Journal of Sciences and Multidisciplinary Research
Volume 8, No. 2, 2016
ISSN: 2277-0135

COMPARATIVE ANALYSIS OF RESOURCE USE EFFICIENCY AND ADOPTION OF RECOMMENDED RICE-BASED TECHNOLOGIES BY AGRICULTURAL DEVELOPMENT PROGRAMME (ADPs) IN THE PRODUCTION OF LOCAL *(Oryza glaberrima steud)* AND IMPROVED (*Oryza sativa linn {faro44}* VARIETIES OF SWAMP RICE BY FARMERS IN CROSS RIVER STATE, NIGERIA

[1]Adinya I. B. and [2]Mahmood, H. U.

[1]Department of Agricultural Economics and Extension, Cross River University of Technology, Obubra Campus
[2]Department of Agricultural Economics and Extension, Taraba State University, Jaligo
Email: dradinyaignatius@gmail.com

Abstract: This study compares and analyzes resource use efficiency and adoption of recommended rice-based technologies by Agricultural Development Programme (ADPs) in the production of local and improved varieties of swamp rice by farmers in Cross River State of Nigeria. Data were collected from 224 rice farmers from twelve Local Government Areas in Cross River State were interviewed using three-stage stratified random sampling procedure involving simple random sampling technique was used to selected respondents. Data collected were analyzed using descriptive statistics, stochastic frontier function that incorporated inefficiency effects were estimated using the Maximum Likelihood Estimate (MLE) and probit and logit analyses. The result showed that some of the farmers were illiterate 48.21% and 43.75% of local variety rice farmers and improved variety rice farmers. The result also showed that the sum of elasticity of 1.33 and 1.65 for local and improved varieties of swamp rice respectively indicates that local and improved varieties of swamp rice farmers in the study area were operating in the inefficient stage (ΣP is greater than 1; increasing return to scale region). The gamma (γ) were 0.60 and 0.75 for local and improved varieties of swamp rice respectively and significant at the 1% level. It is an indication that 60 and 75 percent variation in output of local and improved varieties of swamp rice respectively are attributed to technical inefficiency. The sigma-square (δ2) on the other hand were 0.45 and 0.51 for local and improved varieties of swamp rice respectively and significant at the 5% level. The Likelihood Ratio Test (LRT) for local variety of swamp rice (25.61) and improved variety of swamp rice (20.53) were technically inefficient. The mean efficiency values were 0.67 and 0.75 for local and improved varieties of swamp rice respectively, the analysis showed that both local and improved varieties of swamp rice produced in the study area has not reached frontier threshold, as such , within the context of efficient production, rice production can still be increased by about 33 percent and 25 percent for local and improved varieties of swamp rice respectively using available technology. The result of the study showed that improved variety of swamp rice farmers(75%) were more efficient than local variety of swamp rice farmers(0.67).The result of the finding also shows that coefficient of frequency of extension contact entered the model with a prior expected positive sign. The variable turned out to be a significant determinant of adoption decision in the study area. The positive sign associated with the variable in the model, implies that adoption decision of rice farmers in the study area, would depend significantly on the information they get through the extension agent and the frequency of such information. Frequency of extension contact to disseminate information encourages early adoption. The result of the finding shows that a net return of ₦145.667.00K with ₦6.27K made on every naira invested in local variety of swamp rice produced in the study area. Comparatively, improved swamp rice farmers realized a net return of ₦277,397.00K with ₦9.80K made on every naira invested in improved variety of swamp rice produced in the study area. Rice farming business is a profitable business, with attractive net return on investment. It was therefore recommended that the government should post more extension agents to the study area because agricultural extension visit / training of rice farmers would enable non-adopters of new technologies in rice production to adopt innovations. Rice farmers in the study area should use labour saving machines for rice production.

Keywords: Agricultural Extension Service, Efficiency, Resource use, *Oryza sativa linn* {faro44}, *Oryza glaberrima steud),* Swamp Rice, Farmers.

INTRODUCTION

Agricultural production in Nigeria is labour intensive and more than 90 percent of populations are small-scale farmers cultivating one to two hectares, and utilizing unpaid family labour as a major source of farm labour supply (Olayide and Atobatele, 1980). In Nigeria, the sizes of individual farm holdings are small; average is from 1.0 to 2.0 hectares (Anon, 1972) with limited capital resources and characterized by hand tool technology. In Cross River State, about 83.9 percent of the population is engaged in agricultural production; they depend on agriculture for their sustenance. According to the United Nation Demographic Year Book (1990) only 16.1% of Nigerian lives in urban areas while majority of the people living in rural areas depend directly or indirectly on agriculture for their livelihood.

The lack of information among farmers has result to low productivity. The lack of information among farmers also immensely affects their health status, increasing the incidences of diseases and consequent low productivity (Abeng and Ononugbo, 2006). The farmers' lack information about crop price, new farming techniques and new markets for their products, they remain excessively dependent on middlemen, unable to adapt to climatic change and market changes, and unable to get the best yield from their crops (Abeng and Ononugbo, 2006; Ekumbe, 2008). The problem of low productivity in crop and animal production in the recent years is cause by gap in knowledge/information, inefficient use of available resources, non-adoption of new innovations, weak research institutes-extension agents – farmers linkage system and un-focus government policies in Nigeria (Adinya *et al,* 2006). According to Adinya (2011), opportunities for developing and adopting better technologies provide a possible solution for raising productivity and improve efficiency. Efficiency is a very important factor for productivity growth especially in the area where resources are meager, and can be achieved through optimal resources allocation.

Agricultural extension helps to empower farming communities by helping them to decide on how best to use the available resources, information and technologies (Eze, 2006). Agricultural extension service in developing countries is believed to be a catalyst for national development. The role of agricultural extension service cannot be over emphasized considering the dependence of developing countries on agriculture as the primary contributors to Gross Domestic Product (GDP). It is also a source of employment and livelihood for majority of the population in Nigeria (Aboje, 2006; Adinya *et al,* 2006).

Agricultural extension service is a necessary prerequisite to widespread and sustained agricultural development. It is not possible, even in highly developed countries, to encourage farmers to adopt new technology or more efficient production practices based on continuously advancing research results and new agricultural techniques to farmers, some one must teach farmers how these practices should be used and adopted under their own individual farming and resource availability. Thus agricultural extension service is needed to teach farmers how to adopt improved production practices. Efficient food supply in any country depends to a large extent on the level of agricultural production, research and agricultural extension services of such nation (Adinya *et al,* 2006).

The major roles of agricultural extension services are to impart knowledge, vocational skills and stimulate farmers' adoption, application and continuous use of the new farm innovations and technologies in improving the farming practices and standard of living (William, 1984; Onu *et al,* 2003). According to Ajayi and Madukwe (2001) many technological innovations have been generated, but little or nothing is known about their dissemination processes to the ultimate users (farmers), the issue is not whether to use the innovations but how to transfer them to farmers (Ajayi and Madukwe, 2001; Udokang, 2011). As good as any scientific innovation may be, without getting to farmers for the purpose of their productivity and hence, generating more income, it is useless and it is as good as not being discovered. Furthermore, the role of agricultural extension service is to facilitate effective transfer of these innovations to farmers.

Agricultural extension services are unique services that provide non-formal education and improved information services that help in increasing small and large-scale farmers' productivity and ensure food security. Onu *et al,* (2003) revealed that agricultural extension services is one of the means available to promote the exchange of information that can be converted into functional knowledge, which is instrumental in helping to promote productivity and generate income to alleviate poverty. The transformation of agriculture from low productivity to high productivity is a major problem facing agricultural development in Nigeria (Ibrahim, 2006). Raising productivity is necessary to increase domestic food and animal production and farmers' income. Idiong *et al* (2006) observed that productivity enhancement can be achieved through the adoption of innovations and improvement in efficiency of resource use by farmers. However, given the high rate of inefficient use of resources by farmers, adoption of innovations remains the most effective way in enhancing productivity in the short run.

Adinya, (2001) noted that in order to solve the problems of farmers, it is important for input supply agencies to open up more distribution centres in rural areas and increase the stock of goods meant for sale to farmers and at reduced prices. The rapid demand for agricultural inputs without corresponding supply of agricultural inputs (fertilizers, herbicides, and insecticides) use for food production has resulted to food supply deficit, hunger and poverty (Adinya, 2001). He further noted that, successful agricultural development cannot take place in Nigeria until the problems which militate against effective agricultural extension and adoption of improved technologies are identified and solved. Ime (2003) revealed that in Nigeria, series of extension strategies have been used to promote the transfer of new technologies and farming practices, but have been hindered mostly by poor monitoring system; poor research communication system, poor financial allocation to various extension agencies. All these have created a wide gap in technology development and transfer in all aspect of agriculture to farmers.

Rice is widely cultivated as a major crop in the tropical and sub-tropical regions of all the continents. Over 90 percent of the total rice crop is grown in South-East Asia, India and China. However, China and India are the leading countries in the world in rice production. Africa accounts for 2 percent of the total quantity of rice production in world. Important rice producing countries producing more than 1 million tones annually in tropical Africa are Madagascar and Nigeria (Onweme and Sinha, 1991). Rice production in Nigeria has always fallen short of its demand in-spite of huge investments in its production; and in spite of the production resources in Nigeria, self-sufficiency in rice production and availability of carbohydrate in the diet of an average Nigerians are yet to be achieved (Goni, *et al,* 2007). The country needs 5 million metric tones of paddy for self-sufficiency but currently 3.2 million metric tones are produced leaving a deficit of 1.8 million metric tones. This has gulped a lot of our scare foreign exchange to the tune of $758 million in 2002 and sum of $810 million in 2003. unfortunately, out of the total 4.6 million hectares paddy land available in Nigeria only 1.8 million hectares is currently under cultivation (Central Bank of Nigeria (CBN, 2005); Goni *et al,* 2007).

Ike (2003) revealed that there is a wide gap between what research findings have shown to be possible and feasible on the one hand, what actually obtains on the other. He further stated that, irrespective of the potentials and promise of any agricultural research findings, the full potential cannot be realized until it has been brought to the knowledge of the intended beneficiaries (farmers). He noted that many factors affected communication of agricultural innovations to farmers, these include; inappropriate communication strategies are used by extension agents to reach farmers and many research institutes have not fashioned out effective means of disseminating their improved research results to farmers.

In Nigeria, dissemination of agricultural technologies is the responsibility of the government. The Agricultural Development Programme (ADPs) are agencies responsible for extension service under the recognized and unified extension services of the state government (Unamma, 1994, Ahong, 2011, Udokang, 2011). To achieve the main goal which is dissemination of agricultural innovations to farmers, Cross River Agricultural Development Programme (CRADP) have adopted the training and visit (T and V) system technology transfer as recommended by World Bank (Udokang, 2011).

Cross River Agricultural Development Programme (CRADP) se goals for the rural extension workers, aimed at increasing the productivity and income of farmers in their areas of jurisdiction. To achieve this laudable objective, the extension aim of CRADP has an organizational structure, which permits the flow of information from the Chief Agricultural Extension Officer down to the baseline staff describe as extension agents (EAs) or village extension worker who teaches improved production technologies, he also brings back to the research station information on actual farm production condition, impact of agricultural extension service on the farmers and farmers' reaction to recommended practices (Benor and Baxter, 1984).

The Cross River Agricultural Development Programme (CRADP) covers an area of about 22,342.176 square kilometers (Quarterly Newsletter of the Ministry of Local Government Affairs, Cross River State, 2006). There are three agricultural zones in the state, each headed by zonal manager as follows:

(i) Calabar Zone comprises of Calabar South, Calabar Municipal, Bakassi, Akpabuyo, Odukpani, Akamkpa and Biase Local Government Areas.
(ii) Ikom Zone comprises of Boki, Etung, Ikom, Obubra, Yakurr and Abi Local Government Areas.
(iii) Ogoja Zone comprises of Bekwarra, Yala, Ogoja, Obudu and Obanliku Local Government Areas.

RESEARCH QUESTIONS

This study is therefore anchored on the following research questions:

(i) What are the socio-economic characteristics of swamp rice farmers in the study area?
(ii) What are the major sources of information in the study area?
(iii) Are rice farmers efficient or in-efficient in local and improved swamp rice production in the study area?
(iv) What are innovations adopted by rice farmers in production of local and improved rice varieties?
(v) What are the factors militating against local and improved rice production in the study area?

OBJECTIVE OF THE STUDY

The main objective of this study is to compare and analyze resource use efficiency and adoption of recommended rice-based technologies by Agricultural Development Programme (ADPs) in the production of local *(Oryza glaberrima steud)* and improved *(Oryza sativa linn* {faro44} verities of swamp rice by farmers in Cross River State of Nigeria.

Specific objectives of the study are to:

(i) describe the socio-economic characteristics of farmers in the study area;
(ii) determine the major sources of information for rice production in the study area;
(iii) analyze and compare resource use efficiency in local and improved swamp rice production in the study area;
(iv) determine innovations adopted by rice farmers in production of in local and improved rice varieties;
(v) what are the factors militating against local and improved rice production in the study area?

METHODOLOGY

Study area: The research was conducted in Cross River State. The state occupies an area of about 22,342.176 square kilometers (Quarterly News Letter of the Ministry of Local Government Affairs, C.R.S 2006). It is located on latitude 5° 25'N and longitude 25° 00'E. The soils of Cross River State are ultisol and alfisol but predominantly ultisol (FAO/UNESCO, 1974). There are eighteen Local Government Areas and one hundred and ninety-three communities in the state (five local government areas in Northern Senatorial Zone (Bekwarra, Yala, Ogoja, Obudu and Obanliku Local Government Areas), six local government areas in Central Senatorial Zone (Boki, Etung, Ikom, Obubra, Yakurr and Abi Local Government Areas) and seven local government areas in Southern Senatorial Zone (Calabar South, Calabar Municipal, Bakassi, Akpabuyo, Odukpani, Akamkpa and Biase Local Government Areas) (Quarterly News Letter of the Ministry of Local Government Affairs, Cross River State, 2006).

Cross River State is bordered on the North by Benue State, South by BIGHT of Bonny, and in the East by Ebonyi and Abia States, while in the West by Republic of Cameroon (Menakaya and Floyd, 1978). About 2,888,966 people inhabit the area, of which the Efiks, Ejaghams and Bekwarras are the major ethnic groups (Population census, 2006 in: Agbor, 2007 In: MOFINEWS, 2007).

Cross River State has the largest rainforest covering about 7,290 square kilometers. It is described as one of Africa's largest remaining virgin forest harbouring as many as five million species of animals, insects and plants (MONFINEWS, 2004). The state is located within the evergreen rainforest zone. There are two distinct climate seasons in the area, rainy season from March to October and dry season from November to February. The annual rainfall varies from 2,942mm to 3,42mm (Cross River Agricultural Development Programme (CRADP, 1992). The average temperature is about 28°c (CRADP, 1992). Cross River State is characterized by presence of numerous ecological and zoo-geographically important high gradient streams, rapids and waterfalls.

Fishing and subsistence agriculture are the main occupations of the people. Crops grown in the locality include rice, maize, yam, cassava, plantain and banana. Population depends largely on natural water sources for all their water-related activities, as pipe-borne water supply is limited and grossly inadequate. Health services in the area require a lot of improvement. Level of hygiene in the communities is generally poor (Arene *et al,* 1991).

SOURCE OF DATA COLLECTION

Both primary and secondary data were used for this study. The primary source of data was mainly from field survey. While secondary source of data include review of annual reports, books, census data, Central Bank of Nigeria statistical document and Journals.

METHOD OF DATA ANALYSIS

Data obtained for this study were subjected to different types of analyses: descriptive statistics, costs and returns analysis, and the Cobb-Douglas functional form of the stochastic frontier analysis. Objectives (i) (ii) and (v) were analyzed using descriptive statistics. This involved the use of measures of central tendency such as mean, mode, frequency distribution, simple percentages, ratio and measures of dispersion such as standard deviation.

The Cobb-Douglas production functional form of the stochastic frontier analysis was used to achieve objective (iii); objective (iv) was analyzed using costs and returns analysis.

MODEL SPECIFICATION

The model for the study with respect to rice output and the recommended rice – based technologies have been specified. Precisely, the hypothesized structural relationship for the rice – based technologies was given as follows:

Stochastic frontier production function

$Y = f(Xi\ \beta i) + Vi - Ui$... equation (i)

Where: Y = observed output of the ith farmer in kg

F(.) = Cobb-Douglass, Tan slog, etc

Xi = vector of inputs (known functions of factor inputs (farm size, labour, herbicide, rice seed and quantity of fertilizer applied) and their relevant explanatory variables associated with the production of the ith farmer.

βi = vector of unknown parameters associated with explanatory variables in the production function.

Vi = random error term

Ui = non-negative one sided error term that measures inefficiency

Using the method of Jondrow *et al* (1982), technical efficiency can be measured using the adjusted output as shown:

$Y^* = f(Xi\beta i) - Ui$... equation(ii)

Where Ui can be estimated as

$E(Ui/\varepsilon_i) = \delta\lambda\ [F^*(\varepsilon_i\ \lambda/\delta) - \varepsilon_i\lambda]$

$$1+\lambda^2[1-F^*(\varepsilon_i \lambda/\delta)- \delta \ldots \text{equation(iii)}$$

Where F* and F*(1) are standard normal density and cumulative distribution functions respectively.

$\lambda = \delta u/\delta v$
ε_i = Vi-Ui
$\delta^2 = \delta v^2 + \delta u^2$
V* is the observed output adjusted for statistical noise.

When ε_I, δ and λ estimates will be replaced in equation (ii) and (iii), the estimates of Vi and Ui were obtained.
Cobb-Douglas production function = $Yt = AK^{ά1}L^{ά2}L^{*ά3}M^{ά4}N^{ά5}Ut$...equ(iv)
This is non-linear function and could be converted into MRΔ
$Yi = A + _{ά1}K_t + _{ά2}L_t + _{ά3}L^*_t + _{ά4}M_t + _{ά5}N_t + Ut$...equation (v)

$L_n Y_t = L_nA + _{ά1}L_nK_t + _{ά2}L_nL_t + _{ά3}L_nL^*_t + _{ά4}L_nM_t + _{ά5}L_nN_t + Ut$...equation (vi)
$\log Y_t = \log A + _{ά1}\log K_t + _{ά2}\log L_t + _{ά3}\log L^*_t + _{ά4}\log M_t + _{ά5}\log N_t + \log Ut$...equ(vii)

In this study Cobb-Douglass production function was fitted to the frontier model of the two varieties of rice production systems and estimated using the maximum likelihood method. This is specified as follows:
$Ln\ Yi = Ln\ b_o + b_1\ LnX_{1i} + b_2LnX_{2i} + b_3LnX_{3i} + b_4LnX_{4i} + b_5LnX_{5i} + \varepsilon i$...equation(viii).

Where: Y = total output of rice (local / improved) in (kilogram)
X_1 = farm size (land planted to rice (in hectares).
X_2 = labour used in rice production in (man-days per hectare)
X_3 = adoption of herbicide application in (litre per hectare) which takes the value of Unity (1) if the farmer adopted herbicide application and zero(0) otherwise
X_4 = quantity of rice seeds (local =0 and improved seeds=1) used in respect of rice production (kilogram per hectare)
X_5 = adoption of fertilizer application in (kilogram per hectare) which takes the value of unity (1) if the farmer adopted fertilizer application and zero(0) otherwise
Ln = natural logarithm
b_o – b_5 = Regression coefficients to be estimated.
ε_i = composite error term (Vi-Ui)

Vi is assumed to be independent and identically distributed random errors with a zero mean and variance $\delta u^2 v$.
Ui is the technical inefficiency effects assumed to be independent of Vi and non-negative truncating at zero of the normal distribution. It has a mean and variance. Inefficiency factors were incorporated in the model to ascertain the effects of these variables on technical efficiency.

DETERMINANTS OF TECHNICAL EFFICIENCY

In order to determine the factors contributing to the observed technical inefficiency the following model was formulated and will be estimated jointly with the stochastic frontier model in a single stage maximum likelihood estimation procedure using the computer software frontier version 4.1 (Coelli, 1996).

This is defined mathematically as:
$TE_i = a_o + a_1Z_1 + a_2Z_2 + a_3Z_3 + a_4Z_4 + a_5Z_5 + a_6Z_6 + a_7Z_7 + a_8Z_8 + e$...equation (ix)
Where TE_i = the technical efficiency of the i-th farmer.

Z_1 = farmer's educational level (years of schooling)
Z_2 = farming experience (years)
Z_3 = age of farmer (years)
Z_4 = credit access, (a dummy variable) which takes the value of unity (1) if the farmer has access to credit and zero (0) otherwise
Z_5 = frequency of extension visit, (a dummy variable) which takes the value of unity (1) if the farmer was visited by extension agent and zero (0) otherwise (not visited by extension agent)
Z_6 = gender, (a dummy variable) male =1, female = 0
Z_7 = variety of planting materials (seeds) used, improved variety (*Oryza sativa:* Farro 44) = 1, local variety of rice (*Oryza glaberrima steud)* =0
Z_8 = member of cooperative; member =1, non=member=0
e = error term
a_o = intercept
a_1-a_8 = parameters to be estimated

Rate of Return to Scale: the elasticity of production which is the percentage change in output as a ratio of a percentage change in input was used to calculate the rate of return to scale which is a measure of a firm's success in producing maximum output from a set of inputs (Farrel, 1957; Awoke 2001; Adinya *et al,* 2008; Adinya *et al,* 2010a; Adinya *et al,* 2010b; Adinya *et al,* 2010c; Adinya, 2011a; Adinya, 2011b).

EP = MPP/APP
Where EP = elasticity of production ...equation(x)
MPP = marginal physical product
APP = average physical product

DECISION RULE

ΣEP = 1; constant return to scale

ΣEP is less than 1; decreasing returns to scale

ΣEP is greater than 1; increasing returns to scale

Allocative efficiency of resource use:

The allocative efficiency index (AEI) was used to determine whether the farmer was efficient or inefficient in allocation of his productive resource in swamp rice farming.

This is expressed as:

$$Ki = \frac{MVP}{Py} \quad \text{........equation (xi)}$$

Allocative efficiency is the ability of a farmer/farm/firm to equate marginal value product (MVP) of a factor to its price. Following Bagi (1981) and Onyenweaku *et al,* (1991), the allocative efficiency index "Ki" is expressed as follows:

$$Ki = P_{fi} = \frac{MVPi}{Px} = \frac{Py(d_y/d_{xi})}{Px} \quad \text{....................equation(xii)}$$

Where; MVPi = marginal value product (MVP) of the ith input (MPP x Px)

Px = unit price of the ith input

Py = price of unit of output

fi = marginal physical product of the ith input

Ki = allocative efficiency index (AEI) of the ith input

$$\text{Allocative Efficiency (AEI)} = \frac{MVP}{P} = 1 \text{ (efficiently utilized) ...equation (xiii)}$$

Where; MVP = marginal value product (MVP)

P = price

DECISION RULE:

If AEI is equal to (unity) = the farmer is allocatively efficient

If AEI ≠1, the farmer is allocatively inefficient

If AEI is less than 1 = the productive resources are over utilized

If AEL is greater than 1 = the productive resources are under utilized

According to Koutsoyiannis, (1977); Kohls and Uhl, (1980); Olayemi, (1988); Awoke, (2001); Adinya, 2009; Adinya *et al,* 2010b; Adinya *et al,* 2010c; Adinya, 2011a; Adinya, 2011b), a production input is efficiently utilized if the ratio of the MVP/ input price equates to unity, a ratio less than unity indicates over-utilization of production inputs while a ratio greater than unity shows that resources are under-utilized. The efficiency of each resource was ascertained by comparing the marginal value product of the resource and it marginal cost comparison of the efficiency associated with each resource use was done by adopting Mijindadi (1980) method. Thus marginal physical product will be obtained from the formula:

$$Mppx_i = \frac{d_y}{d_{xi}} = b_1\frac{Y}{X} \quad \text{......equation(xiv)}$$

Marginal value product was then derived from Mpp_{xi} as

$MVP_{xi} = Mpp_{xi}. Py$

$$MVPxi = \frac{d_y.}{d_{xi}} Py \quad \text{......equation (xv)}$$

Where; Mpp_{xi} = marginal physical product of the ith input, which is given by $\frac{d_y}{d_{xi}}$

d_y = change in unit of output
d_{xi} = change in unit of input
P_{xi} = price per unit of output

ECONOMIC EFFICIENCY OF RESOURCE USE

The following ratio was used to estimate the relative efficiency of resource use(r)

r = MVP/MFC ....equation (xvi)

Where: Marginal Value Product (MVP) is the change in total value of product (TVP) as a result of unit change in the variable input (ΔX_i). It is expressed as

$$MVP = \frac{\Delta TVP}{\Delta X_i}$$

MVP = value added to rice output due to the use of an additional unit of input, it was calculated by multiplying the MPP by the price of output as shown:

MVP = MPP x Py

Where; ΔTVP = change in total value of product (TVP)
ΔX_i = change in X_i
MPP = marginal physical product (MPP)
Py = price of output (Y)

Marginal Factor Cost (MFC) is the addition to total cost resulting from using an extra unit of input. It is expressed as:

$$MFC = \frac{\Delta TC}{\Delta X_i}$$

Where: ΔTC = change in total factor cost (TC)
ΔX_i = unit change in X_i

DECISION RULE

If r = 1, resource is efficiently utilized,
If r is less than 1, resource is over utilized,
If r is greater than 1, resource is under utilized.

Economic optimum takes place where MVP = MFC, if r is not equal to 1, it suggest that resources are not efficiently utilized (Olukosi and Ogungbile, 1989; Awoke, 2001; Goni *et al,* 2007; Adinya *et al,* 2008; Adinya *et al,* 2010a; Adinya *et al,* 2010b; Adinya *et al,* 2010c; Adinya, 2011a; Adinya, 2011b).
Gross margin analysis (GM)

The gross margin analysis that was used for this study is expressed as:

GM = TR-TVC ....equation (xvii)
Profit (π) = GM-TFC ......equation (xviii)
Where: GM = Gross Margin (naira)
TR = Total Revenue from production of rice (naira)
TVC = Total Variable Cost of production of rice (naira)
TFC = Total Fixed Cost of production of rice (naira)

Probit and logit model was used to determine if farmers adopted innovation/ technology in rice production in the study area or not;
A form of the logit model adopted in this study (Pindyck and Rubinfeld, 1981).
Pi = C/(1 $-e^{2}{}_{1}$)......equation(xix)

Pi = probability that a farmer I (I = 1, 2 ...110) choose to adopt recommended innovation or not, given the information embodied by index Z_1 = Unobserved, was investigated as being predicted by the following relationship:
Z_1 = BO + B_1X_1 + B_2X_2 + ... B_iX......equation (xx)

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Where choice index Z_1, on which to classify farmers in technology adopters and non - technology adopters

X_1 – X_5 = are factors influencing the farmer's decision to adopt technology or not;
X_1 = farm size (ha)
X_2 = frequency of extension visit, (a dummy variable) which takes the value of unity (1) if the farmer was visited by extension agent and zero (0) otherwise (not visited by extension agent)
X_3 = adoption of herbicide application in (litre per hectare) which takes the value of Unity (1) if the farmer adopted herbicide application and zero (0) otherwise

X_4 = quantity of rice seeds produced (yield from technology adoption plot) (local =0 and improved seeds=1) used in respect of rice production (kilogram per hectare)

X_5 = adoption of fertilizer application in (kilogram per hectare) which takes the value of unity (1) if the farmer adopted fertilizer application and zero (0) otherwise

C = A constant assumed to be unity without loss of generality and the form in which the logit model was estimated is:

$Ln\ (Pi/1\text{-}Pi) = B_1X_1 + B_2X_2 + \ldots B_iX_i$......equation (xxi)

RESULTS AND DISCUSSION

Table 1: Distribution of Respondents According to Socio-Economic Characteristics

Educational Attainment	Non-adopter (Local variety *(Oryza glabberrima steud)* rice farmers) Frequency	Percentage	Adopter (Local Improved variety (FARO 44) rice farmers Frequency	Percentage
No formal education	54	48.21	49	43.75
Adult education	4	3.57	7	6.25
First School Leaving Certificate	20	17.86	28	25.00
Junior Secondary Certificate	13	11.61	7	6.25
Senior Secondary Certificate	10	8.93	6	5.36
OND/HND	11	9.82	15	13.39
B.Sc/M.Sc/Ph.D	-	-	-	-
Total	**112**	**100**	**112**	**100**
Gender				
Male	100	89.29	90	80.36
Female	12	10.71	22	19.64
Total	**112**	**100**	**112**	**100**
Marital status				
Married	70	62.50	75	66.96
Single	31	27.68	29	25.89
Widowed	6	5.36	5	4.46
Divorced	5	4.46	3	2.69

Total	**112**	**100**	**112**	**100**
Age (years)				
21-30	15	13.39	32	28.57
31-40	33	29.46	37	33.04
41-50	42	37.50	40	35.71
50 and above	22	19.64	3	2.68
Total	**112**	**100**	**112**	**100**
Farming experience (years)				
Less than 5 years	22	19.64	20	17.86
5-10	23	20.54	25	22.32
11-15	40	35.71	42	36.61
16-20	20	17.86	25	22.32
21 years and above	7	6.25	1	0.89
Total	**112**	**100**	**112**	**100**
Farm size (hectares)				
Small-scale farmers (0.1-2)	43	38.39	52	46.43
Medium-scale farmer (3-14)	40	35.71	42	37.50
Large scale farmers (15ha and above)	29	25.89	18	16.07
Total	**112**	**100**	**112**	**100**

Source: Field Survey, 2016

Table 1 revealed that 17.86% and 25% local and improved varieties of swamp rice farmers had attended primary school. Further analysis of Table 4.1 showed that 48.21% and 43.75% of non-adopter (local) and adopter (improved varieties of swamp) rice farmers respectively were illiterates. This result corroborated with earlier findings by Ibrahim *et al,* (2006); Idiong *et al* (2006).

The Table also indicated that 89.29% of non-adopter (local) and adopter (improved varieties of swamp) rice farmers in the study area were males and 10.71% were females. While 80.36% of improved variety rice farmers in the study area were male and 19.64% were females. This information implied that the male rice farmers out number the female ones in the study area. This findings are collaborates with earlier results by Alimi (2002); Ibrahim *et al* (2006); Antigha, (2007), who were of the opinion that 80% of rice farmers were males and 20% were females. Further analysis of Table 1 revealed that 62.50 percent and 66.96 percent of non-adopter (local) and adopter (improved varieties of swamp) rice farmers respectively were married. While 27.68 percent and 25.89 percent of local and improved varieties of swamp rice farmers respectively were single. This implied that most of the respondents were married. The results of the investigation were in line with the findings of Fujimoto (1988); Ali and Flinn (1989); Goni *et al* (2007).

Furthermore, Table 1 indicated that farmers within the age range of 41-50 years were highest in number for both of local (37.50%) and improved (35.71%) varieties rice farmers. The implication of the results was that majority of the respondents were within the economically active age. These findings were synonymous with Asa (2003) that people in age group of 41-50 years are more economically active and independent than those in age group of less than 21 years and above. The years of farming experience was shown in Table 1. The result showed that 35.71% and 36.61% of non-adopter (local) and adopter (improved varieties of swamp) rice farmers respectively had between 11-15 years of farming experience. Only 19.64% and 17.86% of local and improved varieties of swamp rice farmers respectively had farming experience less than 5 years. This implies that most of the respondents were well experienced in rice production.

Table 2: Distribution of Swamp Rice Farmers According to Extension Visit

Extension Visit	Non-Adopter (Local Variety *(Oryza glabberrima steud)* Rice Farmers Frequency	Percentage	Adopter (Improved Variety (FARO 44) Rice Farmers Frequency	Percentage
Yes	79	70.54	82	73.21
No	33	29.46	30	26.79
Total	**112**	**100**	**112**	**100**

Source: Field Survey, 2016

From Table 2, above, 70.54% and 73.21% of local and improved varieties of swamp rice farmers were visited by extension agents and the Extension agents adopted the group method or information disseminated to the swamp rice farmers in the study area. The information disseminated to the swamp rice farmers include: introduction of better land preparation and farm management techniques, fertilizer and herbicide application methods, completion of loan application forms, which the respondents claimed assisted them to obtain better yield and farm income. This implies that majority of the farmers were visited by extension agents. The result of this finding corroborates with the findings by Ibrahim *et al* (2006) and Idiong *et al* (2006), who reported the importance of extension visit on farmers' adoption of improved rice production techniques. Ingye (2005) also reported that extension visit had positive effect on the adoption of improved farming techniques, because it enabled farmers to implement skills acquired during extension training.

Table 3: Distribution of Swamp Rice Farmers According to Sources of Information Regarding to New Technologies in Rice Production by Swamp Rice Farmers in Cross River State

Sources of Information Regarding to New Innovation in Rice Production	Local Variety *(Oryza glabberrima steud)* Rice Farmers Frequency	Percentage	Improved Variety (FARO 44) Rice Farmers Frequency	Percentage	Ranking
Through meeting Extension personally	50	44.64	55	49.11	I
Through Radio	25	22.32	23	20.54	II
Through Television	20	17.86	18	16.07	III
None of the above	17	15.18	16	14.29	IV
Total	**112**	**100**	**112**	**100**	

Source: Field Survey, 2016

Table 3 gave a percent citation of sources of information regarding to new innovation sin rice production in Cross River State. The findings showed that extension agent as a major source of information regarding to new technologies in rice production. The radio and television were ranked second and third respectively. Only 15.18% and 14.29% of local and improved swamp rice farmers claimed total ignorance of sources of information service in the state. The result corroborated with earlier findings by Ilevbaoje and Odume (2001).

Table 4: Distribution of Local and Improved Varieties of Swamp Rice Farmers According to Type and Quantity of Fertilizer used in Rice Production in Cross River State, Nigeria

Types of Fertilizer used in Rice Production	Local Variety (*Oryza glabberrima steud)* Rice Farmers Frequency	Percentage	Improved Variety (FARO 44) Rice Farmers Frequency	Percentage
NKP 15:15:15	40	37.71	42	36.61
NKP 17:17:17	12	10.71	8	7.14
NKP 20:0:0	18	16.07	20	17.86
NKP 26:0:0	17	15.18	15	13.39
NKP 46:0:0	5	4.46	1	0.89
No Fertilizer Applied	20	17.86	26	23.21
Total	**112**	**100**	**112**	**100**
Quantity of Fertilizer Applied (kg/ha)				
10-100	9	8.04	7	6.25
101-200	17	15.18	21	18.75
201-200	37	33.03	30	26.79
301-400	29	25.89	28	25.00
No Fertilizer Applied	20	17.86	26	23.21
Total	**112**	**100**	**112**	**100**

Source: Field Survey, 2016

Table 4 revealed that 35.71% and 36.61 of local and improved varieties of swamp rice farmers respectively disclosed that they used fertilizer (NKP 15:15:15) in rice production in the study area. further analysis of Table 4.4 showed that 33.03% and 26.79% of local and improved varieties of swamp rice farmers respectively disclosed that they applied 201-300kg/ha of fertilizer. Only 17.86% and 22.32% of local and improved varieties of swamp rice farmers respectively accepted that they did not used fertilizer in rice production in the study area.

Table 5: Distribution of Local and Improved Varieties of Swamp Rice Farmers According to Credit Access

Credit Access	Local Variety (*Oryza glabberrima steud)* Rice Farmers Frequency	Percentage	Improved Variety (FARO 44) Rice Farmers Frequency	Percentage
Yes	55	49.11	77	68.75
No	57	50.89	35	31.25
Total	**112**	**100**	**112**	**100**

Source: Field Survey, 2016

Table 5 revealed that 49.11% and 68.75% of local and improved varieties of swamp rice farmers respectively have access to formal credit. While 50.89% and 31.25% of local and improved varieties of swamp rice farmers respectively disclosed that they had no access to formal credit caused by lack of collateral, lack of knowledge and experience to complete loan application forms, rigorous process involved in obtaining loan.

Other problems include high interest rate, delay in loan approval and release of fund to swamp rice farmers before planting season and short repayment period. This implied that majority of the respondents were aware of sources of credit and had access to credit while some of them had no access to formal credit because of one reason or the other. The result of the findings also implied that credit demand had risen. This agreed with the findings of Ijere (1986) who opined that agricultural credit has risen over the years in Nigeria because of rapid rate of urbanization, population growth, which has resulted in increased food demand. Enya and Alimba (2007) maintained that agricultural credit had the potential to enhance efficient resource allocation, permit application of new technology, reduce post harvest waste and stabilize farm price, farm income and enhance efficient marketing of agricultural products. Agricultural credit is not only important for accelerating agricultural development but also for improving farmers' efficiency (Adinya *et al,* 2008).

Table 6: Distribution of Respondents According to adoption of Recommended Rice-Based Technologies by Agricultural Development Programme (ADPs) (Type of Herbicide used in Rice Production in Cross River State)

Type of Herbicides used in Rice Production	Local Variety (*Oryza glabberrima steud)* Rice Farmers Frequency	Percentage	Improved Variety (FARO 44) Rice Farmers Frequency	Percentage
Pre-Emergence Herbicide (Butaforce, Sarosate, Oxadiazon, Thiobencarb)	50	44.64	23	20.54
Post-Emergence Herbicide (Propanil, Glyphosate Gramoxone, Ronstar + Propanil)	34	30.36	64	57.14
No Herbicide Applied	28	25.00	25	22.32
Total	**112**	**100**	**112**	**100**

Quantity of Herbicide (Pre-Emergence Herbicide or Post-Emergence Herbicide) used in Rice Production (Litre Contains Active Ingredient of 1.0-2.2kg/ha				
1 Litre of Herbicide	6	5.36	11	9.82
2 Litres of Herbicide	13	11.61	14	12.5
3 Litres of Herbicide	31	27.68	22	19.64
4 Litres of Herbicide	2	1.79	12	10.71
5 Litres of Herbicide	9	8.04	10	8.93
6 Litres of Herbicide	8	7.14	11	9.82
7 Litres of Herbicide	10	8.93	5	4.46
8 Litres of Herbicide	5	4.46	2	1.79
No Herbicide Applied	28	25.00	25	22.32
Total	**112**	**100**	**112**	**100**

Source: Field Survey, 2016

Table 6 gave detail information on the type of herbicides used by the farmers in swamp rice production in the study area. Some of the farmers (44.64%) and (20.54%) of local and improved varieties of swamp rice farmers used pre-emergence herbicide. These include Btaforce, Sarosate, Oxadiazon, Thiobencarb for weed control. While 30.36% and 57.14% of local and improved varieties of swamp rice farmers used post-emergence herbicide like Propanil, Glyphosate, Gramoxone, Ronstar and Propanil for weed control.

Only (25%) and (22.32%) of local and improved varieties of swamp rice farmers respectively did not used herbicide for weed control. They rather used hand tool technology for weed control in the study area. the result agreed with earlier findings by Olayide and Atobatele (1980): Ogar *et al* (2002); Awoke and Okorji (2003), who were of the opinion that more than 70 percent of the population of farmers in Nigeria are small-scale farmers cultivating 1.0-2.0 hectares with limited capital resources and characterized by hand tool technology. The study also revealed significant drop in use of hand tool technology by swamp rice farmers for weed control in the study area. according to Olayide and Atobatele (1980); Ogar *et al* (2002); Awoke and Okorji (2003) about 75% of farmers used hand tool technology for weed control but the results of this study shows decline from 75% to 25% for (local variety rice farmers) and (22.32%) for improved variety of swamp rice farmers. The result of this finding implied that there was increase in adoption of the new innovation like herbicides by swamp rice farmers for weed control because of the fact that farmers received little or no form of assistance from their children in carrying out their farm activities. This decline in family labour, hired labour, age grade labour and communal labour supply has led to increased demand for herbicides. However, swamp rice farmers in the study area attributed this increase in adoption of herbicides to effective extension teaching/service delivery by extension agents, readily acceptability of new innovation by farmers and lack of hired labour.

Further analysis of Table 4.3 revealed that 25 percent and 22.32 percent of local and improved varieties of swamp rice farmers respectively used hoes and cutlass for weed control. This result implied that some of the respondents were aware of the availability of herbicide in the markets or stores but could not afford it due to either high cost or lack of capital. While 5.36% and 9.82% of local and improved varieties of swamp rice farmers respectively used 1 litre per hectare of pre-emergence herbicides like Butaforce, Sarosate, Oxadiazon, Thiobencarb and post-emergence herbicides such as Propanil, Glyphosate, Gramoxone, Ronstar and Propanil) for weed control. This implied that improved rice farmers adopted the use of herbicide more than local rice farmers in the study area. The result of this finding corroborated with earlier findings of Diallo (1984), who demonstrated that the pre-emergence application of Oxadiazon at the rate of 1.0-1.5 kilogram of active ingredient per hectare in rice suppressed weeds up to one month.

The combination of pre-emergence Thobencarb and post-emergence Propanil effectively controlled weeds in rice in Ghana (Carson, 1975), Nigeria (Akobundu, 1981; Obadoni and Remison, 2007), Ivory Coast (Merlier, 1983) when applied at the rate of ingredient per hectare at 21 days after sowing of rice seed.

Obadoni and Remison (2007) reported that herbicides varied greatly in their ability to control weeds they further maintained that Gramoxone controlled 80 percent of the weeds, while tank mixture of Ronstar and Propanil alone, Moltinate were fairly 50-70 percent of treated weeds but its high weed control efficiency did not retranslated to increase rice grain yield: only 3917.2kg per hectare was obtained compared to 4409.25kg and 4120.50kg per hectare recorded from Molinate and Gramoxone treated plots respectively (Obadoni and Remison 2007).

Table 7: Distribution of Local and Improved Varieties of Swamp Rice Farmers According to Labour used in Rice Production in Cross River State

Labour used in Rice Production Man-Days	Local Variety (*Oryza glabberrima steud)* Rice Farmers Frequency	Percentage	Improved Variety (FARO 44) Rice Farmers Frequency	Percentage
10-15	32	28.57	28	25
16-20	64	57.14	52	46.43
21-25	11	9.82	20	17.86
26 man-days	5	4.46	12	10.71
Total	**112**	**100**	**112**	**100**
Type of Labour used in Rice Production				
Family labour	10	8.93	5	4.46
Part-time hired labour	67	59.82	96	85.71
Full-time hired labour	18	16.07	6	5.36
Age grade labour	12	10.71	3	2.68
Communal labour	5	4.46	2	1.79
Total	**112**	**100**	**112**	**100**

Source: Field Survey, 2016

From Table 7, 57.14% and 46.43% of local and improved varieties of swamp rice farmers respectively used between 16-20 man-days in rice production. Only 4.46% and 10.71% of local and improved varieties of swamp rice farmers respectively used 26man-days and above. Several studies have shown that labour resource significantly influences output of swamp rice (Fujimoto, 1988; Modey, 1994; Ogar *et al,* 2006; Goni *et al,* 2007). However, Joe (1992) considered labour for weeding and related it to output and found that, labour for weeding resources significantly influenced output of swamp rice.

Data in Table 4.2, also indicated that 59.82 percent and 85.71 percent of local and improved varieties of swamp rice farmers respectively used part-time hired labour. While 10.71 percent and 2.68 percent of local and improved varieties of swamp rice farmers respectively used age grade labour. Only 4.46 percent and 1.79 percent of local and improved varieties of swamp rice farmers respectively used communal labour. The findings also agreed with Singh and Solomon (1987), who reported that in Cross River State, there were four types of labour used by farmers in the state namely: family labour, hired labour, age grade labour and communal labour. From the result of the study, it implied that part-time hired labour was the most popular source of farm labour among the rice farmers. This could be due to the fact that farmers received little or no form of assistance from their children in carrying out their farm activities. This was attributed to the farmers' children's engagement tin educational training in schools. Johnson (1982) maintained that owing to decline in polygamy and rise in schooling, family labour was becoming less plentiful, insufficient for optimum farming system which limited further production growth. This decline in family labour supply had led to increased demand for labour and decline in food production in the country.

Table 8: Costs and Returns Analysis of Local and Improved Varieties of Swamp Rice Production in Cross River State

Items	Quantity	Unit Price (Naira)	Total Value of Local Variety Swamp Rice	Total Value of Improved Variety Swamp Rice	
Labour (man-days)	72 man-days	62.5	4,500.00	-	
	32 man-days	62.5	-	2,000.00	
Fertilizer (kg/ha)	2bags/ha	4,000.00	8,000.00	-	
	4bags/ha	4,000.00	-	16,000.00	
Seeds planted	1000kg/ha	3,000.00	3,000.00	-	
	1000kg/ha	3,800.00	-	3,800.00	
Herbicide	2litre/ha	1,500.00	3,000.00	3,000.00	
Transportation cost	naira	-	1,500.00	1,250.00	
Miscellaneous (feeding and drugs)			3,230.00	2,250.00	
Total Variable Cost (TVC)			23,230.00	28,300.00	
Fixed Cost					
Rent on land	2 hectares	1,000.00	2,000.00	2,000.00	
Depreciation on hoes		5	1,000.00	450	450
Depreciation on cutlass		3	700.00	189.00	189.00
Depreciation on rakes		2	500.00	90.00	90.00
Depreciation on K. sprayer		1	8,000.00	720.00	720.00
20% of interest on loan		12	200	54.00	54.00
Total Fixed Cost (TFC)				13,503.00	13,503.00
Sales/revenue					
Local rice produced	3800kg	48naira/kg	182,400.00	-	
Improved rice produced	5600kg	57naira/kg	-	319,200.00	
Gross Margin GM= (TR-TVC)			159,170.00	290,900.00	
Profit (π) = (GM/TFC)			145,667.00	277,397.00	
Profitability Indicator (NR/TC)			2.67	9.80	

Source: Field Survey, 2016

FOOTNOTE:

Farm gate price of rice
Local rice ₦70 per kg = 3.5 cups
Improved rice ₦90 per kg = 3.5 cups
Market price of rice
Local rice ₦255 per kg = 3.5 cups (₦85 per cup)

Improved rice ₦350.00 per kg = 3.5 cups (₦100 per cup)

Cost and return analysis was used to estimate and compare the costs and returns from both local and improved varieties of swamp rice produced in the study area yielded data as presented in Table 8.

The total variable cost (TVC) of improved variety of swamp rice exceeded that of local variety of swamp rice production. The values stood at ₦23,230.00k and ₦28,300.00k for local and improved varieties of swamp rice respectively. However, total fixed cost (TFC) for local and improved varieties of swamp rice was ₦13,503.00kg.

Gross margin (GM) for two varieties of swamp rice shows that gross margin values of ₦159,170.00k and ₦290,900.00k for local and improved varieties of swamp rice production respectively. Table 8 revealed that local rice production yielded a profit figure of ₦145,667.00k with ₦6,27k made on every naira invested in local variety of swamp rice produced in the study area. Comparatively, improved swamp rice farmers realized profit of ₦277,397.00k with ₦9.80k made on every naira invested in improved variety of swamp rice produced in the study area. The implication of the result is that improved rice production was more profitable than local rice production.

Rice farming business was profitable business, with attractive net return on investment. Therefore, unemployed youths in Cross River State are encourage to start rice farming and also form Young Rice Farmers Cooperative or joint existing cooperative groups to enable them obtain loans from banks.

Table 9: The Relationship between Inputs and Output in Rice Production (Maximum Likelihood Estimates of Stochastic Frontier Production Function for Local and Improved Varieties

Variables	Local Variety (*Oryza glabberrima steud)* Rice Farmers Frequency	Improved Variety (FARO 44) Rice Farmers Frequency
Constant	0.45	5.75
	(3.45)**	(5.06)**
Farm Size	0.07	0.09
	(1.57)**	(1.89)*
Labour	0.04	0.08
	(1.49)**	(3.20)*
Herbicide	0.15	0.13
	(1.3)*	(1.2)*
Seed	0.03	0.06
	(8.60)**	(2.96)**
Fertilizer	0.08	0.026
	(3.2)**	(9.23)*
Sum of Elasticities	1.33	1.65
Diagnostic Statistics		
Gamma (γ)	0.60	0.75
	(2.78)**	(3.04)**
Sigma - square (δ^2)	0.45	0.51
	(3.43)*	(2.91)*
Log-likelihood	-35.23	-53.85
L Ratio-test	25.61	20.53
R	0.68	0.65
R^2	0.63	0.61
F-ratio	15.39**	10.50**

Source: Field Survey, 2016

* = significant at 5%
** = significant at 1%
Footnote = the figures in parenthesis under the coefficients are the corresponding standard error

Table 9 indicates that the coefficients of farm size, labour, seed and fertilizer were significant at 1% level for local variety of swamp rice, while improved variety of swamp rice coefficients(farm size, labour, seed and fertilizer) were significant at 5% level. Herbicide input was significant at 5% level of significant in both local and improved varieties of swamp rice. Farm size appears to be one of the important varieties with elasticity of 0.07 and 0.09 for local and improved varieties of swamp rice respectively. It implies that increasing farm size by 10 percent will lead to about 0.7 and 0.9 increase in output in local and improved varieties of swamp rice respectively. The sum of elasticity of 1.33 and 1.65 for local and improved varieties of swamp rice respectively indicates that local and improved varieties of swamp rice farmers in the study area operated in the inefficient stage (∑Ᵽis greater than 1; increasing return to scale region). The gamma(γ) were 0.60 and 0.75 for local and improved varieties of swamp rice respectively and significant at the 1% level. It is an indication that 60 and 75 percent variation in output of local and improved varieties of swamp rice respectively are attributed to technical inefficiency. The sigma- square (δ^2) on the other hand were 0.45 and 0.51 for local and improved varieties of swamp rice respectively and significant at the 5% level. The Likelihood Ratio Test (LRT) for local variety of swamp rice(25.61) and improved variety of swamp rice(20.53) were technically inefficient.

The was 0.63 for local variety of swamp rice and 0.61 for improved variety of swamp rice, indicates that the predictor variables explained about 63 percent and 61 percent of the variation in output for local and improved varieties of swamp rice respectively. The F-ratios were 15.39 and 10.50 for local and improved varieties of swamp rice respectively.

However, the result of the study shows that improved variety of swamp rice farmers were more efficient than local variety of swamp rice farmers.

Table 10: Technical Efficiency Level of Local and Improved Varieties of Swamp Rice Farmers in the Study Area

Efficiency Class	Local Variety Swamp Rice	Percentage Swamp Rice	Improved Variety	Percentage
≤0.50	13	11.61	18	16.07
0.51-0.60	15	13.39	16	14.29
0.61-0.70	20	17.88	23	20.54
0.71-080	17	15.18	11	9.82
0.81-0.90	7	6.25	10	8.93
0.91-100	40	35.71	34	50.35
Total	112	100	112	100
Mean	0.67		0.75	
Standard deviation	0.11		0.12	
Minimum	0.55		0.48	
Maximum	0.99		0.99	.

Source: Field Survey, 2016

Table 10 revealed that technical efficiency range from 0.48-0.99 and 0.55-0.99 for local and improved varieties of swamp rice respectively. The mean efficiency values were 0.67 and 0.75 for local and improved varieties of swamp rice respectively, the analysis showed that both local and improved varieties of swamp rice produced in the study area has not reached frontier threshold, as such, within the context of efficient production, rice production can still be increased by about 33 percent and 25 percent for local and improved varieties of swamp rice respectively using available technology. The result of the study showed that improved variety of swamp rice farmers(75%) were more efficient than local variety of swamp rice farmers(0.67). The result of the findings are in line with the findings of (Idiong et al,2006; Goni et al,2007).

Table 11: Description of Symbols of Explanatory Variables in the Model and Result of Maximum Like Hood Estimates of the Logit Model for Local and Improved Varieties of Swamp Rice Production in Cross River State)

Variable Symbols	Description Measurement	Coefficient Local Variety	Improve	Co-Efficient Var
X_1	Farm size(hectares)	2.579 (1.006)*		2.581 (1.008)*
X_2	Frequency of extension contact (Number)	2.13 (0.812)*		2.15 (0.827)*
X_4	Estimated yield From rice farm technology Adopted (Kg)	0.39 (0.103)		0.38 (0.101)

Source: Field Survey, 2016

* = significant at 5%
* * = significant at 1%
Footnote = the figures in parenthesis under the coefficients are the corresponding standard error

Farm Size (X_1)

The coefficient of the farm size entered in the model with a positive sign and significant relationship at 5% level of significant between farm size and adoption decision that was saw as evident in the model. This implies that rice farmers in the study area are likely to choose / adopt innovation as their farm size increases because of lack of fund to purchase fertilizer; they choose to use farm yard manure as alternative. The result of findings agrees with Ofuoku et al (2005), they posited that farmers are faced with several constraints in the use of fertilizers. These constraints include among others; escalated price of fertilizers because of the activities of middlemen that hoard fertilizers, unavailability or late arrival of fertilizer is, insufficient quantities of fertilizers, lack of information on correct usage, lack of incentives and low benefit cost ratio forced farmers to use farm yard manure that are cheaper and always available.

Frequency of Extension Visit (X_2)

The coefficient of frequency of extension contact entered the model with a prior expected positive sign. The variable turned out to be a significant determinant of adoption decision in the study area. The positive sign associated with the variable in the model, implies that adoption decision of rice farmers in the study area, would depend significantly on the information they get through the extension agent and the frequency of such information. Frequency of extension contact to disseminate information encourages early adoption. However, adoption of an innovation is the decision of a farmer or group of farmers to use or apply innovation. Farmers are said to go through a logical, problem – solving process known as adoption process when considering any technology. A farmer's decision about whether or not to adopt a recommended agricultural/farm practice is recognized to occur over a period of time in stages rather than instantaneous (Arikpo and Adinya, 2011).

Estimated yield from technology adopted plot (X_4)

The coefficient of estimated yield from adoption of technology (X_4) entered the model with a prior expected positive sign.

This implies that fertilizer adoption is positive in conformity with a prior expectation that fertilizer adoption would increase crop yields. The result of these findings is in line with the earlier findings of Van den Ban Hawkin (1996); Arikpo and Adinya (2011) reported similar result in line with adoption behaviour of farmers.

Table 12: Distribution of Swamp rice Farmers According to Constraints against Rice Production in Cross River State, Nigeria

Constraints	Local variety (*Oryza glabberrima steud) rice* farmers serious (percentage)	Local variety (*Oryza glabberrima steud) rice* farmers serious not serious (percentage)	Improved variety (FARO 44) rice farmers not serious (percentage)	Improved variety (FARO 44) rice farmers (percentage)
Inadequate land	100	-	100	-
Low fertility of land	100	-	84.82	15.18
Land fragmentation	88.39	11.61	87.50	12.50
High cost of buying land	88.39	11.61	86.61	13.39
Stringent customary law	8214	17.86	81.25	18.75
Lack of fertilizer subsides	87.5	12.5	100	-
Lack of fertilizer due to activities of middlemen	100	-	100	-
Wrong application of fertilizer	100	-	100	-
High cost of fertilizer	100	-	100	-
Lack of extension agents to advise farmers on how to apply fertilizer	100	-	100	-
Lack of improved seeds rice	100	-	100	-
Lack of money to buy improved seed	88.39	11.61	100	-
High cost of improved seed	100	-	100	-
Poor extension service	100	-	100	-
Seasonal labour shortage	100	-	100	-
High cost of labour	100	-	100	-
Emigration of farm workers	83.03	16.96	100	-
Traditional belief	83.92	16.07	100	-
Sex discrimination	84.82	15.18	100	-
Lack of collateral	88.39	11.61	100	-
Delay in loan approval	100	-	100	-
Risk and uncertainty	100	-	87.50	12.50
Inadequate capital	100	-	100	-
Lack of educational				

training	100	-	100	-
Low wages	100	-	100	-
Lack of market facilities	100	-	100	-
Bad working condition and environment	100	-	100	-
Long hour of work	100	-	87.50	14.28
Bad climatic and physical condition	100	-	85.71	14.28
Lack of good storage	100	-	100	-
Lack of input-output Data on rice production	100	-	100	-
High cost of transportation	100	-	100	-
Sickness and pain	100	-	86.61	13.39
Unhealthy working environment	100	-	100	-
Lack of farm tools	100	-	100	-
Price impediment on allocation of resources	88.39	11.61	100	-
Lack of good roads	100	-	100	-
Non-adoption of new innovation/scientific technologies	100	-	100	-
Inadequate information on resource use efficiency	100	-	100	-
Lack of rainfall	100	-	86.61	13.39
Lack of hospital/health centres in rural area where rice farms are established	100	-	82.14	17.85

Source: Field Survey, 2016

From Table 12, the study revealed that several constraints were militating against efficient resource use in swamp rice production in Cross River State. These constraints include among others seasonal labour shortage, lack of inputs-output data on rice production, delay in loan approval/late arrival of loan, non-adoption of scientific technologies/innovations and inadequate information on resource use efficiency occupied (100%) for both local and improved varieties of swamp rice farmers. The result of the study agreed with the findings of (Adenyi, 1988; Imolehin and Wada, 2000; Awoke and Okorji, 2003).

CONCLUSION

The findings of the study showed that non-adopter and adopter of new technologies rice farmers were faced with several problems or constraints that significantly affect the efficiency of resource use. The constraints constitute series of concern and need to be considered or address by policy makers. Therefore, there is wide scope to increase rice production through efficient utilization of productive resources and adoption of new technologies. The constraints associated with swamp rice production if tackled, could pave way for increase yields, farmers' income and also improve the standard of living of the people.

RECOMMENDATIONS

Based on the findings of the study, the following were recommended;

i) Capacity building of rice farmers through regular training by extension agents on adoption of new innovations in rice production.
ii) Extension agents should also encourage rice farmers to use labour saving tools and machines in order to allow for optimum labour utilization in rice arm operations.
iii) Government should subsidize price of agricultural inputs (fertilizers, herbicides, insecticides, pesticides and seeds).
iv) Steps should be taken at federal, state and local government levels to depoliticize fertilizer distribution and check hoarding of agricultural inputs that crates artificial scarcity of fertilizers and other agricultural inputs.
v) Swamp rice farmers who cannot afford fertilizers can make moderate profit from the use of poultry droppings, especially as it is cheaper and readily available in poultry farms in Cross River State.
vi) Cross River State needs serious land reforms. Efforts should be made by the state government towards improving current land acquisition pattern so as to encourage swamp rice farmers with farm sizes of 0.1-2 hectares to increase their farm size, which will crate room for mechanization of farm operations and improve labour productivity.
vii) In order to stimulate local production of rice, government should make policy that will reduce importation of rice or ban importation of rice. This will stimulate rice farmers to optimally allocate resources to achieve optimum production of rice.
viii) For efficient production of swamp rice in the study area, production constraints that were identified must be drastically addressed to the barest minimum. This can be done through efficient policy formulation and proper supervision of swamp rice production in the study area.

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