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Towards food security in developing economies: a purposive household survey of credit accessibility and rice productivity in North East Nigeria

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Abstract

This study investigated the influence of credit accessibility on rice productivity in North East Nigeria. The study used a multistage sampling strategy to choose 865 rice farming households. We analyzed the data using the endogenous switching regression model (ESRM) and inverse probability weighted regression adjustment (IPWRA). According to the conditional treatment effect, having access to financing increases the average farmer's yield by 0.731 times. The conditional treatment effect, which measures the impact of credit availability on rice yield, was 0.739 and statistically significant. As a result, the average farmer with credit would produce 0.739 times more than he or she would without credit. After accounting for both observable and unobservable variables, the study discovered that access to finance improves rice productivity among farmers in North East Nigeria. The study concludes by proposing policy options to improve rice productivity in North East Nigeria, and other rice-production regions in Nigeria generally.

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1. Introduction

Rice is a widely consumed staple crop that ranks third in terms of production and consumption, following wheat and maize (Akinbile et al., 2011). According to Fukagawa and Ziska (2019), it accounts for more than 20 percent of the overall caloric consumption of the human population. Rice is a staple grain in Nigeria that has historically played a significant role in providing sustenance, economic gain, and employment opportunities. Nigeria engages in rice cultivation using swampy lowland, highland, mangrove, and irrigated regions. Nigeria is regarded as a model for countries that produce rice on a global scale. Rice, a fundamental dietary component in Nigeria and worldwide, has the potential to alleviate poverty and food insecurity in Nigeria (Onuwa & Dalla, 2023; Efayena et al., 2021; Efayena et al., 2018). On the African continent, Nigeria currently holds the top position as the primary rice producer. It is paradoxical that Nigeria is both a giant rice producer and importer (Magbadelo, 2018).

Nigeria is a significant global market for parboiled rice, with an annual consumption value of approximately US$4 billion (International Trade Administration, 2023). Nigeria continues to rely on around 1.7 million metric tonnes of imported parboiled rice in order to satisfy its domestic rice consumption needs. In Nigeria, rice milling capacity has seen significant growth, rising from 350,000 metric tonnes per year (mtpy) in 2015 to over 3 million mtpy in 2021. Within the same timeframe, the quantity of integrated rice mills experienced a significant increase, rising from 10 to more than 60 mills (International Trade Administration, 2023). The disparity in local rice output has led to a substantial surplus of rice imports, positioning the country as a prominent rice importer (Yusuf et al., 2020; Okpiaifo et al., 2020). This deficit necessitates rice importation or illegal smuggling to meet the nation's consumption demands. The Nigerian government has recently implemented a ban on its land borders to limit the importation of rice from neighboring West African countries. The rationale behind restricting rice imports in Nigeria is to mitigate unfair competition against domestically produced rice, stimulate local producers to improve their rice production, and enhance their production abilities, among other things. The policy's ultimate impact will be to improve Nigerians' well-being by encouraging the use of locally produced rice, which is considered to be relatively fresh from the farmers. Additionally, we hypothesised that the policy would increase farmers' income, shift consumption patterns from foreign to local goods, and contribute to heightened economic growth and improved welfare. Technical definitions classify this impact on citizens as economic development.

Nigeria's rice production hub is located in the northeastern area of the country. Experts predicted a national output of 8,171,750 metric tonnes in 2020. Out of this, the Northeast zone contributed 1,448,700 metric tonnes, which accounts for 17.73 percent of the total production (National Agricultural Extension Research and Liaison Services [NAERLS] and Federal Ministry of Agriculture and Rural Development [FMARD], 2020). North East Nigeria consists of Yobe, Adamawa, Borno, Taraba, Gombe, and Bauchi states. The region hosts multiple rice market outlets that function as distribution centres inside and beyond the zone.

Credit accessibility challenges are among the menaces facing agricultural productivity or output given its potentials to access farming inputs (Wongnaa et al., 2023; Adewale et al., 2022; Osabohien et al., 2022; Osabohien et al., 2020; Fowowe, 2020; Khandker & Koolwal, 2016). The credit constraints encountered by farmers are being associated largely with supply-side factors, such as limited availability of alternative credit sources in local areas, unavailability of financial

products that suit the needs of smallholders, or high costs of borrowing. Therefore, experts often recommend enhancing credit through policies that alleviate these supply-side constraints as a successful approach to increase technology adoption and agricultural productivity. But making it easier for farmers to access and utilize credit might not necessarily lead to more credit utilization and modern inputs if demand-side factors and behaviours that make it difficult for farmers to access and utilize credit are not also changed (Adjognon et al., 2017; Woutersen & Shahidur, 2013). Most previous studies in Nigeria x-raying the influence of credit accessibility on rice productivity have suffered severely from several shortcomings including utilization of macro data which lack micro characteristics (Ojo et al., 2019; Akinbode, 2013) and reltively restrictive scope of study which constrain policy relevance (Obagbemi, 2023; Tanko & Darma, 2022; Yuni et al., 2022; Anas et al., 2022; Alfa & Aldulfatah, 2019; Oladokun, 2019; Ibrahim et al., 2019).

Moreover, no previous research has examined how access to credit affects agricultural yields, particularly rice yields. The primary goal of this study is to determine how access to credit affects rice productivity. This paper shows a novel way to figure out how access to credit affect rice yield. Such household-based study has several policy implications (Efayena & Ichoku, 2024; Efayena & Olele, 2024). The study uses inverse probability weighted regression adjustment (IPWRA) and endogenous switching regression model (ESRM), thereby tackling selection bias problem occasioned by heterogeneity of unobservable and observable factors. This paper examines the possible outcomes of the cause-and-effect nexus between credit accessibility and rice productivity. It does this by answering hypothetical questions that may help us better understand how cash transfers might help rice farms increase yields. To validate the ESRM results, we employed the IPWRA approach, which provides extra robustness tests. Our empirical study demonstrates that the availability of credit has a beneficial effect on rice production among farmers in Northeastern Nigeria. This effect is in contrast to what would have occurred if credit access was not available, taking into account both observable factors (self-selection) and unobservable factors (heterogeneity). The paper is structured thus: sections 2 and present the methods utilized and the discussion of findings, while section 4 concludes the study.

2. Methodology

2.1. Study Area

This study consists rice farmers in North-eastern Nigeria. It comprises six states: Yobe, Taraba, Gombe, Borno, Bauchi, and Adamawa. It was the country's largest geopolitical zone, covering nearly one-third of Nigeria's total landmass (Ideki & Weli, 2019). The region's environment primarily divides into the semi-deserted Sahelian Savannah and the tropical west Savannah eco-regions. The zone shares an international boundary with Cameroon Republic to the east, Niger and Chad Republics to the north, and nationally, it borders north-central Nigeria to the west and south-eastern Nigeria to the south (Mayomi & Yelwa, 2019). The zone has a total land mass of 272,395 km^2. According to the National Population Commission (NPC, 2020), the zone has a projected population of approximately 18,971,965 million people at a growth rate between 2.4 percent and 3.4 percent. The north-eastern region of Nigeria experiences an average yearly temperature of 40°C. The average annual rainfall in the zone ranges from 500 mm in the far north to 12000 mm in the southern subregion (Mayomi and Yelwa, 2019). For decades, a variety of ethnic groups, including Fulani, Hausa, Kanuri, Babur-Bura, Shuwa-Arab, Jarawa, Marghi, Gerawa, Mumuye, Sayawa, Jukun, Wurkum, Chamba, and Bandawa, have populated the region. The primary

agricultural crops cultivated in the region are millet, maize, rice, cowpea, sorghum, and cassava. They also farm cash crops like sesame, cotton, and peanuts.

2.2. Sources of Data

The study elicited data from primary source by utilizing a standardized questionnaire distributed among the target group.

2.3. Sampling Procedure and Size

We used a multistage sampling procedure to determine the sample size for this study. We purposively selected Bauchi, Borno, and Taraba states in the first stage due to their prominence in rice production. The second stage included a purposive selection of seven Local Government Areas (LGAs) from the selected states in the zone. We purposively selected Dass and Warji from Bauchi State, Biu and Jere from Borno State, and Gassol and Sardauna from Taraba State because of their high concentration of rice farmers. The third stage involved a random selection of five villages from each of the chosen LGAs, resulting in a total of 30 villages being considered for the study. We established the sample frame of each village using information from Agricultural Development Programs (ADPs) in each of the selected states. Finally, we selected a proportionate 65% of rice farmers from each village, resulting in a total sample size of 865 rice farmers.

2.4. Method of Analysis

The study used an endogenous switching regression model and the inverse probability weighted regression adjustment to analyze the elicited information.

2.4.1.The ESRM Framework

Assessing the possible influence of credit accessibility on rice productivity is intricately complex, since the probability of accessing credit is not arbitrary, but rather contingent on certain distinct socioeconomic attributes of the households. Consequently, households who are granted credit may possess distinct socioeconomic attributes compared to those that are not. This difference could be attributed to unobservable household variables. Observable socioeconomic indicators, such education level, household size, assets, and the age of the household head, can affect both the accessibility of credit and rice productivity, alongside the unobservable features of the households. Lee (1978) proposed the ESRM as a broader version of the Heckman selection model (Heckman, 1976). Therefore, we chose ESRM to account for selection bias for both observable and unobservable variables when assessing the impact of access to credit on rice yield. The advantages of this method have been emphasized in previous studies (Kehinde & Ogundeji, 2022; Alene & Manyong, 2007; Lokshin & Sajaia, 2004). The model consists of a probit model evaluating determinants of credit accessibility, and two functions of rice productivity, with one model showing the rice productivity of households who access credit, and the other model, households who did not access credit. Assume credit accessibility earnings as F_i^* for individual rational rice farmer i. F_i^* is a latent variable which cannot be observed but depends on specified observable household characteristics denoted as Z, which can influence credit accessibility. This is expressed as;

$$\begin{cases} F_i^* = \beta Z + \varepsilon \\ F_i^* = 1 \; if \; F_i^* > 0 \\ F_i^* = 0 \; otherwise \end{cases} \quad (1)$$

The error term is shown as ε, and F and Z have been operationalized previously. The model specifies rice yields for both famers who access credit and those who do not. Note that Q_{i1} yields of the farmer who access credit, Q_{i0} yields of farmers with no access to credit, R represents the plot

characteristics that influence output, while *W* represents the household characteristics that determine output. The equations below are formulated for each respondent *i*:

$$Q_{i1} = f(R, X, \alpha_1) + \vartheta_{i1} \; if \; F_i = 1 \tag{2}$$

$$Q_{i0} = f(R, X, \alpha_0) + \vartheta_{i0} \; if \; F_i = 0 \tag{3}$$

Conditional on positive investment output, a rice producer will utilize accessed credit in production ($Q_{i1}>Q_{i0}$). Selection bias, therefore, can modelled by a nexus between the productivity equation and the choice equation. The Average Treatment Effect on Treated (ATT) can, hence, be derived from the ESRM estimates as follows:

$$ATT = E[Q_{i1}|F_i = 1] - E[Q_{i0}|F_i = 1]$$

$$ATT = \; f(R, X, \alpha_1) + \delta_{i1}\varphi_{\varepsilon\vartheta_1} - (R, X, \alpha_0) + \delta_{i0}\varphi_{\varepsilon\vartheta_0} \tag{4}$$

The average treatment effect on untreated households (ATU) is computed to show the anticipated change in households lacking access to credit.

$$ATU = E[Q_{i1}|F_i = 0] - E[Q_{i0}|F_i = 0]$$

$$ATU = \; f(R, X, \alpha_1) + \delta_{i1}\varphi_{\varepsilon\vartheta_1} - (R, X, \alpha_0) + \delta_{i0}\varphi_{\varepsilon\vartheta_0} \tag{5}$$

ESRM addresses selection bias (δ_{i0} and δ_{i1}) and the covariance terms ($\varphi\varepsilon\vartheta_0$ and $\varphi\varepsilon\vartheta_1$)

2.4.2.The IPWRA Model

IPWRA serves as an appropriate method for addressing ATTs that may arise due to misspecification (Wooldridge, 2007; Robins et al., 2007). Wooldridge (2003) asserts that IPWRA estimates maintain consistency regardless of the precise definition of treatment or outcome. The dual-robust structure of the IPWRA allows for accurate results despite the presence of misspecification. Consequently, the study chose the estimator to evaluate the robustness of ESRM estimations. Imbens and Wooldridge (2009) describe IPWRA as a two-step method for calculating the Average Treatment Effect on the Treated (ATT). Assume Q_i serves as the outcome indicator, defined as defined as follow:

$$Q_i = \sigma_i + \pi_i X_i + \epsilon_i \; for \; i = [0, 1] \tag{6}$$

The propensity score is represented by the selection equation as follows:

$$ps = p(X; \tau) \tag{7}$$

First, the propensity score is estimated as $p(X; \hat{\tau})$. Second, it employs linear OLS to estimate (σ_0, π_0) and inverse probability weighted least squares (IPWLS). The IPWLS is as follows:

$$min \sum_{\sigma_0\pi_0}^{N} (Q_i - \sigma_0 - \pi_0 X_i)/p(X; \hat{\tau}) \tag{8}$$

The ATT is computed as

$$ATT = \frac{1}{N_w}\sum_{i}^{N_w}[(\hat{\sigma_1} - \hat{\sigma_0}) - (\hat{\pi_1} - \hat{\pi_0})X_i] \tag{9}$$

Where $\hat{\sigma}_1 \; and \; \hat{\pi}_1$ are the estimated inverse probability weighted for the treated farmers and $\hat{\pi}_0 \; and \; \hat{\sigma}_0$ are the control households' IPWLS estimates, while the treated households are denoted by N_w.

3. Results and Discussion

3.1. Descriptive Statistics

Table 1 presents the socioeconomic characteristics of the sampled rice farming households. The t-test indicates a statistically significant difference in various socioeconomic characteristics, including age, age squared, non-farm income, household size, rice yields, and farm size, between rice farming households that accessed credit and those that did not. This indicates that the sampled rice farming households with access to credit tend to be older, have improved economic viability or standard, consist of larger family members, have improved access and control of land resources, and achieve higher rice yields compared to those without credit access. This suggests the presence of selection bias in the sample.

Table 1. Socioeconomic Factors of Rice Farming Households

	Households with credit accessibility		Households without credit accessibility		
Variable	Coefficient	Standard deviation	Coefficient	Standard deviation	Diff. (t-test)
Age	52.89	15.38	49.04	18.61	5.11***
Age squared	3168	819.21	2779	798.03	5.03***
Farm income	267,932	2135.81	118,362	1790.33	2.76**
Education (years)	8.03	4.26	7.91	4.01	1.88*
Household size	7.06	3.41	5.37	2.98	2.57**
Farm size	11.47	7.82	9.52	7.35	1.92*
Non-farm income	104,192.2	1806.7	91,811	1620.5	0.52
Experience (years of farming)	16.09	5.17	15.39	5.02	0.21
Yield (kg./ha.)	1096.42	31.49	813.54	29.74	3.99***
Gender	76.9		82.45		

Source: Field Survey (2022)

Descriptive statistics also indicated that the sampled rice farming households with access to credit accumulate more assets compared to those without access. Female-headed households accessed credit more effectively than their male counterparts. The results indicate that most respondents were adults who exhibited energy and entrepreneurial spirit. Consequently, an increased number of stable households are now more effectively positioned to participate in rice cultivation.

3.2. Credit Accessibility and Rice Yield: Econometric Evidence

Table 2 (Panel A) shows presents the effect of credit accessibility on rice yield. There were significant results from the joint independence likelihood ratio test [chi2 (2) = 181.41, p > 0.000]. This suggests that due to their lack of joint independence, the three equations in the models cannot be evaluated independently. Consequently, the results support the utilization of the ESRM to address the endogeneity and selection bias issue. The correlation coefficients for the ESRM's rho_0 and rho_1 are both statistically significant and negative. This illustrates the fact that while farmers

with access to credit yield higher-than-average yields whether or not credit is available to them, credit accessibility benefits them. On the other hand, in both cases, farmers without access to credit have yields that are below average, even though they would gain by having access to credit. The probit model demonstrates that the likelihood of farmers accessing credit is significantly impacted by the household size, square of age, years of schooling, gender, farm revenue, and asset ownership. Positive signs can be seen in the coefficients of farm income, age, and household size. This implies that a rise in any one of these variables would enhance the likelihood that farmers would be able to access credit. Years of schooling, income, gender, and assets, on the other hand, have negative coefficients. This implies that a rise in any of these variables may lessen the likelihood that farmers will be able to access credit.

Table 2. Credit Accessibility and Rice Output

Panel A. Effect Model

			Rice output (disaggregated)			
	Factors determining credit accessibility		**Households with credit accessibility**		**Households without credit accessibility**	
Variable	Coefficient	z-value	Coefficient	z-value	Coefficient	z-value
Age	0.129	0.27	0.138	0.17	0.205	1.33
Age squared	0.105**	2.98	-2.566	-1.31	-1.640**	-2.99
Farm income	0.609***	4.07	0.196**	2.88	-0.120***	-3.64
Education (years)	-0.211***	-5.03	-0.409***	-3.61	0.148*	1.91
Household size	0.371**	3.02	0.936***	3.95	0.512**	2.87
Farm size	-0.163	-1.43	-0.335**	-2.91	0.240	1.17
Non-farm income	-0.106	-0.52	-0.361***	-4.36	0.115***	3.83
Experience (years of farming)	0.146	1.17	0.239	0.92	0.405***	3.79
Gender	-0.318***	-3.41	-0.227*	-1.86	1.835	0.74
_con	0.538***	3.09	0.564***	3.62	1.107***	3.44
Rho_0	-1.061***	-4.01				
Rho_1	-0.805***	-3.80				
LR test	179.05	[prob>chi2 = 0.000]				

Panel B. Impact model

Variable	Mean	Standard error	t-test
IPWRA	0.695	0.237	3.08***
ATU	0.731	0.150	4.94***
ATT	0.739	0.188	3.77***

Source: Field Survey (2022)

A plausible result of the first part of the ESRM is the positive and significant coefficient of age squared, which represents experience and is indicative of a positive and significant categorization between farmers with credit accessibility and those without. This suggests that selectivity bias in the categorization between the two groups of farmers must be taken into consideration. The findings of the switching regressions of rice yield between rice farmers who obtained credit and those who did not are shown in the third and fourth columns, respectively. The model demonstrated that variables including years of schooling, household size, farm income, farm size, gender, asset ownership, and non-farm income, have a major influence on rice output among households that are able to access credit. It is important to note, too, that access to credit and household size as well as farm income significantly increase rice yields. Moreover, there are favourable indications in the household size and farm income factors. This suggests that among households that accessed credit, an increase in any of these variables would result in an increase in rice yield. The probable explanation for the positive nexus between rice yield and household size among credit-seeking households is that homes are crucial providers of family work in the agricultural sector and may act as a safety net against a scarcity of farm labour. This suggests that although many labour activities are necessary in many stages of rice cultivation, farmers with larger households are better positioned to benefit from family labour. Given the labour-intensive nature of rice farming, raising household size would result in an increase in rice yield. In farm production, this is desired, consistent, and significant because employment for farms may be more dependent on family members in rural families than on hired personnel. When farmers use loans, farm income positively affects rice yield. Higher income farmers can make investments in rice production, such as buying cutting-edge supplies to increase rice yield.

The coefficients for years of education, farm size, gender, non-farm income, and asset ownership indicated negative outcomes. An increase in any of these variables may lead to a decrease in rice yield for households with access to credit. Individuals with higher education levels who relocate to urban areas for white-collar employment may disregard their agricultural occupations, which could exacerbate the inverse nexus between educational attainment and rice yield in credit-using households. This may worsen the adverse effects on rice yield, as non-literate farmers might be resistant to adopting innovations designed to enhance yield. A possible explanation for the negative correlation between farm size and rice yield among households with access to credit is that the increase in rice production in Nigeria is primarily due to an expansion in land area rather than an enhancement in yield. This indicates the prevalence of rice farming, especially in small-scale basis.

The inverse nexus between gender and rice yield in households with access to credit indicates that rice yields are markedly greater on farms managed by females compared to those managed by males. Female farmers are frequently viewed as disadvantaged in the rice sector because they participate in production activities but do not receive equivalent economic benefits compared to their male counterparts. Organizations and programs focused on gender, in conjunction with credit facilities, assist women in improving their agricultural productivity. The tendency of farmers to invest in non-farm enterprises, which subsequently reduces their rice yield, accounts for the negative relationship between non-farm income and rice yield among households with credit access. The study identified a negative nexus between asset ownership and rice yield in households accessing credit, suggesting that the wealth and social status of households, particularly their access to assets, adversely affect their rice yield. This is based on the observation that households

with substantial assets prefer to invest in acquiring additional assets rather than in adopting improved technology to increase their rice yield. In households without access to credit, factors such as years of farming experience, household size, non-farm income, square of age, years of education, asset ownership, and farm income have a significant impact on rice yield. The coefficients for years of education, household size, farming experience, asset ownership, and non-farm income exert positive effects. An increase in these variables may enhance rice yield among households lacking access to credit. A large household may signify an ample labour supply for the family enterprise, thereby increasing rice yield. The nexus between years of education and rice yield in households without credit access may be explained by the enhanced capacity of educated farmers to analyze and assess new production techniques, thereby improving their farm yield. Educated farmers are better equipped to leverage new techniques and innovations, as well as to analyze and conceptualize extension information regarding improved farming methods and related issues that can enhance their farm yield. Their willingness to explore new production techniques to improve rice yield is evident, even with their limited educational background. This finding corroborated previous studies (see Popoola et al., 2015; Adeyemo et al., 2010; Oluwatosin, 2011), indicating that higher education levels contribute to enhanced agricultural production.

Extensive farming experience enhances farmers' comprehension of seasonal patterns, crop management, and effective agricultural practices, potentially resulting in increased farm yields. We can attribute the positive nexus between non-farm income and rice yield in households without credit access to their ability to acquire innovative materials that boost farm productivity. The nexus between asset ownership and rice yield in households without credit access is based on the premise that asset-rich households can invest in improved technologies to increase their yield. The coefficients for the square of age and farm income are negative. Increasing any of these variables would lead to a reduction in rice yield for farmers lacking access to credit. The negative correlation between age squared and rice yield in households without credit access indicates that rice yield diminishes once farmers surpass a certain age threshold, presumably associated with advanced age. Older farmers' reluctance to adopt new and improved techniques, preferring to maintain traditional farming methods and procedures, may exacerbate the negative effect. Farmers who generate income from agricultural activities may allocate their resources to non-agricultural enterprises, resulting in decreased rice production.

The estimate generated by the ESRM may be inadequate or potentially erroneous. The direct coefficients from the model cannot be regarded as the average treatment effect on the treated (ATT) population (See Table 2, Panel B). The study investigated how credit affects rice yields by finding the average treatment effect on untreated (ATU) and average treatment effect on treated (ATT). The utilized endogenous treatment and inverse probability-weighted regression adjustment (IPWRA) to make sure the results were robust and valid. The study utilized endogenous switching regression to explore the average treatment effect on the untreated (ATU) and the average treatment effect on the treated (ATT). The study, therefore, accounted for the effects of endogenous treatment. The coefficient for ATT is 0.74, while the coefficient for ATU is 0.73. The average treatment on untreated results in a 73 percent increase in yields, while the average treatment on treated leads to a 74 percent increase in yields. Both effects are statistically significant at the 1 percent level. The results of the ESR model indicate that access to credit has a positive and significant effect on rice yield. The IPWRA estimation shows that access to credit has a positive and significant impact on rice yield in North East Nigeria, with a value of 0.695. Low-income rice

farming households are more likely to obtain credit and invest it in rice farming. This concept posits that access to credit enhances farmers' purchasing power, enabling investments in superior technologies to boost rice yield. The findings corroborated previous studies (Dabone et al., 2015; Zhang, 2010; De Brauw & Rozelle, 2008).

4. Conclusion

This study examined the effect of credit access on rice yield in North East Nigeria. The research utilized a multistage sampling procedure to gather data. Data were analyzed employing the IPWRA and ESRM methodologies. Upon adjusting for both observed and unobserved covariates, the results from ESRM and IPWRA indicate that access to credit positively and significantly influences rice yield. The socioeconomic characteristics of farmers influence both the likelihood of a household obtaining credit and the amount of cash generated. This study produced several policy recommendations for policymakers. The development of social protection programs, including access to credit, is essential in efforts to enhance rice yield, particularly for impoverished, uneducated female farmers managing small farms. This group of farmers will increase their investment in rice production. Secondly, investing in comprehensive instructional programs for uneducated farmers regarding new varieties, farming techniques, and the effective utilization of accessed credit is essential. Thirdly, it is essential to develop policies aimed at enhancing financial inclusion for impoverished female rice producers in Nigeria by improving access to credit.

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