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TECHNICAL EFFICIENCY OF SAWAH TECHNOLOGY IN RICE PRODUCTION AMONG SMALL SCALE FARMERS IN KEBBI STATE NIGERIA.

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ABSTRACT

The research examined the economics of Sawah technology in rice production among small scale farmers in Kebbi State Nigeria. The study specifically identified the drivers of usage of Sawah rice technology in the study area, estimated the technical efficiency of rice farms using Sawah rice technology and analyzed the effect of Sawah rice technology on the profit of rice farmers in the study. Three hundred respondents were sampled from the study area. The data were analyzed using descriptive statistics, Gross margin analysis, logit model, stochastic frontier model and t-test. The Cobb-Douglas functional form of the stochastic production frontier was employed to estimate the technical efficiency of users and non-users of Sawah rice technology. For users of Sawah technology, all the variables (farming experience, household size, amount of credit obtained and membership of farm group) had negative and significant effect on technical inefficiency. For non-users, all the variables (years of Education, farming experience and membership of farm group) had negative and significant effect on inefficiency. The range of small-scale rice farmers' calculated technical efficiencies was 0.0536 to 99.5%, with an average of 56.7%. Sawah rice technology users had average technical efficiency values of 0.646, or 64.6%, while non-users had average technical efficiency estimates of 0.533, or 53.3%, correspondingly. The study therefore recommended that dissemination of sawah to other states in Nigeria need to consider factors that promote its adoption. Improvement of those factors that significantly affect adoption of sawah technology is also recommended.

Keywords: *Technical Efficiency, Sawah Technology, Rice Production, Small Scale Farmers.*

INTRODUCTION

Nigeria is blessed with varied climatic zones, vast land resources and the potentials for the production, processing, marketing and export of various agricultural commodities Havelock, (1979). Rice (*Oryza sativa*) is a crucial staple food in Nigeria and is enjoyed worldwide by people from all social and economic backgrounds. Government's efforts to increase food security and reduce food imports in order to feed the population that rely heavily on the production of rice, which is significant to Nigerian agriculture (He, *et al.,* 2007). One of Nigeria's states that produce rice is Kebbi State (Helena, 2005). The state is well-known for its irrigation- and low-rain-fell lowland rice farming. The amount of milled rice in Nigeria went from 2,818 million metric ton in 2010 to 5,000 million metric ton in 2021, demonstrating the considerable increase in rice output in the country (Hinton et al., 2004). The amount of land used for rice farming has also dramatically increased (Holden, 2004). Although domestic rice output appears to be rising, Nigerian producers have never been able to keep up with the nation's rising rice consumption. According to Hussain and Hanjra (2004), the consumption of rice in Nigeria is rising quickly as a result of a number of important variables, such as shifting consumer preferences for rice, population increase, rising income levels and quick urbanization. Data on hand indicate that in 2021, the nation's output of essential foods improved slightly. According to data from the US Department of Agriculture, Nigeria's rice production increased from 4.89 million metric tonnes in 2020 to 5.0 million metric ton in 2021 (Hyman *et al.,* 1995).

According to Hyman *et al.,* (1995). Sawah is a man-made, improved rice-growing environment with demarcated, bundled, leveled and puddle fields for water control. Sawah is soil-based eco-technology. In a simpler form, the term Sawah refers to levelled, bundled and puddled rice field with a water inlet and outlet to control water and manage soil fertility, which may be connecting irrigation and drainage facilities including Sawah to Sawah irrigation and drainage.

The term Sawah originated from Malayo, Indonesian (Karangwa, 2010). in the absence of water control, fertilizers cannot be used efficiently. Consequently, the high-yielding varieties performed poorly and soil fertility cannot be sustained. The potential of Sawah-based rice farming is enormous in Sub-Sahara Africa (SSA), especially in West Africa. Ten to twenty million hectares of Sawah can produce additional food for more than 300 million people in the future (Hyman *et al.,* 1995). Through the improvement of the multi-functionality of wetlands of the Sawah type and geological fertilization processes in watersheds, Sawah-based rice cultivation may overcome both low soil fertility and limited water resources (Karangwa, 2010).

Rice is grown virtually in all the agroecological zones of Nigeria. The country is endowed ecologically to produce enough rice to satisfy domestic demand and has the potential to export to other countries considering its vast agricultural land and suitable climatic conditions; however, in spite of this advantage, the efficiency of production and productivity of rice is very low because of lower utilization of improved agricultural technologies (Kamai *et al.,* 2020). Rice production involves both pre-harvest and post-harvest tasks, including land selection, clearing, nursery, rice field preparation, planting and transplanting, weeding, manuring and fertilizer application, scaring away birds and rodents, harvesting, threshing, parboiling, drying, winnowing, packaging and marketing (He, *et al.,* 2007). Each of these stages in the production of rice is significant and necessitates the intelligent deployment of farm resources that come from well-informed farm choices. For the states to be self-reliant in rice production farmers need to find a way to improve the average yield per hectare. Therefore, the profitability of usage of Sawah rice technology in Kebbi State Nigeria was investigated

Objectives of the Study

The main objective of this study is to investigate the economics of Sawah technology in rice production among small-scale farmers in Kebbi State Nigeria.

The specific objective are to:

i. estimate the technical efficiency of rice farms using sawah technology in Kebbi State Nigeria
ii. determine technical efficiency for Users and Non-Users of Sawah technology

Theoretical Framework / Theory of Production

Measuring the production efficiency of farms compared to other farm holdings has been a thing of vast interest to many agricultural economists. In theory, there is sequential exchange about the comparative importance of the different components of efficiency of farms (Lingard *et al.*, 1983). Looking at it from other perspectives, to measure efficiency is very important for the fact that it is the first step in the process of substantial resource saving. Khandaker (1998) stated that efficiency of farm is a major factor in farm productivity improvement. In a situation with scarce resources and lack of opportunities for new technology usage, studies of inefficiency would show the possibilities to increase farm productivity by increasing efficiency or developing or adopting new technology. This will also help to determine the underutilization or over utilization of factor inputs (Inuwa *et al.,* 2011).

The possibility of expanding production by bringing more resources, especially land, into use is becoming more and more limited. It is thus of policy relevance to seek ways of improving the production efficiency of farmers (Rahji, 2005). The connection between actual and ideal or prospective output is what defines the technical efficiency level of a farm (Greene, 1980). Therefore, the determination of how well a farm is performing technically depends on how much its outputs deviate from planned or projected production and/or the boundaries of efficient crop production. Therefore, a crop farm can be considered to be totally efficient if the planned or projected production is achieved. On the other hand, it is deemed to be technically inefficient if the production is below the set border of efficient production (Ligeon *et al.*, 2013).

The Concept of Sawah Rice Technology

Sawah rice technology reported to be one of the best agricultural practices capable of increasing rice yield per hectare (Wakatsuki *et al.,* 2013). Sawah rice technology has a lot of advantages: it enhances effective water control and management, it encourages biodiversity, it encourages nitrogen fixation through decomposition, there is effective weed control through flooding and it can also improve accumulation of soil organic matter and increases the yield per hectare of rice production (Wakatsuki *et al.,* 2013). Thus, Sawah ecology technology could make improvement to irrigation water management and efficiency of fertilizer use (Wakatsuki *et al.,* 2011).

Sawah rice technique includes crucial elements like: (a) hydrology demarcation through bunding, soils, and topography; (b) puddling with levelling to manage and then save water and soil; and tillage. (c) Water outputs for drainage as well as inlets for water for various irrigation facilities (d) Better fertilizer and chemical application techniques; (e) Better seed types. The National Centre for Agricultural Mechanization (NCAM) (2018) noted that these are major fundamental components of Sawah farms for managing irrigation water and using other innovation.

Measurement of Efficiency

The sensitivity result of a study of efficiency in relation to the technique of estimating efficiency points is of great importance. The two major techniques in use for measurement of farm efficiency are the Data Envelopment Analysis (DEA), (Jradi and Ruggiero, 2019) and the Stochastic Frontier Approach (SFA), (Aigner *et al.,* 1977). The first one normally uses linear programming technique, while the latter is using econometric methods.

Several characteristics that affect whether DEA and SFA are appropriate include the data set quality, the relevance of different functional forms and the possibility of making behavioral assumption. For example, there are no particular functional forms needed to be selected when comparing the DEA with the SFA; neither are any behavioural assumption needed since efficiency allocation is not in consideration. Moreover, DEA is a deterministic method, which means that noise in a set of data is not accounted for (Jradi and Ruggiero, 2019). Every deviation in the frontier would be accounted as the inefficiencies. As a result, efficiency of DEA rankings may be subject to measurement inaccuracies. SFA by itself provides an inference method while accounting for random mistakes (Celli *et al.,* 2002). As a result, according to Aigner *et al.,* (1977), SFA is sensitive to the decision made about the functional shape.

METHODOLOGY

Description of the Study Area

The study was carried out in Kebbi State. The State was created in 1991, out of the then Sokoto State. Located between latitude 10°8' N and 13°15' N and longitude 3°30' E and 6°02' E, the state is bounded by Sokoto State, Zamfara State, Dosso Region in the Republic of Niger to the North and East, Niger State to the South, and Benin Republic to the West. It has a total land area of 36,129 km2. Kebbi State has an agriculturally viable environment since it is endowed with high soil fertility, vast farmlands and economically viable rivers sheltered by fine tropical climate.

Sampling And Data Collection

Data were collected from 300 participants selected sawah farmers in the study area. Data used in this study were collected in all the sawah sites in Kebbi State namely Argungu, Birnin Kebbi, Jega and Bagudu. The farmers were selected based on their participation in sawah rice production. A well-structured interview guide was used to elicit information from the farmers

Method of Data Analysis

The study employed descriptive statistics such as standard deviation, mean, percentages, and frequencies. They were used to describe household and farm characteristic information of-the farmers selected for the survey, while inferential statistical methods such-as stochastic frontier model (which was used to estimate technical efficiency) and t-test (which used to test for significant difference) were used for this study.

The Stochastic Frontier Model

The functional framework of Cobb-Douglas function for the stochastic frontiers was used to determine the technological efficiency of Sawah rice innovation non-users and users in this study. It was expressed as follows.

Table 1: Distribution of Rice Farmers according to their Efficiency of Production

Efficiency range	Users of Sawah technology		Non-users of Sawah technology		Pooled	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
≤0.50	92	55.8	76	56.3	168	56.0
0.51-0.60	10	6.1	8	5.9	18	6.0
0.61-0.70	27	16.4	25	18.5 12.6	46	17.3
0.71-0.80	16	9.7	17	0.0	33	11.0
0.81-0.90	8	4.8	0	6.7 100.0	8	2.7
0.91-1.00	12	7.2 100.0	9	0.533 (53.3%)	21	7.0
Total	165	0.646 (64.6%)	135		300	100.0
Mean TE					0.587 58.7%)	
Min.						0.0536
Max.						0.995

Source: Field Survey, 2021

Technical Efficiency Among Non-Users of Sawah Rice Technology:

For non-users, all variables, specifically the quantity of herbicides and the quantity of fertilizer, exhibited a positive and significant impact on rice output.

The coefficient for the quantity of herbicides was 0.324 (z = 5.52**; p = 0.001). This shows that quantity of herbicide has a positive effect on technical efficiency.

The coefficient for the quantity of fertilizer was 0.1596408 (z = 8.30**; p = 0.001), this shows that quantity of fertilizer application has a positive effect on technical efficiency.

Previous research conducted by scholars such as Aye and Mungatana (2011) and Shumet (2011) has suggested that factors like access to advanced agricultural technology and farm machinery, including the use of improved seeds, synthetic fertilizers, and agrochemicals, positively influence efficiency.

To determine the factors influencing technical inefficiency, the Cobb-Douglas functional form of the stochastic production frontier was used for users and non-users of Sawah rice technology as presented in Table 4.7. In this study, the Cobb-Douglas functional form of the stochastic production frontier was used to assess the technical inefficiency of both users and non-users of Sawah rice technology. The influence of various factors on technical inefficiency were examined, shedding light on critical findings. Among users of Sawah technology, several variables exhibited a significant negative impact on inefficiency:

Farming experience (z = 2.51**; p = 0.012)
Household size (z = 3.78**; p = 0.001)
Amount of credit obtained (z = 2.86**; p = 0.004)
Membership in farm groups (z = 1.99**; p = 0.047)

The coefficient for farming experience was -0.2742, statistically significant at the 5% level. This means that the more experienced the farmers are the less technically efficient they become.

The years in farming showed negative but significant value at 5% for users of Sawah technology. This showed that the more experienced the farmers were, the more technically efficient they became and the higher the production efficiency. This result is consistent with the idea that as years in farming increases, more experience will be gathered by the farmers which will in the long run lead to higher production. (Msuya and Ashimogo, 2006).

The amount of credit is expected to have a negative effect on inefficiency, hence the negative value for the variables obtained for users of Sawah technology has a positive effect on technical efficiency. Though, lack of access to credit may deprive the farmer the purchase of inputs to increase efficiency. For non-users, the coefficient for years of education was -0.145 (z = 2.56**; p = 0.010), significant at the 5% level. This indicates that years of education has a negative effect on technical efficiency.

The years of education coefficient showed negative but significant value at 5% level for both users and non-users. Therefore, the more education the farmers had, the more efficient they become and the higher the production efficiency. This result is consistent with the idea that schooling increases information on farming which leads to higher production.

The coefficient for farming experience was -0.3139, statistically significant at the 5% level. This showed that the more experienced the farmers are, the more technically efficient they become and the higher the production efficiency. The result is consistent with the idea that years in farming increases farming information which leads to higher production (Msuya and Ashimogo, 2006).

Membership in farm groups had a negative coefficient of -0.0387. This shows that membership in farm groups has a negative effect on technical efficiency.

Previous studies (Beyene, 2004; Arega and Reshid, 2005; Wambui, 2005; Ephraim, 2007; Elibariki *et al*., 2008; Endrias *et al*., 2010; Otitoju and Arene, 2010) had consistently identified variables such as having a male household head, higher levels of education, family literacy, increased interaction with extension workers, affiliation with farmer's associations or cooperative organizations, the use of irrigation, access to credit, and ecological factors as positively influencing agricultural inefficiency

Table 2: Technical efficiency for (Users and Non Users of Sawah technology (n = 165; n = 135)

Variables	Users (n=165) Coefficient	Z	P>|z	Non-users (n=135) Coefficient	Z	P>|z
Production function						
Labour	0.0322	0.65	0.516	-3.10e-07	-0.00	0.998
Quantity of herbicides	0.0420	0.48	0.629	0.3242042	5.52**	0.001
Quantity of fertilizer	0.03473			0.1596408	8.30**	0.001
Size of land	0.2153	-1.92	0.055	-0.0196364	-0.61	0.540
Quantity of seed	-0.056	-0.78	0.434	-0.1582751	-1.44	0.151
Inefficiency model						
Age	-0.1405995	-0.58	0.563	0.6819387	1.83	0.067
Sex	-.0244094	-0.43	0.669	0.2567668	1.65	0.099
Years of Education	-.0201127	-1.17	0.241	-0.1451129	2.56**	0.010
Farming experience	-0.2742913	2.51**	0.012	-0.3139139	1.98**	0.048
Household size	-0.2615616	3.78**	0.000	0.2635311	1.80	0.072
Amount of credit obtained	-0.106459	2.86**	0.004	-0.0291195	-0.41	0.681
Extension agents visit	0.0167747	0.47	0.639	0.0240144	0.35	0.724
Membership of farm group	-0.0620262	1.99**	0.047	-0.0387042	-0.34	0.735
_cons	13.08152	3.89**	0.000	-6.46183	4.74**	0.000
Sigma2	0.2063					
Gamma	0.0008					
Log likelihood	-220.55451					
Wald chi2	205.57					
Prob > chi2	0.0000					

** = 5% of significant level Source: Field Survey, 2021

The results in table 4.8 are for the transcendental production function approach. From the results, for users of Sawah technology, two variables were the factors having negative impact on inefficiency. Farming experience (Z=3.81, p=0.014). The amount of credit obtained (Z = 2.98, p = 0.005).

The coefficient of farming experience was -0.325, statically significant at 5% level. The years in farming showed negative but significant value at 5% for users of Sawah technology. This means that the more experienced the farmers were, the more technically efficient they became and the higher the production efficiency. This result is consistent with the idea that years in farming increases information which leads to higher production in the long run (Msuya and Ashimogo, 2006).

The coefficient of amount of credit obtained was -0.3142 statistically significant at 5% level. This shows that amount of credit has a negative but significant effect on technical efficiency.
For non-users of Sawah technology only farming experience (z = 2.98, p = 0.046). this means that farming experience with the coefficient of -0.1313 had a negative but significant effect on technical efficiency. This means that the more experienced the farmers were, the more technically efficient they became and the higher the production efficiency

Table 3: Maximum likelihood estimates of stochastic frontier Analysis using transcendental functions

Variables	Users (n=165) Coefficient	Z	P>|z	Non-users (n=135) Coefficient	Z	P>|z
Production function						
Labour	0.06324	0.32	0.821	-4.1364	-0.00	0.6426
Quantity of herbicides	0.0380	0.56	0.726	0.26322	4.85**	0.001
Quantity of fertilizer	0.0244	0.47	0.562	0.25962	0.262	0.000
Size of land Quantity	0.3262 -	4.85	0.045	0.31478	0.346	0.326
of seed	0.085	3.26	0.322	0.25827	1.27	0.131
Inefficiency model						
Age	-0.142386	-0.48	0.356	0.2814	1.38	0.052
Sex	-0.44326 -	-0.34	0.727	0.1576	1.42	0.069
Years of Education	0.20114 -	-0.67	0.421	0.5411 -	1.36	0.001
Farming experience	0.3625 -	3.81**	0.014	0.1313	2.98**	0.046
Household size	0.26448 -	-0.79	0.001	0.3256	1.70	0.027
Amount of credit obtained	0.3142	2.98**	0.005	-0.018	-0.14	0.036
Extension agents visit	-0.2641	0.67	0.396	0.015 -	0.53	0.032
Membership of farm group	0.1348	0.69	0.474	0.016	-0.24	0.031
		3.89**	0.000			

*** = 5% of significant level*
Source: Field Survey, 2021

Analysis of Significant Difference in mean Output Among Users and Non-users

The significant difference between the technical efficiency of users and non-users of Sawah technology was analyzed using independent sample t-test as shown in Table 4.9. The mean output of the users of Sawah rice technology was found to be 1272.7 tons while that of non-users of the technology had a mean output of 1036.5 tons. The mean difference between the output of the users and non-users of Sawah technology was found to be 236.2 tons which was statistically significant. This significant difference between the output of the users and non-users of Sawah rice technology with users having more output indicating an improvement in the output of rice. This finding is an indication that users households had experienced increase in crop production and income. In line with the finding of this study, studies conducted by Legese (2011), Menale *et al.,* (2011), Solomon *et al.,* (2012) and Sosina *et al.,* (2014) on the impact of various improved crop technology, in countries such as Ethiopia, Uganda, Tanzania and Malawi, supported the hypothesis that adopter households experience increase in crop income, consumption expenditure and value of assets accumulation through improved household productivity.

Table 4: Result of independent sample t-test Analysis of the Difference in the output of Users and Non-Users

Variable	Sawah Technology	Number	Mean	Std. Deviation	Std. Error Mean
Total	User	165	1272.7	734988	57218.70977
Revenues	Non-Users	135	1036.5	797912	68673.36709

Source: Field Survey, 2021

CONCLUSIONS AND

The Cobb-Douglas functional form of the stochastic production frontier was employed to

	Test for Equality of Variances					t-test for Equality of Means	.		
	F	Sig.	t-value	Df	Sig. (2- tailed)	Mean Difference	Std. Error Diff	95% confidence in the Difference Lo wer	Upper
Equal Variances Assumed	1.981	0.006	2.664	298	0.008	236200	88654.76406	61741.004	4.102
Equal Variances not Assumed			2.643	275.963	0.009		89386.86757	60242.958	4.125
						236200			

Source: Field Survey, 2021

CONCLUSIONS AND RECOMMENDATIONS

The Cobb-Douglas functional form of the stochastic production frontier was employed to estimate the technical efficiency of users and non-users of Sawah rice technology. For users of Sawah technology, all the variables (farming experience, household size, amount of credit obtained and membership of farm group) had negative and significant effect on technical inefficiency. For non-users, all the variables (years of Education, farming experience and membership of farm group) had negative and significant effect on inefficiency. The range of small-scale rice farmers' calculated technical efficiencies was 0.0536 to 99.5%, with an average of 56.7%. Sawah rice technology users had average technical efficiency values of 0.646, or 64.6%, while non-users had average technical efficiency estimates of 0.533, or 53.3%, correspondingly. Based on the findings, the following recommendation are necessary:

1) A lot of the farmers in the study location lacked public funding in form of micro credits, which would have helped them produce more rice, hence there is therefore need to make credit facilities accessible by all stakeholders.
2) Sawah rice technology significantly improve rice production level, however, there is a need to review the Sawah technological package in order to remove various bottle neck so as to make it accessible to the rice farmers.
3) Increased extension personnel need to be engaged and should be trained to address problem of inadequate extension personnel for timely dissemination of reliable and improved practices/techniques to the farmers in order to boost their production level.
4) Membership of social organization should be encouraged since it is a major determinant of rice output so as to avail better opportunity to access adequate information on sources of credit facilities and other production assets so as to

boost rice production and farmers' income.

5) Farmers should receive more training and knowledge about Sawah technology through steady flow of information from the extension agents.

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