

*Full Length Research Paper*

# Technical Efficiency of Fadama II Grain Farmers in Taraba State, Nigeria

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The study focused on the productive capacity, technical efficiency of Fadama II grain farmers in Taraba State, Nigeria for the 2008/2009 farming season. Data for the study were obtained from primary source with the aid of interview schedule and analysed using descriptive statistics and stochastic frontier model. Findings revealed that the farmers are within the active farming age (37 years), had average farm size of 5.21 ha, annual income of ₦242,000.00, and 11 years of formal education. Farm size (0.01) and fertilizer (0.05) increased grain output by 44.75 and 17.45% respectively. On the other hand, herbicide (0.05) and labour (0.05) significantly decreased grain output by 67.17 and 98.90% respectively. The inefficiency model showed that while age (-0.05) and sex (-0.01) significantly decreased technical inefficiency by 22.17 and 31.57% respectively, education (0.01) and local crop variety (0.01) increased technical inefficiency by 14.05 and 41.85% respectively. Although, the sigma squared (0.73) indicated the correctness of the specified assumptions of the distributions of the composite error term and gamma was high (0.99) and significant, the mean technical efficiency (0.34) was low. Fadama II achieved the goals of input accessibility and increase in income among farmers. It was recommended that farm size and fertiliser should be increased for farmers; extension should focus attention on herbicide and labour efficient utilisation; and that Fadama II should involve farmers within the age bracket of 37 years in grain production.

**Key words:** Fadama II, small-scale, grain farmers, stochastic frontier, technical efficiency.

## INTRODUCTION

Nigeria is endowed with abundant natural resources. According to Ajakaiye (1993), arable land constitutes about 75% of her total land resources. Matthew (2008) reported that the country is endowed with fresh water source covering 68 million hectares, 960 km of coastline, and an ecological diversity of crop and livestock, forestry and fishery products. Lawanson (2005) observed that Nigeria's agricultural sector contributed about 97.30% to

her GDP in the 1960s. Also, the sector employed about 60% of its total population within the same period (Diaz-Bonilla and Gulati, 2003).

Matthew (2008) indicated that, in spite of Nigeria's impressive magnitude of the deposit of primary resources for effective agricultural activities, the sector has continuously stagnated in terms of diminishing productivity. Central Bank of Nigeria (2006) revealed that,

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as from the early 1970s, the contribution of agriculture to GDP began to decline from over 60% to less than 26% by 2003. The utter neglect of the agricultural sector is best captured by Sanni (2006) that its contribution to total export trade remained as low as 4.0% from 1998 to 2004. The implication of this declining productivity is that, agricultural sector could no longer provide decent employment, food and income for those engaged in agricultural production.

It was the realization of the great potential of agriculture that several programmes were launched in the past to reverse the poor trend of productivity and, hence, raise the level of income, productivity, and living standard of rural farmers. Some of the programmes have terminated while others are on-going. An example of the programmes is the Agricultural Development Programme (ADP). The ADP started from 1975 to 1986 and gulped about N1.35 billion. Not less than 6.028 million farm families across the country benefited from the programme (Ayichi, 1995; Ayoola, 2001).

Another programme was the Directorate of Food, Rural Road and Infrastructure (DFRRI) of 1986 to 1992. About ₦2.402 billion was allocated to DFRRI. Under this programme, 289,897.46 km of feeder roads were constructed and rehabilitated; 1,087 rural electricity projects were executed; and 35,281 boreholes were built (Ekpo and Olaniyi, 1995). There was also the Agricultural Credit Guarantee Scheme Fund (ACGSF) which started in 1978. Until 2006, ACGSF had, to its credit, about 497,692 volumes of loan valued at ₦14.9 billion (Central Bank of Nigeria, 2007). The National Special Programme for Food Security, which started in 2001 and National Fadama Development Project have been packaged to tackle poverty and food insecurity problems. By and large, all efforts aimed at enhancing agricultural productivity and farmers' income have not recorded much success. This is depicted in the declining trend in both

national and sectoral productivity measures as reported by Matthew (2008). Fans et al. (2008) also reported that from 1970 to 2000, Nigeria's agricultural sector grew at 1.7% per annum, which is very low in relation to its population growth rate of 2.7%. According to them, this is the principal reason why the country still has one of the highest poverty rates in the world.

Fadama II targeted small-scale farmers as the economic entity that has the best potential to implement agricultural technologies in Nigeria. International Food Policy Research Institute (IFPRI) (2007) indicated that smallholding agriculture is the dominant occupation of rural Nigerians. In spite of their neglect, small scale farmers account for most of the food needs of the entire Nigerian populace. Ayichi (1995) and Ekpo and Olaniyi (1995) showed that rural inhabitants produced 90% of the food marketed and consumed in Nigeria and 2.4% of official export.

The National Fadama Development Project is a major instrument for achieving the Federal Government of

Nigeria's poverty reduction objective in the rural areas of Nigeria. The beneficiaries comprise private economic agents who earn their living directly or indirectly by exploiting natural resources in a given fadama area. The project empowers Fadama Community Association (FCAs) and Fadama User Groups (FUGs) with resources, training, and technical assistance or support to properly manage and control these resources for their own development (Abdullahi et al., 2006). Fadama II included capacity building as a project component to reduce poverty through increased productivity and income generation. In its broadest interpretation, capacity building encompasses human resource development as an essential part of overall development. It focuses on a series of actions aimed at assisting participants in the development process to increase knowledge, skills and understanding and to develop the attitudes needed to engender the desired developmental change (Abdullahi et al., 2006).

To an economist, efficiency is a relationship between ends and means (Olaide and Heady, 2006). It also refers to the attainment of a production goal with minimal waste (Arene and Okpukpara, 2006). Theory of production provides the analytical framework for most empirical research on productivity and efficiency (Ajibefun and Daramola, 2003). Technical efficiency measures the relationship between the physical quantities of inputs and outputs. The output-oriented technical efficiency is the ratio between the observed output of the farm firm to the frontier (Battese and Coelli, 1995). In other words, technical efficiency determines the maximum possible output using the same input mix or different combinations of resources.

According to Ekwurke (2005), sorghum, millet, maize and rice are the most important cereals in Nigeria. This is because they are associated with food and drinks throughout the history of humanity as well as animal feed and fodder. In industrialized countries, maize is largely used as livestock feed and as a raw material for industrial products, while in low-income countries, it is mainly used for human consumption (IITA, 2001). Maize is increasingly being utilised for livestock feed, while it remains very important staple food for millions of Nigerians (Oladejo and Adetunji, 2012). Its various uses cut across several ethnic groups in Nigeria (Abdulrahman and Kolawole, 2006).

The success of a programme depends on the personal characteristics of the key participants. It also depends on the efficiency with which farmers apply available resources to their enterprises. This study was undertaken to determine the technical efficiency of the farmers who benefited from the programme. The outcome of this study will, therefore, serve as a measure of success of Fadama II. Thus, the objectives of this study are to: examine the socio-economic characteristics of grain farmers under Fadama II in Taraba State; evaluate the productivity of the respondents; estimate the level of technical efficiency

of the respondents; and identify the determinants of technical efficiency of the farmers.

## METHODOLOGY

### Study area

The study area for this research was Taraba State, located within the North-East region of Nigeria. The State is one of the participating States in Fadama II Project. The capital is Jalingo. Taraba State lies between longitudes 9°E and 12°E and within latitudes 6°N and 10°N. The major occupation of the people of Taraba State is agriculture. Cash crops produced in the State include coffee, tea, groundnuts and cotton. Crops such as maize, rice, sorghum, millet, cassava and yam are also produced in commercial quantities (Taraba State Government, 2008; National Population Census, 2009).

### Data collection

The population for the study comprised the 16,796 small-scale grain (maize, rice, sorghum and millet) farmers in Taraba State who benefitted from Fadama II. These farmers were located in 10 participating Local Government Areas (LGAs). Simple random sampling technique was used to select respondents from six LGAs, namely Jalingo, Karin-Lamido, Bali, Sardauna, Donga and Wukari. The sample size for the study was determined by applying a fixed sampling proportion of 0.015 to the population of participants to arrive at the total sample size of 252. Up to 235 copies of questionnaire were completed and used for the analysis. Data for the study were obtained from primary source using standard questionnaire. The data were analysed using both descriptive and inferential statistics. Socio-economic characteristics and productivity of the farmers were analysed with descriptive statistics. Stochastic frontier model was used to estimate farmers' level of technical efficiency and identify the determinants of their technical efficiency.

### Stochastic frontier analysis

Battese and Coelli (1995) presented the stochastic production frontier as:

$$Y_i = f(x_i, \beta) \quad (1)$$

Where,  $i = 1, 2, 3, \dots, n$ ,  $Y_i$  = output of the  $i$ th firm,  $X_i$  = vector of input,  $\beta$  = vector of parameter to be estimated.

But the stochastic frontier function has two error terms,  $V_i$  and  $U_i$ , unlike the traditional production function (Amaza and Olayemi, 2002). Thus, the explicit form of the stochastic frontier function is:

$$Y_i = \beta x_i + (V_i - U_i) \quad (2)$$

Where,  $V_i$  = random errors assumed to account for measurement error in the output of the firm. The errors are assumed to be normally distributed with zero mean and constant variance  $(0, \delta^2)$  which are independent of  $U_i$ , and are obtained by the truncation, at zero, of the normal distribution.

$U_i$  = non-negative random errors assumed to account for technical inefficiency in production with zero mean and variances (Coelli and Battese, 1996).

The technical efficiency (TE) of production of the firm is defined as the ratio of the observed output ( $Y_i$ ) to the corresponding stochastic frontier output  $Y^*$ . Mathematically,

$$TE = \frac{Y_i}{Y^*} \quad (3)$$

$$Y^* = \exp(x, B, v_i) \quad (4)$$

Equation (4) described the frontier function. Technical efficiency (TE) is further defined as:

$$TE = \frac{f(x_i, B) \exp(v_i - u_i)}{f(x_i, B) \exp(v_i)} = \exp(-u_i) \quad (5)$$

### Empirical specification

The stochastic frontier production function model used in this study is stated explicitly as follows:

$$\log y_i = b_0 + b_1 \log x_1 + b_2 \log x_2 + b_3 \log x_3 + b_4 \log x_4 + b_5 \log x_5 + v_i - u_i$$

Where,  $Y_i$  = output of the  $i$ th farmer (tons),

$x_1$  = farm size (ha),

$x_2$  = seed (kg),

$x_3$  = fertilizer (kg),

$x_4$  = herbicide (l),

$x_5$  = labour (man – days),  $b_s$  = parameters (coefficients) of  $x_1 - x_5$  to be estimated,  $v_i$  =

random error assumed to be normally distributed with  $(0, \delta^2)$ ,

$u_i$

= technical inefficiency effect independent of  $v_i$ , and have half – normal distribution with  $(0, \delta^2)$

Based on the socioeconomic characteristics of the respondents in the study area, and in accordance with the specification of Battese and Coelli (1995), the factors responsible for technical inefficiency were presented as follows:

$$U_i = \partial_0 + \partial_1 z_1 + \partial_2 z_2 + \partial_3 z_3 + \partial_4 z_4 + \partial_5 z_5 + \partial_6 z_6$$

$z_1$  = farming experience (years)

$z_2$  = education (years)

$z_3$  = age of the farmers (years)

$z_4$  = household size

$z_5$  = sex (1 = male, 0 = female)

$z_6$  = variety of crops (1 = improved, 0 = local)

A significant and high value of gamma ( $\gamma$ ) would show the presence of inefficiency effects in the data. Having received training in their respective technologies, the level of technical efficiency was expected to be, at least, above average.

## RESULTS AND DISCUSSION

### Socio-economic characteristics of the respondents

In Table 1, the mean age of the respondents was 37 years. This is the active farming age, and is consistent with Obinne et al. (2009). The average household of respondents was 7 with a standard deviation of 2.749. Average farm size was found to be 5.21 ha which differs positively with IFPRI (2007) that most small-scale farmers in Nigeria are small-holders. Average farm size in this work was also higher than the 1.3 ha reported by Bamire et al. (2007) and the 2.8 ha in Oboh et al. (2007) for sole cropping. By targeting poverty reduction through increased agricultural productivity, Fadama II expectedly

**Table 1.** Summary statistics of socio-economic characteristics

Variables	Minimum	Maximum	Mean	Standard deviation
Age (years)	17	60	37.14	9.7950
Household size	1	20	6.63	2.75
Farm size (ha)	0.31	13	5.21	2.78
Farm income (N'000)	30	800	241.97	168.35
Farming experience (years)	4	39	13.23	8.55
Education (years)	0	21	11.01	5.77
Post harvest loss (%)	4.00	35	10.80	7.92

Source: Field Study, 2009.

**Table 2.** Production input per hectare.

Statistics	Minimum	Maximum	Mean	Standard deviation
<b>Input quantity</b>				
Farm size (ha)	0.31	5.55	5.21	2.78
Seed (kg/ha)	0.59	238.7	24.79	30.31
Fertilizer (kg/ha)	24.76	800.00	174.11	131.26
Herbicide (l/ha)	0.23	48.39	5.6011	5.87
Labour (man-days/ha)	89.64	4,988.24	897.72	719.65

Source: Field Study, 2009.

enhanced increased farm size of participants.

The mean annual farm income was ₦242000.00. This annual income of Fadama II grain farmers was large relative to Anozie and Okoronkwo (2009) and Jibril et al. (2009) that small-scale farmers in Nigeria earn an average annual farm income of ₦196685.00 and ₦180000.00 respectively. This finding represented an improvement in the income profile of small-scale farmers which could raise their standard of living and sustain agricultural productivity.

Grain farmers that participated in Fadama II in Taraba State had average farming experience of 13 years, with standard deviation of 8.55, which is lower than 16-20 years in Mbah (2009). Nasiru et al. (2006) stressed that farming experience is an important determinant of profitability because it allows farmers to adjust to changing economic conditions and adopt efficient cultural practices. Average number of years of formal education was found to be 11. This implied that most of the respondents had secondary education. This finding is contrary to most previous research results that small scale farmers in Nigeria have low or no formal education (Nwibo et al., 2009), and thus represents a potential improvement for increased agricultural productivity in Nigeria. However, the result was consistent with Balogun et al. (2007) and Mbah (2009) where 50.0 and 46.67% respectively had 12 years of formal education. Idiong et al. (2006) asserted that education enhances the acquisition and utilisation of information on improved

technology by farmers. According to James (2008), education is critical to the attainment of development goals.

### Production input per hectare (ha)

In Table 2, findings revealed that the mean seed quantity used was 24.7937 kg/ha. Seed is a critical input in agricultural productivity. As such, most small scale farmers in Nigeria store part of their produce (seed) as planting materials for the next cropping season. According to Umeh (1998), about 80% of farmers in Nigeria make use of farmer-saved-seeds. This probably accounted for the large variation in seed quantities obtained.

The average quantity of fertilizer, which the farmers got for the 2008/2009 farming season, was 174.11 Kg/ha. In spite of the fact that inorganic fertilizer improves/restores soil fertility for greater yield, not all small scale farmers have fully adopted the use of fertilizer. Studies have shown that fertilizer scarcity among small scale farmers has been persistent and remains the bane of crop productivity (Igwe et al., 2009). The mean quantity of herbicide was 5.6011 l/ha, with a standard deviation of 5.8654. The use of herbicide largely reduces the arduous nature of weeding.

In addition, total labour use was 897.72 man-days/ha, with a standard deviation of 5.378, showing large

**Table 3.** Maximum likelihood estimate for technical efficiency model for Fadama ii farmers in Taraba state for 2008/2009.

Model	Parameter	Coefficient	t-ratio
<b>Production function</b>			
Constant	$\beta_0$	2.83	12.55*
Farm size ( $x_1$ )	$\beta_1$	0.45	3.11*
Seed ( $x_2$ )	$\beta_2$	-0.02	-0.43
Fertilizer ( $x_3$ )	$\beta_3$	0.17	2.67*
Herbicide ( $x_4$ )	$\beta_4$	-0.07	-2.15*
Labour ( $x_5$ )	$\beta_5$	-0.09	-2.37*
<b>Technical Inefficiency function</b>			
Constant	$\delta_0$	1.96	0.67
Farming experience ( $z_1$ )	$\delta_1$	-0.13	-0.78
Education ( $z_2$ )	$\delta_2$	1.41	5.51*
Age ( $z_3$ )	$\delta_3$	-0.22	-2.29*
Household size ( $z_4$ )	$\delta_4$	0.04	0.09
Sex ( $z_5$ )	$\delta_5$	-31.57	-4.99*
Crop variety ( $z_6$ )	$\delta_6$	4.19	3.71*
<b>Diagnostic statistics</b>			
Sigma squared	$\delta^2$	73.17	8.60*
Gamma	( $\gamma$ )	0.99	606.66*
Ln likelihood function		-550.57	-550.56*
LR test		290.47	290.47*

variations. Labour use cuts across all stages of production. Mean labour for this study was large relative to 37 man-days/ha for cassava production in Edeh and Ojemade (2009). This is because in an enterprise combination, labour use would definitely be large. According to Akinpelu and Ogbonna (2005) and Umehali (2007), labour, whose utilisation in man-days varies among men, women and children, is a significant factor of production among small scale farmers.

#### Maximum likelihood estimates (MLE) for the technical efficiency of Fadama II grain farmers in Taraba State

The stochastic frontier model presented in Table 3 showed that, the sigma squared ( $\delta^2$ ), which indicates the correctness of the specified assumptions of the distributions of the composite error term was high (0.73) and statistically significant at 0.01 level. Furthermore, the variance ratio ( $\gamma$ ), which indicates the proportion of total variance attributable to the inefficiency term ( $U_i$ ), was high (0.99) and statistically significant at 0.01 level. The implication is that one percent of grain output was lost to technical inefficiency. There was the presence of one-sided error (LR) (290) component, thus rendering the use of ordinary least square estimating technique inadequate, and lending credence to the appropriateness of the MLE techniques in representing the data.

The elasticities of farm size and fertilizer were of

increasing function. The two variables had positive coefficients and were statistically significant at 1% probability level. Hence, increases in farm size and fertilizer by 1% would lead to increase in grain output by 44.75 and 17.74% respectively. These findings were consistent with Idiong et al. (2006) that farm size and fertilizer are significant resources in production. Herbicide and labour had negative coefficients and were statistically significant at 5% probability level. A one percent increase in these inputs would lead to decrease in grain output by 67.17 and 98.90% respectively. This finding is contrary to Lawal et al. (2008) that labour is positively significant in small-holder agricultural productivity. Akinpelu and Ogbonna (2005) found that labour accounted for high proportion of the variable cost of production. According to Audu et al. (2009), given the ageing trend of our farmers and high rate of rural-urban migration, the high cost of labour is undesirable.

#### Determinants of technical efficiency among grain farmers

In the technical inefficiency function in Table 4, education (0.01) significantly increased technical inefficiency at 1% probability level. The result implied that 1% increase in the number of years of formal education would reduce technical efficiency by 14.05%. This meant that more educated farmers in the study area were technically

**Table 4.** Distribution of technical efficiency among Fadama ii farmers in Taraba state, 2008/2009 farming season.

Technical Efficiency class	Frequency	Percentage
< 1.32E-04	34	14.47
0.108 – 0.09	4	1.28
0.101 – 0.020	22	9.36
0.202 – 0.30	31	13.19
0.301 – 0.393	44	18.72
0.405 – 0.497	40	17.02
0.501 – 0.595	33	14.47
≥ 0.607	27	11.49
Total	235	100.00

Mean technical efficiency = 0.342; Minimum technical efficiency = 2.59E-01; Maximum technical efficiency = 0.855.

inefficient. The result is consistent with Ajaero et al. (2008) that education had inverse relationship with technical education. More educated farmers tend to drift away from core farm production activities. Idiong et al. (2006), however, asserted that education enhances acquisition and utilisation of information on improved technology by farmers. Age and sex significantly reduced technical inefficiency at 5 and 1% probability levels respectively.

By implication, increase in the age of farmers by 1% would reduce technical inefficiency by 22.19%. Given the mean age (37 years) in this study, which fell within the active farming age bracket in Nigeria, additional years could still yield more efficient results. This result validates Panwal et al. (2006). Based on indexing for sex, increase in male dominance in the population of farmers would reduce technical inefficiency in grain production by 31.57%. Farming, generally, requires the utilisation of a lot of physical strength. This is the natural endowment of males.

Crop variety (3.71) significantly increased technical inefficiency in grain production at 1% probability level. The positive sign of this variable corresponds with local variety index. Conversely, improved variety reduces technical inefficiency among the farmers. Improved variety is axiomatically associated with high yield. Umeh (1998) had reported that 80% of Nigerian farmers use farmer-saved seeds, invariably local variety, leading to low yield.

#### **Distribution of technical efficiency among respondents**

In Table 4, majority of the respondents (18.72%) had technical efficiency ranging from 0.30 to 0.39. Only 11.49% had the highest technical efficiency of 0.61 and above. Mean technical efficiency was 0.34, which was very low. Minimum and maximum technical efficiencies

were 2.59 and 0.86 respectively. Following Kebede (2001), the low technical efficiency was an indication that a large proportion of productive inputs could be wasted or misapplied. The low mean technical efficiency is worrisome, given high availability of inputs to farmers. This could only suggest diversion of fund and poor utilisation.

#### **CONCLUSION AND RECOMMENDATIONS**

The respondents possessed appropriate socio-economic characteristics to translate their training to useful ends. Prominent among these characteristics are age and high level of education. The latter indicated a departure from the age-long non-formal and illiteracy status of Nigerian farmers. It is important to note that average input utilisation was high among the farmers, which is one of the aims of the capacity building component of Fadama II. Farmers' income level was relatively higher than those of average small-scale farmers in Nigeria, again pointing to the attainment of another aim of Fadama II. While farm size and the quantity of fertiliser used increased grain outputs, herbicide and labour exerted downward pressure on output. Their mean technical efficiency was, however, below average, indicating poor resource combination technique. Education and use of local varieties of grain seeds accounted for the farmers' low technical efficiency level. Based on the findings of this study, the following recommendations have been put forward:

- (i) Fadama II grain farmers should be assisted by the programme to acquire more farmland so as to produce more grains for the populace;
- (ii) The programme should make more fertiliser available to further assist in the realisation of more output;
- (iii) Extension work should focus on the optimum utilisation of herbicide and labour to minimise and eventually eradicate the negative results of these inputs;

- (iv) Fadama II should include farmers within the age bracket of 37 years in its grain production programme; and  
 (v) Similarly, the use of local varieties of grain should be completely replaced by improved varieties.

### Conflict of Interest

The authors have not declared any conflict of interest.

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