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Profitability and Determinants of System of Rice Intensification Technology Usage among Rice Farmers

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ABSTRACT

In Nigeria, rice is the main component of the food bowl and a staple crop. The majority of the nation's rice is produced using traditional methods. This method has driven up the price of producing rice and made it more difficult for farmers to reach their full output capacity. Due to these, the rice intensification system (SRI) was created in the rice-growing industry. However, research on the financial viability of SRI technology and the variables affecting farmers' use of it in Nigeria is lacking. Therefore, this study investigated the profitability and determinants of the system of rice intensification technology usage among rice farmers. A questionnaire was used to collect information from 180 rice farmers using SRI technology. Descriptive statistics, profitability analysis, and multivariate logistic regression were employed in the analysis of the data. The study discovered that the majority of the rice farmers using SRI technology in Nigeria were economically active males. They made a gross margin of USD 370.55, a benefit-cost ratio of 1.68, and a profitability ratio of 0.41 per hectare; indicating that the use of SRI technology in rice farming is profitable. The result of the multivariate analysis of the determinants of the use of SRI revealed that the availability of extension services, farming experience, association membership, household size, and education influenced the use of different SRI technologies. The study recommends the promotion of SRI through knowledge exchange, extension demonstrations, and farmers' participation in training programs.

Keywords: Adoption, profitability, rice farming, system of rice intensification, technology

INTRODUCTION

Increasing food availability to combat the high food insecurity in developing countries remains at the center of policy debates (Akanbi et al., 2022a; Mukaila *et al.*, 2022a; Falola *et al.*, 2022a,b). Therefore, developing the agricultural sector is a key way to have a world free of hunger, and cereals have a critical role to play. One-third of the world's total cereal crops are rice (*Oryza sativa*) (Tayefe *et al.*, 2014). Roughly 500 million metric tons of rice are produced annually on an estimated 160 million hectares of land worldwide (Kirby, 2017).

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Rice is a staple food widely consumed and supplies the highest calorie intake by the world's population (Akanbi *et al.*, 2022b; Tayefe *et al.*, 2014). Thus, rice is vital to ensuring food security, especially in developing countries (AfricaRice, 2012; Kumar *et al.*, 2021; Le, 2021; Thanh & Duong, 2021). In Nigeria, rice consumption has increased dramatically at a rate of roughly 10% per year as the population keeps increasing. It is the most popular basic meal consumed across the country's geopolitical zones. Thus, more efforts are needed to boost rice production, especially in countries with high food insecurity such as Nigeria and other African countries.

Nigeria's rice output is imbalanced relative to the country's consumption habits (Omofonmwan & Kadiri, 2017). The consumption of rice in Nigeria is higher than the country's output. The disparity between supply and demand for rice will keep growing as both the population and the amount consumed will rise if adequate measures are not put in place. The nation's dependence on rice imports is a result of its inability to produce enough rice on its own. The majority of the nation's rice is produced using traditional methods. This method has driven up the cost of producing rice and made it more difficult for farmers to reach their full output capacity. To counteract the high expense of the traditional approach, the system of rice intensification (SRI) was created in the rice-growing industry.

Fernandes and Uphoff (2002) described SRI as a mechanism for boosting the production of irrigated rice by modifying the handling of plants, nutrients, water, and soil and replanting seeds and seedlings at a wider spacing. The method was created in the 1980s and has been claimed to offer a way to reduce water usage while retaining good yields. The major components of SRI are water management, planting methods that include spacing arrangements, weed control, and soil fertility management (Thura, 2010). According to Dobermann (2004), the SRI is a concept that involves manipulating the development conditions of rice seedlings by enhancing plant, water, soil, and fertilizer management to encourage the formation of larger and richer root systems, as well as increasing the quantity and activity of advantageous soil fauna. The SRI is gaining popularity around the world because farmers can cultivate additional rice with far less water and a lower incidence of pests and illnesses than with the traditional approach (Sudeep, 2011).

Despite the various benefits of SRI technology, its usage in Nigeria remains limited because of high input prices and labor expenses. In addition, different cultivation processes, like SRI, have not yet been thoroughly examined, particularly in terms of their application. Previous research, such as Ndiiri *et al.* (2013), centered on the restrictions and revenues related to SRI. Also, the study of Ndirangu (2015) concentrated on SRI perceptions. Little research has been conducted on the factors that influence SRI usage in Nigeria. Thus, research on the financial viability of SRI technology and the variables affecting farmers' use of it in Nigeria is lacking. Furthermore, farmers confront several challenges while implementing the SRI approach. So, with effective diagnosis and removal of these problems, rice farming might be lucrative for farmers due to the higher yield per unit area that can result from the application of SRI technology. Therefore, this study investigated the profitability and determinants of the system of rice intensification technology usage among rice farmers in Nigeria. Understanding the driving factors for the adoption of SRI technology is critical for policy intervention to improve rice farming through the adoption of SRI technology.

METHODOLOGY

The Study Area

This research was conducted in Niger State, Nigeria, which is the largest of the 36 states that make up the nation. It has 25 local government areas. Farming is the

major occupation of the people, as the majority live in rural areas. They cultivate food crops such as rice, yam, and sorghum and also rear animals such as cattle and small ruminants. Its inhabitants are made up of many ethnic groups, including the majority of Nupes, Gwaris, Kambaris, Bisasan, and Fulani herdsmen who live in nomadic tribes.

Sampling Procedures and Sample Size

The respondents were chosen using a multi-stage sampling approach. Firstly, two of Niger State's three agro-geographical zones were selected for the study, and the list of rice producers was retrieved from the Niger Agricultural Development Project in the second stage. Ninety farmers were sampled from each agro-geographical zone selected. Thus, 180 rice farmers were selected at random for the study. A structured questionnaire was employed to gather relevant information from the rice farmers on the list in Niger State.

Data Analysis

We analyzed the data using descriptive statistics, gross margin, profitability ratio, cost-benefit ratio, and multivariate logistic regression.

Gross margin

Gross margin (GM) analysis was used to estimate the costs and returns to rice farmers using SRI technology in the study area. This includes calculating the respondents' revenue on farm management, labor, and capital employed. The GM is the difference between the total variable cost (TVC) and the gross value of agricultural production (gross farm income, GFI) (Akanbi *et al.,* 2020). It is a valuable tool for planning in instances where fixed capital is an aspect of farming operations.

$$GM = GFI - TVC$$

Profitability ratio

The profitability ratio is indicative of an enterprise's capacity to turn a profit. It shows profitability and financial health (Mukaila *et al.,* 2022b). In this study, the profitability ratio was assessed by dividing the gross margin by the total variable cost.

$$\text{Profitabilityy ratio} = \frac{\text{Gross margin}}{\text{Rvenue}}$$

Cost-benefit ratio

The cost-benefit ratio was determined by dividing the net return by the aggregate cost to get the estimated present benefit from SRI. It measures the strength and viability of rice production using SRI and its benefits. The equation used for calculating the benefit-cost ratio is:

$$\text{Cost} - \text{benefit ratio} = \frac{\text{Revenue}}{\text{Cost}}$$

Multivariate logistic regression

To describe discrete choices such as the adoption of new technology, single probit and logit models are widely used. These models, however, are insufficient for dealing with the simultaneous application of various technologies. Multivariate regressions, such as multivariate logit, are commonly used to assess factors influencing the selection of interdependent options. Multivariate logistic regression finds out how dependent variables with several binary outcomes respond simultaneously to changes in explanatory variables (Falola & Mukaila, 2022). Multivariate logit was used to identify the driving factors behind the use of different SRI technologies by the farmers. Rice farmers were classified as either users with a value of one or non-users with a value of zero (Ghimire *et al.,* 2015). Farmers that employ SRI can have their probability function expressed as a latent variable expression of the observed independent variable, xi, and an error term, εi. SRI users can be defined in two ways: yes, y = 1, or no, y = 0. The likelihood of y = 1 is expressed as shown in the equation below:

$$Y = \beta_0 + \beta_1 X_1 + \cdots \beta_k X_k + \varepsilon$$

Given the predictor variables X_i,..., X_k, this function calculates the farmer's likelihood of utilizing SRI. The intercept is denoted by βo, while the estimated parameters for the predictor variables are denoted by β_1,…, βk, with ε being the error term:

Yi = The SRI technologies adopted by rice farmers are as follows:

i. Use of seed hill technology (1= yes, 0 = no)

ii. Use of water management technology (1= yes, 0 = no)

iii. Use of wide spacing (1= yes, 0 = no)

iv. Use of intermittent weeding (1= yes, 0 = no)

v. Use of manure (1= yes, 0 = no)

vi. Use of transplanting technology (8-12 days) (1= yes, 0 = no)

The explanatory factors employed were the farming experience of the rice farmers (X_1), association membership (X_2), household size (X_3), educational level (X_4), and extension service (X_5).

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Rice Farmers

Table 1 shows the socioeconomic features of the rice farmers. The result showed the mean sex and household size of the rice farmers as 1.0 and 7.6, respectively. This implied that all of the rice farmers using the system of rice intensification technology were men and had approximately 8 people in their households who served as family laborers. They had a mean age of approximately 41 years. This indicates that rice farmers are economically active and productive in producing rice (Mukaila *et al.*, 2022c; Otitoju *et al.*, 2022). The productivity among these farmers could be boosted as a result of using new technologies like SRI. The average year of rice farming experience is around 16 years, meaning that the rice farmers have been in the business for about 16 years. The longer the farmers stay in the farming business, the higher the skills acquired and productivity (Mukaila *et al.*, 2021). According to Nwaobiala (2014), when farmer gain expertise, become less scared of the hazards connected with implementing new technology such as SRI. Furthermore, 99% of the farmers had formal education. Formal education is critical in agriculture because it may lead to the employment of innovative agricultural practices such as SRI, which has the potential to increase farmers' profitability sustainably. Ninety-nine percent of rice farmers are members of one or more cooperative societies. Cooperative membership provides farmers with access to loans, knowledge, and a variety of other inputs that may be advantageous to their farming activity.

Table 1. Socio-economic characteristics of the rice farmers

Socio-economic variable	Measurement	Mean distribution
Sex	Dummy (Male = 1; female = 0)	1.0
Age	Years	40.8
Household Size	Persons	7.6
Rice Farming Experience	Years	15.7
Level of Education	Dummy (1, “Formal Education”; 0, otherwise)	0.99
Cooperative Membership	Dummy (1, “Membership”; 0, otherwise)	0.94

Source: Field survey, 2022.

The Profitability of Rice Farming Under the System of Rice Intensification Technology

Table 2 shows the outcome of the costs and returns analysis for rice production. The labor cost (48.14%) constituted a larger portion of variable costs; this was followed by fertilizer cost (34.09%), herbicide cost (8.82%), cost of seeds (6.52%), and transportation cost (2.43%). The high labor cost could be attributed to the fact

that labor use is more intensive when using SRI technology. This finding is consistent with Das *et al.* (2016), who reported that farmers encountered significant labor costs because the SRI approach needed more labor per hectare than the conventional method. Table 2 also reveals a total cost of ₦230,149 (USD 543.19) per hectare and a total income of ₦387,149 (USD 913.73) per hectare. The high gross margin implies that the SRI rice farmers made a profit of ₦157, 000 (USD 370.55) per hectare over variable costs. The profitability ratio of 0.41 is indicative of the fact that the use of SRI technology among rice producers is profitable. Furthermore, the benefit-cost ratio of 1.68 also indicates that the use of SRI in rice farming is profitable and economical. Therefore, the results from several indicators show that the use of systems of rice intensification technology in rice farming is capable of improving the profitability and productivity of rice farming.

Table 2. Cost and returns of rice farmers using SRI technology

	Items	Amount (₦/Ha)	Amount (USD/Ha)	Percentage
A	**Total revenue**			
	Sales from produced rice	387,149	913.73	
B	**Variable cost**			
	Cost of seeds	15,000	35.40	6.52
	Cost of transportation	5,600	13.22	2.43
	Fertilizer	78,456	185.17	34.09
	Herbicide	20,304	47.92	8.82
	Labor	110,789	261.48	48.14
C	**Total variable cost**	230,149	543.19	
	Gross Margin (TR-TVC)	157,000	370.55	
	Profitability ratio	0.41		
	Benefit-cost ratio	1.68		

Source; Field Survey, 2022.

Driving Factors for The Use of System of Rice Intensification Technology among Farmers

Table 3 shows the result of the multivariate analysis for the determinants of the use of the system of rice intensification technology among rice farmers. The use of technologies such as seed hill technology, water management technology, wide spacing, intermittent weeding, manure, and transplanting days of 8-12 days was regressed against variables such as association membership, farming experience, household size, extension services, and education. These results indicate that the use of the system of rice intensification technology is significantly influenced by certain socioeconomic characteristics of rice farmers.

SeEd hill technology: The result revealed that farming experience, household size, level of education, and extension service were the significant factors that influenced the use of seed hill technology. The coefficient of rice farming experience is significantly positive at a 1% level, implying that the likelihood of the use of seed hill technology in the study area increases with the number of years the farmers spent in rice production. The coefficient of household size is significant at 1%, while the level of education and extension service are significant at 1%. The coefficients were all negatively significant for the use of Seed Hill technology. This implies that a unit increase in these variables will decrease the use of seed hill technology in the study area.

Water management technology: The result also showed that the coefficients of farming experience, association membership, household size, level of education, and extension service significantly influenced

the use of water management technology at a 1%, 5%, 1%, 1%, and 1% significant level, respectively. The coefficients of farming experience, association membership, and extension services positively influenced the use of water management technology. This showed that the availability of extension services significantly increases the use of water management technology among the rice farming households in the study area, stressing the importance of extension in boosting the use of innovations. This supports Asfaw *et al.* (2012) and Mariano *et al.* (2012), who found that extension services enhance the adoption of modern agricultural technology. However, the coefficients of household size and education showed a negative relationship to the use of water management technology, indicating that they reduced the probability of adopting water management technology.

Wide spacing: The result revealed that farming experience, household size, level of education, and extension service significantly influenced the use of wide-spacing technology. The coefficient of farming experience and education positively influenced the use of wide-spacing technology at a 1% significant level. This indicates that the likelihood of using SRI technology such as wide spacing increases with higher education. This is presumably because farmers can assimilate relevant information faster than others. This result conforms to previous studies by Asfaw *et al.* (2012), Kassie *et al.* (2011), and Langyintuo and Mungoma (2008). The coefficients of household size and extension service negatively influenced the use of wide-spacing technology in the study area at 1% and 5% significant levels, respectively. Thus, an increase in these variables will reduce the likelihood of using wide-spacing technology among rice farmers.

Intermittent weeding: Furthermore, farming experience, household size, level of education, and extension service significantly influenced the use of intermittent weeding technology at a 1% significant level, respectively. The positive and significant signs on farmers' farming experience, household size, level of education, and extension service indicated that they increased the likelihood of practicing intermittent weeding in rice farming. This finding is in line with Ravichandran and Prakash (2015), who reported that literacy level, knowledge of farming, knowledge of SRI techniques, and attitude were positively associated with the level of adoption of SRI techniques.

Manure: The results of the analysis also show that farmers' experience, household size, extension service, and education were negative and significantly influenced the use of manure at a 5%, 1%, 5%, and 5% significant level, respectively. This implies that a unit increase in these variables will decrease the use of manure among rice farmers in the study area.

Transplanting days of 8-12 days: The significant factors that influenced the use of transplanting technology among rice farmers were their farming experience, household size, extension service, and education. Extension service, education, and farming experience negatively influenced the use of transplanting technology at a 1% significant level. This implies that a unit increase in these variables will decrease the use of transplanting technology in the study area. Only the coefficient of household size showed a positive relationship to the use of transplanting technology among rice farmers, indicating that an increase in household size enhanced the probability of using transplanting technology. This could be due to the availability of free family labor needed for transplanting in rice farming.

Table 3. Usage intensity of SRI technology

Variables	**Seed hill Technology**	**Water management**	**Wide spacing**	**Intermittent weeding**	**Manure**	**Transplanting days (8-12)**
Experience	0.0468*** (0.007)	0.011*** (0.006)	0.062*** (0.006)	0.021*** (0.009)	-0.034** (0.016)	-0.015*** (0.008)

Association membership	0.205 (0.096)	0.143** (0.058)	0.222 (0.084)	-0.339 (0.123)	-0.020 (0.229)	-0.102 (0.120)
Household size	-0.218*** (0.019)	-0.205*** (0.016)	-0.037** (0.016)	0.096*** (0.024)	-0.364*** (0.044)	0.209*** (0.023)
Education	-0.011*** (0.005)	-0.012*** (0.005)	0.009*** (0.005)	0.015*** (0.007)	-0.037** (0.013)	-0.010*** (0.007)
Extension Services	-0.020*** (0.007)	0.053*** (0.006)	-0.007*** (0.006)	0.049*** (0.009)	-0.032** (0.017)	-0.012*** (0.009)
Constant	4.199*** (0.278)	3.436*** (0.247)	1.793*** (0.244)	0.827** (0.358)	7.527*** (0.665)	1.258*** (0.350)

Source: Field Survey, 2022

*, ** & *** is significance at 10%, 5% and 1%, respectively.

Std. Err. in parenthesis

CONCLUSIONS

This study explored the profitability and drivers of the system of rice intensification technology. The study indicates that the use of systems of rice intensification technology in rice farming is profitable, as shown by the profitability ratio of 0.41. Several factors influence the use of different systems of rice intensification technology among farmers. Farming experiences enhance the use of seed hill technology, water management technology, wide spacing, and intermittent weeding but inhibit the use of manure and transplanting. Association membership enhances the use of water management technology. Household size enhances the use of intermittent weeding and transplanting technology but reduces the likelihood of using seed hill technology, water management technology, wide spacing, and manure in rice farming. Education enhances the use of wide spacing and intermittent weeding but reduces the use of seed hill technology, water management technology, manure, and transplanting technology. Extension services increase water management technology and intermittent weeding but reduce seed hill technology, wide spacing, manure, and transplanting technology. The results from this study show that the use of systems of rice intensification technology in rice farming is capable of improving the profitability and productivity of rice farming. Thus, its adoption should be promoted and encouraged among rice farmers. Given the importance of extension service and farming experience factors, the study proposes a greater focus on information distribution, extension demonstration, farmer-collaborative training, and research programs that promote and encourage the use of the system of rice intensification technology. As a result, planners and decision-makers must examine demonstrations at farmers' fields to improve and promote the usage of SRI Technology.

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الربحية ومحددات نظام استخدام تكنولوجيا تكثيف الأرز بين مزارعي الأرز

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ملخص

الأرز هو المكون الرئيسي لسلة الغذاء في نيجيريا، والمحصول الأساسي. يتم إنتاج غالبية أرز البلاد باستخدام الطرق التقليدية. أدت هذه الطريقة إلى ارتفاع كلفة إنتاج الأرز وادت الى صعوبة وصول المزارعين إلى طاقتهم الإنتاجية الكاملة. نتيجة لذلك ، تم وضع النظام المكثف لإنتاج الأرز (SRI) في صناعة إنتاج الأرز. ومع ذلك ، لا يوجد بحث حول الجدوى المالية لاستخدام تكنولوجيا SRI والمتغيرات التي تؤثر على استخدام المزارعين لها في نيجيريا. لذلك ، قامت هذه الدراسة باستقصاء الربحية ومحددات استخدام النظام المكثف لإنتاج الأرز (SRI) . تم استخدام استبيان لجمع المعلومات من 180 مزارع أرزممن يقوم باستخدام تقنية SRI . تم استخدام الإحصاء الوصفي وتحليل الربحية والانحدار اللوجستي متعدد المتغيرات في تحليل البيانات. اكتشفت الدراسة أن غالبية مزارعي الأرز الذين يستخدمون تقنية SRI في نيجيريا كانوا من الذكور النشطين اقتصاديًا، وحققوا هامشًا إجماليًا قدره 370.55 دولارًا أمريكيًا ، ونسبة فائدة إلى تكلفة قدرها 1.68 ونسبة ربحية قدرها 0.41 للهكتار الواحد. وهذا يشير إلى أن استخدام تقنية SRI في زراعة الأرز أمر مجدي. كشفت نتيجة التحليل متعدد المتغيرات لمحددات استخدام SRI أن توافر خدمات الإرشاد ، والخبرة الزراعية ، وعضوية الجمعيات، وحجم الأسرة ، والتعليم أثرت على استخدام تقنيات SRI المختلفة. وتوصي الدراسة بتعزيز التكافؤ الاجتماعي من خلال تبادل المعرفة والعروض الإرشادية ومشاركة المزارعين في برامج التدريب.

الكلمات الدالة: التبني ، الربحية ، زراعة الأرز ، نظام تكثيف الأرز ، التكنولوجيا.

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