Indian J.L.Sci.3(2) : 15-25, 2014

ISSN : 2277-1743 (Print)
ISSN : 2278-7879 (Online)

TECHNICAL INEFFICIENCY AND SUSTAINABILITY OF RICE PRODUCTION IN THE *Fadama* OF NIGER STATE, SOUTHERN GUINEA SAVANNA OF NIGERIA

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ABSTRACT

The study examined technical inefficiency and sustainability of rice production in the *Fadama* of southern guinea Savanna of Nigeria. A two- stage simple random sampling technique was used to obtain 160 rice farming households interviewed for the study. A single- stage Cobb-Douglas based Stochastic Frontier Model using Maximum Likelihood Estimate (MLE) was used for analysing the data. The MLE of the Stochastic Frontier Model revealed the presence of short run increasing return to scale with a mean technical efficiency of 65%. This result indicated the possibility of improving efficiency of sampled *Fadama* rice farming households by 35% with the existing resources and technology. Farm size, family labour, hired labour, capital, cost of purchased inputs, length of fallow, quantity of fertilizer used, crop diversification index, drainage and nutrient intake index were factors that significantly (P< 0.05) influenced the estimated technical efficiency. The results of the inefficiency model show that farm size, farm experience, access to credit, educational level and extension contact were negative and significant (P< 0.05). This implied that increase in these variables would lead to less inefficiency. Household size had positive and significant relationship on inefficiency which implies that increase would lead to higher inefficiency. The mean Short Run Sustainability Index (SRSI) of - 0.15.56 showed an average productivity decline of 15.56%, which could be reversed by preventive and remedial action. Rice production is thus considered sustainable. Consolidation of household resources to increase holdings, increased use of animal traction and organic fertilizer as well research into labour saving devices that reduces production cost and integrated pest management is recommended.

KEYWORDS : *Fadama*, Technical inefficiency, Sustainability, Stochastic Frontier

Nigeria imported about 2 million metric tonnes of rice worth over US $1 Billion in 2010 (RMM, 2011). Rice self-sufficiency ratio (SSR) calculated as the total domestic supply divided by total domestic demand (SSR=DS/DD) is less than one for the period of 1990-2004 (Rahji and Omotesho, 2006), this trend continues till date. The reality is that Nigeria has not been able to attain self-sufficiency in rice production. Nigeria Government has recently renewed its commitment to attain self-sufficiency and eliminate imports of rice by 2015. These would require a significant change in the level of production and processing of rice in the country.

The major sources of changes in food crop production include changes in hectares of various crops cultivated annually and changing production technologies which affect variation in the yields and the productivity of inputs used in crop production (Olayemi, 1997). Continuing low agricultural productivity is an important feature of Nigeria agricultural system (Okunneye and Ayinde, 2011). The long term success of any effort to raise the productivity of food crops in Africa would depend on the ability of agricultural research bodies to find new ways to maintain the productivity of the land under continuous cultivation. Therefore, sustainability was recognised as a critical pre-condition for putting food production in Sub-Saharan Africa on the path towards steady improvement (IITA, 1992).

Rice is an important annual crop in Nigeria; it is one of the major staples. The three main production ecologies for rice in Nigeria are lowland rice, upland rice and irrigated rice. Among these, lowland (*Fadama*) rice has the highest priority for reduced production costs an important factor in making rice production in Nigeria competitive (Erenstein, et al., 2004; Daramola, 2005).

Fadama inland valleys or lowland are relatively more fertile than the surrounding upland areas. They reduce the risk of crop failure and have potential for longer period of agricultural activities in a year (Lawal, 2008). The *Fadama* size of Nigeria is estimated at about 4.6 million hectares. Out of this, Niger State has an estimated 495,000 hectares. This is second to Adamawa State with 625,000 hectares, the largest in the country.

Within the context of sustainable agriculture, land use and management must aim at addressing the simultaneous aspect of production and conservation. Improving farm productivity and combating land

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degradation problems are the key issues in sustainable agricultural production. Therefore, within the foregoing context, some questions become fundamental in the assessment of *Fadama* land use for rice production; Are *Fadama* rice farming households efficient in the use of inputs? What are the factors that determine the level of inefficiency of the farming household? Is rice production in the *Fadama* sustainable?

The objective of the study is to determine the technical efficiency and productivity of resources use; identify the determinants of technical inefficiency and evaluate the short run sustainability of *Fadama* rice farming households in Niger state.

MATERIALS AND METHODS

The study was conducted in Borgu Local Government Area of Niger State, Nigeria. The area lies between longitude 2^0E and 4^0E of the Greenwich meridian and between latitude 9^0N and 11^0N of the equator. It has a mean annual rainfall of 800 -1500mm and temperature of about 23^0C - 27^0C and falls within the Northern Guinea Savanna ecological zone of a Nigeria. The data were mainly from primary sources; multi-stage, purposive as well as simple random sampling techniques were employed in the selection of the respondents. Babanna district of the local government was purposively selected for the study because of the high level of cotton production in the area as determined during preliminary survey. Simple random sampling techniques were used to select four villages - Babanna, Kabe, Gbeswa and Tungan Bube used for the study from the list of villages in the district obtained from the agricultural department of the local government. 10% of cotton farmers' population collected during the survey visits to the selected villages served as sampling frame for the study. A total of 100 farmers were interviewed during the study.

Area of Study

The study conducted in the *Fadama* areas of Niger State, Southern Guinea Savanna of Nigeria. Niger State lies between longitude 8^o11' and 11^o20' north of the equator and between 4^o30' east of the equator. The vegetation of the state is mainly Southern Guinea Savanna. The mean annual rainfall ranges between 1110 mm in the north and 1600 mm in the south. The average annual number of raining days ranges between 187 and 220 days. The rain starts in late April and ends in October with the peak being in July. The average ranges between 26^oC and 36^oC. The mean humidity ranges between 60%(January to February) and 80% (June to September). The vegetation supports the cultivation of root crops and grains. The predominant crops are; rice, sorghum, millet, yam, groundnut and cotton. (NCRI, 1997)

Data used for this study were from primary source obtained through a farm management survey of *Fadama* rice farming households conducted between August and September 2011. The main instrument for data collection was structured questionnaire. These were administered on head of *Fadama* rice farming households by trained enumerators under the supervision of the researcher. The data covers farming activities for the 2010 cropping season. Multi-stage, purposive as well as simple random sampling techniques were employed in the selection of the respondents.

Niger State is divided into three agricultural zones- Bida, Kuta and Kotangora zones. Bida zone was purposively selected for this study. This selection is based on; one it long history of lowland rice production. Fatoba, 2007 reported that about 66% of rice production in Niger State is from Bida Zone. Two, It proximity to the National Cereal Research Institute (NCRI) at Badeggi where the lowland rice technologies emanate and are disseminated. A multi stage simple random sampling technique was used to select 160 lowland rice farming households from i5 villages in 3 local government area in Bida zone The *Fadama* village and households listing of Niger State Agricultural Development Project (NSADP) served as the sampling frame for the selections.

Method of Data Analysis

The production frontier model derived from the composed error model of Aigner et al., 1977; Meeusen and Van den Broeck, 1977 and Forsund et al., 1980 as used by Coelli and Battese, 1996 was adopted for this study. The frontier production model begins by considering a stochastic production function with a multiplicative disturbance term of the form.

$$Y=f(Xi;\beta)\,e^{\varepsilon} \quad (1)$$

Where

Y = quantity of agricultural output in grain equivalent.

Xi = vector of input quantities.

β = vector of parameters.

e = error term

Where ε is a stochastic disturbance term consisting of two independent element V and U where

$$\varepsilon = V - U \quad (2)$$

The symmetric component V, accounts for random variation in output due to factors outside the farmer's control such as weather and diseases. It is assumed to be independently and identically distributed as N ~ (0, δu2)

A one sided component $U \leq 0$ reflect technical inefficiency relative to the stochastic frontier, f (Xi; β) e^{ε}. Thus, U=0 for a farm output which lies on the frontier and U<0 for output which is below the frontier as N ~ (0.δu2) hence, the distribution of U is half normal.

The frontier of the farm is given by combining equation (1) and (2) as

$$Y= f(Xi;\beta)\,e^{(v-u)} \quad (3)$$

The variance of e is therefore,

$$\delta^2 = \delta_u^{\,2} + \delta_v^{\,2} \quad (4)$$

The ratio of two standard deviations is defined by

$$\lambda = \delta_u/\delta_v \quad (5)$$

Jondrow et al. (1982) have shown that measuring efficiency at the individual farm level can be obtained from the error term ε = V - U for each farm, the measure is the expected value of u conditional on ε i.e.

$$E(u/\varepsilon) = \frac{\delta_u.\delta_v}{\delta}\left\{\frac{f(\varepsilon i\lambda\delta}{1-F(\varepsilon i\lambda/\delta)} - \frac{(\varepsilon i\lambda)^4}{\delta}\right\} \quad (6)$$

where f and F are the standard normal density function and the standard normal distribution function respectively, evaluated at ε λ/δ. Estimation values for ε, λ and δ are used to evaluate the density and distribution functions.

Measures of efficiency for each farm can be calculated as;

$$TE = [\varepsilon(u/\varepsilon)] \quad (7)$$

$$\text{Technical inefficiency} = 1 - [\varepsilon(u/\varepsilon)] \quad (8)$$

The production technology of *Fadama* rice farming household is assumed to be specified by Cobb-Douglas frontier production function defined as follows:

$$\ln Q = a_0 + \Sigma ai \ln Xi + \Sigma aj\, Dj + (Vi - Ui) \quad (9)$$

Where ;

Q = Output of rice measured in kg per household

Physical Inputs(X) - X_1 = Farm size in hectares, X_2 = Family labour in man-days, X_3 = hired labour in man-days, X_4= capital in ₦, X_5 = cost of purchased inputs in ₦, **Land Use Variables (T)**- X_6 = crop diversification index (CDI) , X_7 = nutrient intake index, **Land Management Practices Variable (M)**-X_8=length of fallow in years, X_9 = quantity of fertilizer used in kilogramme, D_1= tillage measured as dummy D_1 = 1 for conventional tillage and D_1 = 0 for zero tillage, Land Resource Quality Variable(R) - D_2 = drainage measure as dummy D_2 = 1 for well drained land and 0 otherwise, D_3 = terrace measured as dummy D_3=1 for flat topography and 0 otherwise, ai, aj = Vector of parameters, Vi = Random error due to mis-specification of the model and variation in output due to factors outside the farmer's control such as weather and diseases, Ui=Inefficiency component of error term. It is assumed that the inefficiency effects are independently distributed and Ui truncation (at zero) of the normal distribution with mean 0 and variance δu2 where Ui is specified as:

$$Ui = a_0 + a_1\ln Z_1 + a_2\ln Z_2 + a_3\ln Z_3 + a_4\ln Z_4 + a_5\ln Z_5 \quad (10)$$

Where;

Ui = Technical inefficiency of *Fadama* food crop farming household.

Z_1 =Access to credit expressed as a dummy, 1 for access and 0 for no access.

Z_2= *Fadama* farming experience expressed in years.

Z_3 =Highest educational level expressed in years.

Z_4= Number of extension contact in years.

Z_5 = Farm size in hectares

a_0, ai, i = 1→5 are parameters estimated

Since the dependent variable of the inefficiency model represent the mode of inefficiency,

(i) a positive sign of an estimated parameter implies that the associated variable has a negative effect on efficiency and this implies inefficiency and

(ii) a negative sigh indicates that the reverse is true i.e. it has positive effect on efficiency and this means a reduction in inefficiency (Yao and Liu, 1998).

Elasticity of Production and Return to Scale Measurement

Other estimates derived from our stochastic equation (9) for rice farming household in the *Fadama* are elasticity of production (EOP) and local measure of return to scale (RTS).

EOP is the same as the estimated coefficients of the independent variables (Kumbhakar, 1994).

$$RTS = \Sigma EOPi \qquad i = 1\ldots,n \qquad (11)$$

Inferentially, RTS < 1, decreasing return to scale

RTS > 1, increasing return to scale

Measurement of Short-Run Sustainability Index (S.R.S.I)

This involves 2 step measurement used by Ali, 1996 and Udoh, 2000. First, is the estimation of farm index of sustainable land use and management (ISM) which was estimated as the partial productivity of equation (9) with respect to all the agronomic practices i.e. land resource quality (R), land use (T), and land management practices (M).. Secondly, product of the ISM index with technical inefficiency index gives the measure of short run sustainability index (SRSI) for each farming household.

$$ISM\,(1 - Te) = SRSI \qquad (12)$$

Inferentially, if the value of ISM is zero, the land use and management practices give no change in land quality. When SRSI is positive, this indicates that the productivity improves owing to the net balance of resources use and environmental management and vice-versa if it is negative Udoh, 2000.

Issue in the Literature on Stochastic Frontier Production Functions Application

A number of empirical work Parikh and Shah, 1994; Liewelyn and Williams, 1996; Ray, 1998; Ajibefun and Daramola, 2000); Awoyinka and Ikpi, 2004; Awoyemi and Adekanye, 2005; Nwaru et al., 2011 have investigated the determinants of technical efficiency among firm in different industry by regressing the predicted efficiencies, obtained from an estimated stochastic frontier on a vector of farmer specific factors such as age of farmer, level of education, access to extension etc in a two stage regression. Ekanayake, 1987 suggested that technical efficiency index must be transformed into natural logarithm of the ratio of the technical efficiency to technical inefficiency as transformed technical efficiency before the second stage regression is estimated. Admassie, 1999 and Rahji, 2005 used this approach to estimate determinant of technical efficiency in different studies. The identification of factors that influence the level of technical efficiency is a valuable exercise because the factors are important for policy formulation. However, Coelli, 1995 has identified a fundamental contradiction in the two-stage approach. In the first stage the efficiency factors are assumed to be independently and identically distributed while, in the second stage, they are assumed to be a function of a number of firm-specific factors which implies that they are not independently distributed. Battese and Coelli, 1995 resolved the inconsistency in the two-stage approach by specifying stochastic frontier models in which the inefficiency factors are made an explicit function of the firm-specific factors and all parameters are estimated in a single-stage maximum likelihood procedure. This single stage approach is less objectionable from a statistical point of view and is expected to lead to more efficient estimator. A number of work Fatoba, 2007; Lawal 2008; Adewumi and Fatimoh, 2008; Nwachukwu and Onyeweaku, 2009; have use this approach in their studies. This work used this single stage model to estimate the parameters of the stochastic frontier function model using the computer program FRONTIER version 4.1, Coelli, 1996.

RESULTS AND DISCUSSION

Diagnostic Statistics

Table 1 shows the MLE of the stochastic production function (Eq 9) for all the sampled farm households during the study. The estimate of sigma-square (2) is 0.6879. This is large and statistically significant at 0.01. Lambda (λ) estimated at 6.5697 which is greater than one indicates a good fit and the correctness of the specified distributional assumption of the composite error term. The variance ratio represented by gamma (γ) is estimated as 93.65 percent. This suggests that systematic influences that are unexplained by the production function are the dominant sources of random error. That is to say that the presence of technical inefficiency among the sampled farm explains about 94 percent variation in error observed in the estimated stochastic production frontier. The generalised likelihood ratio is significant at 0.01 levels suggesting the presence of the one sided error component. This implies that technical inefficiency is significant and a classical regression model of production function based on OLS estimation techniques would be inadequate representation of the data. Thus, the results of the diagnostic statistics confirm the relevance of stochastic parametric production frontier and maximum likelihood estimator for this work.

MLE Estimates of the Parameter of the Stochastic Production Function

The estimated parameters and the related statistical test result from the analysis are presented in Table

Table 1: Stochastic Frontier Estimation (MLE) Result

Variable	parameter	Coefficient	Standard Error (SE)	t-ratio
Physical Input (x_i)				
Constant (x_0)	β_0	2.6852**	1.350	1.9890
Farm size(x_1)	β_1	0.4568**	0.2025	2.2561
Family labour (x_2)	β_2	0.1624**	0.0733	2.2146
Hired labour (x_3)	β_3	0.2189**	0.0860	2.5430
Capital (x_4)	β_4	0.3698**	0.1749	2.1144
Cost of purchase input (x_5)	β_5	1.8525***	0.3674	5.0421
Land use variables				
Crop diversification index (x_6)	β_6	-0.0086**	0.0032	2.6875
Nutrient intake index (x_7)	β_7	-0.6987***	0.2219	-3.1487
Land Management Variable				
Length of fallow (x_8)	β_8	0.0754**	0.0283	2.6643
Fertilizer used (x_9)	β_9	0.2479***	0.0557	4.4506
Tillage used (D_1)	β_{12}	-0.1333	0.2256	-0.5909
Land resource Quality variable				
Drainage (D_2)	β_{10}	0.2619**	0.1317	1.9886
Terrace (D_3)	β_{11}	0.0019	0.1753	0.0104
Inefficiency model				
Constant Term	a_0	0.3689	0.2423	1.5235
Credit (Z_1)	a_1	-0.2454**	0.1060	2.3150
Farming Experience (Z_2)	a_2	-0.3685**	0.1846	1.9962
Education (Z_3)	a_3	-0.2179*	0.0872	2.4988
Extension Contact (Z_4)	a_4	-0.3396**	0.1307	2.5983
Farm size (Z_5)	a_5	-0.4876**	0.2213	2.2033
Diagnostic statistics				
Sigma square	^{2}	0.6879***	0.1359	5.0545
Gamma	γ	0.9369***	0.0355	26.3915
Lambda 6.5697	λ			
Likelihood ratio (H_o) -113.3675				
Likelihood ratio (H_1) -147.8277				
LR Test 68.92***				
δu^2 = 0.6682				
δv^2 = 0.0197				

*** Significant at 1%, ** Significant at 5 %

Source: Summarised from computed output of Frontier 4

1. All the parameters in the model have the expected sign and many of the coefficients are statistically significant at 5 percent level of probability or less. The coefficients can be interpreted as the elasticity of the output with respect to input at the data point (Kumbhakar, 1994).

The stochastic frontier results indicate that the coefficient of physical inputs- land (X2), family labour(X3), capital input(X4), and cost of purchase input (X5) are 0.457, 0.162, 0.219, 0.370 and 1.853 respectively. These coefficients are significant at 5% level which shows that they are inputs that influence technical efficiency of *Fadama* farmers. The hired labour has a higher elasticity relative to family labour. This tend to suggest that unit increase in hired labour add more to output relative to a unit change in family labour. The product elasticity of cost of purchased input (X5) is the highest among physical input followed by capital input. This shows that there exists high scope for increasing output by increasing the use of purchase input especially when improved seed and land augmenting material such as fertilizer/ manure are adequately applied.

The coefficient of land use variables were - 0.009 and -0.6990 for CDI and NII respectively. The significant negative estimate for CDI indicates that higher level of crop diversification is associated with decreasing output (GE) of combined crop. The relationship might be the main reason why rice was grown as sole crop by most of the households during the survey. This result did not support the findings of Alamu and Coker, 2005; and Oseni 2010 who reported higher stability of yield and revenue in mixed crop enterprise. The significant negative estimate of NII shows that output decrease with increase in NII. This is consistent with a priori expectation that crops which have heavy soil nutrient depleting abilities would have lower aggregate yield when soil is poor in status and land augmenting resources is sparsely added to soil and the results support those reported by Fageria, and Baligar,1993; Udoh, 2000, and Lawal et al., 2009.

The land management variables coefficients were estimated at 0.075 and 0.248 for length of fallow and fertilizer used respectively. Elasticity of output is higher with use of fertilizer than fallow which shows that land productivity can be improved faster with the use of fertilizer than with fallow. The use of land augmenting materials in addition to proper farm management practice is important to restore nutrient to *Fadama* farmland. The only significant land resource quality variable is drainage with a coefficient of 0.262 that is significant at 5% percent. The result is consistent with a priori expectation that coefficient of drainage is positive for well-drained soil. This implies that yield increase as the drainage condition improves. This is very true of the *Fadama* area which can be waterlogged very easily. This result is similar to that reported by Lawal et al., 2008.

Determinants of Technical Inefficiency

The determinants of technical inefficiency in rice production in the *Fadama* of Southern Guinea Savanna, Niger State, Nigeria are also presented in Table 1. All the coefficients in the model are negative and significant at 5% level.

Access to credit, *Fadama* farming experience, educational level of head of households, and extension contact had negative and significant relationship ($P< 0.05$) with inefficiency level. This implies that increase in these variables would lead to less inefficiency.

Credit availability reduces cash constraint and enables farmers to make timely purchases of those inputs which they cannot provide from their own resources. Credit may allow the farmer to utilize market and nonmarket inputs in a cost minimizing combination. This result agrees with those of Rahji and Omotesho, 2006. However, the result disagrees with those of Okike, 2000 who found a negative relationship between credit and technical efficiency and Rahji, 2005 who found no significant relationship between access to credit and technical efficiency.

The negative relationship for farming experience implies that households with more experience tend to be more efficient probably because they might be receptive to innovations This result is in line with that of Ajibefun et al., 2002'; Onyewaeku and Okoye, 2007; and Lawal et. al., 2010 who reported a negative and significant relationship between farming experience and technical inefficiency. However, it differs from that of Onu et aI., 2000 whose result showed a positive relationship between farming experience and technical inefficiency.

The study also show that access to education and extension contact reduces technical inefficiency of *Fadama* rice farming household which will invariably increase sustainability of *Fadama* as a result of higher productivity. This result is similar to that of Seyoum et al., 1998 who indicated that the pieces of advice from extension workers were beneficial in helping farmers implement the practices associated with new technology and Rahji, 2005 who reported a positive and significant relationship between extension contact and technical efficiency. This result also agrees with those of Rahji, 2005 and Lawal et.al., 2009 However, the result disagrees with Onyenweaku and Effiong, 2005; Rahji and Omotesho, 2006 and Fatoba, 2007 whose result showed no significant relationship between education and technical efficiency.

Technical Efficiency Indices

The technical efficiencies differ substantially among the sampled *Fadama* rice farming households ranging between 0.12 and 0.93 with a mean technical efficiency index of 0.65. This leaves an inefficiency gap of 0.35. This is expected since the technical inefficiency effect in the estimated model is significant. This suggests that reasonable marketable output is sacrificed and there is resource wastage. The result implies that about 35 percent higher production could be achieved without additional resources or inputs could be reduced by 35 percent to achieve the same level of output. The distribution of the technical efficiencies is presented in table 2.

Table 2: Distribution of farm specific Technical Efficiency indices among Sampled Fadama Rice Farming Households

Class interval of efficiency indices	Frequency	Percentage
0.11 - 0.20	4	2.50
0.21 - 0.30	9	5.63
0.30 - 0.40	10	6.25
0.41 - 0.50	12	7.25
0.51 - 0.60	20	12.50
0.61 - 0.70	39	24.38
0.71 - 0.80	30	18.75
0.81 - 0.90	21	13.13
.91 - 1.00	15	9.38
Total	160	100

Mean=0.6469 Standard deviation 0.23

Min value= 0.12 Maximum value 0.93

Source: Summarized from MLE result frontier 4.1

From table 2, the frequencies of occurrence of the technical efficiency in deciles ranges indicate that most of the farming household has technical efficiencies above 0.5. The sample frequency distribution indicates a gradual rising from left to highest; it then falls to the right of the distribution. The modal class did not fall into any of the extreme classes. Therefore, the assumption of a general truncated normal distribution for the inefficiency term (u1) is therefore justified.

Although, there is a wide range between the maximum and minimum values of technical efficiencies, the estimated technical efficiencies clustered around 0.5 and 0.8 ranges, with reasonable spread among the range. About 77 percent of the farming households have technical efficiency value of 0.50 and above while only about 14 percent have technical efficiency value of less than 0.40. This result is an indication of a fairly efficient group of farming households. Given the wide variation in the level of technical efficiency, there appears to be considerable room for improvements in the technical efficiencies of sampled *Fadama* rice farming households. The distribution of efficiency estimates over a wide range agree with previous works carried out in other peasant farming settings see Udoh, 2000; Amaza, 2000; Amaza and Olayemi, 2002; Oyenweaku and Effiong (2004); Okoruwa and Ogundele (2005); and Fatoba, 2007; Lawal, 2008; Lawal et. al., 2009;. It should be noted that the estimated efficiencies are purely output oriented technical efficiency derived as the ratio of observed to maximum feasible output, condition on technology and observed input usage.

Distribution of Production Elasticity

From the estimates in Table 3, local measure of return to scale measured as the sum of production elasticity of all variables ($\sum\beta i$), is greater than one. The return to scale parameter (5.2287) indicates the presence of short run increasing return to scale. This implies that every addition to production input would lead to more than proportionate addition to the output. Thus, *Fadama* rice farming households could still get more output by intensifying on the

Table 3: Distribution of Production Elasticity Among the Variables

Set of variables	Estimated value	Scale of Production
Physical inputs	5.7460	SR- Increasing re turn to scale
Land use and land management variables	-0.5173	SR- Decreasing return to scale
Total	5.2287	Increasing return to scale

use of production resources until they are able to achieve economic optimum. This result is in line with the findings of Ajibefun et al., 2002; Awoyinka and Ikpi, 2004; Lawal and Adigun, 2012 who reported a short-run increasing return to scale among smallholder food crop farmers in Oyo State; Sugarcane farmers in Jigawa State, and yam farmers in Niger state of Nigeria respectively.

Short-Run Sustainability Index (SRSI)

The indices of sustainable land use and management (ISM) show the accumulated marginal effect of the land use and management practices on the land resource quality. The ISM value of -0.5173 shows that on the aggregate the land use and management practices adopted by the farming household has adverse effect on land resource because the value is negative. The ISM value estimated have to a large extent, measured the effect of land use and management practices normally adopted by rice farming households on *Fadama* land in the Southern Guinea Savanna area.

The Short-run Sustainability Index (SRSI) is a product of farm specific technical inefficiency and indices of sustainable land use and management (ISM). It was estimated using equation 12. The distributions of the estimated indices are presented in table 4. The SRSI shows

Table 4: Distribution of Farm Specific Short -Run Sustainability Index (SRSI)

SRSI	Frequency	Percentage
(0.31 – 0.35)	5	3.13
(0.26 - 0.30)	13	8.13
(0.21 - 0.25)	25	16.63
(0.16 - 0.20)	32	20.00
(0.11 - 0.15)	55	34.38
(0.06 - 0.10)	18	11.25
(0.01 - 0. 05)	12	7.50
	160	100.00

Values in parenthesis are negative values.
Source: - Computed from the MLE result and Field Survey, (2011)

at farm level, the economic and environmental impact of rice production under low-external input agriculture as practiced in the *Fadama* of Niger State, Southern Guinea Savanna of Nigeria.

Table 4 clearly shows a normal distribution of the S.R.S.I indices with the modal class falling between -0.11 to -0.15 which did not fall into any of the extreme class. The estimated SRSI were negative for all the rice farming households. This implies that there was productivity declined owing to the net balance effect of the technical inefficiency and effect of land use and management practices. SRSI distribution shows productivity decline of 1% to 35%, among the sampled *Fadama* rice farming households. The mean productivity decline was 15.56%. However, the high concentration of the households (89 percent) within the SRSI ranges of -0.01 and -0.25 shows that in the short-run, remedial and preventive measures could easily bring about improvement in productivity decline.

Relationship Between Short Run Sustainability Index and Output of the Farms

High crop yield is a measure of sustainability of crop production, and the major concern of farming households is how much yield they get from the production process. So, it is expected that lower productivity expressed in poor yield should reflect on the sustainability index estimated in this study. A simple correlation analysis was used to capture the relationship between short-run sustainability index and average rice yield (Kg) at farm level. Under the assumption of joint distribution of SRSI and rice yield, a correlation coefficient r was estimated to be 0.648. A test of significance at 0.01 probability level shows that r =0.648 is statistically significant and different from zero. It can safely be concluded that there exist a positive joint movement of SRSI and average rice yield per farm, so higher SRSI are accompanied with higher average rice yield. This shows that a farm with higher technical efficiency index is likely going to have high output and that short-run sustainability index is a good proxy to determine farms that are within the path to sustainable farming practices.

CONCLUSION AND RECOMMENDATION

The MLE estimate of technical efficiency revealed a general truncated normal distribution with a minimum efficiency index of 0.12 and the maximum efficiency value of 0.93. The average technical efficiency in the sample was 0.65 leaving an inefficiency gap of 0 .35. Farm size, family labour, hired labour, capital, cost of purchased inputs, length of fallow, quantity of fertilizer used, crop diversification index, drainage and nutrient intake index were factors that significantly ($P<0.05$) influenced the estimated technical efficiency. The results also confirm the presence of inefficiency effects and these effects were stochastic in nature. Access to credit, *Fadama* farming experience, educational level of head of households, and extension contact had negative and significant relationship ($P< 0.05$) with inefficiency level. Short run production of rice in the *Fadama* of southern guinea savanna of Niger state was found to be sustainable although land use and management practices adopted by the *Fadama* rice farming households had adverse effect on land resources as the estimated ISM value was - 0.5173. and average productivity decline of 15.56 was observed. Distribution of sampled households based on short-run sustainability index showed that remedial and preventive measure could easily bring about improvement. The result shows a significant ($P < 0.01$) positive relationship between SRSI and rice yield (Kg). This shows that short-run sustainability index is a good proxy to determine households that are within the path to sustainable farming practices.

The study recommends the use of animal traction and herbicide to reduce labour usage in *Fadama* rice production systems. Efforts at mobilizing farmers into viable cooperative groups should also be pursued vigorously. This will help mobilize rural savings that can be readily available to the farmers. Farmers, if capacitated financially can easily afford necessary inputs like the fertilizer, which was shown to significantly influence on production. In addition labour saving technologies should be researched into and extended to rice producers in the *Fadama* to reduce production cost and make prices of local rice competitive.

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