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Abstract

This study examined the vulnerability of rice farmers to climate-induced shocks in Anambra State, Nigeria. Specifically, it described farmers' socio-economic characteristics, identified the climate-induced shocks experienced, assessed their level of vulnerability, and analyzed the factors influencing vulnerability. A multi-stage sampling procedure involving purposive and random techniques was used to select 80 rice farmers from the study area. Primary data were collected through structured questionnaires and analyzed using descriptive statistics and multiple regression analysis (OLS) at the 0.05 level of significance. Findings revealed that farmers were predominantly older ($\bar{x}$ = 54 years), mostly married (72.5%), fairly educated (82.5% had formal education), and experienced (mean farming experience of 21 years), with an average farm size of 10.7 hectares. The most prevalent climate-induced shocks included increased incidence of pests and diseases ($\bar{x}$ = 3.53), decreased rice yield ($\bar{x}$ = 3.44), delayed rice fruiting ($\bar{x}$ = 3.14), reduced soil moisture ($\bar{x}$ = 3.03), flooding ($\bar{x}$ = 2.66), and post-harvest losses ($\bar{x}$ = 2.91). Farmers recorded a high level of vulnerability to climate-induced shocks, with a grand mean score of 2.64. Regression results from the double-log model showed that age (0.049; $p < 0.05$) and household size (0.170; $p < 0.01$) significantly increased vulnerability, while farming experience (−0.095; $p < 0.05$), education level (−0.181; $p < 0.01$), farm size (−0.246; $p < 0.01$), farm income (−0.147; $p < 0.01$), and cooperative membership (−0.074; $p < 0.01$) significantly reduced vulnerability. The model had a strong explanatory power with an adjusted R^2 of 0.678. The study concludes that rice farmers in Anambra State are highly vulnerable to climate-induced shocks due to high exposure and sensitivity, despite some adaptive capacity. It recommends strengthening extension services, improving access to climate-smart agricultural practices, promoting cooperative participation, and investing in irrigation and drainage infrastructure to enhance resilience and ensure sustainable rice production.

Keywords: Vulnerability, rice farmers, climate-induced shocks, Anambra State, Nigeria.

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Introduction

Rice (*Oryza sativa*) is a staple cereal crop globally and a key source of calories and income for millions, especially in developing regions. In Anambra State Nigeria, rice is predominantly cultivated through rainfed farming systems, which depend heavily on seasonal rainfall rather than irrigation (Azumah *et al.*, 2020). Rice farmers in Anambra State Nigeria are prone to this vulnerability, due to heavy reliance on rainfed agriculture, coupled with limited adaptive capacity, make rice farmers highly susceptible to the negative impacts of climate variability. As climate change intensifies, these farmers face mounting challenges in sustaining crop production and ensuring household food security. Given that agriculture is a major livelihood source in this region, any disruption to farming activities directly affects poverty levels and rural well-being. Recent projections suggest that climate-related disasters are expected to become more frequent and severe, posing greater risks to food availability and undermining the resilience of rural livelihoods in Nigeria (Eneh *et al*., 2024; Okonkwo and Ibrahim, 2024).

Climate change poses a fundamental threat to global food security, sustainable development, and poverty eradication (Amusa *et al*., 2022). Its adverse effects extend across all sub-sectors of agriculture including crop production, livestock, forestry, fisheries, and agro-processing. Countries like Nigeria, where agriculture is predominantly rain-fed, are particularly vulnerable. Persistent droughts, unexpected flooding, off-season rains, and prolonged dry spells are among the climate-induced shocks that have disrupted traditional farming calendars and undermined agricultural productivity (Nnaji *et al*., 2023). These disruptions are not only altering growing seasons but also threatening the livelihoods of millions of smallholder farmers (Ogundele *et al*., 2024).

At the heart of these challenges are climate-induced shocks, which refer to both sudden and gradual changes in environmental conditions driven by climate change such as erratic rainfall patterns, heatwaves, prolonged droughts, floods, and rising temperatures (Adebayo *et al*., 2023). These climate-induced shocks significantly reduce crop yields, damage vital farming infrastructure, and increase vulnerability to pests and diseases, placing immense pressure on rural households that depend on agriculture for their sustenance and income (Adebayo *et al*., 2023; Yusuf and Olayemi, 2024). In Nigeria, where agriculture employs over 70% of the rural population and contributes around 22% to national GDP, these effects are particularly severe due to widespread dependence on rain-fed subsistence farming, limited access to climate-smart technologies, and weak institutional support systems (Ali *et al*., 2021; Okonkwo and Ibrahim, 2024).

Climate-induced shocks in Nigeria manifest in various forms including rising temperatures, erratic rainfall, flooding, and the spread of pests and diseases all of which severely undermine agricultural productivity and resilience (Adams, 2019; Eze and Tanko, 2023; Lawal and Oduwole, 2024). Recurrent floods have destroyed over 110,000 hectares of farmland and displaced more than 1.4 million people, while dam collapses and extreme rainfall events in states like Borno have wiped out over 1.5 million hectares of cropland, threatening the livelihoods of millions (Eze and Tanko, 2023; Lawal and Oduwole, 2024). Meanwhile, desertification and prolonged dry seasons in northern regions such as Sokoto and Adamawa continue to reduce water availability for irrigation and shorten growing periods (Mohammed *et al*., 2024). There is limited empirical evidence on vulnerability within the same analytical framework to reveal how socio-economic characteristics, institutional support, and exposure to climate shocks jointly shape farmers' resilience, this study addresses this gap by providing evidence on of vulnerability of rice farmers to climate-induced shocks in Anambra state, Nigeria.

Materials and Method

Study Area

This study was carried out in Anambra state, Nigeria. The State is located in the South Eastern region of Nigeria between longitude 6^0 36'E to 7^0 21' and latitude $5^0$38'N to 6^0 47'N. The State is bounded in the North by Kogi State, in the west by River Niger and Delta State, in the south by Imo State and on the east by Enugu State. It has twenty one (21) Local Government Areas with Awka as the State Capital. Anambra state was created in 1991 with a population figure of 4,177,828 million people and a land mass of 4415.54 square kilometres, 70% of which is rich for agricultural production. The State for administrative purposes is divided into four agricultural zones of Aguata, Anambra, Awka and Onitsha. The zones are further delineated into 24 extension blocks and 120 circles. Farming is the predominant occupation of the people, majority of who are small holders. The major crops produced include yam, cassava, rice, maize, cocoyam, cowpea, tomatoes and vegetables, while the livestock produced in the state include poultry, sheep and goats.

Sampling Procedure

A multi-stage sampling procedure consisting of purposive and simple random sampling were used in selection Agricultural Zones, Local Government Areas, communities and rice farmers, as follows: The first stage involves the purposive selection of one (1) agricultural zone, based on the intensity of rice farming in these zones. These was Anambra Agricultural zone in Anambra State. The second stage involve the random selection of two (2) extension blocks from each agricultural zone, which will give a total of two (2) extension blocks. The third stage involve a random selection of two (2) circles from each extension block to give 4 circles. In the fourth and last stage, 20 rice farmers that produce rice from each of the circle were selected randomly. This procedure gave a sample size of 80 rice farmers in Anambra State.

Method of data analysis

The data for this study were analyzed with simple descriptive statistics such as means, and percentages, multiple regression analysis was employed to test Hypothesis. To ascertain the extent of rice farmers' vulnerability to climate-induced shocks in Anambra State Nigeria. This objective was measured by providing respondents with fifteen (15) climate

induced shock statements with the response options of; Strongly Agree (SA), Agree (A), Disagree (DA) and Strongly Disagree (SD), with scores of 4, 3, 2 and 1 assigned, respectively as shown in Table 2.
A midpoint was obtained thus; 4+3+2+1 =10/4 =2.50.

Mean score greater than or equal to 2.50 were categorized as follows;
Below 1.0 = Not vulnerable
1.00- 1.99= Lowly venerable
2.00- 2.49 = Moderately vulnerable
2.5 and above = Highly vulnerable

Hypothesis which state that selected socioeconomic do not have significant effect on rice farmers' vulnerability to climate-induced shocks Anambra State Nigeria was achieved using ordinary least square (OLS). The four functional forms are specified as follows:

Linear

$$Y_1 = \beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7X_7+\beta_8X_8+\beta_9X_9+\beta_{10}X_{10}+ \beta_{11}X_{11}+\mu_i \quad (3.1)$$

Exponential

$$LNY=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7X_7+\beta_8X_8+\beta_9X_9+\beta_{10}X_{10}+\beta_{11}X_{11}+ \mu_i \quad (3.2)$$

Semi-log

$$Y=\beta_0+\beta_1LNX_1+\beta_2LNX_2+\beta_3LNX_3+\beta_4LNX_4+\beta_5LNX_5+\beta_6LNX_6+\beta_7LNX_7+ \beta_8LNX_8+\beta_9LNX_9+\beta_{10}LNX_{10}+ \beta_{11}LNX_{11}+\mu_i \quad (3.3)$$

Double log

$$LNY=\beta_0+\beta_1LNX_1+\beta_2LNX_2+\beta_3LNX_3+\beta_4LNX_4+\beta_5LNX_5+\beta_6LNX_6+\beta_7LNX_7+ \beta_8LNX_8+\beta_9LNX_9+\beta_{10}LNX_{10}+ \beta_{11}LNX_{11}+\mu_i \quad (3.4)$$

Double log

$$LNY = \beta_0+ \beta_1LNX_1 + \beta_2LNX_2 + \beta_3LNX_3 + \beta_4LNX_4 + \beta_5LNX_5 + \beta_6LNX_6+ \beta_7LNX_7 +\beta_8LNX_8 + \beta_9LNX_9 + \beta_{10}LNX_{10} +\mu_i \quad (3.4)$$

Where,
Y_1 = *level of vulnerability (mean score used as proxy for vulnerability index)*
β_0 = *intercept*
$\beta_1 – \beta_{10}$ = *Coefficients of the variables to be estimated*
X_1 = *Sex (Male = 1, Female =0)*
X_2 = *Age of the respondents (years)*
X_3 = *Household size (Number)*
X_4 = *Marital status (1 = married, 0 = otherwise)*
X_5 = *Experience in farming (years)*
X_6 = *Level of education (years spent in formal schooling)*
X_7 = *Farm size (hectare)*
X_8 = *Extension contact (number of extension visits)*
X_9 = *Credit amount (₦)*
X_{10} = *Farm income (₦)*
X_{11} = *Membership of cooperative society (1 = yes; 0 = otherwise)*
μ_i = *error term*

Results and Discussion

The distribution of rice farmers by age is presented in Table 1. In Anambra State, rice farming is with a mean age of 54.14 years and 36.3% of farmers within the 54–63 years age group. This suggests a population with deep farming experience but potentially limited physical capacity for labour-intensive activities and reduced openness to innovation. The older age structure in Anambra therefore suggests a higher potential vulnerability to climate-related risks, such as erratic rainfall or flooding. This observation aligns with Adams (2019), who notes that climate change intensifies agricultural risks and requires adaptive responses that are often more readily adopted by younger, more dynamic farmers. The distribution of rice farmers by sex across Anambra State is presented in Table 1. In Anambra State, the near parity between males (51.2%) and females (48.8%) suggests that rice farming is a shared household responsibility. This supports Aldrich, Page, and Paul (2018), who emphasize that social capital, including family networks and shared labour, strengthens collective action and adaptation. In such contexts, both male and female farmers can benefit from mutual support systems that enhance resilience to climate shocks.

The distribution of rice farmers by Marital Status is presented in Table 1. Married farmers dominate rice production in Anambra (72.5%). This pattern is in line with Amusa *et al*., (2022), who found that households with strong social cohesion and pooled labour are better able to sustain agricultural production and manage environmental stress. The high proportion of married farmers therefore suggests that family labour is a key driver of rice farming, supporting continuity in farm operations during peak labour demands such as land preparation and harvesting. The predominance of married farmers also implies greater potential for coordinated adaptation strategies at the household level. This aligns with Azumah *et al* (2020), who argues that vulnerability and adaptive capacity are shaped by household structure and social relationships. Married households are more likely to share responsibilities and resources, which can strengthen their ability to implement adaptation measures such as improved water management or soil conservation. However, Adger also notes that social structures can constrain adaptation when resources are limited or unevenly distributed within the household. Thus, while married farmers may have better labour capacity, their adaptive responses may still be hindered if they lack access to climate information, inputs, or finance.

The distribution of rice farmers by education is presented in Table 1. The education profile of rice farmers in Anambra State shows that the vast majority possess some form of formal education, with 82.5% in Anambra. This high level of formal education indicates that most farmers have basic literacy and numeracy skills, which can improve their ability to access and interpret agricultural information, manage farm records, and adopt improved production practices. This observation is consistent with Ogundele *et al*., (2022) as they highlighted that education enhances farmers' ability to engage with changing food systems and adapt to new technologies and market demands. In this context, the high education levels suggest that farmers in these states may be better positioned to understand climate risks and adopt appropriate adaptation measures. Furthermore, the high proportion of educated farmers may enhance the effectiveness of extension services and climate adaptation programs. Nwaobiala *et al.*, (2024) argue that adoption of climate adaptation practices among rice farmers is strengthened when farmers have access to education and extension support. Therefore, while Anambra State shows strong potential for adaptation due to high educational levels, targeted strategies are still needed to ensure that the uneducated minority is not left behind. This could involve using more visual and community-based extension methods, such as demonstrations, farmer field schools, and radio-based advisories, to ensure inclusive access to climate information and adaptation tools.

The distribution of rice farmers by experience is presented in Table 1The farming experience of rice farmers in Anambra State varies considerably across states, reflecting differences in the maturity of farming communities and potential adaptive capacity. In Anambra State, the mean farming experience is 21.12 years, with 58.8% of farmers having 21–30 years of experience. This indicates a highly experienced farming population that has likely developed extensive knowledge of local agroecological conditions, seasonal patterns, and traditional coping strategies. Such long-term experience can strengthen resilience, as farmers can draw on historical knowledge to anticipate climate variability and make informed decisions. This aligns with Nnaji, Uzochukwu, and Ifeanyi (2023), who emphasize that experienced farmers are better able to interpret weather signals and adjust practices to reduce the impacts of extreme weather on rice yields.

The distribution of rice farmers by farm size is presented in Table 1. The mean farm size of rice farmers across Anambra State indicates that rice production in the region is predominantly smallholder-based, with notable variations among states. In Anambra State, the mean farm size was 10.7 hectares, which is the highest among the three states. Although this value still reflects small-to-medium scale production, it suggests relatively better access to land and a higher production capacity compared to the other states. Farmers in Anambra may therefore have greater potential to invest in improved technologies, mechanization, and climate adaptation measures than their counterparts in neighboring states. The predominance of small mean farm sizes in the study area is consistent with the findings of Gandure, Walker, and Botha (2018), who observed that smallholder farmers in rural settings often face limited access to land and water resources, thereby constraining their ability to adapt to climate stress. In Anambra State, similarly small mean farm sizes may limit access to mechanization and irrigation, reducing productivity and climate resilience. However, Gandure *et al*. (2018) also note that smallholder systems can be flexible and allow for crop diversification and household-level adaptation strategies.

The results for Anambra State show that climate-induced shocks have a varied effect on rice production. The vulnerability was recorded for pests and diseases ($\bar{x}$ = 3.53), decreased rice yield ($\bar{x}$ = 3.44), delayed rice fruiting ($\bar{x}$ = 3.14), reduced soil moisture ($\bar{x}$ = 3.03), and post-harvest losses ($\bar{x}$ = 2.91). These findings indicate that rice farmers in Anambra perceive climate change primarily through its influence on crop health, productivity, and water availability. The vulnerability framework advanced by Eneh, *et al*., (2024) explains that vulnerability is shaped by exposure to hazards, sensitivity of livelihoods, and adaptive capacity. In this case, the high mean scores for pests and diseases ($\bar{x}$ = 3.53) suggest that farmers' exposure to climatic variability is translating into biological stressors that undermine crop health and yield. Asfaw *et al*. (2021) reported that climate-induced hazards significantly increase pest and disease incidence, thereby destabilizing smallholder livelihoods in agroecological systems. This is because higher temperatures and increased humidity create favorable conditions for pests and pathogens, and such biological stresses are often exacerbated when farmers have limited access to improved seeds, agrochemicals, and extension support. The implication is that farmers in Anambra may face escalating costs of production, as increased pest pressure often leads to higher pesticide use, and may also experience reduced household food security if yield declines continue. Similarly, Jamshidi *et al*. (2019) found that pest outbreaks and yield decline are common vulnerability outcomes of climate variability among smallholder farmers, especially where adaptation options are limited. The Anambra result therefore suggests that the rice production system is highly sensitive to climate-driven biological pressures, which in turn can increase production costs and reduce household food security.

The mean score for decreased rice yield ($\bar{x}$ =3.44) indicates that rice farmers in Anambra State are highly vulnerable to climate-related production losses. This relatively high mean suggests that a significant number of farmers frequently experience reductions in their rice harvests, reflecting the severity and prevalence of climate-induced shocks across the study area. Yield reductions can occur due to a combination of factors, including drought, irregular rainfall, flooding, pest and disease outbreaks, and temperature extremes, all of which affect critical growth stages of the crop. The high mean value aligns with the findings of Eneh, Abubakar, and Dike (2024), who observed that climate shocks in smallholder farming systems often lead to substantial losses in agricultural output, particularly where adaptive measures such as irrigation, resilient seed varieties, or technical support are limited. In the context of this study, the score of 3.44 reflects that yield losses are not occasional but represent a persistent challenge affecting the majority of rice farmers, making their production systems inherently unstable. The implications of this high vulnerability are significant. Reduced yields directly translate to lower household food availability and income, constraining farmers' capacity to meet consumption needs or invest in agricultural inputs for subsequent planting seasons. Furthermore, yield reduction limits the potential for marketable surplus, affecting both livelihood security and economic resilience.

The mean score for delayed rice fruiting ($\overline{x}$ = 3.14) indicates that rice farmers in Anambra State are moderately to highly vulnerable to disruptions in crop phenology caused by climate variability. Delayed fruiting occurs when irregular rainfall patterns, temperature fluctuations, or prolonged dry or wet periods disrupt the normal growth cycle of rice, postponing flowering and grain formation. Such delays can reduce the effective growing season, lower grain filling rates, and ultimately diminish overall yield. This finding is consistent with the work of Aigbokie et al., (2024), who observed that climatic stressors, particularly temperature extremes and erratic rainfall, frequently delay rice flowering and maturation, leading to reductions in productivity among smallholder farmers. Similarly disruptions in phenological stages, such as delayed fruiting, compromise the synchronization of rice development with seasonal rainfall, making crops more susceptible to pest infestations and moisture stress. The implication of the relatively high mean score (3.14) is that delayed fruiting is a widespread challenge, affecting a substantial proportion of rice farmers. When rice plants fruit later than expected, it can reduce the opportunity for timely harvest, expose grains to adverse weather conditions, and increase post-harvest losses. This adds another layer of vulnerability on top of production risks, particularly for smallholder farmers with limited access to adaptive technologies, irrigation, or early warning systems.

Reduced soil moisture ($\bar{x}$ = 3.03) is another significant shock perceived by farmers, which may seem contradictory to the high incidence of flooding. However, this reflects the complex nature of climate variability, where farmers can experience both excess water and moisture deficit within the same cropping season. This duality is consistent with the findings of Asfaw *et al*. (2021) and Dendir and Simane (2019), who observed that vulnerability increases when farmers face multiple, interacting climate hazards. In Anambra, soil moisture deficit could arise from irregular rainfall distribution, early cessation of rains, or higher evaporative demand due to increased temperatures. The implication is that rice farmers may face water stress during critical growth stages, such as panicle initiation and grain filling, leading to reduced yield and poorer grain quality. This suggests that farmers' vulnerability is not limited to extreme rainfall events but also includes periods of water scarcity that affect crop development and yield stability. The coexistence of flooding and moisture stress highlights the need for integrated water management approaches, including improved irrigation and water conservation practices.

The mean score for post-harvest losses ($\bar{x}$ = 2.91) indicates that climate-induced shocks extend beyond production into storage and marketing stages. High temperatures and humidity during harvesting and storage can accelerate grain spoilage, insect infestation, and fungal growth, reducing both quality and market value. Ogundele *et al*., (2022) argue that climate change intensifies weaknesses across the entire food system, not just primary production, and the Anambra result supports this perspective. The implication is that even when farmers succeed in producing rice, their ability to store and market the produce is compromised, leading to reduced income and increased food insecurity. Post-harvest losses can undermine farmers' income and food security, especially when storage facilities are inadequate and market access is limited. This is particularly important in rice production, where grain quality and shelf life determine market competitiveness. The finding suggests that improving post-harvest handling, storage infrastructure, and access to drying technologies would help reduce vulnerability.

The acceptance of flooding of rice farms ($\bar{x}$ = 2.66) and loss of rice farms ($\bar{x}$ = 2.89) further suggests that excessive rainfall and waterlogging are notable concerns in Anambra. Flooding is a critical hazard in lowland rice systems, where inadequate drainage and poor infrastructure can quickly turn heavy rainfall into prolonged waterlogging. This finding aligns with evidence from Nigeria and other tropical regions where flooding has been identified as a major climate hazard affecting agricultural productivity, leading to crop loss, soil erosion, and delayed farming operations as noted by Eze and Tanko, (2023). The implication is that the farming system is not only exposed to the physical effects of floodwater but also to the economic effects of delayed farm operations and reduced cropping cycles. Flooding can destroy seedlings and reduce planting windows, forcing farmers to replant or abandon affected fields, which further reduces farm income and increases vulnerability. The occurrence of flooding and farm loss also indicates that rice farmers may have limited access to flood-tolerant varieties and improved field management practices. Deressa (2010) and Dendir and Simane (2019) emphasize that adaptive capacity, including access to improved technologies and information, plays a key role in reducing vulnerability. Therefore, the relatively high means for flooding and farm loss in Anambra suggest that farmers' adaptive capacity may be constrained, and that infrastructural improvements and adaptive interventions are needed to mitigate the impacts of excessive rainfall.

The grand mean of 2.64 for Anambra falls within the "highly vulnerable" range, indicating that rice farmers in Anambra are highly vulnerable to climate-induced shocks. The value is above the midpoint threshold (2.50), suggesting that while farmers recognize the presence of climate shocks. This supports the view that Anambra farmers have high vulnerability, potentially because some drought-related stocks were negative, implying either lower exposure or more effective coping mechanisms. The implication is that while adaptation needs exist, the severity of climate impacts may be somewhat lower than in other states, possibly due to better access to resources or institutional support. This observation aligns with the argument of Ali *et al.*, (2021) that institutional weaknesses increase vulnerability, implying that where institutional support is relatively stronger or more accessible, farmers may exhibit lower overall vulnerability.

***H_0:** Selected socioeconomic do not have significant effect on rice farmers' vulnerability to climate-induced shocks in Anambra State*

From Table 3, the double-log functional form was selected as the lead equation because it recorded the highest explanatory power among the models estimated for Anambra State. The coefficient of determination (R^2) was 0.695 and the adjusted R^2 was 0.678, indicating that about 69.5% of the variation in vulnerability to climate-induced shocks among rice farmers was explained by the socioeconomic variables included in the model. The model was also statistically significant, as shown by the F-ratio of 51.46 ($p < 0.01$).

Age had a positive and statistically significant coefficient (0.049; $p < 0.05$), indicating that older farmers were more vulnerable to climate-induced shocks. This finding is in line with Adebayo et al., (2023), who observed that ageing reduces farmers' physical capacity and responsiveness to changing climatic conditions. In rice farming, which is labour-intensive and highly sensitive to timing, older farmers may find it difficult to carry out essential farm operations promptly, especially under erratic rainfall patterns. The implication of this result is that age increases the sensitivity component of vulnerability while reducing adaptive capacity. It also suggests that ageing farming populations may face increasing challenges in coping with climate variability unless supported by labour-saving technologies, mechanization, or institutional interventions.

Household size was positive and significant (0.170; $p < 0.01$), indicating that larger households are more vulnerable to climate-induced shocks. This result is consistent with the findings of Solomon Asfaw *et al*. (2021), who reported that large household sizes increase consumption pressure and strain available resources. A larger household implies more dependents and higher consumption requirements, which can intensify vulnerability during climate shocks such as droughts or floods. The implication is that household size increases the sensitivity dimension of vulnerability by reducing per capita resource availability and limiting the ability to absorb shocks. Additionally, large households may face difficulties in saving or investing in adaptation measures due to competing consumption needs, thereby weakening their resilience over time.

Farming experience had a negative and significant coefficient (−0.095; $p < 0.05$), indicating that more experienced farmers were less vulnerable to climate-induced shocks. This agrees with the findings of Eneh Chinedu *et al*. (2024), who found that farming experience enhances adaptive capacity through accumulated knowledge and practical skills. Experienced farmers are better able to interpret climatic signals, anticipate changes, and adopt appropriate coping strategies such as adjusting planting dates and selecting resilient crop varieties. The implication is that farming experience reduces both sensitivity and exposure to climate risks while strengthening resilience. It also suggests that experience functions as a valuable internal asset that improves decision-making and enhances the ability to recover from shocks.

Education level was negative and significant (−0.181; $p < 0.01$), indicating that higher levels of education significantly reduce vulnerability among rice farmers. This finding supports the study by Adebayo Adebayo, Ogunleye Ogunleye and Salisu Salisu (2023), who emphasized that education improves farmers' ability to access, interpret, and apply climate-related information. Educated farmers are more likely to adopt climate-smart agricultural practices, utilize extension services effectively, and implement innovative solutions to mitigate climate risks. The implication is that education strengthens adaptive capacity by enhancing cognitive skills, innovation uptake, and informed decision-making, thereby reducing vulnerability.

Farm size had a negative and significant coefficient (−0.246; $p < 0.01$), indicating that farmers with larger farm holdings are less vulnerable to climate-induced shocks. This finding is consistent with the work of Araya Tesfaye *et al*. (2020), who reported that larger farm sizes enable diversification and risk spreading. Farmers with larger landholdings can allocate land to different crops or farming systems, thereby reducing the likelihood of complete crop failure under adverse climatic conditions. The implication is that farm size enhances the asset base of farmers, provides flexibility in production decisions, and reduces exposure to climate risks. It also allows for investment in long-term adaptation measures such as irrigation and soil conservation, thereby strengthening resilience.

Farm income was negative and significant (−0.147; $p < 0.01$), indicating that higher farm income reduces vulnerability. This aligns with the findings of Adebayo et al., (2023), who emphasized that income is a critical determinant of adaptive capacity. Higher income improves farmers' ability to invest in adaptation strategies, absorb shocks, and recover quickly from climate-induced losses. The implication is that income strengthens financial resilience and reduces sensitivity to climate shocks. It also enables farmers to diversify their livelihoods and avoid negative coping strategies, thereby enhancing long-term sustainability.

Cooperative membership had a negative and significant coefficient (−0.074; $p < 0.01$), indicating that participation in cooperative societies significantly reduces vulnerability to climate-induced shocks. This finding is in line with the work of Aldrich *et al*. (2018) and Alare *et al*. (2022), who highlighted the importance of social capital in enhancing resilience. Cooperative membership provides farmers with access to shared resources, information, credit, and collective action mechanisms, all of which improve their ability to cope with climate risks. The implication is that cooperative societies serve as institutional buffers that enhance adaptive capacity and facilitate recovery from climate shocks. Since key socioeconomic variables such as age, household size, farming experience, education level, farm size, farm income, and cooperative membership were found to be statistically significant, the null hypothesis (H01) is rejected. This indicates that socioeconomic factors significantly influence rice farmers' vulnerability to climate-induced shocks in Anambra State.

Conclusion and Recommendation

The study concludes that rice farmers in Anambra State were highly vulnerable to climate-induced shocks due to dependence on rain-fed agriculture, limited access to climate information and extension support, and weak institutional and infrastructural support. Climate shocks such as unpredictable rainfall, flooding, drought, pests, and diseases significantly reduce yield, increase production costs, and threaten food security. The study identified unpredictable rainfall, drought, flooding, and reduced soil moisture as the most prevalent climate-induced shocks affecting rice production. In response, there is a need for increased investment in small-scale irrigation, water harvesting systems, and improved drainage infrastructure to reduce farmers' dependence on rainfall. Public–private partnerships and community-based irrigation schemes should be encouraged, especially in flood- and drought-prone areas, to improve water availability during critical stages of rice growth and minimize crop losses.

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Tables

Table 1: Socioeconomic characteristics of rice farmers in Anambra State

Variables	Frequency	Percentage
Age (years)		
24-33	3	3.8
34-43	16	20
44-53	14	17.5
54-63	29	36.3
64-73	15	18.8
74-83	3	3.8
Mean ($\bar{x}$)	**54**	
Sex		
Female	39	48.8
Male	41	51.2
Household size		
1 – 10	70	87.5
11 – 20	10	1.3
Mean ($\bar{x}$)	**5**	
Marital status		
Single	12	15
Married	58	72.5
Widowed	10	12.5
Level of Education		
No formal education	14	17.5
Primary	4	5.0
Secondary	45	56.3
Tertiary	17	21.3
Experience		
1-10	12	15
2-20	15	18.8
21-30	47	58.8
31-40	6	7.5
Mean ($\bar{x}$)	**21**	
Farm size		
<1	1	1.3
1-5	37	46.3
6-10	13	16.3
11-15	12	15
16-20	17	21.3
Mean ($\bar{x}$)	**10.7**	

Source: Field survey; 2025.

Table 2: Extent of rice farmers' vulnerability to climate-induced shocks in Anambra State

S/N	Climate Induced Shocks	Mean	SD	Remarks
1	Flooding of rice farms	2.66	1.01	HV
2	Loss of rice farms	2.89	1.02	HV
3	Decrease in soil fertility	2.13	1.12	MV
4	Increased incident of pest and diseases	3.53	0.76	HV
5	Increased weed growth in rice farm	2.59	1.03	HV
6	Decreased in rice yield	3.44	0.87	HV
7	Increased incidence of post-harvest losses	2.91	1.03	HV
8	Delayed rice fruiting	3.14	0.90	HV
9	Increase cases of severe drought/delay rainfall	2.33	1.16	MV
10	Drying up of stream, lake, and water bodies	2.11	0.84	MV
11	Drying up of growing rice seedling	2.45	0.91	MV
12	Unusual heavy rainfall	1.96	0.70	LV
13	Decrease soil moisture	3.03	0.87	HV
14	Stunted growth of rice on the field	2.04	0.88	MV
15	Unpredicted rainfall pattern	2.36	0.98	MV
	Grand mean $(\bar{x})$	**2.64**		**HV**

Source: Field survey; 2025. Key: LV= Lowly venerable, MV = Moderately vulnerable, HV = Highly vulnerable

Table 3: OLS for test on influence of selected socioeconomic on rice farmers' vulnerability to climate-induced shocks in Anambra State

Variables	Linear	Exponential	Semi-log	Double-log
Constant (β_0)	2.511 (10.73)***	1.712 (21.88)***	2.947 (6.76)***	1.333 (6.97)***
Sex (X_1)	−0.015 (−0.61)	−0.009 (−0.70)	−0.053 (−0.67)	−0.031 (−0.73)
Age (X_2)	0.008 (1.74)*	0.004 (2.01)**	0.137 (1.81)*	0.049 (2.06)**
Household size (X_3)	0.115 (3.21)**	0.054 (3.94)***	0.304 (3.08)**	0.170 (3.51)***
Marital status (X_4)	0.041 (0.88)	0.022 (1.09)	0.028 (0.83)	0.020 (0.91)
Farming experience (X_5)	−0.022 (−2.96)**	−0.013 (−5.11)***	−0.173 (−2.88)**	−0.095 (−2.61)**
Education level (X_6)	−0.069 (−5.32)***	−0.034 (−7.54)***	−0.311 (−4.77)***	−0.181 (−5.06)***
Farm size (X_7)	−0.172 (−5.94)***	−0.085 (−8.26)***	−0.416 (−5.19)***	−0.246 (−5.61)***
Extension contact (X_8)	−0.058 (−0.25)	−0.033 (−0.37)	−0.181 (−0.29)	−0.124 (−0.32)
Credit amount (X_9)	−2.60e-05 (−1.47)	−1.00e-05 (−0.21)	−0.072 (−0.20)	−0.051 (−0.22)
Farm income (X_{10})	−5.20e-05 (−4.21)***	−2.60e-05 (−5.33)***	−0.228 (−3.42)**	−0.147 (−4.02)***
Cooperative membership (X_{11})	−0.085 (−2.38)**	−0.052 (−4.11)***	−0.079 (−2.11)**	−0.074 (−3.44)***
R^2	0.449	0.611	0.424	0.695
Adjusted R^2	0.423	0.591	0.396	0.678
F-ratio	17.88***	34.02***	16.11***	51.46***

*Source: Field survey (2025) + lead equation, *** Significant at 1%, ** Significant at 5%, *significant at 10%. Figure in parenthesis are t-ratio*