implies that the more the farmer increase their land size for rice production the more the need for water for rice production and subsequent increase in rice production. During dry season, one unit change in the cropped land will lead to 0.5112289 unit increase in productivity on average (Table 1b). This implies that during dry season the number of cropped land decrease compared to the number of cropped lands during wet season for rice production due to insufficient of water supply in the farm field from lwafi river during dry season.

The finding compares well with the study conducted in Tanzania, which argue that rice farming is characterized by various factors including environmental and non -environmental factors, from which land ownership and land size as a factor in rice production turns into positive influence towards yield of rice (Kulyakwave *et al.,* 2019).

Condition of secondary canal

Condition of secondary canal had a statistically significant positive influence on productivity in Lwafi-Katongolo irrigation scheme ($p<0.1$) (Table 1b). This means that a unit change in the condition of the secondary canal during dry season will increase productivity of rice in the scheme by 1.088189 when the other factors remaining unchanged.

This implies that the more improvement of secondary canals, for example canal aligning for water supporting in the farm fields, the more of the production during dry season. During the dry season more water is needed in the farm plots from water intake to compensate for water loss via evaporation which is high during the dry season. To ensure this happens therefore the secondary canals are required to be clean in order to deliver water more efficiently and reduce unnecessary water losses.

Narrations from KII narrated that "*farmers are highly encouraged to practice irrigation farming in Lwafi-Katongolo; however, infrastructure is not well supportive including secondary canals, thus poor returns in productivity especially during the dry season*".

Table 1a. Multivariate regression result on physical, environmental, social-economic and institutional factors influencing productivity of the Lwafi-Katongolo Irrigation scheme during the wet season.

Factors	Coef.	Std.Err.	t	p>It I	[95%conf. Interval]	
Existence of Distribution box	.7804797	1.265593	0.62	0.539	-1.729525	3.290484
Condition of main canal	-.9845623	.7892642	-1.25	0.215	-2.549882	.5807571
Condition of Secondary canal	-.5428989	.7093576	-0.77	0.446	-1.949743	.8639447
Land degradation in scheme	3.419756	2.528418	1.35	0.179	-1.594766	8.434278
Occurrence of flood in the scheme	-.0754557	.9004889	-0.08	0.933	-1.861363	1.710452
Source of water	-1.917987	1.846305	-1.04	0.301	-5.579698	1.743724
Relative position of irrigated area	.1212531	.6028154	0.20	0.841	-1.074289	1.316795
Sand soil in farm plots	.0761017	.5795867	0.13	0.896	-1.073372	1.225575
Responsible for maintenance and Operation	.0033752	.1673356	0.02	0.984	-.3284955	.3352458
Institutional leader existed	1.504536	.9488589	1.59	0.116	-.3773014	3.386374
Source of financial support	-.0505972	.1333416	-0.38	0.705	-.3150487	.2138544
Livestock in scheme	.1041638	.7340896	0.14	0.887	-1.35173	1.560057
Cropped Land Size	.9181199	.3424058	2.68	0.009 *	.2390387	1.597201
Use of water available in canals	.1865448	.1364175	1.37	0.174	-.0840071	.4570967
Experience of farmer in irrigation practice	-.0504018	.0613335	-0.82	0.413	-.1720424	.0712388
GVT-facilitation for maintenance	5.662204	4.75424	1.19	0.236	-3.766709	15.09112
Constant	5.065951	11.86919	0.43	0.670	-18.47378	28.60568

Note: *, ** and ***, are significant at 99%, 95% and 90% levels of significant respectively

Source: Field data (2021)

Table 1b. Multivariate regression result on physical, environmental, social-economic and institutional factors influencing productivity of the Lwafi-Katongolo Irrigation scheme during the dry season.

Factors	Coef.	Std.Err.	t	p>It I	[95%conf. Interval]	
Existence of Distribution box	.2663643	1.079106	0.25	0.806	-1.873789	2.406517
Condition of main canal	.6874959	.6729654	1.02	0.309	-.6471722	2.022164
Condition of Secondary canal	1.088189	.6048331	1.80	0.075 ***	-.1113553	2.287732
Land degradation in scheme	.1447632	2.155854	0.07	0.947	-4.130864	4.42039
Occurrence of flood in the scheme	-.1774551	.767801	-0.23	0.818	-1.700207	1.345297
Source of water	-.5054051	1.57425	-0.32	0.749	-3.62756	2.616749
Relative position of irrigated area	.9571261	.51399	1.86	0.065 ***	-.0622518	1.976504
Sand soil in farm plots	.0267921	.494184	0.05	0.957	-.9533054	1.00689
Responsible for maintenance and Operation	.0211527	.1426785	0.15	0.882	-.2618165	.3041219
Institutional leader existed	-.1166773	.8090436	-0.14	0.886	-1.721225	1.48787
Source of financial support	-.047226	.1136936	-0.42	0.679	-.2727103	.1782583
Livestock in scheme	-.568346	.6259208	-0.91	0.366	-1.809712	.6730204
Cropped land size	.5112289	.291952	1.75	0.083 ***	-.067789	1.090247
Use of available water in canals	-.0799788	.1163163	-0.69	0.493	-.3106646	.1507071
Experience of farmers in irrigation practices	-.1047011	.052296	-2.00	0.048 **	-.2084179	-.0009844
GVT-facilitation for maintenance	30.10553	4.053698	-7.43	0.000 *	-38.14508	-22.06597
Constant	57.38346	10.12025	5.67	0.000	37.31233	77.45459

Note: *, ** and ***, are significant at 99%, 95% and 90% levels of significant respectively

Source: Field data (2021)

Relative position of irrigated area

Relative position of irrigated area had statistically significant positive influence on productivity in Lwafi-Katongolo irrigation scheme (p<0.1) (Table 1b). This means that one unit change in the relative position of irrigated area closer to water intake will increase the production by 0.9571261 on average. This implies that there is relationship between position of farm plots and direction of water sources, the closer the farm field to the water source the more the chance of getting sufficient water by gravitational force.

These findings share the same with the study by (Materu *et al.,* (2018) on water use and rice productivity for irrigation management as it explains farm plots above the water source (river) are still facing the problem of water allocation, already levelled, get water at the right time hence good yield per area of production

Experience of farmers in irrigation practices

Experience of farmers in irrigation practices had statistically significant with negative influence on productivity in Lwafi-Katongolo irrigation scheme ($p<0.05$) (Table 1b). This means that a unit reduction in the experience of farmers in irrigation practices during dry season will decrease productivity of rice in the scheme by 0.1047011 when the other factors remaining unchanged.

The finding is also elaborated using FGD, as they pin pointed that ,the most farmers who engage in Lwafi-Katongolo irrigation scheme for rice production are non-owner of the land in the scheme, this contradict much on productivity since, most of the farmers are with less experience in irrigation practices from which , some of farmers has less knowledge on water saving, as well as poor participation in payment for water collection fees, thus failure for regular maintenance of the irrigation scheme as demanded by water user association for sustainability of irrigation scheme.

Government Facilitation for Maintenance

Government facilitation for maintenance has a statistically significant positive influence on productivity in Lwafi-Katongolo irrigation scheme ($p<0.01$). This means that a unit change in the government facilitation for maintenance during dry season will increase productivity of rice in the scheme by 30.10553 holding other factors unchanged (Table 1b). This means that sufficient funding from government is crucial in ensuring productivity irrigation schemes. It might as well reflect issues associated with availability of extension staff and their physical presence during critical periods of production and expert input into the operation of these schemes. The findings compared well with (Mdemu *et al.* (2017). in Tanzania, that, the lack/insufficient financing by the government in irrigation schemes is a critical barrier for increasing the overall productivity in the scheme. While there are many factors that seem to influence productivity in the scheme not all of them were significant and thus cannot be considered to influence production. it seems that government facilitation and condition of the secondary irrigation canals are of significant importance in ensuring productivity in the irrigation scheme as their unit influence is greater than all other factors. This would mean that for success in improving productivity the two factors are of high importance. Government facilitation may be in the form of funding part of the production process such as subsidies in agriculture inputs, technical assistance during the growing season and onsite extension services to ensure proper implementation from the technical point of view. Maintenance of irrigation canals and water intake to ensure efficient water delivery is of importance especially during the dry season when the quantity of water dwindles and proper allocation becomes of paramount importance to ensure each farmer or each field is allocated water properly and sufficiently.

Climatic factors

Rice production in irrigation schemes does not only depend on the physical, environmental, social - economic factors but it also depends on the climatic condition of the area (Kawasaki & Herath, 2011).Though not included in the model and taken care by the seasons, but it has an effect on rice production in the scheme.

Temperature

The mean annual minimum temperature at Lwafi - Katongolo 20.6 °C and the maximum temperature is 30.6 °C and has been constant and consistent over the years (Fig. 2). This is a normal trend and optimum temperature for rice production in the scheme. The optimal temperature for optimal rice production has been said to be between 22°C and 31°C, above which yield of rice tend to decrease due to high rate of evaporation (Thakur, 2018). It has been argued that the effect of minimum and maximum temperatures in the field has a relationship with productivity due to dynamics of solar radiation and crop evapotranspiration per day (Thakur, 2018).

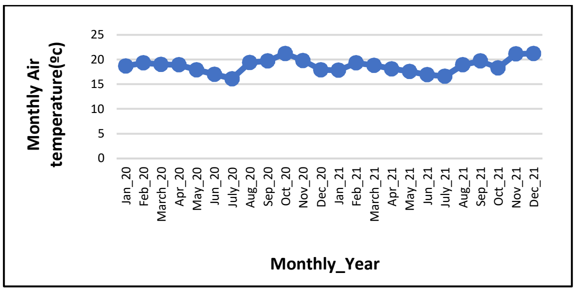

Fig. 2. Trend of air temperature in the year 2020 and 2021. Source: Sumbawanga Metrological Station

Rainfall

The amount of rainfall shows to have increased by 1.5837 annually verified by four years from 2017 to 2020 with a range of 200mm (1300-1500mm) (Fig. 4). Such high rainfall had extreme negative implications on rice production by causing destruction of infrastructure leading to poor production. Rainfall in Lwafi -Katongolo shows increasing trend since the year 1981 (Fig. 4) but decreased by 5.9169 from 2020 to 2021 (Fig. 3). Focus Group Discussions revealed that among the challenges facing the scheme were floods and over flows in the river making it difficult to cultivate during the growing season with side effect of land degradation.

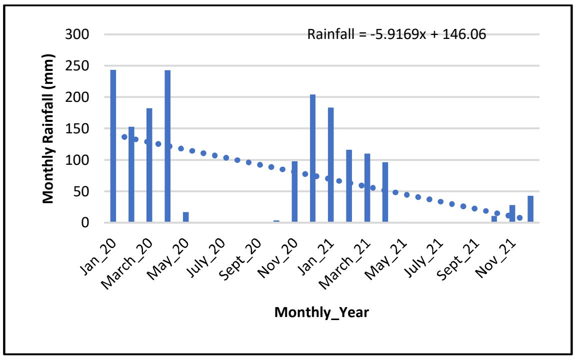

Fig. 3. Trend of rainfall in the year 2020 and 2021.

Source: Sumbawanga Meteorological station

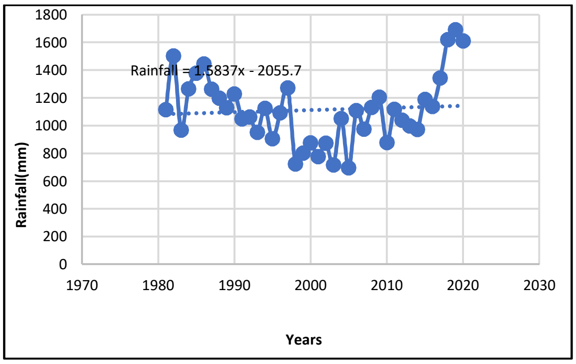

Fig. 4. Trend of annual rainfall in Lwafi-Katongolo.

Source:https://power.larc.nasa.gov/data-access-viewer/

Field data: Latitude: 7.26 °S Longitude:30.43 °E

Water discharge

The climate variability had an effect on the water supply and delivery in the irrigation scheme. Lwafi - Katongolo irrigation Scheme uses the Lwafi River as the main water source for irrigation activities. The flow trend over the period 2019 to 2021 (Fig. 5). It is apparent that there has been a general decreasing flow of 40.36m³/s for the three years period. However, the trend in Fig. 5, shows an increase in wet season with water flow of 421.34m³/s on average from October to May and rapid decrease of water flow from June to September of 19.42m³/s on average. Likewise, the trend of water flow (m³/s) from the river went proportionally with rainfall trend for 2020 to 2021 period (Fig. 3) with a decrease of 5.9169mm for rainfall. This signals a decrease in rice production since the scheme is much dependent on the river and rainfall as a main water source for rice production.

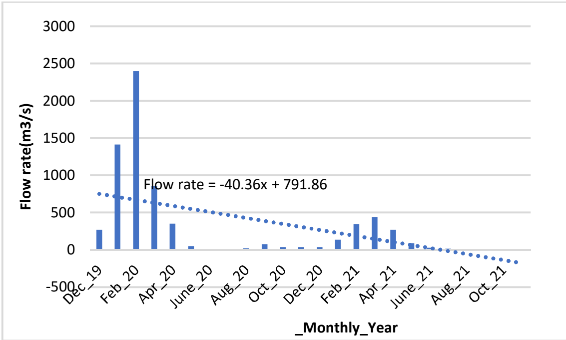

Fig. 5. Trend of flow rate(discharge) for Lwafi river in a respective year.

Source: Lake Tanganyika basin water board

The findings on trends for water flow compare well with a study done in Chao Phraya River basin, which show the river face un-precedented challenges on water resources, as it exist with water deficiency that made impossible for the scheme to realise the potential production in dry season, based on water demand for most farmers (Molle *et al.,* 2001).

Farmers satisfaction on irrigation services

Different statements were used to measure the level of satisfaction on irrigation services in Lwafi - Katongolo scheme using farmers response (Table 3). Majority of farmers were neutral as to the extent of satisfaction in regards to water management and delivery services to enhance productivity in the irrigation scheme (Fig. 6). Majority of the farmers (62.5%) were dissatisfied with the way planning of water delivery schedule were done by the Regional Irrigation Officer (RIO) and water the User Associations (WUA).

This means that there is unsatisfactory service from the RIO toward WUA for better irrigation performance. Most farmers (72.5%) were neutral as to the satisfaction on discussions by the chairman of irrigation organisation (IO) and WUA for schedule planning agreements. This means most of farmers stood in the middle of the road (undecided) on the issues of water scheduling. This stance however may mean some problem issue in the scheduling of water delivery and may as well influence productivity. Water scheduling to ensure each farmer accesses water for irrigation is crucial if productivity in irrigation schemes have to be successful. Furthermore, majority of farmers seem not to be satisfied by the way farmers seek and respond to opinions from WUA and IO ((85.8%) as well as announcement of irrigation schedule (82.5%) and were in neutral position in this respect. The adequacy of timeliness (49.2%), fairness (55%) in water distribution reliability of continuous flow (65.8%) and ditch condition (clean/smooth) (50%) in the scheme was quite dissatisfactory among farmers. This reflects the flaws/imperfections in on time irrigation water availability which may affect negatively the productivity of the irrigation scheme.

Table 2. Minimum, Maximum temperature and solar radiation (Average from 1981-2020).

Monthly	Min_Temp (°c)	Max_Temp (°c)	Solar rad, MJ/m²/day
January	21.5	29.1	28.9
February	21.9	29.4	29.1
March	21.9	29.6	28.1
April	21.4	29.1	26.3
May	19.6	29.4	24.0
June	17.6	28.9	22.8
July	17.1	29.1	23.4
August	18.8	31.4	25.5
September	21.1	33.3	27.7
October	22.8	34.1	28.9
November	22.3	33.6	29.0
December	21.7	31.1	28.8
Average	20.6	30.6	26.9

Field data: Latitude: 7.26 °S Longitude:30.43 °E

Source: https://power.larc.nasa.gov/data-access-viewer/

Table 3. Level of farmer satisfaction on irrigation services.

Variables	Response: Frequency (Percentage)					
	SD	D	N	S	SS	Mean
1.Planning of water delivery schedule by RIO and WUA	5 (4.2)	75 (62.5)	38 (31.7)	2 (1.7)	0 (0)	2.308
2. Meeting between chairman of IO and WUA for Schedule planning agreement	0 (0)	20 (16.7)	87 (72.5)	13(10.8)	0 (0)	2.942
3. Listening to the opinion of WUA from RIO	0 (0)	13 (10.8)	103(85.8)	4 (3.3)	0 (0)	2.925
4. Announcement of the irrigation Schedule to all WUA	0 (0)	14 (11.7)	99 (82.5)	7(5.8)	0 (0)	2.942
5.Adequacy of water distribution	0 (0)	55 (45.8)	59 (49.2)	6 (5.0)	0 (0)	2.592
6. Accountability of timeliness and fairness of water distribution	0 (0)	52 (43.3)	66 (55)	2 (1.7)	0 (0)	2.583
7.Reliability of continuous flow	1 (8)	39(32.5)	79 (65.8)	1 (8)	0 (0)	2.667
8. Canal/ ditch condition (clean/smooth)	4 (3.3)	56 (46.7)	60 (50.0)	0 (0)	0 (0)	2.467

Source: field data (2021)

* SD-Strongly dissatisfied; D-Dissatisfied; N-Neutral; S-Satisfied; SS-Strongly satisfied

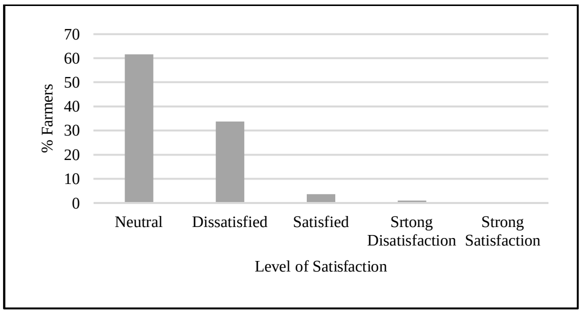

Fig. 6. Response overall statements toward irrigation service.

These findings are well in opposite of the study conducted in South Africa on farmers satisfaction in irrigation services using multinomial logistic regression model in which 57% of farmers were satisfied with the irrigation services,30% were not and 13% were neutral (Gomo *et al.,* 2014).

Conclusion

The finding of the study indicated that 4 variables among of 16 variables tested influence positively toward productivity of the scheme. These included cropped land size as a socio-economic factor, condition of secondary canal as a physical factor, relative position of irrigated area as environmental factor and Government facilitation for maintenance as the institutional factor. However, one variable which was experience of farmers in irrigation practices (socio-economic factor) influence negatively toward productivity of the scheme and only one factor (cropped land size) had influence during the wet season. The influence of the other factors was during the dry season. Water flow in the Lwafi River as a water source for irrigation in the scheme increase substantially during the rainy season sometimes becoming destructive due to flooding though flows decrease during the dry season resulting into water shortage. Such conditions create substantial constraints in water allocation and satisfactory performance of the irrigation scheme. Majority of farmers were neutral as to the extent of satisfaction in regards to water management and delivery services to enhance productivity in the irrigation scheme. Dissatisfaction was more prevalent in the way planning of water delivery schedule were done, communication among stakeholders planning of irrigation schedule, and reliability of continuous flow. Flaws/imperfections in on time irrigation water supply and availability is likely to affect negatively the productivity of the irrigation scheme.

Recommendation

i. Proper planning for improvement and rehabilitating damaged infrastructure and completion of the constructing of remaining secondary and, tertiary canals are imperative to ensure maximum potential of the scheme is achieved
ii. A water dam as per design of 2016/2017 of Lwafi-Katongolo irrigation scheme is important to ensure adequate water especially during the dry season due to unpredictable flow of Lwafi-river in dry season
iii. Maintenance and operation of the scheme including scheduling of water delivery should be done collaboratively between farmers, WUA and technical government staff with WUA taking the upper hand for sustainability of the scheme.

Acknowledgement

Many thanks go to the staff of Nkasi District council, irrigation organization leaders, the local village government of Katongolo, Masolo, Kamwanda and Mpata villages. More grateful to farmers and other stakeholder who gave their valuable time and response during data collection and study evaluation.

Abbreviations

WUA= Water user association
RIO= Regional irrigation officer
IO= Irrigation organization
FGD= Focus Group Discussion
KII= Key Informant

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