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Research Article

Socioeconomic Drivers of Food Insecurity Among Rural Households: Evidence from Participating Farmers in the Integrated Rice-Fish System in Ebonyi State, Nigeria

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Nigeria has been facing a food crisis, with most of the poor population having limited access to an adequate quantity and quality of food. Food security reflects the stability of the food supply, availability of, and access to food, and affects the amount of food consumed, which has implications for the population's health. Thus, this study examined the socio-economic drivers of food security among smallholder rice farmers in Ebonyi State, Nigeria. Primary data were collected under the Feed the Future Innovation Lab for Fish (Integrated rice-fish farming system) funded by USAID through a three-stage sampling technique. The Foster–Greer–Thorbecke (FGT) and the Endogenous Switching Regression model were applied in the data analysis. The mean per capita household food expenditure is N 2,456.42, and the food security line is N 1,026.43. The food security measure shows that 46.67 percent of the households experience the incidence of food insecurity, 24.6 percent point is the food insecurity depth, and 17.2 percent point is the severity of food insecurity. The ESR model shows that the drivers of food security are access to credit, marital status, farming experience, primary occupation, education, and farm size. The study proposed implementing more developmental programmes that focus on poverty alleviation, which should be gender-inclusive with an option of credit support for the rice farmers.

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1. Introduction

Food security is comprehensive, encompassing four dimensions: accessibility, availability, utilisation, and stability[1][2]. Food availability has to do with "sufficient food" and is associated with physical quantities, while food accessibility measures the ability to obtain/secure food[3]. The utilisation entails consuming food and determining how essential nutrients are acquired from the food consumed by a person[4]. At the same time, stability deals with the axiom *"at all times"* in the definition of food security by the FAO[5][6]. To this end, achieving food security by an individual (rice farmer/households), region, or country requires adequate good nutrition and food consumption and maintaining this level at low risk over time[6][7]. *"Thus, food security exists when all people have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and preferences, enabling them to lead an active and healthy life."*

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Many of the world's poorest people are small-scale food producers in developing nations whose livelihoods depend on agriculture and who are becoming increasingly food insecure. They are affected and have multidimensional social and environmental problems with far-reaching consequences on health, child development, welfare costs to society, and human capital[8][9]. The urgency of this crisis cannot be overstated. Many empirical studies have shown that many rural farming households, particularly in Nigeria, experience poverty and food insecurity[10][11][12]. Several factors, such as low productivity, limited agricultural output, and limited access to fertilisers, improved seeds, and irrigation systems, cause this food insecurity problem[13][14]. Also, rural farmers are characterised by poor storage facilities, leading to the spoilage of crops after harvest and a reduction in available food. Farmers also struggle to sell their crops reasonably, impacting their income and ability to buy food. They are characterised by large household sizes, leading to more people to feed and straining resources, especially with limited production. Poor infrastructure facilities in the rural areas where the farmers reside make it difficult for farmers to get their produce to market where they can earn a good income, and erratic rainfall patterns and droughts can disrupt agricultural cycles and reduce harvests[15][16]. The consequences of this food insecurity are not just concerning; they are urgent. Nutritional deficiencies, a direct result of food insecurity and malnutrition, mainly affect the health and development of children. The impact on livelihoods is equally severe, with reduced food security limiting a family's ability to invest in their farm or other income-generating activities, thereby perpetuating the cycle of food insecurity[17][18].

Addressing the food insecurity crisis requires a multi-faceted approach. Implementing policies that improve storage facilities, transportation networks, and market access can significantly enhance the situation, enabling farmers to reach consumers and earn a fair price for their produce. Educational programs focusing on improved farming techniques, crop diversification, and storage methods can boost productivity and reduce losses. Access to credit can empower farmers to invest in better seeds, fertilizers, and irrigation, leading to higher yields. Like a social safety net, government programs that provide food or income support during difficult times can help families meet their basic needs. These comprehensive measures promise a brighter future, significantly reducing poverty and food insecurity among rural farmers.

Furthermore, Ebonyi State, despite being a primary rice-producing state in the country, is still one of the states with very high food and nutrition insecurity problems[19], with a poverty rate of 79.76 percent (National Bureau of Statistics (NBS), 2020, Statista[20]). Introducing the integrated rice-fish system to rice farmers in Ebonyi State is a novel way of reducing food and nutrition insecurity in the study area. Fish provides additional protein and essential nutrients for farm families and communities, and the farmers can sell fish for additional income, diversifying their revenue streams. Also, rice and fish are produced simultaneously, maximising land use and potentially doubling a farmer's output. Fish waste decomposes into nutrients that feed the rice plants, reducing the need for chemical fertilisers and their costs.

Previous studies on food security determinants among farming households in Nigeria used binary choice models[21][22][23][24][25][26][27][28]. They assume that the independent variables directly influence the dependent variable. However, in some cases, an unobserved factor might influence the choice of a particular state (regime) and the outcome within that state, thus leading to biased estimates. Given this, the study adopted the Endogenous Switching Regression model, which allows for interaction effects between treatment and the variables affecting outcomes, unlike the ordinary probit or Logit model, which did not have a selection equation. The ESR model is adopted because of a treatment (participation in the integrated rice-fish technology) on an outcome on food security. However, participation in the program might not be random; people with specific characteristics might be more likely to participate. This model controls for this selection bias. Also, the study adopted the FGT food poverty measure, which considers the extent of severity (deviation from the minimum requirement). The FGT measure also introduced a new class of food security (severity, gap, and incidence) that is theoretically understandable and robust in application[29]. Our study addresses crucial research questions: What is the food security of rice farmers, and what are the drivers of food security among the rice farmers in Ebonyi State, Nigeria? These questions are paramount as they delve into the heart of the food security issue in the state. Specifically, the study investigates the food security status and the drivers of food security among rice farming households in Ebonyi State, Nigeria. Our findings from the study will provide solid recommendations for development planning on food insecurity situations among rice farmers in the study area.

The paper proceeds as follows: The next section discusses the methodology, study area, sampling techniques, and data analysis methods. The presentation of the empirical results and discussions also follows this section. The paper ends with drawing conclusions and recommendations.

2. Theoretical Framework

2.1. Entitlement Theory of Food Security

This study drew its framework from Amartya Sen[30] concept of food security of "entitlements." The central premise of the entitlement approach is that the prevailing economic, social, and legal context of a particular society influences the ability of a person to acquire food. The theory's central idea is that food security is more than just producing enough food (supply). It is about people's ability to access that food (entitlement). He criticises the notion that food security stems from aggregate food availability, arguing that what we can eat depends on what we can acquire (Kyaddondo and Whyte, 2003). In other words, Sen argues that food availability in any given economy does not translate into entitlement or consumption by individuals in need of food in that same country. The entitlement approach introduces a valuable dimension to studying gender dimensions and food security. It is a practical framework for understanding variations in food acquisition, making it a valuable tool for professionals in the field. It is also helpful in analysing inter- and intra-camp variations in the options available for food acquisition and inter- and intra-household variations in entitlements. The entitlement theory is robust and comprehensive, shifting the focus to access and distribution of food, not just production. It also explains how social and economic factors influence food security and provides a framework for analysing the causes of famines beyond just food shortages. This comprehensive nature of the theory reassures its effectiveness in understanding and addressing food security issues. Although the theory can be complex and requires in-depth analysis of specific situations, it needs to fully account for the role of natural disasters in food insecurity.

3. Methodology

3.1. Study Area and Sampling Techniques

The study area was Ebonyi State, a state in South-East Nigeria. The state lies in the humid tropical agro-ecological zone of Nigeria within Longitudes 70 30'E and 80 30'E and Latitudes 50 40'N and 60 45'N[31]. It has a land area of 5,935 km2, with a projected population of an estimated 3,242,500 persons in 2022, using a growth rate of 2.5 percent (https://citypopulation.de/en/nigeria/admin/NGA011__ebonyi/). The state shares boundaries to the north with Benue State, to the west with Enugu State, to the east with Cross River State, and to the south with Imo and Abia States. The climate of Ebonyi State is that of a humid tropical climatic region, with a mean annual temperature standing at 28°C and an average rainfall of 1200mm - 2500mm. It has luxuriant tropical rainforest vegetation, with basically clayey and loamy soil. The clayey, swampy soil is suitable for rice farming (Chidiebere-Mark, 2019).

This study used data from the Feed the Future/United States Agency for International Development (FTF)/USAID Innovation Lab on integrated rice-fish technology in Ebonyi State, Nigeria. The study adopted a three-stage sampling technique where Ebonyi State was purposively selected among the rice-producing states in Nigeria (Federal Ministry of Agriculture and Rural Development [FMARD] (2016), with a high food insecurity rate, and as part of the zone of influence for the FTF/USAID project in Nigeria. This was followed by a random selection of three local governments: Ikwo, Izzi, and Onicha LGAs. In the final stage, a proportionate-to-size selection of 143 rice farmers was selected in the three LGAs. See details in Table 1 below.

Sample Selection

The Cochran (1977) sampling method was applied to select the sample. It is given as:

$$n_0 = \frac{Z^2}{e^2} Pq = \frac{(1.96)^2(0.5)(0.5)}{(0.082)^2} = 143$$

- n_0 = the sample size,
- z = 1.96 (95percent) is the selected confidence interval level,
- P = the estimated proportion of an attribute that is present in the population (expectation of 50 percent per LGA),
- q = 1-p,
- e = the desired level of precision (5 per cent).

The formula that was used to select the proportionate to-size selection is

$$n_h = \frac{N_h}{N} n \qquad (1)$$

Where

- n_h = Number of elements in each of the strata,
- N_h = Number of elements in each of the strata,
- N = Total population, and
- n = Sample size

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LGAs	Total estimated participating farmers (N_h)	Proportionate to size selection of participating farmers (n_h)	Total estimated non-participating farmers (N_h)	Proportionate to size selection of non-participating farmers (n_h)
Izzi	80	22	110	73
Onicha	100	30	150	78
Ikwo	90	25	120	60
Total	**N=170**	**n=77**	**N=380**	**n=66**

Table 1. Sample Size Selection

Source: Author's Computation, 2022.

3.2. Analytical Framework

Two reliable analytical frameworks were adopted in this study. The Foster Greer and Thorbeck (FGT) class of poverty analysis was adapted to determine the food security status of the rice farmers. At the same time, an Endogenous Switching Regression model was used to examine the determinants of food security among the rice farmers in Ebonyi State, Nigeria. Therefore, this study adopted this analytical framework as used by (Zakari *et al.*[32], Mansaray and Jin[33], and Ibitola *et al.*[34]). Further details of each of the frameworks are discussed below.

3.2.1. Foster Greer Thorbercke (FGT) Class of Poverty Measure

The FGT index was used to determine the threshold, which forms the basis for categorizing the rice farmers' level of food security in the study area. Following Foster Greer and Thorbeck[35] as used by Ibitola *et al.*[34], this index is computed with the mathematical formula stated below:

$$p_{\propto} = \frac{1}{\mathrm{n}} \sum_{i=1}^{\alpha} \left[\left(z - \frac{y}{z} \right) \right]^{\propto} 1 \qquad (2)$$

Where

- n = total number of households,
- Y = total Household monthly expenditure of the i^{th} household,
- Z = poverty line (the poverty line was determined by calculating 2/3 of the mean per capita monthly household expenditure),
- α = is a measure of the sensitivity of the index to poverty or the degree of severity of poverty (food security index, which takes values of 0, 1, and 2)

3.2.2. The Endogenous Switching Regression (ESR) model

This regression-based model method models two outcome equations (two regimes), one for treatment and one for comparison, allowing for the endogeneity of selection into treatment[36]. It is a natural extension of classical experimental design, which allows tests of assumptions about the exogeneity of treatment effects from survey data. It is a particular case of the Heckman model, where the second stage (outcome) equation is a switching regression. For this study, the endogenous switching regression model estimates a simultaneous equation with endogenous switching by the complete information Maximum Likelihood (FIML) with the various covariate variables that influence rice farmers who are food secure and those who are not food secure. The method simultaneously estimates the binary selection (determinants) and the binary outcome (impact) parts of the model to yield consistent standard errors:

$$\Omega = \begin{bmatrix} \sigma_{\mu}^2 & \sigma_{1\mu} & \sigma_{2\mu} \\ \sigma_{1\mu} & \sigma_1^2 & \cdot \\ \sigma_{2\mu} & \cdot & \sigma_2^2 \end{bmatrix} \qquad (3)$$

Where

$$\sigma_{\mu}^2 = \mathrm{var}(\mu_i), \sigma_1^2 = \mathrm{var}(\varepsilon_1), \sigma_2^2 = \mathrm{var}(\varepsilon_1), \sigma_{1\mu} = \mathrm{cov}(\mu_i, \varepsilon_1$$
$$\sigma_{2\mu} = \mathrm{cov}(\mu_i, \varepsilon_2) \qquad (4)$$

Furthermore, σ_{μ}^2 is estimated up to a scalar factor and can be estimated to be equal to 1[37] and (ε_i, ε_2) is not defined as Y_1 and Y_2 cannot be observed simultaneously, hence the dots in the covariance matrix. Moreover, the correlation between the error term of the selection equation and the outcome equation is not zero, i.e., ((μ_i, ε_1) ≠ 0) & (μ_i, ε_2) ≠ 0, which creates selection bias. ESR addresses this selection bias by estimating the inverse Mills ratios (λ_{1i} *and* λ_{2i}) and the covariance terms ($\sigma_{1\mu}$

and $\sigma_{2\mu}$) and including them as auxiliary regressors in equations (4) and (5). If $\sigma_{1\mu}$ and $\sigma_{2\mu}$ are significant, the absence of selection bias will be rejected. In addition, $\sigma_{1\mu}$ < 0 represents positive selection bias (i.e., households with above-average welfare are more likely to choose to be in the treatment). The logarithmic likelihood function, given the previous assumptions regarding the distribution of the error terms, is

$$\ln L_i = \sum_{i=1}^{N} \left\{ T_i \left[\ln \phi \left(\frac{\varepsilon_{1i}}{\sigma_1} \right) \ln \sigma_1 + \ln \Phi \left(\theta_{1i} \right) \right] + \left(1 - T_i \right) \left[\ln \phi \left(\frac{\varepsilon_{2i}}{\sigma_2} \right) - \ln \sigma_2 + \ln(1 - \Phi \left(\theta_{2i} \right)) \right] \right\} \quad (5)$$

Where ϕ and Φ are the standard normal probability density function and normal cumulative density function, respectively, and

$$\theta_{ji} = \frac{\gamma Z_i + \rho_j \varepsilon_{ji} / \sigma_j}{\sqrt{1 - \rho_j^2}} \quad (6)$$

With j = 1,2 and ρ_j denoting the correlation coefficient between the error term μ_i in the selection equation and the error term ε_{ji} of the outcome equations

$$\rho_1 = \frac{\sigma_{21}^2}{\sigma_u \sigma_1} \quad (7)$$

$$\rho_2 = \frac{\sigma_{21}^2}{\sigma_u \sigma_2} \quad (8)$$

To ensure that ρ_1 and ρ_2 are bounded between -1 and 1, and that the estimated σ_1 and σ_2 are always positive, the maximum likelihood directly estimates ln σ_1, ln σ_2, and atanh ρ:

$$\operatorname{atanh} \rho_j = \frac{1}{2} \ln \frac{1 + \rho_j}{1 - \rho_j} \quad (9)$$

A negative and significant rho (ρ), i.e., correlation coefficient, indicates that rice farmers who are food secure have more effect or impact on the treated group than any randomly sampled individual would have from the sample[38].

- Y_0 = Food insecurity status (0=food secure, 1=non-food secure)
- X_1 = Access to credit (Yes=1, 0 otherwise)
- X_2 = Age of farmers (years)
- X_3 = Squared of Age
- X_4 = Sex (Female = 0, 1 = Male)
- X_5 = Marital status (Married=0, 1=otherwise)
- X_6 = Years of education (Years)
- X_7 = Household sizes (Number of persons)
- X_8 = Farming Experience (Years)
- X_9 = Primary occupation (Farming =0, 1=otherwise)
- X_{10} = Farm Size (Hectares)
- X_{11} = Access to extension (Yes=1, 0 otherwise)
- X_{12} = Distance to market (Km)
- X_{13} = Cooperative association membership (Yes=1, 0 otherwise)
- e_i = Error term

Variable	Obs.	Mean	Std. Dev.	Min	Max
Food security index	143	0.377	0.486	0	1
Access to credit	143	0.546	0.5	0	1
Age	143	44.123	14.91	20	89
Squared of age	143	2167.446	1402.316	400	7921
Sex	143	0.531	0.501	0	1
Marital status	143	0.1	0.301	0	1
Years of education	143	9.131	7.853	01	75
Household size	143	8.108	3.231	01	20
Farming experience	143	21.254	15.792	01	70
Primary occupation	143	0.092	0.291	0	1
Farm size	143	5.185	7.41	01	10
Access to extension	143	0.723	0.449	0	1
Distance to market	143	6.029	7.689	01	50
Cooperative member	143	0.792	0.407	0	1

Table 2. Summary of Descriptive Statistics of the Variables

Source: Authors' Computation, 2022

4. Results and Discussions

4.1. Socio-economic Characteristics of the Rice Farmers

The socioeconomic characteristics of the rice farmers, which are crucial for understanding their living conditions and farming practices, are shown in Table 1. The table reveals that most of the farmers were male, 54.20 percent, and 90.08 percent were married; this aligns with the findings of Omotesho *et al.* [39]. The mean age of the farmers was 44 years, indicating a relatively young farming population. A significant proportion, 66.41 percent, of the farmers were between 31-60 years old, suggesting that they are mostly youth, very agile, and with more energy for farming activities. There are slightly more male rice farmers (54.2 percent) than female rice farmers (45.8 percent), and most (90 percent) of the rice farmers are married. The farmers' education level shows that most rice farmers (90 percent) had education (ranging from primary and secondary to adult literacy), indicating a relatively high level of education among the farming population. The total years spent in school by the farmers' highest percentage was with the group that had 0-10 years of education, with 21-30 years having the lowest. The mean household size of the farmers was 51.15 percent of the farmers had about 16-20 years of household members. The prominent household members might be due to the use of household members for family labour on their farms. The farmers' mean years of farming experience were 21 years, while 30.47 percent had experience from 1-10 years.

About 87.60 percent of the farmers had access to formal agricultural training, implying that getting new information passed to the farmers might not be difficult, with only 12.40 percent having no access to agricultural training. The majority, 78.29 percent of the respondents, engaged primarily in farming as their primary occupation, while 12.40 percent of the farmers majored as rice farmers. The farm size distribution shows that the farmers were smallholder farmers, with 96.88 percent cultivating between 0-25 acres. The rice production or operation modality shows that the farmers are smallholder farmers, with 83.46 percent operating smallholding farming while 14.17 percent working on a commercial scale. Access to credit was very poor, as only 41.86 percent of the farmers had access to credit for their production; the source of the credit was majorly the cooperative association, an indication that the cooperative association is a substantial factor in credit accessibility among the farmers. The origin of land used for rice farming by the farmers mainly was inherited, 38.93 percent, and private land, 24.42

percent, respectively, while others acquired their land through rented/lease and bought the land, 18.32 percent. Access to land has been a significant issue among rural farmers in southeast Nigeria. About 51.91 percent of the farmers did not belong to any cooperative association, while 48.09 percent were members of one cooperative association or others. Access to extension could have been better, a justification for poor access to agricultural training, with only 23.66 percent of the farmers having access to extension services. Also, a more significant percentage of farmers needed access to extension services. The distance covered by the farmers to the farm distribution shows that 72.52 percent covered between 0-5 km, while 14.50 percent covered around 6-10 km in reaching their farm. The distance covered by the farmers to the farm has been identified as a significant factor affecting farmer productivity. About 88.55 percent of the farmers usually pay between ₦100-2000 to access the input market, while 3.45 percent pay beyond or higher amounts to access input markets. Lastly, the farmers' awareness of integrated rice-fish technology, a potential innovation for diversifying farming practices, indicates that only 25.95 percent of the farmers were aware of the technology, with a more significant percentage of 74.05 percent unaware. Of the 25.95 percent aware, only 3.05 percent said they had previously engaged in or practised the technology, suggesting a need for more widespread adoption and implementation.

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Variable	Frequency	Percentage	Mean
Age (years)			
18-30	27	20.61	Mean =44
31-60	87	66.41	Min = 18
61-89	17	12.98	Max =89
Sex			
Female	60	45.80	
Male	71	54.20	
Marital status			
Married	118	90.08	
Not married	13	9.92	
Education Level			
Formal Education	116		
No formal Education	15	11.45	
Household Size			
0-5	22	16.79	Mean= 8
6-10	08	6.11	Min =01
11-15	34	25.95	Max= 20
16-20	67	51.15	
Farming Experience			
1-10	39	30.47	Mean=21
11-20	35	2.34	Min= 01
21-30	26	20.31	Max= 70
31-40	10	07.81	
> 40	18	14.06	
Membership of Association			
Yes	63	48.09	
No	68	5.91	
Formal Agricultural training			
Yes	113	87.60	
No	016	12.40	
Primary Occupation			
Farming	117	89.31	
Non-farming	014	10.69	
Access to Extension			
Yes	031	23.66	
No	100	76.34	
Access to Credit			
Yes	54	41.22	
No	74	56.49	
Farm Size			
0-25	124	94.66	
Above 25	007	5.34	

Variable	Frequency	Percentage	Mean
Farming experience (year)			
1-10	39	30.47	Mean=21
11-20	35	27.34	Max=70
21-30	26	20.31	Min=01
31-40	10	7.81	
Greater than 40	18	14.06	
Distance to Input Market (Km)			
0-20	96	91.43	
21-40	8	7.62	
Greater than 40	1	0.95	

Table 2. Socio-economic Characteristics of the Rice Farmers in Ebonyi State

Source: Authors' Computation, 2021

4.2. Distribution of the Rice Farmers by Incidence, Depth, and Severity of Food Poverty

The food insecurity index or headcount (P_0), the food insecurity gap or depth (P_1), and the food insecurity severity index (P_2) are not just numbers but crucial indicators of the FGT class of food insecurity measures. The headcount index (P_0) measures the proportion of the poor population, providing a stark reality of the situation. The food insecurity gap or depth (P_1) measures the extent to which individuals fall below the food security line, a clear indication of the depth of the problem. The food insecurity severity index (P_2) averages the squares of the poverty gaps relative to the food insecurity line, allowing different weights on the income (or expenditure) level of the poorest. These measures are not just academic jargon but tools that can guide policy and action. As shown in Table 3, the P_0 among rice farmers in Ebonyi State was 0.4667, indicating that 46.67 percent of the respondents live below the food insecurity line. The food insecurity depth (P_1) was 0.2462, implying that the food expenditures of the poor households in Ebonyi State must be raised by 24.62 percent to move out of insecurity. The severity of the food insecurity index (P_2) was 0.1721; this explains that 17.21 percent of the rice farmers are extremely poor, indicating that food insecurity is less severe among rice farmers in Ebonyi State.

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Food Poverty Indices	Percentage
Food insecurity incidence (P_0)	0.4667
Food insecurity depth (P_1)	0.2462
Food insecurity Severity (P_2)	0.1721
Mean per capita Food expenditure.	N 2456.42
Food security line	N 1,026.43

Table 3. Food Security Indices of Rice Farmers in Ebonyi State, Nigeria

Source: Field Data computation, 2021

4.3. Decomposition of the households by socioeconomic and food security indices

Table 4 shows the decomposition of the households with their socio-economic characteristics based on the food insecurity measures or indices generated by the adopted Foster *et al*.[35] method. P_0 measures the incidence of food insecurity, P_1 implies the depth of food insecurity, and P_2 values imply the severity of food insecurity situations. Higher P_0, P_1 and P_2 values imply that the incidence, depth, and severity of food insecurity are high in the study area and vice versa. The incidence percentage of food insecurity of 49 percent was higher among female household heads than 46 percent among their male counterparts. Among the male-headed households, a 21 percent increase in per capita food expenditure is needed to bring the food-insecure households to the food insecurity line, as against the 24 percent increase required for the female-headed households' rice farmers. This is in line with the expectation of this study, as female-headed households are always prone to food insecurity and most food insecurity. Food insecurity incidence increases with the increase in the age of the farmers; the values of 43 percent, 45 percent, and 66 percent correspond to 0-30 years, 31-60 years, and 61-90 years old rice farmers, respectively. Likewise, a progression of 17 percent, 22 percent, and 40 percent in per capita food expenditure is needed to bring food-insecure households to the food insecurity line among the age categories. This agrees with Oguniyi *et al*.[40] and Ogundipe *et al*.[41].

Food insecurity incidence was higher among non-married households, with an 88 percent incidence value compared to a 43 percent value for married households, and depth and severity were higher at 44 percent and 29 percent, respectively. Non-educated rice farming households have a higher incidence, depth, and severity of poverty, with values of 63 percent, 31 percent, and 25 percent, compared to educated households, with values of 45 percent, 22 percent, and 15 percent, respectively. In comparing the values with the demographic variable, households that belong to members of the cooperative association have low incidence, depth, and severity values of 47 percent, 22 percent, and 16 percent, in contrast to households that did not belong to the cooperative association, with values of 49 percent, 27 percent, and 17 percent, respectively. Access to credit is also an important variable determining the food security of rural farmers. In this study, rice farmers without access to credit have a high poverty incidence of 61 percent with a poverty depth of 29 percent and poverty severity of 19 percent, while farmers with access to credit have 32 percent, 17 percent, and 12 percent poverty incidence, depth, and severity, respectively. Also, households with access to extension services have poverty values of 38 percent, 26 percent, and 17 percent incidence, depth, and severity. Also, households without extension access have values of 51 percent, 18 percent, and 12 percent, respectively.

Variables	Food security indices		
	P_0	P_1	P_2
Sex			
Male	0.46	0.21	0.14
Female	0.49	0.24	0.17
Age			
0-30	0.43	0.17	0.08
31-60	0.45	0.22	0.15
61-90	0.66	0.40	0.29
Marital Status			
Married	0.43	0.21	0.15
Non-Married	0.88	0.44	0.29
Education Status			
Educated	045	0.22	0.15
No Education	0.63	0.31	0.25
Household Size			
1-5	0.52	0.32	0.23
6-10	0.40	0.17	0.11
11-15	0.55	0.31	0.24
16-20	0.86	0.51	0.35
Farm Size			
0-10	0.49	0.24	0.17
11-20	0.57	0.19	0.06
21-30	0.00	0.00	0.00
31-40	0.00	0.00	0.00
40-50	0.00	0.00	0.00
51-60	0.00	0.00	0.00
Years of Farming experience			
1-10	0.55	0.29	0.21
11-20	0.38	0.17	0.10
21-30	0.00	0.00	0.00
Above 60 years	1.00	0.24	0.06
Cooperative Membership			
No	0.49	0.27	0.18
Yes	0.47	0.22	0.16
Formal Agricultural training			
No	0.47	0.26	0.17
Yes	0.54	0.23	0.16

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Variables	Food security indices		
	P_0	P_1	P_2
Primary occupation			
Farming	0.47	0.23	0.16
No-farming	0.56	0.27	0.17
Access to credit			
Yes	0.32	0.17	0.12
No	0.61	0.29	0.19
Access to extension			
No	0.51	0.18	0.12
Yes	0.38	0.26	0.17

Table 4. Decomposition of the households by socio-economic and food security indices

Source: Authors Computation, 2021

4.4. Determinants of Food Insecurity among Rice Farmers in Ebonyi State

An Endogenous Switching Regression (ESR) was used to examine the determinants of food security among rice farmers in Ebonyi State, Nigeria. The results of the correlation coefficient (ρ) indicate selection bias and the existence of observed and unobserved factors influencing the food security status of the rice farmers. The non-significance of covariance estimates for both food-secure and non-food-secure households shows that in the absence of association membership, there will be a difference in evidence in the food security status between the food-secure and non-food-secure households. The Wald test's significant value for the equations' independence suggests interdependence between the selection and outcome equations for food-secure and non-food-secure rice farming households. This offers more proof of endogeneity, and the test results established our instrument's validity because it significantly affects rice farmers' food security status.

The selection equation (column 1) results indicate the first stage of providing the driving force behind rice farmers' food security status. That had been interpreted as standard probit coefficients. The results show the statistical significance of the coefficients of a relative number of variables. Sex was significantly different from zero and negative in the selection equation. This indicated that the availability of more female farmers increased the inclination to be food secure, suggesting that female rice farmers are more likely to be food secure than their male counterparts. This agrees with Oyebanjo *et al.* (2013)[42], who state that female household heads will increase household food insecurity. Access to agricultural extension by the rice farmers was positive and significantly different from zero. That suggests that all things being equal, as the access to extension agents increased, their propensity or likelihood to be food secure improved. This might be because contact with extension services provided more access to improved production techniques, inputs, and other production incentives. These would positively affect farmers' output and income-generating ability, reducing their poverty level[43]. Association membership by the farmers was also positive and significantly different from zero. This implies that as the membership of cooperative associations increases, the possibility of households having secure food increases. Fasakin and Popoola[44] emphasized the importance of cooperative association membership positively in improving the livelihood of rural farming households. This may be due to some advantages the households are likely exposed to that can enhance their food insecurity problems.

The results of the endogenous switching regression show that access to credit has a familiar and adverse effect on both food-secure and non-food-secure households. This means that credit access can significantly decrease rice farmers' food security. This corroborates the study of Adekoya[45]. Access to credit is a veritable tool for a household's food security. It assists farm households in purchasing farm inputs such as fertilizer, herbicides, improved seeds, and investment demand, ultimately increasing their productivity. The gender of the households was positive in influencing the food security of the non-food-secure rice farming households. This implies that the availability of more male farmers

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increases the likelihood of being non-food secure. This might be because male-headed households are already exposed to food insecurity or not being food secure since they do not engage in domestic activities like food preparation. This contradicts the findings of Obayelu and Orosile[46] and Awotide *et al*.[47]. Still, it agrees with Ogunniyi *et al.*[40] and Milazzo and Van de Walle[48]. They found a decline in the aggregate food insecurity incidence among African female-headed households. The marital status of the households negatively influenced the food security of the food-secure rice farming households. This implies that unmarried rice farmers are more food secure than married rice farming households. This might be because unmarried farmers have less family responsibility to care for than married households, hence the reason for their food security status. The years of education coefficient was negative for food-secure households. This implies that as the education of the food-secure group increases, the likelihood of the households attaining better food security status decreases, i.e., the more educated the respondents, the higher their food security status. This is in line with the findings of Oluyole and Taiwo[49]. They opined that education is a form of human capital and could positively impact the household's ability to make excellent and well-informed production and nutritional decisions.

The farming experience coefficient was negative among the non-food-secure households. This implies that the level of food security among rice farmers decreases as the years of farming experience increase. This may be due to reduced income over time, as continuous rice production could result in lower yields without improvement in production techniques since most farmers need access to extension services for training. This contradicts the findings of Mohammed *et al.*[50], where the higher the years of farming experience by the head of the household, the higher the likelihood of the household being food-secure. The primary occupation coefficient was positive for food-secure households. This implies that household members with rice farming as their primary occupation will be more food-secure than other households. This agrees with the findings of Amao and Ayantoye[51], who opined that engaging in farming as the primary occupation has the likelihood of reducing food insecurity. The positive coefficient of farm size suggests that as the non-food-secure rice farming households cultivate more farm size, the possibility of the households being food-secure rapidly increases. This implies that non-food-secure farming households will be more food-secure if they grow more rice farmland. This disagrees with[33], who opined that farmers who cultivate small farms are more food-secure than farmers who cultivate large farms. It may further imply that farmers with small farm sizes are more effective (or productive) than farmers with larger farms in providing more food. The relationship between food security and farming on given farmland is mainly appropriate for farm households.

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Variables	Selection Eq	Food security	
		FS=0	NFS=1
Access to credit	0.110 (0.272)	-0.190* (0.109)	-0.344*** (0.124)
Age	0.003 (0.040)	0.003 (0.015)	-0.005 (0.026)
Age squared	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Sex	-0.587** (0.280)	0.184 (0.123)	0.558*** (0.171)
Marital status	0.005 (0.486)	-0.334* (0.177)	-0.230 (0.245)
Years of education	-0.018 (0.016)	0.006 (0.006)	-0.028** (0/014)
Household size	-0.038 (0.044)	-0.026 (0.018)	-0.031 (0.015)
Farming experience	-0.001 (0.010)	-0.008** (0.004)	0.007 (0.004)
Pry occupation	-0.157 (0.545)	0.341* (0.195)	-0.182 (0.191)
Farm size	-0.002 (0.013)	-0.003 (0.008)	0.008** (0.003)
Access to extension	0.705** (0.288)	0.128 (0.144)	-0.068 (0.167)
Distance_ market	0.022 (0.021)	-0.001 (0.007)	-0.011 (0.008)
Coop Association	1.270*** (0.318)	-	
Constant	-0.758 (1.030)	0.704 (0.424)	1.065 (0.521)
Wald chi^2	20.28		
Log-likelihood	-127.345		
LR test of ind. Variable	1.92		
/lns		-0.820*** (0.107)	-1.094*** (0.154)
Rho		-0.477 (0.296)	-0.231 (0.992)

Table 5. Endogenous Switching Regression estimates for the determinants of food insecurity among Rice Farmers in Ebonyi State

, **, * denote significance at the 0.1, 0.05, and 0.01 levels.*
Source: Author's computation.

5. Conclusion and Policy

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Recommendations

The findings of this study reveal some policy issues in the Nigerian context. The reported incidence of food insecurity across households (male and female-headed) calls for more action regarding the food insecurity situation in the country. Programs that will help alleviate poverty among households should be prioritised, and existing programs on food security should be sustained. The focus should be on programs that will make credit facilities available to farmers across genders and ages, and consideration should be given to experienced farmers with larger farm sizes. However, the most crucial aspect is education. The importance of education in reducing rural households' food insecurity cannot be overstated. Therefore, policy on revamping the education sector in the study area should focus on households with low education levels while strengthening existing educational institutions.

Statements and Declarations

Conflict of Interests

None.

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Declarations

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