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Resource Use Efficiency of Upland Rice Farmers in Ivo Local Government Area of Ebonyi State

Ume Smiles Ifeanyichukwu[1*], Ezeano Caleb Ike[2], Edeh Ogochukwu Nnenna[3] and Udefi Ifeanyi Onochie[4]

[1]Federal College of Agriculture, Ishiagu, Ebonyi State, Nigeria.
[2]Department of Agricultural Economics and Extension, Nnamdi Azikiwe University Awka, Anambra State, Nigeria.
[3]National Root Crops Research Institute, Igbarian Substation, Anambra East, Anambra State, Nigeria.
[4]Nigerian Stored Products Research Institute, Yaba Lagos, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author USI designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author ECI managed the literature searches, analyses of the study performed the spectroscopy analysis and author UIO managed the experimental process and author EON identified the species of plant. All authors read and approved the final manuscript.

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ABSTRACT

A stochastic frontier production function which incorporated a model for the technical inefficiency effects was used to investigate the technical efficiency of upland farms in Ivo Local Government Area of Ebonyi State, Nigeria. Farm level and farmers' socio economic characteristics data were obtained using structured questionnaire from 120 farmers that were selected using multi stage random sampling technique. The parameters of the stochastic frontier production function were estimated simultaneously with those of the model of inefficiency effects. Results indicated, except for capital, all other factors were significant (P<0.10). Findings further revealed that none of the sampled cocoyam farms reached the frontier threshold.

Keywords: Resource use; efficiency; upland rice; farmers.

**Corresponding author: Email: umesmilesi@gmail.com;*

1. INTRODUCTION

Rice is among the emerging staple and commercial crops grown in many countries of Africa. The steady increase in the demand and growing importance is evident given its' important place in the strategic food security planning policies of many countries [1,2]. In Nigeria and many West Africa countries, the increasing demand for rice could be attributed to rising per caput consumption, increased per capital income, rapid population growth, changes in the tastes and diet of Nigerians to the growing appetite for rice, the ease at which rice can be preserved and served for the table and as well as positive high income elasticity of demand [3].

A decade ago, rice rank fourth in return per labour among the staple crops grown in Nigeria [4,5]. On the other hand, rice has an estimated annual output of 1,779,000mt which accounts for about 40.8% and 0.6% of total West Africa and world output of rice respectively [6]. The crop is ranked second among cereal crops grown in the country [7].

Although, the crop is growing rapidly in demand, available statistics revealed that Nigeria is a net importer of rice and this situation will persist, unless domestic production improves significantly. A case in point, rice production in Nigeria as opined by Amaza and Olayemi [8], Erenstein [9] between 2001 -2003 was 2.03million mega grams, while consumption was 3.96 million mega grams. The insufficient domestic productions had to be complemented with enormous imports in both quantity and values at various time to the detriment of the nation's meagre resources [10,11]. According to Onyishi and Vaughan [12] Nigeria is the largest importer of rice, spending over US$300 million annually in rice imports alone. However, improving the domestic production is feasible, considering her numerous rice ecologies and successive government policies and programmes on attainment of self-sufficiency in rice production [13,14].

Despite, the incontestable growing importance of rice in Nigeria, research in rice, particularly upland type is still very scanty. Upland rice, although has low yield, but accounted for important part of rice agricultural land (11% of the world area of rice of 14 million hectare) and major share of rural poverty alleviation especially among poor resource farmers of the countries of Africa and Asia [9]. In Nigeria, 25% of 4.6 -4.9 million hectares of paddy is devoted to upland rice cultivation [5]. Nevertheless, research shows that upland rice potential yield in sub Saharan Africa is 5 metric tonnes per hectare with use of fertilizer but on farmers' field, 1.6 -2.4 metric tonnes hectare is obtained [12,15]. The above depict for big potentials for increased output. However, one of the biggest challenges is limited knowledge on the cause of this gap. This study therefore, aimed at analysing the sources of inefficiency in rice production so as to fill the identified gap, as inefficiency of resource use and utilization in farming can seriously hamper or jeopardize the production and availability of this staple food. Also, efficiency is an important factor in attainment of high productivity especially in an economy where resources are scarce and opportunities for new technologies are lacking. In addition, inefficiency studies would guide researchers and policy designers to raise productivity through improving efficiency without increasing the resource base or developing new technology. More so, estimation of technical efficiency result would assist farmers in making production decisions and ensure optimal productivity of input to maximize output. Efficiency study would enable farmers, government and scholars to test the presence of and measures the level of efficiency in production, thus, making theory to come close to real life situation [16,17].

1.1 Empirical Review of Stochastic Frontier Models and Theoretical Framework

Stochastic Production functions have been widely applied in agricultural management and production analysis. The first application [18] of the stochastic frontier model to farm level agricultural data was presented by Battese and Battese [19]. Data from 1973-74 Australian Grazing Industry Survey were used to estimate deterministic and stochastic Cobb-Douglas sheep production frontiers for the pastoral zone of Eastern Australia. It was concluded in this work that the stochastic frontier production functions were significantly different from their corresponding deterministic frontiers. As asserted by Akande [20] membership of cooperative, access to credit, farming experience and educational level to be positively related to technical efficiency of National Fadama iii facility in arable farmers in Imo State using a tran slog stochastic frontier production function, Daramola [21] examined the technical efficiency of pig farmers in Imo State during 2007. The parameters of the frontier were estimated using the Maximum likelihood method. Based on the results of empirical analysis, the individual efficiencies ranged from 0.23 to 0.78 with mean technical efficiency of 0.59.

Akande [20] studied the technical efficiency of Hausa potato (*Solesnostemon roundifolius poir*) production in southern Kaduna state, Nigeria. They analyzed primary data generated from a sample of 60 farmers by stochastic frontier modeling using maximum likelihood estimation. Results of the analysis show that material input, labour and wage rate affected the output of Hausa potato. The spread of technical efficiency indices was large with the best farm having 0.12 and the worst farm having 0.9 and the mean being 55. They observed that improve technology could be applied to improve current resource endowment to boast Hausa potato output. Omoruyi et al. [22], WARDA [23] analyzed resourced use efficiency among dry season vegetable gardeners in Enugu urban Enugu State. 120 farmers were fitted in stochastic frontier production function approach. Result indicated that the range in the technical efficiencies were from 68.01 to 98.64 with mean of 83.4. They also estimated the following factors as determinants to dry season vegetable in the study area to include, level of education and household size.

Omoruyi et al. [22] applied stochastic production frontier model in estimating a production frontier for the upland rice farmers across gender in Anambra agricultural zone of Anambra State. Data from 120 sample farmers were used in the empirical analysis, 60 males and 60 females. The result showed that only level of education and access to credit were found to be positive and significant at 1% between the two farmers groups. The mean economic efficiencies for the male and female farmers were 0.65 and 0.61 respectively, indicating wide range of opportunities for improvement of upland rice farmers which could be through the use of improved production inputs.

Iheke [24], Nwilene et al. [25], Ogbodo [26] studied the relative economic efficiency among gender cassava farmers in Anambra State of Nigeria. Primary data generated from 120 sample farmers (60 males and 60 females) was analyzed by stochastic frontier modeling using maximum likelihood estimation. The result shows that educational level and membership of cooperative were positive and significant in the same farmer groups. More so, among the male group, the best practicing farmer having 0.78 and the worst farmer having 0.56 with mean efficiency of 0.65. The female group had best practicing farmer and worst farmer having 0.72 and 0.52 respectively with mean of 0.62.

Ajibefun and Ajibefun [27] studied the technical efficiency in food crop production in Gombe State, Nigeria. They analysed primary data generated from a sample of 123 food crop farmers by stochastic frontier modeling using maximum likelihood estimation. Results of this analysis revealed that family labour, hired labour and material inputs were the major factors that affected the output of food crops. The distribution of technical efficiency indices revealed that the current state of technology used by the sample farmers was inferior. The spread of technical efficiency indices was large with the best farm having 0.89 and the worst farm having 0.13 and the mean being 0.69. Although they did not examine the factors responsible for this wide variation, these scholars observed that a superior technology is needed, this could be applied to the current resources endowment to enhance food crop output. This would involve the use of improved seeds and the application of agro-chemicals in food crop production. Also, the excess and hence inefficient use of family labour could be reduced through the creation of alternative use of family labour could be reduced through the creation of alternative employment opportunities in the study area. This will tend to absorb excess family labour and hence enhance efficiency in food crop production, having 0.72 and 0.52 respectively with mean of 0.62.

The term efficiency of a firm can be defined as its ability to produce the largest possible quantity of output from a given set of inputs. The modern theory of efficiency dates back to the pioneering work of [28] who proposed that the efficiency of a firm has two components namely: technical and allocative efficiency and the combination of these two components provide a measure of total economic efficiency (overall efficiency). Technical efficiency is the ability to produce a given level of output with a minimum quantity of inputs. It is be measured either as input conserving oriented technical efficiency or output-expanding oriented technical efficiency [19,29,30]. Measurement of farm efficiency via frontier approach has been widely utilized and studied. The term frontier involves the concept of maximality in which the function sets a limit to the range of possible observations

[29,31,32]. The observation of points below the production frontier for firms producing below the maximum possible output can occur, but there cannot be any point above the production frontier given the available technology. Deviations from the frontier are attributed to inefficiency. Frontier studies are however classified according to the method of estimation. Farrell [33] grouped these methods into two broad categories – parametric and nonparametric methods. The parametric method can be deterministic, programming and stochastic depending on the specification of the frontier model. Many researchers including Ashraf [34] have argued that an efficiency measure from deterministic model is affected by statistical noise. However, this led to the alternative methodology involving the use of the stochastic production frontier models.

The major feature of the stochastic production frontier is that the disturbance term is a composite error which consist of two components; one symmetric and one-side component. The symmetric component, Vi, captures the random effects due to measurement error, statistical noise and other influences, and it is assumed to be normally distributed. The one-sided component Ui, captures randomness under the control of the firm. It gives the deviation from the frontier which is attributed to inefficiency. It is assumed to be either half-normally distributed or exponentially distributed. By definition, stochastic frontier production function is Yi =F (Xi; ß) exp (Vi – Ui) i = 1,2, ., N (1) where Yi is the output of the ith firm; Xi is the corresponding (MX_2) vector of inputs; ß is a vector of unknown parameter to be estimated; F(.) denotes an appropriate form, Vi is the symmetric error component that accounts for random effects and exogenous shock; while Ui = 0 is a one sided error component that measures technical inefficiency.

2. METHODOLOGY

The research project I covered Ivo Local Government Area (LGA) of Ebonyi State, Nigeria. Itis located between latitude 5^o56^1 and 6^059^1N of equator and Longitude 7^o35^1 and 7º4E of Greewich Meridian. It covers an area of 3506 km^2 with population of 220,919 people (31). It has rainfall range of 1500-2500mm, temperature range of 28-45ºC and moderate relative humidity of 65%. It comprises of five (5) autonomous communities and many villages. Ivo Local Government Area is bounded in the North by Ohaozara, Aninri and Awgu Local Government Areas, in the south by Bende and Afikpo South Local Government Areas, in the East by Onicha Local Government Area and in the West by Umunneochi and Isuikwuato Local Government Areas of Abia State. The people in the LGA are mainly agrarians and still engage in other economic activities such as hunting, vulcanizing, mechanic, petty trading and barbing. Data for this study were collected from primary and secondary sources. A total of 120 rice farmers were randomly sampled from six communities where rice cultivation is intensive. Baseline information on farmers' socio-economic characteristics such as age, gender, marital status, farming experience, level of schooling, household size, farm size and membership of organization were captured. Also, data on farm inputs (such as land, labour inorganic fertilizer, planting materials and capital) used and output levels were collected and analysed.

2.1 Model Specification

In this study, the Cobb Douglas technical efficiency as used by Battese and Coelli [18] which builds hypothesized efficiency determinants into the inefficiency error component such that one could identify the focal point for action to bring efficiency to higher levels was used. The explicit form of the empirical stochastic frontier production function model was specified as follows:

$$\ln Y_j = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + V_i - U_i \quad (1)$$

Where y = gross income in arable crop production per farmer, X_1 = planting materials (kg); X_2 = fertilizer use (kg); X_3 = Labour input (mandays); X_4 = Farm size (ha); X_5 = depreciation in capital inputs (in naira); Vi = random error and Ui = technical inefficiency. In addition, Ui is assumed in this study to follow a half normal distribution as is done in most applied frontier production literature.

$$\text{Where: } Ui = б_0 + б_1z_1 + б_2z_2 + б_3z_3 + б_4z_4 + б_5z_5 + б_6z_6 + б_7z_7 + б_8z_8 + б_9z_9 \quad (2)$$

Where

U_i = technical inefficiency of the i^{th} famer, z_1 = age of the farmer (yrs),
z_2 = level of education (yrs), z_3 = household size (No), z_4 = farming experience (yrs),

z_5 = farm size (ha), z_6 = extension contact (No), z_7 = credit access,
z_8 = membership of organization (No), z_9 = marital status (dummy),
$б_0$ = constant, $б_1$ – $б_7$ = coefficients to be estimated.

3. RESULTS AND DISCUSSION

The model specified was estimated by the maximum likelihood (ML) method using frontier 4.1 software developed by Biswas and Choudhuri [29]. The ML estimates and inefficiency determinants of the specified frontier are presented in Table 1. The total variance was 0.86 and statistically significant at 1% probability level. The implication is goodness of fit of the model and the correctness of the specified distribution assumption of the composite error term. The variance ratio (T) was 7746 which was significantly different from zero, which showed that the farm specific variability contributed about 74.46% variation in yield among the respondents. This meant that about 74.46% of the differences between the observed and maximum production frontier output were due to differences in farmers' level of technical inefficiency and not related to random variability. These factors are under the control of the farmer and the influence of which can be reduced to enhance technical efficiency of rice farmers.

The relative importance of resource inputs is revealed in the production function estimate. The coefficients of labour, farm size, seed and fertilizer were positively signed, except the coefficients of depreciation of capital in line with apriori expectation. Labour appears to be the most important factor of production with an elasticity of 4.141. This shows the labour intensive nature of arable crop cultivation in most developing countries where many farming activities are not mechanized. There is need to employ energetic, able-bodied and active youth that are not only enterprising but would supply the much needed farm labour in the farm enterprises to curtail minimally the problem of urban drift [35,36].

Farm size is the second most important factor, with an elasticity of 1.904. Anyanwu [37], Idiong [38], Onyenweaku et al. [39] reported that farm size played an important role in farm success because it reflects the availability of capital, access to credit and even good management ability. However, the need for urgent land reforms policies and programmes that would give farmers access to more land holdings for increasing agricultural production should be enacted.

Table 1. Maximum likelihood estimation of Cobb Douglas stochastic production function

Variable	Parameters	Coefficient	Standard error	t. value
Production factors				
Constant term	β_o	22.444	3.377	6.646***
Farm size	B_1	1.904	0.327	5.823***
Seed	B_2	0.464	0.147	3.156***
Labour input	B_3	4.141	0.622	6.658***
Fertilizer	B_4	0.166	0.125	1.328*
Depreciation	B_5	-0.209	0.116	-1.802*
Efficiency factor				
Constant	Z_o	7.667	2.451	3.128***
Age	Z_1	-0.006	0.003	-2.000**
Educational level	Z_2	4.222	0.641	6.587***
Farming experience	Z_3	4.633	2.320	1.997*
Extension visit	Z_4	0.084	0.021	4.000***
Access to credit	Z_5	-1.184	0.421	-2.812***
Membership of organisation	Z_6	2.782	1.621	1.716*
Household size	Z_7	0.531	1.721	0.309
Diagnostic statistic				
Total variance ∂ =0.86				
Variance ratio Y= 7746				
Log likelihood ratio = 30.551				
Log likelihood function =167.445				

*Source: Field Survey, 2015, *** = indicating 1% probability level, **indicating 5% probability level *indicating 10% probability level, LL Test Log likelihood test*

This followed by seed and inorganic fertilizer with elasticity of 0.464 and 0.166 respectively. Fertilizer according to Akande [20] is an important determinant of agricultural productivity as it has the capacity to shift production upwards, especially when applied in the right proportion. Coelli [4], Onyenweaku et al. [2] cited high cost of fertilizer at farm level as a limiting factor to its use by most poor resourced farmers at farm level.

The non-significant of capital resource coefficient explains the labour intensive nature of small scale rice production in the study area. This finding concur with the work of Onyenweaku and Agwu [40], Semon et al. [41] on cocoyam farms in Akwa Ibom state, Nigeria.

The result of analysis of the determinant of technical inefficiency as presented in Table 1 revealed the coefficients of age and credit had negative signs which indicate technical inefficiency and significant at 5% and 10 % respectively. The technical inefficiency of age of the farmers can be can be reduced by employing young people in the farm, while that of credit could be abridged by increasing farmers' access to credit, avoid possible diversion of the resource to nonfarm uses and avoid over-application / use of the resource [42,43,12]. The technical inefficiency of age is comparable to the finding of Aigner et al. [16] who posited that technical efficiency decreases with increasing age, since an ageing farmer would be less energetic to work in the farm. The negative sign of the coefficient of credit concurred with the finding [20] but differs with [44,12] on economics of cocoyam production in South East Nigeria. Credit facilitates adoption of innovations in farming, encourages capital formulation and marketing efficiency [3]. However, the coefficients of the other variables considered in the model were positive and by implication had technical efficient effects on upland rice production in the study area. These variables are discussed herein.

In line with *apriori* expectations, the coefficients of education, farming experience and membership of farmers' organisation were positively signed but statistically significant at different levels of probability. This agreed with the finding of IRRI [7], Onyenweaku et al. [2], who opined that education increases productivity and enhances farmers' ability to understand and evaluate new production techniques. Therefore, policies for ensuring education attainment amongst farm households through enhanced formal and informal educational programmes would impact positively to farmers' efficiency and therefore should be encouraged. Furthermore, the level of farming experience one acquired in a particular occupation, as reported by Omoruyi et al. [22], [45] could contribute significantly to his/her level of managerial ability and decisions in farm operations. These subsequently results in high level of competence in utilization of resources for optimal productivity. Nevertheless, the positive relationship between farming experience and technical efficiency as posited in Table 2 was in line with classical economic theory which recognized that specialization is a key determinant of efficiency [46,47]. However, this result disagreed with the finding from [25], who explained that experience correlates with age, which would always be associated with reduced energy and optimism necessary in farming.

As expected the coefficient of Membership of organisation had direct relationship with technical efficiency and significant at 10% alpha level. [48,49,25] opined cooperative facilitates members' access to information on improved innovations, material inputs of the technology (fertilizer and chemicals), credit for payment of labour, capacity building and training. Several studies [20,12] made similar conclusions. Conversely, Social organisation had a negative correlation with smallholder Technical efficiency. Social groups are known to be sources of rotational farm labour and credit among smallholder farm households [50,51,52] which may lead to over-employment of farm labour. Participation in many social groups may also commit more of the farm household's time to the extent that supervision of farm activities is reduced, thus making use of farm inputs less efficient. Alternatively, participation in many social groups may overload the farmer with agricultural information that making decision with regards to input use is adversely affected.

The wide technical efficiency indices differentials among the farmers as revealed in Table 2 is an indication that the farmer has of a substantial potentials to enhance their efficiency. To become the most efficient farmer, an average rice farmer require, 48.42% $(1-0.54/0.95)^{100}$ cost saving to attain the status of the most efficient rice farmer among the sampled best 10 category while the least performing farmer would need 81.05% $(1-0.23/0.95)^{100}$ to become the most efficient rice farmer among the worst sampled farmer.

Table 2. Frequency distribution of technical efficiency index

Technical efficiency index	Frequency	Percentage
0.21 – 0.30	4	3.3%
0.31 – 0.40	10	8.3%
0.41 – 0.50	11	9.2%
0.51 – 0.60	20	16.7%
0.61 – 0.70	25	20.8%
0.71 – 0.80	40	33.3%
0.81 – 0.90	10	8.3%
Maximum technical efficiency	=	0.95%
Minimum technical efficiency	=	0.23%
Mean technical efficiency	=	0.54%
Mean of best 10	=	48.42%
Mean of worst 10	=	81.05%

Source: Field Survey, 2015

The sum of production elasticity (return to scale) has a coefficient of 1.184, deducing that the farmers are in stage III of production phase as indicated in Table 3. This is necessitated by the high and negative coefficient of capital. Therefore, the rice farmers in Ivo L.G.A. were either under or over-utilizing their labour and other factor inputs, hence did not attained optimum allocative and technical efficiencies.

Table 3. Elasticity and return to scale for rice production

Inputs	Elasticity
Farm size	1.904
Seed	0.464
Labour input	4.41
Fertilizer	0.166
Depreciation	-0.209
Return to scale	1.184

Source: Field Survey, 2015

4. CONCLUSION AND RECOMMENDATIONS

The major conclusions deduced from the study were; upland rice farmers were 46% inefficient in their resource use as they were 54% efficient. This implied a wide variation below their production frontiers and this suggested existence of opportunities for increasing productivity and income through improved efficiency in resource use. Important factors directly related to technical efficiency were level of education, farming experience, extension visit and membership of cooperative. More so, although upland rice was a profitable venture but its production was limited by factors, included; poor access to credit, high labour cost and high cost of pesticide.

Based on the result obtained from the study, the following recommendations were proffered in order to increase the efficiency of upland rice farmers' production in the study area.

1. Policy that encourages the formation of cooperative societies should be encouraged. This is due to the importance of cooperatives in capacity building, acquisition of credit and procurement of production inputs at low cost.
2. Since upland rice farmers years of experience was found to have significant and positive influence on technical efficiency, therefore policies that would ease novice farmer access to productive input should be encourage.
3. The positive influence of fertilizer on yield of crops had been noted. In this direction, increased subsidy policy should be imposed on fertilizer not only to ensure the availability of this input but its affordability by resourced poor farmers at farm level.
4. The study revealed that size of farm holding was positive and significantly influences farmers' technical efficiency. Therefore , programme policy that would enforce land use act of 1990 which encourages land acquisition by farmers is advocated.
5. Farmers' access to credit should be encouraged through micro finance bank and commercial banks at reduced interest rate.
6. Labour saving device such as hand driven plough should be developed and disseminated to genuine farmers at subsidized price.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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