

Influence of Agro-ecologies and Land use Intensity on Efficiency of Food Crop Farmers in South Western Nigeria.

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Abstract

Rapid population growth underscores the importance of intensification and efficiency as necessary precursors for sustainable growth in food production. The implication of land use intensity and agro-ecological diversities on food production has not been adequately explored in Nigeria. This study therefore investigated the effect of land-use intensity (very high, high, medium and low) and agro-ecology (forest, derived savannah and Southern Guinea savannah) on the efficiency of food crop production in South Western Nigeria (SWN). The study utilized data from a survey of 341 farmers selected from Ondo and Oyo States by multi-stage sampling technique while data were collected on production systems, cropping cycle, crop combinations, input and output in food crop production using questionnaire. Data were analyzed using descriptive statistics and regression at $p=0.05$. Technical, Allocative and Economic efficiencies of the farmers averaged 76.5%, 62.8% and 46.3% respectively. There was no significant difference in the estimated technical and economic efficiency scores of farmers across the agro-ecologies whereas farmers in southern guinea savannah had significantly higher allocative efficiency than those in other agroecologies. The economic efficiency of farmers who cultivated their farmland under high (47.4%) and very high (47.4%) land use intensity were significantly higher than the economic efficiency of farmers that cultivated their arable land under low (41.5%) and medium (42.1%) land use intensity respectively. Generally, farmers in the derived and southern guineas savannah agro-ecologies that engaged in arable land under very high intensity have higher potential for increased productivity in food crop production through greater allocative and economic efficiency.

Keywords: Efficiency, Food crop production, Land use intensity.

Introduction

Nigeria's economy has groaned continuously under the burden of enormous food import to feed its population. Recently, the economic recession accompanying sudden drop in oil price exposed the danger in the country's dependence on oil for its major earning and food import to feed its teeming population. Consequently, attainment of self-sufficiency in food production emerged as a focal point in the development agenda of various regimes in recent past. Attaining the desired self-sufficiency in food production requires the achievement of sustainable growth in food production. One of the sources of such growth has also been identified as increased productivity through greater

efficiency in response to the dynamics of the production environment.

In Nigeria, FAO (2017) estimates have shown that most increases in food production are largely traceable to expansion in land area cultivated to arable crops than increase in productivity of arable farms. Such approach is gradually facing increasing challenges with increasing pressure on arable land as a result of high population growth rate and climate change. Indication of this pressure has manifested in decline in land-man ratio, reduction in average size of farmland, increase in frequency of cultivation of farmlands as a form of

intensification (Bamire and Manyong, 2003, Oluwatosin *et al.*, 2008; Saka *et al.*, 2011, FAO, 2017) and frequent clashes between farmers and pastoralists. It is therefore most probable that sustainable growth in food production will be sought through productivity increase that is predicated on efficient intensification.

In many developing economies, particularly in sub-Saharan Africa (SSA), improving agricultural productivity remains a necessary condition for economic growth, poverty reduction and improving food and nutrition security (Schaffnit-Chatterjee, 2014). The achievement of efficient intensification for sustainable increase in productivity is also predicated on appropriate use of modern technologies. However, empirical studies ((Kebede, 2001, Saka *et al* 2011) have suggested that peasant farmers in developing countries fall short of exploiting the potential inherent in the use of modern technologies in their production and consequently, farm level decision capable of resulting in inefficient allocation of resources are often made. The inability of farmers to access and procure modern inputs has consequently remained a major hindrance to sustainable increase in agricultural productivity.

Agricultural productivity which refers to the effectiveness with which inputs are converted to output within a production process, has been observed to depend on the prevailing level of production technology and the efficiency of the production systems (Zaibet and Dharmapala, 1999; Kebede, 2001). The efficiency of a production system refers to how effectively the system uses the available resources in attaining the objective of profit maximization.

Literatures have however decomposed efficiency measurement into two

components: Technical and Allocative Efficiency. Technical efficiency (TE) refers to the maximum attainable level of output for a given level of production input, given the range of alternative technologies available to the farmer while Allocative Efficiency (AE) refers only to the adjustment of input and outputs to reflect relative prices, having chosen the production technology or the ability to choose optimum input levels for given factor prices (Gavian and Fafcamp, 1996; Sharma *et al*, 1999; Ogundari and Ojo, 2006). Consequently, economic efficiency refers to the product of technical and allocative efficiencies. The practice of agro-forestry in Ondo State represent a domain that offers opportunity for exploring the influence of cash cropping on opportunity for intensification among food crop farmers. In addition to the fact that tree (cash) compete with food crop for land, Jayne *et al* (2004) noted that the influence of cash cropping on intensification is inherent in the mobilization of substantial fund for investment in external inputs thereby providing a spill-over benefit to food crop production especially for credit constrained farmers. Arising from evidence of increased land-use intensity among food crop farmers in South western Nigeria and drawing from the above framework, this study examines the tradeoff between land-use intensification and efficiency of the prevailing production systems among food crop farmers in Southwest geopolitical zone of Nigeria.

Materials and Methods

Data for this study were generated through a farm survey of 341 farmers selected by multistage sampling technique from South Western Nigeria. South western

Data were collected on farmer- and farm-specific characteristics including household size, size of landholding, cropping cycle, production systems, crop combinations, input and output data in food crop production using questionnaire. The study categorized farmers into land use intensity categories taking into consideration the frequency of cultivation and the cropping intensity following.

The determination of the efficiency of food crop farmers in the zone was based on production function analysis of individual farm technical efficiency. Following Sharma *et al* (1999), the stochastic frontier production function for the estimation of farm level technical efficiency is specified as $Y_i = f(X_i; \beta) + \varepsilon_i$ (1) where Y_i is the output intensity of farm i ; X_i is a vector of actual input quantities used by the farmers, β is the parameter to be estimated and ε_i is the composite error term ($\varepsilon_i = V_i - U_i$) comprising of V_i which is independently and identically distributed $N(0, \sigma_v^2)$ random errors and the U_i which is a one-sided error term that is independent of V_i and is normally distributed as $N(0, \sigma_u^2)$ thereby allowing the actual production frontier to fall below the frontier output. This shortfall is consequently attributed in part to the random noise and also to technical inefficiency differential. These stochastic elements are incorporated into stochastic production frontier as a measure of firms' technical efficiency to capture the producer specific random shocks. Hence, the new production frontier is defined by

$$Y_i = f(X_i, \beta) + V_i - U_i \dots\dots\dots(2)$$

Subtracting V_i from both sides,

$$Y_i - v_i = Y_i^* = f(X_i; \beta) - \mu_i \dots\dots\dots(3)$$

Hence equation (3) gives the basis for deriving the technically efficient input combinations whereby Y_i^* are the observed output intensity of farm i adjusted for the stochastic noise.

Consequently $Y_i = f(X_i, \beta) - U_i \cdot TE$ (4)

Hence $TE_i = Y_i / f(X_i; \beta) - U_i$ (5)

where $Y_i = f(X_i; \beta) - U_i$ if $TE_i = 1$ and otherwise $TE_i < 1$

In recognition of the influence of choice of functional form on the validity of the stochastic estimates and consequently the inferences based on such estimates, the study considers four functional forms for the stochastic frontier, comprising of the error component and inefficiency variant of both the Cobb-Dougllass and the Translog functional forms. The Translog production functional form has often been noted to be more general and flexible in permitting the derivation of estimates for interaction among variables included in the model. However, a situation whereby the coefficients of the second order term are zero (Battese and Broca, 1997) i.e., $\beta_{jk} = 0, j \leq k = 1, 2, \dots, 5$. results in Cobb-Douglas production frontier.

Following Bishop and Brander (2003), the study considered the Cobb Douglass and Translog production functions with their error component and inefficiency variants to accommodate the testing of the various hypotheses relating to the choice of the functional form that is adequately representative of the data collected on food crop production in the study area. The tested hypotheses concerning the appropriate functional forms were:

- (i) The functional form for the Stochastic frontier model is not Translog

$$H_{01} : \beta_{jk} = 0, j \leq k = 1, 2, \dots, 5)$$

(ii) Inefficiency is not random $H_{02}: = 0$
 where $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma^2)$

(iii) Inefficiency is not influenced by explanatory variables:

$$H_{03} : \partial_j = 0, j \geq 1, 2, \dots \dots \dots (12)$$

The Hypotheses were tested using the generalized likelihood ratio test defined by the test statistic which has a mixed chi-square (χ^2) distribution with the degree of freedom equal to the number of excluded parameters in the restricted model (Ogundari and Ojo, 2007, Bishop and Brander, 2003). The test statistics is given by

$$\chi^2 = -2[L(H_0) - L(H_a)] \dots \dots \dots (6)$$

The Translog and Cobb-Dougllass production frontier models were specified as shown:

$$\ln Y_i = \beta_0 + \sum \beta_j \ln(X_{ij}) + V_i - U_i \dots \dots \dots (7)$$

$$\ln Y_i = \beta_0 + \sum \beta_j \ln X_{ij} + \sum_j \sum_j \beta_{jj} \ln X_j \ln X_j + \frac{1}{2} \sum \beta_{jj} (\log X_j)^2 + V_i - U_i \quad (8)$$

Where:

Y_i = Quantity of crops produced by farmer i (Grain equivalent)/year

X_{ij} are input variables including:

X_1 =Land (ha) engaged in food crop production

X_2 = Level of hired labour engaged in food crop production (manday)

X_3 = Proportion of land area cultivated to improved crop variety

X_4 = Quantity of fertilizer input (kg)

X_5 = Quantity of pesticides used (Litre).

β_0 = Constant term

β_j = Vectors of parameters to be estimated

V_i and U_i are as defined earlier.

Although the initial exposition on Gamma functions (equation 9) specified the function as

$$\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma^2) \dots \dots \dots (9)$$

thereby equating gamma to the ratio of the variance of inefficiency to total residual variance. But rather than the variance of the inefficiency been equal to σ_u^2 as shown, Coelli *et al* (1998) gave the variance of the inefficiency as

$$\frac{[(\pi - 2)]\sigma^2}{\pi} \dots \dots \dots (10)$$

Consequently, the relative contribution of the variance of inefficiency to total variance is estimated as adjusted gamma given by

$$\frac{\gamma}{[\gamma + (1 - \gamma)\pi / (\pi - 2)]} \dots \dots \dots (11)$$

Also, following the choice of Translog and Cobb Douglass function which are self-dual, the dual cost frontier derivable algebraically is written in general form (Sharma *et al*, 1999; Ogundari and Ojo, 2006) as

$$C_i = h(P_i, Y_i^*, \alpha) + \varepsilon_i \dots \dots \dots (12)$$

Where ($\varepsilon_i = V_i + U_i$) $\dots \dots \dots (13)$

C_i represents the production cost of the i^{th} farm associated with farm's efficient output Y_i^* (i.e. farm's observed output adjusted for stochastic noise captured by V_i), P_i is the vector of input prices for the i^{th} farm and a are parameters to be estimated respectively while V_i and U_i are as earlier defined. In estimating the cost function, the specification of the composite is adjusted as shown in equation (13) to reflect the fact that inefficiency tends towards increasing cost consequent upon which the error term specification was changed from $(V_i - U_i)$ to $V_i + U_i$ to transform the production function into the cost function (Coelli, 1996) for estimation using Frontier 4.1 computer programme. Consequently, the farm

specific economic efficiency is defined as the ratio of minimum (C*) to observed production cost C (Ogundari and Ojo, 2006). In determining the economic efficiency of the farmers, equation (12) is estimated both for the Translog and Cobb-Douglass models but the test of the hypotheses on the appropriate functional form was in favour of the Cobb-Douglas model. The Translog and Cobb-Douglass models were specified respectively as:

$$\ln C_i = \beta_0 + \sum \beta_j \ln P_j + \sum \beta_j \ln Q_i^* + \frac{1}{2} \sum \beta_{jk} (\ln P_j)^2 + \frac{1}{2} \sum \beta_{jk} (\ln Q_j^*)^2 + \sum_j \sum_k \beta_{jk} \ln P_j \ln P_k + \sum_j \sum_k \beta_{jk} \ln Q_j^* \ln P_k + V_i + U_i \dots\dots\dots(14)$$

$$\ln C_i = \beta_0 + \sum \beta_j \ln P_j + \sum \beta_j \ln Q_i + V_i + U_i \dots\dots\dots(15)$$

Where

- C_i = Total Input cost for of the ith-farm/year
- P_{ij} = Per unit input price for input (j = 1, 2,5) such that
- P_{i1} = Wage rate per manday of hired labour
- P_{i2} = Average price of planting material/unit
- P_{i3} = Price per Kilogram of fertilizer
- P_{i4} = Price per litre of pesticides
- P_{i5} = Average unit price of equipment
- Q*_i = Crop output/year adjusted for stochastic noise (Grain equivalent)

Further to estimating the production and cost frontier models, the study also estimated production and cost inefficiency models simultaneously using Frontier 4.1 with explanatory variables as defined for equation 16 and 17 respectively. The inefficiency production and cost models are respectively of the forms;

$$U_i = \delta_0 + \delta_i Z_{ij} + W_i \dots\dots\dots(16)$$

$$\text{Exp}(-U_i) = \delta_0 + \delta_i Z_{ij} + w_i \dots\dots\dots(17)$$

Where:

- Z₁ = Sex (male = 1, female=0)

- Z₂ = Age of farmer (years)
- Z₃ = Farmer's years of education
- Z₄ = Extension contact (Yes =1, No =0)
- Z₅ = Use of tractor in land preparation (Used = 1, Not used = 0)
- Z₆ = Access to credit (Yes =1, No =0)
- Z₇ = Access to non-farm income (Yes =1, No =0)
- Z₈ = Proportion of total labour supplied by the family
- Z₉ = Crop Diversification Index (Herfindhal Index) measured as $HI = \sum_{i=1}^n P_i^2$

with P_i as the proportion of land area cultivated to a particular crop i. The value of Herfindhal index ranges between 0 and 1 with 0 denoting perfect diversification and 1 perfect specialization (Sanzidur, 2008).

- Z₁₀ = Soil Nutrient depletion index measured as $\frac{1}{n} \sum_{i=1}^n W_i T_i$ i = (1,2,.....n)

Where n =number of crops in combination per plot for farm i

- W_i = nutrient uptake weight attached to particular crop T_i: Root and tuber = 4, Cereals =3, vegetables =2 and legumes=1 (Udoh, 2000).

- Z₁₁ = Cropping Intensity Index (CII)
- Z₁₂ = Continuous Cultivation Intensity Index (CCII)

- Z₁₃ = Distance of farm to market (Average of distance to input and output market in Kilometers)

δ₀ = Constant term for the inefficiency model

- δ_i = Vectors of parameters to be estimated.
- W_i = the disturbance term.

The production and cost frontiers were estimated using maximum likelihood method as in the computer software FRONTIER version 4.1 (Coelli 1996). However, the Frontier 4.1 estimation of the

cost function gives U_i that measures how far a farm operates above the minimum (frontier) cost and is thus referred to as cost efficiency (Coelli 1996). The economic efficiency scores were obtained as the inverse of the cost efficiency scores obtained from Frontier 4.1 estimation following Ogundari and Ojo (2006). The maximum likelihood estimate of the Technical Efficiency (TE) and Economic Efficiency (EE) were then used to estimate the Allocative Efficiency (AE) of the farmers using the relation between Technical, Economic and allocative efficiencies (Bravo-Ureta and Evenson, 1994, Sharma *et al* 1999 and Ogundari and Ojo 2006) given as:

$$AE_i = \frac{EE_i}{TE_i} \dots\dots\dots(18)$$

The resulting efficiency scores were compared across agro-ecology and land use intensity categories using Anova. Also, given the predicted technical and economic efficiency scores, the potential maximum output intensity, potential cost saving and the potential minimum cost are given in equations 19, 20 and 21 respectively as:

Potential Maximum Output Intensity = $\frac{\text{Average Output}}{\text{Average Technical Efficiency}} \dots\dots\dots(19)$

Potential Cost Saving = $\left[1 - \left(\frac{\text{average Economic efficiency}}{\text{Full Economic efficiency}} \right) \right] \times 100 \dots\dots(20)$

Potential Minimum Cost = $\text{average cost} \times \text{economic efficiency} \dots\dots(21)$

Results and Discussion

Results of the stochastic frontier production and Cost functions

The descriptive of the variables included in the stochastic production, cost frontiers and inefficiency models are shown in Tables 1 to 3 respectively. The results of test of hypotheses concerning the appropriateness of the two proposed models are shown in Table 4. The first null hypothesis that the functional form is Cobb-Dougllass was accepted as the calculated Chi-square value (19.78) was less than the critical value (25.00). However, the second null hypothesis that the variation in output intensity among the farmers is not due to technical inefficiency differential such that OLS estimates would be sufficient to describe the data was rejected as the calculated Chi-square value (151.73) was greater than the critical value (12.59). Also, the third hypothesis that the explanatory variables in the inefficiency model have zero coefficients was also rejected as the calculated chi-square value (160.31) was greater than the critical chi-square value (22.36). Consequently, the Cobb-Douglas frontier inefficiency model was selected for further analysis and discussion of the farmers' technical efficiency. Similar results were obtained for the cost frontier function as shown in Table 4.

The Gamma estimate of the production frontier model (Table 5) shows that about 79.0% of the variation in output of the farmers is attributable to inefficiency. However, using the Coelli *et al* (1998) derivation, the relative contribution of farmers' inefficiency to total variance was estimated at 57.8% still showing that more of the variation in output of the farmers is attributable to difference in technical inefficiency. The LR test of the one sided

Table 1: Descriptive of Variables included in the Stochastic Production Frontier Model.

Variable	Mean	Standard Deviation
Output (kg/year)	5491.81	3841.84
Farm Size (ha)	1.75	1.04
Hired Labour (manday)	104.71	30.20
Proportion of Land Area planted to Improved Seed	0.68	0.40
Fertilizer use (kg)	169.53	574.41
Agrochemical use (lit)	1.29	3.31

Source: Computed from Field Data (2008)

Table 2: Descriptive of Variables included in the Stochastic Cost Frontier Model.

Variable	Mean	Standard Deviation
Total cost/ha/year	115,623.10	72,314.42
Labour wage (₦/persons day)	901.30	294.08
Seed price (₦/unit)	102.05	51.61
Fertilizer price (₦/kg)	48.14	7.25
Agrochemical price (₦/ L)	1039.06	156.92
Output (kg grain equivalent/ha/year)	5491.81	3841.84
Equipment price (₦/unit)	579.92	39.64

Source: Computed from Field Data (2008)

Table 3: Descriptive of Variables included in the Inefficiency Models.

Variables	Mean	Standard Deviation
Age (years)	54.02	10.06
Years of formal education	5.45	5.45
Proportion of family labour	0.27	0.27
Herfindhal Crop Diversification Index	0.19	0.19
Nutrient depletion index	0.48	0.48
Cropping Intensity Index	0.60	0.60
Continuous Cultivation Intensity Index	0.19	0.19
Distance of farm to market (km)	5.83	5.83

Source: Computed from Field Data (2008)

Table 4: Results of the Hypothesis Test on the Generalized Likelihood Ratio of the Stochastic frontier Functions

Hypotheses	DF	L(H ₀)	L(H _a)	Calculated χ^2 Value	Critical χ^2 Value	Decision
Production Function						
H ₀₁ : $\beta_{jk} = 0$	13	-44.90	-36.34	19.78	25.00	Accept
H ₂ : $\gamma = 0$	6	-120.77	-44.90	151.73	12.59	Reject
H ₀₃ : $\delta_j = 0$	13	-99.26	-44.90	108.71	22.36	Reject
Cost Function						
H ₀₁ : $\beta_{jk} = 0$	21	-215.13	-266.83	-103.40	21.00	Accept
H ₂ : $\gamma = 0$	7	-295.28	-215.13	160.31	14.06	Reject
H ₀₃ : $\delta_j = 0$	13	-295.29	-215.13	160.31	22.36	Reject

Source: Computed from Field Data (2008)

residual which is significant at ($P < 0.01$) implied that the maximum likelihood estimate of the frontier function is a significant improvement over the OLS estimates.

The estimates of the coefficients which imply elasticity of production of the respective factors showed that a 1% increase in hired labour and proportion of land area grown to improve varieties would increase output intensity of the food crop farmers by about 0.04% and 0.03% respectively. However, a 1% increase in land area cultivated to food crop would reduce output intensity by 0.05% especially in a situation whereby farmers are incapacitated to invest adequately in commensurate use of productivity enhancing and cost-effective technologies such as fertilizer and herbicides in the midst of scarcity and increasing wage rate to hired labour.

In addition, the results of the technical inefficiency model in Table 6 showed that technical inefficiency is significantly reduced among the farmers by access to credit and increase in soil nutrient depletion index. However, technical inefficiency of

the farmers is significantly ($P = 0.05$) aggravated by change in production system towards monocropping as implied by higher Herfindhal index, increased frequency of cultivation (CCII) and longer distance between farms and major input and output markets.

The results implied that increase in land area within the threshold of the prevailing technology has the tendency of decreasing output intensity of food crop but output intensity can be enhanced by increasing the use of hired labour and proportion of land area grown to improved crop varieties. Similarly, the results of the inefficiency imply that farmers' efficiency can be enhanced by improved access to credit facility and this is in accordance with the findings of Ogundari (2008). Improved access to credit promotes timely investment on farm operations and when such operations are carried out by farmers at the optimum period in the crop cycle, increased productivity may result.

However, the coefficient of nutrient depletion index is contrary to expectation even when the prominent crop combinations are those that have greater

Table 5: Results of the Cobb-Douglass Stochastic Frontier Production Functions

Production Function			
	Parameter	OLS Model	Stochastic Frontier Model
Constant	β_0	3.585(0.400)***	3.904(0.058)***
Log(lnd)	β_1	-0.051(0.042)	-0.049(0.014)**
Log(hrdlab)	β_2	0.028(0.011)**	0.037(0.009)***
Log(ImpSd)	β_3	0.012(0.013)	0.027(0.010)***
Log(Fert)	β_4	0.017(0.008)	0.007(0.007)
Log(Agrchm)	β_5	-0.015(0.011)	-0.008(0.009)
Sigma-squared	σ^2	0.121	0.167(0.041)***
Gamma	γ	0	0.79(0.065)***
Adjusted Gamma	γ^*		0.578
log likelihood function	LLF	-120.77	-45.69
LR test of the one-sided error	LR		151.73***

***Significant at $P < 0.01$, **Significant at $P < 0.05$. Values in parentheses are standard errors

Source: Computed from Field Data (2008)

Table 6: Determinants of Technical Inefficiency

Variables	Parameter	Estimates
Constant	δ_0	-0.142(1.34)
Sex	δ_1	0.004(0.127)
Age	δ_2	0.011(0.013)
Years of Education	δ_3	0.010(0.008)
Extension Contact	δ_4	0.162(0.130)
Use of Tractor	δ_5	0.042(0.093)
Use of Credit	δ_6	-0.269(0.114)**
Alternative Source of Income	δ_7	0.126(0.116)
Family labour proportion	δ_8	-0.279(0.191)
Herfindhal Index	δ_9	0.555(0.249)***
Nutrient Depletion Index	δ_{10}	-0.635 (0.135)***
Cropping Intensity Index	δ_{11}	0.117(0.098)
Continuous Cultivation Intensity Index	δ_{12}	1.312 (0.282)***
Distance of farm to market	δ_{13}	0.019(0.009)***

***Significant at $P < 0.01$, **Significant at $P < 0.05$. Values in parenthesis are standard errors

Source: Computed from Field Data (2008)

potential for soil fertility depletion alongside low level of use of fertilizer. This points to the ability of the prevailing soil fertility to compensate adequately to the yield depressing competition between component crop in the intercrops. In addition, reducing effect of shift towards monoculture on technical efficiency implies that farmers gain higher technical efficiency through intercropping thereby pointing to greater agronomic advantage of intercropping over sole cropping. However, the intercropping had to be accompanied by lower land-use intensity through longer fallow periods for greater technical efficiency as indicated by the aggravating influence of continuous cropping on technical inefficiency. However, the sustainability of this is in doubt considering the increasing trend on land scarcity.

The estimates of the frontier cost function (Table 7) shows that the estimated

Gamma function which is significant ($P < 0.01$) was 97.0% while the adjusted gamma estimate of 0.922 implied that 92.2% of the variation in cost incurred by farmers in food crop production was attributable to difference in cost inefficiency of the farmers. Similarly, the significant LR estimates for the one sided error attest to the improvement of the stochastic cost model over OLS estimates.

The estimates of the coefficients of the cost function showed that a 1% increase in wage rate paid to hired labour, price of hand tools, and efficient output intensity significantly increased cost incurred by the farmers in food crop production by 0.27%, 0.16% and 0.24% respectively. Also, the results of the inefficiency model in Table 8 showed that farmers' economic inefficiency was significantly aggravated by use of tractor, increase in family share of labour use; increase in frequency of cultivation of

Table 7: Results of the Cobb-Douglass Stochastic Frontier Cost Functions

Cost Function	Parameter	OLS Model	Stochastic Frontier Model
Constant	β_0	3.145(0.998)***	3.534(1.044)***
Wage to hired labour	β_1	0.176(0.109)	0.268(0.109)***
Planting Material Price	β_2	0.079(0.063)	0.108(0.062)
Fertilizer price	β_3	-0.383(0.240)	-0.177(0.235)
Chemical Price	β_4	0.218(0.215)	-0.382(0.244)
Equipment Price	β_5	0.199(0.064)***	0.203(0.064)***
Output	β_6	0.165(0.055)***	0.154(0.054)**
Sigma-squared	σ^2	0.071	0.054(0.005)***
Gamma	γ	0	0.970(0.279)***
Adjusted Gamma	γ^*		0.922
log likelihood function	LLF	-295.29	-215.13
LR test of the one-sided error	LR		102.08***

***Significant at $P < 0.01$, **Significant at $P < 0.05$, Values in parenthesis are standard errors

Source: Computed from Field Data (2008)

Table 8: Determinants of Economic Inefficiency

Inefficiency Model		
	Parameter	Inefficiency Estimates
Constant	δ_0	1.041(0.109)***
Sex	δ_1	0.064(0.068)
Age	δ_2	-0.003(0.003)
Years of Education	δ_3	-0.006(0.003)**
Extension Contact	δ_4	-0.026(0.043)
Use of Tractor	δ_5	0.092(0.033)***
Use of Credit	δ_6	-0.343(0.049)***
Alternative Source of Income	δ_7	-0.098(0.043)**
Family labour proportion	δ_8	0.077(0.030)***
Herfindhal Index	δ_9	0.417(0.077)***
Nutrient Depletion Index	δ_{10}	-0.108(0.098)
Cropping Intensity Index	δ_{11}	-0.017(0.033)
Continuous Cultivation Intensity Index	δ_{12}	0.250(0.100)**
Market distance	δ_{13}	0.007(0.003)**

***Significant at $P < 0.01$, **Significant at $P < 0.05$, Values in parenthesis are standard errors

Source: Computed from Field Data (2008)

arable land and longer distance between farm and market. However, economic inefficiency was significantly reduced by increase in years of formal education, use of credit, possession of non-farm sources of income and increased crop diversification (i.e. decreased Herfindhal index).

The results of the inefficiency model have further buttress the importance of formal education in enhancing the managerial capabilities and consequently the efficiency of farmers as has been widely established (Seyoum *et al*, 1998, Akintola and Udoh, 2004). Similarly, credence has been laid to the positive influence of improved access to investible fund through credit and income from alternative non-

farm sources. Zaibet and Dharmapala (1999) noted that farmers with off-farm activities tended to hire more labour available at low wages to compensate for the time they spent outside the farm, which tends to increase efficiency. However, the result undermined the complementary role that use of family labour is expected to play and possibly a pointer to the dwindling fortune of reliance on family labour by farming households.

The result has also justified the farmers' choice of intercrop as the dominant cropping system although such cropping system has been identified as limiting the potential for farm mechanization. This possibly explains the unexpected

Table 9. Descriptive of the technical, economic and allocative efficiency scores of food crop farmers

Estimates	Technical Efficiency	Allocative Efficiency	Economic Efficiency
Mean	0.765	0.628	0.463
Standard Deviation	0.147	0.180	0.112
Minimum	0.296	0.269	0.232
Maximum	0.952	1.00	0.884

Source: Computed from Field Data (2008)

aggravating effect that use of tractor had on the farmers' inefficiency. The scenario could also be attributed to the small and non-contiguous size of holdings which limits farmers' potential of benefiting from internal economies of scale derivable from mechanization. In addition, Seyoum *et al* (1998) suggested that the limiting influence of tractor usage on farmers' efficiency could be attributed to the unorganized tractor hiring system which often makes it difficult for farmers to get tractors timely for land preparation and consequently, most of the farm operations do not correspond to the cropping calendar especially for farmers who depend on rain.

Furthermore, the limiting effect of increased frequency of cultivation of arable land suggests that as fallow rotation gets shorter, (increased cultivation intensity) economic inefficiency increases among the farmers. Such practices when carried out at low level of use of soil fertility enhancing inputs is known to have depleting effect on land productivity. In addition, one of the evidence of declined soil fertility is weed invasion (Smith *et al*, 1994) and when such occurs, farmers are compelled to incur more labour cost on weeding which is often untimely in supply. In the midst of low level of use of herbicides, increasing cost of labour adds more to cost of production than

may be adequately compensated for through increase in output. The interactions of such factors constitute possible sources of economic inefficiency among the farmers.

The influence of distance as a measure of access to market has formed a major discourse on the potential of agricultural intensification. Although, the attendant causal influence on efficiency is two-way, the prominent concession is in favour of shorter distance facilitating closer access to input and output market. Other incentives offer by shorter distance include higher farm gate prices, greater access to credit facilities and capabilities to procure productivity enhancing technologies for increased efficiency (Smith *et al*, 1994; Bagamba *et al*, 2007).

Technical, Allocative and Economic efficiency of Food Crop Farmers

The descriptive of the Technical efficiency (TE), Allocative efficiency (AE) and Economic Efficiency (EE) scores of the farmers are presented in Table 9. The predicted average TE of the food crop farmers ranged between 29.6% and 95.2% with a mean of 76.5%. and standard deviation of 14.7%. The results imply that about 23% of the maximum output intensity from food crop production is lost to

Table 10: Comparison of the Technical, Allocative and Economic Efficiency Scores of Food Crop Farmers by Agro-ecology and Land use intensity Categories

Group	N	Technical Efficiency (%)	Allocative Efficiency (%)	Economic Efficiency (%)
Agro-ecology				
Forest	152	76.71(13.14)	63.37(16.75) ^a	47.35(11.49)
Derived Savannah	144	77.66(14.86)	60.57(17.21) ^a	45.03(8.47)
Southern Guinea Savannah	45	71.77(18.20)	68.18(22.88) ^b	46.99(16.76)
F. Statistic		2.82	3.24**	1.67
Land use intensity Group				
Low	17	74.05(13.30)	58.30(24.06) ^{ab}	41.54(15.01) ^a
Medium	49	81.85(10.87)	52.69(16.83) ^a	42.10(11.72) ^a
High	75	76.56(14.65)	63.98(17.46) ^b	47.42(11.34) ^b
Very High	200	75.31(15.41)	65.25(17.04) ^b	47.35(10.44) ^b
F. Statistic		2.85	7.25*	4.25*

*Significant at P<0.01, **Significant at P<0.05, Values in parenthesis are standard deviations

Source: Computed from Field Data (2008)

Table 11: Results of the Test of between-subjects Effect for Technical, Allocative and Economic Efficiency (Anova Table)

Source of variation	DF	MSS	MSE	F-Stat
Technical Efficiency				
Agro-ecology	2	0.02	0.01	0.54
Land use intensity Class	3	0.18	0.06	2.85**
Agro-ecology x Land-use Intensity	6	0.16	0.03	1.28
Error	329	6.91	0.02	
Corrected Total	340	7.3		
Allocative Efficiency				
Agro-ecology	2	0.04	0.02	0.66
Land use intensity Class	3	0.42	0.14	4.73*
Agro-ecology x Land-use Intensity	6	0.46	0.08	2.62**
Error	329	9.66	0.03	
Corrected Total	340	10.98		
Economic Efficiency				
Agro-ecology	2	0.02	0.01	
Land use intensity Class	3	0.12	0.04	0.74
Agro-ecology x Land-use Intensity	6	0.18	0.03	3.35**
Error	329	3.90	0.027	2.53**
Corrected Total	340	4.29		

*Significant at P<0.01, **Significant at P<0.05

Source: Computed from Field Data (2008)

inefficiency and consequently the farmers stand the opportunity of raising their TE by about 23%.

In absolute terms, given an average output intensity of 5,491.81kg/year of grain equivalent, the potential maximum output intensity was 7,178.84kg/year. This indicated that food crop farmers in the study area are experiencing a loss of potential output of about 1687.03kg/year (23.5%) due to technical inefficiency. The predicted AE scores of the farmers also averaged 62.8% with minimum and maximum value of 26.9% and 100% respectively thereby implying that average farmer in the study area still have the opportunity of raising their AE by about 37%.

The estimated average EE of the food crop farmers was 46.3% with minimum and maximum values of 23.2% and 88.4% respectively. Consequently, food crop farmers in South western Nigeria could improve their EE in food crop production by 53.7% so as to be economically efficient. Also, given the average economic efficiency of 46.3%, average farmers stand the opportunity of achieving a cost saving of 53.7% if they were to attain full technical and Allocative efficiency levels. Hence, given an estimated average total cost of N115,623.10 and the average economic efficiency estimate from the frontier cost function as 0.463, the potential minimum cost for the farmers in the study area is N53,533.50.

Technical, allocative and economic efficiency by agro-ecology and land-use intensity categories.

The comparison of the TE, AE, and EE scores across agro-ecologies and land use intensity categories in Table 10 showed that there was no significant difference in the

estimated average technical and economic efficiency scores of farmers across the agro-ecologies. However, the estimated average AE scores (68.2%) of farmers in the southern guinea savannah agro-ecology was significantly higher than the average AE score of farmers in the forest (63.4%) and derived savannah (60.6%) agro-ecologies respectively. The results also showed that the TE score of farmers who engaged their arable land under medium land use intensity (81.9%) was significantly higher than the TE of farmers in the low (74.1%), high (76.6%) and very high (75.3%) intensity categories respectively. Also, farmers who cultivated their arable land under high and very high land use intensity categories had AE scores of (64.0% and 65.3%) that were significantly higher than the AE scores of 58.3% and 52.7% estimated for farmers that cultivated their arable land to low and medium land use intensity categories respectively.

The results also shows that the EE of farmers who cultivated their arable land under high (47.4%) and very high (47.4%) land use intensity were significantly higher than the economic efficiency scores of farmers that cultivated their arable land under low (41.5%) and medium (42.1%) land use intensity respectively. Generally, food crop farmers who cultivated their farmland to high and very high land use intensity were significantly more efficient than farmers who cultivated theirs under low and medium land use intensity respectively.

However, the results of the test of between subject effects (Table 11) attributed a larger part of the variations in technical, allocative and economic efficiency scores of the farmers significantly to the separate influence of

land use intensity categories and the interaction between agro-ecology and land use intensity category. The lack of variation in the technical and economic efficiency of the farmers across the agro-ecologies is indicative of the homogeneity of the farmers as regards input combination and crops response to input level across the agro-ecologies. However, the comparison across land use intensity categories showed that technical efficiency decreased with increase in land use intensity whereas allocative and economic efficiency increased as farmer attained higher level of land use intensity.

The decrease in technical efficiency arises from reduction in yield due to depletion in soil fertility when increased intensity is accompanied by low level of use of fertilizer or inappropriate crop combinations and production practices. However, increased land use intensity under shortened fallow can reduce weed intensity and this can result in substantial reduction in cost of land clearing. Similarly, increased land use intensity under land scarcity can make farmers to be more conscious of the economic gains from optimal combination of resources relative to their prices. This is usually the case when farmers have to support the increase in land use intensity with fertility maintaining and cost –effective purchase inputs such as fertilizers and agrochemicals without compromise to the cost effectiveness of such decisions. The economic efficiency of such decision is enhanced when substantial decrease in cost is attained with the use of existing technologies without necessarily applying new technologies. (Bravo-Ureta and Pinheiro, 1997, Gautam *et al*, 2012).

The significant contribution of land use intensity level and the interaction between ecology and land use intensity

category to variations in the technical, allocative and economic efficiency suggests that policy recommendation targeted at increasing overall efficiency of the farmers should consider the specific land use intensity scenario under each agro-ecology. Hence, this implies that farmers in the derived and southern guineas savannah agro-ecologies that engaged arable land under very high intensity stand the chance of attaining greater efficiency and consequently higher potential for growth in food crop production through greater allocative and economic efficiency.

Conclusion

The study shows that it is not economically efficient for farmers to rely on family labour while shortened fallow period has the potential to aggravate inefficiency in food crop production. However, the results show the positive influence of farmers' years of formal education, use of credit, possession of non-farm sources of income and increased crop diversification on overall efficiency (economic efficiency) of the farmers. If farmers are to increase their economic efficiency, there is need for them to engage more hired labour which has the potential of guaranteeing timely conduct of farm operations for improved productivity. This however requires timely and sufficient access to fund possibly through improved access to credit and income from other sources. The fact that use of tractor did not impact significantly on technical efficiency and hinders economic efficiency is traceable to the small size of plots thereby pointing to the need for incentives that could encourage increased size of farm plots by farmers.

The positive influence of mixed cropping on efficiency of the farmers shows the comparative advantage of intercropping

over sole cropping. However, this has to be accompanied by appropriate fallow rotation pattern that allows for soil nutrient replenishment through longer fallow than already being practiced by the farmers. This may no longer be feasible considering the prevailing increased pressure on land. The option is gradually giving way for agricultural intensification built on appropriate type, quality and quantity of modern input for greater and sustainable production. However, improved access to market can be enhanced through improvement in input distribution system and the conditions of the rural road towards making the input and output markets more accessible to farmers.

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