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Economics of Rice Irrigation Technologies in Kilombero Sub-Basin: A Case of Farming Households from Kilombero in Morogoro, Tanzania

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Abstract

The System of Rice Intensification (SRI) is strongly emphasized by the Ministry of Agriculture in Tanzania to replace traditional flooding. SRI technologies have been scientifically proven to be more efficient in water use than traditional flooding (TFIT). SRI irrigation is therefore a good solution to approach climate change impacts that leads to water stresses, particularly in the country's water basins where rice farming is largely taking place. However, the economics of these irrigation technologies has not been satisfactorily evaluated especially at the farming household level. The information on the economics of the two technologies is important in understanding why some farmers are still using TFIT. Kilombero sub-basin presents a compelling case for this study as 90% of irrigable land in the sub-basin is under TFIT. The study used Net-Revenue (NR) to evaluate profitability, and multiple linear regressions to evaluate factors influencing the profitability of the two irrigation technologies at household level. Results from the study show that an average of TZS 816,425 accrued by SRI irrigators, which is relatively higher than TZS 336,646 per acre accrued by TFIT irrigators. These benefits are obtained at different variable costs, for instance, SRI had an Average Variable Cost of TZS 471,572, which is relatively higher than TZS 248,939 per acre under TFIT. Also, results show that household head years in irrigation, years spent in education, access to extension services, application of fertilizers, and size of land allocated to rice production, are significant predictors of the profit of both technologies. For example, each incremental unit of fertilizer applied would cause an NR increase of TZS 534, 181 (in SRI plots), and TZS 5145 (in TFIT plots). The study thus recommends that subsidization of inorganic fertilizers could be adopted in an effort to increase rice productivity and profit accrued by farming households.

Keywords: *Irrigation technologies, sub-basin, Net revenue, Traditional flooding, SRI, and farming household*

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Introduction

Increased water demand and reduced river flows due to Climate change impacts that have led to low rainfall are affecting Tanzania's 9 major basins (i.e. Pangani, Wami and Ruvu, Rufiji, Ruvuma and the Southern Coast, Lake Nyasa, Lake Tanganyika and the Lake Victoria and internal drainage such as Lake Rukwa Basin). Water quantity in many of these basins is reduced at an alarming rate. This effect is indicated by reduced water flow in the streams and rivers draining from these basins (Hella *et al.*, 2020; Mutayoba, 2019; Näschen *et al.*, 2019). As a result of reduced water flow, agricultural activities in these basins are at high risk as the activities could be vulnerable to climate change impacts on the basins., The most recent report by Wilson *et al* (2017) on the Kilombero sub-basin (KSB) has raised the concern about the future water availability in the basin. According to this report water in the basin will continue to decline over time, a situation that threatens the health of the sub-basin and its economic activities like irrigation agriculture.

To overcome the effects of reduced water flow in the sub-basin, it is deemed imperative to think about the way irrigation is done in the area. Rice production being one of the major crops produced in the area that needs water, an effort to cope with this water stress caused by the climate change effect is needed because water is decreasing in an area over time. Agricultural economics just like other economic studies is a study of choice-making, it is therefore important to provide necessary economic insights into what is driving the choice of appropriate irrigation technology in KSB. Irrigation is one of the copying strategies for climate change impacts, however choosing an appropriate technology [1]is imperative to this climate change impacts coping strategy.

Irrigation as a technology entails a managerial approach of using water to grow crops in an area of low rainfall or extend the production season where there is water availability. KSB is one of the areas where production can be extended because of water availability. However, as noted above the area is facing a reduced water flow because of climate change. Households in this area are faced with the challenge of choosing an appropriate irrigation technology, the decision includes how water is used, whether flooding or controlled watering for plant growth (Mnyenyelwa, 2008). Also, Amankwah and Egyir (2013). Irrigation technologies for rice production in the sub-basin may be categorized into traditional flooding and SRI irrigation. Under the former technology, with the exclusion of the period of controlling weeds, constant pond water is maintained in the field until when drainage is done for harvesting (Orasen *et al.*, 2019). Meanwhile, the later technology involves minimum use of existing water through alternate wetting[2] and drying[3] the fields during the vegetative period of the plant (Katambara *et al.*, 2013).

Scientifically, traditional flooding irrigation technology (TFIT) is mentioned to be the technique that uses large amount of water as it allows a lot of water to be lost through surface evaporation. Yet, the technology has low water productivity, implying low water use efficiency(Gowele *et al.*, 2020). This is contrary to SRI irrigation, which assures preciseness in providing plants with water in accordance with its requirement. This SRI irrigation technology has been proven ergonomically to be relatively efficient in water usage (Makoye, 2013). Therefore, emphasis has been put especially by the government of Tanzania (GoT) to convince farmers to shift from TFIT which is less water use efficient to SRI irrigation which is more water use efficient in KSB.

Further, it was expected that farmers would switch from traditional flooding irrigation to SRI because of high-efficiency water use. However, more than 90% of the sub-basin irrigable land is still under TFIT (Olson *et al.*, 2015). This implies that more investigations need to be done on the two irrigation technologies that can be used in the sub-basin given the ongoing reduced water flow. From an agronomic perspective, it is clear that irrigation under SRI is water-use efficient but it is not clear about its economics. Information on the economic performance of the two rice irrigation technologies is important in designing appropriate intervention policies to induce the shift (Musamba *et al.*, 2011). Costs incurred and benefits accrued between SRI irrigation and TFIT

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[1] Appropriate technology refers to a technology that is both water use and economically efficient.

[2] Alternate wetting entails adding water to the field where rice plants are grown

[3] Drying means removing water from the field where rice plants are grown.

will be additional information to policymakers besides the already known agronomic performance. Equally important, information on what determines the profitability of these irrigation technologies is imperative to the policymaker to introduce policies that will help shift from TFIT to SRI in the area. To achieve this, the study aimed at evaluating profitability and its determinants for both rice irrigation technologies in KSB, using household as the unit of analysis.

Materials and Methods

Location and description of the study area

Kilombero Sub-basin Basin extends into three districts namely Kilombero, Ulanga, and Malinyi which are administratively found in the Morogoro region located in Southern Central Tanzania. The sub-catchment is suitable for the production of a range of crops distributed according to the differences in microclimatic conditions. Kilombero district is the leading district in rice farming and following this fact, data for this study was collected in Kilombero District during the midst of the year 2022 (June-July). The district headquarters are found in Ifakara town which is located 410 km away from Dar es Salaam. Geographically the district is located in the Western part of the Morogoro region, lying between the latitude 70°21' South of the equator and between the longitude 35°20′ and 37°48′ East of longitude 0 (KDC, 2017). The district is surrounded by Mufindi district in the Northern part, Kilosa, Mvomero, and Morogoro Districts to the East, and Songea and Ulanga Districts to the South-East. According to Wilson *et al* (2017), the district has a population 407 880 based on the census of 2012, and the sub-catchment has about 400 000 hectares of arable land of which rice production occupies more than 90% of the land.

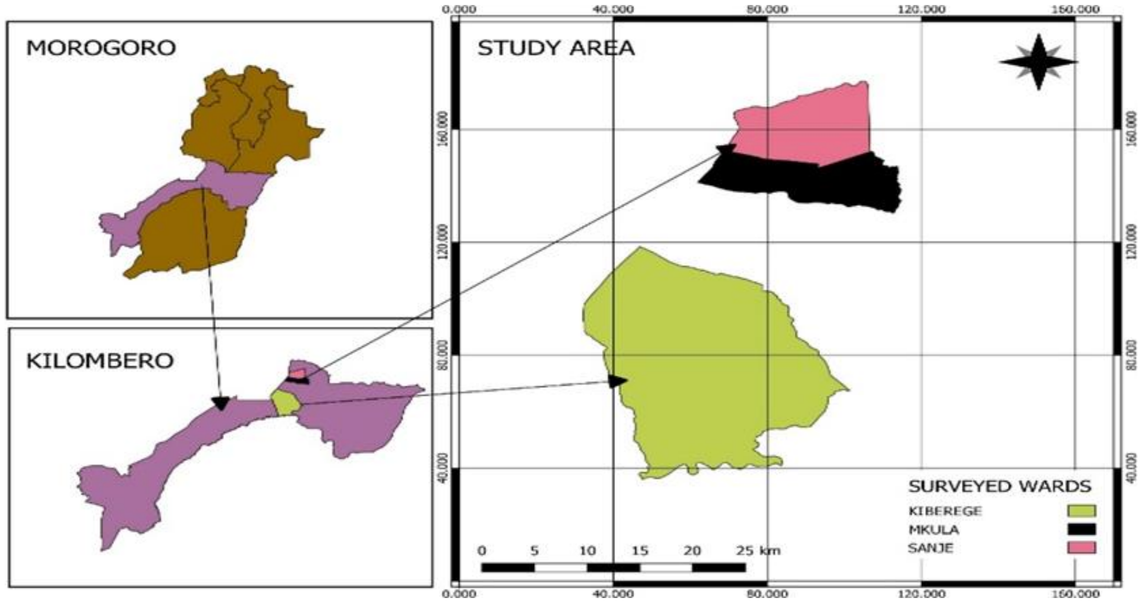

Figure 1. Map of Kilombero Districts showing surveyed villages

Data for this study were collected in four villages which were purposefully selected from three wards. These villages included (1) Sululu village which is found in Signal ward ; (2) Mkula village which is found in Mkula ward; (3) Sanje village which is found in Sanje ward; and (4) Msolwa Ujamaa Village which is found in Sanje ward. The villages and the respective wards were intentionally selected based on the existence of rice irrigation schemes where SRI irrigators could be easily approached.

Data collection

Primary data were used and these data were collected by using a face-to-face household survey using structured household questionnaires. The survey employed stratified random sampling. The stratification was done to separate households using SRI irrigation from those using traditional flooding irrigation as two strata. 50 households were selected from each stratum to make a total of 100 rice farming households. In addition, Sululu, Mkula, Msolwa Ujamaa, and Sanje were randomly represented by 24, 25, 22, and 29 rice farming households respectively to make the sum of 100 rice farming households.

Moreover, data on demographic and socio-economic characteristics of rice farming households, food security (rice), income sources, labor days spent on rice production, quantitative information on production inputs used, and rice harvest were collected from farming households. Adding on that, prices of rice and inputs in farmers' nearby markets were also collected. Data collection was scheduled and done in June 2022 when the 2021/22 cropping season was not yet over. This means that the study was able to collect information and production and harvesting for the production season of the year 2020/21

Analytical framework

The profitability of households engaged in the production of irrigated rice in the study area was calculated considering the value of all rice harvested (consumed or sold) by a particular household. The farm budgeting method was used to calculate profitability. The farm budgeting method was used to compute Net Revenue (NR)[4] per acreage and individual farming terms.

For individual farming households, NR of traditional flooding and SRI irrigated area were calculated as follows:

$$NR_t^i = P_{r\,t}^i * RS_t^i - \sum\left(Q_{seed\,t}^i * P_{seed\,t}^i\right) + \left(Q_{pesticide\,t}^i * P_{pesticide\,t}^i\right) + \left(Q_{fertilizer\,t}^i * P_{fertilizer\,t}^i\right) + \left(MD_{labor\,t}^i * W_{labor\,t}^i\right) \quad (1)$$

Where: NR_t^i = net revenue earned by farming household under technology i at time t, $P_{r\,t}^i$ = market price of rice grown in technology i at time t, RS_t^i= total household rice under technology i at time t, $Q_{seed\,t}^i$= total quantity of seeds applied in technology i at time t, $P_{pesticide\,t}^i$= market price of pesticide used in technology i at time t, $Q_{fertilizer\,t}^i$ = total quantity of fertilizers used in technology i at time t, $P_{fertilizer\,t}^i$= market price of fertilizer used in technology i at time t, $MD_{labor\,t}^i$= total number of man-days used in technology i at time t and $W_{labor\,t}^i$= wage paid for man-days in technology i at time t.

After obtaining profit, the following multiple linear regression model was specified to evaluate what determines the profit under a given rice irrigation technology applied. This analytical tool was used to make an evaluation to address the first and second specific objectives

$$\pi_t^i = \beta_0 + \beta_1 Hlab_t^i + \beta_2 Hexp_t^i + \beta_3 FS_t^i + \beta_4 HYedu_t^i + \alpha_1 HHsex_t^i + \alpha_2 CA_t^i + \varepsilon \quad (2)$$

Whereas π_t^i is the endogenous variable of profit realized by rice farming household in the technology applied 'i' in period t, while exogenous variables are $Hlab_t^i$ representing household labor provided in technology i in period t, $Hexp_t^i$ is the farming household experience in rice irrigation technology i in period t, FS_t^i is farm size where irrigation technology i is applied in $period$ t, $HYedu_t^i$ is the years in the education of household head that applied technology i in period t, $HHsex_t^i$ is the sex of household head that applied technology i in period t and CA_t^i stands for whether farming household applied technology i in period t accessed credit or otherwise. β_0 β_1 β_2 β_3 β_4 α_1 and α_2 are parameters being estimated, where the first four are continuous and the last three parameters in the sequence are for dummies, ε represents error term.

Results

Social Economic Aspects of Households Surveyed.

The statistics in Table 1 show that of the 100 households interviewed, 54% were male-headed. The average age of household heads is 46.71 years. Household size ranges from 1 to 11, with an average of 4.81 persons per household. Education levels in the study area are quite low;

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[4] Net revenue values are not discounted; they are just values from point analysis recorded in the 2020/21 season

the average number of years of education f a household head is 8.845 year, which corresponds to primary education given that even years spent in nursery education are all considered. In addition, only 27% of household heads interviewed completed secondary education.

Table 1. Descriptive socio-economic aspects of household surveyed

Variable	Mean
Household size	4.81
Household head level of education attained (years in schooling)	8.845
Age of household head (years)	46.71
Household labor force	2.91
Irrigation experience (in years)	6.3
Rice quantity consumed (Threshed Kg/household/month)	27.71
Land size (acres)	2.255
Labor used in rice farming (days/household/season)	26.95
Rice retained for own consumption (threshed Kgs)	435.28
The yield of rice sold (threshed kgs)	1,350.82
Revenue from rice sales (TZS)	1,340,258
Net Revenue (TZS)	1,089,538
Extension access (number of extension officer visits/last two seasons)	3.33

In response, this finding answers another result found in the study area, that is, most households entirely depend on-farm activities as shown in Figure 3. This can be shortened by stating that households in the area find themselves in the farming sub-sector alone, probably due to their low level of education which ultimately hinders them from getting formal employment

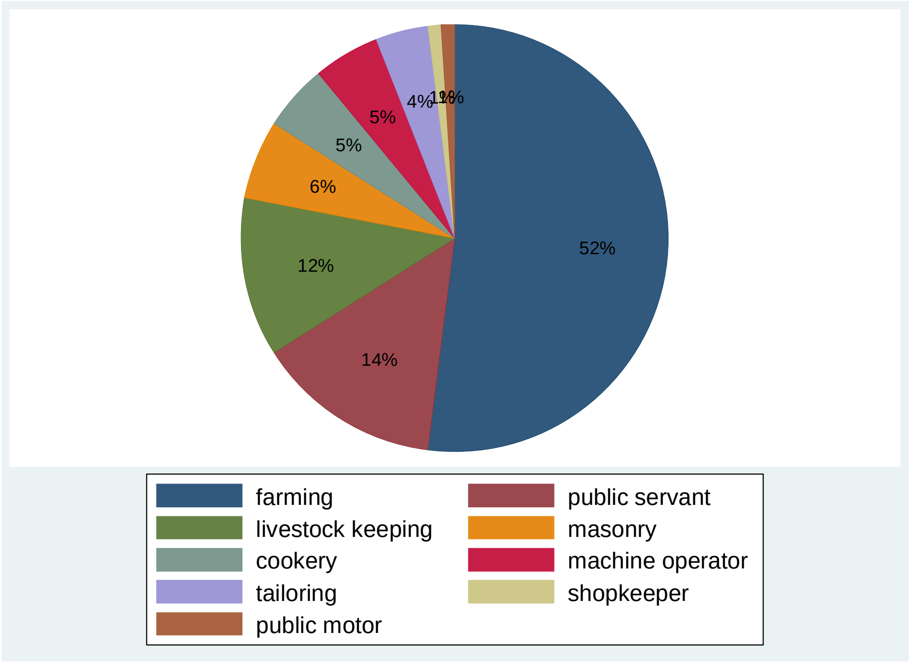

Figure 2. Household head occupations

Figure 2 describes other economic activities that were reported by representative household heads in the four villages surveyed. 52% utterly relied on farming activities meanwhile the rest were also undertaking other economic activities like public service, livestock keeping, masonry, and fewest in shopkeeping.

Production costs in a given irrigation technology applied.

The findings in Table 2 indicate that the average cost per acre incurred in managing soil fertility is relatively higher in SRI than in traditional farming technology. This is because most of the farm plots under SRI are located in less fertile areas than plots under traditional flooding. Results in Table 2 also show that the average labor service charge in SRI was TZS 322,594 which is higher than 171,682 observed in traditional flooding, this can be attributed to the fact that the two technologies differ in labor requirement. SRI is labor intensive than traditional flooding. More important, a minimum cost of zero in both technologies implied that some farming households did not incur costs for labor services. These households had zero man-days paid because they devoted their labor. Nonetheless, the cost incurred in purchasing pesticides under SRI is higher than in traditional flooding by about TZS 18,164 compared to TZS 9,043.619 respectively indicating that farmers in SRI plots were much invaded by pests and hence munch more expenditures in pesticide purchases.

Table 2.

Table 2. Production Costs

Variable (Costs in TZS)	SRI			Traditional flooding		
	Mean	**Min**	**Max**	**Mean**	**Min**	**Max**
Seed	14,854.67	0	300,000	6,883.3	0	45,000
Rent	44,066.67	0	200,000	40,667.3	0	200,000
Granular fertilizer	68,142.8	0	240,000	19,047	0	120,000
Liquid fertilizer(booster)	3,750.0	0	42,000	1,616.67	0	14,000
Labor	322,594.3	0	666,666.7	171,682	0	615,000
Insecticide	18,164.0	0	120,000	9,043.6	0	97,142.9
TVC	471,572.5	0	1,018,333	248,939.9	0	950,000

Table 2 also reveals that the average rent of land per acre in SRI was TZS 44,066 which was higher than the 40,667 observed in traditional flooding. This implies most SRI farmers rented their land which is driven by the fact that SRI plots in the surveyed areas are found in irrigation schemes where most farmers rent plots on a seasonal basis as buying cost is greater than convectional plots for traditional flooding found outside of the scheme. Further, zero minimum rent cost tells that some farming households did not incur the cost for land renting in the season under consideration since they already owned the land permanently by inheriting or purchasing. Generally, SRI had a higher total variable cost (TVC) of TZS 471,572 than 248,939 in TFIT due to higher labor requirements and soil management of the former technology. Adding to that, zero minimum TVC, indicated that some farming households did not incur any cost in renting, fertilizers and insecticides probably due to failure to afford these agricultural inputs.

***Net Revenue accrued to farming households*.**

Results in Table 3 show that on average households who applied SRI and TFIT in the 2020/2021 cropping season, recorded total NR of TZS 1,276,841 and 902,236 respectively, and an average of TZS 816,425 and 336,646 per acre of SRI and TFIT respectively which generally indicate that almost all farming households engaging in rice production in both technologies were operating at profit. More important is that SRI was found to be more profitable than TFIT due to controlled water usage that accelerates water productivity. The implication drawn from total NR (TZS 1,276,841) in SRI is at least half of the current Tanzania GDP per capita. Therefore, even in the neglection of other economic activities possibly undertaken by surveyed household heads, still farming households under SRI technology in the study area are not far from the threshold individual Tanzanian income.

Table 3. Net Revenue under the technologies applied

Variable	TFIT				SRI			
	Obs	Mean	Min	Max	Obs	Average	Min	max
Total NR	50	902,236	-277,000	4,377,000	50	1,276,841	-347,000	7,530,250
NR/acre	50	336,646	-144,666.7	1,682,000	50	816,425.9	-184,400	2,960,000

However, negative figures in minimum NR in both technologies indicated that some farming households were operating at a loss. Results show that a small number of households operated at loss with a minimal NR per acre of TZS -184,000 and –144,666 for SRI and TFIT respectively. SRI had a smaller minimum NR over TFIT probably since few farmers in SRI had no income to acquire the required pesticide on time. Also, this undesirable return from their farming could be attributed to low yield which is further caused by low frequency of weeding and low experience in farming (Kangile, 2015).

Determinants of profitability per technologies applied

Results in Table 4 present factors determining net revenue in TFIT and SRI from the multiple linear regression models. Results show that explanatory variables specified in the model for TFIT and SRI successfully explained variation in the NR by 73.28% and 77% respectively derived from adjusted R-squares. From these results, it has been observed that household head's years spent in schooling are positively related to profit accrued from traditional irrigation and SRI technologies. Results show that for each increment in a year spent in schooling by the household head will increase the profit by TZS 39,163.09 and 75,793.58 for TFIT and SRI respectively. These imply that education has a more substantial effect on understanding the scientific role of the technologies in question in increasing revenue accrued from the two technologies.

Household experience in irrigation has a positive effect on profit accrued from both technologies. However, the effect was significant on TFIT and not significant on SRI. Results in Table 4 show that each increase in experience measured as years in practicing a given irrigation technology increase profit accrued by TZS 75,671.08 and -86,609 for TFIT and SRI respectively. The interpretation that is drawn from the finding is that an experienced farmer in TFIT is getting more profit compared to the experienced SRI applier.

In furtherance, as was initially expected, the number of extension visits was positively associating with profit accrued by farming households of rice grown in both technologies. Provided that all other factors are held constant, every extension visit (be it a farm visit or other visiting form) would cause a rise in profit level by TZS 101,695 for TFIT and TZS 169,915 for SRI. The magnitude of the relationship shows extension visits have a bigger impact on profit for SRI irrigators compared to TFIT appliers.

In soil management, profit was significantly increased by each unit of granular fertilizer added in the production process under TFIT, at the same time profit among SRI irrigators was significantly increased by each unit of liquid fertilizer added in farming. Table 4 shows liquid fertilizers have more significant profitability in SRI irrigated farms while granular profitability is significantly realized in TFIT farms. Output data in Table 4 however shows SRI has a bigger change in profit of TZS 534,181 caused by a unit change in fertilizer compared to TFIT which is TZS 5145.787. This variation in fertilizer coefficients can be justified by the fact that SRI appliers were more knowledgeable and skillful in using fertilizers as they were very close to extension officers compared to TFIT irrigators.

Table 4. Regression results on profitability determinants under TFIT and SRI

Independent variables	Expected sign	NR under TFIT	NR under SRI
Household headship	+/-	-38,479.86(0.20)	34,539.3(0.12)
Household head years in schooling	+	39,163.09(2.11)**	75,793.58(2.12)**
Household head experience years in irrigation	+	75,671.08 (2.71)**	-86,609.44(1.32)
Form of rice sold	+	-251,564.7(1.04)	323,445.1(0.97)
Extension Visits	+	101,695.2(2.33)**	169,915.8(2.82)**
Credit borrowing	+	138,759.8(0.45)	595,989.9(2.10)*
Insecticides	+	-7,058.311(0.13)	-24,423.06(0.36)
Liquid fertilizer	+	101,750.7(1.22)	534,181(3.64)**
Granular fertilizers	+	5,145.787(2.00)*	2,556.79(0.78)
Village residing	+	215,894.3(0.87)	566,808.9(2.10)*
Land size	+/-	76,290.69(2.10)**	485,595.6(2.65)**
Intercept	+	-232,488.8(0.48)	-467,534.4(0.63)

** and * indicate Significance at 1% and 5% levels respectively.0.7328 and 0.7703 are the adjusted R-squared for the regression of TFIT and SRI GM respectively. T-values are in parentheses.

Furthermore, an acre increase in land size significantly caused an increase in net revenue by TZS 76,290 and 485,595 for TFIT and SRI irrigation respectively. This indicates, given the same amount of seeds and other inputs, an increase in land size has been shown to have led to more net revenue for SRI compared to TFIT.

Location (village) in which farming household resided was also found significant to explain variation in profitability among farming households especially under SRI where holding other factors constant, households residing in Mkula ward were found to have significantly earned higher NR than those residing in Msolwa Ujamaa by an average of TZS 566,808.9 difference. This locational difference in profit could be attributed to the presence of advantageous infrastructures like a huge rice milling plant in Mkula village that makes farming households in the ward sell threshed paddy that from a grain marketing perspective is expected to be sold at higher prices due to value addition.

Discussion

Results from socioeconomic aspects of the surveyed farming households showed each farming household had an average of 5 members. This has very important implications for the food security status of these households, as it was reported in FGDs conducted in all villages surveyed, representative household heads were complaining of food shortage in the months of February, March, and the beginning of April because most households are extended families with a high number of members. The finding is in line with what Awoke *et al* (2022) found in Ethiopia where the mean household size reached 6 and there was found a direct positive relationship between household size and the probability of the household suffering food insecurity in any month of the year. Nevertheless, the average years spent by household head in schooling was 8.84, indicating that the majority ended their journey of formal education just after completing standard seven as a result, it was further found that 52% of the household heads surveyed solely relied on agriculture for making their livelihoods. This result according to Khoza *et al* (2019) has often meant an increase in family labor devoted to farming activities as the room for formal jobs is likely to be closed for such household heads. Also, the mean age of household heads is 46.7 years which indicates that the majority of household heads are in working years either by directly participating in farm operations or provision of managerial roles to laborers. Adding on that the mean household labor force is almost 3, indicating that household dependents are relatively fewer to the mean household size. The age of the household head and the labor force available could possibly tell that household labor has a substantial contribution to rice production.

Moreover, findings from the breakdown of production cost in Table 2 showed that the cost of labor represented the highest expense incurred by farming households in both rice irrigation technologies. Farming households who applied SRI irrigation were incurring relatively higher expenses in the labor of TZS 322, 594 than their counterparts, TFIT farmers who incurred an average of TZS 171, 682 per acre. This has generally indicated that SRI irrigation is labor intensive probably due to the added activities like alternate wetting and drying which are common in SRI irrigation but not in TFIT. The finding is consistent with what Kumar and Nayak (2013) found in India that SRI irrigation needs 50% more man-days than traditional irrigation to cover the added set of activities. Also, one of the noteworthy findings in the cost breakdown was that higher costs were incurred in pesticide purchases for SRI irrigated acre over it was in TFIT. The pesticide cost figure (18, 164) for SRI was almost doubled to TFIT one (9043). This could be attributable to the fact that SRI irrigation allows for pests to hide under the plant leaves while traditional flooding doesn't because of flooded water under the plant leaves. This is because SRI has less water under the leaves compared to traditional flooding (Dobermann, 2004).

In terms of profitability realized by farming households applying any of the two technologies (table 3), Net Revenue (NR) accrued in an acre irrigated under the SRI regime was found to be TZS 816, 425 which was more than twice of NR accrued in TFIT acre which was TZS 336, 646. Based on this performance, SRI irrigation could plausibly be more profitable than TFIT in acreage terms. This result is in consensus with the findings by Styger (2019) who found SRI irrigation to be twice more profitable than traditional flooding irrigation in Timbuktu, Mali. This good profitability of SRI in some places like Mbeya is often realized at an expense of higher bird scaring costs (majoring in labor expenses) as was cautioned by Katambara *et al* (2019) who conducted their study in Chimala- Mbarali district, Tanzania.

Moreover, the profitability of rice production under TFIT and SRI irrigation was found to be significantly predicted by several factors to the differing extent as presented in Table 4. For instance, household head years spent in education were influential in explaining the variation of NR accrued between farming households with a more positive effect in SRI irrigating households than TFIT ones. This is built from the fact that SRI is the newly and scientifically recommended rice irrigation technology, it could thus be expected that more educated farmers could easily understand and apply the technology efficiently over less educated people. More educated household heads are risk-takers than less educated, therefore, have less resistance to change toward new innovations (Ndabila, 2018). Equally important, an increase in household head years of experience was found to cause more NR in TFIT compared to SRI irrigation. The reason for this is that experience goes with an increase in farmer age, most SRI appliers were by far older than TFIT appliers, increase in years of experience makes an increase in productivity and profit for TFIT farmers as he/she is still in productive ages meanwhile it causes no significant impact on SRI farmer profit as he has reached to the unproductive ages.

Profitability accrued by both farming households irrigating using SRI and TFIT was found statistically to be explained by the number of extension visits. As it was presented in Table 4, each incremental extension visit caused a higher NR in SRI irrigation than it was for TFIT. This is attributed to the fact that SRI irrigation needs extension service much more because of its technical and unique requirements unlike convectional rice irrigation (Kumar & Nayak, 2013). It is from this argument, farmers' access to extension services is deemed essential as through accessing the services they are exposed to good farm management practices like timely transplantation and controlled water usage. Nevertheless, in both technologies, more extension visits entail more profit as with high frequency in service, the farmers are also likely to manage risks like crop failures that jeopardize potential rice harvest and profit. As reported in different FGDs, villages like Mkula and Sululu were the victims of declining profit attributable to seldom extension visits meanwhile villages like Sanje and Msolwa Ujamaa appreciated the role that extension officers played in their good NR realized in the season. In addition to that, soil management (inorganic fertilizer application) was statistically influencing the profit level of rice grown using any of the two irrigation technologies. This is supported by Saweda *et al* (2014) who confirmed that fertilizer application was found profitable in rice farming in Nigeria but cautioned efficient management practices in growing the crop, especially under convectional flooding technology.

Furthermore, as it was expected, the land size used by farming household positively determined the margin of profit that farming household was going to get in any of the two irrigation technologies. The positive association between land size and profit in both irrigation technologies could be attributed to the mode of land ownership that is common in the surveyed wards. Most farming households cultivate freely given plots of land through inheritance and government allotment. These farmers at large incur no cost when adding the size of land during the season in question, thus they still get sales with the grace of no land acquiring cost. More important, table 4 reveals that SRI has higher net revenue over TFIT in each acre of land added in production because SRI technology requires more land due to its wider space between plants which is recommended under the technology (Selvaraju, 2013).

Conclusion and Recommendations

This study intended to evaluate the economics of Traditional flooding and SRI rice irrigation technologies. The study first conducted profitability evaluation using NR, then evaluated what significantly determined the profitability of rice under the two irrigation technologies. The findings showed that average rice production costs per acre were higher for SRI than TFIT, meanwhile, Labour cost represented the highest expense incurred by farming households in both irrigation technologies. Also, the study found that both total and average Net Revenue per acre under SRI was higher than TFIT which finally implied that SRI was more profitable.

Further, results from the specified multiple linear regressions for SRI and traditional flooding technologies were found to be not far from what was anticipated earlier. For example, in soil management, profitability was positively influenced by granular and liquid fertilizers for TFIT and SRI respectively. Policy implication that could be drawn from these findings is that subsidization of inorganic fertilizers could be a viable option by the Ministry of Agriculture to benefit rice farmers in both technologies. This is based on the substantial profitability that the application of inorganic fertilizers has on respective technology. Therefore, by subsidizing more inorganic fertilizers, farmers' access to this important agricultural input would increase and eventually rise in profit level accrued by farming households.

Extension service was another strong influencer of profitability in both technologies but with more profitability in SRI irrigation. An important implication revealed here is that farming households must change and make use of extension officers available in their areas, yet, the responsible ministry is obligated to recruit even more extension officers to be placed in the villages with inadequacy like Sululu. Also, extension officers who also act in other administrative roles like the acting VEO should be exempted from carrying this additional burden of job position and stick with their originally placed job to increase extension efficiency.

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