

## Technical Efficiency of Rice-Based Farming Systems Under Selected Soil Conservation Practices in Ogun State, Nigeria

O.A.C. OLOGBON, D.O. AWOTIDE, A.O. OTUNAIYA, A.O. IDOWU  
Olabisi Onabanjo University, Ogun State, Nigeria

**Abstract.** Technical efficiency in rice-based farming systems was estimated and compared for high- and low-level adopters of selected soil conservation practices in Ogun State, Nigeria. Primary data collected from 260 rice farmers in three (3) prominent rice-producing LGAs in Ogun State were analysed and results presented. Multistage sampling techniques were used to select the communities where the data were collected. Four methods of soil conservation technology were commonly practiced in combination in the study area, namely: use of inorganic fertilizers, mulching, shifting cultivation and ploughing back of plant residues into the soil. High- and low-level technology adopters operate at technical efficiency of 70-74% and 40-44%, respectively. For low-level adopters of the selected soil-conservation practices, size of land cultivated (1%); amount of hired labour engaged in production (1%); and the worth of capital invested (5%) will statistically determine the level of rice output. For high-level adopters, worth of capital invested (1%) will influence rice output in addition to land size and amount of hired labour engaged. Quantity of herbicide used (5%) will also statistically determine level of rice output but with a negative influence. Planting local variety of rice cultivar (1%) will statistically increase inefficiency in rice production for high-level adopters as they also tend to use more of

inorganic fertilizers to enhance production efficiency (at 5%).

**Keywords:** Technical efficiency, soil conservation, technology adopters, rice cultivars

### 1. Introduction

Nigeria has a population of over 140 million people (NPC, 2006) with her domestic economy dominated by agriculture which accounts for about 40% of the Gross Domestic Product (GDP) and two thirds of the labour force. Of all the staple food crops, rice has risen to a position of pre-eminence. Rice is the food for both man and animal; it is a very good source of carbohydrate. Rice is the preferred food of the world appreciated for its taste and also easy to prepare compared to other traditional foods. Its paddy is used in feed mills for poultry and pig feed. Rice is processed into different forms including jollof rice, fried rice, pilaf rice and white rice. Rice is also milled into flour which is then cooked in boiling water and turned into a thick paste called *Tuwo* in Northern parts of Nigeria. Since the mid-1970s, rice consumption in Nigeria has risen tremendously, at about 10% per annum due to changing consumer preference. Domestic product has never been able to meet the demand, leading to considerable imports which, on the average, currently stand at about 1,000,000 metric tones yearly. The

imports are procured on the world market with Nigeria spending annually over US \$300 million on import alone (Alimi, 2000).

Rice cultivation is well suited to countries and regions with low labour costs and high rainfall, as it is very labor intensive and requires plenty of water for cultivation (Opeke, 2006). Rice is cultivated in virtually all the agro-ecological zones in Nigeria. Despite this, the area cultivated to rice still appears small. In 2000, out of about 254 million hectares of land cultivated to various food crops, only about 6.37 million was cultivated to rice. During this period, the average national yield was 1.47 tonnes per hectare. Throughout the 1980s, rice output and yield increased tremendously, but in the 1990s while rice output increased, the yield of rice declined (Alimi, 2000). There was great disparity among the states of the Federation in rice production in terms of both output and yield. In 2000, Kaduna State was the largest producer of rice accounting for about 22% of the country's rice output, followed by Niger State 16%, Benue state 10% and Taraba State 7% (FMARD, 2001). The seemingly increased production over the last two decades could be attributed to the ban imposed on rice imports in 1985. In spite of the presence of suitable environments, however, Nigeria is yet among leading world rice producers (Moses and Adebayo, 2007).

Only 1.7 million or 35% of Nigeria's total land mass was cropped to rice in the 1990s (Imolehin and Wada, 2000). Most rice farmers in Nigeria belonged to the small to medium scale production categories with extensive dependence on crude implements; while the average farm size among the traditional rice farmers was 2.5 hectares that of technology-based farms was 6.52 hectares. Shortage of land to increase crop productivity as a result of poor land conditions, low land fertility, land degradation, erosion and poor land maintenance have also contributed to the low yield in rice production in Nigeria (Olaf *et al*, 2002). Zinnah *et al* (1993) noticed an increasing gap between the levels of supply and demand for rice in Nigeria, arising from the subsistence system of production, high production costs and the need for appropriate soil conservation technique. A

remarkable effort to develop suitable rice varieties for the Nigerian farmers was made in the 1990s with the release of FARO 51, a variety widely known for its resistance to the African Rice Gall Midge (ARGM) *Orseolia oryzivora* (World Bank, 1997). Recently, the West African Rice Development Agency (WARDA) has developed an improved variety mainly for upland cultivation, known as the New Rice for African Countries (NERICA) and it was observed that the yield could be as high as 3.0tons per hectare or more with strict compliance with recommendation (Olorunfemi, 2006). However, the performance of these varieties would still be dependent on the adoption of the appropriate cultural and management practices.

Aromolaran (1992) analyzed the preference intensity of small-scale farmers in Ogun State for all the conservation practices they were aware of. The result showed that the sampled farmers preferred the use of inorganic fertilizer, manuring and plant residue management to other soil conservation practices; the preference which was traceable to the farmers' perception of their major soil conservation problems as that of nutrient deficiency rather than soil degradation and loss. Bamire and Amujoyegbe (2001) observed that only few rice farmers in Southwestern zone of Nigeria practice sole cropping which they claimed was suitable for rice production to meet household consumption and local market needs in the area. However, the risk associated with sole cropping had compelled most rice farmers to embark on crop diversification on their farm plots rather than investing on soil conservation practices that may increase rice yields to enable them cope with such risk-induced economic losses. This study had measured and compared the technical efficiency of rice-based production systems under different adoption levels of selected soil conservation practices in Ogun State, Nigeria.

## 2. Theoretical Framework

Efficiency is the maximization of output input ratio. There are three components of efficiency namely; technical, allocative and economic efficiencies. Technical efficiency is a measure of

effectiveness in which maximum output is obtained from a given combination of inputs i.e. the ability to operate on the production frontier. Technical Efficiency assumes the essential nature of output of goods and services to remain unchanged and focus on reducing the cost of input for production. Allocative efficiency refers to the situation where resources are given in profit maximizing sense so that the marginal value products of resources are equal to their unit prices. Economic efficiency combines Technical and Allocative Efficiencies. Perfect technical and allocative efficiencies imply that the firm is maximizing profit and minimizing cost for a given level of output; in other words, the firm is operating on the expansion path (Ojo, 2003). Stochastic elements are incorporated into the stochastic production frontier as a measure of the farm's technical efficiency to capture the farmer's specific random shocks. The farm technology is represented by a stochastic production frontier as follows:

$$Y_i = f(\beta_i X_i) + \varepsilon_i \tag{1}$$

where  $Y_i$  denotes output of the  $i$ th firm;  $X_i$  is a vector of actual input quantities used by the  $i$ th rice farm,  $\beta$  is a vector of parameters to be estimated and  $\varepsilon_i$  is the composite residual term comprising of a random error term  $V_i$  and an inefficiency component  $U_i$  (Aigner *et al.*, 1977) defined as:

$$\varepsilon_i = V_i - U_i \tag{2}$$

$V_i$ 's are assumed to be independently and identically distributed random errors  $[V_i \approx N(0, \sigma_v^2)]$ , and the  $U_i$ 's are non-negative random variables associated with technical inefficiency in production, which are assumed to be independently and identically distributed and truncated (at zero) of the normal distribution with mean  $\mu$  and variance,  $\sigma^2$ , that is,  $[U_i \approx N(0, \sigma_u^2)]$ . The maximum likelihood estimation of equation (1) provides estimators for  $\beta$  and variance parameters, thus:

$$\sigma^2 = \sigma_u^2 + \sigma_v^2 \text{ and } \gamma = \frac{\sigma_u^2}{\sigma^2} \tag{3}$$

Subtracting  $V_i$  from both sides of Equation (1) and adjusting for the stochastic noise captured by  $v_i$  yields:

$$Y_i - v_i = y_i = f(X_i; \beta) - \mu_i \tag{4}$$

where  $y_i$  is the observed output of the  $i$ th farm adjusted for the noise disturbance. Hence, equation (3) provides the basis for deriving the technically efficient input vector, and for analytically deriving dual cost function of the production function.

For a given level of output  $Y_i$ , the technically efficient input vector for the  $i$ th firm,  $X_i^t$  is derived by simultaneously solving Eq (3) and the input ratios  $X_1/X_i = K_i (i > 1)$ , where  $K_i$  is the ratio of observed inputs  $X_1$  and  $X_i$ . Assuming that the production function in Eq. (1) is self-dual (e.g Cobb-Douglas), the dual cost frontier can be derived algebraically and written in a general form as follows

$$C_i = h(r_i, Q_i, \alpha) \tag{5}$$

where  $C_i$  is the minimum cost of producing output  $Q_i$  by the  $i$ th farm;  $r_i$  is a vector of input prices associated with the  $i$ th farm; and  $\alpha$  is a vector of parameters. The economically efficient input vector for the  $i$ th firm  $X_i^e$  is derived by applying Shepherd Lemma and substituting the firm's input prices and output level into the resulting system of input demand equations:

$$\frac{\partial C}{\partial r_i} = X_i^e(r_k, Q, \psi)$$

$$k = 1, 2, \dots, m \text{ inputs} \tag{6}$$

where  $\psi$  is a vector of parameters. The observed technically efficient  $(X^t)$  and economically efficient  $X^e$  costs of production of the  $i$ th firm are equal to  $r_i X_i, r_i X_i^t$  and  $r_i X_i^e$ , respectively. The relation above can then

be used to compute the various efficiency measures for the *ith* firm as follows:

$$TE_i = \frac{r_i X_i^t}{r_i X_i} \quad \text{Technical Efficiency,} \quad (7)$$

$$EE_i = \frac{r_i X_i^e}{r_i X_i} \quad \text{Economic Efficiency,} \quad (8), \text{ and}$$

$$AE_i = \frac{EE_i}{TE_i} = \frac{r_i X_i^e}{r_i X_i} \quad \text{Allocative Efficiency,} \quad (9)$$

### 3. Methodology

#### 3.1 The Study Area

Ogun State is bounded in the West by Republic of Benin; on the South by Lagos State and the Atlantic Ocean; on the North by Oyo and Osun States; and shares boundaries on the East with Ondo State. It lies within Latitude 6<sup>0</sup>N and 8<sup>0</sup>N and Longitude 3<sup>0</sup>E and 5<sup>0</sup>E, with a temperature range of 27<sup>0</sup>C and 32<sup>0</sup>C. Ogun State, with 20 LGAs, is divided into 4 socio-political zones, namely: Egba, Yewa, Ijebu and Remo zones, under the three existing Senatorial zones (Ogun West, Ogun Central and Ogun East) in the state. Ogun State has large expanse of arable land cultivated largely to such food crops as rice, cassava, yam, cocoyam and maize among crops. It has a tropical climate with a rainy season from March to November and dry season from December to February; average temperature of about 31<sup>0</sup>C; humidity of about 95% and an average annual rainfall of 192mm. Obafemi-Owode ranks highest among the three major rice-producing Local Government Areas (LGAs) in Ogun State with high tonnage of cultivated rice, specializing in a special variety popularly known as Ofada rice, which is largely consumed among many households in the State and its environs. The two other rice-producing LGAs are Ogun Waterside and Yewa North in that order of production capacity and produce turnout.

#### 3.2 Data Source and Sampling Technique

Multi-stage sampling was used to collect data from 275 respondents in a focused interview. Information obtained from the rice farmers were filled into structured questionnaires for ease of extraction and processing. In the first stage, Obafemi-Owode, Ogun Waterside and Yewa North LGAs were purposively selected among other LGAs on the basis of their highest concentration of rice farmers in Ogun State. In the second stage, seven, five and four villages were systematically selected from the list of rice-growing communities/villages in each of the three LGAs. From the list of rice farmers as obtained from the local government data base, 15-20 farming households were randomly selected and included in the sampling frame, proportionate to the number of rice farmers in each community. Fifteen (15) of the questionnaires were discarded to minimize heterogeneity, resulting to 260 respondents whose data were eventually analyzed and presented in this study. Information was sought from the household head only except on few occasions where the spouse or other adult member of the household stood in for the household head.

### 4. Estimation Procedure and Analytical Techniques

#### *Measurement of technical efficiency estimates of rice-based production systems under different levels of soil conservation practices.*

A one-stage switching regression model was used in measuring technical efficiency estimates for two different levels of the selected soil conservation technology adopted. This model corrects for self-selection bias by introducing self-selectivity variables into the production model. Self-selection could arise from the arbitrary classification of rice farmers into two groups, namely (i) *high-level adopters*, and (ii) *low-level adopters* of soil conservation practices. Based on pilot survey and prior evidence (Aromolaran, 1992), data were obtained on four major soil conservation practices (referred to in this study as technology) observed to be prevalent among sampled farmers in the study area, namely: use of inorganic fertilizer, mulching, shifting cultivation, and ploughing

back of plant residues into the soil (Table 4, Appendix I). These four selected soil improvement technologies were also observed to be more commonly adopted in combinations. Level of soil conservation adoption of any technology was adjudged ‘high’ if at least 50% of the farmer’s cultivated land area is placed under the selected technology, and ‘low’ if otherwise. A production function was specified for each of the two-level adopters of selected soil conservation practices, expressed as:

$$Y_{1i} = \phi_1 X_{1i} + \alpha_1 W_{1i} + V_{1i} - U_{1i}$$

(for high level adopters)

(11)

$$Y_{2i} = \phi_2 X_{2i} + \alpha_2 W_{2i} + V_{2i} - U_{2i}$$

(for low level adopters) (12)

where  $Y_1$  and  $Y_2$  are rice output (tonnes) for farmers with high and low level of adoption of the selected soil conservation practices, respectively;  $\phi_1$  and  $\phi_2$  are random variables reflecting noise and other stochastic shocks entering the frontier;  $U_i$  captures the technical inefficiency (TI) relative to the stochastic frontier;  $W_1$  and  $W_2$  are the self-selectivity variables whose coefficients ( $\alpha_1$  and  $\alpha_2$ ) are vectors of exogenous variables defined as:

$X_1$  = Size of land cropped to rice (ha)

$X_2$  = Seed rate (kg/ha.)

$X_3$  = Number of household labour engaged in rice production (manday).

$X_4$  = Number of hired labour engaged in rice production (manday).

$X_5$  = Amount of capital invested (₦)

$X_6$  = Quantity of herbicides used (liters)

The translog functional form has been found most appropriate in allowing for interaction among variables (Winter *et al*, 2004) and thus considered for this study. The technical inefficiency (TI) of the two levels of technology adopters was jointly estimated in a single-stage maximum-likelihood approach, where TI is modeled as a function of specific socio-economic variables thus:

$$U_i = \lambda_0 + \beta_i \sum_{i=1}^m F_{ni} + \varepsilon_i$$

(13)

Where  $U_i$  = inefficiency effect defined as a normal random variable truncated at zero;

$\lambda_i$  and  $\beta_i$  are unknown parameters and  $\varepsilon_i$  is random noise, assumed to be independently distributed.

$F_{ni}$  = vectors of household-specific variables, including:

$F_1$  = Age of farmers (year)

$F_2$  = Years of formal education

$F_3$  = Year of experience in rice farming

$F_4$  = Household size (Number)

$F_5$  = Sex of farmer (1= male; 0 = female)

$F_6$  = Type of rice cultivars planted (1= local variety; 0 = improved variety)

$F_7$  = Type of soil conservation practice adopted (1= recommended/inorganic external input; 0 = traditional/organic input).

***Test of structural differences in the production functions of the two levels of soil conservation technology adopters.***

A chow test of structural difference in the production function of high adopters and low adopters of soil conservation technology was conducted. This entailed (a) estimating the production function separately for high adopters and low adopters of the selected soil conservation practices; (b.) estimating the two equations using the pooled data, and (c) estimating the pooled regression with an intercept shifter dummy variable (D) introduced as shown below:

$$Y = \theta_i X_{1i} + \alpha_1 W_{1i} + V_{1i} - U_{1i}$$

(14)

The underlying hypothesis in the test for structural change is stated thus;

$H_0$ : There are no structural differences in the production functions of rice farmers who were high adopters and low adopters of selected soil improvement technologies.

$H_1$ : There are structural differences in the production functions of rice farmers who were high adopters and low adopters of selected soil improvement technologies. The test consists of the following three stages:

***Overall test for structural changes***

This is an overall test of significant differences in the structural parameters (intercepts and slopes) of the production functions of the two categories of farms. The test statistics is

$F_{1-\alpha/2, v_1, v_2}$  while the calculated F-value ( $F_c$ ) was obtained as:

$$F_c = \frac{[\Sigma e_3^2 - \Sigma e_1^2 - \Sigma e_2^2] / [K_3 - K_1 - K_2]}{[\Sigma e^2_1 + \Sigma e^2_2] / [K_1 + K_2]} \quad (15)$$

where:

$\Sigma e_3^2$  = error sum of square for the pooled data without a dummy variable ;

$\Sigma e_1^2$  = error sum of square for high adopters production function;

$\Sigma e_2^2$  = error sum of square for lo adopters production function;

$K_3$  = degree of freedom for pooled data;

$K_1$  = degree of freedom for high adopter farmers' regression

$K_2$  = degree of freedom for low adopter farmers' regression

The calculated F-statistics was compared against the tabulated F-value,  $F_1 = F_{0.95, v_1, v_2}$ . The decision required the rejection of the null hypothesis of no structural differences in the production functions of high adopters and low adopter of soil conservation technologies if  $F_c > F_1$ , or failure to reject the null hypothesis if otherwise.

**Test for homogeneity of slopes**

Where the first test revealed that some structural differences exist in the production functions of the two categories of farmers, it is necessary to investigate further on the nature of the structural differences .The first test is the homogeneity of slopes. The test statistics is  $F_{1-\alpha/2, v_1, v_2}$  while the calculated F. value ( $F_c$ ) is defined as:

$$F_c = \frac{[\Sigma e_4^2 - \Sigma e_1^2 - \Sigma e_2^2] / [K_4 - K_1 - K_2]}{[\Sigma e^2_1 + \Sigma e^2_2] / [K_1 + K_2]} \quad \text{where } \Sigma e_2^2, \Sigma e_1^2, K_1, K_2 \text{ are as previous defined}$$

$\Sigma e_4^2$  is the error sum of square for the pooled regression with an intercept dummy variable;  $K_4$  is the degree of freedom for the pooled regression with an intercept dummy variable. This statistics was compared against the

tabulated F-value,  $F_{0.95, v_1, v_2}$  following the decision rule to reject the null hypothesis of no difference in the slopes of the production functions of the high adopters and low adopters of soil conservation technologies, or fail to reject if otherwise.

**Test for homogeneity of intercepts**

The final stage of the tests for structural differences in the production functions of the two categories of rice farmers is the test for homogeneity of intercepts of the two production functions. The test statistics is  $F_{0.95, v_1, v_2}$  while the calculated F-value ( $F_c$ ) is given as:

$$F_c = \frac{[\Sigma e_3^2 - \Sigma e_4^2 - \Sigma e_2^2] / [K_3 - K_4]}{[\Sigma e^2_{42}] / [K_4]}$$

where  $\Sigma e_3^2$ ,  $\Sigma e_4^2$ ,  $K_3$  and  $K_4$  are previously defined. The statistics was compared with the tabulated F-value following the decision rule above to reject the null hypothesis of no difference in the intercepts of the production functions of high adopters and low adopters of soil conservation technologies, or failed to reject if otherwise.

**5. Results and Discussion**

**Determinants of technical efficiency among various soil conservative technology adopters in rice-based production system**

Land size (0.602;  $p < 0.01$ ) and the amount of invested capital on the rice farm (0.013;  $p < 0.01$ ) will increase the quantity of rice output among high-level technology adopters and conversely, increased use of hired labour (-0.015;  $p < 0.01$ ) and herbicides (-0.017;  $p < 0.1$ ) will decrease the quantity of rice output and therefore should be discouraged among this category of technology adopters. By implication, investment of large capital resources on soil improvement and less of it on hired labour and herbicides will increase rice output in the study area.

Table 1: Stochastic production frontier in rice-based production system

Variables	High-level adopters		Low-level adopters	
	Coefficient	t-value	Coefficient	t-value
Constant	0.4313	5.018	5.1041	4.198
Land size	0.6015***	2.705	0.6042***	2.645
Quantity of Seeds	0.2991	0.207	0.3231	0.421
Household labour	0.1526	0.180	0.1526	0.180
Hired labour	-0.0154***	-3.300	-0.0136***	-3.433
Amount of capital invested	0.0126***	4.010	0.1141**	2.117
Quantity of Herbicide	-0.0170*	-1.733	-0.0321	-0.915
<b>Diagnosis statistics</b>				
Sigma Square	0.926		0.836	0.836
Gamma		0.00232 (0.001)		0.00194 (0.003)
Log of likelihood Function	-19.87	-18.47	-31.58	-29.47
LR test		5.514		7.603
<b>Inefficiency model</b>				
Variables	Coefficient	t-value	Coefficient	t-value
Constant	0.0295	0.042	0.0105	0.061
Age	0.03587	0.104	0.06546	0.095
Education	-0.0040	-0.047	-0.0048	-0.038
Years of experience	-0.0053	-0.175	-0.0105	-0.321
Household size	-0.0189	-0.013	-0.0091	-0.031
Sex	0.0133	0.281	0.0234	0.325
Type of rice cultivars	0.0061***	3.219	0.0861	0.229
Type of soil conservation practice	-0.0214**	-2.128	-0.0132	-0.313

Source: computed from survey data, 2010

\*\*\* = 1% significant level; \*\* = 5% significant level; \* = 10% significant level

Similar factors (except the quantity of herbicides used) influence rice output in similar direction but different magnitudes among low-level technology adopters. Planting local variety of rice cultivar (0.006;  $p < 0.01$ ) will statistically increase inefficiency in rice production for high-level adopters as the yield will not justify the level of investment in soil improvement; but it may not have significant effect on the production efficiency of low-level technology adopters. As it were, high-level adopters of soil conservation practices tend to be using more of inorganic fertilizers to enhance production efficiency (significant at 5%) as evident from their high technical efficiency estimates (Table 2).

Table 2: Technical efficiency estimates of rice farmers

High-level technology adopters			Low-level technology adopters		
Class interval	Frequency	Percentage	Class interval	Frequency	Percentage
<60	6	4.1	< 40	2	8.7
60 – 64	8	14.7	40 – 44	9	39.1
65 – 69	15	23.9	45 – 49	5	21.7
70 – 74	17	25	50 – 54	3	13.1
75 and above	19	32	55 – 59	3	13.1
			60 and above	1	4.3
Total	65	100.0	Total	23	100.0
Min = 34%; Ave. = 72%; Max = 96%			Min = 19%; Ave. = 46%; Max = 88%		

Source: Computed from Survey Data, 2010

Majority (25%) of the high-level adopters are efficient at 70–74% approaching the technology frontier, the least being those with efficiency estimates < 60%. For low-level adopters, 39.1% of the farmers operate at efficiency interval of 40 – 44%. Comparatively, low-level adopters of soil conservation technology are farther from the technology frontier in the study area.

**Structural differences in the estimated production functions of low- and high-level soil conservation technology adopters**

Table 3: Result of test for structural differences in the estimated production functions of low- and high-level soil conservation technology adopters

Test	$F_{CAL}$	$F_{TAB}$
Test for structural changes	5.48	4.79
Test for homogeneity of slopes	3.68	1.53
Test for homogeneity of intercepts	0	3.07

Source: Computed from Survey Data, 2010.

Table 3 shows that the F-calculated value is greater than the F-tabulated value for the test for structural changes in the production functions of high- and low-level adopters of soil conservation technologies in rice production hence, the null hypothesis of no significant differences was rejected. Upon further test for homogeneity of slopes, a greater value for the F-calculated was returned therefore rejecting the null hypothesis of no differences in the slopes of the production functions of high- and low adopters of soil conservation practices in rice production. However, the test for homogeneity of intercepts indicated failure to reject the null hypothesis of no differences implying that the estimated variables have varying degree of influence on the technical efficiency of rice production under high- and low-level adoption of soil conservation technologies, but operating at relatively similar production frontiers.

## 6. Conclusion

The result of this study established that majority of the high-level adopters of soil conservation technology are more technically efficient than their low-level adoption counterparts. Investment of capital resources in soil improvement, especially the use of inorganic fertilizers, is expected to increase rice output in the study area, more than the adoption of traditional/organic methods. This is not unlikely to be connected with the reducing availability to arable land as is being experienced in the major rice-producing communities in the study area as more land is being used for non-agricultural purposes. Supply of improved variety of rice cultivar, access of farmers to adequate quantity of inorganic fertilizers as well as sound financing systems are major interventions needed by the surveyed rice farmers. A sustainable linking of rice farmers to these inputs will encourage good soil improvement practices and boost rice production for domestic

consumption and exports, especially the Ofada Rice that is indigenous to the study area.

## References

- Aigner D., Lovell and Schmidt P. 1977. Formulation and estimation of Stochastic frontier production function models. *Journal of Econometrics*; 6:21-37
- Alimi T. 2000. Resources Use Efficiency in Food Crop Production in Oyo State of Nigeria. *Journal of Agriculture and Environment.1 (1); 1-7*
- Aromolaran A.B. 1992. Multiple Objectives and Resources Allocation Behaviour of Small Farmers In Ifelodun Area of Oyo State, Unpublished Ph .D Thesis, Department of University of Ibadan, Oyo state, Nigeria.
- Bamire A.S and Amujoyegbe, B.J. 2001. Economic Analysis of Land improvement Technique in Small holder Yam-based production systems in the Agro-ecological zones of Southwestern Nigeria, Unpublished Ph .D Thesis, Department of Agricultural Economics, Obafemi Awolowo University, Ile Ife, Osun state.
- Federal Ministry of Agriculture and Rural Development (FMARD-2001) Crop, Area and Yield Survey.
- Imolehin E.D and Wada, A.C. 2000. Meeting the rice production and consumption demand of Nigeria with improved Technology, International Rice Commission Newsletter 53.
- Moses, J. and Adebayo E.F. 2007. Efficiency of factors determining rainfed rice production in Ganye Local Government Area, Adamawa State. *Journal of Agricultural Economics and Extension*, 3; 20-30

- National Population commission, (NPC 2006): Provisional Census results, Abuja, Nigeria.
- Ojo, S.O. 2003. Productivity and Technical Efficiency of Poultry egg production in Nigeria. *International Journal of Poultry Science*; 2(6): 459-464.
- Olaf E., F. Lancon, S.O. Akande, S.O. Titilola, G. Akpokodje and Ogundele, O.O. 2002. "Rice production systems in Nigeria: A survey". In: The Nigerian rice economy in a competitive world: Constraints, Opportunity and Strategic choices. Final draft, WARDA, Abidjan Cote de'voire. Unpublished.
- Olorunfemi 2006. African Economic Research Constrium, Nairobi, Technical efficiency Differentials in Rice Production Technologies in Nigeria. Paper 159
- Opeke L.K. 2006. 'Essential of Crop Farming'. Spectrum Books, Ibadan, Oyo State, Nigeria.
- Project Coordinating Unit (PCU). 2002. "Crop Area Yield Survey (CAY)". Federal Ministry of Agriculture, Abuja.
- Winter P., Crissman, C. and Espinosa, P. 2004. Inducing the Adoption of Conservation Technology: Lessons from the Ecuadorian Andes. *Environment and Development Economics*; 695-719
- World Bank 1997. Research Highlight, National Agricultural Research Project (NARP) Annual Report .The World Bank, Washington D.C
- Zinnah M. M, Compton, J.L and Adesina, A.A. 1993. Research Extension Farmers' linkage within the Context of the Generation Transfer and Adoption of Improved Mangrove Swamp Rice Technology in West Africa. *Quarterly Journal of International Agriculture*; Vol. 32, No 2, pp.201-211.

