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Original Article

Factors influencing resilience building for climate change among rice farmers in Niger State, Nigeria

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ABSTRACT

This study identified factors influencing resilience-building mechanisms to climate change amongst rice farmers in Niger State, Nigeria. Two-stage sampling procedure was used to select 347 rice farmers. A survey research design was used with the aid of an interview schedule to collect primary data. Data collected were analysed using frequency, percentage, mean, and regression tools. Results showed that the use of efficient irrigation infrastructures ($\bar{x}$=3.71), planting early maturity varieties ($\bar{x}$=3.63) and planting date/season adjustments ($\bar{x}$=3.64) were the leading resilience-building mechanisms used by farmers. Regression analysis showed that sex (β=4.264), marital status (β=13.658), years of schooling (β=17.037), annual income (β=2.85E-05), access to loan (β=103.347) and access to extension services (β=44.783) were factors that positively influenced climate resilience mechanisms of rice farmers while household size (β= -1.234), household members involved in rice farming (β= -1.045), and years of experience (β= -0.887) indicated negative influence on climate resilience mechanisms of rice farmers at $p \leq 0.05$ level of significance. The study established that several factors affected the climate resilience-building mechanisms of rice farmers in Niger State. Therefore, extension programmes aimed to build farmers' climate resilience mechanisms should prioritize significant socioeconomic characteristics.

HIGHLIGHTS

- Efficient irrigation enhances climate resilience ($\bar{x}$=3.71).
- Early maturity varieties boost resilience ($\bar{x}$=3.63).
- Planting date adjustments aid resilience ($\bar{x}$=3.64).
- Loans and extension services improve resilience (β=103.347).

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1. Introduction

Rice farming in the tropical region is highly dependent on natural environmental conditions, including climate (Dhanya et al., 2022). Studies have affirmed the occurrence of climate change in Nigeria (World Bank, 2022; Ogunleye et al., 2021), most especially among smallholder farmers who are the largest producers of staple food (Mkwambisi et al., 2021). Some of the significant effects of change in climate in rice production in Nigeria include drought, flooding, leaching, dryness of germinated or transplanted seedlings and length of germination period and crop loss among others (Izuogu et al., 2021; Bolarin et al., 2022). Other studies have revealed that change in weather conditions has affected food production in Nigeria through reduced crop yield which has the resulting impact on food security of the country in terms of affordability, availability, and per capital calorie food consumption (Izuogu et al., 2021; Adejuwon & Ogundiminegha, 2019). These effects have forced farmers to diversify into non-agricultural income and this is a relevant part of rural household socioeconomic strategy (Keshavarz & Moqadas 2021) and adversely affects food production and farmers' livelihoods (Tiet et al., 2022). This is why the issue of climate change is paramount and important for sufficient food production in Nigeria. The impact of climate change in Nigeria is mostly felt by the smallholder farmers who produce about 80% of staple crops in the country (Chukwuemeka et al. 2018).

Due to the negative impacts of climate change on agriculture, climate resilience is becoming an increasingly important topic to consider in agriculture because of the necessity to adapt to unpredictable conditions climate change is causing (Wang et al., 2021). Agricultural resilience is a facet of overall agricultural sustainability needed to thrive in a changing climate. Resilience is the capacity of any system to absorb change and disturbances, and still retain its basic structure and function—its identity (Walker, 2020). Resilience is the tendency for a system to envisage, curtail, tolerate and survive the outcome of incidences that are hazardous to its existence in such an efficient and timely manner by utilizing sustainable execution of preservation, advancement, and restoration of its essential structure and functions (IPCC, 2019).

Smallholder farmers' ability to build resilience to adapt and mitigate the effects of climate change has economic, social, and technological advancement dimensions. However, studies conducted in the North-central states of Nigeria to understand

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these dimensions have dealt extensively with the climate resilience methods (adaptation and mitigation) among crop farmers (Bakare, Ogunleye & Kehinde, 2023) and the influence of demographic factors, economic incentives, ownership of resources/asset, technologies factors, institutional and political factors, among others as they influence the choice of climate change adaptation strategies (Ayuba & Oruonye, 2022; Ayanlade et al., 2018) while others have mainly focused on social capitals of crop farmers (Ayanlere, 2018). However, less research attention is placed on investigating the adaptive capacity for climate resilience among rice farmers, thus these factors influencing the resilience-building mechanisms of rice farmers in Niger state appear scarce in the literature. Hence, there is a need for a detailed assessment of factors that can influence smallholder rice farmers' resilience building mechanism for climate change. The study therefore seeks to provide answers to the following research questions:

i. what are the strategies used by farmers in reducing rice crop exposure to climate change effects?
ii. what are the strategies used by farmers in reducing rice crop sensitivity to climate change effects?
iii. what are the strategies used by farmers in improving the adaptive capacity of farmers to climate change effects?
iv. are there factors associated with building resilience against the climate change effects among rice farmers?

The general objective of the study is to examine factors influencing resilience building mechanisms to climate change amongst rice farmers in Niger state, Nigeria. The specific objectives were to:

i. assess strategies used by farmers in reducing rice crop exposure to climate change effects,
ii. assess strategies used by farmers in reducing rice crop sensitivity to climate change effects,
iii. investigate strategies used by farmers in improving the adaptive capacity of farmers to climate change effects,
iv. identify factors associated with building resilience against the climate change effects among rice farmers.

2. Methodology

2.1. The Study Area

This study was conducted in Niger State, Nigeria. Niger State is located in North Central Nigeria and is the largest state in the country by land mass World Bank report, 2022. This State lies between the latitude of 3.20' east and longitude of 11.3' north.

2.2. Population and Sample Size Determination

The population of the study comprises of all the rice farmers in the four LGAs having the most populated members of rice farmers' association of Nigeria in Niger State. The LGAs and their population are Lavun LGA (1150), Wushishi LGA (748), Gbako LGA (451) and Paikoro (260). Thus, the total population for the study consists of 2,609 rice farmers (National Cereals Research Institute [NCRI], 2023).

Determination of sample size was done with the use of Taro Yamane Formula to arrive at 13.3% of the population; 347 rice farmers. The 347 rice farmers were selected by three-stage sampling procedure. The first stage involved a purposive selection of four prominent rice producing LGAs in Niger State namely: Lavun, Wushishi, Gbako and Paikoro. The second stage involved a proportionate selection of 13.3% from the list of members of the rice farmers' association in each selected LGA based on the sample size formula used while the third stage involved a simple random selection of 153 members from Lavun LGA, 99 members from Wushishi LGA, 60 members from Gbako LGA and 35 from Paikoro LGA, which made a total of 347 rice farmers that represented the 13.3% obtained. The summary of the sample size is presented in Table 1.

Table 1. Summary of sample size

Selected LGAs	Association/cooperative members	Sample (13.3%)
Lavun	1150	152.9 = 153
Wushishi	748	99.4 = 99
Gbako	451	59.9 = 60
Paikoro	260	34.6 = 35
Total	2609	347

2.3. Instrument for Data Collection

The research approach for this study is a survey of rice farmers. Primary data were obtained through an interview schedule. The instrument was modified by experts in the Department of Agricultural Economics and Extension Services to ensure its validity. The co-efficient obtained by Cronbach's Alpha reliability test of the instrument was 0.96, indicating that the instrument was considered reliable.

2.4. Measurement of Resilience Building Mechanisms of Farmers

Strategies for reducing crop exposure climate change effects, strategies for reducing crop sensitivity to climate change effects, and strategies for increasing farmers' adaptive capacity to climate change effects were measured on 4-point Likert type scale to be measured as: always used=4, sometimes used=3, rarely used=2 and never used =1.

To group respondents into levels of resilient building mechanism, overall score of each farmer were obtained. Minimum to maximum possible score ranges from 33 (12+9+12) – 132 (48+36+48). Farmers scoring 33 to 66 points were grouped having low resilient building mechanism, farmers scoring between 67 to 99 were grouped having moderate resilient building mechanism while farmers scoring between 100 to 132 were grouped having resilient building mechanism.

2.5. Data Analysis

Primary data to address objectives of this study were analyzed using frequency count, percentage, mean, and standard deviation while research question 4 was assessed by multiple regression. Ordinary least square regression model as used by Bolarin et al.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 + \dots + e_i \quad (1)$$

where Y= Access to social capitals, (X) = Independent variables, X_1 = Sex (male 1 otherwise 0), X_2 = Age (in years), X_2 = Marital status (married=1, otherwise 0), X_3 = Education- years of schooling (years), X_4 = Household size (in persons), X_5 = Farming experience (in years), X_6 = Farm size (in hectares), X_7 = Farm income per annum (in Naira), X_8 = Access to land (yes=1, no=0), X_9 = Access to loan (yes=1, no=0), X_9 = Access to extension services (yes=1, no=0) and e = Error term

Table 2. Frequency of practices to reduce rice crop exposure to climate change effects

Mitigation/Prevention of loss strategies	Mean	Rank
Use of efficient irrigation infrastructures	3.71±0.709	1st
Use of agricultural extension services	3.57±0.620	2nd
Use of accurate and timely weather forecasting	3.41±0.934	3rd
Construction of wide drainage channels for flood and erosion control	3.31±1.098	4th
Row cropping systems	3.31±0.815	5th
Use of mulching	3.27±1.068	6th
Mixed cropping systems	3.21±0.880	7th
Planting of trees and Afforestation	3.17±1.099	8th
Avoidance of deforestation/ tree felling	3.17±0.765	9th
Livestock-crop integration	3.16±0.909	10th
Growing more cover crops to protect the soil from erosion and leaching	3.10±0.910	11th
Intercropping system	2.93±1.302	12th

(2022) was adopted. The model was specified implicitly according to Equation 1.

3. Results and Discussion

3.1. Resilience Building Mechanisms of Farmers

In this study resilience-building mechanisms of farmers were investigated by farmers' strategies for reducing rice exposure to climate change effects, strategies for reducing crop sensitivity to climate change effects, and strategies for increasing farmers' adaptive capacity (adaptation strategies) on climate change effects.

Farmers' Strategies for Reducing Crop Exposure to Climate Change Effects

Respondents were questioned on the strategies employed to reduce rice crop exposure to climate change effects. Information provided as displayed in Table 2 shows that use of efficient irrigation infrastructures ($\bar{x}$=3.71±0.709) was ranked first, while the use of agricultural extension services ($\bar{x}$=3.57±0.620) was ranked second. Also, the use of accurate and timely weather forecasting ($\bar{x}$=2.41±0.934) was ranked third, and construction of wide drainage channels for flood and erosion control ($\bar{x}$=3.31±1.098) were both ranked fourth, Furthermore, row cropping systems ($\bar{x}$=3.31±0.815) was ranked fifth and the use of mulching ($\bar{x}$=3.27±1.068) was ranked sixth while intercropping system ($\bar{x}$=2.93±1.302) was ranked as the least practice indicated by the farmers. This shows that that the use of efficient irrigation infrastructures, agricultural extension services, and accurate and timely weather forecasting were the leading strategies employed by farmers to reduce rice crop exposure to climate change effects in the study area. Prominent use of irrigation, extension services and weather forecasts implies that farmers prioritize regular water supply for rice farms, and agricultural extension agents to get timely technology and timely weather forecast information to make timely decisions regarding weather variability. These findings agreed with studies that indicated use of efficient irrigation infrastructures, and use of timely weather forecasting as measure to mitigate the effects of climate change in rice farming (Ansari et al., 2023; Olayide et al. 2016; Mousumi et al., 2023).

Farmers' Strategies for Reducing Crop Sensitivity Climate Change Effects

Respondents were asked to indicate strategies used to reduce rice crop sensitivity to climate change effects. Results provided in Table 3 showed that planting early maturing varieties ($\bar{x}$=2.63±0.724) was ranked first, planting drought/heat-tolerant varieties ($\bar{x}$=3.36±0.867) was ranked second, planting flood resistant varieties ($\bar{x}$=3.33±0.916) was ranked third. Also, early planting date ($\bar{x}$=3.29±0.988) was ranked fourth, planting of pest and disease resistant crops ($\bar{x}$=3.29±0.930) ranked fifth while planting trees in rows to serve as wind breakers and to check erosion ($\bar{x}$=2.97±1.024) was ranked position as the least practice indicated by the farmers. This finding shows that planting early maturing varieties, drought/heat-tolerant varieties and flood

Table 3. Frequency of practices to reduce rice crop sensitivity to climate change effects

Sensitivity strategies	Mean	Rank
Planting early maturing varieties	3.63±0.724	1st
Planting drought/heat-tolerant varieties	3.36±0.867	2nd
Planting flood resistant varieties	3.33±0.916	3rd
Early planting date	3.29±0.988	4th
Planting of pest and disease resistant crops	3.29±0.930	5th
Planting of short-cycle varieties	3.25±0.869	6th
Planting cover crops to protect the soil	3.23±0.889	7th
Regular weeding to avoid breed of some insects pest	3.03±1.239	8th
Planting trees in rows to serve as wind breakers and to check erosion	2.97±1.024	9th

Table 4. Frequency of practices to adapt or manage the effects of climate change on rice crops

Management/Adjustment strategies	Mean	Rank
Planting date/season adjustments	3.64±.867	1st
Green manuring/ organic fertilization	3.41±1.020	2nd
Conserving of soil moisture through appropriate tillage operation	3.39±.971	3rd
Crop diversification	3.15±.917	4th
Reducing the cultivated area	3.09±.939	5th
Soil and water conservation	3.08±1.095	6th
Deepened wells for irrigation	3.05±1.085	7th
Minimum and strip cropping systems	3.03±.932	8th
Built water reservoirs	2.90±1.306	9th
Rainwater collection for irrigation	2.87±1.310	10th
Installing or altering the irrigation system	2.86±1.358	11th
Conversion of livelihoods to non-agriculture and income diversification	2.85±1.002	12th

resistant varieties of rice were the foremost practices used to reduce rice crop sensitivity to climate change effects by the rice farmers in the study area. This finding is consistent with findings that indicated the prominent cultivation of early maturing varieties of rice and drought/heat-tolerant varieties of rice as strategies to reduce crop sensitivity to climate change effects (Noviana et al., 2023; Onyeneke, 2020). In agreement with the prominent use of flood resistant varieties by farmers to reduce rice crop sensitivity to climate change effects, Mwakyusa et al. (2023) similarly stated that many rice farmers in Africa are using flood tolerant varieties to mitigate the effect of flood as a result of climate change. This is because flood tolerant cultivars exhibit rapid growth having significant increase in height and equivalent to up to 25 cm per day. The varieties were characterised by anaerobic germination, short-term vegetative submergence facilitates tolerance by conserving energy as a survival response in stagnant flooding and deep-water rice (Agbeleye et al., 2019; Oteyami et al., 2018; Anna et al. 2019).

Farmers' Adaptive Capacity (Adaptation Strategies) On Climate Change Effects

Respondents were requested to indicate strategies used to adapt or manage the effects of climate change on rice crops. As shown in Table 4, planting date/season adjustments ($\bar{x}$=3.64±.867) ranked first, application of green manuring/ organic fertilization ($\bar{x}$=3.41±1.020) ranked second, conserving of soil moisture through appropriate tillage operation ($\bar{x}$=3.39±.971) ranked third, crop diversification ($\bar{x}$=3.15±.917) ranked fourth, reducing the cultivated area ($\bar{x}$=3.09±.939) ranked fifth while conversion of livelihoods to non-agriculture and income diversification ($\bar{x}$=2.85±1.002) ranked the twelfth as the least practice indicated by respondents. This result indicated that planting date/season adjustments, application of green manuring/ organic fertilization, and conserving of soil moisture through appropriate tillage operation were the practices used by farmers to adapt or manage the effects of climate change on rice crops. This findings comform with the findings of Tajudeen et al. (2022) and Yakubu et al. (2020), which submitted that planting that planting date/season adjustments, application of green manuring/ organic fertilization, and conserving of soil moisture through appropriate tillage operation were the prominent adaptation strategies used by rice farmers (Tajudeen et al., 2022; Yakubu et al., 2020).

3.2. Level of Resilience Building Mechanisms

The overall level of resilience building mechanisms of farmers which consists practices to reduce crop exposure, sensitivity and adaptive capacity is presented in Table 5. The table reveals that 27.1% of the respondents had high level of resilience, 57.9% had moderate level of resilience while 15.0% had low level of resilience. By implication, the resilience building mechanism of rice farmers for climate change effects on rice crop is considered moderate. This suggests a vacuum for stronger resilience capacity for climate change effects in building their knowledge in reducing rice crop exposure, and sensitivity to climate change effects as well as their adaptive capacity to mitigate/adapt the effects of climate change effects on rice farms through their social networks.

Determinants of resilience building mechanisms for climate change effects of rice farmers

Results in Table 6 show that certain socioeconomic factors had significant influence on farmers' level of climate resilience mechanisms with the R square of 0.702; F=51.958; p=0.00). The overall prediction shows that the model predicted 68.8% farmers' level of climate resilience mechanisms among the farmers. Specifically, the findings show that sex (4.264, p<0.05), marital status (13.658, p<0.01), years of schooling (17.037, p<0.01), annual income (2.85E-05, p<0.01), access to loan (103.347,

Table 5. Aggregated level of resilience-building mechanisms of farmers (reducing crop exposure, sensitivity and adaptive capacity)

Level	Obtained score range	Frequency	Percentage	Mean ± *SD*
High	100 – 132	94	27.1	
Moderate	67 – 99	201	57.9	73±22.23
Low	33 – 66	52	15.0	
Total		374	100.0	

Minimum to Maximum possible score; 33 (12+9+12) – 132 (48+36+48)

Table 6. Determinants of resilience building mechanisms for climate change effects

Climate resilience building mechanisms	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Errr	Beta		
(Constant)	-21.536	8.046		-2.677	0.008
Sex	4.264*	2.01	0.096	2.121	0.035
Age	0.262	0.265	0.06	0.991	0.322
Marital status	13.658**	3.334	0.201	4.096	0.000
Years of schooling	17.037**	2.936	0.77	5.804	0.000
Household size	-1.234**	0.368	-0.293	-3.353	0.001
Household members involved in rice farming	-1.045**	0.291	-0.326	-3.589	0.000
Years of experience	-0.887**	0.335	-0.222	-2.65	0.008
Rice farm size	-0.529	0.371	-0.052	-1.425	0.155
Annual income	2.85E-05**	0	0.608	9.579	0.000
Ownership of farmland	-2.143	1.864	-0.037	-1.149	0.251
Years of membership in rice farmers' cooperative	0.136	0.219	0.042	0.618	0.537
Access to loan	103.347**	5.888	1.033	17.551	0.000
Access to extension services	44.783**	8.487	-0.541	-5.277	0.000

Dependent variable: Resilience building mechanisms for climate change; Model Summary: R^2 = 0.702; Adjusted R^2 = 0.688; Std. Error of the Estimate = 12.407, F-stat. = 51.958, Sig. =0.000; *, ** implies significant at 0.05 and 0.01 level respectively

p<0.01) and access to extension services (44.783, p<0.01) significantly influenced farmers' resilience mechanism. These findings imply that a unit increase in years of schooling, annual income, access to loans and access to extension services will lead to an increase in climate resilience mechanisms of rice farmers in the study area. This finding is expected because education, income and extension services are essential human, financial and information assets needed for farmers to expand their farming business.

Furthermore, household size (-1.234, p<0.01), household members involved in rice farming (-1.045, p<0.01), and years of experience (-0.887, p<0.01) were found to have negative influence. This implies that the increasing number of household size, household members involved in rice farming and years of experience in rice farming, the less climate resilience mechanisms of rice farmers in the study area. Findings of this study may be connected to the increase number of household members who serve as dependants and liability instead of assets for farm labour. Also, farmers with long years of experience may perceived to be self-dependent, relying on the old successful strategies to manage climate change effects rather than sourcing for updated information on climate change adaptation strategies.

Conclusion and Recommendation

Based on the findings of this study, it can be inferred that rice farmers in Niger State had built moderate resilience mechanisms against the effects of climate change, with topmost mechanisms for the use of efficient irrigation infrastructures, planting early maturing varieties, and planting date/season adjustments respectively. Factors that positively increase farmers' adaptive capacity for climate resilience were sex, marital status, years of schooling, annual income, access to loans and access to extension services. Therefore, there is a need to intensify extension services delivery to further build the climate resilience mechanisms of rice farmers for reducing rice exposure to climate change effects, reducing crop sensitivity to climate change effects, and increasing farmers' adaptive capacity to climate change effects on rice crop, with special focus on the use of efficient irrigation infrastructures, planting early maturing varieties, and planting date/season adjustments.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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