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Analysis of factors influencing the output of improved rice varieties among small-scale farmers in Ebonyi State, Nigeria

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Abstract

This study investigates the socioeconomic and operational factors influencing the output of Improved Rice Varieties (IRVs) among small-scale farmers in Ebonyi State, Nigeria. Utilizing primary data collected through a field survey in 2018, the research employed descriptive statistics and multiple regression analysis to achieve its objectives. The findings reveal a significant level of IRV adoption, with an average of 60.9% of total rice land allocated to IRVs, and popular varieties including FARO 44, ITA 306, MAS 11, and NERICA 8. Despite this, the average paddy rice output from IRVs (1318.4 kg or 1.69 tons/ha) indicates a substantial yield gap when compared to optimal potential, suggesting limitations in realizing the full benefits of these varieties. Perceived operational factors highlight access to credit (2.73), cost of inputs (2.62), location of swamp and land type (2.67), and transplanting practices (2.55) as major constraints. The multiple regression analysis, with an R-squared of 0.907 and a significant F-ratio of 106.34 ($p < 0.01$), identified farming experience, farm size, and membership in a cooperative as significant positive determinants of paddy rice output from IRVs, all conforming to a priori expectations. These findings highlight the need for targeted interventions focusing on improving credit access, ensuring affordable inputs, supporting appropriate agronomic practices, and strengthening farmer cooperatives to bridge the yield gap and enhance food security and livelihoods in the State.

Keywords: Improved Rice Varieties; IRVS; Rice; Small-Scale Rice Farmers; Ebonyi State

1. Introduction

Nigeria plays a significant role in rice production across Sub-Saharan Africa (SSA), contributing substantially to the region's agricultural output (Ndindeng *et al.,* 2021). Rice is a fundamental staple food crop, providing sustenance and essential calories to over half the global population (Sanusi *et al.,* 2025; Wu *et al.,* 2023). Beyond its nutritional value, rice also serves as a crucial income source for countless farmers, especially in Africa (Hussain *et al.,* 2020). Within Nigeria, rice cultivation is concentrated in the North-Central (31%), North-West (30%), North-East (24%), and South-East (8%) regions (United States Department of Agriculture, USDA, 2022). The two primary cultivated species are Oryza sativa, commonly associated with Asia, and Oryza glaberrima, indigenous to Africa (Sanusi *et al.,* 2022). In 2021, rice accounted for approximately 8.3% of the world's major crop production (FAO, 2022). While Africa's share of global rice production was a modest 4.7% (with 3.8% of main crop yield), demand across Sub-Saharan Africa is rapidly increasing. This demand is growing over 6% annually, driven by factors like population expansion, increasing urbanization, and evolving consumer preferences, outpacing the demand for any other staple food (Arouna *et al.,* 2021). In Nigeria's agri-food system, the limited availability of imported alternatives has heightened reliance on local rice production. Though

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this has prompted farmers to expand cultivation areas, it has concurrently contributed to soil degradation, leading to diminished agricultural productivity and perpetuating a cycle of low yields (Olasehinde *et al.,* 2022).

Africa's burgeoning rice demand has primarily been met through a combined increase in local production and imports, often fueled by expanding cultivated land rather than significant yield improvements per hectare. Indeed, over the past three decades, the area under rice cultivation has grown by approximately 400,000 hectares annually (Yuan *et al.,* 2024; Jiang *et al.,* 2025). However, future production shortfalls are anticipated as growth rates in both production levels and harvested areas are declining, further exacerbated by climate change and urbanization (Barthel *et al.,* 2019). This pressing challenge necessitates a fundamental shift from the current paradigm of "low yields, extensive area expansion" to one focused on "increasing yields with reduced area expansion." Prioritizing solutions that enhance agricultural productivity, particularly through improved farm technology, is therefore essential (Edwards et al., 2023). A significant technological advancement in boosting agricultural productivity is the adoption of improved crop varieties, widely recognized as an economical and effective means to enhance yields (Rizieq *et al.,* 2023). Rice systems in these regions must prioritize enhancing rice production efficiency, nutrition, and quality through sustainable technologies, prominently including these improved rice varieties (IRVs) to ensure food security and foster societal stability (Checco *et al.,* 2023). A pivotal shift is thus required in Africa's farming systems: transitioning from the predominant use of traditional local rice varieties to IRVs, and concurrently increasing the land area cultivated with these superior varieties. This transition is crucial for the widespread and intensified use of IRVs, which offer higher yields, greater resilience to pests, diseases, and climate change, and improved nutrient use efficiency compared to many traditional local varieties (Ndip and Sakurai, 2025; Islam et al., 2024; Addison et al., 2023). In Nigeria, commonly cultivated IRVs include FARO 44, FARO 61, FARO 60, FARO 52, MAS 11, and NERICA 8, with FARO 44 favored for its early maturity and increased yield potential, and MAS 11 for its taste, long grain size, and yield (Adeleke *et al.,* 2022; Mba *et al.,* 2021).

The successful integration and subsequent output of improved rice varieties (IRVs) among small-scale farmers, particularly in Ebonyi State, are influenced by a complex interplay of operational and socioeconomic factors. Key operational factors include agro-ecological conditions, such as the specific terrain, example, sloped land often yields less productive outcomes for IRVs (Wang et al., 2020), and the inherent attributes of the IRV technology itself. These attributes encompass a variety's perceived yield potential, its maturity period, ease of management, marketability, and overall technical efficiency, all of which significantly influence the actual output achieved on farms (Checco et al., 2023). Socioeconomic characteristics of farmers are equally central to realizing the full productive potential of IRVs. These include a farmer's educational background. A farmer's education can significantly enhance their understanding of different IRV characteristics, such as disease resistance, yield potential, and optimal growing conditions, leading to more informed management decisions and ultimately higher yields (Bancin *et al.,* 2024). Beyond this, other crucial factors impacting IRV output include the size of their farm holdings, access to vital extension services and training programs, and the availability of critical inputs like credit and quality seeds, which directly contribute to expanding the area cultivated with IRVs and enhancing their productivity, are also critical factors influencing the scale and efficiency of IRV production. Membership in farmer-based organizations also plays a role by enhancing resource access and information flow, thereby influencing overall IRV productivity (Islam *et al.,* 2024; Jones-Garcia and Krishna, 2021; Ruzzante *et al.,* 2021; Bannor et al., 2020). Additionally, the age of the household head can indirectly impact output by affecting a farmer's access to and effective application of relevant agricultural knowledge (Adam *et al.,* 2021). Understanding these localized factors is crucial for transitioning from extensive, low-yield farming to sustainable, high-yield practices essential for national food security. This paper, therefore, aims to identify the specific operational and socioeconomic factors influencing the output of IRVs among small-scale farmers in Ebonyi State, Nigeria, thereby addressing a critical knowledge gap and informing targeted interventions to enhance rice production in the State. The specific objectives are to; examine the paddy rice output (kg) of IRVs in the area; and determine the perceived operational and socioeconomic factors influencing the output of improved rice varieties in the area.

2. Methodology

2.1. Study Area

The Study was conducted in Ebonyi State, Nigeria. Ebonyi State is one of the thirty-six states of Nigeria, with Abakaliki as its capital. Located in the South-East geo-political zone, and occupies a land area of about 5,935 square kilometers, divided into thirteen Local Government Areas. The State is bounded in the North by Benue State, in the South by Abia State, in the East by Cross River State and in the West by Enugu State (Global Data Lab, 2018). Ebonyi State has an estimated population of about 2.9 million people and projected to increase to 3.2 million people by 2022 (National Population Commission of Nigeria, 2018), and the major occupation in the area is farming [(National Bureau of Statistics (NBS), 2007)]. The State has a mean temperature of 30^{o}C during the hottest period of the year (February to April) and a mean temperature of 21^{o}C during the coldest period (December to January), with mean annual rainfall ranging from

1,500mm and 1,800mm (Nigerian Meteorological Agency (NiMET), 2020). Ebonyi State is endowed with vast area of swampland and is popular for the cultivation of swamp rice. Ebonyi State produces more than 50% of the total Nigerian output of rice. Rice is commonly produced in lowland/swamp lands (Ebonyi State Ministry of Land Survey and Urban Planning, 2015).

2.2. Analytical Techniques

Well-structured questionnaires were administered to small-scale rice farmers in the study area. Multi-stage and purposive sampling techniques were employed, leading to the random selection of 120 small-scale farmers. The collected data were subsequently analyzed using both descriptive statistics and multiple regression analysis. Descriptive statistics were utilized to analyze Objective (i). Objective (ii) was approached in two distinct parts. First, the perceived operational factors influencing the output of improved rice varieties (IRVs) were measured using a 3-point Likert scale. This scale's response options were ordered as: 3 (major influencing factor), 2 (minor influencing factor), and 1 (not a factor). A cut-off mean value of 2.0 was established, where any factor with a mean score greater than or equal to this point was accepted as a major influencing factor on IRV output in the area; otherwise, it was rejected. The second part involved conducting a multiple regression analysis to assess the influence of socioeconomic characteristics on the output of IRVs, specified as:

$$Y_i = f(X_{1i}, X_{2i}, X_{3i}, X_{4i}, X_{5i}, X_{6i}, X_{7i}, X_{8i}, X_{9i}, X_{10i}).$$

Where,

Y_i = Output of IRVs for the ith farmer (kg)
X_{1i} = Age (years)
X_{2i} = Level of education (years)
X_{3i} = Occupation (Dummy variable, farming a major occupation = 1; otherwise = 0)
X_{4i} = Household size (Number)
X_{5i} = Farming experience (years)
X_{6i} = Farm size (Hectares)
X_{7i} = Gender (Dummy variable, male =1; female = 0)
X_{8i} =Marital status (Dummy variable, married= 1, otherwise=0)
X_{9i} = Access to extension services (Dummy variable, yes = 1; No=0)
X_{10i} = Membership of cooperative (Dummy variable, member=1, otherwise=0)

It was hypothesized a priori that education, occupation, experience, farm size, gender, marital status, access to extension services and membership of cooperative would positively influence the output of IRVs, whereas age and household size would negatively influence it.

3. Results and discussion

3.1. Average Land Use and Improved Rice Variety Output (kg) in the area

Table 1 shows the estimated average land use patterns and paddy rice output from Improved Rice Varieties (IRVs) among small-scale farmers in the study area. Results showed that the farmers cultivated an average total rice land area of 1.28 hectares. This figure corroborates the classification of the sampled population as small-scale farmers, consistent with the study's focus. Results also showed that the average land area sown with improved seeds/seedlings was 0.78 hectares. This suggests that, on average, approximately 60.9% of the farmers' total rice cultivation area is allocated to IRVs. This proportion indicates a significant degree of IRV adoption within the study area. However, it also implies that a substantial portion of the rice land, or other farm plots, may still be cultivated with local varieties, possibly due to various constraints preventing complete conversion to IRVs. Results indicated a clear preference for specific varieties, with FARO 44, ITA 306, MAS 11, and NERICA 8 identified as the most extensively utilized in the study area. The widespread adoption of these four varieties underscores their crucial role in enhancing rice productivity within Ebonyi State. FARO 44 demonstrates significant post-adoption utilization, with 86.67% of surveyed farmers reporting its use. This high percentage suggests that FARO 44 possesses characteristics highly valued by farmers in the State, such as superior yield potential, robust disease resistance, or strong market demand. This finding aligns with previous research (Adeleke *et al.,* 2022; Mba et al., 2021) which also indicated FARO 44's preference, adoption, and widespread utilization among farmers. Specifically, Mba *et al.* (2021) attributed this preference to FARO 44's early maturing and increased yield potential.

Results further showed that the average total paddy rice output from IRVs for these farmers was 1318.4 kg (or average yield approximately 1.69 tons/ha for the 0.78 ha under IRVs). This figure is considerably lower when compared to the potential yields of improved rice varieties such as FARO 44, ITS 306, MAS 11, and NERICA 8, under optimal management and environmental conditions. This substantial disparity highlights a significant yield gap, which could stem from the operational factors such as poor site-specific nutrient management (Ahmad and Mahdi, 2018), and other factors limiting the full realization of the inherent benefits and higher yield potential of these specific improved varieties. Understanding these multifaceted limiting factors is paramount for developing targeted and effective interventions that can help small-scale farmers in Ebonyi State bridge this yield gap, thereby enhancing food security and improving their livelihoods.

Table 1 Estimated average paddy rice output of IRVs in the area

Metric		Values
Average total rice land area (ha)		1.28
Average land area sown with improved seeds/seedlings (ha)		0.78
Average paddy rice output of IRVs in the area (kg)		1318.4
Varieties	**Frequency**	**%Distribution**
FARO 44	104	86.67*
FARO 46	21	17.50
FARO 52	7	5.83
FARO 55	10	8.33
FARO 57	17	14.17
ITA 306	88	73.33*
MAS 11	82	68.33*
NERICA 8	73	60.83*

∗ Major varieties; Source: Field Survey Data, 2018

3.2. Perceived Operational and Socioeconomic Factors influencing the Output of IRVs

3.2.1. Perceived Operational Factors influencing the IRV Output in the area

Table 2 shows the frequency distribution of small-scale farmers' perceptions regarding various operational factors that influence the output of Improved Rice Varieties (IRVs) in the study area. These perceptions were measured on a 3-point Likert scale (3 = major influencing factor, 2 = minor influencing factor, 1 = not a factor), with a cut-off mean of 2.0. Factors with a mean score of 2.0 or higher were considered "Accepted" as key influences. Results showed that seven out of the nine factors evaluated had mean scores equal to or greater than the 2.0 cut-off point, thus being accepted as key influencing factors. Specifically, access to credit emerged as the most significant perceived influencing factor (mean: 2.73), with an overwhelming 76.67% of farmers identifying it as a "major" factor. This perception is consistent with existing literature, which consistently identifies access to credit as a crucial determinant influencing the uptake and productivity of modern rice cultivars (Islam et al., 2024; Thanh and Duong, 2021; Ruzzante et al., 2021). The inability to access credit significantly constrains farmers' capacity to optimize IRV output, as it limits their ability to invest in necessary inputs and improved practices.

Results also showed that the cost of Inputs was strongly perceived as a major influence (mean: 2.62, 70.00% "major"). This is closely linked to the challenge of credit access. An increase in the cost of seeds, for instance, is likely to deter farmers from adopting or fully utilizing IRVs (Addison et al., 2023). Beyond seeds, the affordability of other critical inputs like fertilizers is essential, as access to seeds and fertilizers can significantly expand the area planted with IRVs and enhance their productivity (Bannor et al., 2020). Location of swamp (mean: 2.67, 75.00% "major") and transplanting (mean: 2.55, 65.00% "major") were identified as having key factors influencing IRV output. This highlights the farmers' recognition of specific biophysical and agronomic requirements for successful rice cultivation. The suitability of land type and position is known to affect IRV adoption and yield at both farm and plot levels (Ghimire et al., 2015; Checco et al., 2023). This suggests that while farmers understand the importance of appropriate land and specific cultivation practices, they may still face challenges in optimally managing these factors. Finally, the availability of land (mean: 2.10) and rainfall (mean: 2.03) were also accepted as influencing factors, although a higher percentage of farmers viewed them as "minor" rather than "major" influences. This could indicate that farmers have developed coping mechanisms for existing land constraints or adapted to prevalent rainfall patterns, or that other factors present more immediate limitations to their output. However, reliable water management, including irrigation, is recognized as vital for encouraging farmers to allocate more land to IRVs and maximize yields (Thanh and Duong, 2021).

These results show that for small-scale rice farmers in the study area, the immediate, resource-based and technical constraints, particularly financial access (credit), input costs, and specific agronomic practices (transplanting, swamp location), are the most prominent perceived barriers to optimizing IRV output. The consistent emphasis on credit and input costs aligns with the broader agricultural development discourse, which recognizes improving the rice seed system (availability, accessibility, and affordability of seeds) as crucial for enhancing IRV uptake and productivity (Assaye et al., 2022). While farmers in the study area seem to have adopted IRVs to some extent, their ability to translate this into higher yields is heavily impeded by these factors. Therefore, policy interventions and support programs aimed at enhancing IRV productivity in Ebonyi State should prioritize improving credit access, ensuring the affordability and availability of quality inputs, and providing targeted support for best agronomic practices suited to local conditions. Understanding farmers' perceptions is critical for designing effective agricultural support programs that directly address their most pressing operational challenges.

Table 2 Frequency distribution of farmers' perceptions of operational factors influencing the output of improved rice varieties in the area

Factors	**(3) Major**	**(2) Minor**	**(1) Not a Factor**	**(2.0) Mean**	**Remark**
Availability of land	22 (18.33)	88 (73.33)	10 (8.33)	2.10	Accepted
Location of swamp/land type	90 (75.00)	20 (16.67)	10 (8.33)	2.67	Accepted
Cost of inputs	84 (70.00)	26 (21.67)	10 (8.33)	2.62	Accepted
Demand and supply	22 (18.33)	18 (15.00)	80 (66.67)	1.52	Rejected
Access to credit	92 (76.67)	24 (20.00)	4 (3.33)	2.73	Accepted
Availability of labour	28 (23.33)	8 (6.67)	84 (70.00)	1.53	Rejected
Transplanting	78 (65.00)	30 (25.00)	12 (10.00)	2.55	Accepted
Bird Control	23 (19.17)	15 (12.50)	82 (68.33)	1.51	Rejected
Rainfall	14 (16.67)	96 (80.00)	10 (8.33)	2.03	Accepted
Total	453	454	173	2.14	Accepted

$Mean \geq Cutoff\ point\ (2.0) \rightarrow Accepted\ major\ influencing\ factor$; *Figures in parenthesis are percentage; **Field Survey Data, 2018**

3.2.2. Socioeconomic Factors Influencing the IRV Output in the area

Table 3 shows the estimated multiple regression results of the socioeconomic factors influencing paddy rice output of IRVs in the area. The model was estimated in four functional forms of linear, exponential, semi-log and double log. Among the functional forms of the regression analysis fitted into the data for rice output in Ebonyi state, exponential was chosen as lead equation. This is because the functional form had highest level of coefficient of determination (R^2), F– value, number of significant variables of the estimated equation estimates and conformity with a *priori expectation*. The model demonstrated strong explanatory power, with an R-squared value of 0.907, indicating that approximately 90.7% of the variation in paddy rice output was attributed to the included socioeconomic factors. The model's overall statistical significance was further confirmed by an F-ratio of 106.34, which was significant at the 1% level ($p < 0.01$). Results showed that farming experience, farm size, and membership in a cooperative significantly influence paddy rice output, and importantly, their respective positive signs align with a priori expectations. Farming Experience (X_5) showed a positive and statistically significant influence on paddy rice output at the 5% level ($p < 0.05$), with a coefficient of 0.00531. This positive sign is consistent with the expectation that farmers with more experience have accumulated practical knowledge and skills, leading to better farm management and increased output. This aligns with the general understanding that experience often leads to better decision-making and more efficient farming practices. Farmers' characteristics, including experience, are crucial in explaining technology adoption behavior and influencing their ability to convert information into action (Islam et al., 2023; Adam et al., 2021).

Farm Size (X_6) emerged as a highly significant positive determinant, with a coefficient of 0.0285, statistically significant at the 1% level ($p < 0.01$). The positive sign for farm size is as expected, as larger farms generally allow for greater scale of production and potentially more efficient use of resources, leading to higher total output. Farm size is often considered a proxy for a household's economic power, access to inputs, economies of scale, and risk-bearing capacity (Jones-Garcia and Krishna, 2021). This positive relationship is consistent with previous research highlighting farm size as a key factor influencing the adoption of modern rice cultivars and improved agricultural technology (Feyisa, 2020; Mektel and Mohammed, 2021). Membership of cooperative (X_{10}) also showed a positive and highly significant influence on paddy rice output at the 1% level ($p < 0.01$), with a coefficient of 0.1185. The positive sign here is also in line with a priori expectations, as cooperative membership is anticipated to provide farmers with enhanced access to resources, knowledge, credit, and collective marketing opportunities, all of which can contribute to increased productivity. Farmer-based organization membership has been consistently identified as a significant factor in influencing the adoption of modern rice cultivars (Zeleke et al., 2021; Islam et al., 2024). Cooperatives provide farmers with improved access to resources, information, and collective bargaining power, ultimately enhancing their productivity. These results highlight the importance of policies and interventions that support farmers in increasing their farm size, leveraging their farming experience, and encouraging participation in agricultural cooperatives to boost paddy rice output from IRVs. Addressing systemic challenges like poor infrastructure and limited access to credit (Thanh and Duong, 2021) also remains crucial for optimizing IRV output.

Table 3 Estimated multiple regression results of the socioeconomic factors influencing paddy rice output of IRVs in the area

Variable	**Coefficients**	**Descriptive**
Intercept	8.093 (97.118)	
Age (X_1)	-0.0016 (-1.178)	$\bar{X} = 45$
Education (X_2)	3.93339E-05 (0.0149)	Primary: 51.67%
Occupation (X_3)	0.00546 (0.668)	Farming: 66.67
Household Size (X_4)	-0.00074 (-0.2480)	$\bar{X} = 9$
Farming Experience (X_5)	0.00531 (2. 319)**	$\bar{X} = 17$
Farm Size (X_6)	0.0285 (17. 894)***	$\bar{X} = 1.24$
Gender (X_7)	0.00674 (0.3522)	Male: 83.33%
Marital Status (X_8)	-0.00409 (-0.203)	Married: 88.33%
Contact with Extension Agent (X_9)	0.00620 (0.390)	Majority: 75.00%
Membership of Cooperative (X_{10})	0.1185 (5. 158)***	Majority: 80.83%
R^2	0.907	
F. Ratio	106.34***	

Statistically Significant at 5%; * Statistically Significant at 1%. Figures in parenthesis are t-values Source: SPSS Computed Results (2018)

4. Conclusion and Recommendations

This study provides a comprehensive understanding of the factors influencing paddy rice output from Improved Rice Varieties (IRVs) among small-scale farmers in Ebonyi State. While there's a commendable level of IRV adoption, evidenced by the allocation of over 60% of rice cultivation area to these varieties and the widespread use of popular IRVs like FARO 44, a significant yield gap persists. The average output of 1318.4 kg (approximately 1.69 tons/ha) falls considerably short of the potential yields of these improved varieties under optimal conditions. This is an indication that adoption alone isn't sufficient; the realization of full yield potential is hindered by a combination of operational and socioeconomic challenges. Farmers' perceptions strongly indicate that limited access to credit and the high cost of inputs are major impediments to optimizing IRV output. These financial constraints restrict farmers' ability to invest in necessary inputs and adopt recommended practices, thereby preventing them from fully leveraging the benefits of IRVs. Furthermore, specific agronomic challenges related to the location of swamps or land type and transplanting practices are recognized by farmers as crucial factors affecting their output. The regression analysis definitively confirmed the positive and significant influence of farming experience, farm size, and membership in a cooperative on paddy rice output. These findings align with established agricultural development theories and prior research, reinforcing the importance of accumulated knowledge, economic scale, and collective action in enhancing agricultural productivity. In essence, while small-scale farmers in Ebonyi State have embraced IRVs, their ability to translate this adoption into optimal yields is severely constrained by financial access, input affordability, and specific on-farm management challenges. Strengthening the support systems around these key areas is paramount to unlocking the full potential of IRVs and improving the livelihoods of these farmers.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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