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Economic Analysis of Plantain Production Under Agroforestry System in Edo State, Nigeria

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ABSTRACT

Plantain is one of the staple crops commonly planted in the Southern part of Nigeria under various cropping systems. This study investigated the economics of plantain production under agroforestry system in Edo State, Nigeria. Sixty (60) farmers operating under the agroforestry system were purposively selected for the study. A translog stochastic production frontier function using the maximum likelihood estimates was used as analytical tool. The results revealed that labour and capital were the major factors that influence the production of the crop. The coefficients of labour and capital were positive and significant at 1 percent level implying that they contribute positively to plantain output. The coefficient of plantain suckers was positive but not significant, implying that increase in the planting densities of plantain suckers is not a requirement to increase yield (kg ha^1) linearly, that is, planting an excessive number of plantain suckers within an area leads to competition for space and other resources. However, the coefficients of the interaction between farm size and labour (β_9) and between farm size and capital(β_{10}) and between farm size and suckers (β_{11}) were positive and significant indicating that increases in the joint use of farm size and other inputs (labour, capital and plantain suckers) increased plantain output. Therefore, formulation and judicious enforcement of policies that ensure the provision of farm land, improved plantain planting materials and labour availability and affordability will go a long way to improve the efficiency of the farmers and increase their farm output. These variables have been found to influence the technical efficiency of plantain in the study area. In order to improve production of plantain, farmers should be assisted by the relevant government agencies to access finance in order to acquire farm inputs, hire labour, and acquire suitable farmland.

Keywords: Plantain, agroforestry, stochastic frontier analysis, Nigeria

INTRODUCTION

Plantain (*Musa paradisiaca)* is a major food staple in developing countries and in Western and Central Africa. It is undoubtedly one of the oldest cultivated fruits in West and Central Africa and one of the most important staple food crops grown in the tropics and sub-tropics of the world. It is estimated that about 70 million people in West and Central Africa derive more than 25% of their carbohydrates from plantains, making them one of the most important sources of food energy throughout the African lowland humid forest zone (Swennen, 1990). It ranks as the fourth most important global food commodity after rice, wheat and maize in terms of gross value of production (FAOSTAT, 2010). Frison and Sharrock (1998) observed that banana and plantain represent more than 25 percent of the food energy requirement of Africa. Plantain plays vital roles in the feeding systems of both human beings and farm animals. It has a very high nutritional value in source of dietary carbohydrates, vitamins and minerals. Plantain is extremely rich in vitamin A. At the household levels, plantain is consumed raw, fried, boiled, roasted and can be dried and grounded into flour for other uses. Apart from its consumption as a staple food; plantain is also used in thefood industries for the manufacture of chips, flakes, cakes, thereby creating important opportunities to the populace directly or indirectly and invariably income for small holder farmers.

Plantain and banana are major sources of food in many regions throughout the world. Plantains and bananas represent the world's second largest fruit crop with an annual production of 144 million metric tons (FAOSTAT, 2013). About 70 million people in the African sub-region are estimated to derive more than one quarter of their food energy requirements from plantain. Plantain is very critical in bridging the gap between the demand and supply of the basic carbohydrate staples. The majority (82%) of plantains and banana in Africa are produced in the area stretching from the lowlands of Guinea and Liberia to the central basin of the Democratic Republic of Congo. West and Central Africa contribute 61 and 21%, respectively (FAO, 1986). Nigeria is one of the largest plantain producing countries in the world with annual production of about 2.8 million metric tons mostly obtained from the southern states (FAO, 2013; Maps of world, 2016). Despite its prominence, Nigeria does not feature among the plantain exporting nations as she produces more for local consumption than for export (Fortaleza, 2012).

In Nigeria, plantain production is becoming a significant economic activity for income generation for both large scale and small holder farmers, especially for those who produce them within their home compounds or gardens. Plantain also plays an important role in the structuring of rural landscape throughout the producing areas in the country. Also, the gross value of plantain and banana in terms of their annual product exceeds that of several other crops such as maize, rice, cassava and sweet potato in sub-Saharan Africa (FAO, 2013). Plantain is produced under different farming systems in Nigeria (Akinyemi *et al*, 2010). In some places it is cultivated in home gardens while in others places it planted alongside with cash crops like cocoa. In Sapoba Forest Area in Edo state, plantain is cultivated under a system where it is planted with others crops like yam, cocoyam in between trees called agroforestry. Agroforestry is a land use management system in which woody perennials are grown with food crops and/or livestock leading to many beneficial, ecological and economic interactions between trees and non-trees components. It is one of methods designed to create a climate-smart agriculture, increase food security, alleviate rural poverty and achieve a truly sustainable development (Garrity and Stapleton, 2011). Agroforestry supports food and nutrition through the direct provision of food, by raising farmers' income, providing fuel for cooking and through various ecosystem services (Dawson *et al*, 2013). This study therefore focuses on the production of plantain under agroforestry system in Sapoba Forest Area in Edo State. The general objective of the study is to assess the economics of plantain production in the study area. Specific objectives include the examination of the socioeconomic characteristics of plantain farmers in the area and investigation of the efficiency of farmers involved in plantain production among others.

METHODOLOGY

This study was carried out in Sapoba Forest Area in Orhionmwon Local Government Area of Edo state. Edo state is located between latitude 5^o5^1N -7^o33^i N and longitudes 5^oE-6^o40^iE. It shares common boundary with Ondo state in the West, Delta State in the East and Kogi state in the north. The vegetation of the state is moist rain forest in the South and derived savanna in the North. Sakpoba Forest Reserve lies between latitudes 4^o - 4^o 30' and longitudes 6^o - 6^o 5'E. It is bounded on the South by Delta State, on the East by Urhonigbe Forest Reserve and on the West by Free Area, B.C. 30. It is located in Orhionmwon Local Government Area, about 30 kilometers South-East of Benin City. Some of the major villages located within and around the reserve are Ugo, Ikobi, Oben, Iguelaba and Amaladi in Area B.C 32/4, and Ugboko-Niro, Iguere, Idunmwowina, Evbarhue, Idu, Evbueka, Iguomokhua, Ona, Abe, Igbakele, Adeyanba, Evbuosa in Area B.C 29. Orhionmwon LGA has a population of about 182,717 according to 2006 census with a land area of 2.382 km^2 (NPC, 2006). The people of the area are farmers and traders. Crops grown in the area include: yam, cassava, maize, plantain, and cocoyam planted with some tress like *Tectona grandis* (teak), *Gmelina arborea*, *Terminalia ivorenisis*, *Khaya ivorensis* and so on. The primary data were obtained using well structured questionnaire. A total of 60 agroforestry farmers were purposively selected and interviewed among the villages namely: Ageka (10), Evbuosa(12), Ona(8), Iguomokhua(10) and FRIN Camp (20) in the LGA where agroforestry system is being practiced.

Data Description and Regression Model

The data employed in this study consist of information on the socio-economic characteristics and input-output information of a sample of 60 agroforestry farmers in Sapoba Forest Area of Orhionmwon Local Government Area of Edo State, Nigeria. The farmers produce various crops such as yam, plantain, maize, cassava, cocoyam, pepper melon etc. The inputs used in production include the land which is usually allocated to the farmers on annual basis, labour, capital (e.g. machetes, hoes) while the socioeconomic characteristics are the farmers' level of formal education, years of farming, age. The production variables are also measured in value terms. Hired labour is measured in terms of man days. The average daily wage rate for agricultural farmers in the study area of ₦1400 is used. Education as a variable is measured in terms of years of formal education.

Model specification

Stochastic frontier production function was specified and adopted in data analysis. Following Ajibefun and Aderinola (2004) and Ameachi, *et al*. (2014), the stochastic frontier model is represented as:

$Yi = f(Xi; \beta) \exp(Vi - Ui)$ i = 1,2,…, n. …………… (1)

Where:

Yi = Output of ith farmer; Xi = Vector of input quantities used by the ith farmer; β = Vector of unknown parameters estimated; f(.) = an appropriate function (in this case, translog frontier); Vi = the symmetric component of the error term, associated with random factors not under the control of the farmer.; Ui = the non-negative random variable under the control of the farmer. It represents inefficiency in production relative to the stochastic frontier quantity defined by f(Xi, β) exp (Vi).

The random errors, Vi's are assumed to be independently and identically distributed as $N(O,\delta v^2)$ random variables independent of Uis. Given the density function of Ui and Vi the translog stochastic frontier function is estimated by Maximum Likelihood Methods.

Technical efficiency (TE) of an individual farm is defined as the ratio of the observed output (Yi) to the corresponding frontier output (Y_i^i) both in original units and can be given as

$$TE = \frac{Yi}{Y_i^i} = \frac{f(Xi;\beta)esp(Vi-Ui)}{f(Xi;\beta)esp(Vi)} = esp\,(-Ui) \quad \ldots\ldots 2$$

Where

Yi = observed output; Yi* = frontier output; ln = Natural logarithm.

The measurement of firm specific technical efficiency requires the estimation of the non-negative error (Ui) and the random normal error (Vi). The variance ratio y, explaining the total variation in output from the frontier level of output attributed to technical efficiencies were computed as $y = \delta^2 u/\delta^2$.

The estimation of the stochastic frontier translog production function made it possible to verify whether the deviation in technical efficiencies from the frontier output was due to firm specific factors or due to external random factors. Technically efficient farmers are those that operate on the production frontier and the level by which a farmer lies below its production frontier is taken as a measure of technical inefficiency (Ajibefun and Aderinola, 2004).
The following translog stochastic frontier production function was used in this study

$$Y_i = \beta_i + \sum_i \beta\, lnXi + \sum_j \beta_j ln\, X_j + \tfrac{1}{2}\sum_i \sum_i \beta_i\,(lnX_i))^2 + \tfrac{1}{2}\sum_j \sum_j \beta_{ij}\,(lnX_j))^2 + \sum_i \sum_i \beta_{ij}\, lnX_i lnX_j + V_i - U_i \quad \ldots\ldots 3$$

where: Yi denotes the total quantity of output (kg); Xi denotes a vector of input *i* and *j* are positive integers $i \neq j$= 1,2,3--). βs are vectors of parameters to be estimated. Vis are assumed to be identical and independently distributed, N($\theta, \sigma^2\, v$) are random errors independent of Uis and Vis are non-negative random variables called technical inefficiency effects which are assumed to be independently distributed such that Vi is defined by the truncation at zero of the normal distribution with mean, Ui and variance σ^2.

Considering the general formulation of the stochastic frontier production function in the equation above, the transformed empirical model is specified as follows

$$Ln\ Y = \beta o + \beta_1 lnX1 + \beta_2 lnX2 + \beta_3 lnX3 + \beta_4 lnX4 + 0.5\beta_5 (lnX_1)^2 + 0.5\beta_6 (lnX_2)^2 + 0.5\beta_7 (lnX_3)^2 + 0.5\beta_8 (lnX_4)^2 + \beta_9 lnX_1 * lnX_2 + \beta_{10} lnX_1 * lnX_3 + \beta ln_{11} X_1 * lnX_4 + 4\beta_{12} lnX_2 * lnX_3 + \beta_{13} lnX_2 * lnX_4 + \beta_{14} lnX_3 * lnX_{4\,+e} \quad \ldots\ldots 4.$$

Where:

Y= output in *Kg;* X_1=farm size in hectares; X_2= labour in man days; X_3= capital in naira (₦); X_4= plantain suckers in numbers. The parameters of the transformed translog production frontier as specified in equation 4 were estimated for the various farmers using the maximum likelihood method in the FRONTIER econometric software. Given a flexible and interactive production frontier for which the translog production frontier is specified, the farm specific technical efficiency (TE) of the jth farmer was estimated by using the expectation of ui conditional on the random variable ei as shown by Battese and Coelli (1992). That is (5).

$$TE = esp(-Uj = e^{-uj} \quad \ldots\ldots (5)$$

So that $0 \leq TE \leq 1$. Farm specific technical inefficiency (TI) was computed by using the expression below (6)

$$TI = (1-exp\{-Uj\}) \quad \ldots\ldots (6)$$

RESULTS AND DISCUSSION

The summary of the demographic and socio-economic characteristics of farmers is presented in Table 1. The demographic and socio economic variables considered include age, gender of farmers, household size, farm size, years of farming, level of education and marital status. About 63.3 % of the sampled farmers were between the age bracket 20 -50 years. This shows that majority of the farmers were middle aged and this implies that the farmers were still in their economic active age which could result in a positive effect on production. This result agrees with the findings of Kainga and Seiyebo (2012) who observed that farmer's age has great influence on plantain production in Bayelsa state with younger farmers producing more than the older ones plausibly because of their flexibility to new ideas and risk. Furthermore 83.3% of the sampled respondents had one form of formal education or the other. Apata *et al* (2010) and Idiong *et al* (2006) observed that formal education has positive influence on the acquisition and utilization of information on improved technology by the farmers as well as their innovativeness adoption of innovations. Some of the farmers (73.3 %) have been farming for over 5 years. This means that they must have acquired good experience in agroforestry system. Rahman *et al* (2003) indicated that the length of time in farming business can be linked to age. Age, access to capital and experiences in farming may explain the tendency to adopt innovation and new technology.
Table 2 revealed that the average age of the farmers was 49.2 years. About 83% of the farmers are married while 82% are male. An average farmer has a fairly large household of 6.5, cultivating about 1.12 hectares of land typifying a small scale holding with no one having more than one field suggesting that land fragmentation is not common in the forest reserve because farm lands are allocated to them by the government on year to year basis.

Table 1: Socio economic characteristics of sampled farmers (N=60)

Variables	Respondents	Percentage
Age in Years		
21-30	12	20
31-40	12	20
41-50	14	23.3
51-60	09	15
61-70	03	5
71-80	04	6.7
Above 80	06	10
Level of Education		
Informal	10	16.7
Primary	23	38.3
Secondary	22	36.7
Vocational	3	5
Tertiary	2	3.3
Marital status		
Single	4	6.6
Married	46	76.7
Divorced/ widow /widower	10	16.7
Year of farming experience		
1-5	16	26.7
6-10	8	13.3
11-15	7	11.7
16and above	29	48.3
Household size		
1-5	15	25
6-10 above	45	75
Sex		
Male	50	83.3
Female	10	16.7
Farm size(Ha)		
0-5-1.0	6	10
1.5-2.0	19	31.7
2.5-3.0	11	18.3
3.5-4.0	2	3.3
Above 4.0	22	36.7

Source: Field Survey 2012

Table 2: Summary of socioeconomic variables of respondents (N= 60)

Variables	Minimum	Maximum	Mean	Std. Deviation
Age(years)	20	90	49.18	18.02
Household size	3.0	11	6.5410	1.68
Years of Farming (years)	4.0	65	19.66	16.56
Farm size (hectares)	0.20	2.02	1.1179	0.52
Hired labour (mandays)	0	98	35.03	26.20
Revenue(₦)	0	1,748,000.0	359,478.69	430,677.94

Source: Calculated from field data

Table 3: Maximum likelihood estimates of plantain farmers

Variable	P Parameter	Coefficient	t-ratio
Constant	β_0	2.857	12.643***
LnX_1	β_1	-0.0285	-0.763
LnX_2	β_2	0.3008	2.999**
LnX_3	β_3	0.3126	8.989***
LnX_4	β_4	0.0799	0.5265
$½(lnX_1)^2$	β_5	-0.0148	-0.3287
$½(lnX_2)^2$	β_6	-0.0602	-0.8671
$½(lnX_3)^2$	β_7	-0.1439	-3.060**
$½ (lnX_4)^2$	β_8	-6.324	-12.8771***
LnX_1x lnX_2	β_9	12.458	12.61***
LnX_1x lnX_3	β_{10}	2.735	1.999*
LnX_1x lnX_4	β_{11}	-5.421	1.976*
LnX_2x lnX_3	β_{12}	0.0145	0.5188
LnX_2 x lnX_4	β_{13}	0.0073	0.5548
LnX_3x lnX_4	β_{14}	0.0289	0.4891
sigma-squared		0.0386	3.365**
gamma		0.8626	7.235***
Log likelihood function		44.42	

Computed from field data, 2012; ***significant at 1% level; ** significant at 5% level; *significant at 10% level

Factors Influencing Plantain production.
The maximum likelihood estimates of the stochastic translog production frontier are presented in Table 3. The results show that the variance ratio parameter (γ) is statistically greater than zero and large (0.8636), implying that variation in plantain output from maximum output between farmers mainly arose from differences in farmers' practices rather than random variability. These factors are under the control of the farmers and the influence of which can be altered to enhance technical efficiency of the farmers. The result also shows that the coefficients of quantity of labour ($\beta 2$) and capital ($\beta 3$) were positive as expected and statistically significant, implying that increase in the magnitude of these inputs increased plantain output. A plausible reason could be that because plantain production is labour intensive, increase in the use of labour especially during the planting season will ultimately affect output. Also capital is usually needed during farming; having enough capital to work with will ease production and output. Surprisingly, the coefficient of plantain suckers was positive but not significant implying that increase in the planting densities of plantain suckers is not a requirement to increase yield (kg ha^1) linearly (Niels, 2009). This shows that there is a limit of the number of plantain suckers that can be planted within an area beyond which there will be competition for space and nutrients (Ademiluyi, 2013). However, the coefficients of the interaction between farm size and labour (β_9) and between farm size and capital(β_{10}) and between farm size and suckers (β_{11}) were positive and significant indicating that increases in the joint use of farm size and other inputs (labour, capital and plantain suckers) increased plantain output.

Distribution of technical efficiency
The frequency distribution of technical efficiency of plantain farmers is presented in Table 4.

Table 4: Frequency distribution of plantain farmers' technical efficiency estimates

Technical Efficiency range (%)	Frequency	Percentage
<0.40	1	1.7
0.41-0.50	0	0
0.51-0.60	2	3.3
0.61-0.70	5	8.3
0.71-0.80	7	11.7
0.81-0.90	10	16.7
0.91-1.00	35	58.3
Total	60	100
Mean Efficiency	86.91	
Minimum Efficiency	34.95	
Maximum Efficiency	98.75	

Source: Calculated from survey data, 2012

Individual technical efficiency indices ranged between 34.95% and 98.75% with a mean of 86.91%. Results also showed that 8.3%, 11.7% and 75% of the plantain farmers had technical efficiency indices ranging between 61-70 percent, 71-80 percent and 81-100 percent respectively. The wide variation in the farmers' technical efficiency from the frontier level as revealed by the analysis implies that the plantain farmers are not fully technically efficient in resource use. This result further suggested that there are still opportunities to increase productivity and income from plantain production through increased efficiency in resources utilization by plantain farmers in Edo State.

Sources of technical inefficiency

The estimated determinants of technical inefficiency of the plantain farmers in the study are presented in Table 5. The coefficient of age was positive and significant; indicating that as the farmer's age increases, his technical inefficiency increases. The coefficient of years of schooling was negative but significant implying that years of schooling decreases inefficiency, that is, farmers with higher education are technically efficient that those with lower years of education.

Table 5: Estimated determinants of technical inefficiency of plantain farmers in Edo State

Variables	Coefficient	T-ratio
Constant term	0.3935	2.813**
Age	0.0453	3.119**
Year of Schooling	-0.01947	-2.360**
House hold size	0.04304	1.170
Years of Farming	-0.04994	-1.2196

Source: Computed from field data, 2012.

Constraint to Plantain Production

The problems faced by farmers in plantain production in the area include lack of adequate farm inputs (50%), high costs of hired labour (83.3%) and lack of improved plantain suckers (66.7%) (Table 6). This conforms to the findings of Akinyemi *et al* (2010) and Baruwa *et al* (2011) who listed some of the variables as constraints to plantain production in Nigeria respectively. Others constraints faced by the farmers are lack of extension services (100%), inadequate fund (95%) and the problems of diseases and pests among others.

Table 6: Constraints in plantain production

Problems encountered	Frequency	Percentage
Lack of inadequate inputs	30	50
High cost labour cost	50	83.3
Inadequate Fund	57	95
Lack of improved plantain suckers	40	66.7
Problems of pest and diseases	30	50
Lack of extension services	60	100

Note: Multiple responses

CONCLUSION

The results of this study showed that the small-scale plantain farmers operating under agroforestry system were not fully technically efficient. They had mean technical efficiency of 83.35%, and range of efficiency of 40.49% - 99.81%. These imply the existence of wide variation of output below their production frontier and indicate the existence of potentials for improving productivity with proper allocation of their existing resources. Therefore, in order to improve the production of plantain in the area, relevant government agencies and non-governmental organizations (NGOs) could assist the farmers through the provision of funds and loan facilities so as to be able to acquire farm inputs, hire labour, and acquire suitable farmland. This will go a long way to improve their efficiency and increase their farm output.

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