Sustainable Land Management Practices and Profit Efficiency of Maize and Cassava in Nigeria: Evidence from Ogun State

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Abstract

The management of land resource is imperative to achieve sustainable food production and development and to ensure agricultural sustainability, as highlighted in the millennium development goals. This study assessed the effect of Sustainable Land Management Practices (SLMP) on efficiency of production of maize and cassava in Ogun State, Nigeria. Multi-stage sampling technique was adopted in selecting 388 respondents for this study. Information collected covered farmers" socio-economic characteristics, inputs and output values and specific SLMPs used. The SLMPs studied included Structural and Mechanical Erosion Control (SMEC), Agronomic Practices (AP), Cultivation Practices (CP) and Soil Management Practices (SMP). Data were analyzed using descriptive statistics and the stochastic frontier profit function. The farmers had an average of nine years of formal education, 54% participated in Community Based Organizations (CBOs), 91% had access to extension education, 55% had land tenancy security and 81% favoured the use of AP more than other SLMPs. About 47% of the farmers cultivated undulating farmlands which were vulnerable to degradation. In maize production, a percentage increase in the use of SMEC, AP and CP reduced profit inefficiency by 2.37%, 0.44% and 0.21% respectively. Similarly, in cassava production, a percentage increase in the use of SMEC, AP and CP reduced profit inefficiency by 1.06%, 1.25% and 0.55% respectively. Other factors which reduced profit inefficiency in maize and cassava production included farmers" experience in farming, their access to extension services and credit facility, years of formal education, participation in CBOs and government initiated programmes. Overall results from this study show that the adoption of SLMPs contributes significantly to the reduction in profit inefficiency.

Key Words: Land Management, Profit Efficiency, Nigeria

INTRODUCTION

Land is a critical input in agricultural production. With approximately 98 million hectares of land, it is obvious that Nigeria is abundantly endowed. However, land degradation has made several parcels of land uncultivable (Babalola, 2012). Over 10 percent land mass in most parts of Nigeria is wasted by erosion (Elumoye, 1991). The annual monetary value of lost production through land degradation can be as high as $65 million (Ezeaku & Davidson, 2008). Loss of valuable agricultural land results in dwindling food supply and therefore calls for adoption of Sustainable Land Management Practices (SLMP). SLMP is the adoption of land use systems that, through appropriate management practices, enables land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources (FAO, 2009).

Various soil conservation and land management practices have been employed in Nigeria to reverse the ugly trend of land degradation. However, most of them have not yielded the expected results (Fameso, 1992). The reasons for this low performance could be traced to the nature of soil conservation technologies introduced (Anande-Kur, 1986) and socioeconomic conditions of the users of the technologies among other factors (Jansen *et al.*, 2006). World Bank Review (2006) highlighted the need to reduce or even reverse natural resource degradation in order to ensure continued and profitable food production. Projected reductions in crop yields as a result of land degradation in Sub-Saharan African countries, such as Nigeria could be as much as 50 percent by 2020, while crop net revenues could fall by as much as 90 percent by 2100 (Woodfine, 2009). This will inevitably affect food security adversely.

The quality of land is a major determinant of its productivity, therefore, an understanding of the quality use and management interaction of land as well as attitudes towards management is necessary for sustainability of the resource and sustainability in food production. It is against this background that this study analyzed the effects of SLMP on crop profit efficiency in Ogun State, Nigeria and tested the hypothesis that farmers' characteristics and land management practices do not significantly influence profit efficiency of crop production.

The efficiency analysis of a production or service unit refers to the comparison between the outputs and inputs used in the process of producing a product or service. Efficiency can be measured with respect to maximization of output, minimization of cost or maximization of profits. Farrell (1957) divided efficiency measurement into two components: technical efficiency (TE) and allocative efficiency (AE). He defined technical efficiency as a firm's ability to obtain maximal output from a given set of inputs and allocative efficiency as a firm's ability to use inputs in optimal proportions, given their respective prices and production technology. Farrel opined that the combinations of two components will produce overall economic efficiency (OE).

The use of the stochastic function, originally proposed by Aigneir *et al.* (1977) has proved successful in measuring efficiencies. Hence, this study adopted the stochastic model in estimating the profit efficiencies for maize and cassava production in the study area.

MATERIALS AND METHODS

The study was carried out in Ogun State of Nigeria. Ogun State is located in the South-Western part of Nigeria. It lies within latitude 6^{O}N and 8^{O}N and longitude 2^{O}E and 5^{O}E. It has a land area of about 16,762 square kilometers and a population of about 3,728,098 (NBS, 2007), which is approximately 2.70 percent of Nigeria's population. Farming is the major occupation of the people, particularly those living in the rural areas. The climate favours the production of arable crops such as maize, yam, cassava, rice, cocoyam and tree crops like kola nuts, cashew and oil-palm. There are twenty local government areas in the state.

A structured questionnaire was used to collect data for this study. The multi-stage sampling method was used to select the respondents. Ten local governments were eventually used for the study. Two villages were randomly selected from each of the selected local government areas and twenty farmers growing cassava and maize were sampled from each giving a total of four hundred farmers. Descriptive statistics of frequencies and percentage distribution were used to describe the socio-economic characteristics of the respondents and the Stochastic Frontier Profit Function (SFPF) was used to determine the factors influencing farmers' profit efficiency. The Cobb-Douglas (C-D) functional form was chosen for its popularity in estimating farm efficiency. The maximum likelihood estimate of the parameters in the Cobb-Douglas stochastic frontier production function is specified as:

$$\ln \pi' = \alpha_0 + \sum_{i=1}^{5} \alpha_i \ln p_i + \sum_{i=1}^{2} \alpha_i \ln z_i + vi - ui \quad \text{..} \quad (1)$$

where: $u_i = \delta_0 + \sum_{d=1}^{11} \delta_d w_d + \vartheta$ (2)

π' restricted normalized profit computed for jth farm defined as gross revenue less variable costs divided by farm specific output price p_j.

Ln = natural log; p_i = price of variable inputs normalized by price of output where (for i =1, 2, 3, 4 and 5) so that:

p_1 = the cost of hired labor normalized by price of maize/cassava (p_y)

p_2 = the cost of fertilizer normalized by price of maize/cassava (p_y)

p_3 = the cost of herbicide normalized by price of maize/cassava (p_y)

p_4 = cost of planting materials normalized by price of maize/cassava (p_y)

p_5 = imputed cost of family labour normalized by price of maize/cassava

z_i = the quantity of fixed input (i = 1, 2) where :

z_1 = land under cultivation for each farm j

z_2 = capital used in farm j (sum of total cost of hoes and cutlasses etc. The items were assumed to be used up in one production year therefore no depreciation is necessary).

u = inefficiency variable

ϑ = truncated random variable

δ_0 = constant term in equation 2

w_d = variables explaining inefficiency effects and are defined as follows:

w_1 = use of SMECP; w_2 = use of AP; w_3 = use of SMP

w_4 = use of CP; w_5 = tenancy security; w_6 = farming experience

w_7 = extension service; w_8 = years of education; w_9 = access to credit

w_{10} = CBO; w_{11} = participation in government program

α_0, α_i, δ_0 and δ_d, are the parameters to be estimated.

RESULTS AND DISCUSSION

Farmers' Characteristics and Farm Practices

Results in Table 1 shows that the average age across the study area was 50 years. This has implication on available farm labour, productivity and the ease with which improved agricultural practices are adopted. The average year of education of the farmers was 9 years showing that literacy level is rather low in this area and could negatively influence their participation in development programmes, adoption of innovations and production efficiency (Fawole & Fasina, 2005). The average household size among the farmers was 8. The household size among the farmers was on the high side judging by the state's average of approximately 6 and national average of approximately 5 (NBS, 2007). Although, this may imply higher availability of family labour, large household size has been reported to be a determinant of food insecurity and poverty of households especially in Nigeria (Ajani, 2005).

Farmers' year of experience in farming is expected to increase quality and quantity of output by reducing pre-harvest and post-harvest losses, increase use of conservation technologies and increase efficiency of the farmers. It is even more important among farmers with low literacy level. The result in Table 1 shows that the average years of farming experience in the study area was 24 years indicating a high potential for increased productivity among farmers, if they are adequately supported and motivated. Furthermore, the farmers reported that they used their current land for production, on the average, for 10 years. The more years a farmer puts to cultivating a particular parcel of land could influence efficiency in production and the choice of SLMP used (Awoyinka *et al.*, 2009). It also has a lot of implications on the tenure system in place in the study area.

The results as presented in Table 2 show that 54% of farmers belong to one form of CBO or the other. The most prominent CBOs are the farmers' cooperative societies. These results are consistent with the findings of Awoyinka *et al.* (2009) and Jagger and Pender (2003).

Table 1. Socio-economic characteristics of respondents

Variables	Study Area (n= 338) Freq
Age (mean)	*50*
S.D.	10
Min	25
Max	80
Years of Education(mean)	9
S.D.	4
Min	0
Max	16
Household Size (mean)	8
S.D.	3
Min	2
Max	20
Years of farming experience (mean)	24
S.D.	12.7
Min	2
Max	65
Years of farming current land(mean)	10
S.D.	9.3
Min	1
Max	45
Access to credit facility	
Access	91
No access	24

Source: Field survey, 2011

Results in Table 2 reveal that farmers had a good level of participation in such programmes across the state (66% had participated). Participating in SLMP programes has positive influence on eventual adoption of SLMP by farmers. Further examination showed that the major types of LMP-related programme that the farmers had participated in were those initiated by the Agricultural Development Project (ADP) (35%). About 91% of the farmers had access to extension service. The extension agents visited the farmers, on the average, twice a month and the quality of extension service, as reported by 79% of the farmers, was excellent.

Table 2. Institutional characteristics of farming households

Institutional Factors	Study Area (n= 338)	
	Freq	%
Membership of farming org		
Yes	182	54
No	156	46
Major LMP related Programme Participated in		
None	115	34
ADP initiative	117	35
FADAMA	61	18
NGO initiative	45	13
Contact with Extension Agents		
Yes	306	90.5
No	32	9.5
Number of ext. visit per month (mean ±STD)	2(±1.77)	
Quality Ranking of Extension Services		
Poor	29	8.6
Fair	43	12.7
Excellent	266	78.7

Source: Field survey, 2011

Farm-Level Factors of the Farmers

Results on Table 3 show that 55% of the farmers had land tenancy security. Farmers' tenancy security on land owned and cultivated could determine the choice of SLMP used on the farm for increasing agricultural productivity (Gebmedhin & Swinton, 2003). Land tenancy security or insecurity has been described on the basis of type of land tenure, as presented in Table 3.

Table 3. Farm-level factors of the farmers

Factors	Study Area (n= 338)	
	Freq	%
Tenancy security		
No	151	45
Yes	187	55
Source of Land Cultivated/Type of Tenure		
Inheritance	131	38.8
Lease	92	27.2
Family	45	13.3
Gift	28	8.3
Government	22	6.5
Purchase	20	5.9
Farm Size Cultivated in Hectares (mean ±STD)	3.2 (±2.36)	
Topography of Farmland		
Flat	179	53
Hilly/ Steep slopes	119	35.2
Depression Area	40	11.8

Source: Field survey, 2011

The result in Table 3 indicates that cumulatively, 53 percent of the farmers obtained the land they cultivated through inheritance (39%), purchase (6%), and gift (8%). These sources usually secure land tenancy. On the other hand, 47% of the farmers obtained their land through leasehold (27%), family land (13%) and government land (7%). These are usually insecure forms of land tenancy.

The result further shows that average farm size cultivated by farmers in the study area was 3.2 hectare. This suggests commercial food production in the study area. The topography of the farmland may also determine the use of SLMP. The results show that, although, 53 percent of the farmers cultivated flat lands, 47 percent cultivated hilly (35%) and undulating (12%) lands, an evidence of land degradation and vulnerability to degradation in the study area. Farmers cultivating on sloppy or undulating lands are expected to be more conscious of information on SLMP.

The results of the analysis of inputs used and outputs from production by the farmers are presented in Table 4. Major inputs used are farm land cultivated, fertilizer applied, family and hired labour, planting materials and herbicide. Recommended quantity of fertilizer (predominantly NPK), quantity of planting seeds and volume of herbicide used in maize cultivation have been given as 200-300 kilograms of fertilizer per hectare (can be up to 400Kg for savannah), 20-25 kilograms of seed per hectare and 3-5 litres of herbicide per hectare. About 400 kilograms fertilizers are recommended for cassava cultivation (ICS-Nigeria, 2002). Also average yields of 2-3 tonnes per hectare (can be up to 3-5 tonnes for rainforest) and 20 tonnes per hectare are expected from maize and cassava production respectively. When compared with the recommended standards, the farmers across the state recorded lower fertilizer and herbicide use, higher seed rate for maize and lower yields for both maize and cassava.

Table 4. Average production inputs and outputs per hectare

Inputs	mean	± Standard dev.
Average Farm size in ha	3.2	2.6
Average Mandays of Labour/Annum	72.5	57.5
Average Kg/ha of Fertilizer	109.5	89
Average Kg/ha of maize seed planted	36.8	22.3
Average Kg/ha of cassava cuttings planted	30	20
Average Litre/ha of Herbicides	2.9	2.0
Average Output/ha in Tons of maize	2.0	1.1
Average Output/ha in Tons of cassava	18.5	4.3

Source: Field survey, 2011

Specific Land Management Practices adopted by Farmers

The result on Table 5 shows that among the Structural and Mechanical Erosion Control Practices (SMECP), construction of ridges across the slope was the most widely used by farmers in the study area (28%). Majority of the farmers (94%) engaged in multiple cropping, 81% in Agronomic Practice (AP) and application of inorganic fertilizers was the major Soil Management Practice (SMP) ((58% always used) while minimum tillage was the identified Cultivation Practice (CP) among the majority (79%) of the farmers. This result agrees with the findings of Awoyinka *et al.* (2009).

Estimation of Profit Function

Table 6 shows the effects of the variable inputs in maize and cassava production. The estimated sigma-squared (ζ^2) for maize and cassava enterprises are significantly different from 0 at the 10 percent level indicating a good fit and correctness of the specified distributional assumptions of the composite error term. The significance of ζ^2 conforms with the results obtained by Adeleke *et al.* (2008). Also, the estimated gamma (γ), which is the ratio of the variance of farm specific profit efficiency to the total variance of profit, is 0.96 for maize and 0.98 for cassava. This means that 96 percent and 98 percent of the total variation in crop production were due to profit inefficiency in maize and cassava production respectively.

Table 5. Specific land management practices adopted by respondents

Land management practices	Always practiced Freq	%	Often practiced Freq	%	Sometimes practiced Freq	%	Not practiced Freq	%
Structural and mechanical erosion control practices (SMECP)(n=338)								
Terraces	4	1.2	9	2.7	40	11.8	285	84.3
Contour bund	7	2.1	35	10.4	38	11.2	258	76.3
Construction of ridges across the slope	93	27.5	27	8	38	11.2	180	53.3
Agronomic practices (AP)(n=338)								
Multiple cropping	274	81.1	38	11.2	14	4.1	12	3.6
Mulching	128	37.9	38	11.2	63	18.6	109	32.2
Crop rotation	143	42.3	45	13.3	56	16.6	94	27.8
Cover cropping	140	41.4	49	14.5	79	23.4	70	20.7
Strip cropping	7	2.1	11		41		279	82.5
Soil management practices (SMP)(n=338)								
Compost	11	3.3	13	3.8	37	10.9	277	82
Farm/green manure	63	18.6	51	15.1	119	35.2	105	31.1
Use of fertilizer	195	57.7	69	20.4	37	10.9	37	10.9
Cultivation practices (CP)(n=338)								
Minimum tillage	167	49.4	50	14.8	51	15.1	70	20.7
Conventional tillage	118	34.9	57	16.9	49	14.5	114	33.7

Source: Computed from field survey data

The result shows that, for maize production, the coefficients of cost of hired labour ($p < 0.1$, elasticity = -0.15), cost of planting material ($p < 0.05$, elasticity = -0.14), imputed family labour (($p < 0.01$, elasticity = -0.02), land cultivated ($p < 0.1$, elasticity = 0.43) and cost of capital ($p < 0.1$, elasticity = 0.02) were found to be statistically significant with their respective signs. Similar results were obtained for cassava with the coefficient of cost of hired labour ($p < 0.1$, elasticity = -0.14), cost of planting material (stem cuttings) ($p < 0.05$, elasticity = -0.19), imputed cost of family labour ($p < 0.01$, elasticity = -0.22), land cultivated ($p < 0.1$, elasticity = 0.53) and cost of capital utilized ($p < 0.1$, elasticity = 0.08) were found to be statistically significant with their respective signs. This result implied that to increase efficiency in maize and cassava production, cost of labour and planting materials must be lowered while increasing size of cultivated land and capital.

Table 7 shows the profit inefficiency for both maize and cassava. The result shows that the use of SMECP, AP and CP as well as access to extension services, years of education, and participation in CBOs and government agricultural programmes negatively and significantly influenced profit inefficiency meaning that these factors contributed to reducing technical inefficiency among farmers in the study area. The null hypothesis that farmers‘ characteristics and land management practices do not significantly influence profit efficiency of crop production is therefore rejected in favour of the alternative hypothesis.

Table 6. Frontier profit function analysis for maize and cassava production (*dependent variable = normalized profit)*

General Model Variables	maize		cassava	
	Coeff	t-ratio	Coeff	t-ratio
Constant	5.01*	1.73	8.11*	3.00
cost of hired labour (p_1)	-0.15*	1.83	-0.14*	-1.93
cost of fertilizer (p_2)	-0.41	-1.47	-0.01	-0.67
cost of herbicide (p_3)	-0.20	-0.17	-0.20	-1.24
cost of planting material (p_4)	-0.14**	-2.00	-0.19**	-2.31
Imputed cost of family labour (p_5)	-0.02***	3.05	-0.22***	-3.05
Land cultivated in hectares (z_1)	0.43*	1.65	0.53*	1.75
Cost of capital (z_2)	0.02*	1.82	0.08*	1.82
Sigma-squared	0.77*	1.68	0.71*	1.68
Gamma	0.96	2.60	0.98	2.69
Log likelihood	-240.13		-266.22	
N	338			

**** Significant at 1%; **Significant at 5%; * Significant at 10%* **Source:** Computed from field survey data (2011)

Table 7. Determinants of inefficiency among farmers in the study area (dependent variable = inefficiency μ)

	Maize		Cassava	
Variables	Coeff	t-ratio	Coeff	t-ratio
Intercept term w_0	12.09***	3.01	13.84***	2.59
Use of SMECP (w_1)	-2.37*	1.81	-1.06*	1.89
Use of AP (w_2)	-0.44***	3.08	-1.25***	4.50
Use of SMP (w_3)	0.16	0.00	0.26	0.00
Use of CP (w_4)	-0.21***	3.15	-0.55***	3.05
Tenancy security (w_5)	-1.07	1.67	-0.94	0.77
Farming experience (w_6)	-0.38**	2.07	-0.14	0.36
Extension service visits (w_7)	-2.06**	2.23	-1.37**	2.09
Years of education (w_8)	-0.098**	-2.26	-0.17**	-1.97
Access to credit (w_9)	0.25**	2.22	0.55**	2.07
Belonging to CBO (w_{10})	-0.20**	2.15	-0.32**	-2.25
Farmers‘ participation in government programme (w_{11})	-1.25*	1.69	-1.09*	1.68

*** Significant at 1%; **Significant at 5%; * Significant at 10%
Source: Computed from field survey data (2011)

CONCLUSION AND RECOMMENDATIONS

The study has shown the nexus between farmers‘ personal, institutional and farm-level characteristics and their choice of land management practices. Based on the survey results the following recommendations have been suggested for policy action:

1. More attention should be focused on the input subsidy arrangements for the farmers. Also, alternative strategies to control the rising trend in the cost of these important inputs should be designed.
2. Labour and land-augmenting technologies such as improved planting materials and minimum tillage would be appropriate for improving profit efficiency.
3. If farmers have to reduce profit inefficiency, appropriate policies must address the factors that were found to reduce profit inefficiency

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BIO-DATA

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