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Analysis on Resource Use Efficiency of Smallholder's Rice Production Farmers in Federal Capital Territory of Nigeria: Probit Model Approach

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Abstract: This study examined the resource-use efficiency of smallholder rice production farmers in Federal Capital Territory, Nigeria. The problem of resource use among small-scale rice production farmers is preponderance in the country. Hence, the study investigated the drivers of the problem in the Federal Capital Territory of Nigeria. Specifically, the study was designed to determine the factors influencing the resource-use efficiency of the respondents. A multi-stage sampling technique was used to select a total sample size of one hundred and seventy-five (175) rice farmers in Federal Capital Territory, Nigeria. Seven estimators such as age, household size, farming experience, educational level, extension services, access to credit, and off-farm income in the Probit model were found statistically significant. Results show that the probability of resource use efficiency of inputs used by the farmers increases with age, farm size, household size, educational level, extension services, experiences in farming, access to credits, but decreases where they have off-farm income. Mc Fadden Pseudo-R^2 gives 0.6772, and the Probit model explains a significant proportion of the variations in smallholder farmers' resource use. The study concluded that the socio-economic variables in the model play an important role in influencing resource use efficiency. The study recommends that government agencies and donors should provide simplified, accessible and obtainable credits and grants to existing and prospective rice farmers in order to sustain the current giant stride in rice production in the country.

Keywords: Resource-use, efficiency, rice production, probit, Nigeria

1. Introduction

Rice (*Oryza sativa*) is cultivated in almost all the agro-ecological zone in Nigeria (Adeola et al., 2008). Rice is consumed across the entire geographical spread of the country and represents a major diet at home and at official events. Hence, it is important staple nourishment contributing a significant proportion of the food requirements of Nigerians. In recent years, rice production has been on the increase but not sufficient to meet the demand of the growing population. By estimate, the bulk of the food and fiber produced in Nigeria is from rain-fed agriculture (Ingawa, 2007). According to Akintayo & Rahji (2011), rainfed lowland and upland rice production have the potential to meet national demand. However, their average rice yield of 1.8 tons/ha falls short of the expected national average potential yield of 5.0 tons/ha and 3.0 tons/ha, respectively (Ogundele & Okoruwa, 2006). The current average increase in yield of about 2.5-3.2 tons/ha for lowland rice is a tremendous growth but still below the optimal production level. Hence, there is a gap in the optimum capacity of smallholders' rice farmers in realizing the expected output. The research is therefore set to ascertain the validity of this claim.

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Similarly, several studies revealed gross inefficiency in the resource-use efficiency among small-scale rice farmers in Nigeria (Ajoma et al., 2016; Akintayo & Rahji, 2016; Abid et al., 2011). The results indicated that the allocative efficiency of the inputs such as farm size (282.90), labour (1.97), seed (241.80), pesticide (223.12), and herbicide (194.05) was under-utilized implying sub-optimal resource allocation in rice farming while fertilizer (0.5%) was over-utilized thereby requiring a reduction in usage for optimum output. Farmers are sentenced to be operating at a sub-optimal level in deploying production factors. To this end, it can be simply put that the critical issues of concern in addressing small-scale rice production and self-sufficiency of the food crop in Nigeria include productivity, and resource-use efficiency, among others.

It is in the interest of this research that the resource-use efficiency of small holders' rice farmers in the Federal Capital Territory of Nigeria is determined to understand the factors influencing their ability to appropriately use production resources such as land, labour seed, fertilizer, and herbicides on the rice farms. Concerns over sustainable rice production and zero importation of rice have been a major discussion among successive governments in Nigeria. Growth Enhancement Scheme, FADAMA III AF, and Anchor Borrowers Scheme, among other programs, have helped to increase rice production. However, to effectively meet efficient resource use among small-scale rice production farmers in Nigeria, there is a need to focus on how resources at the disposal of the farmers are used and the factors that affect the optimum use of the resources. In order to achieve optimum production level, resources must be available, and whatever quantities of available resources must be used efficiently. Farm planning and policies require the knowledge of productivities of farm resources to know the resources whose quantity or rate of use should be increased or decreased (Alimi, 2000). As a result of these, attention is presently being focused on small-scale farmers who constitute the bulk of the farming populace in Nigeria (Abdussalam et al., 2007).

Several studies emphasized the influence of socio-economic characteristics on production, resource use, saving, and credit utilization (Mohammed et al., 2019; Tiku et al., 2017; Kuye, 2016; Ike & Umuedafe, 2013; Ibitoye, 2010), among others. Tiku et al. (2017) studied the socio-economic factors affection local rice production in Cross River, Nigeria. They concluded that age, farming experience, level of income, and household size influence the growth and development of local rice production in the study area. Mohammed et al. (2019) estimated the effect of the demographic characteristics of forest resources utilization on the rural farming populace in Kogi and Niger State, Nigeria. They found out that lack of education, non-membership of cooperative society, and lack of access to capital militate against effective utilization of forest resources for the livelihood of the farmers.

This research, therefore, appraises resource use under small-scale rice production farmers in the study area. This study intends to provide the answer to the following research questions:

- What is the socio-economics characteristics of rice farmers in the study area?
- What are the factors influencing the resource-use efficiency of the rice farmers in the study area?

The broad objective of the study is to evaluate smallholder rice farmers in Federal Capital Territory, Nigeria. The specific objectives were:

- Identify the socio-economic characteristics of rice farmers in the study area.
- Examine the factors influencing resource-use efficiency of rice farmers.

2. Methodology

2.1 The Study Area

This study was conducted in the Federal Capital Territory, Nigeria. The Federal Capital Territory is located in the center of Nigeria and has a land area of 8,000 Square Kilometers **(**Jaiyeola, 2016**)**. It is bounded to the North by Kaduna State, to the West by Niger State, to the East and South-East by Nasarawa State, and to the South-West by Kogi State. It falls within the coordinates of Latitudes 9° 4' 20.1504" North and Longitudes 7° 29' 28.6872" East. The Federal Capital Territory has rich soil for agriculture and enjoys an equable climate that is neither too hot nor too cold all year round. The inhabitants are predominantly farmers. Crops grown in the Federal Capital Territory, Nigeria, are rice, millet, cowpea, groundnut, and eggplant. Fig. 1 is the map of Nigeria showing the study area.

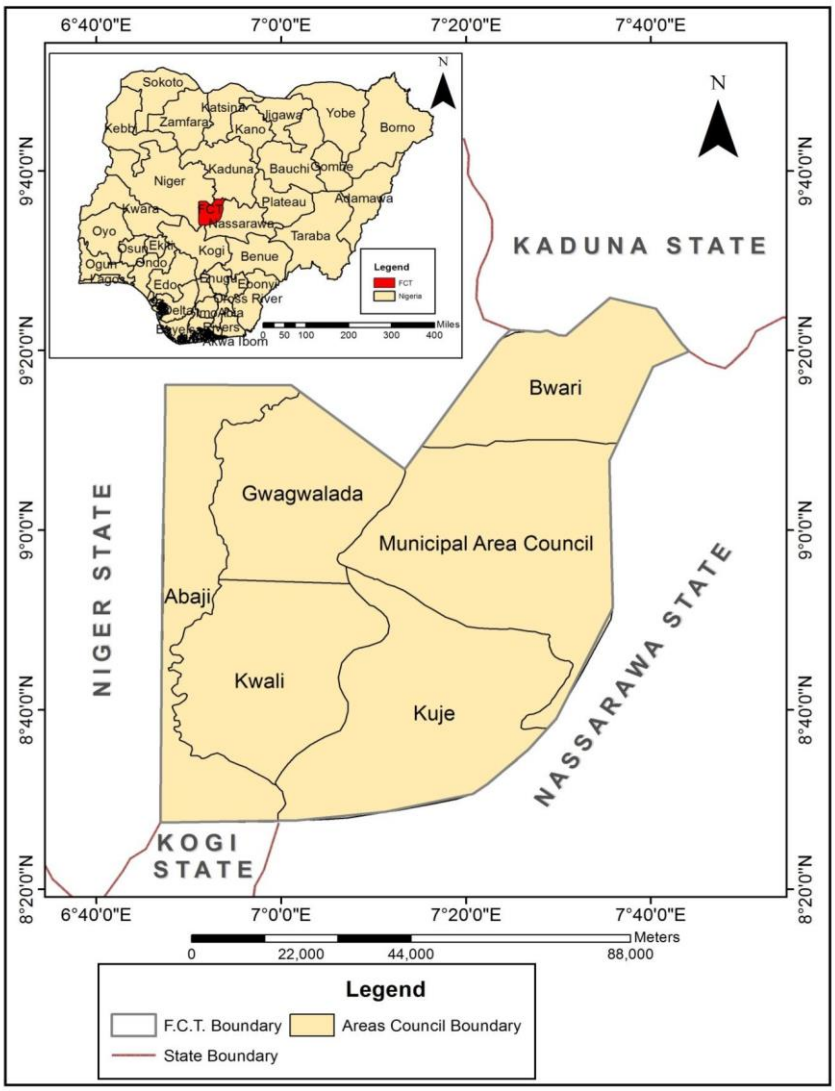

Fig. 1: Map of Federal Capital Territory, Nigeria showing the study area. Source: FCDA (2016)

2.2 Sampling Techniques and Sample Size

Federal Capital Territory was purposively selected because of the presence of rice farmers in the villages. A multi-stage random sampling method was used for selecting the respondents. A total sample size of one hundred and seventy-five (175) smallholder rice farmers was selected for the study.

2.3 Method of Data Collection

Primary data were used for this study. Preliminary data were collected from rice farmers in the study area. Trained enumerators from Agricultural Development Project (ADP) were employed for data collection using well-structured questionnaires. The questionnaire was sectioned appropriately to cover all the specific objectives stated, such as the socio-economic characteristics of the respondents and factors affecting factors of production.

2.4 Methods of Data Analysis

Data analysis methods used were descriptive statistics and the Probit model. Descriptive statistics were used to gain an insight and understanding of the inherent socio-economic characteristics of the smallholder rice farmers. Probit model following Alabi et al. (2014) was adopted for this study and used to evaluate the factors influencing resource-use efficiency of rice

farmers. The Probit model represents another widely used statistical model for studying data with binomial distributions. The Probit model can be expressed in probability thus: -

$$\text{Prob}\ (Y = 1) = 1\text{- F}\ [-\ \textstyle\sum_{k=1}^{K} \beta_k b_k] = \text{F}\ [\textstyle\sum_{k=1}^{K} \beta_k b_k] = \varphi\ [\textstyle\sum_{k=1}^{K} \beta_k b_k] \quad (1)$$

The equation for the probability of non-event is then:

$$\text{Prob}\ (Y = 0) = 1 - \varphi\ [\textstyle\sum_{k=1}^{K} \beta_k b_k] \quad (2)$$

The farmer's resource use of a particular input depends on the criterion function:

$$Y^* = \gamma\ Z_i + U_i \quad (3)$$

Where:

Y*= Underlying index reflecting the difference between the use of an input and its non-use.
γ = Vector of Parameters to be estimated.
Z_i = Vector of Exogenous Variables which explain Use of an Input (resource use).
U_i = Standard Normally Distributed Error Term.

Given the farmers' assessment, which crosses the threshold value, 0, we observe the farmer using the input in question. In practice, is unobservable. Its counterpart is which is defined by:

$Y_i = 1$ If $Y_i^* > 0$ (Farmer I use the input in question), and;

$Y_i = 0$ If otherwise.

In the case of the normal distribution function, the model to estimate the probability of observing a farmer using an input can be stated as:

$$P = (Y_i = \tfrac{1}{x}) = \varphi\ (X\beta) = \textstyle\int_{-\alpha}^{X\beta} \sqrt[1]{2\pi}\ exp\ (\frac{-Z}{2})dz \quad (4)$$

Where:

P = Where, Probability that the ith farmer use the input and 0 otherwise
X = K by 1 Vector of the explanatory Variables.
Z = Standard Normal Variable (i.e $Z \sim N\ (0, \delta^2)$ and
β = K by 1 Vector of the Coefficients estimated.

For a non-dichotomous variable, the marginal probability is defined by the partial derivative of the probability that Y_i = 1 with respect to that variable. For the jth explanatory variable, the marginal probability is defined by:

$$\frac{\partial P}{\partial X_{ij}} = \varphi\ (Xi\beta)\ \beta_j \quad (5)$$

Where:

φ = Distribution Function for the Standard Normal Random Variable.
β_j = Coefficient of jth explanatory Variable.

The Probit model specification in this analysis can be written as:

$$Y_i^* = Xi\beta i + \varepsilon_i \quad (6)$$

$$Y_i^* = \begin{cases} 1\ if\ Y_i^* \geq 0 \\ 0\ if\ Y_i^* < 0 \end{cases} \quad (7)$$

Where:

Y_i^* = Observed Dichotomous Dependent Variable which takes Value 1 when the ith Smallholder Farmer uses agrochemical inputs and 0, otherwise.

Y_i^* = Underlying Latent Variable that indexes the use of agrochemicals. Row Vector of Values of K Regressors for the ith Smallholder Farmers.

$\beta = K\ X\ 1$ Vector of Parameters to be estimated.

ε_i = Error term which is assumed to have standard Normal Distribution.

3. Results and Discussion

3.1 Descriptive Statistics of Sampled Smallholder farmers and Apriori Expectations

The variables used in Probit model and their apriori expectations are presented in Table 1. The age classification is relevant to this study in that physical ability and productivity depend on age, and this will influence their output positively or negatively, as indicated in Table 1. The average age was 42 years. This implies that the majority of the farmers are in their economically active age, and it will have a direct influence on their ability to work on the farm (Raufu, 2010). This result is also in line with the findings of Akerele et al. (2019), who reported that farmers in their study are more energetic, mature, and can use innovation. Household size is a crucial factor, especially in determining labour for farm work in the agrarian community. A farmer with a large household size has the potentials to use family members as part of their farm labour. From the result presented in Table 2, farmers were blessed with an average family size of 12 persons per household. According to Becker & Becker (2009), farmer with large household member has the potential to obtain higher output due to the easy accessibility and usage of family labour supply.

Farming experience is used as a measure of management ability. The more experienced the farmer is, the more his ability to make farm decisions. However, at times the older farmers that are used to particular ways of doing certain things on the farm may be reluctant to accept new innovation or methods of application of input. Therefore, the experience can contribute positively or negatively (Table 1). The mean farming experience was 22 years (Table 2). This is an indication that the majority of the farmers sampled in the study have gathered adequate experience in rice farming enterprise for over two decades which will have a positive effect on their output. Education is of great importance in decision-making. It can directly influence the farmers' understanding of rice production activities, adoption of research innovations, and ways to maximize gains. The average school-age was 15 (Table 2). This implies that smallholder rice farmers had post-primary education. By implication, farmers in the area should be able to understand the use of improved technologies and apply it to achieve increased rice production. Through education, there is an increased propensity to adopt new techniques (Tijani, 2006). The land is the most important input for agricultural production. Nigerian farms are classified into small scale, medium scale, and large scale. According to Obayelu et al. (2014), farm sizes classification of fewer than 5 hectares are classified as small, between 5 and 10 hectares as a medium, and more than 10 hectares on a large scale. The average farm size of rice farmers was found to be 1.74 hectares (Table 2). Farm size has been reported to have a positive and significant relationship with technical efficiency (Rahman, 2013). The larger the farm size, the greater the output.

Table 1: Variables Used in Probit Model and Expected Signs (Apriori Expectations)

Variable	Unit of Measurement	Expected Signs
Age	Years	(±)
Household size	Number Per Household	(+)
Farming Experience	Years	(±)
Educational Level	Years	(+)
Extension Visit (Service)	Dummy (1, Yes; 0, Otherwise)	(+)
Access to Credit	Dummy (1, Yes; 0, Otherwise)	(±)
Farm Size	Hectares	(+)
Off-Farm Income	Naira	(+)

Table 2: Descriptive Statistics of Sampled Smallholder Farmers

Variable	Average (Value)
Age (Years)	42.00
Household size (Number Per Household)	12.00
Farming Experience (Years)	22.00
Educational Level (Years)	15.00
Farm Size (Hectares)	1.74

3.2 Maximum Likelihood Estimates and Marginal Probabilities for the Explanatory Variables in the Probit Model

Table 3 shows that age was statistically significant ($P<0.001$). The positive effect of age on resource use efficiency among smallholder rice production in the studied area is a thorough reflection of small-scale agriculture in Nigeria, in which agricultural production is dominated by the aging population. According to the marginal effect, a unit increase in the age of the smallholder rice farmers increase the probability of their resource use by 0.1%. This trend does not portend the right future for smallholder rice production in the country because the product is in the hand of aging farmers whose productivity and efficiency will continue to reduce over time. Household size was used as a proxy for labour availability and had a positive effect on smallholder rice farmer's resource use efficiency. The coefficient is statistically significant at the 5% level in the Probit model. The results in Table 3 indicate that a unit increase in household size raises the probability of resource use among smallholder farmers by 17.6%. The results are inconsistent with the findings of Zegeye et al. (2001) in the adoption of improved maize technology but contrary to the findings of Obasi et al. (2013). Access to credit has a negative association with resource use of inputs by smallholder rice farmers in the studied area. The result is consistent with the expected sign (Table 1 and 3). The estimated coefficient of access to credit (-0.022) had a negative signal and was significant at 1%, showing an inverse relationship with resource use efficiency. The finding suggests that the farmers use the credits to engage in non-farming activities that will bring more returns than rice production, and as a result, it shows that access to credit is not a critical factor that influences the resource use of smallholder rice farmers.

The result presented in Table 2 indicated that the marginal effects of farming experience were positive and statistically significant at a 10% level of probability. The marginal effect was 0.006. This implies that a unit increase in farming experience will lead to a probability of an increase in the resource-use efficiency of rice farmers by 0.6%. This result conforms with the fact that the farming experience has a positive influence on the resource-use efficiency of the farmers. This is in line with the finding of Rahji (2005) and Aiyedun (2003). Similarly, the coefficient of the level of education has the expected positive sign and is statistically significant at a 5% level for resource use. It has a marginal effect of 0.058. This means that a unit increase in educational level will increase the probability of resource-use efficiency of rice farmers by 5.8%, all other variables remaining constant. This result is in line with a research report that stipulated that human capital development improves resource utilization and decision making (Alabi et al., 2014). This result is also in conformity with other research in agriculture in Sub-Saharan Africa (Chirwa, 2005; Chianu & Tsiyii, 2004; Bacha et al., 2001; Zegeye et al., 2001). The coefficient of extension service was highly significant at 1% and positively related to resource use efficiency. Extension contacts and services, when appropriately deployed, are known to improve innovative effectiveness, knowledge transfer, information dissemination, and adoption drive of the farmers. The marginal effect implies that a unit increase in the extension services will increase the probability of resource use among the smallholder rice farmers by 41.5%. This is in line with the findings of Ofuoku et al. (2009). Furthermore, the coefficient of off-farm income was found to impact positively on resource use efficiency of smallholder farmers at a 5% significant level. The result is in tandem with Agbomlahor et al. (2016), which revealed that smallholder farmers often subsidize farming operations with income from non-farming activities. As presented and explained in Table 3, the results of estimates from the probit model using the maximum likelihood method indicated that the model was significant at a 1% level of probability. McFadden's Pseudo-R^2 was calculated, and the obtained value suggests that the independent variables included in the Probit model explain a significant proportion of the variations in smallholder farmers' resource use. It was calculated as 0.6772. This value represents those variables placed in the model explain the high level of the probabilities of resource use (inputs) by smallholder farmers.

Table 3: Maximum Likelihood Estimates and Marginal Probabilities for the Explanatory Variables in the Probit Model

Variables	Coefficient	Std. Err.	t-Ratio	Marginal Probabilities
Age	0.1747***	0.0546	3.2000	0.001
Household size	0.5523**	0.2260	2.4467	0.176
Farming Experience	0.020*	0.0090	2.2900	0.006
Educational Level	0.189**	0.0800	2.3500	0.058
Extension services	0.8685***	0.2780	3.1220	0.415
Farm Size	0.1560	0.1060	1.4700	0.047
Access to Credit	-0.0220***	1.0000	-2.8770	-0.025
Off-Farm Income	0.0659**	0.0310	2.1200	0.063
Log likelihood	**-188.20074**			
Chi square	**66.01*** **			
Pseudo R^2	**0.6772**			
Source: Computed Field Data 2020				
***- Significant at 1% Probability Level				
**- Significant at 5% Probability Level				
*- Significant at 10% Probability Level				

4. Conclusions

The study examines resource use efficiency among smallholder rice farmers in Federal Capital Territory, Nigeria. The study concluded that appropriate use of resource inputs depends on age, household size, farming experience, educational level, extension services, access to credit, and off-farm income. Based on the findings, the study recommends that government agencies, international donors, and private stakeholders in the rice value chain industry should make loans and credit more available and accessible to farmers. Also, extension services should be sustained to improve the knowledge and capacity skills of rice farmers. Overall, these suggestions will help in encouraging more investment in rice production.

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