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Effect of Production Practices on Rice Production Efficiency in North- Central Ecological Zone of Nigeria and the Implication for Productivity and Food Security

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Abstract: Rice is a critical food in Nigeria, so farmers need to make appropriate choices in rice production practices to maximize production and ensure an adequate domestic supply for food security.. As a result, this study used descriptive statistics and the Tobit model to examine the impact of rice production practices on the economic efficiency of paddy rice farmers in Nigeria. 360 paddy rice farmers in the study area were selected using multi-stage sampling methods. 360 paddy rice farmers in the study area were selected using multi-stage sampling methods. The results showed that farming practices included low land 247 (68.6%), upland 59 (16.4%), and irrigated 54 (15.0%). The study also found that the average number of years of experience with paddy rice cultivation for all samples was 9.1 years. Results indicated that output/yield was the most influential factor for participating in rice farming practices, as it ranked first with irrigated rice production practices having 67.7%. Similarly, plot wetness ranked second, with about 76.5% going to lowland production practice. Others are fertile soil ranked third with upland practice having 56% while distance to the nearest road ranked fourth and 60% goes to upland production practice. It was observed that Lowland practices have less economic efficiency than other practices (irrigated and upland). The effect of irrigation practice on economic efficiency is approximately 0.034, which means that farmers participating in irrigation farming are more economically efficient in their rice production than those in upland practice by 0.34, and the effect of lowland practice on economic efficiency is approximately -0.033, implying that farmers using lowland practice are 0.33% less economically efficient in rice production than those using upland practice. It is therefore recommended that farmers be encouraged to produce more under irrigation and upland for increased yield, profit, and food security.

Keywords: Production practice, Efficiency, Productivity.

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INTRODUCTION

Nigeria has a comparative resource advantage in rice production due to favorable climatic, edaphic, and ecological conditions, with a potential land area for rice production ranging from 4.6 million to 4.9 million hectares. (Nneka *et al.,* 2019, FMARD, 2012, Akintayo *et al.,* 2011). Despite the very favorable ecologies for rice production in the country, production of paddy rice remains low; therefore, farmers need to make appropriate choices of rice production practices to optimize production and ensure an adequate domestic supply to guarantee food security. (Nneka et al., 2019). Farmers' attitudes toward the chosen enterprise may differ. Farmers with positive attitudes may not plant certain crops for a variety of reasons. (Ojo *et al.,* 2013). The decision to put a parcel of farmland under any sustainable agricultural practices depends on the plot of land, household and village characteristics, including ecological and climatic factors like rainfall. (Teklewold et al. 2013). Farmers' decisions to adopt and use sustainable agricultural technologies on farmland can be significantly influenced by weather-related information, particularly the amount, timing, and distribution of rainfall. (Teklewold and Mekonnen 2017).

In any productive venture, and inclusive agricultural production activity and especially rice cultivation, Efficiency measurement is crucial because it directly affects productivity and economic growth, efficiency studies assist businesses in determining how much they can increase production, income, and profit by improving their efficiency, given their current resource base and technology. Such research could also assist with decisions about whether to focus on improving efficiency first or developing a new technology in the near future. More importantly, increased efficiency will allow farmers to not only raise their output and profit but also provide guidance for the long-term modifications needed to achieve food sustainability. This type of analysis is necessary for a critical food security crop like rice that has more or less become a very important crop in the households menu in Nigeria. The goals of this research are to identify production practices in the region and assess the effects of those practices on farm household economic efficiency in Nigeria.

METHODOLOGY

The research area is the Southern Guinea Savanna ecological zone in Nigeria (North-Central), which lies between 38º and 148º E longitude and 78º to 108º N latitude. Nigeria's Corn Belt is a term that describes the savanna eco-system. Kwara, Niger, Kogi, FCT, Taraba, Plateau, and Benue are all part of the zone, which spans a huge geographical area. The Southern Guinea Savanna in Nigeria has a lot of potential for agricultural production because of its bimodal rainfall pattern (short early growth season followed by a long late season) characterized by intense solar radiation and optimal temperature during the cropping season This zone is characterized by variable weather, weak soils with low moisture holding capacity, and vulnerability to drought (Nigeria Geographic Information System 2017).

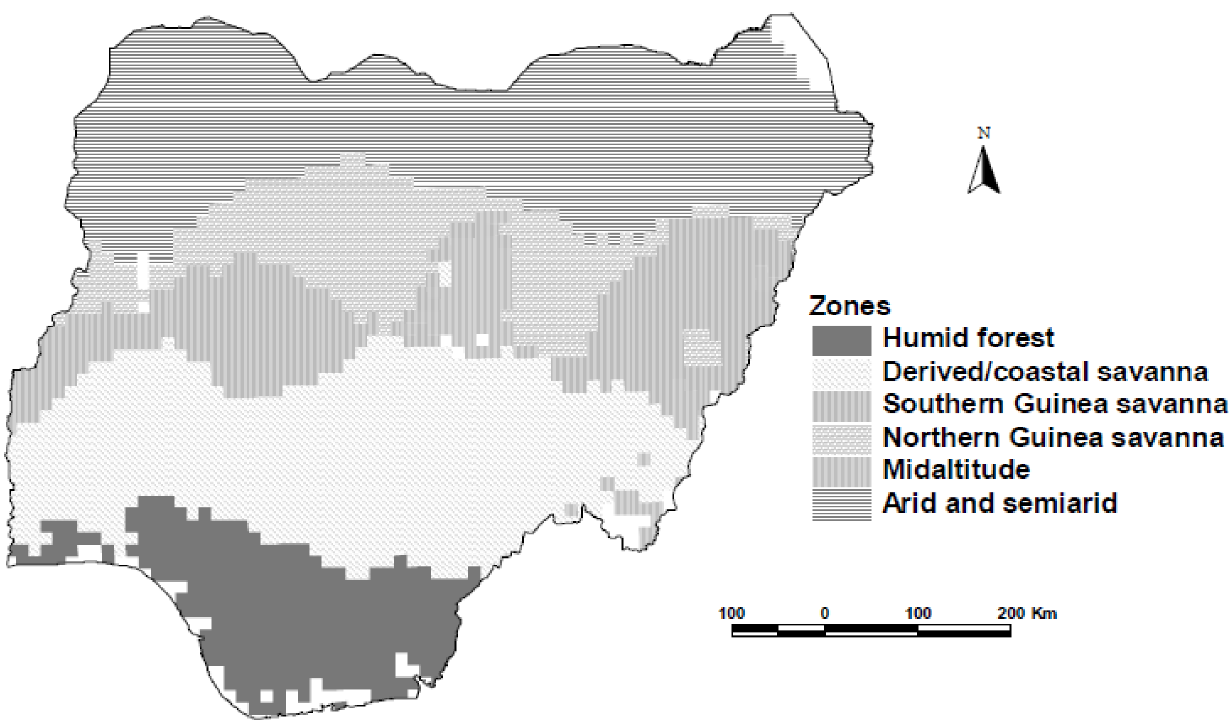

Figure 1: Map of Nigeria

Sampling Technique and Sample Size

This study's respondents were selected using a four-stage sampling technique. The first stage involved the purposive selection of Niger State, Kogi State, and the Federal Capital Territory (FCT) Abuja due to the prevalence of various rice production practices (lowland, upland, and irrigated) in these states. The second stage also included the purposive selection of Wushishi and Katcha Local Government Areas in Niger State; Yagba and Kogi Local Government Areas in Kogi State; and Kwali and Abaji Area Council in FCT based on their prevalence in the three rice production practices. Stage three involved selecting two villages from each of the sampled Local Government Areas randomly for a total of 12 villages. The fourth stage included a random selection of paddy rice farmers justified by probability proportional size (p p s), which is a quotient between the size of the population and the size of the sample. (Tedowos 2017). Considering Tewodros (2017), A sample size of 10 to 30 percent is thought to be adequate for defining the target population. The survey included 360 paddy rice farmers from the sampling frame.

$$nh = \frac{n\,Nh}{N} \quad (1)$$

Where

nh = the sample size to be determined

n = the number of the targeted respondents

Nh = total number of the population size

N = targeted population

A reconnaissance survey was conducted to collect sampling frames of rice producers from the Agricultural Mechanization and Farmers Development Authority, the State Ministry of Agriculture, village heads, and the Farmers Association.

Data collection

The study's objectives were accomplished using both primary and secondary data. The primary data were collected using structured questionnaires that addressed the study's objectives. This was supplemented with interview schedules. Primary data collected from respondents include the total output of rice produced per year in kilograms (kg), farm land devoted to rice production in hectares, quantity of seeds used as planting materials in Kg, quantity of fertilizer used in kg, quantity of agro-chemicals used in litres (l), Data includes labor utilization (both family and hired), input and output unit prices in Naira (₦), and more. Others include data on respondents' socioeconomic characteristics such as age, marital status, household size, level of education, access to extension education, and membership in farmers' associations, among others. Farmer income information includes crop income, livestock income, agricultural wage income from other farms, and non-agricultural wage income from formal and informal employment, self-employment income from a business, remittance income from relatives and friends who are not currently living in the household, capital gains, and pensions. Secondary data were collected from journals, textbooks, and the internet.

Data analysis

The analytical tools used to achieve the research objectives included descriptive statistics and tobit regression analysis. Data was gathered from primary sources. Primary data was collected using a well-structured questionnaire administered via personal interview. Pretesting the questionnaire was used in this study to improve the reliability of recall information provided by the sampled households. Pretesting allowed enumerators to learn how to detect and respond to reporting errors. Data was analyzed using descriptive statistics such as frequency, percentage, mean score, and chart, among others.

ANALYTICAL FRAMEWORK

Theoretical Framework

Over fifty years ago, Farrell (1957) proposed a method for measuring economic efficiency. Farrell (1957) developed a system for measuring economic efficiency (EE), technical efficiency (TE), and allocative efficiency (AE), with EE equal to the product of TE and AE by definition. According to Farrell, TE refers to the ability to create on the isoquant frontier, whereas AE refers to the ability to produce at a certain level of output, while reducing input costs (Figure 1). Technical inefficiency, on the other hand, is associated with deviations from the frontier isoquant, whereas allocative inefficiency is associated with deviations from the lowest cost input ratios. As a result, EE is defined as a company's ability to produce a specific amount of output at the lowest possible cost using a given level of technology (Farrell 1957; Kopp and Diewert 1982). Productive units can be inefficient by producing less than the maximum output possible from a given set of inputs (technical inefficiency) or by failing to purchase the lowest priced package of inputs given their respective prices and marginal productivities (allocative efficiency).

Technical efficiency can be measured in two ways: input-oriented and output-oriented. Input-oriented efficiency measures how much input quantity can be reduced without decreasing output quantity, Whereas output-oriented efficiency measures how much output quantity can be increased without affecting input quantity (Coelli, 1994).Farrell's methodology has been widely used while undergoing several revisions, and it is best exemplified by relating both allocative and technical efficiency

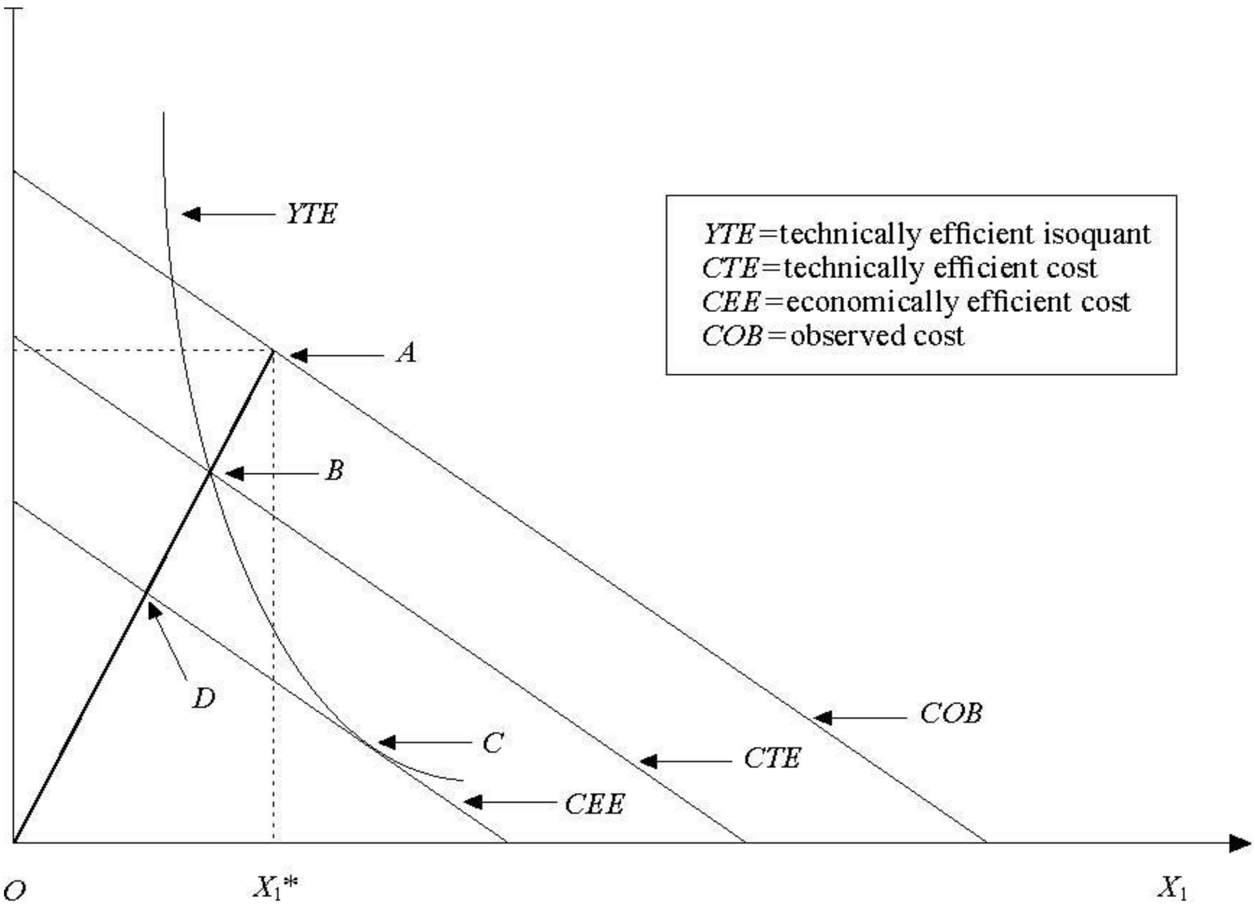

Figure 2: Graphical Representation of Observed, Technically, and Economically Efficient Cost Measures. (Adopted from Samuel et al., 2015)

Technical Efficiency (TE), Allocative efficiency (AE) and Economic Efficiency (EE) are equal to:

TE=OB/OA=CTE/COB,

AE=OD/OB=CEE/CTE, and

EE=TE*AE= OD/OA=CEE/COB.

Methods of Data Analysis

The collected data was summarized using descriptive statistics such as frequency, percentage, mean score, chart, and

Tobit regression. However, estimated cost efficiency (CE) has an inverse relationship with economic efficiency (EE) (Ogundari, 2006; Ehirimet al., 2019). Thus, farm-level economic efficiency (EE) was calculated using the equation EE = 1 cost efficiency (CE). In the second stage, the economic efficiency score was used as a dependent variable to investigate the effect of production practice on economic efficiency using the Tobit regression technique.

The Tobit model

The Tobit model was used to regress economic efficiency estimates against production practices. The model was deemed more appropriate because the values of the dependent variable (efficiency scores) fell within a specific range (0 - 1). Efficiency effects were assumed to be independently distributed, with Yk* resulting from the truncation (at zero) of the normal distribution with mean Yk* and variance σ2.$\boldsymbol{Y}_k^* = \boldsymbol{X}_k\boldsymbol{\beta} + U_k$(2)

Where Y_k is the k^{th} farm's latent (hidden) independent variable, and X_k is the vector of independent variables thought to affect efficiency. U_k is an independently distributed error term considered to be normally distributed with zero mean and constant variance, and the vector contains the unknown parameters associated with the independent variables for the k^{th} farm.

The model is specified as

U_i*=β0+β1X1i+β2X2i

U*= Economic efficiency ratio

X1 = lowland practice

X2 = irrigation practice

RESULTS AND DISCUSSION

1. Years of involvement with rice production practice

Table 2 shows that the average years of experience with paddy rice cultivation for all samples was 9.1 years. The results also revealed that 55.4% of respondents had 1-3 years of experience in rice production. This is due to a greater understanding of the crop's potential to make its producers happy in the study area. This suggests that there is a high likelihood of increased crop production in the future. The results also revealed that 26.0% of the farmers had 4-6 years of paddy rice production experience, 12.3% had 7-9 years of farming experience, and 6.3% had paddy rice farming experience of 10 years or more. The findings also indicated that all production practices in the sampled areas are gaining traction in the study area.

Table 1: Distribution of respondents by years of involvement with rice production practice

Years of farming a System	Niger(n=148)			Kogi (n=145)			FCT (n=67)		
	Lowland (%)	Upland (%)	Irrigated (%)	Lowland (%)	Upland (%)	irrigated (%)	lowland (%)	upland (%)	irrigated (%)
1-3	32	17	3	34	19	4	42	14	3
4-6	20	6	1	19	6	1	18	6	1
7-9	13	3	0	11	1	0	6	3	0
10 and above	5	1	0	5	1	0	6	1	0

Total mean exp. 9.1
Source: field survey (2020) data.

2. Type of production practice engaged in by respondents

The following procedures were used to analyze the production patterns of rice farmers in the study areas: First, different production practices were assessed in terms of lowland, upland, and irrigated methods. Second, the factors influencing these decisions and the motivations driving these intentions were investigated. In addition, the income generated by each production practice was examined to determine its profitability. Table 1 summarizes the various farming practices used by rice farmers in the study areas. The results showed that farming practices included low land cultivation 245 (68.6%), upland cultivation 97 (26.4%), and irrigated cultivation 18 (5.0%) (Table 1). The data analysis also revealed that irrigation facilities were virtually absent in the majority of the study area. As a result, the majority of farmers have relied on rainwater cultivation. This finding implies that technology that promotes lowland farming practices will be welcomed, as more rice farmers will benefit greatlyThe findings also revealed that Niger State had the highest prevalence of lowland practices (82%), followed by Kogi (68%), and FCT (67%). Kogi State had the highest upland practice spread (27%), followed by FCT (22%), and Niger State (20%).

Table: 2: Distribution of the production methods engaged in by respondents

Production practice	Niger (n=148) Frequency	Percent	Kogi (n=145) Frequency	Percent	FCT (n=67) Frequency	Percent	Total (360) Frequency	Percent
Upland	20	13	39	27	15	22	75	21
Lowland	121	82	99	68	46	67	269	74
Irrigated	7	5	7	5	6	3	17	5
Total	148	100	145	100	67	100	360	100

Source: Field Survey, 2020.

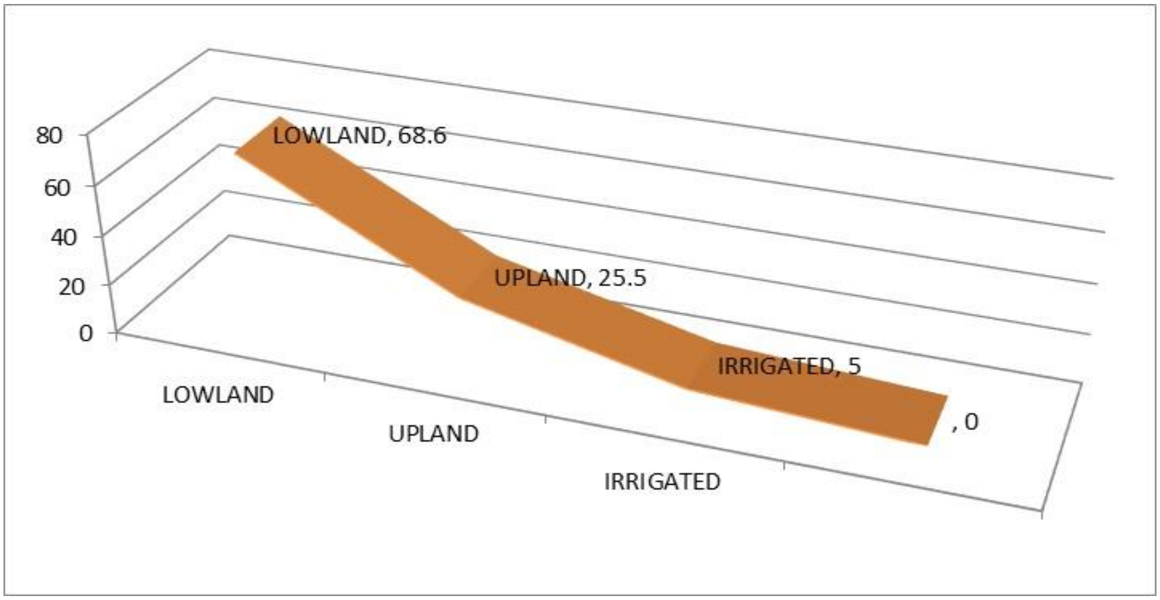

Figure 2: Distribution of rice farmers by production method**.**
Source: field survey (2020) data.

3. Reason for Choosing Rice Production practice

The reasons for the preference of a particular production practice over the other differ from one respondent to the other. Various reasons were observed to be influencing rice production practices being adopted by the rice farmers. These reasons were listed as stated in Table 3. These include output/yield, plot wetness, fertile soil, and distance to the nearest road. Results indicated that output/yield was the most influential factor for participating in rice farming practices, as it ranked first with irrigated rice production practices having 67.7%. Similarly, plot wetness ranked second, with about 76.5% going to lowland production practice. Others are fertile soil ranked third with upland practice having 56% while distance to the nearest road ranked fourth and 60% goes to upland production practice

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Table 3: Reason for Choosing Rice Production practice

Variable	type of field cultivated								
	upland		lowland		irrigated		Total		
	Freq	%	Freq	%	Freq	%	Freq	%	Rating
output/ yield	35	14.3	44	18.0	165	67.6	244	67.7	1st
Plot wetness	19	23.5	62	76.5	0	00	81	22.6	2nd
fertile soil	14	56	8	32	3	12	25	6.9	3rd
distance to nearest road	6	60	2	20	2	20	10	2.8	4th

Source: Field Survey, 2020

4. Effect of Choice of production practice on economic efficiency of the sampled areas.

The study uses upland practices as the base outcome variable as it gives a more consistent result compared to the other practice groups' categories. The estimated tobit results showed that estimated Pseudo R^2, the log-likelihood ratio, and other indicators were highly significant. The results in Table 6 suggested that farmers who participated in irrigated practice in Niger and FCT had a coefficient of 0.0296 and 0.140, respectively, which were statistically significant and positively influenced the economic efficiency of paddy rice production in the study areas. This implied that farmers participating in irrigated practice in these states were more economically efficient (0.0296 and 0.140 more efficient) in their rice production than those in upland practice. This finding is in accord with the findings of John *et al.* (2018).

Lowland practice had coefficients of -0.016 and -0.073 for economic efficiencies. The impact of irrigation ecology on

economic efficiency in Niger and Kogi is approximately -0.016 and -0.073, respectively. This implies that lowland farmers are less economically efficient than upland farmers in rice production (-0.016 and -0.073, respectively). This finding is consistent with Evans' (2015) findings from his comparative analysis of upland and lowland rain-fed rice production in selected Local Government Areas in Kaduna State, Nigeria
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Table 4: Estimates of the choice of production practice on economic efficiency of the sampled areas

	Niger (n=148)			Kogi (n=145)			FCT (n=67)		
EEcort	Coef	SE	t-ratio	Coef	SE	t-ratio	Coef	SE	t-ratio
constant	0.952798	0.0195504	48.74***	0.952539	0.0197490***	48.23	0.729466	0.0564894	12.91***
Irrigated	0.0296266	0.0322274	0.9193**	0.0146183	0.0268881	0.5437	0.140863	0.0765991	1.839*
Lowland	-0.016313	0.0204577	-0.7974*	-0.073316	0.0242458***	-3.024	0.0822002	0.0590013	1.393
Log-likelihood	176.6396			105.5660			33.64315		
Chi-square(2)	2.867161			17.76492			3.562283		
sigma	0.0727615			0.116837			0.147535		

5. The Pooled Effect of Production Practice on Economic Efficiency.

The choice of rice production practice may differ depending upon the concerns of the farmers, which are defined by their desire to improve farm household income and food security. The study uses upland practices as the base outcome variable as it gives a more consistent result compared to the other practice groups' categories. The estimated tobit regression results showed that estimated Pseudo R2, the log-likelihood ratio, and other indicators were highly significant. From the table, paddy rice producers who participated in irrigation practice had a coefficient of 0.034, which is better when compared to upland practice.

Lowland practice had a coefficient of -0.033 for economic efficiency. The effect of lowland ecology on economic efficiency is approximately -0.033. This implies that farmers in lowland practice are less economically efficient in rice production by -0.033 than those in upland practice. It may not be unconnected with the topography of the farms. Lowland rice production is carried out in water-logged environments whereby some of the production activities like land preparation, weeding, application of fertilizer, harvesting, among others, may be challenging due to floods during the production season.Ordinarily, one would have expected lowland producers to be very efficient since rice is a moisture loving crop. However, it appears that farmers in the study areas lack the agronomic and management skill to manage rice production under lowland condition compared to production under irrigation and upland practices. This finding is consistent with Evans' (2015) findings from his comparative analysis of upland and lowland rain-fed rice production in selected Local Government Areas in Kaduna State, Nigeria.

Table 5: Pooled Estimates of the choice of production practice on economic efficiency

EE cort	Coef	SE	t-ratio
constant	0.926637	0.0160338	57.79***
Irrigated	0.0341942	0.0224676	1.692*
Lowland	-0.0333165	0.0176013	1.893**
Log-likelihood	252.8037		
sigma	0.119891		

Source: Computer output from Frontier

CONCLUSIONS AND RECOMMENDATIONS

The study revealed that there are three main rice production practices in the study areas, namely: lowland, upland and irrigated, with irrigated practice getting gradual attention. Output/yield was the most influential factor for participating in rice farming practices, as it ranked first followed by plot wetness which ranked second. Others are fertile soil ranked third while distance to the nearest road ranked fourth. The production practices chosen by rice farmers in the study area have a significant impact on the economic efficiency of rice production in one way or another.It was discovered that lowland practices have a lower impact on economic efficiencies than other practices (irrigated and upland); thus, it is recommended that farmers be encouraged to participate more in irrigation and upland rice production rather than lowland production because they are more efficient economically.

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