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Intensive Land Use and Efficiency of Food Production in Southwestern Nigeria

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Abstract: Declining agricultural production on some tropical farmland has prompted increased use of some inputs while continuous cropping prevails. This study analyzed the effect of intensive use of land on technical efficiency of farmers in Southwestern Nigeria. Data collected randomly from 303 selected farmers in 3 states. Results show that farmers from Osun State have the highest indices of intensification with respect to land use intensity, fertilizer use intensity and crop diversification. The Maximum Likelihood Estimates (MLE) of the frontier production function showed that the farmers are grossly inefficient. The parameters of chemical fertilizer and land areas are statistically significant ($p<0.01$) while the coefficient of land area is with the highest elasticity of 0.265. Average technical efficiency is 24.78%, which portrays low agricultural productivity. Intensity of land use, at the present level reduces inefficiency possibly due to adoption of some soil conservation practices like application of fertilizer. The crop diversification parameter implies that as increasing crop specialization reduces farmers' level of inefficiency. Use of mulching and organic manure significantly increases inefficiency. It was recommended that in the face of increasing land degradation, farmers' access to effective soil conservation technologies must be increased in order to increase food production efficiency.

Key words: Intensive land, MLE, diversification, conservation, fertilizer, Nigeria

INTRODUCTION

The use of land for agricultural production remains one of the strongest influences affecting environmental quality in many developing countries. Practices like unguided application of agrochemicals, bush burning and mechanized land cultivation affect the quality of soil and vegetative covers (Scherr, 1999). Policymakers are now confronted with the challenges of increasing agricultural production to feed a rapidly growing population and finding a way of stimulating economic growth and reduce poverty, while the issue of natural resource degradation requires an urgent attention. Although these goals cannot be abandoned, the welfare of future generations is seriously threatened because resources are not managed in a way that ensures sustainability (Vosti, 1992; Vosti, 2001).

The gravity of this problem for many developing countries can be well conceptualized if one realizes that agriculture is the principal engine for economic growth and development and it is the main source of livelihood for the rural poor (Malik, 1998). Therefore, given the projections of population growth, agricultural land expansion and agricultural intensification in the next few decades, there exists a serious conflict between the goals of environmental protection and sustainable food production (Pinstrup *et al*., 1997; Scherr, 1997).

The problems of environmental degradation and low resource productivity in many developing countries are closely interrelated (World Commission for Environment and Development-WCED, 1987). Because of increased population pressure, the long time needed for regenerating natural resources once degraded and persistent economic hardship in many African nations, natural resource degradation is a common phenomenon among the poor, as they try to escape the scourge of poverty. Farmers face the consequences of land degradation and are implicated in some of its processes. Therefore, they are key players in promoting unsustainable agricultural intensification, expansion of farming into marginal lands and over-exploitation of forest resources. However, because they lack sufficient asset base to cushion its effects, the poor farmers are more seriously affected by the consequences of environmental degradation (Scherr, 1999).

In Nigeria, persistent stagnation in agricultural production is now a matter of serious concern. Although outputs in some crops have recently increased, it had been realized that most of these increases resulted from increase in land areas cultivated (Falusi, 1997). Increasing crop production is therefore putting a lot of pressure on the forest and this may not be sustainable as population further increases. Economic policy makers in Nigeria are concerned, because the need to ensure adequate management of land becomes crystal clear from the fact that, despite that Nigeria becomes highly dependent on oil revenue since the 1970s, agricultural land remains the most important long term resource base for the direct and indirect support of plants and animals which man uses (NEST, 1991). Therefore, given the several forms of environmental degradation, the general consensus is that, for any meaningful economic growth and development to be experienced, Nigeria needs to first and foremost address widespread poverty, especially among its rural populace.

This study intends to find the effect of agricultural intensification on food production efficiency in the southwestern part of Nigeria. The key question to be answered is that does the process of agricultural intensification positively influence efficiency of food production and can this be sustained if further intensification continues? Provision of answers to these questions will assist food policy makers to determine the ways of ensuring increased food production in Nigeria.

Theoretical concepts: Intensive agricultural production can be expressed as increase in the use of inputs of labour or capital on a smallholding in order to increase output per hectare (Tiffen *et al.*, 1994). FAO (2004) submitted that agricultural intensification can be defined as an increase in agricultural production per unit input of labour, land, time, fertilizer, seed, feed, or cash. It was also noted that intensification that takes the form of increased productivity of inputs is necessary when there is need to expand the food supply due to population growth and that which takes the form of a more efficient use of inputs may be more critical when environmental problems or social issues are involved. Intensification as applied to this study focuses on the former approach.

Land use intensity, which measures the allowance farmers give their farmland to fallow is a widely used indicator of intensification (Ruthenberg, 1980; Okike *et al.*, 2001). Okike *et al.* (200I) noted that labor use intensity, manure use intensity, fertilizer use intensity and intensity of animal traction are other indicators that could be used. It is observed that some Nigerian farmers resolve to continuous cropping as family size increases and agricultural land becomes scarcer. There may also be an increase in the use of seeds where agricultural extension officers are not readily available to give specification about crop spacing. In practice, therefore, the intensification process in Nigeria results from an increase in gross output in fixed proportions due to proportionate expansion in inputs without any technological change (Okike *et al.*, 2001).

The induced innovation concept of Boserup (1965) asserts that increasing population stimulates increasing demand for agricultural products. Therefore, as land becomes more costly compared to labour, incentives emerge for more intensive, yet sustainable land management in order to reap the benefits of the enlarged market opportunities. Also, Cleaver and Schreiber (1994) hypothesized that poverty, over population and land degradation create a self-reinforcing downward spiral leading to land degradation and increasing poverty. This is because the process of soil mining triggers soil erosion and results into decline in land productivity (Scherr, 1999).

Scherr (1999) noted that both the downward-spiral and induced innovation scenarios have been reported under different situations (Pender, 1998). Cases of the downward spiral were described by Durning (1989), Lopez (1998) and Ram *et al.* (1999). Also, induced innovation had been reported by Leach and Mearns (1996), Mortimore and Adams (1999), Templeton and Scherr (1999), Tiffen (2002) and Tiffen and Mortimore (2002). A comparison of the downward spiral and induced innovation reveals that outcome is largely dependent on how well a society adapts to rapid population growth, globalization, market development, technological change, climatic change and agro-ecological conditions (Lele and Stone, 1989; Kuyvenhoven and Ruben, 2002; Mortimore and Harris, 2004).

MATERIALS AND METHODS

The study area and sampling procedures: The study was carried out in Southwestern part of Nigeria. Specifically, the States involved were Oyo, Osun and Ekiti. These States enjoy tropical climate with two distinct seasons- rainy season from April to October and dry season from November to March. The traditional practice of slash and burn agriculture predominates and this is expected to be followed by a period of fallow for the soil to regain the lost fertility.

In Oyo State, 2 local government areas (Akinyele and Lagelu) were randomly chosen. A total of 120 questionnaires were administered out of which only 100 were good for inclusion in the final analysis. In Ekiti State, a total of 110 were randomly administered to farmers selected from 2 Local Government Areas (LGAs). The selected local government areas were Ikole and Ado Ekiti. Out of the questionnaires administered, only 100 were also good for inclusion in the final analysis. In Osun State, a total of 120 questionnaires were administered in 2 randomly selected local government areas. The selected LGAs were Obokun and Ife Central. Out of the administered questionnaires, 103 were good for inclusion in the final analysis.

Descriptive methods of data analysis: The study employs the use of descriptive analytical methods like percentage, mean etc. for the description of the indicators of agricultural intensification. Specifically, Land Use Intensity of ith farmer (LUI_i) is measured as the modified Rutherberg's index (Rutherberg, 1980).

$LUI_i = A_i / L_i$ with A_i = Number of seasons the land was cultivated by ith farmer, L_i = Total number of seasons land would have been cultivated if under continuous cropping.

CDI_i = Crop Diversification Index measured by the Herfindal Index which is

$$\sum_{i=1}^{13}\left(\frac{Ci}{\sum_{i=1}^{13} Ci}\right)^2$$

with C_i being the area of land planted to ith crop.
FUI_i = Fertilizer Use Intensity (fertilizer applied/land area sq mt)
LUI_i = family labour use intensity (number of family labour (man day)/land area (ha)

Production and inefficiency models: The modeling and estimation of stochastic frontier production functions, originally proposed by Aigner *et al.* (1977), Battesse and Corra (1977) has been an important area of economic study in the last few decades. The linear convex hull approach to the estimation of production frontier was proposed by Farrel (1957). More specifically, he distinguished between technical and allocative efficiency and this kindled interest in the measurement of economic efficiency. The stochastic frontier developed by Coelli (1994) is one of the available and most widely used methods. Generally, measurement of efficiency is advantageous because it accounts for the presence of measurement errors in the production and exogenous factors that could have been beyond the control of the production unit, in addition to the efficiency components. The model estimated in this study can be stated as:

$$\ln Zi = ß_0 + ß_1 \ln FLi + ß_H \ln HL_i + ß_3 \ln FC_i + ß_4 \ln LD_i + (v_i - u_i) \quad (1)$$

$$v_i \sim N(0, s^2 v)$$

Where:
ln = Natural logarithm.
Z_i = Grain equivalent of farmers output computed from Olayemi.
Ld_i = Land area cultivated by ith farmers (ha)
Fl_i = Family labor used by ith farmer (man-day)
Hl_i = Hired labor used by ith farmer (man-day)
Fc_i = Fertilizer /chemical inputs by ith farmer (kg)
v_i = Symmetry error
u_i = Inefficiency

The inefficiency model can be stated as follows:

$$|u_i| = \alpha_0 + \alpha_1 CDI_i + \alpha_2 LUI_i + \alpha_3 DMC_i + \alpha_4 DCR_i + \alpha_5 DOM_i + \alpha_6 DCC_i + \alpha_7 DED_i + z_i \quad 6$$

where:
$|u_i|$ = Inefficiency of ith farmer
DED_i = Dummy for Education (formal education = 1, otherwise = 0)
DMC_i = Dummy for using Mulching (Yes = 1, otherwise = 0)
DOM_i = Dummy for using Organic Manure (Yes = 1, otherwise = 0)
DMT_i = Dummy for using Minimum Tillage (Yes = 1, otherwise = 0)
Other variables are as defined in Eq. 1
v_i = Error term

RESULTS AND DISCUSSION

The results in Table 1 shows that 91.75% of the house heads in all the States are male. Average age highest in Ekiti State with 54.17 years, while all the farmers have an average of 52.83 years. In like manner, average farming experience is highest in Ekiti State with 31.17 years while farmers from all the states have an average of 28.75 years. Ekiti State records the highest average household size of 7.19 persons, while Osun State records the highest percentage of 57.28 being formally educated.

The upper segment of Table 2 shows the indices of agricultural intensification. Results show that land use intensity is highest in Osun State with 95.43%, while Ekiti State has the lowest (51.20%). The 3 States have an average land use intensity of 71.09%. This shows that continuous cropping is most predominant among farmers from Osun State.

Table 1: Some socio-economic variables of the farm households in Southwestern Nigeria

Variable	Oyo State	Ekiti State	Osun State	All States
Total number of households	100	100	103	303
Male farmers (%)	96.00	92.00	87.37	91.75
Age of house head (mean)	50.22	54.17	54.06	52.83
Years of farming (mean)	26.69	31.17	28.42	28.75
Household size (mean)	6.68	7.19	6.74	6.87
Formal education (%)	52.00	57.00	57.28	55.44

Table 2: Agricultural intensification indices and use of some cultural practices in Southwestern Nigeria

Variable	Oyo State	Ekiti State	Osun State	All States
Index of Intensification Land use intensity (mean)	65.90	51.20	95.43	71.09
Crop Diversification (Mean)	18.48	43.19	68.19	43.53
Fertilizer use intensity (kg sq^{-1} meter)	0.0070	0.0056	0.0092	0.0073
Labour use intensity (family) (man day per hectare)	31.22	31.90	27.03	29.75
Labour use intensity (hired) (man day per hectare)	16.94	18.15	26.19	20.23

Also, using crop diversification as index of agricultural intensification, the indices were computed. The crops planted were maize, tomatoes, leafy vegetables, okro, melon, cassava, cocoyam, plantain/banana, pepper, soybean, yam and cowpea. Farmers from Osun State have the highest output diversification index of 68.19%, while Oyo State has the lowest (18.48%). Average output diversification for the 3 States is 43.53%.

Intensity of fertilizer use is another form of agricultural intensification. The analysis reveals that Osun State farmers have the highest (0.0092), while Ekiti State has the lowest (0.0056). It can be deduced that allowance for fallowing as shown by land use intensity decreases where fertilizer usage is high. Intensity of fertilizer use is an average of 0.0073 kg m^{-2} for all the 3 States.

Farmers from Ekiti State have the highest family labour use intensity (31.90 man-day per hectare), while those from Osun State have the lowest (27.03 man day per hectare). However, Osun States farmers have the highest hired labour use intensity (26.19 man-day per hectare), while Oyo State farmers have the lowest (16.94 man-day per hectare).

Food crop production and efficiency: The summary statistics of some quantitative variables used to estimate the Maximum Likelihood Estimation (MLE) of the production function are contained in Table 3. The table clearly reveals that average farm size for food crop is low (0.13 ha). The farmers were also using more of family labor than family labour. An average of 0.38 kg of fertilizer was applied per farmer on the farmland cultivated. This quantity is too low and may not support the current intensification process without the development of better soil conservation practices.

Table 4 shows the Maximum Likelihood Estimates (MLE) of the frontier production function specified as Eq. 2, given the specifications of the inefficiency relationship expressed as Eq. 3. The diagnostic statistics reveal that the efficiency effects jointly estimated with the production frontier function are not simply random errors. The gamma is the ratio of the errors in Eq. 2. If $\gamma = 0$, inefficiency is not present and if $\gamma = 1$, there is no random noise. The estimated value of γ is 0.0.9999 and it

Table 3: Summary statistics of variables

Variable	Mean	Standard deviation
Food output (grain equivalent)	304.78	67.75
Family labor (man day)	42.31	27.86
Hired labor (man day)	3.82	3.64
Fertilizer/chemicals (kg)	0.38	0.36
Land (ha)	0.13	0.34
Crop diversification index	43.53	25.49
Land use intensity	71.08	22.78

Table 4: Maximum Likelihood Estimates (MLE) and determinants of efficienc

Variable	Parameters	T-ratio
Constant	4.354	31.69*
Family labor	0.080	0.928
Hired labor	0.121	1.679***
Chemicals fertilizer	0.191	7.081*
Land area	0.265	3.707*
Inefficiency model		
Constant	2.546	16.99*
Crop diversification	-0.908	-8.040*
Land use intensity	-0.865	-8.772*
Mulching	0.0856	2.017**
Crop Rotation	-0.108	-1.753***
Organic manure	0.131	1.766***
Cover crop	-0.026	-0.436
Education	0.025	0.606
Diagnostic statistics		
Sigma squared	0.1620	7.081*
Gamma $\gamma = \sigma_u^2/(\sigma_u^2 + \sigma_v^2)$,	0.9999	12.31*
$\gamma^* = \gamma/[\gamma+(1-\gamma)\pi/(\pi-2)]$	0.9997	
Log likelihood	-153.52	
LR test	134.11	
N = 217		
Average technical efficiency	24.78	

Note: * Statistically significant at 1% level, ** Statistically significant at 5% level, *** Statistically significant at 10% level

is statistically significant ($p<0.0001$) This confirms that the farmers are grossly inefficient. The parameter of gamma is not the same as the ratio of the variance of the efficiency effects to the total residual variance because the variance of u_i is equal to $[(\pi-2)/\pi]\sigma^2$ not σ^2. The relative contribution of the inefficiency effect to the total variance term is measured by γ^* (Coelli *et al.*, 1998). Therefore, the corresponding variance-ratio parameter γ^* implies that 99.97% of the differences between observed and the maximum frontier output for the food crop farmers is due to the existing differences in efficiency levels among them. Also, the generalized likelihood ratio test reported in Table 4 is highly significant. This suggests the presence of one sided error component and implies that the effect of technical inefficiency is significant and a classical regression model of production will be inadequate for the model.

The elasticity coefficients are presented in the upper segment of the table. These show that the parameters of chemical fertilizer and land areas are statistically significant ($p<0.01$), while hired labour show statistical significance at $p < 0.10$. The coefficient of land area is with the highest elasticity of 0.265. This is followed by that of chemical fertilizers (0.191) and hired labour (0.121). Increasing the land area cultivated by 1% will result in

Table 5: Distribution of farmers' efficiency in rainforest belt of Nigeria

Range of efficiency	Frequency	Mean
<0.20	147	0.1399
0.20 < 0.40	115	0.2784
0.40 < 0.60	29	0.4699
0.60 < 0.80	9	0.6747
0.80-1.00	3	0.9354
State		
Oyo	0.1684	
Ekiti	0.1658	
Osun	0.4045	
ANOVA F value	82.196	

0.265%. The likely reason may be expansion of land into marginal land and inability to secure fertile land by these farmers. Increasing the use of fertilizers by 1% would only lead to about 0.191% increase in the output. This could be so because most of the farmers do not have access to the input on a timely basis and those using it may not use the required quantities due to higher price and scarcity. In some cases, degraded land may not be able to promptly respond to fertilizer use due to over-depletion of the soil nutrients. In this case, output may not so much increase. The inefficiency equation reveals that crop diversification, land use intensity, use of mulching, crop rotation and addition of organic manure have statistically significant effect of farmers' level of inefficiency ($p<0.10$). Average technical efficiency is 24.78%, which portrays low agricultural productivity. Okike *et al.* (2001) computed 61.98 and 77%s respectively for some regions of Nigeria. Intensity of land use, at the present level reduces inefficiency. The crop diversification parameter implies that as increasing crop specialization reduces farmers' level of inefficiency. However, the use of mulching and organic manure significantly increases inefficiency. This may result from inability of organic manure to promptly supply soil nutrients in cases where soil degradation had taken place. However, the use crop rotation reduces inefficiency possibly due to replenishment of soil nutrients as leguminous crops are being grown interchangeably on a plot of land.

Table 5 presents the distribution of farmers' efficiency. The least efficient farmer has efficiency of 3.0%, while the most efficient has 99.99%. Distribution of efficiency groups reveals that 86% of the farmers have efficiency level less than 40%. The table further shows that average efficiency level in Osun state is highest while the lowest is from Ekiti State. The single factor ANOVA reveals that the mean efficiency values are significantly different ($p<0.001$) between the States.

CONCLUSION

Agricultural intensification in southwestern part of Nigeria will continue to increase due to scarcity of fertile arable land and decline in fallow periods. This study investigates the intensification processes in the use of land and labor and concludes that farmers are overexploiting the land nutrients by using continuous cropping and the agricultural production process is somehow labor intensive. This study found that elasticities Elasticities of production inputs in the MLE are too low since farmers were already operating at decreasing return to scale. Farmers would therefore need an upward shift in technology in order to substantially increase output given their input levels. Expansion in land and use of more labor would not help much, more so that most agricultural land expansion is on marginal land. The analysis revealed that Ekiti State farmers are least efficient than their counterparts from Oyo and Osun States. Special attention should therefore be given to these farmers in order to boost their productivity.

Therefore agricultural intensification in south-western part of Nigeria will continue to increase due to scarcity of fertile arable land and decline in fallow periods. This study investigates the intensification processes in the use of land and labor and concludes that farmers are overexploiting the land nutrients by using continuous cropping and the agricultural production process is somehow labor intensive. The onus rests on stakeholders in the agricultural industry to stand to the challenges in order to foster sustainable agricultural production and address hunger and poverty in Nigeria.

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