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Effects of Livelihood Strategies and Sustainable Land Management Practices on Food Crop Production Efficiency in South-West Nigeria

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Abstract: Efficiency in food crop production is a topical issue in food security programme of Nigerian government. However, past policies directed for increased food crop production efficiency have not been effective because of neglect of Livelihood Strategy (LS) and attributes of Land Management Practices (LMP) used by farmers in food crop production policy analysis. The effect of LS and LMP on crop production efficiency was investigated. Multistage random sampling was used to collect primary data from 400 farmers in South West Nigeria. Data collected were analyzed with Translog stochastic model. The four LS identified were staple crops/off-farm income (LS1 = 30.0%); staple crops/wages and salary (LS2 = 22.5%); LS1/vegetable/fruits/livestock production (LS3 = 27.5%); LS3/Tree Crops (LS4 = 20.0%). Farmers adopted multiple LMPs for crop production. Agronomic Practices (AP = 80.0%) was preferred to others including Soil Management Practices (SMP = 65.0%), Conservation Practices (CP = 60.0%), Structural and Mechanical Erosion Control Practices (SMECP = 34.0%). The mean Technical Efficiency (TE) was 0.52 for the farmers and TE increased with LS3 ($p<0.01$) and LS4 ($p<0.1$). The level of LMP used by farmers, joint effects of LMP and physical inputs (except for fertilizer) and LMP and LS (except for LS4) was unsustainable with respect to crop output and TE ($p<0.05$). The most beneficial LS that ensured sustainable LMP for food crop production efficiency among farming households is LS4. The LS4 significantly improved TE in South-West Nigeria.

Key words: Livelihood strategy, land management practices, food crop production technical efficiency, South-West Nigeria

INTRODUCTION

Production economists are concerned with any phenomena, which have bearing on economic efficiency in the use of agricultural resources (Heady, 1952). Efficiency in agricultural production may be affected by government policies, social, economic environmental and cultural factors, which may change production possibilities, cost structures and resource management. In Nigeria, efficiency in food crop production is a topical issue in food security programme of Nigerian government. However, past policies directed for increased food crop production efficiency have not effectively achieved the salient objectives of food security because of neglect of Livelihood Strategy (LS) and attributes of Land Management Practices (LMP) used by farmers in food crop production (Awoyinka, 2009). This has constrained policy analysts with access to empirical information on the effects of LS and LMP attributes on food crop production efficiency.

Studies have been carried out of agricultural production efficiency in Nigeria. Amaza and Olayemi (1999) established the role of income diversification and the use of organic manure on economic efficiency in food crop production, without including the effect of farm-specific land management practices and different Livelihood Strategies (LS) of households on technical efficiency in crop production. The study assumed that efficiency or inefficiency in agricultural production is a function of physical production inputs and socio economic characteristics of the households and thus, constraining policy/programme targeting. While, Udoh (2000) investigated the role of LMP on output of crop and technical efficiency in crop production, his study, however, did not incorporate interaction between LS and LMP and implication for technical efficiency in crop production. There is also a rapidly growing literature on rural non-farm income and livelihood diversification in developing countries (Ellis, 2000; Barret *et al*., 2001; Reardon *et al*., 2001), but little of this investigates the implications of livelihood diversification on food crop production efficiency of the households. Previous studies Nkoya *et al*. (2004) and Jansen *et al*. (2006a) have established the policy relevance of the nexus between LS and LMP; they have not examined the influence of LMP on technical efficiency in crop production. Effect of LS

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and LMP on food crop production efficiency has policy relevance for food security programme targeting and implementation (Awoyinka, 2009). This study therefore, examined the effect of LS and LMP on food crop production efficiency using stochastic production frontier estimating procedure.

In estimating agricultural production efficiency, stochastic efficiency frontier has been used extensively for measurement of efficiency in agriculture, the econometric approach independently proposed by Aigner *et al*. (1977) and Meeusen and Van Den Broeck (1977). The approach has the advantage that it accounts for the presence of measurement error in the specification and estimation of the frontier production function. The stochastic frontier function differs from the traditional production function in that the former identifies two error terms. The 1st error term accounts for technical inefficiency, while the 2nd error term, accounts for factors such as, measurement error in the output variable, weather and the combined effects of unobserved inputs on production.

In the study, the econometric approach has generally been preferred in the empirical application of stochastic frontier production model in agriculture. This is probably due to a number of factors. First, the assumption that all deviations from the frontier arise from inefficiency, as assumed by Data Envelopment Analysis (DEA) is difficult to accept, given the inherent variability of agricultural production due to uncontrollable factors such as weather, pests and diseases. Second, farm records are seldom kept on small, family-owned enterprises. Consequently, available data on production are likely to be subject to measurement errors. This study adopted this econometric approach to identify the effect of LS and LMP on food crop production efficiency of farming households in South West Nigeria.

Conceptual framework/literature review: Agricultural productivity according to Heady (1952) is determined by the amount of productive resources used and the quality of factors such as the soil fertility, distribution profile of farmers as well as the form that capital takes e.g. tractors, fertilizer, seed etc. The principle is that provided the technological and managerial skills are the same, farmers with equal access to identical resources both in quality and quantity may produce identical outputs of a given crop, which means that their productivity may be identical. Accordingly, differences in technologies, quantities and qualities of other factors (e.g., fertility of land, health, education) and form of capital, LS and LMP will definitely bring about differences in productivity of agriculture.

Analysis of resource-use efficiency, in particular, technical efficiency has been carried out using stochastic frontier production function model. The stochastic production frontier otherwise known as the decomposed error model, was suggested by Aigner *et al.* (1977) and Meeusen and Van Den Broeck (1977). It has been used variously to estimate technical efficiency due to its consistency with theory and relative ease of estimation (Bravo-Ureta and Rieger, 1990; Kalirajan, 1991; Parikh and Shah, 1994; Battese and Coelli, 1995; Meeusen and Van Den Broeck, 1997). Measurement of efficiency is important because of the limited resources in developing countries and few opportunities in developing and adopting better technologies. According to Bravo-Ureta and Riegler (1990) the frontier function models are neutrally upwardly scaled versions of the Ordinary Least Square (OLS) model. Having obtained and compared estimates of technical efficiencies from four different models, they detected that though levels of technical efficiency vary from one estimation method to the other, yet they are highly correlated. Bravo-Ureta and Evenson (1994) detected this, Koop and Smith (1980) both of whom concluded that functional specification has a discernible but rather small impact on estimated efficiency.

An extension of stochastic frontier production function model is translog form. An unrestricted translog production function is generally flexible and allows analysis of interactions among variables estimates (Ali, 1996; Udoh, 2000). Translog function can be estimated with or without efficiency model (Coelli, 1994). Seyoum *et al.* (1998) in measuring technical efficiency of maize farmers in Eastern Ethiopia for farmers within and outside the Sasa-kawa Global (2000) project used a translog stochastic production function and a Cobb-Douglas production function and found mean technical efficiency of farmers within the SG 2000 project to be 0.94; while, farmers outside the project had 0.79. Udoh (2000), used a translog function and found a significant relationship between land management and land area cultivated with output of food crop in southern Nigeria. Awudu and Richard (2001) used a translog stochastic frontier model to examine maize and beans production in Nicaragua, the average efficiency levels were 69.8 and 74.2% for maize and beans, respectively. Larger farms also appeared to be more efficient than smaller farms as this ensures the availability of enough family labour for farm operations as soon as required. Amara *et al.* (1999) estimated two flexible functional forms for their study on the technical efficiency and farmers attitudes towards technological innovation: the case for potato farmers in quebec-the transcendental and transcendental logarithmic (translog) functional forms; the

Cobb-Douglas production function was finally estimated. The result indicated that the average potato farm was 80% efficient suggesting that improvements in technical efficiency are still possible. The policy suggested that large-farms owners, which were found to be less efficient be targeted for improved technical efficiency.

The application of translog stochastic production frontier model is said to have some advantages. The biggest advantage is the introduction of a disturbance term representing noise, measurement error and exogenous factors beyond the control of the production unit in addition to the efficiency component. This property of the stochastic model accounts for its appropriateness for efficiency analysis in agriculture due to agriculture's inherent characteristics. Second, it allows for estimation of interaction terms and policy targeting. Most studies that used translog function model in estimation of technical efficiency have proved the relevance of the model in estimating joint effect of interaction variables on output of agricultural enterprises. Except for the study of Udoh (2000) that investigated the interaction of land management and physical production inputs on output of food crop, no study has investigated the joint effect of LMP and LS on output of food crop and technical efficiency. This study, thus, filled in the gap and established clear path for policy targeting.

MATERIALS AND METHODS

The study was carried out in South West, Nigeria. The choice of the study area is based on the severity of erosion, which Evoked land depletion in terms of loss of soil fertility and output of crops and high rainfall erosivity in combination with intense cultivation pressure. This has negatively affected farming livelihood activities of the households (FDALR, 1988). South West of Nigeria falls on Latitude 6° to the North and Latitude 4° to the South. It is marked by Longitude 4° to the West and 6° to the East. The zone comprises of 6 states (Oyo, Osun, Ondo, Ogun, Ekiti and Lagos). The vegetation is typically rainforest; however, climatic changes over the years have turned some parts of the rainforest to derived Savannah. The geographical location of South West Nigeria covers about 114,271 km^2 that is, approximately 12% of Nigeria's total land mass. The total population is 15,456,789 and >96% of the population is Yorubas (NPC, 2006). The zone is bounded in the North by Kogi and Kwara states, in the East by Edo and Delta states, in the South by Atlantic Ocean and in the West by Republic of Benin. Two main seasons the rainy and dry seasons are common in both states. Livelihood activities in both states are agricultural activities, off-farm income activities and wages and salary earning jobs. Agriculture in the area comprises of cultivation of staple crops, fruits, vegetables and tree crops; livestock activities (backyard poultry, extensive goat and sheep production) and fish farming. Farming households mostly practiced mixed farming and mixed cropping and they use LMP (Structural and Mechanical Erosion Control Practices, Agronomic Practices, Soil Management Practices and Cultivation Practices) for increased agricultural production activities (FDALR, 1988). Off-farm income of the households comprises of trading, processing of agricultural produce, carpentry, bricklaying, tailoring, crafts making, driving, sawmilling, gathering, vulcanizing and mechanics. Wages and salary earning jobs include teaching, civil service works, office attendant works and informal sector employment.

The sampling frame used for the study was collected from state Ministry of Agriculture and state Agricultural Development project. The data were collected with the aid of structured questionnaire between February and September, 2007. Multistage sampling was used in data collection. The first was the selection of Osun and Ekiti states from the states in South West geopolitical zone. The second stage was the stratification of the study area into rainforest and derived Savannah. This was done in order to examine effect of location variable on technical efficiency in food crop production. The third stage was the selection of 6 (3 each from rainforest and derived Savannah belts) Local Government Areas (LGAs). The fourth stage was the selection of 21 villages from LGAs. This was followed by the selection of 44 extension blocks and 23 extension cells from villages. The final stage of the sampling was the proportionate selection of the farming household's head from the selected cells. Based on the population of the head of farming households in the extension cells, a total of 400 farming household's head from both states responded to the interview. They completely filled the questionnaires and information provided was used for analysis.

Stochastic frontier production function model: Multiple regression model based on stochastic parametric form was used to examine the influence of physical production inputs, LMP variable, LS variables of the farmers, joint effect of LS and LMP on output of crops and technical efficiency. Consider a Stochastic production frontier as:

$$Q_i = g\ (X_i, L_i, M_i\ R_i; \beta)\ \exp\ (V_i - U_i)\ i = 1, 2 \ldots.\ N)\ (1)$$

where:

Q_i = Output of crops harvested by ith farmer in kg (grain equivalence)
X_i = Vector of physical inputs used by ith farmer in (unit/farm)
L_i = Vector of LS of the ith farmer, measured as dummy variable
M_i = Vector of index of LMP used by ith farmer
R_i = Vector of location of the farmers and it is a dummy variable
β = Vector of parameters to be estimated
V_i = Random error due to mis-specification of the model
U_i = Inefficiency component of error terms
g(.) = The suitable function (in this study, a translog function)

The parameters (β_i) of Eq. 1 and the density functions of V_i and U_i are estimated by maximizing the log-likelihood function given as:

$$\text{Ln } \varphi = {}^N/_2 \text{ Ln } ({}^2/\text{JI}) - \text{N In}\,\sigma + \sum_{i=1}^{N} \text{In} 1 - F\{[-\underline{\varepsilon_i}\underline{\lambda}]\} \\ -_{1/2}\sigma^2 \sum_{i=1}^{N} \varepsilon_i^{\ 2} \qquad (2)$$

where:

N = The number of observations (400 farms)
σ = The standard deviation of the total error term
λ = σ_u/σ_v
F (.) = The standard distribution function
ε_i = Component error term
JI = 3.1415

Implicitly, an unrestricted translog production function which is general, flexible and allows analysis of interactions among variables was estimated. This was in line with researches of Driscol *et al*. (1992), Ali (1996) and Udoh (2000). However, it should be noted that the estimates of the translog may be invalid because of the violation of regularity conditions at extreme sample values to the inclusion of the second order terms, especially in small sample. But in this study, the problem is partially solved with the large sample size (N = 400) with better degree of freedom. The general form is:

$$\text{In}Q_i = a_o + \sum_{i=1}^{n} a_i \text{ In}(X_{ij}) + \sum_{j=1}^{n} b_j (\text{In } X_{ij})^2 + {}_{1/2}\sum_{i=1}^{n}\sum_{k=1}^{n} c_{ik} \\ (\text{In } X_{ij} \text{ In} X_{ij}) + {}_{1/2}\sum_{i=1}^{n}\sum_{l=1}^{n} d_{il} (\text{In } X_{ij} \text{ In } M_{ij}) + \sum_{e=1}^{n} e_m (\text{In } M_{ij}) \\ + \sum_{f=1}^{n} f_n (L_{ij}) + {}_{1/2}\sum_{i=1}^{n}\sum_{g=1}^{n} g_o (\text{In } M_{ij} \ L_{ij}) + \sum_{h=1}^{n} h_p (R_{ij}) + U_j + V_i \qquad (3)$$

where:

a_o = Parameter of intercept
a_i = Parameters of physical inputs
b_j = Parameters for square terms of physical inputs
c_k = Parameters for interaction across ith and jth physical inputs
d_l = Parameters for interaction between physical inputs and index of LMP
e_m = Parameter for index of LMP
f_n = Parameter for livelihood strategy of the households head
g_o = Parameters for interaction among LS and index of LMP
h_p = Parameters for location variable

It should be stated that X_i are the conventional inputs that are normally considered in transformation process. But L and M are conditioning variable whose inclusion into the model is to capture the effects of LS and LMP on output of crop production.

Measurement of efficiency index: Measurement of farm level efficiency, e^u, requires first the estimation of the non negative error U, i.e., decomposition of error term into its two individual components, U and V. The technique of decomposition as suggested by Jondrow *et al*. (1982) involves the conditional distribution of U given ε expressed a:

$$E\langle u_i | \varepsilon_i \rangle = \frac{\sigma_u \sigma_v}{\sigma} \left[\frac{f^*(\varepsilon_i \lambda/\sigma)}{1 - F^*(\varepsilon_i \lambda/\sigma} - \frac{\varepsilon_i \lambda}{\sigma} \right] \qquad (4)$$

where:

ε_i = U + V
σ = Standard deviation of the total error term
λ = σ_u/σ_v
f (.) = The standard normal Density Function (PDF)
F(.) = The standard Distribution Function (CDF)

The population average technical efficiency is given as:

$$(E(e")) = 2e^{\sigma 2\, u/2} [1\text{-}F(\sigma")] \qquad (5)$$

where:

F = The standard normal distribution function. It should be noted that by taking the natural logarithm of -u, the farm specific resource use efficiency index is measured
1-e" = Give resource use inefficiency

Model specification: The specification of the translog model is as follows:

$$\text{In } Q = \text{In } \beta_0 + \beta_1 \text{In } X_1 + \beta_2 \text{In } X_2 + \beta_3 \text{In } X_3 + \beta_4 \text{In } X_4 + \beta_5 \\ \text{In } X_5 + \beta_6 \text{In } (X_1)^2 + \beta_7 (X_2)^2 + \beta_8 \text{ In } (X_3)^2$$

$$+ \beta_9 \ln (X_4)^2 + \beta_{10} \ln (X_5)^2 + \beta_{11} \ln (X_1 * X_2) + \beta_{12} \ln (X_1 * X_3) + \beta_{13} \ln (X_1 * X_4) + \beta_{14} \ln(X_1 * X_5) + \beta_{15} \ln(X_2 * X_3) + \beta_{16} \ln(X_2 * X_4) + \beta_{17} \ln(X_2 * X_5) + \beta_{18} \ln (X_3 * X_4) + \beta_{19} \ln(X_3 * X_5) + \beta_{20} \ln (X_4 * X_5) + \beta_{21} \ln(X_1 * M) + \beta_{22} \ln (X_2 * M) + \beta_{23} \ln(X_3 * M) + \beta_{24} \ln (X_4 * M) + \beta_{25} \ln(X_5 * M) + \beta_{26} (M) + \beta_{27} (L_2) + \beta_{28} (L_3) + \beta_{29} (L_4) + \beta_{30} (L_1 * M) + \beta_{31} (L_2 * M) + \beta_{32} (L_3 * M) + \beta_{33} (L_4 * M) + \beta_{34} (R) + U + V \quad (6)$$

where:

In = The natural logarithm (i.e., to base e)
Q = The total output of crop produced by farmers in kg
X_1 = The total farm area cultivated for crop production in ha
X_2 = Total man-days of family labour used in crop production
X_3 = The total man-days of hired labour used in crop production
X_4 = Total quantity of planting materials in kg
X_5 = The total quantity of fertilizer in kg

However, the estimation of translog stochastic frontier used in this study is without efficiency component. The parameters of the translog stochastic frontier function model are estimated by the method of maximum likelihood, using the computer program FRONTIER version 4.1 (Coelli, 1994).

Test for multicollinearity: To determine the presence of multicollinearity in the Eq. 6, the Farrar- Glauber test that utilizes Chi-square test (χ^2) was carried out. The test statistic is:

$$\chi^2 = [n - 1 - {}^1/_6(2k + 5)] \ln D \quad (7)$$

where:

χ^2 = Computed Chi-square statistic
n = Sample size
k = Number of explanatory variable
lnD = Natural logarithm of the determinant of the matrix of pair-wise correlation coefficients (r_{ij})

According to Olayemi (1998), the chi-square distribution has ½ k (k-l) degree of freedom and the null hypothesis to be tested is that $r_{ij} = 0$ (for l # j) against the alternative hypothesis that r_{ij} # 0.

RESULTS AND DISCUSSION

Households in the study area engaged in farm and non-farm livelihood activities for income diversification purpose. Livelihood activities of the households are related to their endowment of social, human, financial, physical and natural capital/asset (Nkoya *et al.*, 2004; Jansen *et al.*, 2006a, b). The result of livelihood choices of the households reveals four combinations of livelihood activities. They are staple crop and off-farm activities (LS1 = 30%); staple crop and wages and salary (LS2 = 22.5%); staple, fruit and vegetables crops, livestock production and off-farm income (LS3 = 27.5%); staple, fruit, vegetables and tree crops, livestock production and off-farm income (LS4 = 20%).

Farmers adopt multiple LMP for crop production with Agronomic Practices (AP = 80.0%) preferred to other LMPs including Soil Management Practices (SMP = 65.0%), Conservation Practices (CP = 60.0%), Structural and Mechanical Erosion Control Practices (SMECP = 34.0%). The results further shows that majority of the households in the study area (61%) preferred Soil Management Practices (SMP) to other LMP for soil retention attributes of the LMP. On the basis of soil loss and run off prevention majority of the households (58%), preferred CP to other LMP. Based on capacity of LMP to sustain yield of crop, AP was preferred to other LMP. On account of direct and indirect cost, most households (56%) in the study area preferred CP to other LMP. Livelihood strategy-wise, household pursuing LS1 (60%) and LS2 (61%) preferred AP to other LMP for soil fertility retention; while, those pursuing LS3 (62%) and LS4 (63%) preferred CP to other LMP for the same purpose. On account of capacity of LMP to prevent soil loss and run off, households pursuing LS1 (58%) and LS2 (62%) preferred CP, while those pursuing LS3 (62%) and LS4 (68%) preferred SMECP to other LMP. On the basis of capacity of LMP to sustain yield of crop households pursuing LS1 (68%), LS2 (70%) LS3 (76%) and LS4 (79%) preferred AP to other LMP. Households pursuing LS1 (70%); LS2 (70%); LS3 (66%) and LS4 (76%) preferred CP to other LMP on account of direct and indirect cost.

Effect of livelihood strategies and land management practices on food crop production efficiency: The frontier function was estimated using Maximum Likelihood Estimation approach (MLE) through the FRONTIER 4.1 program (Coelli, 1994). The result of MLE (without inefficiency component) is presented in Table 1. The result shows the likelihood parameter estimates of the stochastic production frontier for all farms in the study area. It is evident that the estimate of δs^2 (1.2813) is large and statistically significant and the specified distributional assumption of the composite error term and the variance ratio (defined as $\gamma = \delta u^2/(\delta u^2 + \delta v^2)$) estimate is 93.24%, suggesting that systematic influences that are unexplained by the production function are the dominant sources of random errors. Thus, the presence of

Table 1: Maximum likelihood estimation result for translog frontier model

Variables	Parameters	Coefficient	SE
Physical inputs			
Land (ha)	β_1	1.6412***	0.1761
Family labour (man-days)	β_2	-1.0372**	0.545
Hired labour (man-days)	β_3	-1.4477***	0.3765
Planting material (kg)	β_4	- 0.3876**	0.1791
Fertilizer (kg)	β_5	-1.4786	1.1814
Squared terms			
Land^2	β_6	1.2808***	0.0932
Family labour^2	β_7	-0.2099**	0.0757
Hired labour^2	β_8	-0.0827	0.2583
Planting material^2	β_9	0.0089	0.0259
Fertilizer^2	β_{10}	-0.0696	0.0879
Interaction of physical inputs			
Land × family labour	β_{11}	-1.6701***`	0.1151
Land × hired labour	β_{12}	0.0121	0.1320
Land × planting material	β_{13}	1.9768***	0.2116
Land × fertilizer	β_{14}	-0.0012	0.0682
Family labour × hired labour	β_{15}	1.6704***	0.1132
Family labour × planting material	β_{16}	0.1478	0.2336
Family labour × fertilizer	β_{17}	-0.2251	0.1933
Hired labour × planting material	β_{18}	-0.1439***	0.0549
Hired labour × fertilizer	β_{19}	0.0331	0.0686
Planting material × fertilizer	β_{20}	0.0901	0.1068
Physical inputs and index of land management practices			
Land × index of sustainable land management practices	β_{21}	-7.51940***	1.1447
Family labour × index of sustainable land management practices	β_{22}	-0.2676**	0.1392
Hired labour × index of sustainable land management practices	β_{23}	-1.1401***	0.1600
Planting material × index of sustainable land management practices	β_{24}	0.0412	0.1507
Fertilizer × index of sustainable land management practices	β_{25}	0.8418***	0.2019
Land management practices			
Index of sustainable land management practices (dummy)	β_{26}	-1.5199***	0.2255
Livelihood strategy (cf livelihood strategy)			
2	β_{27}	0.0431	0.2034
3	β_{28}	0.6900***	0.1248
4	β_{29}	2.1631***	0.1330
Interaction of index of land management practices and livelihood strategy			
LS1 × index of land management practices	β_{30}	-0.3221**	0.1471
LS2 × index of land management practices	β_{31}	-3.4198	0.2084
LS3 × index of land management practices	β_{32}	-0.6195***	0.2270
LS4 × index of land management practices	β_{33}	2.3943***	0.2201
Location variable			
Dummy for households in rainforest relative to derived savannah	β_{34}	4.1431***	0.2331
Intercept	β_0	17.8603***	1.6546
σ^2	σ	1.2813***	0.1214
γ	γ	0.9324***	0.0211

Log-likelihood = -0.41163093E+03; LR test = 80.02; *Significance: ***1%, **5% and *10%, respectively; Source: Computer printout of Frontier 4.1

technical inefficiency among the sample farm explains 93% variation in the output level of the crops grown. This confirms that in the specified model, there is presence of one-sided error component. This actually implies that the effect of technical inefficiency (E (e^u) = $2e^{\sigma 2u/2}$ [1-F(σ_u)]) is significant and that a classical regression model of production function based on ordinary least square estimation would be inadequate representation of the data. Therefore, the result of the diagnosis statistics confirms the relevance of stochastic parametric production frontier and maximum likelihood estimation. The maximum likelihood estimates indicate the relative importance of the conventional and conditioning variables in the Eq. (1). Predominantly, most of the coefficients of the variables are of the right signs and magnitudes.

The coefficient of land (1.6412) is statistically significant ($p<0.01$) showing that land is an important factor explaining changes in output. But the magnitude of the coefficient shows elastic nature of output with respect to land. This result agrees with findings of Amaza and Olayemi (1999), Coelli and Battese (1996). The elasticity of crop output with respect to family labour utilized in the study area is negative and it is statistically significant ($p<0.01$). Crop output is inelastic to family labour. Thus, output of crop increases with a decrease in family labour input and vice versa. The negative production elasticity with respect to family labour conforms to previous findings (Battese *et al*., 1996; Amaza and Olayemi, 1999). The production elasticity with respect to man-days of hired labour use in crop production is negative and statistically significant ($p<0.01$). The result implies that man-day of hired labour is inelastic in relation to crop output produced by farmers. The production elasticity of the quantity of planting material used by the households in crop production is negative and statistically significant ($p<0.05$). The result implies that quantity of planting material is inelastic in relation to crop output produced by farmers (Amaza and Olayemi, 1999). The production elasticity with respect to the use of inorganic fertilizer in crop production is negative and statistically insignificant. Fertilizer variable is not a determinant of output in the study area. Reason for this as revealed by the farmers was based on application of inappropriate dose to crops, unavailability and high cost.

The squared term with respect to land, have positive relationship with output level that is, doubling land under cultivation will result in higher output of crop. The results show statistically quadratic type of relationships with output. With respect to family labour, doubling man-days result in lower crop output. Therefore, doubling labour would lead to overcrowding on the land and over utilization of man-days of family labour (Udoh, 2000). This interaction term of land and family labour has a negative effect on output level and is statistically significant ($p<0.01$). It therefore, implies that combination of land with corresponding family labour resulted in lower output of crop. Thus, to get increased output of crop, small expanse of land and fewer man days of family labour must be available (Udoh, 2000). The estimated coefficient of the joint effect of land and quantity of planting material is statistically significant ($p<0.01$) and is positively related to output level. The result shows that more than proportionate increase in output is produced when farm size is increased by one unit given a corresponding unit increase in cost of planting. The interaction term of man day of family and hired labour has a positive effect on output level and is positive and statistically significant ($p<0.01$). It therefore, implies that combination of hired and family labour increases output of crop harvested. The estimated coefficient of the joint effect of hired labour and quantity of planting material is statistically significant ($p<0.01$) and is negatively related to output level. This result shows that more than proportionate increase in output level resulted from 1 unit increase in farm size given a corresponding unit increase quantity of planting material.

The estimated coefficient of the joint effect of land and index of sustainable LMP is negative and significant ($p<0.01$). The result implies that output of crop decreases with farming households that cultivated small farm size combined unsustainable LMP. The estimated coefficient of the joint effect of family labour and index of sustainable LMP is negative and significant ($p<0.05$). The result implies that output of crop decreases with fewer man-days of family labour and the use of unsustainable LMP. The estimated coefficient of the joint effect of man-day of hired labour and index of sustainable LMP is negative and significant ($p<0.01$). The result implies that output of crop decreases with man-day of hired labour combine with unsustainable LMP for crop production activities. The estimated coefficient of the joint effect of fertilizer and index of sustainable LMP is positive and significant ($p<0.01$). The result implies that output of crop increases with farming households that combine fertilizer with sustainable LMP for crop production activities.

The estimated coefficient of index of sustainable LMP is negative and significant ($p<0.01$). The result implies that output of crop decreases with the index of LMP used by the farming households. The result further shows that the current level of LMP used by the farming households is not sustainable with respect to output of crop produced. The estimated coefficient of farming households pursuing LS3 relative to LS1 is positive and significant ($p<0.01$). The result implies that output of crop decreases for farming households pursuing LS3 relative to LS1. The estimated coefficient of farming households pursuing LS4 relative to LS1 is positive and significant ($p<0.01$). The result implies that output of crop increases for farming households pursuing LS4 relative to LS1. The estimated coefficient of the joint effect of LS1 and dummy for index of sustainable LMP is negative and significant ($p<0.05$). The result implies that output of crop decreases with households pursuing LS1 and using unsustainable LMP for crop production activities. The estimated coefficient of the joint effect of LS3 and index of sustainable LMP is negative and significant ($p<0.01$). The result implies that output of crop decreases with households pursuing LS3 and using unsustainable LMP for crop production activities. The estimated coefficient of the joint effect of LS4 and index of sustainable LMP is positive and significant ($p<0.01$). The result implies that output of crop increases with households pursuing LS4 and using sustainable LMP for crop production activities. The estimated coefficient of farming households in rainforest belt relative to derived savannah belt is positive and significant ($p<0.01$). The result implies that output of crop increases for households in rainforest relative to derived savannah belt.

The farm specific resource-use efficiency indices were estimated. To give a better indication of the distribution of the individual efficiency, frequency distribution of farm specific efficiency is presented in Table 2. The frequency distribution of efficiency shows a gradual rising from

Table 2: Distribution of farm-specific resource-use efficiency indices

Class interval of efficiency indices	Frequency	Percentage
0.01-0.10	8	2.000
0.11-0.20	15	3.750
0.21.0.30	35	8.750
0.31-0.40	42	10.50
0.41-0.50	59	14.75
0.51-0.60	56	14.00
0.61-0.70	59	14.75
0.71-0.80	62	15.50
0.81-0.90	34	8.500
0.91-1.00	30	7.500
Total	400	100.0

Mean = 0.5207; Source: Computed from Eq. 11

lowest to highest and then a sharp fall to the right of the distribution. As the distribution spread from left to right at different intervals with modal class not falling into any of the extreme classes, therefore, the occurrence of the mode of distribution, 0.43 supports the use of more general distributions (than the often considered half normal distribution or exponential distribution) for efficiency effects. The assumption of a general truncated normal distribution for the efficiency term (Ui) is therefore, justified. The distribution of the efficiency estimates agree with previous researches carried out in other peasant farming settings (Coelli and Battese, 1996). The average resource use efficiency in the sample was 0.52 leaving an inefficiency gap of 0.48. This implies that about 48% higher production could be achieved without additional resources, or input use could be reduced to achieve the same output level. The minimum efficiency index observed among the farmers was 0.01 while, the maximum efficiency index observed among the farmers was 0.94. It therefore, shows that the most efficient farmers in terms of resource use had index of 0.98 and the least efficient ones had resource use efficiency of 0.011. It should be noted that the estimated efficiencies are purely output oriented technical efficiencies derived as the ratio of observed to maximum feasible output, conditional on technology and observed input usage. The observed efficiency can be attributed to various factors ranging from technical, production constraint and land management practices. When LMP used by farmers is not sustainable, degradation of land may not be controlled and thus, frontier production hindered, which consequently lead to crop loss.

Policy implication of findings: The findings of this study have shown the joint effects of LMP and LS on food crop production efficiency. The findings also reveal the need to promote sustainable LMP that for enhancing resource use and food crop production efficiency of the farming households. The current level of LMP used by the households is unsustainable for households pursuing LS2 and LS3, it is however, sustainable for households pursuing LS4. Except for fertilizer variable, combination of other physical variables with index of LMP resulted into low crop output. The hypothesis that LMP influences technical efficiency in crop production was confirmed. Land management programme targeting households pursuing LS1-LS3 is therefore, pertinent for increased food crop production efficiency, while controlling for land degradation problem.

CONCLUSION

Livelihood framework has the potential to succour policy makers in the implementation of LMP policy, as well as enhancement of technical efficiency in crop production. The most beneficial LS that ensure sustainable LMP for food crop production efficiency among farming households is LS4. LS4 significantly improves TE in South West, Nigeria.

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