Taungya Farming -a Strategy for Sustainable Land Management and Agricultural Development in Nigeria

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Abstract

In Nigeria, land degradation in the form of erosion oriented, soil physical property deterioration, vegetation degradation and hydrological changes are remotely caused by man's inefficient usage of land and its resources. Other causes are inadequate on-farm conservation and shortened bush fallow with inadequate supply of farmyard manure. The consequences of the inefficient land usage are decrease in land productivity and production and the inability of the agricultural sector to produce adequate food to feed the ever growing population. To avert the dire consequences of land degradation, some sustainable land management practices (such as taungya farming) which allow the production of increased agricultural and forest products simultaneously on the same unit of land are being canvassed. Taungya farming is a system of raising forest plantation along with crop husbandry in which the clearing of the site, planting and tendering of the trees are done wholly or in part by the farmers in exchange for the privilege of growing their annual crops on government reserved forests. Taungya farming ensures more land availability to landless farmers, increased food crop production, increased income to farmers, increased production of exotic and indigenous forest species, productive and integrated use of land, it provides an efficient low input biological recycling to substitute the expensive inputs and it increases the productivity of small holder farmers. This paper looked at the profitability, productivity and technical efficiency of Taungya farming in Nigeria for its policy implications. Data obtained from 100 farmers that were selected using multistage sampling technique were analyzed using descriptive statistics, gross margin and the stochastic frontier production function. The study revealed that Taungya farming was profitable. Ageing and farmers with low level educational level were involved. The farmers were relatively technically efficient (TE) with about 85 percent of them having TE above the mean TE of 0.912 for the study area. The study observed that educational level of the farmers, location of farms and technical assistance in form of extension visits led to increase in TE. The TE of the farmers would improve if more land is made available for at locations under government control and thus Taungya farming would be a driving force in ensuring a sustainable land resources management with increased productivity in Nigeria.

Keywords

Taungya Farming; Land Degradation; Productivity; Technical Efficiency; Stochastic Frontier Production Function

Introduction

Throughout the history of the world, one of the greatest and most persistent threat to human existence has been environmental degradation. It is no wonder therefore that all countries of the world are devoting a lot of energy and resources in tackling this critical problem. Disturbed by the alarming rate of environmental degradation all over the world, the United Nations Conference on Environment and Development (UNCED) or the Earth Summit met in Rio-de-Janeiro, Brazil in June 1992 for the first time to address this common global issue.

The Summit attempted to harness the global resources to address common problems related to the environment, ranging from protection of tropical forests, seas, the air and sound management of chemical. The UNCED also met in Washington, USA in 1997 and Japan in 1998 to review actions taken by various countries of the world in addressing environmental problems since the 1992 Rio-de-Janeiro Summit.

Most developing countries including Nigeria faced with the problem of ensuring acceptable economic growth are also confounded by deteriorating environment. The problem of environmental degradation and its attendant consequences such as poverty, unemployment and quality of life poses one of the most critical and challenging tasks facing productivity in the country today.

Types and Causes of Land Degradation: In Nigeria, land degradation is remotely caused by man's inefficient usage of land and their resources and it comes in four different forms viz:

- Erosion oriented such as gully, sheet and wind erosions are caused by poor road design, destruction of vegetation cover, intensive cultivation, overgrazing and destruction of tree cover.
- Soil degradation such as declining soil fertility, soil solidity & salinity and soil physical deterioration are caused by shortened bush fallow, inadequate supply of organic & inorganic fertilizers, cultivation practices and inadequate irrigation practices.
- Degradation of the Vegetation such as range land degradation and deforestation are caused by overstocking, bush burning over exploitation of economic trees and firewood
- Hydrological changes such as flooding & Siltation, wetland degradation and coastal erosion are caused by inadequate coastal protection, on farm conservation, irrigation development and vegetation destruction.

The consequences of the inefficient land usage are decrease in land productivity and production and the inability of the agricultural sector to produce adequate food to feed the ever growing population. In Nigeria, the population grows at a rate of about 2.83 percent making it one of the fastest growing populations in the world. The resultant effects are enormous on the scarce economic resources available for production of goods and services required by the populace. Mostly affected by the astronomically growing population growth rate are food production and forestry products. The demand for more food to feed the ever-increasing population grows at a rate of about 3.5 percent while forestry products such as planks, soft wood and others are required in very large quantities for provision of shelter, paper for books, furniture materials and other household materials.

The consequences of efforts by the smallholder farmers that account for over 90 percent of all agricultural production in Nigeria to produce enough food and forestry products for the population are:

- Shortened fallow period of the shifting cultivation in addition to some destructive agricultural practices which could lead to decrease in land productivity and overall agricultural production.
- Over exploitation of the forest resources at an alarming rate that exceeds the natural growth rate thereby causing serious dis-equilibrium in the ecosystem.

Should the over exploitation continue, it would ultimately lead to total destruction of the forest resources and desert encroachment. To avert the dire consequences of land degradation, destruction of the forest resources, reduce desertification, conserve the environment and bring more lands into agricultural and forestry production, some sustainable land management practices (such as taungya farming) which allow the production of increased agricultural and forest products simultaneously on the same unit of land are being canvassed.

Taungya farming is a system of raising forest plantation along with crop husbandry. Taungya farming as it is practiced in Nigeria has a symbiosis presentation in that the landless prospective farmers are allowed to farm the government forest reserves with or without payment of any form of rent but the clearing of the site, planting and tendering of the tree species the government is interested in raising are done wholly or in part by the farmers in exchange for the privilege of growing their annual crops on government reserved forests (Nair 1993).

Taungya farming among other benefits ensures:

- More land availability to landless farmers who are constrained by the prevailing land tenure system from getting required land for increased agricultural production.(Ojo 2008)
- Increased food crop production and income to farmers
- Increased production of exotic and indigenous forest species by government on appreciable scale
- Productive and integrated use of land
- provision of an efficient low input biological recycling to substitute the expensive inputs
- Increase in the productivity of small holder farmers.

- Efficient soil and environmental conservation
- Reduction in encroachment of the desert

This paper examined the profitability, productivity and technical efficiency of taungya farming in Nigeria for its policy implications as a sustainable agro-forestry and land management strategy in solving food insecurity and forest development problems with a view to advising the appropriate authorities to formulate enabling policies that will incorporate this environmentally friendly and sustainable land management practice into the nation's land use and agro-forestry policy reforms.

Theoretical Framework

Stochastic frontier production function model (SFPF): The stochastic frontier production function model was used to examine the resource-use efficiency (productivity) and the technical efficiency of Taungya farming in the study area.

The stochastic frontier function model is defined as:

$$Y_i = f(\beta_j;X_{ij}) + (V_j - U_i)$$

where; Y_i is the output of the i-th farm; f is a suitable functional form to represent the production frontier; X_{ij} is a vector of *j-th* inputs used by i-th farm, β_j is a vector of parameter of *j-th* inputs to be estimated. The systematic component V_i are random error terms assumed to be independent and identically distributed (iid) with zero mean and constant variance, as

$V_i \sim N(0, \sigma^2 v)$, and U_{is} are non-negative random variables associated with the technical inefficiency effects of the farmers which are assumed to be independent and identically distributed (iid) with mean μ_i but truncated as $U_i \sim N(\mu_i, \sigma^2 u)$ and independent of V_{is}.

Following the Battese and Corra (1977) parameterization of Vi and Ui as implemented in the software (FRONTIER 4.1 written by Coelli (1996)) employed in this study, the stochastic frontier variance parameters are expressed in terms of

$$\sigma^2 = \sigma^2 v + \sigma^2 u$$

and

$$g = \sigma^2 u \; / \; \sigma^2.$$

where g (gamma) measures the total variation of output from the frontier which can be attributed to technical inefficiency (Battese and Corra, 1977). The larger value of g implies that the variance of the inefficiency effects represents larger proportion of the total variance of the terms, U_i and V_i. The restriction that g equals zero (g = 0) can be tested to determine if the stochastic frontier regression is appropriate for the data set.

Accordingly, the technical efficiency of the i-th farm, denoted by TE_i, is defined as the ratio of the mean of production for the i-th farm, given the values of the explanatory variables, X_i, and its technical inefficiency effect, $(E\ (Y|Xi,Uu)$, to the corresponding mean of production if there was no inefficiency in production $(E\ ((Y|Xi,U_i = 00))$ (Battese and Coelli,1988).

The TE can be specified as

$$TE = \frac{f(X_i b) + V_i - U_i}{f(X_i b) + V_i}$$

Thus, $0 \leq TE \leq 1$

The focus of this study is not only to estimate the technical efficiency of the Taungya farms, but to examine sources of differences in technical efficiencies of the Taungya farms. In the light of this, the study follows Battese and Coelli (1988) model in which distribution of mean inefficiency (μ_i) is related to the farmers' socio-economic variables. The Battese and Coelli model allows heterogeneity in the mean inefficiency term to investigate sources of differences in technical efficiencies of the farms (inefficiency effect). With this, the farm-specific mean inefficiency (μ_i) is introduced and subsequently truncated at zero, such that non -negative error terms is ensured.

The model is defined as:

$$U_i = d_0 + d_k Z_{ik}$$

where, U_i are as earlier defined, Z_{ik} is the matrix of k-th Taungya farmer's socio-economic variables for the i-th Taungya farm to explain the determinant of technical inefficiency of the Taungya farms and d_k is a vector of parameters to be estimated.

Research Methodology

Study Area: This study was carried out in Ondo State Nigeria. The state is one of the 36 states making up the federating unit Nigeria and lies in the western part of Nigeria. It has three distinct ecological zones. The mangrove forest to the south, the rain forest in the middle and the guinea savannah to the north. The average rainfall of the state is between 1500mm to 2000mm per annum. The state enjoys a bimodal type of rainfall pattern which normally spreads between

March and July followed by a break in August and a short rainy season from late August to early November. The state is agrarian and majority of the farmers are small-scale and 00smallholder farmers with an average farm size of less than one hectare. Farmers in the study area engage in the production of food crops (yam, maize, cassava, vegetables and so on)and cash crops such as cocoa, oil-palm and kola-nut. Also lumbering in the forest zone and artisanal fishing in the coastal zone are thriving businesses.

Sampling Technique and Data Collection: The data mainly from primary sources were collected from 100 farmers practicing Taungya farming from four local government areas (LGA). The LGAs were Akure South, Idanre, Odigbo and Owo. The sampling technique used was multistage sampling technique. The first stage of the multistage sampling was the purposive selection of the four LGAs because they were in the rain forest belt of the state where the government forest reserves and Afforestation Project Scheme are located, and also because some farmers in these areas were involved in taungya farming in their quest to take advantage of the very fertile forest reserves to grow food crops for the few years before the newly planted forest species form canopy. The second stage involved a random selection of 25 farmers from each of the four local government areas from the frame of farmers involved in Taungya farming in the study area, thus making 100 respondents.

Information was collected with the use of structured questionnaire on the following variables; farm output, farm size, labour use in man-days and monetary value in naira, operating expenses in naira, farmers age, highest educational level of farmers, farming experience, level of government assistance(technical and financial assistance) and other data influencing their production activities.

Method of Data Analysis: The data collected were analysed using descriptive statistics (tables, mean and standard deviation), budgetary and stochastic frontier production function analyses.

Model specification for stochastic frontier production function: This study assumed the stochastic frontier production function model of the Taungya farms was best specified by the Cobb-Douglas function. The choice of Cobb-Douglas functional form for this study was as result of the following properties related to the functional form;

i) The functional form has been widely used in farm efficiency studies for the developing and developed countries,

ii) The functional form meets the requirement of being self-dual, allowing an examination of economic efficiency.

iii) Nonetheless, Taylor *et al.* (1996) argued that as long as interest rests on efficiency measurement and not on the analysis of the general structure of the production technology, the Cobb-Douglas production function provides an adequate representation of the production technology.

The production technology of the Taungya farms was assumed to be specified by the Cobb-Douglas stochastic frontier production function which when linearised was defined as:

$$LnY_i = \beta_0 + \sum \beta_j \, LnX_{ji} + (V_i - U_i)$$

where;

Y_i = Output of i-th Taungya farm in naira

X_1 = Farm size in ha

X_2 = Age of tree planted

X_3 = labour utilization in naira

X_4 = operating expenses

X_5 = Age of Taungya farmer in years

V_i and U_i as earlier defined.

β_j denote unknown scalar parameters to be estimated

The inefficiency model in addition to the general model was defined to estimate the influence of some farmer's socio-economic variables on the technical efficiency of the Taungya farms.

The model is defined as:

$$U = d_0 + d_1Z_1 + d_2Z_2 + d_3Z_3 + d_4Z_4$$

where;

Z_1 = Level of Education measured as years of schooling

Z_2 = Taungya Farming Experience

Z_3 = Technical assistance (Number of extension agents visits per annum)

Z_4 = Location of taungya farm (dummied as 1 for government reserved forests, 0 elsewhere)

δ_m represent unknown scalar parameters to be estimated.

Results and Discussion

Performance Analysis of Taungya Farming: The summary statistics of variables involved in the study are presented in Table 1. The study revealed that farmers involved in taungya farming were ageing, had low education and small farm sizes. About 72 percent had ages above 50years while about 85 percent had less than or primary education. The farmers operated small holdings with average farm size being 1.49 ha and about 63 percent of each having holdings that was less than one hectare. This corroborates the apriori assertion that small scale farmers in Nigeria are ageing and have low education with their dire consequences on productivity and production (Ajibefun & Abdulkadri, 1999 and Ojo & Ajibefun, 2000). The farmers were quite experienced with about 85 percent of them having farming experience of 11 years and above. The taungya farmers were mostly landless farmers who did not have access to agricultural land due to the prevailing tenure system in the study area. In other words about 74.5 percent of the farmers were non-indigenes who could not get land through inheritance or purchases. The study revealed that the taungya farmers got information about the system through their community leaders and forestry officers. About 84 percent of the farmers interviewed were involved in taungya farming mainly out of the various agro-forestry practices introduced to them because the abundance of forest reserves in the study area. The main tree species planted by the government were the Gmelina specie and Tectona specie because of their fast rate of growth. It was revealed that the practice ensured a very high rate of survival for the tree planting programme of the government with about 96.8 percent of the taungya farmers recording 100 percent success in the tree planting programme in the study area. The average age of planted trees was 6years with about 65 percent of the planted trees under 5 years old. It was also revealed that farmers in the scheme were only allowed to plant arable crops such as cassava, maize, yam and vegetables. Planting of permanent crops was forbidden even though some of the farmers still planted permanent crops like cocoa illegally. The arable crops planted do very well in the first three years of inter-planting with the fast growing planted tree. Crop output starts declining after five years of using the plot with the planted trees because the trees must have started forming canopy. Due to the decline in crop output arising from canopy formation of the trees the taungya farmers would now resort into the negative tendency of illegally pruning the planted trees. Taungya farming is faced with a lot of problems such as; fire outbreak, illegal pruning of planted trees by farmers, poor road networks & transportation problems, uncontrolled logging activities by sawmillers with the support of fraudulent activities of forestry officers.

Performance and Profitability Analysis: The performance analysis of farmers under the taungya farming is presented in Table 2. A mean net revenue of N129405.11 per ha with a standard deviation of N55504.85 shows that agricultural production under taungya agro-forestry practice is profitable apart from solving the problem of land ownership and availability for agricultural production.

TABLE 1: SUMMARY STATISTICS OF VARIABLES OF TAUNGYA FARMING

Variables	Details	Percent	Mean
Age of farmer	>50years	72	60years
Educational level of farmer	≤ primary education	85	
Farming experience	≥ 11years	85	
Farm size	< 1 ha	62.8	1.49 ha
Age of tree planted	≤ 5years	65	6years
State of origin	Non-indigene	74.5	
Awareness of taungya	Forestry officer and community leaders	97.9	
Agro-forestry practices	Taungya farming	84	
Tree species planted	Gmelina/Tectona	92.5	
Survival of trees planted	100%	96.8	

TABLE 2: PROFITABILITY ANALYSIS

Variable	Mean	Std dev
Farm size(ha)	1.49	1.81
Labour cost/ha	50345.5	25030.00
Operating expenses/ha	10213.39	2303.80
Total fixed cost/ha	3500.00	1200.00
Total cost/ha	74058.89	43004.17
Total Revenue/ha	203464.00	98225.25
Net Revenue/ha	129405.11	55504.85

Stochastic Frontier Production Function Analysis: The estimates of the stochastic frontier production function are presented in Table 3. The choice of model for further econometric and economic analyses was based on the test for presence of technical inefficiency effects using the generalised likelihood ratio test. The test confirmed that there was presence of technical inefficiency effects in taungya farming production activities, that is, the gamma coefficient (g) was significantly different from zero ($g \neq 0$) as confirmed by the computed test statistic, chi-square (X^2) that was greater than the tabulated chi square at 5 percent level of significance and degree of freedom of six. Therefore, model 2 was chosen for further econometric and economic analyses.

TABLE 3: ESTIMATES OF THE STOCHASTIC FRONTIER PRODUCTION FUNCTION

Variables	Model 1	Model 2
General model		
Constant	5.985 (2.13)	2.676 (3.14)
Farm size	*0.367 (2.54)	*0.283 (2.72)
Age of tree planted	*-0.213 (4.03)	*-0.157 (-3.89)
Labour	*0.526 (3.12)	*0.497 (2.86)
Operating expenses	261.261.(1.21)	0.272 (1.26)
Age of farmer	-0.436 (-0.800)	-0.345 (-1.21)
Inefficiency model		
Constant	0	6.111 (4.11)
Educational level	0	*-0.121 (2.10)
Farming experience	0	0.055 (1.44)
Extension visits	0	*-0.073 (-2.42)
Location of farms	0	*-0.004 (2.07)
Variance parameters		
Sigma squared	0.251	*0.332 (6.39)
Gamma	0	*0.791 (3.21)
Log likelihood function	42.52	101.12
Technical Efficiency		
Mean TE		0.912
Min TE		0.563
Max TE		0.984

*Estimate is significant @ 5 percent level of significance
Figures in parentheses are t-ratios

Productivity Analysis: The estimated coefficients in the general model of model 2 were used for the productivity (resource use efficiency) analysis. The estimated coefficients of the farm size, labour, and operating expenses were positive and each was between zero and unity. This implies a direct relationship between output and each of the variable inputs and that the allocation of the variable inputs was in the stage of efficient allocation in the production function. This finding corroborated the a-priori assertion that resources allocation is efficient in small-scale agricultural production in the developing countries (Ojo and Ajibefun 2000). The coefficients of age of planted trees and age of farmers were negative, implying as each of these variables increases output from taungya farming decreases.

The return to scale (RTS) analysis is presented in Table 4. The summation of the elasticity of production for each of the included variables of the general model of the stochastic frontier production function as presented in Table 4 is the return to scale analysis. The RTS of 0.550 indicates that agricultural production under the taungya farming is in stage II, the stage of economic relevance of the production function and thus production is efficient.

TABLE 4: ELASTICITY OF PRODUCTION AND RETURN TO SCALE

Variables	Elasticity of production
Farm size	0.283
Age of tree planted	-0.157
Labour	0.497
Operating expenses	0.272
Age of farmer	-0.345
RTS	0.550

Technical Efficiency Analysis: The TE of farms under the taungya farming scheme varied significantly between 0.563 and 0.984 with a mean of 0.912, (Table 3). The farmers were relatively technically efficient with about 85 percent of them having TE above the mean TE of 0.912 for the study area. The inefficiency model of the taungya farms presented in Table 3 showed that improved educational level of the farmers and increase in amount of technical assistance in form of extension visits would lead to increase in the technical efficiency of the taungya farmers because the coefficients of these variables had negative sign in the inefficiency model and thus led to decrease in technical inefficiency. Also increase in farming experience and membership of cooperative societies would only reduce the technical efficiency of the farms as the coefficients of the variables had positive sign in the inefficiency model and thus would only further lead to increase in technical inefficiency.

Conclusion

The study revealed that agricultural production under taungya farming was profitable, productively and technically efficient and also ensured the production of choice economic trees that would guarantee continuous production of such trees. The technical efficiency of the taungya farms would improve with improved education and increased technical assistance in form of extension visits.

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