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Impact of Nerica-1 Rice Adoption on Income of Rural Household Farmers in North-East Nigeria

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Abstract

This study examined the impact of Nerica-1 Rice adoption on income of rural household farmers in north-east, Nigeria. A multistage sampling procedure was used to select 605 NERICA-1 rice. The primary data and secondary information were used for this study. Frequencies, percentages, means, adoption index and propensity score matching were used to analysed data. The result revealed that the average ages of NERICA-1 and non-NERICA-1 rice farmers were 34 and 35 years respectively in the northeast region. It further showed that on average 72% of Nereica-1 rice farmers adopted 70-100% of the production practices in the north-east region. The ATE indicated that NERICA-1 rice farmers earned N 478,328.100 more income than non-NERICA-1 rice farmers. It is thus concluded that the level of adoption of Nerica-1 rice was high in the north-east, Nigeria and that the adoption of NERICA-1 rice had positive and significant impact on the income of NERICA-1 rice farmers. Thus, it is recommended that farmers should be motivated to sustain the production of Nerica-1. This should be through the supply of farm inputs such as quality rice seeds, herbicides, pesticides and operational cash so as to continue to generate more employment and income through farming.
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Keywords: Impact, Adoption, Rice and Rural
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1.0 Introduction

Rice is a major staple food crop worldwide as its preference has been shifted from ceremonial to daily household use in both urban and rural areas. The daily demands for the crop, across the globe, makes it popular, thereby attract attention for more production. According to Namibian Agronomic Board (NAB) (2025) rice is a key source of income and employment in many developing countries. Rice is a dietary staple food for billions of people in the world, serving as a primary source of carbohydrates and nutrition (Africa Exchange, 2024). It is commonly boiled and eaten with stew or vegetable soup. It is also used in the preparation of several local dishes that are eaten in every home, especially during festivals and ceremonies (Kamai et al., 2020).

According to John et al. (2023) farmers decision to adopt various agricultural production practices is a key strategy for farmers to overcome low yield, achieve food security, reduces food crop prices, and increase income as well as food accessibility for low-income households. Agricultural research efforts can only be successful when technologies developed by research institutes such as the National Cereal Research Institutes, the Institutes of Agricultural Research, the National Agricultural Extension Research and Liaison Service, and the International Institutes of Tropical Agriculture are adopted by farmers to increase production. Hence, an agricultural innovation that is unable to boost production on this ground shows

unsuccessful research efforts. For this reason, it is of enormous importance to determine the adoption and impacts of NERICA-1 rice by target farmers in north-eastern Nigeria. This study therefore brings out fresh insights on the level at which NERICA-1 rice were adopted by farmers and this helps the researchers to evaluate whether the research effort has been achieved or not.

Several studies have been conducted on adoption and impact of improved rice production technology. For example, Ojo et al. (2018), Adeyemi et al. (2020), Lateef et al. (2020), Ochube and Ndalazhi (2021). However, very few of these studies such as Bala (2021) studieds 'adoption and impact of NERICA-1 rice in Balanga, Yamaltu-Deba local government area of Gombe State. This creates a knowledge gap that this study seeks to address by investigating the level to which NERICA-1 rice specifically was adopted and the impact it has made on farmers income in north-east, Nigeria. The broad objective of this study was to examine the adoption and impact of NERICA-1 rice on farmers' income in north-east, Nigeria, while the specific objectives were to: describe the socio-economic characteristics of NERICA-1 rice farmers in the study area; assess level of adoption of NERICA-1 rice; and determine the impact of the adoption of NERICA-1 rice on the income of farmers. It was hypothesized that adoption of NERICA-1 rice has no significant impact on income of farmers.

Section two reviews the relevant literature on rice, NERICA-rice, adoption and impact assessment, Section three described the study area; elaborate the sampling procedure; source and methods of data collection as well as analytical tools used in the analysis of the data collected.

2.0 Literature Review

2.1 Conceptual Review

Rice belongs to the genus Oryza and the tribe Oryzeae of the grass family Gramineae (Poaceae). The genus Oryza to which grown rice belongs may have originated at least 130 million years ago and dispersed as a wild grass in Gondwanaland, the supercontinent that eventually broke up and drifted apart to become Asia, Africa, Australia, and Antarctica (Daudu et al. 2014). NERICA, an inter-specific hybrid between the local African rice (Oryza glaberrima) and the Asian rice (Oryza sativa), offers new opportunities for upland rice farmers. NERICAs have unique characteristics such as shorter duration (mature between 30 and 50 days earlier than traditional varieties), higher yield, tolerance to major stresses, higher protein, and good taste compared with the traditional rice varieties (Wopereis et al., 2008). NERICAs have also been reported to have stable yields under different management conditions, and their introduction into farmers' fields was considered a first step towards stabilization and sustainable intensification of Africa's fragile uplands rice (Paul et al., 2010). In particular, areas under NERICA were estimated to be about 244,000 ha in Nigeria (Khatib, 2016).

Adoption can be viewed as the incorporation of new farming practices in to existing practices in order to improve the quantity and quality of farm produce. According to Kerk (2017), adoption is modification by an individual or an organisation. Therefore, adoption is an individual or organizational process that leads to diffusion as a systemic process. Adoption in this study is the use of improved NERICA-1 rice and its default production practices by farmers for the purpose of improving productivity. The level at which farmers adopted the NERICA-1 rice as a package may determine the yield as well as income to be derived from the rice farming. The impact of NERICA-1 rice refers to the quantity of rice yield acquired by the farmers in the previous farming season which may likely improved productivity of farmers that may likely translate to increase in income hence; the level of living may change.

2.2 Theoretical Review

This study is guided by social change theory propounded by Talcott Parsons (1902–1979). Social change is a process of bringing about a change in society by transforming customs, values, cultures, and structures of a particular settlement. These changes can be observed at various stages of societal development. Whether gradual or rapid, social change is inevitable and occurs regardless of the type or location of human society. Social change in agriculture is shifting towards modern, innovative, and scientifically informed farming technologies. Social change may be a planned or unplanned change. Planned changes are deliberate, purposeful, and have a responsible authority for implementing the change to attain the desired targets. Therefore, the social change theory guided this study in that NERICA-1 rice is an example of a planned change that seeks to move the farmers from a traditional low-yield rice variety to a modern (improved) and high-yield rice variety (NERICA-1), thereby improving the income of farmers in the study area through the adoption of NERICA-1 rice.

2.3 Empirical Review

Alabi et al. (2024), conducted a study on 'Factors influencing adoption of recommended rice Production practices in two selected local government areas of Kogi State, Nigeria' found significant proportion of the respondents were within the age range of 30-39 years with mean age of 34 years. It was also revealed that majority of the respondents were males. Most of the respondents were married across the adopters of recommended rice production practices. Majority of the respondents had household size ranging from 1-10 members with mean household size of 6 members. Similarly, Bulus et al. (2023), on 'Determinants of Technical Efficiency of Rice Farmers in Wukari Local Government Area of Taraba State, Nigeria' found a mean age of 43 years and an average of 6 persons per household, mean years spent in rice farming were 12 years with the majority of the rice farmers were females, married and had at least first school leaving certificates. Likewise, Ephraim, Abu, & Suleiman (2021) in their study 'Adoption of Rice Production Technologies among Women Farmers in the Central Zone of Bauchi State, Nigeria' revealed that 61.2% of the rice farmers were in the age range of 20–40.

Bala et al. (2020), investigated 'Impact of Adoption of the New Rice for Africa 1 on Farmers' Yield in Gombe State, Nigeria', established that a greater proportion of the rice farmers were conservative and not ease adopters of innovations, with an adoption index of 0.01-0.39. Also, Assaye et al. (2023) Investigated 'Adoption of improved rice technologies in major rice producing areas of Ethiopia: a multivariate probit approach' reported that the majority of farmers adopted at least one improved rice technology package in Ethiopia.

Ochube and Ndalazhi (2021) in a study 'An evaluation of the impacts of adopting modern technology of rice farming on output, income and farm size in Makurdi Local Government of Benue State' reported that there was a positive and significant difference in change in rice outputs and income of farmers before and after adoption of technologies. Bala et al. (2021), conducted a study on the 'Impact of adoption of the new rice for africa 1 on farmers' yield and income Balanga and Yamaltu-Deba local government area in Gombe State, Nigeria' discovered that adoption of NERICA 1 rice has a significant impact on farmers yield and income compared to non-NERICA 1 rice farmers.

2.4 Conclusion

It is concluded that studies were conducted on the impact of adoption of Nerica-1 rice on yield and income of farmers, but the scope is limited a single state in North-East region hence create

a knowledge gap that need to be address to in order to provide reliable empirical result so as to generalize the actual impact of Nerica-1 rice adoption on income of farmers in North-East, Nigeria.

3.0 Methodology

3.1 Study Area

This study was conducted in Northeastern Nigeria, which consists of six states. The states are Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe. The zone is located between Latitude 90 08' to 140N and Longitude 80 68' to 150E (Figure 4.1). It has a total land mass of 280,419 km2 (National Bureau of Statistics (NBS), 2017). The region has a projected population of 29,470,062 people in 2025 based on a population growth rate of 3%. The main economic activities in the area include farming (crops and livestock), hunting, fishing, food processing, transportation, and crafts, with inputs largely sourced from the government (Murtala et al., 2021). The region has three (3) different Savanna zones, which include Sahel, Sudan, and Guinea savanna. Its mean annual rainfall ranges from less than 250 mm in the Northern Sahel to 1500 mm in the derived savannah in line with the southern part, and it has a unimodal pattern (National Population Commission (NPC), 2010).

3.2 Sampling procedure and sample size

A multistage sampling procedure was used for this study. The first stage involved the random selection of Adamawa, Bauchi, and Taraba. In the second stage, one (1) LGA was selected randomly using balloting method from each Agricultural zone of each state. The third stage was purposive selection of three communities from each LGA selected. In the fourth stage, NERICA-1 rice farmers were randomly selected from 1,280 and non-NERICA-1 rice farmers were also randomly selected from 1,300 using a Slovian formula (adopted by Bala et al., 2021) for calculating sample size based on the assumption of 5% expected margins of error, 95% confidence interval. The formula is expressed as follows:

$$n_o = \frac{N}{1 + N(e^2)} \tag{1}$$

Where

n_o = sample size
N = Population
e2 = level of precision

$$n_0 = \frac{1280}{1+1280(0.05*0.05)}$$

$$n_0 = \frac{1280}{1=+1280(0.0025)}$$

$$n_0 = \frac{1280}{1+3.2}$$

$$n_0 = \frac{1280}{4.2}$$

$$n_0 \approx 305$$

Therefore the sample = 305/1280 x 100 = 24%

3.3 Source and Method of Data Collection

Primary data and secondary information were used for this study. The primary data were collected through the use of a scheduled interview and a structured questionnaire with the help of trained enumerators. Secondary information was obtained from published journals, conferences, reports, and newspapers.

3.4 Method of Data Analysis

The data were analysed using descriptive statistics such as frequencies, percentages, means and standard deviation, adoption index and Propensity Score Matching (PSM).

The adoption index formula is as follows:

$$Y_i = \sum \frac{a}{b} \tag{2}$$

Yi = adoption index
$\sum$ = Summation of
a = number of NERICA-1 rice production practices adopted by ith farmer
b = total number of NERICA-1 rice production practices

Farmers with an adoption index of 0.1–0.4 were classified as low adopters, 0.5–0.6 as medium adopters, and 0.7–1.0 as high adopters.

PSM is a non-experimental method for estimating the average effect of technology or programmes. The method compares the average outcomes of participants and non-participants, depending on the propensity score value. The average comparison measures the average impact of the technology. The PSM approach can be used to check the robustness of the estimated treatment effect (Tora et al., 2022).

According to Caliendo and Sabine (2005), the average treatment effect is defined as the outcome variable of NERICA-1 rice farmers can be observed, but the outcome of non-NERICA-1 rice farmers cannot be observed. PSM relies on the assumption of conditional independence, where, conditional on the probability of adoption, given observable covariates, an outcome of interest in the absence of treatment, Y1, and adoption status, P, are statistically independent. Another important assumption of PSM is the common support condition, which requires substantial overlap in covariates between NERICA-1 rice farmers and non-NERICA-1 rice farmers, so that farmers being compared have a common probability of being both NERICA-1 rice farmers and non-NERICA-1 rice farmers, such that $0 < p(X) < 1$. If the two assumptions are met, then the PSM estimator for ATT can be specified as the mean difference of the NERICA-1 rice farmers and non-NERICA-1 rice farmers who are balanced on the propensity scores and fall within the region of common support, defined as:

$$ATT = E(Y1/P=1), p(X)0 - E(Y0/P=1, p(X)) \tag{3}$$

4.0 Results and Discussion

4.1 Socioeconomic Characteristics of the Respondents

The result in Table 1 showed the distribution of the respondents according to their age. The results revealed that larger number (49%) of NERICA-1 rice farmers in northeast were within the age range of 21-30 years with the least (6%) of same respondents had age greater than 60 years. On the other hand, half (50%) of non-NERICA-1 rice farmers were within the age range of 21-30 years while the very few (8%) of same farmers were within the age range of 51-60 years. The average ages of NERICA-1 and non-NERICA-1 rice farmers were 34 and 35 years respectively in the north-east region. The result implies that the majorities of the rural rice farmers in northeastern Nigeria were young and active and, hence could be able to participate and produce more rice crops to have an improvement in their livelihood. The finding from this study is similar to that of Ephraim et al. (2021) and Alabi et al. (2024) who reported that significant proportion of the respondents were within the age range of 30-39 years with mean age of 34 years.

The result also, showed that about (41%) of NERICA-1 rice farmers attended tertiary level of education with a few (13%) attended primary education in northeastern region. Furthermore, the results revealed that large number (46%) of non-NERICA-1 rice farmers had no education and a small number (13%) had primary and secondary education in the study area. Education is very crucial and helps farmers to understand the new farming technology. This suggests that farmers may likely accept NERICA-1 rice as they can be able to understand the benefit of accepting improved technology. This is similar to the findings of Bulus et al. (2023) and Alabi et al. (2024) revealed that the majority of rice farmers have formal education. The result in Table 5.3a established that a NERICA-1 rice farmers had a majority (71%) of NERICA-1 rice farmers had a household size of 1-6 persons per house with a lower proportion (2%) had ≥ 25 persons. On the other hand, more than two third (73%) of non-NERICA-1 rice farmers had 1-6 persons in a house. The mean household size was 5 persons in a house for NERICA-1 rice farmers and 4 persons for non-NERICA-1 rice farmers in the northeast region. The size of the family shows the availability of labour to farmers. The finding suggests that farmers have more free labour available for farm activities. The result is related to the findings of Bulus et al. (2023) and Alabi et al. (2024) who found that majority of the rice farmers' had household size ranging from 1-10 members with mean household size of 6 members.

Table 1: Socio-economic characteristics of respondents

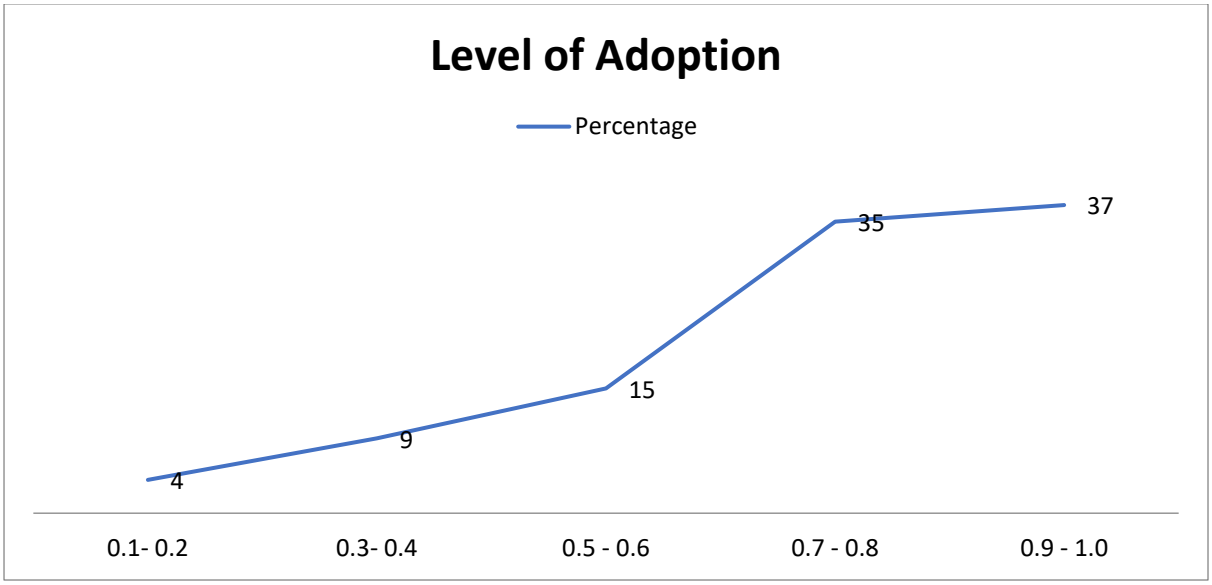
Variables	**Nerica-1**		**Non-Nerica-1**	
Age	**Frequency**	**Percentage**	**Frequency**	**Percentage**
21-30	150	49	150	50
31-40	65	21	62	20
41-50	49	16	36	12
51-60	23	8	23	8
>60	18	6	29	10
Total	**305**	**100**	**300**	**100**
Mean	**34**		**35**	
SD	**13.9**		**14.9**	
		Educational Level		
No Education	89	29	138	46
Primary	41	13	40	13
Secondary	51	17	38	13
Tertiary	124	41	84	28

Total	**305**	**100**	**300**	**100**
		Household Size		
1-6	215	71	218	73
7-12	49	16	51	17
13-18	23	8	16	5
19-24	11	3	8	3
≥25	7	2	7	2
Total	**305**	**100**	**300**	**100**
Mean	**5**		**4**	
SD	**6.1**		**5.8**	
Farm Size				
≤1.5	181	59	188	63
1.6-3.2	94	31	97	32
≥3.3	30	10	15	5
Total	**305**	**100**	**300**	**100**
Mean	**1.6**		**1.5**	
SD	**1.1**		**1.2**	

Source: Field survey, 2024

4.2 Adoption of Nerica-1 Rice

The result in Table 2 revealed that large number (37%) of Nerica-1 rice farmers adopted 90-100% of Nerica-1 production practice. Few (4%) of the Nerica-1 farmers adopted 10-20% of the production techniques. On average 72% of Nereica-1 rice farmers adopted 70-100% of the production practices in the north-east region. This result suggests that most of the farmers in the north-east region are high adopters of Nerica-1 rice production practices. This could be related to high yield and grain quality of the crop which attract higher prices in the markets. The finding of this study differs from that of Bala et al. (2020) who established that a greater proportion of the rice farmers were conservative and not ease adopters of innovations, with an adoption index of 0.01-0.39. This could be related to poor credit access by farmers which may be used to finance the adoption of the technology. However, consistent to that of Assaye et al. (2023) who reported that the majority of farmers adopted at least one improved rice technology package in Ethiopia.



4.3 Impact of NERICA-1 rice adoption on income of farmers in northeast

The result in Table 3 nearest neighbour matching revealed a difference of N 537,000 between the NERICA-1 rice adopters and non-NERICA-1 rice farmers in favour of NERICA-1 rice farmers after comparing each of the adopter with the non-adopter and the difference was significant at 1% probability level as denoted by the t-value (7.52) in the study area. This difference could be attributed to the physical quality of the rice grains which attracts higher prices to farmers in the market. This is because people tend to patronized quality grain rice no matter the price. It has the least bias corrected which signifies a more reliable impact of adoption on farmers' income in the study area. The result is different from the findings of Bala (2021) who established that NERICA-1 rice farmers earn more income as compared to non-NERICA-1 rice farmers in Gombe State, Nigeria.

Similarly, radius matching showed that NERICA-1 rice farmers generated more income of about N 554,000 as compared to the non-NERICA-1 which indicates a positive and significant impact at 1% probability level as shown by the t-value (11.212). This implies that NERICA-1 rice production is profitable in the study area. The profitability of the Nerica-1 rice is associated to the high demand of the commodity with a better process. The finding conforms to Ochube and Ndalazhi (2021) who reported that there was a positive and significant difference in rice income of farmers before and after adoption of technologies.

In Kernel matching the result revealed that the income generated from NERICA-1 rice farmers differs from the non-NERICA-1 rice farmers by about N 533,000 which is significant at 1% probability level as indicated by t-value of 9.732 after comparison. It has the lowest N -5,047.30 bias reduced, hence has the best result with respect to impact of NERICA-1 rice adoption on farmers income. This also revealed that adoption of Nerica-1 rice generated higher income to farmers than non-Nerica-1. The possibility may be due to high patronage of Nerica-1 that could be related to high yield and grain quality which may increase adopters' income more than the non-adopters. The finding is similar to Bala et al. (2021) who discovered that adoption of NERICA 1 rice has a significant impact on farmers' income compared to non-NERICA 1 rice farmers.

Also, the result further showed that stratification indicated a difference of N 468,000 after comparing NERICA-1 with non-NERICA-1 rice adopters. The result indicated that NERICA-1 rice had an impact on the income of farmers as shown by the t-value (8.51) which is significant at 1% level of probability. This implies that Nerica-1 rice adopters had more income from rice farming than non-Nerica-1 rice farmers because Nerica-1rice had qualitative produce that attract more market value than the non-Nerica-1. The result is related to Ochube and Ndalazhi (2021) who reported that there was a positive and significant difference in rice income of farmers before and after adoption of technologies.

The ATE indicated a difference of N 478,328.100 in the income generated by NERICA-1 rice farmers. The t-value is 11.47 and therefore significant at 1% probability level. This implies that NERICA-1 rice farming had a positive and significant impact on the income of farmers while the pomean showed that non-NERICA-1 rice farmers were losing about N 538,344.70 as a result of non-adoption of NERICA-1 rice which is significant at 1% probability level as shown by the t-value (23.92). This might be related to the higher yield and quality of Nerica-1 rice as compared to non-Nerica-1. The Nerica-1 rice adopters had advantage of gaining high yield from the adoption of the Nerica-1 production techniques as well as very good grain quality that gave the crop huge market value.

Table 3: Impact of NERICA-1 rice adoption on income of farmers

Matching Algorithm	ATT	Std. Err. Before Bootstrap	Std. Err. After Bootstrap	Bias Reduce	t-value
Nearest Neighbour	537,000***	1,050	71,319.45	-19,698.19	7.52
Radius	554,000***	51,454.12	49,374.65	-7,952.23	11.21
Kernel	533,000***	49,718.90	54,766.29	-5,047.39	9.73
Stratification	468,000***	49,818.97	55,062.40	5,243.43	8.50
ATE	478,328.10***		41,719.89		11.47
POmean	538,344.70***		22,510.30		23.92

**** significant at 1% probability level, ATE: Average Treatment Effect, Pomean: Potential Outcome Mean*

Source: Field survey, 2024

4.4 Test of Hypothesis

It was hypothesized that the adoption of NERICA-1 rice has no significant impact on income of farmers. The results in Tables 3 revealed that there exists a significant impact of adoption of NERICA-1 rice on farmers income at 1% probability level. Therefore, the null hypothesis that states that adoption of NERICA-1 rice has no significant impact on farmers' income is hereby rejected and the alternative hypothesis accepted.

5.0 Conclusion

It is concluded that NERICA-1 rice farmers in the northeast were within active age and smallholder in nature. The level of adoption of Nerica-1 rice was high in the north-east, Nigeria. Adoption of NERICA-1 rice had positive and significant impact on the income of NERICA-1 rice farmers. Thus, it is recommended that farmers should be motivated to sustain the production of Nerica-1. This should be through the supply of farm inputs such as quality rice seeds, herbicides, pesticides and operational cash so as to continue to generate more employment and income through farming.

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