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STOCHASTIC ANALYSIS OF ALLOCATIVE EFFICIENCY OF UPLAND RICE PRODUCTION SYSTEM IN SOUTH EAST NIGERIA

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Abstract

This study examined the allocative efficiency of South East Nigeria's upland rice producing system using stochastic analysis. The study's precise goals were to ascertain the elasticity of the upland rice production system in the study area, assess the costs and returns associated with it, and determine the allocative efficiency of the system. Purposive and multi-stage random sampling techniques were used to select one hundred and twenty (120) respondents for the study. Objectives (i) and (iii) were analysed using allocative efficiency model, while objective (ii) was realized using cost and returns analysis. The allocative efficiency analysis results showed that educational level, labour, seed (planting material), fertilizer, pesticides, herbicides and capital had positive coefficients while farm size had a negative coefficient. Upland rice production system had a return per hectare of 26.5% indicating that the venture is operating at the increasing returns to scale. However, there is need for government and Non-Government Organization (NGO) to aid farmers in procuring irrigation facilities to guide against poor rainfall distribution, which often affect their crop yield.

Key words*: *Stochastic analysis, Allocative efficiency, Upland rice, Production system, Southeast Nigeria

INTRODUCTION

Upland is the rainfed rice grown on free-draining fertile soils. This is also called dry uplands. Upland rice is the safest and most guaranteed investment platform in paddy rice production as it is less prone to flooding since it's planted on dry land, the species are long, durable and sweeter than lowland rice, the demand for upland rice is higher as it's use to complement lowland rice and the cost of production per hectare is lower compared to lowland [18]. Rice is one of the three major crops cultivated globally, alongside with wheat and corn [3]. More than one hundred countries cultivate rice, and during the 2018 growing season, an estimated 158 million hectares of harvested land were used for the crop. Each year, more than 700 million tons of rice (or 470 million tons of milled rice) are produced from a variety of ecologies [26]. In Nigeria, 20% of the total rice produced is generated in upland areas. In Nigeria, upland areas have the potential to yield optimal output. Approximately 4.6 to 4.9 million hectares of land are available for rice production, of which 1.7 million hectares are now under cultivation. Of the 1.7 million hectares, 25% are made up of the rainfed upland rice ecosystem. About 800,000 hectares is still available for rainfed upland rice across the following States; Benue, Delta, Edo, Ekiti, Kaduna, Kebbi, Kogi, Kwara, Niger, Ogun, Ondo, Osun, Oyo and Sokoto States. In the upland ecology, the rice crop depends strictly on natural rainfalls for its growth and productivity. This ecology accounts for 55 to 60 percent of the rice cultivated land areas, and yielding an estimated 30 to 35 percent of total national rice production. Rice yields in the upland ecology are generally low in production and range from 0.8 to 2 tonnes/ha [15]. Hence, the upland ecology accounts for 32 percent of the total rice area in Nigeria [14].

Efficiency as opined by [25] is the ratio of effective output to the required input. In addition, as reported by [17], efficiency measures how efficient the goal of the farm firm, which is often profit maximization is achieved. Farm efficiency measurement through frontier approach has been widely studied [12]. Frontier involves the concept of maximally in which the function sets a limit to the range of possible observation. The observation of points below the maximum possible output can occur but there cannot be any point above the production frontier given the technology. Deviations from the frontier are attributed to inefficiency. Allocative efficiency refers to the adjustment of inputs and outputs relationship until marginal value product (MVP) equals the marginal factor cost (MFC) for any single variable input, (the equi-marginal principle [24]. Allocative efficiency as put by Esheya [7] is the manipulation of available scarce resources and technical know-how to achieve the highest possible economic benefits within given resource where its' marginal value product is equated to its unit price. For rice farmers to be assisted to enhance their productivity, attentions should not only be paid on whether or not they have adopted productivity-enhancing technologies, but to evaluate how good the producers are in making maximum use of the technologies or inputs available to them [20].

In the southeast Nigeria, rice is cultivated primarily in upland and swamp production ecosystems. Upland is portions of plain that are conditionally categorized by their elevation of 200m-500m above the sea level [8]. Also, upland has major characteristics of dry soil, source of water for irrigation is hard to find, low rainfall from 1,000 to 4,500 mm annually and uses rain-fed for sufficient water needs [4]. Against the back drop, this study tends to stochastically assess the allocative efficiency, mean output and return to scale of the upland rice production system in the study area, as little is known about the exact level of inefficiency of resource allocation of smallholder farms. The allocative efficiency aids in facilitating the rice farmers' productivity through choosing an optimal set of inputs from the alternates especially when combined with good access to information and education. This study's main goal is to evaluate the upland rice production system in South East Nigeria's allocative efficiency using stochastic analysis. Its particular goals are to ascertain the elasticity of the upland rice production system in the research area, estimate the costs and returns in the system, and ascertain the allocative efficiency of the upland rice production system.

MATERIALS AND METHODS

The South East (Igboland) is the one of the six geopolitical zones of Nigeria representing both a geographic and political region of the country's inland southeast. It comprises five states: Abia, Anambra, Ebonyi, Enugu, and Imo. South-eastern Nigeria is an area covering about 76,358km^2 east of the lower Niger and south of the Benue valley. The region is located between latitudes 4 and 7 degrees north of the Equator and between longitudes 7 and 9 degrees east [22]. The area is one of the most populous regions in the country. Its population was 13,467,328 in the 1963 census, but by the 1991 census, it had increased to almost 22,000,000 of the 88.5 million people living in the country, or 25% of Nigeria's total population on just 8.5% of the country's total land [21]. The region is home to many diverse ethnic groups, with the majority of inhabitants being Igbo-speaking people. The majority of people in the region—nearly 70%—live in rural areas [9].

Purposive and multi-stage random sampling techniques were used to select respondents from each of the five states for this study. In stage one, four local government areas were purposively selected from each state to obtain a total of twenty LGAs. In stage two, two communities were purposively selected from each of twenty local government areas to bring a total of forty communities. In the third stage, three upland rice farmers were randomly selected from each community, making a sample size of one hundred and twenty (120) upland rice farmers for detailed study. A structured questionnaire and oral interview were used to elicit information on primary data. Secondary data were obtained from different literature sources related to this study such as published and unpublished survey articles, journals, textbooks, the internet, proceedings and other periodicals. Objectives (i) and (iii) were analyzed using allocative efficiency model, while objective (ii) was realized using costs and return analysis. Data analysis of the upland rice production was done using ordinary least square regression method. This can be explicitly represented as:

$Y = f(X_1\ X_2\ X_3\ X_4\ X_5 + e)$: ....(1)

where: Y = Output of upland rice in (Kg)
X_1=Age of the farmer (Years),
X_2,= Educational level (Years),
X_3 = Farm size (Ha);
X_4 = Seed (Dummy),
X_5 = labour (md);
X_6 = fertilizer (kg);
X_7 = pesticides (Litre),
X_8 = Herbicides (Litres),
X_9 = capital input (₦);
$b_1 – b_5$ = coefficient of the parameter;
b_0 = intercepts; and e = error term.

The data in this study were fitted with the exponential, semi-logarithmic, linear, and Cobb-Douglas functions. The coefficient of multiple determination, R2, adjusted R-2, regression coefficients, F-ratios, and t-values are among the statistical analysis or tests that were performed.

Linear functional form:

$Y = bo+ b_1X_1 +b_2X_2 +b_3X_3+b_4X_4 +b_5X_5 +U$ …...(2)

Double-Logarithmic or Cobb Douglas function:

$Ln\ Y = Lnb_0 + b_1lnX_1+ b_2lnX_2+ b_3lnX_3+ b_4lnX_4+ b_5lnX_5+ U$ ………………....................................(3)

Semi-Logarithmic functions:

$Y = Lnb_0 + b_1lnX_1+ b_2lnX_2+ b_3lnX_3+ b_4lnX_4+ b_5lnX_5+ U$ ……………………......................................(4)

Exponential functions:

$Ln\ Y = b_0 + b_1X_1+ b_2X_2+ b_3X_3+ b_4X_4+ b_5X_5+ U$ ……………………………….........................(5)

The choice of the best functional form was based on the magnitude of the R^2 value, number of the significant variables, size and the signs of regression coefficient as they relate to *a priori* expectation.

Efficiency Ratio

The Allocative efficiency was determined by equating the marginal value product of the resource to its unit price.

$MVP= p_yf_i = p_{xi}$…..(6)

Profitability

Profitability (net returns) is obtained by deducting the total cost of production from the total revenue.

Profitability = *TR – TC* ……….………..........(7)

Gross margin=
(G.M.) = TR – TVC ………….............(8)

Returns per Naira invested can be calculated as follows:

Returns/GH₵ = net income/TC ……......(9)

RESULTS AND DISCUSSIONS

Allocative Efficiency of Upland Rice Production System

The figure in parenthesis in Table 1 is the t-ratio. The model was estimated in four functional forms. Based on statistical and econometric reasons, double-log equation was chosen as the lead equation. In the model, the coefficient of determination was 0.8906, implying that 89.06% in the variations in output were explained by the explanatory variables of the model. The remaining 1.94% were explained by the error term. The coefficient of age of the farmers as expected was negative and statistically significant at 5.0% probability level. The indirect relationship could be related to conservative nature of aged people to adoption of new technology, as they preferred maintaining the status quo. Study by [10] corresponded to the above assertion. In addition, the coefficient of educational level of the farmer had direct correlation to the dependent variable and statistically significant at 1.0% alpha level. [1] and [13] had positive signs with the variable in their studies. Educated individuals as reported by [11] are more receptive to innovation, have more access information and have good managerial ability, thus could be more economically efficient through having good allocative and technical efficiency for high productivity. As well, farm size coefficient was positively related to farmers' output. In adoption and production literatures, there is mixed relation between adoption and farm size. In contrast to farmers with smaller farms, [4] suggested that farmers with larger farms are more likely to accept new technologies because they can afford to set aside a portion of their land for the experiment [6]. In addition, lumpy technologies such as mechanized equipment or animal traction require economies of size to ensure profitability. However, [19] noted that a small farm size could encourage the adoption of a technology, particularly when it comes to an input-intensive invention like a labor- or land-saving technique. Farmers with small land may adopt land-saving technologies such as greenhouse technology, zero grazing among others as an alternative to increased agricultural production [7].

Moreover, the coefficient of labour had a positive sign and significant to rice output at 1% significant level. The finding of [16] concurred to above relationship. They opined that labour cost contributed more than 75% of the total costs of production. Also, the coefficient of seed had a positive relationship with the dependent variable (rice output) and was significant at 5% alpha level. This was in resemblance with *apriori* expectation and in line with the findings of [24]. He reported that seed is a vital, cheapest and one of the most economical and efficient inputs use in improving crop productivity and profitability. Also, the estimated coefficient of fertilizer had direct relationship with output of rice and statistically significant at 1.0% probability level. This implied that a 5.0% increase in use of fertilizer would increase the rice output by45.87 %. Fertilizer particularly inorganic fertilizer when applied at right quantity and at right doses is capable of pushing crop production frontier forward. This result concurred to several findings [23]. As well, the pesticides coefficient was positive in line with to *apriori* expectations and significant at 10.0% alpha level. The finding of [2] was synonymous with the above assertion. They reported on the important of pesticides in pest control, especially where the resource is rightly applied. Additionally, the coefficient of herbicides was found to be positive and significant at 5.0% probability level. Herbicide use as reported by [15] reduces erosion, reduces fuel use and reduces greenhouse gas emissions.

Table 1. Estimated Production Function for Upland rice Production System

Variable	Linear	Exponential	Cobb- Douglas+	Semi Log
Age	0.0931 (1.8765)*	0.4421 (2.5409)*	2.8600 (4.0075)***	0.5521 (1.2390)*
Education	0.9213 (0.0035)	0.2130 (05402)	0.4389 (-1.7650)*	1.0098 (0.9321)
Farm Size	0.7654 (1.0098)*	0.3409 (1.0081)*	- 0.4210 (2.0421)**	0.4599 (1.7788)*
Seed	1.9012 (0.5620)	2.0033 (3.9800)***	0.6541 (2.0055)**	0.6500 (0.6501)
Labour	0.6543	0.6543	0.4587 (0.8114)	0.5321
Fertilizer	0.5321	0.7244	0.5688 (1.5498)	0.6522
Pesticides	1.7896 (0.7632)	0.9851 (3.9001)***	0.4488 (2.0055)***	0.1155 (0.6690)
Herbicides	0.7651 (1.9812)*	1.0092 (1.0076)*	0.3341 (3.0921)**	0.0087 (3.9011)***
Capital	0.3214 (0.6540)*	0.9351 (0.5032)	0.0736 (1,7320)*	1.2277 (2.0031)**
R^2	0.5467	0.6009	0.8906	0.7612

Source: Field Survey, 2022

NB: ***, **, * significant at 1.0%, 5.0% and 10.0% levels of probability respectively.

Elasticity of Production and Return to Scale

The elasticity of production is the change in output relative to unit change in input [5]. The elasticity of production of upland rice production system was estimated directly from Cobb Douglas coefficients. When the individual input resource used is less than one, indicating that the factor inputs and the rice production systems' outputs had inelastic relationship. This implied under-utilization of the input. Whereas, inverse relationship (that is when the individual input resource used is greater than one), implies over-utilization. Therefore, From Table 1 above, all the resources were over-utilized in the upland production system, with (herbicides, 0.4488; planting material. 0.6541; farm size, 0.4210; labour, 0.5688, pesticides, 0.3341 and capital, 0.0736).

However, one of the implications of over-utilization of all the inputs used by the farmers could be that the farmers having enough for least to break even.

Thanks to government numerous programmes (tractor hiring units, Agricultural Development Programme (ADP), seed certification programme etc), policies, research institutions and Universities in making some of the inputs available to the farmers for farm use [24].

However, the return to scale, which is the sum of the elasticity of all inputs used in rice production no matter the production system were elastic as their return to scales (upland, 3.0) was greater than 1, indicating that all the farmers were in stage 2 of production function.

Table 2. Elasticity of Production and Return to Scale of Upland Rice Production System

Variables	**Upland**
Farm size	0.4210
Seed (Planting material)	0.6541
Fertilizer	0.4587
Labour	0.5688
Herbicides	0.4488
Pesticides	0.3341
Capital	0.0736
Return to Scale	3.00

Source: Computed from Table 1 Above.

This implied that when all factor inputs were varied by 1%, the responsiveness of farmers' output cultivating in the upland production system would be 3.0%.

Cost and Returns of Upland Rice Production System

The viability of an enterprise is indicated by the amount of profit realized per period of time.

Profit is the difference between the monetary value of goods produced and the cost of the resources used in their production [1].

The amount of revenue realized and operating cost of a business venture determines how much gain or loss the enterprise can achieve within a certain period.

Total Variable Cost is the operating costs of the respondent which are the day-to-day cost incurred for producing rice.

The Total Variable Cost (TVC) incurred by the sampled upland rice farmers was N228,900.00 with Gross Margin (GM) of N607,100.00 as shown in Table 3.

Using the upland rice production strategy, the farmers' net returns per hectare came to N606, 916.00. Additionally, the upland rice production system had a 26.5% return on investment.

This meant that for every N1 invested in upland rice farming, N265.00 was returned. It is crucial to note that, under the upland rice production system, labor costs accounted for the majority of the TVC.

For instance, in upland production system, labour accounted for 79.2% of the total cost of production.

This is in line with a study by (16) that found that labor costs accounted for more than 75% of the total cost of production in rice-based production systems in Nigeria. Labor costs dominated the study.

This is also consistent with the results of [25], who discovered that labor accounted for the largest portion of the entire cost of manufacturing.

The employment of paid manual labor for significant rice-producing tasks (such as clearing land, planting, weeding, etc.) is responsible for the high cost of labor. Additionally, Nigerian migration from rural to urban areas contributes to inefficient labor use in agricultural output. This was followed by high cost of fertilizer and with the cost of seed being the least.

The majority of farmers use their old or previous stock as planting material, which accounts for the least amount of the seed's cost to TVC.

Additionally, the majority of farmers use inexpensive local rice cultivars to upgrade the variety on their rice farms.

Table 3. Cost and Returns of Upland Rice Production systems

Variable	Unit price	Quantity	Amount
(A) Revenue	380,000	2.2	836.00
Operating Capital			
Seed	N300/kg	30kg	N9,000
Agrochemical			
Herbicides	N500/litre	4L	N2,000
Insecticides	N300/Litre	1litre	N300
Fertilizer	N9,000/ 50kg	200kg	N36,000
Total Capital Operating Cost (TCOC)			47,300
Labour			
Land clearing	N3,000	7	21,000
Land preparation	4,000	12	48,000
Nursery	1,000	1	1,000
Planting/ Transplanting	2,500	12	30,000
Application of herbicides	1,200	4	4,800
Application of fertilizer	2,000	4	8,000
Weeding	3,000	10	30,000
Bird scaring	800	2	1,600
Harvesting	1,800	4	7,200
Threshing/winnowing	1,500	8	12,000
Others (Bagging)	500	2	1,000
Total Labour Input (TLI)			181,600
C. Total Variable Cost (TVC=TCOC+TLI)			228,900
D. Gross Margin (R-TVC)			607,100
Fixed cost			
Depreciation on equipment			56.8
Rent on land			68.8
Interest on operating capital(27%)			58,4
F. Total Fixed Cost			184
G. Total Cost (TC = TVC+TFC)	,		229,084
H. Net Return (R - TC)			606,916
I. Return on investment (H/G)			26.5

Source: Calculations based on Field Survey, 2022.

CONCLUSIONS

The upland rice production system demonstrated profitability, yielding a 26.5% return per hectare. Furthermore, by matching the value marginal product (VMP) to their factor prices, farmers in the upland rice production system failed to attain allocative efficiency. As a result, they failed to maximize profit and optimize input consumption. Thus, in upland rice production system, the following coefficients were positive; educational level, labour, seed (planting material), fertilizer, pesticides, herbicides and capital, with farm size coefficient being negative**.** In view of the fact that most production inputs were under-utilized, hence to achieve optimum or absolute allocative efficiency and hence, maximum profit, the farmers should be encouraged to increase the use of these under-utilized resources; through appropriate policies that would enhance their access to these production inputs.

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