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Sustainability of Rice Enterprise and Its Determinants in South East Nigeria

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Abstract
Global rice production needs to double by 2050 to meet the projected demand at current market prices, this will put significant pressure on natural resources and the environment through sustainable development. Thus sustainability has grown in recognition and importance because the farms are trying to balance their performance among economic, environmental and social domains. This study therefore analyzed the sustainability of rice enterprise and its determinants in South East Nigeria. A multi-stage sampling procedure was used in selecting two hundred and eighty (240) rice farmers in the study. Data were analyzed using descriptive and inferential statistics such as sustainability Index (SI) and Tobit regression. The result showed that the average sustainable index was 0.751, with about 23.75% of total respondents having a sustainability index of less than 0.65 units (poor sustainability level), and 10.8% had a sustainability index between 0.65 and 0.74 (deficient sustainability level). About 28.7% had a sustainability index between 0.75 and 0.84 (adjusted regularly to the sustainability goals). About 19.2% had a sustainability index between 0.85 – 0.94 (Well sustainability level). While 17.5% had a sustainability index between 0.95 – 1.00 (Very well sustainability level). Determinants of sustainability were labour used ($p<0.01$), government support for rice production ($p<0.05$), use of high-yielding rice varieties ($p<0.05$), farming experience ($p<0.01$), fertilizer used ($p<0.01$), credit use ($p<0.1$) and management practice ($p<0.05$). The study therefore concluded that the rice farmers had a moderate sustainability level, which is regularly to the sustainability goals and has significant improvement potential. The study therefore recommends that government policies and interventions should focus on the development and rehabilitation of more land and the application of appropriate rice production technologies such as the use of improved high-yielding varieties, fertiliser and herbicides. Also, the Government should formulate and implement numerous field projects to improve rice-based production under regular and special programmes; for example, projects on rice extension, pre-processing, village storage and rice, processing; and a specialized effort to encourage, specialized field projects aimed at assessment of rice, at various stages of harvest and post-harvest operations in South East, Nigeria.
Keywords: Sustainability, Rice Enterprise, Determinants, South East, and Nigeria

Introduction

Rice (*Oryza sativa* L.) is one of the most important food crops for more than 50% of the world's population (Atera *et al*., 2018). It is the leading cereal crop which can be grown in the standing water of areas of flat, low-lying tropical soils. It is grown in over 100 countries of the world (Oko *et al.,* 2012). Globally, about 160 million hectares are estimated to be under rice production with an annual production of approximately 500 million metric tons (Kirby *et al*., 2017). Rice cultivation is the principal activity and source of income for millions of households around the globe. Several countries in Asia and Africa are highly dependent on rice as a source of foreign exchange earnings and government revenue (Kadiri *et al*., 2014). It is relatively easy to produce and it is grown for sale and home consumption. Rice is primarily consumed in its parboiled form which adds value to rice in the production and consumption chain. Also, the demand for rice has increased steadily over the years, thus playing a major role in many countries in terms of strategic food security planning policies. In recent years, rice crop yield has not kept up with the population growth thus leading to shortages and higher prices than available ones (Lee and Kobayashi, 2017).

Sustainable rice production is the major concern of policymakers, the probable reasons for this concern are as follows: (1) rice farming is highly vulnerable to climate change such as floods (ActionAid, 2011), (2) land is becoming an extremely scarce commodity and declining by 1 % per annum (MoA, 2010), (3) the price of fertilizers, pesticides, and fuels for irrigation gradually increasing (MoA, 2006a), (4) irrigation water crisis and groundwater arsenic contamination in the South Western part of the country (Brammer, 2009), and (5) rice-based monoculture pushing out the major non-cereal crops such as oilseed and pulse (Hossain, 2009). Moreover, ever-increasing population pressure and soils with poor organic matter content, i.e., most of the soils, have 1.5 % organic matter, whereas good soil should have at least 2.5 % organic matter in rice-producing areas that are the grave threats to rice production and sustainability (MoA, 2010).

For sustainable rice cultivation, the Sustainable Rice Platform (SRP) was first introduced in 2015 and updated in 2019, SRP was the world's first voluntary sustainable standard for rice production (SPR, 2019). It was the standard applied to all farm-level processes in rice production, including postharvest processes under the farmer's control, and it is a tool for practitioners in public and private sectors to drive wide-scale adoption of climate-smart sustainable best practices (SRP, 2019). The SRP standard comprises 41 requirements and 12 performance indicators, namely, Farm profitability, Labor productivity, Productivity: Grain Yield, Food Safety, Water use efficiency, Nutrient-use efficiency: Nitrogen, Nutrient-use efficiency: Phosphorus, Pesticide-use efficiency, Greenhouse gas emissions, Worker health and safety, Child labour and Women Empowerment (SRP, 2015).

Despite all the human and material resources devoted to rice production, the production efficiency of rice farmers still falls below 60% (Abdul-Gafar *et al.,* 2017). One of the major risks in Nigeria centres on the efficiency with which farmers use resources on their farms. Other problems include how the various factors that explain efficiency could be examined to improve rice production in the country. The inefficiency problem is also attributed to factors such as the use of low-input technology, low volume of credit access, lack of knowledge of high-input technologies and poor farm management skills, poor extension services, unavailability and high cost of inputs (Anyanwu and Obasi, 2010).

According to Erhie *et al*. (2022), the agricultural industry employs 36 percent of Nigeria's workers and generated around 22 percent of the country's GDP in the first quarter of 2020. Smallholder farmers account for 80% of Nigerian farmers and contribute over 90% of the country's agricultural output. The production of rice is mainly in the hands of smallholder farmers, whose productivity and growth are hindered by limited access to loan facilities, and domestic production has not increased to meet the economy's demand. Farmers' productivity and revenue have suffered as a result of the limited availability of resources, which has also hindered them from adopting contemporary technologies and inputs in their farming operations.

Rice production in the southeast is constrained by bio-physical and economic bottlenecks. The biophysical constraints consist of frequent floods, irregular patterns of rainfall, water shortage, low soil fertility, and pest menace, while the economic constraints are high cost of production, low productivity, instability of price of paddy, agricultural labour shortage and higher wages due to the high opportunity cost of labour in other activities. In addition, technological constraints like low-yielding varieties and accelerated conversion of rice land to shrimp farms are other major threats (Angvitthayathorn, 2001). Also, rice production has raised environmental concerns such as soil compactness and acidity (Jahiruddin and Satter, 2010). Moreover, the declination of agro-biodiversity, rural poverty, and food price speculation exacerbate the growing concerns, indicating that the present rice production trends are not environmentally sound, profitable, and socially responsible (Shahid and Behrawan, 2008).

For rice production to be sustainable in Southeast Nigeria, there must be optimality in production and this can be tackled if local production of rice in Nigeria has been able to keep pace with national demand of about five million tonnes (USDA-ERS, 2020). Thus if there is optimality in the use of various inputs in rice production, rice output will therefore be sustainable in Southeast Nigeria.

Methodology

The study was conducted in South Eastern Nigeria. The Zone consists of five states, namely, Abia, Anambra, Ebonyi, Enugu, and Imo. According to NPC (2018), the population of the South East Zone is 16, 381, 729 persons, disaggregated into 8, 306,306 males and 8, 075, 423 females with a population growth rate of 2.6% per year. The South East population is now 23,053,581. The region lies in the humid tropical agro-ecological zone of Nigeria, between latitude 6° and 9°E and 4° and 7°N longitude. It has a total land mass of 109,524 square kilometres. A multi-stage and purposive sampling technique was used in the selection of states, Agricultural Zones, Local Government Areas, communities and rice farmers. The first stage involved the purposive selection of three states (namely- Ebonyi, Enugu and Anambra) from the five states of the Southeastern region based on the intensity of rice production. Secondly, from each of the selected states, one agricultural zone was purposively selected based on the dominance of rice farming in these Zone (for Ebonyi - Ebonyi South agricultural zone, Enugu- Nsukka South agricultural zone and Anambra- Anambra Agricultural Zone). Thirdly, from each agricultural zone, two Local Government Areas (LGAs) were randomly selected. The fourth stage involves a random selection of two communities each from the selected LGA (i.e. 12 communities). The fifth stage involves a random selection of two villages each community selected (i.e. 24 villages). In the last stage, 10 farmers that produce rice from each of the villages were selected randomly, giving a sample size of 240 rice farmers. The primary data were obtained through the aid of questionnaires and interview schedules.

Model Specification

The measurement of economic sustainability in this study followed the approach proposed by Sellito *et al.,* (2010) with little adjustment by the author

The economic sustainability index is given as:

$$SI = \sum_{j=1}^{j=3} \sum_{i=1}^{i=n} PM_j \, GR_j \, OR_j \, R_j \ldots\ldots()$$

Where,

SI = Sustainability Index

PM = Profit margin (Net profit/total sales)

GR = Gross ratio (Defined in equation 3.6)

OR = Operating ratio (Cost of rice Sold + Operating Expenses) / Total Revenue

R_j = Rate or normalized value of the sustainability indicator

The normalization of the indicators can be done through the formula given:

$$Rj = \begin{cases} \frac{X_{ij}}{max\{X_{ij}\}} \text{ if } X_{ij} \text{ satisfies the condition "more is better";} \\ 1 \text{ if } X_{ij} \geq \max\{X_{ij}\} \text{ "more is better"} \\ \frac{min\{X_{ij}\}}{\{X_{ij}\}} \text{ if } X_{ij} \text{ satisfies the condition "less is better";} \\ 1 \text{ if } X_{ij} \leq \min\{X_{ij}\} \text{ "less is better"} \end{cases}$$

X_{ij} = value of the indicator to normalize (GR, OR and PM):

i = number of the indicators: of 1 to 3.

j =number of farmers: 1 to 240.

The procedure defines four sub-indexes that match with the three indicators of the sustainable index and they will illustrate the indicator's behaviour of the farmers

In the case where the indicators are homogenous and do not need a normalization procedure, an improvement potential model which measures the level of sustainability of rice farming was estimated as follows:

$$SI = PM_j * GR_j * OR_j \, R_j \ldots\ldots (2)$$

Decision rule: A scale of the economic sustainability index to give an evaluation of the rice performance will follow the one presented in Table 1. The farming strategies to be adopted are defined in Table 2. The total mean per strategy was computed by dividing the total strategy score by the number of respondents involved. **The mean was rated on a 5-point scale and computed thus;**

$$\overline{X} = \frac{\sum X}{N} \ldots\ldots (3)$$

$$\overline{X} = \frac{1+2+3+4+5}{5} = 4$$

The mean score of each strategy was computed by multiplying the total number of responses for a particular strategy with the weight attached to the responses chosen and then dividing by the total number of respondents.

$$\text{Evaluation scale} = \frac{\text{Grand Mean}}{5} \ldots\ldots (4)$$

The index is based on a score between 0 and 1(0 – 100%)

Since the sustainable index will range from 0 – 1, a Tobit Model was employed to give room for censoring the dependent variable. The Tobit Model is specified as:

$\mathbf{V_j = \beta Z_{ij} + e}$ **…..(5)**

$\mathbf{V_j = V_j \text{ if } V_j > 0}$

$\mathbf{V_j = 0 \text{ if } V_j \leq 0}$

j = 1- - - n

$\mathbf{V_j^*}$ **= Limited or censored dependent variable. It is the measure of sustainability. It is defined as** $\mathbf{(K\text{-}Y_j) / K}$ **……. (6)**

Where K = threshold level;

$\mathbf{Y_j = j^{th}}$ **rice farming sustainability level;**

B = **Parameter estimates;**

$\mathbf{Z_{ij}}$ **=Vector of the explanatory variables.**

The following determinants of the sustainability level of rice farming were fitted into the Tobit Regression Model and expressed as follows:

$$Y_j = \Phi_0 + \Phi_1 X_1 + \Phi_2 X_2 + \Phi_3 X_3 + \Phi_4 X_i + \Phi_5 X_5 + \Phi_6 X_6 + \Phi_7 X_7 + \Phi_8 X_8 + \Phi_9 X_9 + \Phi_{10} X_{10} + \Phi_{11} X_{11} + \Phi_{12} X_{12} + U_i \quad \ldots\ldots (7)$$

Where;

X_1 = Total area of farming lands (ha)

X_2 = Labour used (man-days)

X_3=Government Support for rice production (dummy variable; 1=yes, 0=no)

X_4 =Use of high-yielding rice varieties (Yes =1, No = 0)

X_5 =Access to training (Yes =1, No = 0)

X_7 =Level of education (number of years spent in school)

X_8 =Farming experience (Years)

X_9 = Fertilizer used (kg)

X_{10} = Extension visit (contact with extension 1, non-contact 0)

X_{11} = Credit use (N)

X_{12} =Number of existing management practices/technology (Number)

$\Phi_{1-}\Phi_{12}$= coefficient of the model

Results and Discussion

Sustainability Index evaluation scale was used to achieve part of objective six, the result was summarized and presented in Table 3. The measurement of sustainability in this study follows the approach proposed by Sellito *et al.* (2010) for measuring sustainability. The components of sustainability include profit margin, gross ratio and operating ratio. The sustainability index captured integrated indicators, the complexity involved in environmental systems and how this manifests itself systemically in rice production. Subsequently, the indicators were combined into a global index which varies between 0 – 1 (i.e. 0 – 100%).

Table 3 indicates that the values of the sustainable index obtained lie between 0 and 1. From the result, the average sustainable index was 0.751 which implies that on average, rice farming sustainability is adjusted regularly to the sustainability goals and has significant improvement potential. This conforms to the findings of Frank *et al*., (2014) who noted an index of 0.75. An index of 0.75 and above is moderate for the enterprise as it allows the enterprise to refocus production efforts towards the worst indicators. Furthermore, the result shows that about 23.75% of total respondents have a sustainability index of less than 0.65 unit, this implies that these respondents had poor sustainability levels, the implication is that the enterprise's sustainability performance is bad regarding the defined sustainability goals and has large opportunities for improvements. Also, 10.8% of total respondents have a sustainability index between 0.65 – 0.74, this implies that these respondents have deficient sustainability levels. The implication is that they are deficient in certain aspects of production concerning the sustainability goals defined by the enterprise and have several opportunities for improvement. About 28.7% of the total respondents had a sustainability index between 0.75 – 0.84; which implies that the enterprise's sustainability performance is adjusted regularly to the sustainability goals and has significant improvement potential. About 19.2% of the total respondents have a sustainability index between 0.85 – 0.94; which implies that the business sustainability performance is adjusted well to the goals defined with some possibilities of improvement. While 17.5% of the total respondents have a sustainability index between 0.95 – 1.00, which implies that these respondents have a very good sustainability level: the implication is that the business sustainability performance is adjusted very well to the goals defined in the organizational strategies. This classification corresponds with Sellito *et al.* (2010) for measuring sustainability.

The Tobit regression analysis was employed to assess the factors associated with sustainability level (Table 4). The model was used because the estimated regression coefficients were censored variables having values between 0 and 1. The result showed chi-square significance at a 1% level (20.48), log-likelihood (126.435) and Pseudo R^2 (78.81) showing strong explanatory power of the model. The sustainability level index was regressed on the total area of farming lands, labour used, government support for rice production, use of high-yielding rice varieties, access to training, level of education, farming experience, fertilizer used, extension visit, credit use and management practice. The result reveals that the estimated coefficients were significant for labour used ($p<0.01$), government support for rice production ($p<0.05$), use of high-yielding rice varieties ($p<0.05$), farming experience ($p<0.01$), fertilizer used ($p<0.01$), credit use ($p<0.1$) and management practice ($p<0.05$). A positive sign of an estimated coefficient parameter implies that the associated variable has a positive (direct) effect on the sustainability of rice enterprises in the study area. However, a negative sign of an estimated coefficient parameter implies that the associated variable has a negative (inverse) effect on sustainability. The result in Table 4.11 shows that labour used ($p<0.01$), use of high-yielding rice varieties ($p<0.05$), farming experience ($p<0.01$), fertilizer used ($p<0.01$), credit use ($p<0.1$) and management practice ($p<0.05$) were positively related to level of sustainability, this implies that increase in any of this variables will increase the level of sustainability and vice versa. The coefficient of labour used ($p<0.01$) was significant at 1% and positively related to the level of sustainability, this implies that an increase in labour used in rice production increases the level of sustainability and vice versa. This is in line with the findings of Kadurumba *et al*. (2020) and Oluyole *et al*. (2011) as they noted that an increase in labour utilization in rice production increases sustainability level. This is so because labour utilization stimulates other factors of production and converts other farm inputs into the outputs needed which sustain the level of production and vice versa. While Sarma *et al*. (2011), Akanni and Dada (2012) and Anyiro *et al*. (2013) noted that lack of farm labour has hurt sustainability, planting accuracy, improved weed control, timely harvesting and crop farming. The implication is that efficient utilization of labour continuously in rice production will sustain the level of production in South East Nigeria.

The use of high-yielding rice varieties ($p<0.05$) was significant at 5% and positively related to the level of sustainability, this implies that an increase in the use of high-yielding rice varieties in rice production increases the level of sustainability and vice versa. Several technologies have been identified as potential for sustaining rice production including high-yielding rice varieties, efficient agronomic management techniques, enhancing nutrient and water availability and controlling weeds. Among these technologies improved or high-yielding varieties have a significant and positive effect on the level of sustainability as noted by many authors including (Chen *et al*., 2010, Peng *et al*., 2019; Abdul-Rahaman and Abdulai, 2018). Generally, modern varieties have more yield potential and more response to chemical fertilizers resulting in a sustainability level (Nhamo *et al*., 2014). Thus high-yielding variety (HYV) seed breeding has been one key approach to improving the sustainability of rice production. The coefficient of farming experience ($p<0.01$) was significant at 1% and positively related to the level of sustainability, this implies that an increase in several years spent in rice production increases the level of sustainability and vice versa. This is because by experience the farmers have learnt better management practices, have better knowledge of the farming environment, and improve their output which is sustained for years. This also supports Berg *et al*. (2017) whose results also showed a positive relation relationship between years of farming and the level of sustainability. The use of fertilizer ($p<0.01$) was significant at 1% and positively related to the level of sustainability, this implies that an increase in fertilizer used in rice production increases the level of sustainability and vice versa. This finding by Zhang *et al*. (2015), Tam (2016), and Umme *et al*. (2019) noted that fertilizer application is a widely accepted strategy to sustain or improve rice production. Their results show that fertilizer has a positive impact on the sustainability of rice production. Long-term application of fertilizer also improves soil fertility through significantly altering physicochemical properties (Xia *et al*., 2013). Shen-yan *et al*. (2017) also reported that rice farmers must implement the management of fertilizers appropriately to maintain the sustainability of rice production. Credit use ($p<0.1$) was significant at 5% and positively related to the level of sustainability, this implies that an increase in the use of credit in rice production increases the level of sustainability and vice versa. The implication is that farmers who have access to credit will record higher yields and higher profits which may support the economic sustainability of their enterprise. According to Adetiloye (2012), as most peasant farmers are uneducated and ageing, the introduction of sustainable credit and guarantee into agriculture will attract the youth and educated farmers and thus make rice farming sustainable. Economic sustainability is basically about ensuring that organizations (and enterprises including agriculture) are built to last and can function efficiently over a long period and remain profitable, this is possible through the availability of credit for large-scale production.

Also, the result in Table 4 shows that several existing management practices/technologies were significant at a 5% level. This shows that an increase in number of number of existing management practices/technology translates to an increase in sustainability. This finding is akin to the finding of Nguyen-Van-Hung *et al*. (2023) as they noted that several management practices positively affect the level of sustainability of rice production. Studies (Nguyen *et al*., 2020a, 2020b,) have shown that rice enterprise possesses environmental-related issues in that risks such as bushfires affect their sustainability, thus management practices to prevent such practices will increase the sustainability of rice production. Connor *et al*., (2021) noted that best postharvest management practices play an important role in upgrading the rice value chain tailored to sustainability. Furthermore, the coefficient of government support for rice production ($p<0.05$) was significant at 5% but negatively related to the level of sustainability, implying that rice farmers who did not receive government support in the form of improved seedlings were more sustainable than their counterparts. This is against *a prior* expectation, although maybe because of inadequacy or outright diversion of funds for improving seedlings supplied by the government as well as provision of finance, price guarantees, input subsidies and tax barriers. This is against the findings of Thanapan (2019) who noted that government policy has an influence on the sustainability of rice farming, and such policy can qualitatively affect the farmers' production in that the government provides production technology and knowledge for farmers so that they can improve their productivity in the long run. Quantitatively, the government's policy results in increasing rice production, especially the rice productivity of farmers. Also government provides financial and production assistance for farmers via price guarantees or input subsidies (Laiprakobsup, 2017), and on the other hand, it imposes tax barriers on imported inputs and machines and controls rice prices (Laiprakobsup, 2010).

Conclusion

Based on the findings the study, therefore, concluded that rice farmers had a moderate sustainability level which regularly to the sustainability goals and has significant improvements potentials while labour used ($p<0.01$), government support for rice production ($p<0.05$), use of high-yielding rice varieties ($p<0.05$), farming experience ($p<0.01$), fertilizer used ($p<0.01$), credit use ($p<0.1$) and management practice ($p<0.05$) are the significant factors affecting sustainability of rice production in South East Nigeria.

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Table 1: Sustainability index (SI) evaluation scale

Range SI	Evaluation level
$0.95 \leq SI \leq 1$	**Very well:** The rice farm business sustainability performance is adjusted very well to the goals defined in the farming strategies
$0.85 \leq SI < 0.95$	**Well:** The rice farm business sustainability performance is adjusted well to the goals defined with some possibilities for improvement
$0.75 \leq SI < 0.85$	**Regular:** the rice farm business sustainability performance is adjusted regularly to the sustainability goals and has significant improvement potential
$0.65 \leq SI < 0.75$	**Deficient:** is deficient concerning sustainability goals defined by the farming and has several opportunities for improvement
$0.65 < SI$	**Poor:** the rice farm business sustainability performance is bad regarding the defined sustainability goals and has large opportunities for improvements

Source: Sellito et al. (2010) with little adjustment by the author

Table 2: Strategies for achieving optimum quality of rice output

S/N	Strategies
1	Expanding the production area
2	Using the best variety and qualitative seeds
3	Provision of adequate incentives for rice farming
4	Accelerated rural development
5	Use of crop calendar/ Time of planting
6	Effective weed management
7	Fertilizer application
8	Pest and disease management
9	Harvesting on time
10	Storing and Milling

Table 3: Distribution of respondents based on sustainability level

Sustainability level	Frequency	Percentage	Ranking	Evaluation level
0.05 – 0.14	3	1.3	9th	Poor
0.15 – 0.24	7	2.9	8th	Poor
0.25 – 0.34	7	2.9	8th	Poor
0.35 – 0.44	10	4.2	7th	Poor
0.45 – 0.54	11	4.6	6th	Poor
0.55 – 0.64	19	7.9	5th	Poor
0.65 – 0.74	26	10.8	4th	Deficient
0.75 – 0.84	69	28.7	1st	Regular
0.85 – 0.94	46	19.2	2nd	Well
0.95 – 1.00	42	17.5	3rd	Very well
Mean	**0.751**			
Total	**240**	**100.00**		

Source: Field Survey Data, 2023

Table 4: Tobit Regression Model Result on the determinants of sustainability level

Variables	Coefficients	Std. Error	z-value
X_1 = Total area of farming lands	-0.002735	0.011187	-0.24
X_2 = Labour used	0.003592	0.000436	8.24***
X_3=Government Support for rice production	0.043970	0.018884	-2.33**
X_4 =Use of high-yielding rice varieties	0.004264	0.019168	2.22**
X_5 =Access to training	0.000264	0.021107	0.01
X_7 =Level of education	0.004023	0.003011	1.34
X_8 =Farming experience	0.011091	0.001049	10.57***
X_9 = Fertilizer used	0.001239	0.000166	7.46***
X_{10} = Extension visit	5.80e-09	5.79e-07	0.01
X_{11} = Credit use	0.000505	0.000268	1.89*
X_{12} = Management practice	0.043097	0.019113	2.25**
Constant	1.44547	0.060904	23.73***
LR chi^2 (9)	20.48		
Prob> chi^2	0.03		
Pseudo R^2	78.81		
log likelihood	126.435		
Number of observation	240		

Source: Field Survey, 2023 *, **, *** denotes 10%, 5% and 1% significant respectively