Economic Viability of System of Rice Intensification (SRI) Technology in Morogoro, Region, Tanzania

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Abstract

The objective of this study is to analyze the benefits and costs of the system of rice intensification in the Morogoro Region, Tanzania. The cost-benefit analysis theory was used in this study. Data were collected by using a questionnaire and checklists after a preliminary survey that aimed at familiarizing the researcher with the study area and pre-test the questionnaire to gauge the relevance of the questions and their comprehensiveness. The study adopted a multistage sampling method. The sample size of 384 farmers was randomly selected. The viability of each production method (SRI and Conventional) was estimated using the Cost-Benefit Analysis. Overall, the results of the comparison of economic viability between SRI and Conventional method projects indicated that the former (SRI) was more profitable and viable than the latter (Conventional Method) at discount rates (Interest rates) equal to or less than 12% respectively. In terms of both NPVs and BCRs interest rates often decrease, making borrowing money less expensive. However, the increase in NPV revealed that the System of Rice Intensification was more profitable than the conventional method of rice production. The sensitivity analyses, of the NPVs for the SRI and Conventional Method projects, respectively, were negative at discount rates of more than 54.17749% and 32.10396%, indicating that the projects were not financially feasible at rates higher than these, but when measured in terms of IRR, SRI outperformed the conventional technique. In general, the empirical findings showed that the System of Rice Intensification produces rice at a higher profit than the conventional method. Therefore, it is important to encourage rice farmers to use the System of Rice Intensification.

Keywords: Cost-benefit analysis, NPV, Benefit-cost ratio, internal rate of returns, Discount rates

Introduction

The System of Rice Intensification (SRI) is an array of practices for increasing the productivity of irrigated rice by changing the management of plants, soil, water, and nutrients (Boardman, 2018). The System of Rice Intensification (SRI) is an innovation in rice production systems that is more efficient in raising factor productivity and incomes for more than one million smallholder farmers producing rice around the world over one million hectares (Benoit, 2016). SRI originated in Madagascar in the 1980s and is based on the cropping principles of significantly reducing plant population, improving soil conditions and irrigation methods for root and plant development, and improving plant establishment methods (David, 2018).

SRI was introduced in Tanzania in 2009 to increase the country's food security (Tusekelege *et al.,* 2013). By using SRI, the yield increased to 11.6 t/ha compared to 1-1.5 t/ha before SRI (CUCAL, 2015). There is evidence of very high rice productivity by using SRI technology for example in India, SRI farmers displayed comparatively higher yields, higher gross margins, and lower production costs. An average yield in SRI in all states of 0.85 t/ha or 22 % higher than the non-SRI fields (FAO, 2018). Moreover, Johnson (2017), states that in Indonesia SRI generates significant estimated yield gains of an average of 7.23 t/ha compared to 3.92 t/ha with conventional methods (84%

increases in yield).

National rice development strategy (NRDS II) 2019-2030 aims to double the area under rice cultivation from 1.1 million Ha (2018) to 2.2 million Ha by 2030. The Government's commitment is to transform rice production from the current subsistence farming towards commercialization and modernization (URT, 2019). In Tanzania, the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) was the catalyst for the implementation of SRI. Under this programme, SRI is promoted as one of the approaches for increasing rice production in the country (David, 2018). This programme (SAGGOT) initiatives and strategies have been accompanied by government investments in SRI projects through support from various development partners, including IFAD, FAO, Sida, Tanzania Commission for Science and Technology (COSTECH) and USAID Tanzania staples value chain (NAFAKA) project under partnerships with Kilombero Plantations Ltd (KPL) (URT, 2018).

Tanzania deemed it mandatory to invigorate rice production to promote food security (Andreas and Karen, 2022). An assumption is often made that SRI is profitable; farmers can use it to increase productivity and incomes and reduce poverty (Benoit, 2016). The economic viability of SRI for poor farmers in Tanzania is questionable, especially taking into consideration that the production system has hardly been able to increase yields beyond 2 tons per ha. This poses a conceptual and practical challenge for the scientific evaluation of SRI methods (Hussain, 2019).

Although there are several promising benefits offered by SRI as revealed in several studies (Rosemary, 2013 and Saurabh, 2022), there is limited empirical evidence on the economic viability of SRI (Cornel, 2018). Its slow uptake by smallholder farmers raises questions about whether this SRI project was evaluated and offers all the total factor productivity gains (Kabri, 2017). Economic viability is a vital component of project development and is used to support decision-making (Jordan, 2017). Therefore this study aims to assess the economic viability of the system of rice intensification (SRI) technology in Tanzania.

Theoretical framework

Cost-Benefit Analysis Theory

Cost Benefit Analysis (CBA) is defined differently by different scholars. David *et al.* (2013) for example, define CBA as "a systematic approach to estimating the strengths and weaknesses of alternatives used to determine options which provide the best approach to achieving benefits while preserving savings; for example, in transactions, activities, and functional business requirements". The analysis helps to gauge if a project or decision is a worthwhile undertaking by establishing if and by how much, its benefits outweigh its costs (ibid). Boardman (2018) defines CBA as "a procedure for estimating all costs involved and possible profits to be derived from a business opportunity or proposal that takes into account both quantitative and qualitative factors for analysis of the value of money for a particular project or investment opportunity". In this subsection, we survey theories and practices for conducting CBA.

Despite being useful, an erroneous Benefit Cost Ratio (BCR) can result in wrong investment decisions (David, 2018). Arrow (2020) point out the advantages and limitations of the Benefit Cost Ratio (BCR). BCR is based on the pricing of costs and pricing of benefits: each is given a dollar value, and then costs and benefits are compared. If there is a net loss, then one turns the project down. BCR can be dangerous if taken literally on large issues, and on large timescales. This is because some of the largest items, such as water resources and their services are difficult to price (Johnson, 2017).

Net present value (NPV) is a central tool in Discounted Cash Flow (DCF) analysis, and it is a standard method for using the time value of money to appraise long-term projects (David, 2018). Used for capital budgeting, and widely throughout economics, finance, and accounting, it measures the excess or shortfall of cash flows, in present value terms, once financing charges are met (Feder, 2018). Arrow (2020) states that the weaknesses of NPV are that, it is very sensitive to the discount rate: a small change in the discount rate causes a large change in the

NPV. As the estimate of the suitable discount rate is doubtful, this makes NPV numbers very unreliable Also NPV often relies on uncertain forecasts of future cash flows. The magnitude of this problem depends on how uncertain the forecasts are.

The Internal Rate of Return (IRR) is a rate of return used in capital budgeting to measure and compare the profitability of investments (Kassie, 2021). In many situations, the IRR procedure will lead to the same decision as the NPV procedure, but there are also times when the IRR may lead to different decisions from those obtained by using the net present value procedure (Emongor, 2020). Arrow (2020) stated the situations where IRR and NPV lead to different conclusions, for example, if the chosen discount rate for the analysis is less than the minimum rate of return, then a positive NPV may still not add more to the company's net worth than the alternate investment (yielding the minimum rate of return). This leads to situations where the NPV is positive (suggesting management should invest) but the IRR is less than the minimum rate of return (suggesting management should NOT invest).

According to Bierman (2016), the IRR is an easy measure to calculate and provides a simple means by which to compare the worth of various projects under consideration. The IRR provides any small business owner with a quick snapshot of what capital projects would provide the greatest potential cash flow. Emongor (2020) explained that the disadvantage of using the IRR method is that it does not account for the project size when comparing projects. Cash flows are simply compared to the amount of capital outlay generating those cash flows (Khush, 2020). This can be troublesome when two projects require a significantly different amount of capital outlay, but the smaller project returns a higher IRR (Bierman, 2016). All other things being equal, using internal rate of return (IRR) and net present value (NPV) measurements to evaluate projects often results in the same results if used in the same project (Len, 2020). Therefore in this study both BCR, NPV, and IRR will be used together to verify the results if they lead to contradicting conclusions CBR and NPV will be used for analysis in this study (Johnson, 2017).

Methodology

Study Area

Morogoro region is found between longitude 35°25" and 35°30" to the east and latitude 5°58" and 10°0" south of the Equator. Morogoro Region covers 72,939 square kilometres in total or about 8.2% of the total land area of Tanzania. The area is chosen because it is near the big irrigation schemes in Kilosa District, Kilombero District, Mvomero District, and Morogoro Rural District are focus areas for SRI projects.

Research Approach

Data were collected by using a questionnaire and checklists after a preliminary survey that aimed at familiarizing the researcher with the study area and pre-test the questionnaire to gauge the relevance of the questions and its comprehensiveness. The questionnaires were used to collect primary data from farmers and were administered during the survey through personal interviews. The checklists were used to collect data from key informants to supplement the information obtained from interviews.

Estimation of a sample size

This study opted to use the proportion sample statistic to estimate the sample size of farmers using SRI and those using conventional methods in the Morogoro Region. Below is the proportion sample statistic that was used to determine the sample size. In this study, a 95% confidence interval was used which led to Z= 1.96; and e = + 5%.

$$n_s = \frac{Z^2 e^2 N}{e^2(N-1) + Z^2 pg} \qquad \text{(i)}$$

ns = Sample size
N = Total study population
Z= Standard score at a given confidence level
e = acceptable error

$$n_s = \frac{1.96^2 * 0.05 * 0.05 * 28526}{0.05^2 * 28525 + (1.96)^2 * 0.05 * 0.05} = 384 \qquad \text{(ii)}$$

Sampling Technique

The study adopted a multistage sampling technique because it is more flexible than one-stage sampling. Multistage sampling techniques were implemented in two stages: Firstly Morogoro region was selected followed by the

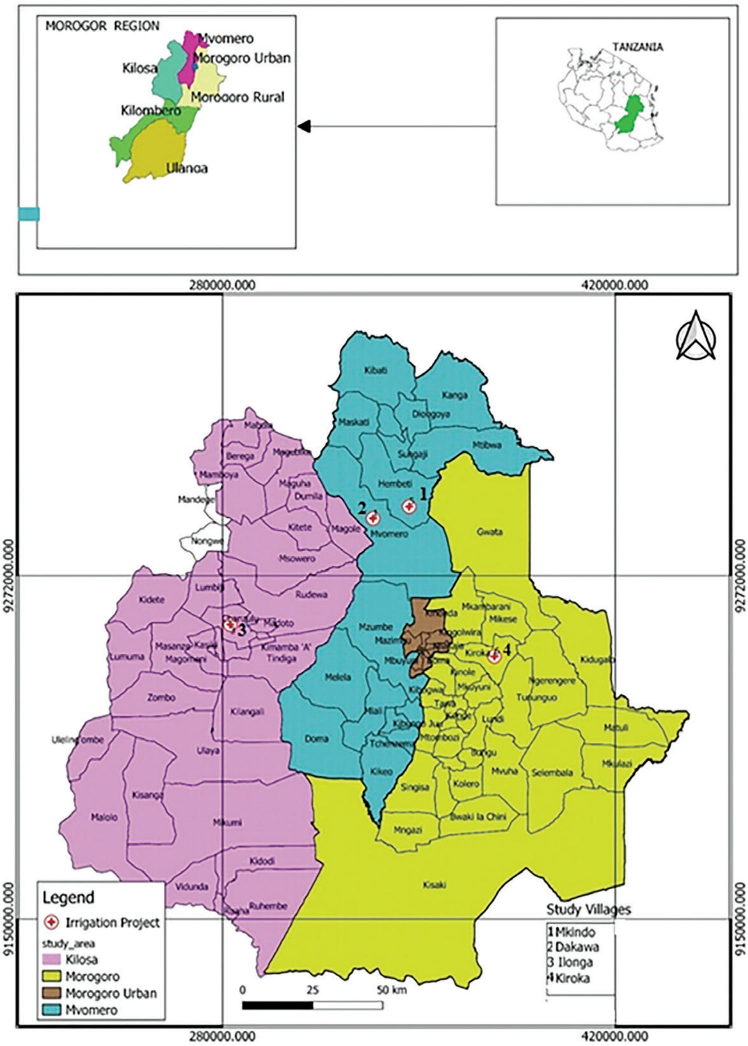

Figure 1: The map of the Morogoro Region showing study Locations

selection of three districts within the Morogoro region (Kilosa, Mvomero and Morogoro District). Secondly, four wards were purposively selected: Hembeti and Dakawa in the Mvomero district, Chanzuru in the Kilosa district and Kiroka in Morogoro District. Furthermore, four villages were purposively selected (Kiroka in Morogoro District, Dakawa and Mkindo in Mvomero District and Illonga in Kilosa District). Then, 96 randomly chosen farmers (48 using SRI and 48 using the conventional approach) from each of the four village mention above, creating a sample size of 384 farmers. Wards and villages selection was based on the conditions that they have irrigation schemes and implemented SRI projects in those schemes. The criteria for the farmer to be an SRI farmer is the Use of an improved variety of seeds, the Use of uprooted seedlings for 8 days on an SRI farm, drying and wetting the land, weeding at least two times and applying fertilizer twice. Farmers are referred to as Progressive SRI Farmers when they meet the criteria for practicing SRI and are constantly engaged in farming. All SRI farmers SRI farmers meet the above criteria and were identified by tracking the extension officer's records around the selected irrigation schemes.

Data Analysis

Benefit- Cost Data Analysis

The Benefit - Cost analysis is used to analyse the economic viability of the System of Rice intensification. The assumptions made in the analysis include: (i) Time horizon of 30 years (from 2020 to 2050) was chosen. Both the short and long-term costs and benefits had taken into consideration to ensure that the projections were based on the realistic lifespan of the respective Irrigation project. In general, as irrigation systems age beyond 30 years, they tend to experience more frequent breakdowns, components become obsolete, and finding replacement parts may be more difficult. However, just because parts of an irrigation system are old in no way implies they are past their usefulness; age is just a relatively easy way to anticipate general fatigue and wear on irrigation systems. The high potential of SRI, government ranks it as a long time project and it can sustain for many years in irrigation schemes projects where there are good structures easy for SRI practices. (ii) A social interest rate (12%) of 2021/2022 was used according to the Central Bank of Tanzania. The choice of a 12% discount rate can make a huge difference to the desirability of government irrigation projects because their cost and benefits occur over long periods. With these assumptions, the financial streams of revenues from crop sales and costs incurred were discounted to determine the NPV, BCR, and IRR. Tim (2013) and Ioannis (2017) stated that the computation of NPV, BCR, and IRR is done in Microsoft Excel software using the built-in command and also using the following information:

i) Discount rate:12% is the accepted discount rate widely used in evaluating irrigation Schemes in the African environment
ii) Operation and maintenance (O&M) cost: 1.5% of the Initial cost investment conducted yearly
iii) Replacement cost/ major repair: 2% of the Investment cost with an interval of 5 years.
iv) Single cropping: applies to both scenarios (SRI and Conventional)
v) Initial investment cost/Ha: 6 370 888 TZS (average amount per ha of all irrigation schemes).
vi) Project Lifetime: 30 years (irrigation project's lifetime lies between 20 – 50 years depending on the project environment according to the African development bank).

Net present value

The NPV was calculated as the present value of the SRI project cash inflows minus the present value of the SRI project cash outflows. In the present study, cash inflows were the revenue obtained from selling crops obtained from the irrigation scheme and the cash outflow was the inputs cost for producing crops and initial investment cost. This relationship is expressed by the following formula:

$$\mathrm{NPV} = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t} \qquad \text{(iii)}$$

Whereby, NPV is the net present value, Bt is the benefit at time t, Ct is costs incurred in production at time t, r is the discount rate and n is the time horizon.

Benefit-cost ratio

The benefit-cost ratio (BCR) is the ratio of all the discounted (yearly) incremental benefits and costs of a project. Thus, it expresses the benefit generated by the project per unit of cost of the project expressed in present values. The ratio was obtained by using the following formula:

$$B/C = \sum_{i=0}^{n} \frac{B_i}{(1+i)^t} \Big/ \sum_{i=0}^{n} \frac{C_i}{(1+i)^t} \qquad \text{(iv)}$$

Where the BCR expresses the benefit generated per unit of cost and it was interpreted as follows:

i) BCR > 1: present value of benefits exceeds the present value of costs.
ii) BCR = 1: present value of benefits equals the present value of costs.
iii) BCR < 1 the present value of costs exceeds the present value of benefits.

Selection Criterion: projects with a BCR of 1 or greater were economically acceptable when the costs and benefit streams were discounted at the opportunity cost of capital. The absolute value of the BCR varies depending on the discount rate chosen; the higher the discount rate, the smaller the BCR.

Internal Rate of Return

Internal Rate of Return (IRR) is the minimum discount rate that management uses to identify capital investments or future projects. IRR is uniform for investments of varying types and, as such, IRR can be used to rank multiple prospective projects on a relatively even basis. The formulae to calculate IRR are shown below

$$IRR = r_1 + [(r_1 + r_2)\left(\frac{NPV_1}{NPV_1 - NPV_2}\right) \text{.......(v)}$$

r_1=The lower discount rates
r_2= The higher discount rates
NPV_1 = Net present value of lower discount rate
NPV_2 = Net present value of higher discount rate
IRR = Internal rate of return

Interpretation on IRR

i) If costs of investment were equal among the various projects, the project with the highest IRR would be considered the best and be undertaken first.
ii) If the IRR of a new project exceeds a company's required rate of return, that SRI project is desirable. If IRR falls below the required rate of return, the project should be rejected. (If IRR is greater than the discount rate capital should be accepted. While If IRR is less than the discounted rate of capital it should be rejected)

Sensitivity analysis

Discounted the streams of benefits and costs using a discount rate of 12%, which was the current social interest rate in Tanzania during the time of data collection. CBA was repeated using different interest rates (1%, 3%, 4%, 5%, 6%, 7%, 8%, 10%, 12%, 20%, and 25%), primarily as part of the sensitivity analysis to test the robustness of the CBA results to changes in interest rates. The use of sensitivity analysis is an important tool to identify the relevance of uncertainty over the value of the discount rates. Project flows that are more sensitive to market returns and other factors should have a higher discount rate, while less sensitive projects should have a lower one. Further sensitivity testing is used to help determine the appropriate rate, such as calculating the project rate of return (the rate at which the net present value is zero). If the plausible level of discount rate is below the rate of return, then the project improves efficiency

Results and Discussion

Economic Viability of SRI

Cost of inputs used in crops production

In the study area, farmers incur a cost for labour, fertilizer, buying sacks, pesticides herbicides, and spraying. Table 1 shows the mean value for the cost (TZS) of the inputs used by the households in production. By using inputs such as chemical fertilizers, labour intensive, available resources of land, and enough water for irrigation, SRI gives greater returns to farmers. Farming is an important economic activity for respondents around all irrigation schemes in Morogoro. It was observed that in conventional irrigation, more costs were incurred for seeds (20 000 TZS), nursery management (62 500 TZS), fertilizer management (76 100TZS), and pesticide management (59 375 TZS) while for SRI the cost was less for seeds (8 000 TZS), nursery management (93 750 TZS), fertilizer management (67 200TZS), and pesticide management (65 750 TZS).

Moreover, Survey results showed that SRI needs more expenditure only for weeding, crop harvesting and threshing. The total weeding cost (manual weeding) for SRI was found to be high (208 125 TZS), than that of conventional methods (158 125 TZS). The result supported by Chirwa (2019) stated that When the comparison of production costs between conventional methods and SRI was analysed, it was found that the conventional method was somewhat more expensive (2 843 441.25 TZS /ha) than SRI (2781119.25 TZS /ha). Moreover, Biermannu (2016) stated that gross returns with SRI methods were found to be very high compared with conventional methods despite the similar cost of inputs. The average gross return with SRI was (7 514 595 TZS /ha), almost double the conventional-method gross return, which was (3 994 720.35 TZS /ha).

Cost and Benefit of SRI and conventional method

Figure 2 show that the operating cost

Table 1: Cost of the inputs used for SRI in TZS per Ha (n= 384)

Variable Cost	Min	Max	Mean	STDV
SRI				
Land preparation	200000	250000	225000	35 355.339
Seed	6000	8000	7000	1 414.2136
Nursery management	62 500	125 000	93 750	36 084.39
Planting	125 000	250 000	218 750	62 500
Herbicides application	25 000	50 000	33 750	11 086.78
Pesticides management	31 250	50 000	40 625	10 825.32
Weeding	62 500	320 000	208 125	107 613.8
Fertilizer application	49 400	85 000	67 200	20 553.67
Pesticide management	8 000	85 000	65 750	38 500
Water charges	8 000	25 000	15 250	8 616.844
Harvesting	90 000	250 000	210 000	80 000
Transporting	160 000	1 249 150	437 288	541 262.2
Conventional Method				
Land preparation	150 000	250 000	212 500	47 871.36
Seed	20000	30000	25000	7071.0678
Nursery management	62500	65500	64000	2121.3203
Planting	115000	125000	120000	7071.0678
Herbicides	30 000	50 000	40 000	11 547.01
Herbicides application	25 000	50 000	33 750	11 086.78
Pesticides management	50 000	62 500	59 375	6 250
Weeding	31 250	360 000	158 125	158 786.1
Fertilizer	25 000	210 000	83 450	85 147.15
Fertilizer application	49 400	85 000	76 100	17 800
Pesticide management	25 000	85 000	52 000	29 200.46
Water charges	12 500	25 000	21 875	6 250
Harvesting	150 000	250 000	200 000	57 735.03
Transporting	60 000	120 000	95 500	25 317.98

for SRI was 1 493 890 TZS/Ha with greater revenue of 5 500 000 TZS/Ha compared to a conventional method whereby the operating cost per ha was 1 204 900 TZS/Ha and revenue was slightly low about 3 400 000 TZS/Ha. Figure 2 shows that when the social interest rate is 12% net present value (NPV) of the SRI project was 21 342 891 TZS/Ha while the net present value (NPV) for the conventional project was 10 379 705 TZS/Ha. The high revenue obtained per ha and increase in NPV revealed that the System of Rice Intensification was more profitable than the conventional method of rice production. Moreover, for NPV the investment cost was positive, indicating that it was economically viable. This means that the lower risk of an SRI project improves access to credit for capital investment in frequently expensive equipment. Nur and Fazleen (2019), stated that the NPV of SRI farmers was TZS 1 255 752.345 per hectare due to the high yield generated. The result implied that the productivity of paddy for SRI farmers was high. Thus, the SRI project was more efficient, especially in production and yields obtained due to low production cost and high yielding.

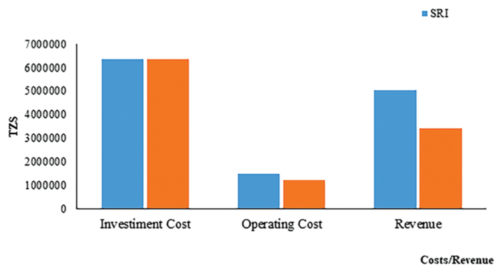

Figure 2: Cost and revenue of SRI and Conventional method

The BCR of SRI in all four zones (Kiroka, Illonga, Dakawa and Mkindo) was 3.137601 while BCR for the conventional method was 2.57004 shown in Table 2. This implies that the BCR of the SRI project was economically acceptable after the costs and benefit streams were discounted at the opportunity cost of capital. It further implies that the present value of the benefit exceeds the present value of the cost SRI project should be selected because it gives big returns compared to rice production using the conventional method. These results were supported by Johnson (2017), who explained that the NPV for the SRI project was a positive number, and its BCR was greater than 1: which means that for the SRI project the present value of benefits exceeds the present value of costs. This suggests that the NPV of the SRI project outweighs the NPV of the Conventional method project, and the SRI project should be selected.

Table 2: Cost Benefit analysis of SRI

Details	SRI	Conventional method
Social interest rate	12%	12%
Appraisal period (years)	30	30
IRR	38%	15%
Benefit Cost Ratio	3.137601	2.57004
Net Present Value	21 342 891	10 379 705

Sensitivity Analysis to Changes in Interest Rates

The problem of uncertainty in cost-benefit analysis is addressed to some extent through sensitivity analysis. The results are presented in Table 3 and Table 4. The values of NPV, and BCR were positive, indicating that changes in discounting rates still make the project viable. The sensitivity analysis indicates that the economic viability of both SRI and conventional method project is most sensitive to increases and decreases in interest rates.

Our results of CBA indicate that both projects were viable at the discount rate equal to the inflation rate (i.e., r = 12 %) with NPVs of 21 342 891 TZS and 10 379 705 TZS per ha respectively. The two projects were viable even at a higher discount rate of 20% yielding NPVs of 10 773 703 TZS and 3 997 321 TZS per ha respectively. For SRI, the BCRs at discount rates of 12% and 20% were 3.138 and 3.143 respectively. The BCRs for the Conventional method at discount rates of 12 % and 20% were 2.57 and 2.58, respectively. Overall, the comparison of economic viability between SRI and Conventional method projects indicated that the former was more profitable than the latter at discount rates (Interest rates) less than or equal to 12% respectively in terms of both NPVs and BCRs. The results are in line with Baum et al (1999) who stated that for SRI the selection criterion for the B/C is that all independent treatments with a B/C ratio of 1 or greater were accepted.

Sensitivity Analysis to Changes price of rice, cost of Production and rice yield

Table 5 shows that when the discount rate falls from 12% to 10%increases from 26% to 28%, NPV increases to 26 054 044 TZS from previously 21 342 891 TZS. While NPV for the conventional method rose from 1 037 9705 to 13 224 519 with its IRR increasing from 15% to 16% respectively. Implies that the SRI is more valuable than the conventional method. If discount rates increase from 12% to 16%. IRR for SRI decreases from 26% to 23%, NPV decreases to 14 891 147 TZS from previously 21 342 891 TZS compared to decreases in NPV of the conventional method by 6 483 918

Table 3: Sensitivity analysis when interest rates increase and decrease (SRI)

Measure (currency Tshs)	Discount Rates									
	1%	3%	4%	5%	6%	7%	8%	12%	15%	20%
PVB	130 328 927	989 822 228	87 324 768	7 763 087 769	69 512 397.32	6 266 568	5685180 588	40678679	33158197	25143629
PVC	41664796.9	31624391.5	27891671	24788272.8	22189689.21	19998536	18138231	1264900	10560402	7999038.1
NPV	82293242	60986950	53062210	46471717	40951820	36296234	32342687	21342891	16226907	10773703
BCR	3.128035	3.122993	3.130855	3.131758	3.132644	3.133512	3.13436	3.137601	3.139861	3.14332

Table 4: Sensitivity analysis when interest rates increase and decrease (Conventional method)

Measure (currency Tshs)	Discount Rates									
	1%	3%	4%	5%	6%	7%	8%	12%	15%	20%
PVB	87746208	66641500.6	58792913	52266333.5	46800425.9	42190740	38276463.4	273876625	22324331	16928383
PVC	34206627.3	25960060	22894446	20345788.2	18211790.7	16412447	14884844.1	10637032	8662900	6560175.3
NPV	47168693	34310553	29527579	5549658	22217748	19407405	17020732	10379705	7290543	3997321
BCR	2.565182	2.567078	2.567949	2.568902	2.569787	2.570655	2.571506	2.57474	2.57004	2.580477

TZS from 1 037 9705 TZS and IRR decreases from 15% to 9%. High discount rates were less preferable, in this case, NPV and IRR for both projects decreases but SRI is more profitable due to the high IRR than the Conventional method. Results supported by Johnson (2017) who stated that when the discount rate increases, the NPV of the project decreases (the NPV profile slopes down and to the right). If the NPV is positive at 7%, then the IRR must be greater than 7%.

When there is a fall in (paddy) yields by 25%, the NPV for SRI decreases from 21 342 891 TZS to 7 092 433 TZS. IRR for SRI decreased from 26% to 16% while NPV for the conventional method decreases from 1 037 9705 TZS to 3 532 799 TZS and IRR decreased from 15% to 6%. A project with a very low IRR than its calculated discounted rate is rejected therefore in this case when there is a fall in (paddy) yield by 25% the conventional method project is rejected, and the SRI project continues.

A decrease in variable cost by 25% resulted in increasing in NPV for SRI from 21 342 891 TZS to 24 351 281 TZS and IRR rose from 26% to 30%. While NPV for the conventional method rose from 1 037 9705 TZS to 12 806 128 TZS and IRR increased from 15% to 18%. Both projects were accepted but much attention was paid to SRI due to higher NPV and IRR.

A fall in (paddy) price by 25% resulted to decreasing in NPV for SRI from 21 342 891 TZS to 11 173 221 TZS and IRR for SRI decreased from 26% to 17%. While for the conventional method, NPV decreases from 10 379 705 to 3 532 799 and IRR decreases from 15% to 6%. Projects with IRR less than discounted rate is rejected there conventional method project are rejected when the paddy price fall by 25% because the conventional method project's NPV will be greater than zero but less than the opportunity cost of capital.

Sensitivity analysis of discount rate which brings Zero NPV

The original choice of the discount rate used in this study is the social interest rate of 12%. The 12% social interest rate is used in all bank and government long-term projects (IADB, 2022). Andreas and Karen (2022) elaborated that for the financial analysis, the discount rate is the cost of borrowing money, which is the interest that the lender is charging to be compensated for foregoing the use of the money now for a project funded through borrowed money and farmers' equity (the difference between assets and liabilities). The discount rate of 12% is the weighted average of the interest on borrowed funds and the farmers' minimum acceptable rate of return.

Table 5: Sensitivity Analysis to Changes price of rice, cost of production, and rice yield

Scenario	B/C ratio	NPV	IRR
System of Rice Intensification			
Base case 12%	3.138	21 342 891	26%
Fall in Discount rate by from 12 to 10 per cent	3.136	26 054 644	28%
Increase in the discount rate from 12 to 16 per cent	3.140	14891147	23%
Fall in (paddy) yields by 25%	2.355	7092433	16%
Decrease in variable cost by 25%	4.086	24351281	30%
Fall in (paddy) price by 25%	2.352	11173221	17%
Conventional method			
Base case 12%	2.574	10379705	15%
Fall in Discount rate by from 12 to 10 per cent	2.573	13224519	16%
Increase in the discount rate from 12 to 16 per cent	2.578	6483918	9%
Fall in (paddy) yields by 25%	1.931	3532799	6%
Decrease in variable cost by 25%	3.336	12806128	18%
Fall in (paddy) price by 25%	1.932	3532799	6%

The 12% of the conversion of investment values to annual equivalent costs (and any other discounting processes required) is utilized at the investment rate of interest or opportunity costs of capital specified by the irrigation project sponsors (IADB, 2022). In addition to comparing the economic values using the measures of NPV and BCR, we also compared the efficiency between the two projects (SRI and convectional method projects) using IRR. In principle, the IRR decision rule is applied when the sign of net benefits (benefits minus costs), does not vary in the different years of the project (Kadigi *et al.*, 2021). This is very easy to verify by plotting the NPVs against different discount rates to see if there are several discount rates, which equate NPV equal to zero (Fig. 3 and 4). In principle, an investment is acceptable if its IRR is greater than an established minimum acceptable rate of return.

Figure 3 and 4 shows that the NPVs were negative at discount rates higher than 54.18 % and 32.10% for SRI and Conventional Methods respectively implying that the projects were not viable beyond these rates. The longer investment horizon of 30 years used for SRI projects and conventional projects increases the chance of increasing the return on investment even if there were very high discount rates of less than 54.17749% and 32.10396% for SRI and conventional methods. According to PWC, (2022), investments with a long-term horizon offer reduced tax liability. Long-term capital gains are taxable at relatively lower tax rates

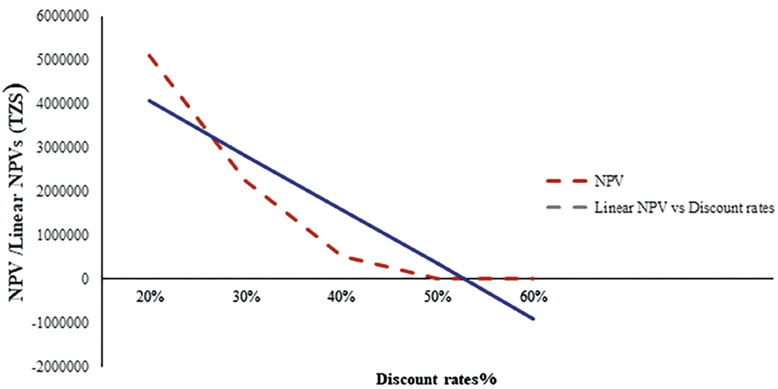

Figure 3: A line plot of NPVs of SRI at different discount rates

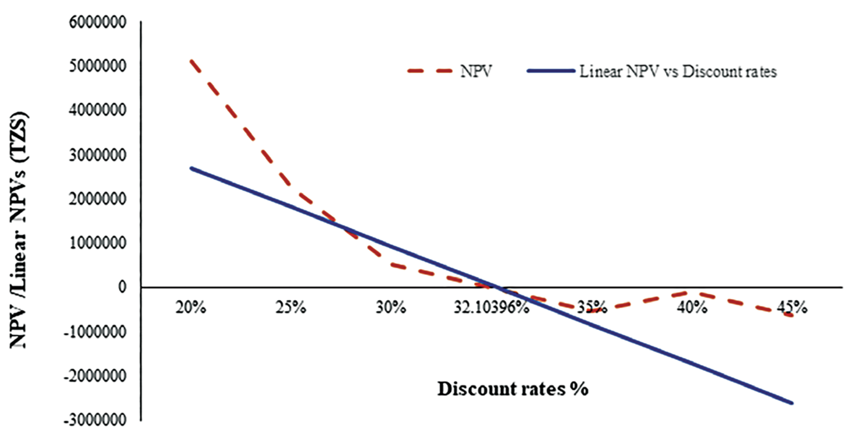

Figure 4: A line plot of NPVs of the Convention Method at different discount rates

when compared to short-term gains. BOT (2022) stated that the higher inflation rates in energy, fuel, and utility sub-groups cause the interest rates offered by banks on deposits to record a marginal decrease in the middle of 2022, with an overall deposit rate averaging 6.69 %, compared with 6.81% and 6.89% recorded in the preceding month and in the corresponding period in 2021. The country's growth rate in real GDP is very low whereby it raised by 4.9% in the quarter ending May 2021 compared with 4.8% in the corresponding quarter in 2021, respectively.

The rising price of petroleum causes to rise in operating costs in irrigation schemes. Energy prices affect the production costs of the rice crop, as well as the demands. Changes in the cost of production due to a rise in energy price directly affect the net returns (expected and realized) from producing rice and planting decisions at the farm level reflect producers' expectations of those net returns (PWC, 2022). Kadigi *et al.,* (2021) elaborated that all else equal, when the cost of producing rice increases, the returns to producing that rice decline, so higher production costs tend to discourage greater rice production. The average interest rate of 12%, the IRR of SRI= is 26 %, and the IRR of the Conventional method is 10% or the depreciation rate of 20 %, the IRR of SRI is 18% and the IRR of the conventional method is 7%. In this regard, both SRI and Conventional method projects were worthy of undertaking through our mathematical and graphical extrapolations of IRR indicating that SRI was more efficient. However, the NPV and BCR of SRI were higher than that of the Conventional method project also IRR of the conventional method after depreciation (7%) is below the original discount rate of 12% means that by using the depreciation rate the conventional method project rejected. NPV is considered a much more reliable measure of project viability than IRR and the most preferable criterion when ranking investments and projects, which are mutually exclusive. Therefore, farmers could benefit more by practising SRI because have a high NPV, B/C, and IRR compared to the conventional method.

Conclusion and Recommendations

The Net Present Values were positive, indicating that rice production under the two methods is profitable. Furthermore, the Benefit-Cost Ratios were greater than one confirming that rice production was profitable under both methods of production. However, the increase in NPV revealed that the System of Rice Intensification was more profitable than the conventional method of rice production. The sensitivity analyses revealed that the NPVs were negative at discount rates higher than 54.17749% and 32.10396% for SRI and Conventional Methods respectively, implying that both projects were not viable beyond these rates. Measured in terms of IRR however, SRI was more efficient than the Conventional method. Overall, the results of the comparison of economic viability between SRI and Conventional method projects revealed that the former was more profitable than the latter in terms of both the NPV and BCR criteria. Profit realized from SRI is substantially higher than from conventional rice cultivation.

It is recommended that future viability studies should use different accounting and econometrics models to decide and predict the future of the SRI projects. Future studies on the economic evaluation of these systems could also evaluate the effect of other crops, such as maize, sorghum, wheat, and other food crops. Since the empirical findings showed that the System of Rice Intensification produces rice at a higher profit than the conventional method, it is therefore important to encourage rice farmers to use the System of Rice Intensification.

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