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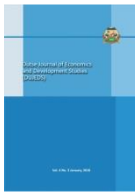
E-Mail: dujeds@fud.edu.ng



ANALYSIS OF TECHNICAL EFFICIENCY AND SUSTAINABILITY OF WORLD BANK'S FADAMA III YAM FARMERS IN BENUE STATE, NIGERIA.

AHEMEN, Member — **Department of Economics, Benue State University, Makurdi-Nigeria**

ABACHI, Philip Terhemen — **Department of Economics, Benue State University, Makurdi-Nigeria**

BAKKIHS David Terkura — **Department of Economics, Benue State University, Makurdi-Nigeria**

Abstract

Donor agencies over the years have embarked on programmes and projects to boost agriculture in Nigeria, unfortunately, most of these projects fold up once funds stop flowing from such agencies. The paper evaluated the technical efficiency and sustainability of World Bank supported Fadama III yam farmers in Benue State. The methodology used in the study is both qualitative and quantitative. The study employed the survey method and data was generated through well-structured questionnaire which was administered to 120 Fadama III yam farmers from Otukpo, Buruku and Logo Local Government Areas of Benue State. The Cobb-Douglas Stochastic frontier production function was used to analyze the technical efficiency of Fadama III farmers while the sustainability index was measured using the Sustainability Assessment of Farming and the Environment (SAFE) framework. Findings from the study show that average savings were below 10% of average income for more than 70% of the Fadama III yam farmers. Estimates of the stochastic frontier production function analysis showed that Fadama III beneficiaries were not efficient in their productive activities. The study concluded that Fadama III yam farming was not sustainable in Benue State. The study recommended that there is need for increase in farm size by Fadama III yam farmers to improve yam output and income, also Deposit Money Banks and Micro-finance Banks should be encouraged to open branches in all the Local Government Areas of Benue State so as to encourage farmers to save.

Keywords: Fadama III, Technical Efficiency, Sustainability, Yam Farmers, Benue State
JEL Classifications:

Introduction

Agriculture is an important sector of the world and the mainstay of majority of people living in the rural areas especially in developing countries. The importance of this sector stems from the fact that it provides employment, income and food security. Okyere and Jemaneh (2012) affirmed that about 65 per cent of the total labour force in Africa is employed in the agricultural sector, contributing about 32 per cent to the continent's Gross Domestic Product (GDP). In Nigeria, agriculture has been the mainstay where over 70 per cent of the population is employed yet, food (crop) production increases have not kept pace with population growth, resulting in rising food imports and declining levels of national food self-sufficiency (FMARD, 2008).

The third National Fadama Development Project (NFDP) was introduced in 2008, a development intervention by the World Bank to enhance food security. The project incorporated the concept of sustainability to ensure that farmers adopt practices that will guarantee the survival and continuity of their farms even after the support from donor agencies. The savings scheme stipulated by Fadama III was largely to promote community–level re-capitalization as well as to ensure sustainability of the investment activities that were funded. The savings in the form of withholding of an amount equivalent to at least 10 per cent of their net annual revenue were not only for replacement of the durable asset but also to maintain a high functionality of the asset before the end of its economic life (Umeh, 2011).

One of the crops supported by the Fadama III project was yam production. Yams are largely produced in the nations of Africa accounting for 95% of the total world production, Nigeria has been the world's leading producer of this food crop with an estimated 38.000 MTs in 2012 (FAO, 2013). Yet Oni, Nkonya, Pender, Phillips and Kato (2009) observed that increase in yam production in Nigeria has been achieved through expansion of cultivated area with little improvement in productivity; the traditional production systems are under pressure due to low soil fertility, increased pest problems, backward farming technology and small holder farmers.

In Benue State, the Fadama III project supported and encouraged yam farmers to adopt new technologies like improved inputs and these were made accessible to them. Also, the sustainability concept incorporated in the Fadama III project was to ensure that farmers adopt practices that will improve productivity, increase incomes and encourage savings which is a form of recapitalization to enable their farms survive after the assistance from donor agencies. Current understanding maintains that agriculture is sustainable when current and future food demands can be met without necessarily compromising economic, ecological, and social needs. To boost the economic needs of farmers, sustainable agriculture stands for maximizing the productivity of the land, maximizing farm income and having optimum knowledge of the industry. Thus, the extent to which these economic needs have been met to achieve technical efficiency and sustainability by Fadama III yam farmers in Benue State is yet to be established.

The paper therefore, has examined the efficiency and sustainability of Fadama III yam farmers in Benue State. Following this introduction is a review of relevant literature, after which the methodology is presented. Results and discussion are presented while conclusion and policy recommendation concludes the paper.

Literature Review

Series of research works have been carried out to assess the technical efficiency of yam farming Etim, Thompson and Onyenweaku (2013) estimated farm-level output-oriented technical efficiency indices in Akwa Ibom State, Nigeria using maximum likelihood techniques; they found the most important production factors as land, family labour, hired labour, planting materials and stakes. Shehu, Iyortyer, Mshelia and Jongur (2010) investigated the determinants of yam production and technical efficiency of yam farmers in Benue State, Nigeria using stochastic frontier production function which incorporated a model of inefficiency effects. They found that land, seed yam, family labour and fertilizer were the major factors that influenced changes in yam output. Farmer-specific variables such as education, membership of association and household size were found to have significant effects on the observed variation in technical efficiency among the yam producers. Ani, Iorkaa, and Ogebe (2014) assessed the technical efficiency of yam production efficiency in Ukum Local Government Area, Benue State-Nigeria. The result identified the most popular cultivar as white yam (Diosocrea rotundata). The cost and returns analysis showed that yam production was profitable in the study area. The result of resource use showed that yam farmers in the study area were over-utilizing their resources. The attainment of the average technical efficiency of 57% indicated that the technical efficiency of the farmers could be increased by 43% through efficient use of available resources. The study also identified common problems of yam production in the study area as pests, inadequate storage facilities, and insufficient improved varieties of yam, land tenure and high cost of inputs. Verter, and Bečvářová (2015) also analyzed the determinants of yam production in Nigeria They found farm size, producer price, fertilizer use, yield (Hg/Ha), and economic growth positively influenced yam production in Nigeria.

Asante,Villano, and Battese (2014) examine whether the adoption of yam minisett technology had an effect on the technical efficiency of production of the yam farmers in Ghana. They found positive and significant effect of the technology in the Ashanti region. Anyiro, Emerole, Osondu, Udah and Ugorji, (2014) examined labour-use efficiency in Abia State, Nigeria. The Cobb-Douglas functional form of labour-use frontier estimates showed that the quantity of harvested yam, size of cleared farm land and quantity of fertilizer applied significantly affected the amount of labour used in yam production. The socio-economic determinants of labour use efficiency were age, education, farm size, gender, labour wage and household size. Agunloye, Fasina and Akimagbe (2017) examined the effects of National Fadama III programme on the scale and scope of beneficiaries farming activities. They found that beneficiaries' scope of crop and scale of crop production increased significantly for yam farmers in South West Nigeria. Nmadu and Simpa (2014) investigated whether socio-cultural factors accentuate technical efficiency of yam farmers in Kogi State, Nigeria. The results indicated that there was more number of socio-cultural factors that determine the level of technical efficiency of yam farmers than the socio-economic factors.

So much has been written on yam production and efficiency in Benue State and Nigeria at large. These papers however to the best of my knowledge did not account for the efficiency and sustainability of Fadama III yam farming. Evaluating the efficiency and sustainability of yam farming is of great importance to the government and the World Bank who are concerned about how well these yam farmers can save and manage their farms with the risk associated with withdrawal of counterpart funds from the government and donor agencies.

Methodology

The study area is Benue State. The State is located between Longitudes 6^0 35'E and 10^0E and between Latitudes 6^0 30'N and 8^0 10'N. The State is on the Eastern side of the Middle Belt of Nigeria. Benue State is considered one of the least urbanized states in Nigeria with a population of 4,219,244 comprising of 2,164,058 males and 2,062,180 females (NPC, 2007).The State is categorized as one of the poorest states in thecountry where 67.1% of her people are living below the poverty line (NBS 2012). Benue State has abundant land estimated to be 5.09 million hectares. This represents 5.4 percent of the national land mass. Arable land in the State is estimated to be 3.8 million hectares (WARDROP, 1993; BENKAD, 1998).

This study employed the survey method. Using a cross-sectional survey, the data for the study was generated through well-structured questionnaire which was administered to 120 Fadama III yam farmers from Otukpo, Buruku and Logo Local Government Areas of Benue State. Stratified and purposive sampling techniques were used to draw out the sample. To analyze the data, both descriptive statistics and econometric methods like the stochastic frontier production function were used to analyze technical efficiency and sustainability of Fadama III yam farmers in the study area.

Efficiency Estimation

The approaches to measure technical efficiency are output-oriented and input-oriented approaches. The input-oriented approach, known as input over-use is concerned about how much inputs could be proportionately reduced to achieve technically efficient levels of production, whereas, the output-oriented approach(output-shortfall) is concerned with by how much output could be expanded from a given level of inputs. In this paper, the output-oriented approach is used for analysis, this is because the analysis of Fadama III yam farmers in Benue State is under traditional agricultural settings where there are concerns of output short-fall and not input over-use (Asefa, 2011). The analysis of variations of actual output from the frontier due to inefficiency and random shocks is captured through the stochastic frontier approach. This approach is preferred to the data envelopment analysis which is a deterministic frontier (meaning that all deviations from the frontier is attributed to inefficiency alone) as a result of inherent variability of agricultural production in developing countries due to exogenous factors like weather shocks, diseases and pests. Also, most available data on production are likely to have measurement errors as a result of low levels of education of farmers in developing countries.

The Stochastic Frontier production function measures relative efficiency, which could account for all factors of production simultaneously. The implicit assumption of production function is that all firms are producing in a technically efficient manner and the representative (average) firm therefore defines the frontier. Variations from the frontier are assumed to be random and are likely to be mis- or un-measured production factors.

The stochastic production frontier function as presented byBattese and Coelli (1995) is given as:

$$y_i = f(X_i, \beta + V_i - U_i) \quad \text{------} \quad 1$$

Where:

y_i = the output of the ith farm

X_i = a vector of input of the ith farm

β= a vector of parameters to be estimated

f =a suitable functional form such as Cobb-Douglas or Translog

V_i = random variable which is assumed to be normally distributed with zero mean and variance σ^2 and independent of U_i.

U_i= are non-negative random variables which are assumed to account for technical inefficiency in production and are obtained by truncation of the normal distribution.

The Cobb-Douglas production function is preferred because its coefficients directly represents the output elasticity of inputs and easy for interpretation and estimation than the trans log frontier (Battese and Coelli, 1995).

As presented in the model, the stochastic frontier has two error terms, one error term U_i accounts for technical inefficiency and the other $V_i$accounts for other factors such as measurement errors.

A Cobb-Douglas Stochastic Frontier model takes the form:

$$\ln y_i = \beta o + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \beta_3 \ln x_3 + \beta_4 \ln x_4 + \beta_5 \ln x_5 + v_i - u_i \quad \text{------------------------------}2$$

where: y_i= Total farm output of ith farmer (kg); X_1=farm size (ha); X_2= Seed/Seedling (kg) X_3 =quantity of fertilizer used (kg); X_4= Agrochemicals (litres); X_5=Labour (man-days); B_{1-5}=coefficient; B_o, v_i= random error that assumed to be normally distributed with zero mean and constant Variance (δ2vi) and u_i= technical in-efficiency effects independent of v_i and have half normal distribution with zero mean and constant variance (δ2Ui) ln = the natural logarithm of the variables.

The inefficiency model following Battese and Coelli (1995) model is defined as:

$$u_i = \delta o + \delta_1 z_1 + \delta_2 z_2 + \delta_3 z_3 + \delta_4 z_4 + \delta_5 z_5 \quad \text{--}3$$

where: U_i= Inefficiency effect; Z_1=Advisory services (number of advisory/ extension workshops attended); Z_2=Adoption of improved technology (1 if farmers adopt improved technology, 0 otherwise); Z_3= Age; Z_4= Sex (1 if male, 0 female); Z_5 = off-farm activity (1 if engaged in off-farm activity, 0 otherwise), δ_1-δ_5 =Coefficient, δ_o= constant.

Measurement of Sustainability

Just as there are many different definitions of sustainability, there are also many differing viewpoints on appropriate ways to measure and assess sustainability. Part of the controversy surrounding sustainability assessments lies in the attempt of these assessments to measure multi-dimensional, dynamic, and complex systems with multiple levels of organization using only a few, easily measured indicators of sustainability. Bossel (2001) observed that sustainability as a concept has to be translated into the practical dimensions of the real world to make it operational.

Von Wire´n-Lehr (2001) identified two frameworks for selecting indicators of sustainability: content and system based frameworks. System-based frameworks are frameworks that use holistic system approach with integrated evaluation of the social, environmental and economic aspect of the system. They are based on the general attribute of the system such as growth, resilience and stability. On the other hand, content-based frameworks provide specific indicators that characterize single part of the system of concern. These frameworks facilitate the translation of functions into specific objectives and quantitative parameters such as farm income, non farm income and access to market.

In this study, a content based framework, the sustainability assessment of farming and the environment (SAFE) framework developed by Van Cauwenbergh *et al.*, (2006) was used to measure the sustainability of the Fadama III yam farmers. Also, only the economic indicators of sustainability: annual income, non-farm income, farm size, savings, technical efficiency, economic efficiency, farming experience, number of advisory services attended and extent of adoption of technology were developed to measure the level of sustainability of Fadama III yam farmers in Benue State. The benefit of this type of framework is that it is easier to determine specific objectives and quantifiable parameters and allows for evaluation of specific components; however, this type of framework does not provide an evaluation of the whole system.

Results and Discussions

Socio-Economic Characteristics of Fadama III yam farmers in Benue State

The socio-economic characteristics of the respondent presented in Table 1 revealed that majority (84.1%) of the yam farmers were aged between 30 and 60 years with a mean age of 50 years. This falls within the active labour force, these findings agrees with the findings of Anyiro *et. al* (2014) who reported that yam production was an enterprise that demanded commitment of persons within the active age to carry out the activities of mound making, planting, staking and weeding.

Table 1: Socio-economic characteristics of Fadama III yam farmers in Benue State

Variable	Frequency	Percentage	Mean
Age (Yrs)			
<30	3	4.2	
30-60	99	84.1	50
>60	18	11.7	
Gender			
Male	87	72.5	
Female	33	27.5	
Household size			
< 10	47	39.2	
10-20	60	50	12
>20	13	10.8	
Farming Experience(yrs)			
<10	1	0.8	
11-20	48	40	
21-30	33	27.5	27
31-40	27	22.5	
>40	11	9.2	
Farm Size(Ha)			
<2	36	27.5	
2-4	83	71.7	2
>4	1	0.8	

Source: Field Survey, 2015

The result in Table 1 also show that the mean farm size was 2 hectares and more than 70% of the respondents cultivated between 2-4 hectares. This means that most farmers in the study area are producing on a small scale and need to be supported to embark on large scale yam production to improve their income. This result shows that majority (72.5) of the respondents were male, the dominance of male shows that yam production involves consuming a lot of energy, this agrees with Anyiro et al (2014) who asserted that yam production requires innate physical exertion of carefully selected force. Farming experience among the respondents was high as majority (59.2%) had farming experience of over 20 yearswith a mean farming experience of27 years.This means that the vast experience in yam farming will have an effect on farm management and adoption of technology. The large household size o the respondent also indicate that birth rate in the study area is still high with a mean household size of 12.persons. Due to the labour intensive nature of yam farming, a large household size was seen as a necessity for large farm sizes and a means to food security.

Savings Rate of Fadama III Yam farmers in Benue State

The resultsof the savings rate Fadama III yam farmers in Benue State are presented on Table 2.The results indicate that savings made by the farmers which were expected to be used as a form of recapitalization by the yam farmers were poor, a large number (71.67%) of the respondents did not save up to ten percent (10%) of their income as stipulated by the recapitalization plan for sustainability of the Fadama Project.

Table 2: Savings Rate of Fadama III Yam farmers in Benue State

Savings Rate	Frequency	Percentage
Less than 10 per cent	86	71..67
10 Per cent or more	34	28.33
Total	120	100

Source: Field Survey, 2015

The result show that over seventy percent (71.67%) of Fadama III yam farmers saved less than ten percent (10%,) while about twenty eight percent (28.33%), saved ten percent(10%)or more of their annual income from productive activities. This shows that the savings made by Fadama III yam farmers in Benue State are not sustainable. The reasons given for the low savings could below income from enterprises and the absence of Deposit Money Banks in two (2) Local Government councils in the study areas (Buruku and Logo).

Maximum Likelihood Estimates for Parameters of the Stochastic Frontier Production Model for Fadama III yam Farmers in Benue State

The one stage maximum likelihood estimation procedure was employed to simultaneously estimate parameters of both the Stochastic Frontier production function and inefficiency effect model of Fadama III yam farmers in Benue State and the result is presented in Table 3.

Table 3: Maximum Likelihood Estimates for Parameters of the Stochastic Frontier Production Model for Fadama III yam Farmers in Benue State

Variable	Parameter	Estimate	Standard Error	t-ratio
Stochastic frontier				
Constant	δ_0	1.14	0.35	3.26*
X_1 Ln(Farm size)	δ_1	0.27	0.24	1.12
X_2 Ln(Seed/Seedling)	δ_2	0.22	0.09	2.44*
X_3 Ln(Fertilizer)	δ_3	0.16	0.07	2.29*
X_4Ln(Agrochemicals)	δ_4	0.18	0.04	4.50*
X_5 Ln(Labour)	δ_5	0.28	0.26	1.08
Inefficiency Model				
Constant	Ψ_0	1.58	0.06	26.33*
Z_1 Advisory services	Ψ_1	-0.15	0.20	-0.75
Z_1 Adoption of technology	Ψ_2	-0.02	0.01	-2.00*
Z_1 Age	Ψ_3	0.01	0.02	0.50
Z_1 Sex	Ψ_4	0.21	0.09	2.33*
Z_1 Off-farm activity	Ψ_5	-0.56	0.15	-3.73*
Variance Parameters				
Sigma squared	δ^2	0.01	0.0007	10.58*
Gamma	Γ	0.84	0.03	32.43
Ln likelihood		-143.48		

Source: Author's computation using Frontier 4.1 *t-ratio is significant at 5% level of significance.

The maximum likelihood estimates of Stochastic Frontier production function as presented in Table 3 shows that the elasticities of frontier output of Fadama III yam farmers was estimated to be an increasing function of farm size (0.27), seedling (0.22) labour (0.28), fertilizer (0.16) and agrochemical (0.18). A one percent increase in farm size, quantity of seed/seedling planted, quantity of fertilizer and agrochemicals applied and man hour increase in labouris expected to increase yam output by 0.27%, 0.22%, 0.28%, 0.16% and 0.18% respectively, ceteris paribus. The result also showed that the positive effect of farm size and labour are not significant but that of seedling, fertilizer and agrochemicals are significant at 1%. The return to scale parameter for Fadama III yam farmers was found to 1.11 implying increasing return to scale. This suggests that a proportionate increase in all the inputs will lead to more than proportionate increase in their output. This increasing return-to-scale implies increasing productivity per unit of input and suggests that Fadama III yam farmers can still increase their level of output at the current level of resources as this will result to higher output.

The explanatory variables in the inefficiency model shows that the estimated coefficients of advisory services (-0.15), adoption of technology (-0.02) and off-farm activity (-0.56) reduced inefficiencies in Fadama yam production while the coefficients of sex (0.21) and age (0.01) increased the inefficiency of Fadama III yam farmers. The results showed a gamma of 0.84 implying that 84% of the variations in productivity of Fadama III yam farmers in Benue State were technically inefficiency and there were significant efficiency variations among the farmers. This indicated that reducing technical inefficiency among respondents will result in substantial productivity increases. The Sigma squared (δ^2) of 0.01 was significant at 1% indicating a good fit.

The frequency distribution of technical efficiency estimates of Fadama III yam farmers in Benue State showed that nearly twenty eight (28%) of the farmers had efficiency score below 0.60. Forty percent (40%) of the farmers had efficiency score ranging from 0.60 to 0.80; and the remaining thirty two (32%) of the respondents had efficiency score above 0.80, the mean technical efficiency value was 0.67. The wide variation in technical efficiency is an indication that most of the Fadama III yam farmers in Benue state were still using their resources inefficiently in the production process and there still exist opportunities for increasing their yam output by improving on the current level of technical efficiency.

Analysis of the Sustainability of Fadama III Yam Farmers in Benue State

The sustainability of Fadama III yam farmers was analyzed using the SAFE model; only the economic indicators of sustainability were calculated using the min-max normalization. The result is presented Table 4.

Table 4 Sustainability indices for Fadama III Yam Farmers in Benue State

	ANNY	NFAMY	FAMSZE	SAV	TEFF	EEFF	FAMEXP	NADV	EXADPT	SUST INDEX
YAM	0.42	0.43	0.33	0.23	0.52	0.39	0.55	0.45	0.40	0.42

Source: Field Survey, 2015

ANNY= annual income, NFAMY=non-farm income, FAMSZE= farm size, SAV = savings, TEFF = Technical Efficiency, EEFF = Economic Efficiency, FAMEXP = farming experience, NADV = number of advisory services EXADPT = extent of adoption of technology and SUST INDEX = sustainability index

The economic indicators of sustainability shows that technical efficiency (TEFF), and farming experience (FAMEXP) of Fadama III yam farmers in Benue State had sustainability indices above average, while savings (SAV), farm size (FAMSZE) and economic efficiency (EEFF) had sustainability indices below average. This shows that the indicators that contributed more to the sustainability of Fadama III yam farmers in Benue State were technical efficiency and farming experience of farmers. On the other hand savings, farm size and economic efficiency were the indicators responsible for the low sustainability index for Fadama III yam farmers in Benue State.

It was observed that the low savings index could be as a result of poor savings of the farmer as only twenty eight percent (28%) were able to save up to ten percent (10%) of their annual income as expected. The low economic efficiency index implied that beneficiaries were not using their inputs in optimal proportions given their respective prices. This finding agree with Asogwa, Umeh and Okwoche (2012) who reported that allocative inefficiencies were worse than technical inefficiencies among farming households in Benue State.

Conclusion and Policy Recommendations

The study used both descriptive and econometric methods to analyze the efficiency and sustainability of Fadama III yam farmers in Benue State. Using one step maximum likelihood estimation procedure, the parameters of the Cobb-Douglas stochastic function and technical inefficiency effects of the model were simultaneously estimated. The results showed that except labour and farm size, all the other inputs have significant effect on Fadama III yam producers in Benue State. That means that the use of more labour does not have significant impact on Fadama III yam farmers in the study area due to the abundance of labour in the study area. The findings show that the predicted efficiency varied widely among the sampled farmers, with a mean efficiency of 0.67 indicating that it is above the mid-way to the frontier. This also implies that yam production by Fadama III farmers in Benue State can be increased by 33% at the current technology and existing level of inputs to operate at full efficiency level.

Results indicate that yam seedling, fertilizer application and the use of agrochemicals have positive and significant effect on efficiency. The policy implication is that improving access to fertilizer, agrochemical and seedling through the availability of these inputs at affordable prices would increase the efficiency of Fadama III yam farmers and subsequently yam output in Benue State. In conclusion, the World bank's Fadama III yam farmers project in Benue state is not sustainable. Savings can be improved upon by encouraging large scale yam production which will increase income and subsequently increase the sustainability of Fadama III yam farming in Benue State. It is recommended that there is need for increase in farm size by Fadama III yam farmers to improve yam output and income, also Deposit Money Banks and Micro-finance Banks should be encouraged to open branches in all the Local Government Areas of Benue State so as to encourage farmers to save.

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