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STOCHASTIC FRONTIER PRODUCTION FUNCTION ON THE RESOURCE USE EFFICIENCY OF FADAMA II CROP FARMERS IN ADAMAWA STATE, NIGERIA

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ABSTRACT: *This study assess the resource use efficiency of Fadama II beneficiary crop farmers in Adamawa state, Nigeria. Data were collected on a sample of 160 farmers and were analyzed using stochastic frontier production function. The maximum likelihood estimates (MLE) for the stochastic production function results shows that the coefficients of farm size, inorganic fertilizer, hired labour and expenses on ploughing, significantly affect food crop output of the respondents. The mean technical efficiency was 0.71 (or 71%), the mean allocative efficiency was 0.76 (or 76%) and the mean economic efficiency was 0.54 (or 54%). The study concludes that, the maximum likelihood estimates (MLE) for the stochastic production function of the coefficients of farm size(*X_1*), inorganic fertilizer (*X_3*), hired labour (*X_5*) and expenses on ploughing (*X_6*) were found to be positive and significantly affect food crop output of the respondents with the mean technical efficiency is 0.71 (or 71%). It is however recommended that, Government and other donor agencies should intensify advisory services activities on effective resource allocation, utilization and other ways of increasing farmers' beneficiary income. Government in partnership with private sector should encourage farmers to increase its technical efficiency in food crop production which could be achieved through improved farmer specific efficiency factors, which include improved farmer education, access to credit, access to improved extension services and less crop diversification. Government to introduce mentorship and pre-job training programmes and to include the youth in policy decisions.*

KEYWORDS*:* Resource, Efficiency, Fadama II, Crop Farmers, Application, Stochastic Frontier Production Function.

INTRODUCTION

Agriculture is a primary based activity among the Nigerian rural families. But, because of the increasing demand for food and jobs for many dwellers, it became necessary for households to embark on agriculture as a means of filling the food demand and supply gap and providing income for other household requirements, wealth generation and food security, Earfan Ali et al, (2013). According to Bukenya (2013), a considerable scope to expand output and also productivity by increasing production efficiency at the relatively inefficient farms and sustaining the efficiency of those operating at or closer to the frontier is an alternative to attaining this. Thus several factors like education level and years in farming experience contributes to increase in the resource use efficiency among farmers Amodu et al, (2011).

However, Crop production in Nigeria is predominantly rain-fed although supplemented with irrigation in the dry season in some areas. Okpe, (2012) observed that, opportunities available in the agricultural sector in Nigeria still remain untapped because most available lands suitable for agricultural production is uncultivated and all year farming have not been carried. However, one way to harness the agricultural potential of this country is by exploiting the available and viable Fadama lands which is small-scale, farmer based, privatized irrigation system for crop production especially during the dry season. It is an alternative to large scale irrigation, which failed to meet the food self-sufficiency and food security of the country (Baba, 1993). The importance of fadama cropping system arises from the fact that fadama activity afforded people some opportunities at a time they would have been idle, besides, the surplus labour during dry seasons is utilized unlike in the rainy season when labour is a constraint (Sanda and Ayo, 1994). The importance of fadama lands stem from their high level of residual moisture even during dry season as well as during drought conditions. The fadamas are also generally higher in organic matter and nutrients than adjacent upland soils (Kyuma, 2001). Until recently, little attention has been given to fadama lands. However, with the realization that population in Nigeria is growing at an alarming rate, while food supply is slow coupled with the wide spread poverty among the population, the National Fadama Development Project-II (Fadana II) was put in place to sustainably increase the income of the Fadama user through increase output. Yet, the issue of increase food productivity has not been achieved. This may be due to low area of land utilized or inefficient use of resource in its production. This study would therefore answer the question of inefficient resource use by the Fadama II beneficiary crop farmers.

Efficiency analysis is generally associated with the possibility of farms producing a certain level of output from a given bundle of resources or certain level of output at least cost. Maximum efficiency is attained when it becomes impossible to reshuffle a given resource combination without decreasing the total output (Adeoti, 2001; Adebayo, 2006).

CONCEPTUAL AND THEORETICAL FARMEWORK

The production function stipulates the technical relationship between inputs and output in the production process (Olayide and Heady, 1982). This function is assumed to be continuous and differentiable in mathematical terms. The concept of efficiency is concerned with the relative performance of the process used in the production process (Upton, 1996). Three types of efficiency were identified. They include: technical, allocative and economic efficiency. Measurement of efficiency according to Ogunjobi (1999) is important for the following reasons: Firstly, it is a success indicator, performance measure by which productive units are evaluated. Secondly, only by measuring efficiency and separating its effects from the effects of the production environment can one explore hypotheses concerning the sources of efficiency differentials. Identification of sources of inefficiency is important to institution of public and private agencies designed to improve performance. Thirdly, the ability to quantify efficiency

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provides decision makers with mechanism with which to monitor the performance of the production system or units under their control. In some cases, theory provides no guidance or provides conflicting signals concerning the impact of some phenomena on performance. In such situations, empirical measurement provides qualitative as well as quantitative evidence (Coelli, 1995).

Technical efficiency is based on expressing the maximum amount of output obtainable from given bundles of production resources with fixed technology. It is the attainment of production goods without wastage (Amaza and Olayemi, 1999). This is regarded as estimating average production function (Olayide and Heady, 1982). This definition assumes that technical inefficiency is absent from the production frontier. Farrell (1957) suggested a method of measuring technical efficiency of a firm in an industry by estimating the production function of firms which are fully efficient (ie frontier production function).

Allocative efficiency on the other hand relates to the degree to which a farmer utilizes inputs in optimal proportions, given the observed input prices (Coelli *et al*., 2002; Ogundari *et al*, 2006). Russell and Young (1983) looked at Allocative efficiency (AE) as a condition that exists when resources are allocated within the firm according to market prices. In a materialistic society according to them, this will represent a desirable characteristic when market prices are a true measure of relative scarcity. This will be the case when prices are determined in perfectly competitive markets, but when prices are distorted by monopolistic influences or where some goods remain outside the market system the role of prices in resource allocation is greatly impaired. Lau and Yotopoulos (1989) stated that a farm is said to be allocatively efficient if it maximizes profit, that is, it equates its marginal product of every variable input to its corresponding opportunity cost. A farm which fails to do so is said to be allocatively inefficient.
In Farrell's framework, economic efficiency (EE) is an overall performance measure and is equal to the product of Technical Efficiency (TE) and Allocative efficiency (AE) i.e EE = TE ´ AE. The simultaneous achievement of both efficient conditions according to Heady (1952) occurs when price relationship are employed to denote maximum profits for the firm or when the choice indicators are employed to denote the maximization of other economic objectives.

According to Adesina and Djato (1997) economic efficiency occurs when a firm chooses resources and enterprises in such a way as to attain economic optimum. The optimum implies that a given resource is considered to be most efficiently used when its marginal value productivity is just sufficient to offset its marginal cost. Thus, economic efficiency refers to the choice of the best combination for a particular level of output which is determined by both input and output prices. This would lead to increase in the farmers output as well as its income invariably leading to poverty reduction, improved living condition and wellbeing.

One of the suggested ways of achieving reduction in poverty is utilizing of the poor endowment for improved income earning and in living standards. In other words, enabling the poor to increase their level of production of economic goods, increase their income level and thereby their living standards. An obvious way of achieving this is enabling the poor to increase their agricultural output, so as not only to improve their income but also lift them above the

subsistence level. The use of the stochastic frontier analysis in studies in agriculture would enable both the researchers and the farmers in the allocation and use of its resources optimally.
In Nigeria, the application of this function is a recent development. Such studies conducted in the recent times include that of Udoh (2000), Okike (2000), Amaza (2000) and Umoh (2006). Udoh used the Maximum Likelihood Estimation of the stochastic production function to examine the land management and resource use efficiency in South-Eastern Nigeria. The study found a mean output-oriented technical efficiency of 0.77 for the farmers, 0.98 for the most efficient farmers and 0.01 for the least efficient farmers. Okike's study investigated crop-livestock interaction and economic efficiency of farmers in the savanna zones of Nigeria. The study found average economic efficiency of farmers was highest in the Low-Population-Low Market domain; Northern Guinea and Sudan Savannas ecological zones; and Crop-based Mixed Farmers farming system. Similarly, Umoh's study employed the stochastic frontier production function to analyse the resource use efficiency of urban farmers in Uyo, Southeastern Nigeria. The result shows that 65% of urban farmers were 70% technology efficient; maximum efficiency is 0.91, while minimum efficiency in urban farm is 0.43

The National Fadama Project-II is among the most recently introduced poverty reduction programmes aimed at uplifting the living standards of people through increase productivity and enhanced income generation. A study by Ayanwale and Alimi (2004) has revealed that regions where agriculture is the main source of employment has higher incidence of poverty. It thus becomes imperative that appropriate technology and efficient resource use as a measure for increase productivity must be taken into consideration.

Consequently, it is against this background that, this study was structured to provide answers to the following questions:

i. What were the optimum quantities of inputs and output for profit maximization in fadama crop production?

ii. How efficient were Fadama II beneficiaries in food crop production?

Hypotheses of the Study

Ho: Fadama II crop farmers were not technically, allocatively and economically efficient in food crop production in the study area.

METHODOLOGY

The study Area

Adamawa State is located in the North Eastern part of Nigeria and lies between latitude 7^0 and 11^oN of the equator and longitude 11^o and 14^oE of the Greenwich meridian (Fig 1). It shares common boundary with Taraba State in the south and west, Gombe State in the northwest and Borno State in the north. The state has an international boundary with the Cameroun republic along its eastern border.

Adamawa State covers a land area of about 38,741 km^2 with a population of 3.17 million people (NPC, 2006). Out of this estimated land area about 226,040 ha is under cultivation with about 400 ha under irrigation (Adamawa ADP, 1996). The State has a tropical climate with maximum temperature reaching to as high as 40°C between December and January (Adebayo , 1999). The mean annual rainfall pattern shows that the amount range from 700 mm in the northern-west part of the state to 1600 mm in the southern part of the state. Generally, mean annual rainfall is less than 1000 mm in the central and north-western part of the state including Song, Gombi, Shelleng, Guyuk, Numan, Demsa, Yola and parts of Fufore local government area (Adebayo , 1999). The major vegetation formations in the state are the southern guinea savannah, northern guinea savannah and the sudan savannah. Within each formation is an interspersion of thickets, tree savannah, open grass savannah and fringing forests in the river valleys.

Nature and Sources of Data

Primary data was used for this study. These were collected through the administration of structured questionnaires to randomly selected Fadama farmers. The data collected included respondents' personal background, production inputs, and cost of production, income and expenditure, accessibility to basic amenities among others. Data collection was facilitated with the aid of trained staff selected from the four (4) zones of the state ADP.

Sampling Procedure and Sample Size

Multistage stratified random sampling and purposive sampling techniques were used in the selection of respondents. In the first stage, the state was stratified into four according to the Adamawa Agricultural Development Programme (ADADP) zones (Table 3.1). In each of the zone, participating local government areas in fadama crop production was purposively selected in proportion to the existing number of Fadama User Associations (FUA).In line with this, four local government areas in Zone II and one each in Zones I, III and IV were selected. In all, a total of seven local government areas were sampled. One hundred and eighty (180) food crop farmers were randomly selected in the FUA groups in the seven selected local government areas in proportion to their number in each local government. The membership of each FUA ranges from 10 – 30.

Analytical tools

Inferential statistics was employed in the analysis of data. Inferential statistics involved the use of stochastic frontier production function to determine the technical, allocative and economic efficiencies of food crop fadama farmers in crop production in the study area. Linear programming was used to determine the crop combination that maximizes the production objective of the farmers.

Stochastic Frontier Production Function

The stochastic frontier production function comprises of a production function of the usual regression type with a composite disturbance term equal to the sum of two error components (Aigner *et al*., 1977; Meeusen and Van den Broeck,1977; Xu and Jeffrey, 1998; Amodu *et al*, 2011). The model is defined by:

$$Yi = f(Xi;\beta)e\epsilon \; i = 1,2, \dots \dots \dots N \qquad (1.1)$$

and

$$\in = Vi - Ui \qquad i = 1,2, \dots \dots \dots \dots \dots . N \qquad (1.2)$$

Where Y_i is the output of the i^{th} farm, f(xi) represents an appropriate function of the vector, X_i of vector of input quantities used by the i^{th} farm and a vector of unknown parameters, β which are to be estimated. $\in$ is a composite error term. The corresponding cost frontier as used by Ogundari *et al*. (2006) can be derived analytically as:

$$C = y(P, Yi; \gamma) + (Vi + Ui) \tag{1.3}$$

Where C is the total production cost, P is a vector variable of input prices, ϵ is a suitable functional form, Y_i is the value of output in Kg, and γ is the parameter to be estimated.
The minimum cost input demand equation is obtained by using Shephard's Lemma (Bravo-Ureta and Rieger, 1991),. ie

$$\frac{\partial C}{\partial Pi} = Xi\ (PYi; \emptyset) \tag{1.4}$$

Substituting equation (3.1) and equation (3.3) into equation (3.4) yields the economically efficient input vector X_e. The technically efficient input vector (X_t) and the economically efficient input vector can be used to compute the cost of the technically efficient (X_t'.P) and the economically efficient (X_e'.P) input combinations associated with the firm's observed output. The cost of farm's actual operating input combination is given by X_a'.P. These three cost measures are the basis for computing the following technical, economic and allocative efficiency indices as explained by Bravo-Ureta and Rieger (1991).

$$TE = Xt.P\ /\ Xe.P \tag{1.5}$$

$$EE = Xe.P\ /\ Xa.P \tag{1.6}$$

$$AE = EE/\ TE = Xe.P\ /\ Xt.P \tag{1.7}$$

Where TE, EE and AE are technical efficiency, economic efficiency and allocative efficiency, respectively.
The empirical stochastic frontier for Adamawa State Fadama II crop farmers is given by:

$$lnYij = \beta o + \beta 1 lnX1ij + \beta 2 lnX2ij + \beta 3 lnX3ij + \beta 4 lnX4ij + \beta 5 lnX5ij + \beta 6 lnX6 + \beta 7 lnXij + \beta 8 lnX8ij + Vij - Uij \tag{1.8}$$

Where:
Subscript ij refer to the j^{th} observation of the i^{th} farmer.
Note: naira = Nigerian Naira
ln = Logarithm to base
Y = Output of food crops (Kg grain equivalent)
X_1 = Farm size (ha)
X_2 = Quantity of agrochemicals/ha (litres)
X_3 = Quantity of inorganic fertilizer/ha (kg)
X_4 = Family labour (mandays)
X_5 = Amount spent on hired labour/ha (naira)
X_6 = Expenses on ploughing/ha (tractor and animal traction) (naira)
X_7 = Water cost/farming season (naira)
X_8 = Other cost/ha (seed, transportation, empty sacks and baskets) (naira).
It is assumed that the technical inefficiency effects are independently distributed and U_i arises by truncation (at zero) of the normal distribution with mean, μ_{ij} and variance δ^2, where μ_{ij} is defined by:

$$\mu ij = \delta o + \delta 1 Z1ij + \delta 2 Z2ij + \delta 3 Z3ij + \delta 4 Z4ij + \delta 5 Z5ij \tag{1.9}$$

Where:
μ_{ij} = The technical inefficiency of the i^{th} farmer
Z_1 = Years of farming experience
Z_2 = Years of formal education

Z_3 = Extension contact (number of meetings)
Z_4 = Household size
Z_5 = Age of farmers (years)

The empirical stochastic frontier cost function for Adamawa fadama crop farmers is given by:

$$LogC1 = \beta o + \beta 1logP1 + \beta 2logP2 + \beta 3logP3 + \beta 4logP4 + \beta 5logP5 + \beta 6logYi + Vi + Ui \quad (1.10)$$

Where:

Note: naira = Nigerian Naira

C_1 =Total production cost (naira)
P_1 = Cost of land (naira)
P_2 = Cost of agrochemicals (naira)
P_3 = Cost of fertilizers (naira)
P_4 = Cost of family labour (naira)
P_5 = Cost of hired labour (naira)
P_6 = Expenses on ploughing (naira)
P_7 = Water cost (naira)
P_8 = Other cost (in naira)

It is assumed that the technical inefficiency effects are independently distributed and U_i arises by truncation (at zero) of the normal distribution with mean, μ_{ij} and variance δ^2, where μ_{ij} is defined by:

$$\mu ij = \delta o + \delta 1Z1ij + \delta 2Z2ij + \delta 3Z3ij + \delta 4Z4ij + \delta 5Z5ij \quad (1.11)$$

Where:

μ_{ij} = The cost inefficiency of the i^{th} farmer
Z_1 = Years of farming experience
Z_2 = Years of formal education
Z_3 = Extension contact (number of meetings)
Z_4 = Household size
Z_5 = Age of farmers (years)

The maximum-likelihood estimates of β and δ coefficients were estimated simultaneously using the computer program FRONTIER 4.1, in which the variance parameters are expressed in terms of $\delta^2_S = \delta^2 v + \delta^2$ and $\gamma = \delta / \delta^2$ (Coelli, 1994).

RESULTS AND DISCUSSION

Efficiency Estimation

The maximum likelihood estimates (MLE) for the stochastic production function used in explaining the influence of production inputs on the output of food crop among beneficiaries of Fadama II, and also in determining the effect of farmer specific characteristics on technical inefficiency is presented in Table 1.1. The parameters were estimated simultaneously using frontier 4.1c developed by Coelli (1996).The results shows that the coefficients of farm size (X_1), inorganic fertilizer (X_3), hired labour (X_5) and expenses on ploughing (X_6) were found to be positive and significantly affect food crop output of the respondents as revealed by the computed t-values. This implies that, any increase in the use of these production inputs would bring about increase in food crop output.

The value of the sigma squared (δ^2) is 0.6548 and is statistically significant at 1% level. This also indicates a good fit and correctness of the distributional form assumed for the composite error term in the model. The variance ratio (γ) is 0.88 and also statistically significant at 1% level, implying that 88% of the variation in crop output of the respondents is due to differences in their technical efficiencies. This explains the reason why the ordinary least squares (OLS) estimates will not be adequate in explaining inefficiency differentials among the farmers. All the estimated coefficients are less than one, indicating that input allocation is in stage II of the production function.

The estimated coefficient for farm size is positive, which conform to *a priori* expectation and significant at 1% level. The magnitude of the coefficient (0.24) indicates that, the output of food crop is inelastic to changes in the level of cultivated land area. Therefore, this implies that a 1% increase in cultivated land area, ceteris paribus, would lead to an increase of 0.24% in the output of food crop, and vice versa.

The production elasticity with respect to inorganic fertilizer is positive as expected and statistically significant at 5% level. This stems from the fact that, fertilizer is a major land augmenting input which improves the productivity of existing land by increasing yield per unit area. Though Fadama lands have superior fertility status, but increase in the quantity of fertilizer used in food crop production would further increase the fertility of the existing land resulting in higher output. This study is consistent with the findings of Umoh (2006) that fertilizers increase crop yield.

The magnitude of the coefficient of hired labour, which is 0.13, indicates that output in food crop production in the Fadama lands is highly inelastic to changes in the amount of hired labour used. Thus, a 1% increase in the mandays of hired labour used would induce an increase of 0.13% in the output of food crop, and vice versa.

The estimated coefficient for expenses on ploughing is positive and statistically significant at 1% level, indicating that food crop output among the respondents is inelastic to changes in the expenses on ploughing. A 1% increase in the expenses on ploughing would bring about 0.05% increase in the output of food crop.

The returns to scale which is the sum of elasticities reveals that food crop production among Fadama II beneficiaries is inelastic (0.663) and is in stage II of the production surface. Thus, additional input would bring about increase in output but at a decreasing rate although it is the rational stage of production.

The inefficiency parameters were specified as those relating to farmers' specific socio-economic characteristics. Three out of the five variables used in the model are significant and also have apriori expected signs. A negative coefficient indicates that the variable increases efficiency in food crop production and vice versa; hence, education, extension contact and age increase the efficiency in food crop production in the study area.

Table 1.1: Maximum Likelihood Estimates of Parameters of Stochastic Frontier Production Function

Variables	Parameters	Coefficient	t-ratio
Constant	β_0	2.2172	3.5468***
Farm Size (X_1)	β_1	0.2372	2.7908***
Agrochemicals (X_2)	β_2	0.0381	0.2045
Inorganic Fertilizer (X_3)	β_3	0.2019	2.1634**
Family Labour (X_4)	β_4	0.0213	1.6310
Hired Labour (X_5)	β_5	0.1332	2.8675***
Ploughing Expenses (X_6)	β_6	0.0549	2.8934***
Water Cost (X_7)	β_7	-0.0226	-0.1762
Inefficiency model			
Constant	δ_0	-2.5813	-2.8675***
Farming Experience(Z_1)	δ_1	-0.0302	-0.2453
Education (Z_2)	δ_2	-0.0210	-2.7564***
Extension Contact (Z_3)	δ_3	-0.0473	-2.1735**
Household size(Z_4)	δ_4	-0.0257	-0.0293
Age (Z_5)	δ_5	-0.2116	-2.5425**
Variance Parameters			
Sigma Square	δ^2	0.6548	39.4293***
Gamma	Γ	0.8756	2.9723***

Source: Computer Output from Frontier Analysis
*** Significant at 1% level ** Significant at 5% level

The estimated coefficient of education variable is negative as expected and statistically significant at 1% level, implying that farmers with formal schooling tend to be more efficient in food crop production, presumably due to their enhanced ability to acquire technical knowledge, which makes them closer to the frontier output. The coefficient of extension variable is estimated to be negative and statistically significant at 5% level. This indicates that increased extension services to farmers tend to increased technical efficiency in food crop production. Finally, the estimated coefficient of age variable is negative and statistically significant at 5% level, depicting that farmers who are older are relatively efficient in food crop production.

Technical Efficiency Distribution of Respondents

The summary of the technical efficiency scores for the respondents is presented in Table 1.2. The technical efficiency is less than 1.0 indicating that all the farmers were producing below the maximum efficiency frontier. A range of technical efficiency is observed across the sampled farmers and the spread is large. The best farmer had technical efficiency of 0.98 (or 98%), while the worst farmer had a technical efficiency of 0.27 (or 27%). The mean technical efficiency is 0.71 (or 71%). This implies that, on the average, the farmers were 71% technically efficient; hence their observed output was about 29% less than the maximum frontier output.

Table 1.2: Technical Efficiency Scores of the Sampled Farms

Efficiency Level	Frequency	Percentage (%)
<0.40	7	4.38
0.40-0.49	15	9.38
0.50-0.59	24	15.0
0.60-0.69	25	15.63
0.70-0.79	31	9.38
0.80-0.89	43	26.88
0.90-0.99	15	9.38
Total	160	100
Mean 0.709		
Maximum 0.274		
Minimum 0.983		

Source: Computer Output from Frontier Analysis

Allocative Efficiency

The estimated stochastic cost function used in determining allocative efficiency is presented in Table 1.3. All the coefficients in the model have the expected signs. Cost of land, cost of family labour, cost of hired labour and expenses on ploughing were all statistically significant at 1% level, implying that these factors are important determinants of total cost associated with food crop production among the selected respondents.

Table 1.3: Maximum likelihood Estimates of parameters of stochastic cost function

Variables	Parameters	Coefficient	t-ratio
Constant	β_0	3.3949	33.7498***
Cost of land	β_1	0.3937	4.6631***
Cost of agrochemicals	β_2	0.0189	1.0121
Cost of Fertilizers	β_3	0.0343	1.4978
Cost of family labour	β_4	0.0878	3.199***
Cost of hired labour	β_5	0.1092	2.3430**
Expenses on ploughing	β_6	0.1531	2.7856**
Water cost	β_7	0.0041	0.0290
Other cost	β_8	0.7970	5.4369***
Inefficiency model			
Constant	δ_0	-9.4065	-4.4815***
Farming Experience	δ_1	-9.1386	13.0778***
Education	δ_2	-0.0258	-0.2639
Extension Contact	δ_3	-0.6935	-1.2544**
Household size	δ_4	-14.9527	-6.0404***
Age	δ_5	-0.9745	-2.5629**
Variance Parameters			
Sigma Square	δ^2	9.5244	7.8853***
Gamma	Γ	0.8958	70.6513***

Source: Computer Output from Frontier Analysis
***Significant at 1% level **Significant at 5% level

The variance ratio which is estimated by gamma, γ (0.90) is very close to one and statistically significant at 1% level, showing the amount of variation in total cost of production brought about by cost inefficiencies. This implies that, 90% of the variation in the total cost of production among the sampled farmers is due to cost inefficiencies. The value of sigma squared (δ^2) is 9.52 and is statistically significant at 1% level, indicating good fit and correctness of the distributional form assumed for the composite error term in the model.

Allocative Efficiency Distribution of Respondents

The allocative efficiency indices which measures the rate at which resources are allocated in optional proportion is presented in Table 1.4. The allocative efficiencies of all the respondents were less than 1.0 indicating that all the respondents were producing below the maximum cost efficiency frontier. A range of allocative efficiencies is estimated to be 0.76 (or 76%), indicating that Fadama II beneficiaries are 76% allocatively efficient in food crop production.

Table 1.4: Allocative Efficiency of the sampled farmers.

Efficiency Level	Frequency	Percentage (%)
0.40-0.49	5	3.13
0.50-0.59	15	9.38
0.60-0.69	22	13.75
0.70-0.79	44	27.50
0.80-0.89	53	33.13
0.90-0.99	21	13.13
Total	160	100
Mean 0.76		
Maximum 0.99		
Minimum 0.45		

Source: Computer Output from Frontier Analysis

Economic Efficiency

Economic efficiency of the farmers which is obtained as the product of technical and allocative efficiency scores is presented in Table 1.5. The result reveals that variation in the economic efficiency levels among the respondents is large, with a minimum efficiency of 0.18 (or 18%), and a maximum efficiency of 0.87 (or 87%). The mean economic efficiency is estimated to be 0.54(or 54%), an indication that the farmers are fairly economic efficient in food crop production. The analysis of the efficiency levels reveal that about 20% of the farmers have economic efficiency level of less than 40%, while about 22% have economic efficiency level of 40-49%. About 40% have economic efficiency level of 50-69%, while only about 18% have efficiency level of 70% and above. Therefore, the simultaneous achievement of both technical and allocative efficiencies is necessary for the achievement of economic efficiency.

Table 1.5: Economic Efficiencies of sampled Farmers

Efficiency Level	Frequency	Percentage (%)
<0.30	11	6.88
0.30-0.39	21	13.13
0.40-0.49	35	21.88
0.50-0.59	27	16.88
0.60-0.69	37	23.13
0.70-0.79	23	14.38
0.80-0.89	6	3.75
Total	160	100
Mean 0.54		
Maximum 0.87		
Minimum 0.18		

Source: Computer Output from Frontier Analysis

Distribution of Farm-level Technical inefficiency indices, Average Farm size and output level

The extent to which farm size and output level relates to farm specific technical inefficiency indices is presented in Table 1.6. As seen in the table, inefficiency effects have inverse and linear relationships with output levels, but undefined relationship with farm size. As such lower inefficiency index (<0.40 to 0.49) corresponds with greater output level and vice versa.

Table 1.6: Distribution of Farm-level Technical inefficiency indices, farm and output level of Respondents

Efficiency Level	Mean Farm size (Ha)	Mean Output (kg)
<0.40	3.86	12,660.00
0.40-0.49	6.53	15,133.33
0.50-0.59	3.16	4,760.42
0.60-0.69	3.30	6,742.00
0.70 - 0.79	3.66	7,685.48
0.80- 0.89	3.88	8,744.18
0.90-0.99	2.40	2,753.33

Source: Data Analysis, 2011

CONCLUSION

The study concludes that, the maximum likelihood estimates (MLE) for the stochastic production function of the coefficients of farm size(X_1), inorganic fertilizer (X_3), hired labour (X_5) and expenses on ploughing (X_6) were found to be positive and significantly affect food crop output of the respondents with the mean technical efficiency is 0.71 (or 71%). The Economic efficiency of the farmers which is obtained as the product of technical and allocative efficiency revealed a mean economic efficiency of 0.54(or 54%), an indication that the farmers are fairly economic efficient in food crop production. It therefore suggests that, productivity and output of the farmers can be increase for every increase in the resource efficiency use of the farmers. Similarly, it indicates that the scope of output and productivity of farmers can be increased if better efficiencies are reached. The study therefore, would help other researchers and research institutions in further research for more effective combinations of resources for better efficiencies as well as increase output and productivity in the farming business, it would also help the government, policy makers and other donor agencies in planning, designing and formulations of agricultural programmes that would tends towards increase resource, resource availability as well as affordability. The study therefore recommends: Government and other donor agencies should intensify advisory services activities on effective resource allocation, utilization and other ways of increasing farmers' beneficiary income. Government in partnership with private sector should encourage farmers to increase its technical efficiency in food crop production which could be achieved through improved farmer specific efficiency factors, which include improved farmer education, access to credit, access to improved extension services and less crop diversification. Government to introduce mentorship and pre-job training programmes and to include the youth in policy decisions. Government should establish farmer field days right at the site of the farmer's farm to honour individuals.

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