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Determining the Efficiency of Rice Production in the Kadawa Rice Cluster of Kano State, Nigeria

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Abstract

In an efforts to increase the production of rice for food security and reduced deflation of foreign reserves, the Nigerian government eases access to fertilizer, extension services and improved rice seed. Therefore, the paper examines the effect of access to fertilizer and extension services infrastructures and improved rice seed on the productivity of rice farmers as well as identify their level productivity in the Kadawa rice cluster. A five Likert structured questionnaire randomly administered to a sample of 80 rice farmers in the 2018 crop season. The Cobb-Douglas stochastic frontier production model was used to analyze the data. The descriptive result shows that males (83.3%) dominated rice farming. The economically active age group are 53%, the married group are 65.2%, those with at least six years of experience in rice farming are 74.2%, and 22.7% attained tertiary education. Further, the stochastic frontier result shows that improve rice seed and extension services positively affect rice production, while fertilizer negatively affects rice production. Further, the result shows that years of experience in rice farming reduces technical inefficiency. While qualification, age, and marital status reduce rice production. Therefore, the study recommends the provision of educational facilities for quality education. Expanding extension workers' services to farmers, since one visit per crop season seems to be not enough to offer the necessary information to farmers. Finally, to attract experienced, educated young married farmers to partake in rice cultivation in the study area.

Keywords: *Rice Productivity, Extension, Fertilizer, improved seed, Kadawa*

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INTRODUCTION

Rice (Oryza sativa) is one of the critical crops due to the rate of its consumption because it is the most consumed crop in the state and Nigeria (Maji, Bashir, Oduba, Gbanguba, & Audu, 2015). The population growth, urbanization, profession edifice, and changes in nutritional desires in Nigeria lead to an increase in the demand for rice (Tanaka et al., 2017). Also, partly owing to an increase in income (Uduma, Samson, & Mure, 2016). Statistical data shows that Kano has the highest number of rice farmers, both rainfed (214,332) and irrigated (143,768) (Kano state Agricultural and Rural Development Authority [KNARDA], 2017). Further, Tanko, Kang, and Islam (2019) reported that full harnessing of irrigated rice potentials in Kano could produce 81% of the rice demanded in the country. Unfortunately, rice farmers in the Kano cannot produce rice that can meet the demand of the state. Thus, leads to the importation of thousand tons of milled rice into the country to bridge the gap.

To increase the productivity of rice farmers in the country, the government devised a policy that improves the ability of farmers to access nitrogen fertilizer, improved rice seed, and extension services. Productivity is measured as the ratio of output produced to the total inputs used (Ben-Chendo & Joseph, 2014). Productivity is said to have increased when the rate of growth of output is faster than the growth rate of inputs used in the production (Tanko, Yong, & Islam, 2019). Therefore, the preferred increase in productivity is the growth in productivity without an increase in the inputs used in production (Nin-pratt & Yu, 2009). This paper attempt to examine the effect of nitrogen fertilizer, improve rice seed, and extension services on the productivity of rice farmers as well as their level of productivity in Kadawa rice cluster of Kano.

LITERATURE REVIEW

Fertilizer

The convenient method to increase crop productivity is to enhance micronutrient (Tiwasing, Dawson, & Garrod, 2019). A study result shows that fertilizer nutrients increase produce from 30% to 50% (Stewart, Dibb, Johnston, & Smyth, 2005). Also, Tashikalma, Giroh, and Ugbeshe (2014) and Zhu and Chen (2002) report a positive effect of chemical fertilizer on crop production. Another study result shows that the correct usage of fertilizer by the farmers led to an annual increase in crop return by 35% and annually by 69% (Duflo, Kremer, & Robinson, 2008). Similarly, (Zhang et al., 2017) report that nitrogen usage increases the growth rate of rice; and positively and significantly affect rice yield. Further, Osanyinlusi and Adenegan (2016) and Mandal, Patra, Singh, Swarup, and Masto (2007) reports a positive effect of fertilizer usage and quantity used on the productivity of farmers. Moreover, a comparative study by Ahmed, Xu, Yu, and Wang (2017) report that an improvement in access to fertilizer could boost rice productivity in Hainan, China and

Niger, Nigeria. Therefore, Ajani and Ugwu (2008) recommend providing fertilizer to farmers at the right time and place.

Improved Rice Seed

Moshynets et al. (2019) reported that improved seeds could be used to improve crop growth, increase yield, and reduce fertilizer usage. Further, an increase in yield lead farmers to participate in a farmers' association (Abdul-Rahaman & Abdulai, 2018). Also, Abro, Legesse Debele, and Kassie (2019) reports that improved seeds lead to an increase in crop productivity and that improved seeds are more productive than traditional seeds. Therefore, improved rice seeds positively and significantly affect rice productivity (Xue et al., 2017); because treated seeds improve crop sprouting by 93.33% (Anupama, Murali, Jogaiah, & Amruthesh, 2014). Further, Zhou et al. (2017) reported that improved rice is capable of sustaining soil with water deficit, assurance of an increase in rice output, and efficient in water use.

Similarly, Qaim and Zilberman (2003) indicated that genetically modified seeds significantly lessen pest damages and rise output. Furthermore, assuring farmers that they will have access to improved seeds increase their return by 30% (Shiferaw, Kebede, & You, 2008). Besides, societies where most farmers adopt improved seeds, both farmers and consumers enjoy a better price (Minten & Barrett, 2008). Improve seed adopters are 88% efficient while non-adopters are 66% efficient, and in a period of lower yield adopters are 74% efficient, and non-adopters are 44% efficient (Thirtle, Lin, & Piesse, 2003).

Extension Services

Extensions are the services offered by the extension workers to farmers on the methods of improving the productivity of crop by the farmers (Antle, Zhang, Mu, Abatzoglou, & Stöckle, 2018; Golan & Kohli, 2013). Further, Adekunle et al. (2004) reported that extension services could be through direct contact with extension agents and farmers. They added that it could be through publications on pamphlets and radio programs. But the latter is preferred due to its broader coverage and in the physical absence of extension agent. A study result shows that extension services offered positively and significantly stimulate the adoption of modern agriculture (Maffioli, Ubfal, Vazquez-Bare, & Cerdan-Infantes, 2013; Verkaart, Mausch, Claessens, & Giller, 2019).

Furthermore, investment on extension services increase returns (Jin & Huffman, 2016) and extensions offered led to an increased return to investment by 77% on groundnut, 73% on maize, and 75% on cropping of groundnut and maize (Binam, Tonyè, Wandji, Nyambi, & Akoa, 2004). Therefore, Berhanu and Poulton (2014) affirm that investment on extension services is the most effective policy to increase the productivity of farmers. So, Garnett et al. (2013) emphasize on extension services to motivate an increase in the productivity of farmers. Further, Evenson (2001) reiterates that most research results are consistent, that the result of estimate shows a more than 40% return of investment in extension services. Therefore, concludes that extensions increase the productivity of farmers. Similarly, Dercon, Gilligan, Hoddinott, and Woldehanna (2009) reports a reduction of poverty by 9.8% and an increase in consumption by 7.1% due to one extension visit. While Owens, Hoddinott, and Kinsey (2003) report that one to two extension visits increase crop yield by 15% though, farmers misunderstood extension services (Al-Zahrani, Khan, Baig, Mubushar, & Herab, 2019).

MATERIALS AND METHOD

Data on rice production in Kadawa is obtained from the farmers in the cluster for the 2018 cropping season. A five Likert structured questionnaire was administered randomly to a sample of 80 rice farmers in the cluster. The usable questionnaires were 66 collected with the assistance of an extension worker who already has a good rapport with the rice farmers. The Cobb-Douglas stochastic frontier production model was used to analyze the data. Data on the dependent variable, rice productivity and independent variables, fertilizer, improved rice seeds, and extension services were collected from the respondents. Data on the socio-economic characteristics of the rice farmers were also collected. Such data includes the gender of the farmer, farmer's age, level of education, farmer's marital status, and years of experience in rice farming.

The Dependent Variable

Production (Y)

Is defined as the aggregated paddy rice in the study area for the 2018 cropping season measured in tons. The output of rice produced obtained was from the individual farmers in the study area.

The Independent Variables

Fertilizer

Fertilizer comprises of all chemical fertilizer used in the production of rice, and it is measured as access to fertilizer by the rice farmer.

Improved Rice Seed

Improved rice seed comprises of all available hybrid rice seeds used in the production of rice, and it is measured as access to improved rice by the farmer.

Extension Services

Extension services are vital in improving the productivity of farmers, especially in rural areas where most of the farmers have little knowledge about modern agriculture. In this study, extension services refer to the number of visits that the farmer has in a cropping season.

Model Specification

Stochastic Frontier Model

The analytical method employed for the study is the stochastic frontier production model. The stochastic frontier is an econometric and parametric approach. The model has the potential to separate the effects of the symmetric error term (noise) from the asymmetric error term (technical inefficiency). The model confounds the effects of misspecification of the functional form.

Rice production in Kano is a single output with multiple inputs in production. The study uses the stochastic frontier production model in assessing the efficiency of rice farmers. Following Coelli, Rao, O'Donnell, and Battes (2005), we specify a Cobb-Douglas production function to estimate the stochastic frontier production function as:

$$Y_i = \beta_0 + \sum_{i=1}^{n} \beta_1 \mathrm{Ftz} + \beta_2 \mathrm{Ext} + \beta_3 \mathrm{Ips} + V - U \quad (1)$$

Where, Y = output (tons), Ftz = Chemical fertilizer access, Ips = Improved rice seed access, and Ext = Access to extension visit (all measured in five-Likert scale). = the random error (symmetric) beyond the control of the farmer, it is assumed to be independently and identically distributed N (0, σ2v). The error term (asymmetric) is the technical inefficiency of a farmer; it is non-negative and one-sided. The inefficiency effects are assumed to be independently distributed with a half-normal distribution $\{U \sim |N(0, \sigma^2_u)|\}$.

The technical inefficiency effects in the stochastic frontier equation (1) is defined as;

$$U = \upsilon_i = \delta_0 + \delta_1 \mathrm{Gen}_i + \delta_2 \mathrm{Age}_i + \delta_3 \mathrm{Qual}_i + \delta_4 \mathrm{Mst}_i + \delta_5 \mathrm{Exp}_i + S_i \quad (2)$$

Where, U = technical inefficiency effect, Gen = gender (1 if male farmer, 0 otherwise), Age = age of the rice farmer (years), Qual = qualification (level of education /number years of schooling of the respondent), Mst = marital status (1 married farmer, 0 otherwise), and Exp = experience (number of years spent in rice farming).

The coefficients of the parameters and δ in the stochastic frontier function would be estimated using the maximum likelihood method. Further, the variance parameters would be estimated expressed as presented by Aigner *et al.*, (1977) and Battese and Corra (1977) estimated as:

$\sigma^2_s = \sigma^2_v + \sigma^2_\upsilon$ (3)

$\gamma = \sigma^2_\upsilon \div \sigma^2 s$ (4)

so that $0 \leq \gamma \leq 1$

where; σ^2_v = variance of the error term (symmetric), σ^2_υ = variance of the error term (asymmetric) shows the deviation from the maximum output that should be produced by an efficient farmer. σ^2_s = total variation in output produced ($\sigma^2_v + \sigma^2_\upsilon$), and γ = is the shortfall of output that deviates from the maximum likelihood due to the technical inefficiencies of a farmer. γ lies between 0 and 1 if γ = 0 it means absence of inefficiency; therefore, all deviations from the frontier is due to noise. If γ = 1, implies that all underperformances are caused by technical inefficiency.

However, the inefficiency effects model (2) can only be estimated if the technical inefficiency effects are stochastic and have a specific distribution. Therefore, the need arises to test the following null hypotheses; there is no inefficiency effect in the model, H0: γ = δ0 = δ1 = δ2 = … = δ6 = 0 and there is technical efficiency effect, yet it is non-stochastic so, δ = 0. The tests were conducted by the generalized likelihood ratio test (LR). The LR test requires the estimation of the model under the null and alternative hypotheses. Under the null hypothesis, H0: γ = 0, the model without the technical inefficiency effect (U). The test statistic was conducted as parametrized by Battese and Corra (1977):

$LR = -2[\ln\{L(H_0)\} - \ln\{L(H_1)\}]$ (5)

Where, $L(H_0)$ and $L(H_1)$ are values of the likelihood function under null hypothesis and alternative hypothesis respectively.

3.2.3 Determining the Level of Rice Farmers' Productivity

$TE_i = Y_i^* \div Y_i$ (6)

Where; TE_i = The technical efficiency of the rice farmer. Y_i^* = The frontier output (tons) that could be produced by an efficient rice farmer. Y_i = The observed output of the rice farmer (tons).

RESULT AND DISCUSSION

The demographic result shows that male rice farmers (83.3%) dominated rice farming, implying there are more male rice farmers than female. The age of the economically productive respondents is 53%, relatively productivity is expected to be moderate. Further, the married rice farmers are 65.2%, which reemphasized a moderate productivity level in the cluster. Also, 74.2% of the respondents spent six years and above in rice cultivation, and 22.7% of the respondents have tertiary education.

Table 1. Descriptive statistics of rice farmers in Kadawa rice cluster

Gender	Percentage
Male	83.3
Female	16.7
Age	
Less than 20 years	6.1
20-29 years	31.8
30-39 years	30.3
40-49 years	22.7
50 and above years	9.1
Marital status	Percentage
Single	34.8
Married	65.2
Qualification	
No formal education	13.6
Primary education (6 years)	22.7
Secondary education (6 years)	40.9
Tertiary education (4 years)	22.7
Experience	
1-5 years	25.8
6-10 years	37.9
11 and above years	36.4
Access to fertilizer	Percentage
Yes	72.7
No	27.3
Access to improved rice seed	Percentage
Yes	75.8
No	24.2
Access to extension services	Percentage
Yes	63.6
No	36.4

Source: computed by the authors

Estimation of the Cob-Douglas Stochastic Frontier for rice production

The Stata 14 was used to obtain the MLE of the parameters of the Cobb-Douglas stochastic frontier of rice production. Table 2 present the result of the maximum-likelihood estimates for the parameters of Cobb-Douglas stochastic frontier production. The result shows that all the variable inputs used in the model are significant.

The coefficient of improved rice seed is positively significant at 1% level. The positive elasticity conforms to a priori expectation and follows Chinwa (2007), who reported a significant positive impact of hybrid seeds on crop productivity. Therefore, the positive effect implies that an additional unit increase in access and usage of improved rice seed would result in an increase in the productivity of rice by 0.42 percentage point in the cluster. Hence, hybrid rice is an efficient means of increasing rice production because farmers who apply hybrids are more efficient than non-users.

Also, the coefficient of extension services is positively significant at 5% level. The positive effect of extension services conforms to a priori expectation and in line with the findings of Lawal et al. (2009). They found that extensions have a significant positive effect on crop production. Further, the positive elasticity signifies that one additional increase access to extension services offered to rice farmers would upsurge rice productivity in the cluster by 0.13 percentage point.

While, the coefficient of fertilizer is negatively significant at 1% level, contrary to a priori expectation and the findings of Dennanmann et al. (2017). They reported a significant positive effect of fertilizer on the productivity of farmers. The negative result implies that a unit increase in access and usage of nitrogen fertilizer would reduce the level of rice production by 1.48 percentage point in the cluster. Some of the possible reason for the negative coefficient of fertilizer is the wrong application of fertilizer. The wrong application could be excessive usage of urea as a source of nitrogen fertilizer. Nitrogen fertilizer is relatively cheap and uses very little compared to expensive fertilizer like P and K. Further, lack of knowledge by the farmers on the need to balance fertilizer application, government policy on sale and distribution of fertilizer, and poor access to extension services could lead to misapplication of fertilizer.

Table 2. Parameter estimates of the stochastic frontier analysis and technical inefficiency model.

Variable	**Coefficient**	**Std. Error.**
Constant	1.481***(4.03)	0.389
Fertilizer	-0.324***(-2.97)	0.109
Improve seed	0.415***(5.29)	0.078
Extensions	0.133**(1.68)	0.079
Q^2_s	0.444	
γ	0.977	
Q^2_v	0.010	
Level of productivity	0.832	
Inefficiency effects		
Constant	-4.206***(-5.52)	
Gender	0.630(1.39)	
Age	0.548***(3.40)	

Qualification	0.535***(2.71)
Marital status	1.893***(3.67)
Experience	-0.718***(-2.95)

Sources: Computed by the authors.
Note: *, **, ***indicate significance at 10%, 5%, and 1% level, respectively. p-values are in parenthesis.

The selection of the empirical frontier model was made based on the generalized LR test as specified in equation 1. Further, the LR test was conducted to test the hypotheses relating to the parameters of the frontier and inefficiency models. The test results are presented in Table 3.

Table 3: Generalized LR tests of hypotheses for the parameters of the stochastic frontier and inefficiency models

Null Hypothesis	Test statistic	X^2 - Critical value	Decision
H_0: $\beta = 0$	2.06	7.045	Accept H_0
H_0: $\gamma = 0$	19.16	8.761	Reject H_0
H_0: $\gamma = \delta_0 = \delta_1 = \delta_2 = \ldots = \delta_0 = 0$	22.35	7.045	Reject H_0

Source: Computed by the authors.

The functional form of the stochastic frontier was determined by testing the adequacy of the Cobb-Douglas model. From Table 3, the first null hypothesis specifying that the Cobb-Douglas model is an appropriate representation of the data was found to be adequate; therefore, accept the null hypothesis. Hence, the Cobb-Douglas stochastic frontier model is an adequate representation of the model.

The second null hypothesis specifies that the technical inefficiency effects are not stochastic. The test result confirms that the technical inefficiency effects are stochastic; therefore, the null hypothesis is rejected. Further, the third null hypothesis specifies that the coefficient of determinants of inefficiency model is zero was rejected. The test result confirms that the stochastic frontier model is inefficient.

Furthermore, the estimated γ is 0.977 which is the shortfall of output that deviates from the maximum likelihood. Hence, 98% of the shortfall in the production of rice is due to the technical inefficiency of rice farmers in the cluster.

Determinants of technical inefficiency of rice farmers

Table 2 present the results of the inefficiency parameters of the rice farmers in the study area. All the socio-economic characteristics used in the inefficiency model were found to have a significant impact on the technical inefficiency of rice farmers except gender.

The coefficient of age is positively significant at 1% level. The result conforms to the findings of Shehu (2007) who reported that young farmers are more technically efficient than older farmers. The positive effect infers that older rice farmers are less technically efficient compared to younger ones. The ability to adopt technology and supervise farming activities declines as the farmer becomes old. Further, older farmers are weak due to a decrease in their energy. So, they may not possess the necessary strength to withstand hardship compared to younger farmers. Tiamiyu et al. (2008) reported that young farmers are more likely to have some formal education that enables them to be successful in accessing information. They added that education improves understanding of new technology that would improve the ability to be technically efficient.

Also, the coefficient of qualification is positive and significant at 1% level. The positive relation means that additional qualification of a rice farmer would lead to an increasing inefficiency by 0.54 percentage point in the cluster. An increase in technical inefficiency of rice farmers is equivalent to reducing their productivity, thereby decreasing rice output. Further, the result implies that lower educational level and poor-quality education reduces the technical efficiency of a rice farmer. Further, insufficient and unqualified teachers in the area deliver insufficient training, thus, leading to a decline in the productivity of farmers. Similarly, a low level of literacy leads to failure in the adoption of modern farming tools.

Likewise, the coefficient of marital status is positively significant at 1% level. The positive relation implies that a unit increase in married farmers would reduce productivity by 1.9. The possible reason could be that as the number of family growth in a household, their feeding expenditure rises. Thereby making little money available for the purchase of necessary farm inputs and meeting other farms financial obligation; consequently, increases technical inefficiency.

While the coefficient of experience is negatively significant at 5% level, the negative effect affirms that practice makes perfect. Further, the negative sign conforms with a priori expectation and conformity with the findings of Ajibefun et al. (2002). Thus, the years spent in rice farming by the farmers is reducing inefficiency in the use of resources and boosting rice production in the state.

From Table 4, the TE indices shows that an average rice farmer could approximately increase output by 18.75% [that is, 1-(2.21/2.72)] while, the most technically inefficient rice farmer could approximately increase production by 29% [that is, 1- (1.93/2.72)]; if both could increase their level of TE to most efficient counterpart. The mean TE is 29% implying that 71% of the produce lost is due to the inefficiency of rice farmers. It could be due to inefficiency in the rice production system or a combination of the two in the cluster. Further, the TE indices indicate that on average, a small farm can gain an output growth of 18.75% by improving farmers' efficiency in the cluster. Further, the level of rice farmers productivity in the cluster is 83%.

Table 4. Technical efficiency level

Mean	Std. Dev.	Min	Max
2.2104	0.1530	1.9286	2.7156

CONCLUSIONS

The result of the study shows that improvement in access to improved rice seed and extension services positively impact on the productivity of rice farmers. While fertilizer negatively affects the productivity of rice farmers. The negative effect of fertilizer on rice productivity implies that additional access to fertilizer by rice farmer reduces rice production. Some of the possible reasons are over-usage or under usage of fertilizer. Also, there is poor awareness by the farmers on the need to balance fertilizer usage. Further, inadequate extension services and unqualified extension agents can lead to inappropriate application of fertilizer.

Hence, the study recommends an increase in the number of extension agents so that the services could be expanded to cover more farmers at regular intervals. Because single visit in a crop season seems not enough to deliver the necessary information to the farmers. Further, there is need to encourage educated young, experienced married farmers to join rice farming in the study area. The government should improve educational facilities so that the young graduate would have a quality education that would make them more efficient in production.

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