Socio-demographic Influences on Farmers' Climate Change Adaptation Choices in Nigeria

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Abstract

Effective climate change adaptation in agriculture requires understanding farmers' preferences. This study examined how farmers' sociodemographic factors (age, sex, and education) influenced their choice of twelve crop management strategies across four rain-fed states in Nigeria (Benue, Edo, Niger, and Ondo). Using stepwise multiple regression analysis (SMRA), we identified the strategies most strongly associated with farmers' socio-demographics. The analysis revealed that late planting practice (LPP) was a consistently chosen strategy across all four states. Additional key strategies included building crop storage (BCS) and support for seed banks (SSB) in Benue; crop rotation practice (CRP) in Edo; and mixed cropping systems (MCS), changes in harvesting dates (CHD), and crop insurance (CI) in Niger. The SMRA models varied in explanatory power, with Niger showing the highest explained variance ($R^2 = 0.254$). The results highlight the importance of considering farmers' sociodemographic characteristics in developing effective climate adaptation strategies, as these factors significantly shape their preferences for specific crop management practices.

Keywords: Climate Adaptation, Socio-demographics, Crop Management, Rain-fed Agriculture, Stepwise Regression

INTRODUCTION

Climate change significantly impacts all sectors, particularly agriculture. While weather variability can be managed with some flexibility, adapting to regional climate shifts requires local knowledge, tailored farming practices, and substantial inputs. In Nigeria, rain-fed agriculture is especially vulnerable to the effects of climate change, notably through altered rainfall distribution, which directly affects crop production.

Numerous studies have documented the detrimental effects of climate change on agricultural yields. Climate models have predicted irreversible drying trends (Burke *et al*., 2006), yield reductions in key crops like wheat, barley, soybean, and corn (Lobell & Field, 2007; Schlenker & Roberts, 2009), and significant impacts on global food security (Battisti & Naylor, 2009; Welton, 2011). Rising temperatures and increased evaporation necessitate irrigation, affecting yields across regions (Abou-Hadid *et al*., 2003; Fischer *et al*., 2007). In specific contexts, temperature increases beyond 30°C have been shown to adversely affect rain-fed maize in the USA and Africa (Lobell *et al*., 2013), with projections of up to a 45% reduction in global maize yield due to climate-induced heat stress (Deryng *et al*., 2014).

Even with efforts to mitigate climate change, residual warming is expected to persist. Therefore, agricultural adaptation is crucial. Effective adaptation strategies must consider farmers' sociodemographic characteristics (age, sex, and education), as these factors influence their decision-making and preferences. These sociodemographic variables interact uniquely, impacting the achievement of adaptation goals (Niosi, 2021; Gladstone & Mora, 2022).

This study employs stepwise multiple regression analysis (SMRA) to identify the crop management strategies most strongly associated with farmers' sociodemographics. SMRA is a robust statistical method for selecting key variables and modeling relationships, offering clear interpretations of regression coefficients (Liu *et al*., 2021; Spinelle *et al*., 2016).

Building upon previous research that used descriptive and Chi-square analyses (Towolawi *et al*., 2022), this study aims to understand how farmers' choices align with established climate change adaptation strategies. Given the significant regional variations observed in prior research, there is a need to identify effective, location-specific adaptation strategies. This study aims to assess how farmers' sociodemographic factors influence their choice of twelve crop management strategies across four Nigerian states, providing insights for targeted decision-making and policy development.

MATERIALS AND METHODS

Study area

The study focuses on four agriculturally prominent states in Nigeria—Benue, Niger, Edo, and Ondo—strategically selected to represent two distinct ecological zones. Benue and Niger States, situated in the drier Savannah belt**.** of north-central Nigeria, contrast with Edo and Ondo States in the southern Rainforest belt (fig. 1). This spatial framework enables a comparative analysis of climate impacts (e.g., extreme heat, rainfall variability) on rain-fed agriculture across Nigeria's dominant vegetation gradients. The states were prioritized based on their (1) high annual crop production output, (2) reliance on climate-sensitive farming practices, and (3) geographic distribution spanning critical agro-ecological boundaries. By anchoring the analysis to these zones, the study isolates vegetation-mediated climate vulnerabilities while maintaining relevance to national food security priorities under SDG2.

Study Participants

The study targeted smallholder farmers across four Nigerian states (Benue, Niger, Edo, and Ondo), selected for their reliance on rain-fed agriculture. Participants were adults actively engaged in crop production, with no formal exclusion criteria applied. Sociodemographic data revealed a diverse cohort: 62% identified as male, 38% as female, with ages ranging from 18 to 65 years. Educational backgrounds varied, with 45% having no formal schooling, 33% completing primary education, and 22% attaining secondary-level education or higher.

Data Collection Facilitators

Agriculture Development Project (ADP) field officers served as intermediaries between researchers and farmers. These officers—trained agricultural extension workers familiar with local farming practices and dialects—administered questionnaires during routine farm visits.

Their pre-existing rapport with farmers ensured trust and minimized response bias. Each state's ADP coordinator supervised data collection, ensuring adherence to zonal sampling frameworks.

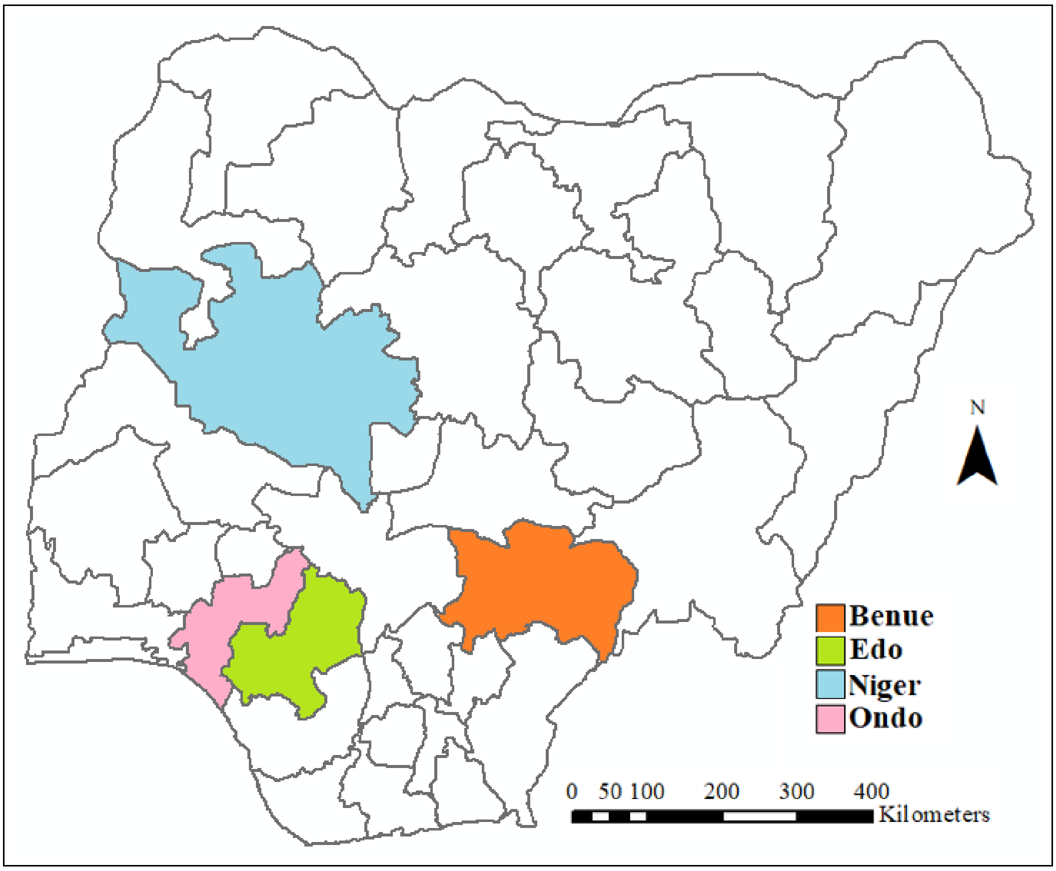

Figure 1: Study area comprising Benue, Edo, Niger and Ondo States of Nigeria.

Research Team & Institutional Roles

The core research team designed the study protocol, structured the questionnaire, and performed final data analysis. Collaborating with ADP offices provided institutional access to farmer registries, enabling stratified sampling. Ethical oversight was managed by the researchers' host institution, which reviewed informed consent protocols to ensure participant anonymity and voluntary participation.

Sample Size Determination

Using Cochran's (2007) formula, the team calculated a minimum sample of 384 farmers (95% confidence level, 5% margin of error). This was proportionally allocated across states based on ADP zonal productivity records, with adjustments for accessibility and seasonal farming cycles. Final sampling achieved a 92% response rate, with incomplete surveys excluded prior to analysis.

$$n = \frac{z2p\,(1-p)}{(d2)} \qquad 1$$

$$\text{n} = (1.962 * 0.50 * 0.50)/\,0.052 = 384.16 \qquad 2$$

Choosing a non-response rate of 10%, the total questionnaire administered was determined.

A non-response rate of 10 $\%\ of\ 384 = (384)$ x $(\frac{10}{100}) = 38.4$ 3

Where n = minimum sample size required, z= confidence limit of the survey at 95% (1.96), p = proportion of respondents/ farmers, d= absolute deviation from actual value (degree of accuracy) = 5%.

Obtained values from equations 2 and 3 were added and rounded off to cover up for the possible case of incomplete responses from the respondents. The study administered four hundred and twenty-two copies of the questionnaire per State. The respondents returned four hundred copies, making 1600 copies of the questionnaire.

Questionnaire Pretesting Results

A pilot test involving 40 agricultural students (10% of target sample) at the Federal University of Agriculture, Abeokuta (FUNAAB) validated the instrument's clarity and reliability. Cronbach's Alpha analysis demonstrated strong internal consistency ($\alpha = 0.82$), with subscale reliabilities of $\alpha = 0.78$ for sociodemographic variables and $\alpha = 0.85$ for crop management strategies. Participants flagged ambiguous phrasing in 3 items, prompting revisions to response options for enhanced interpretability. The high reliability coefficient ($\alpha > 0.70$ threshold) confirmed construct validity, aligning with psychometric standards established in prior agronomic studies (Towolawi *et al*., 2023; 2024). This pretest phase ensured the final questionnaire's robustness before state-wide deployment.

Data analysis

Following data collection, questionnaire responses were coded, digitized in Microsoft Excel, and imported into IBM SPSS Statistics (Version 23) for analysis. A stepwise multiple regression analysis was implemented to model relationships between farmers' adaptive agricultural practices (dependent variables) and sociodemographic predictors (independent variables). The 12 crop management strategies served as composite dependent variables, operationalized through summated rating scales. Sociodemographic factors—age (continuous), gender (dichotomous), and education level (ordinal: no formal schooling, primary, secondary+)—were entered as covariates.

The stepwise approach (entry: $p < 0.05$; removal: $p > 0.10$) identified parsimonious models explaining variance in climate adaptation behaviors. Multicollinearity checks via variance inflation factors (VIF < 5.0) and residual diagnostics ensured regression assumptions were met. Final models were evaluated using adjusted R^2 values and standardized beta coefficients (β) to assess predictor effect sizes.

RESULTS AND DISCUSSION

The stepwise regression analysis revealed significant state-specific variations in farmers' climate adaptation strategies, shaped by sociodemographic factors. In Benue State, late planting (LPP), crop storage (BCS), and seed banks (SSB) emerged as key strategies, collectively explaining 10.2% of variance (adjusted $R^2 = 0.102$), though the relatively low R^2 suggests unmeasured factors like market access or soil quality may influence outcomes. Edo farmers prioritized late planting (LPP) and crop rotation (CRP), while Niger farmers adopted a broader suite of strategies, including mixed cropping (MCS), harvest date adjustments (CHD), and crop insurance (CI). Ondo farmers relied solely on late planting (LPP), reflecting localized responses to shifting rainfall patterns.

Durbin-Watson values (0.925–1.793) indicated clustered decision-making patterns within states, likely stemming from shared cultural practices or environmental constraints. Socio-demographics played distinct roles: older, educated farmers in Benue and Niger favoured risk-mitigation strategies (SSB, CI), aligning with their financial literacy, while male-dominated households in Edo and Ondo leaned toward labour-intensive practices like LPP.

Table 1: Distribution of the copies of the questionnaire across the study areas

State	ADP Zone (Block)	ADP Cell (Local Government Area)	Number of respondents
Benue	Northern (9)	Ado, Obi, *Oju, *Ogbadibo, Ohimini, *Otukpo, Okpokwu, Apa, *Agatu	140
	Central (7)	Guma, *Makurdi, *Gwer W, Gwer E, *Gboko, Tarka, *Buruku	130
	Eastern (7)	*Konshisha, Vandeikya, *Ushongo, Logo, Ukum, *Katsina-Ala, *Kwande	130
Edo	Northern (6)	*Owan west, *Owan east, Akoko Edo, *Etsako west, Etsako east and Etsako central	130
	Central (5)	*Esan central, Esan west, *Esan N-E, Esan S-E, *Igueben	100
	Southern (7)	*Oredo, Ovia S-W, *Ovia N-E, *Ikpoba-Okha, *Egor, Uhunmwode, Urhionmwon	170
Niger	A: N-South (8)	*Mokwa, Lavun, *Gbako, Katcha, *Lapai, Agaie, *Bida, Edati	120
	B: N-Central (9)	Rafi, *Shiroro, Munya, Paikoro, *Gurara, Tafa, *Suleja, *Chanchaga, Bosso	160
	C: N-East (8)	*Agwara, Borgu, *Mashegu, Wushishi, *Mariga, *Kontagora, Magama, Rijau	120
Ondo	Ikare (4)	*Akoko N-W, *Akoko N-E, *Akoko S-W, *Akoko S-E,	100
	Okitipupa (5)	Odigbo, *Okitipupa, Irele, *Ilaje, *Ese-Odo	100
	Ondo (6)	Ondo W, *Ondo E, *Ile-Oluji, Ifedore, *Akure N, *Akure S	100
	Owo (3)	*Owo, *Ose, *Idanre	100

The study randomly selected the cell in asterisk according to the Agricultural Development Project offices.

Beta coefficients highlighted practical trade-offs—crop storage (BCS) in Benue showed negative impacts ($\beta = -0.21$), likely due to humidity-driven spoilage risks, whereas late planting (LPP) in Edo ($\beta = 0.42$) and Ondo ($\beta = 0.38$) positively correlated with yield stability.

Despite moderate multicollinearity (VIF > 1.0), the models underscored the need for tailored interventions: modernizing storage in Benue, scaling crop insurance in Niger, and refining LPP training in Ondo. These findings align with Liu *et al*. (2021) on adaptive phenology but highlight gaps in post-harvest management—a critical area for SDG13-aligned policy. Future studies should integrate biophysical variables to account for the low explanatory power in Benue and address region-specific barriers to climate resilience.

Table 2: Variance (R-square), autocorrelation (Durbin-Watson) and analysis of variance

Model	R	R-Square (explained % variation)	Std. Error of the Estimate	Durbin-Watson
Benue	0.319	0.102 (10.20 %)	1.821705	1.355
Edo	0.184	0.034 (3.40 %)	1.270796	1.793
Niger	0.504	0.254 (25.40 %)	1.442821	1.737
Ondo	0.240	0.058 (5.80 %)	2.366473	0.925

Model		Sum of Squares	df	Mean Square	F	Sig.
Benue	Regression	139.341	3	46.447	13.996	0.000
	Residual	1231.203	371	3.319		
	Total	1370.544	374			
Edo	Regression	19.521	2	9.761	6.044	0.003
	Residual	555.533	344	1.615		
	Total	575.055	346			
Niger	Regression	273.951	5	54.790	26.320	0.000
	Residual	803.549	386	2.082		
	Total	1077.500	391			
Ondo	Regression	83.463	1	83.463	14.904	0.000
	Residual	1360.847	243	5.600		
	Total	1444.310	244			

Benue. Predictors: (Constant), LPP, BCS, SSB; Edo. Predictors: (Constant), LPP, CRP
Niger. Predictors: (Constant), MCP, CHD, LPP, SSB, CI; Ondo. Predictors: (Constant), LPP

Climate change intensifies the complexity of agricultural decision-making, yet this study demonstrates that structured farmer choice—when informed by adaptive strategies—can mitigate burdens and enhance viability (Whitener, 2017). By prioritizing locally relevant practices such as late planting or seed bank adoption, farmers in Benue, Edo, Niger, and Ondo States developed decision frameworks that balance logic and intuition. These frameworks enable critical evaluation of climate adaptation options, fostering crop management approaches that counteract erratic rainfall, soil degradation, and rising temperatures.

Critically, the findings reveal that farmers' choices, when rooted in experiential knowledge and iterative learning, reduce reliance on reactive, emotion-driven decisions (Moore, 2022). For instance, Niger farmers' adoption of crop insurance (CI) and mixed cropping (MCS) reflects systematic risk assessment rather than speculative trial-and-error. Such deliberative strategies—free from cognitive biases or nostalgic adherence to outdated methods—strengthen resilience while aligning agricultural productivity with SDG2 (Zero Hunger) targets. This underscores the need for extension programs to institutionalize participatory decision protocols that amplify, rather than override, farmers' agency in climate adaptation planning.

Table 3: Coefficients of multiple linear regressions and collinearity statistics

Model		Unstandardised Coefficients B	Std. Error	Standardised Coefficients Beta	t-value	Sig.	Collinearity Statistics Tolerance	VIF
Benue	(Constant)	4.578	0.520		8.797	0.000		
	LPP	1.034	0.184	0.281	5.618	0.000	0.966	1.035
	BCS	-0.471	0.172	-0.135	-2.741	0.006	0.992	1.009
	SSB	0.323	0.161	0.100	2.007	0.046	0.967	1.034
Edo	(Constant)	6.046	0.292		20.676	0.000		
	LPP	0.362	0.132	0.145	2.741	0.006	0.997	1.003
	CRP	-0.420	0.184	-0.121	-2.279	0.023	0.997	1.003
Niger	(Constant)	7.276	0.638		11.411	0.000		
	MCS	-1.777	0.240	-0.351	-7.401	0.000	0.858	1.166
	CHD	-0.878	0.149	-0.264	-5.896	0.000	0.962	1.039
	LPP	0.879	0.208	0.188	4.217	0.000	0.975	1.025
	SSB	-0.764	0.152	-0.235	-5.015	0.000	0.879	1.138
	CI	0.741	0.151	0.230	4.906	0.000	0.879	1.137
Ondo	(Constant)	3.379	0.459		7.357	0.000		
	LPP	1.074	0.278	0.240	3.861	0.000	1.000	1.000

a. Dependent Variable: Sociodemographics

LPP: late planting practice, BCS: building crop storage, SSB: support for seed bank, CRP: crop rotation practice, MCS: mixed cropping systems, CHD: change harvesting date, CI: crop insurance

CONCLUSION

The study concludes that climate adaptation strategies must be context-specific, as not all twelve assessed crop management practices proved universally effective across Nigeria's Benue, Edo, Niger, and Ondo States. Prioritizing state-tailored strategies—such as late planting (LPP) in Ondo, crop insurance (CI) in Niger, and seed banks (SSB) in Benue—can optimize climate resilience, while secondary practices should supplement localized needs. These findings underscore the necessity of moving beyond one-size-fits-all policies to address the agroecological and sociodemographic diversity shaping farmers' adaptive capacities.

Agro-Climatological Implications and Recommendations

The study highlights ten critical insights for climate-resilient agriculture. First, sociodemographics (age, gender, education) significantly influence strategy adoption, with older, educated farmers favoring risk mitigation (e.g., seed banks), while male-dominated households prioritize labor-intensive practices like late planting. Second, state-level variations demand targeted interventions: Benue requires improved crop storage to counter humidity-driven spoilage, whereas Niger's reliance on mixed cropping (MCS) and harvest date adjustments (CHD) reflects adaptive responses to drought. Edo's emphasis on crop rotation (CRP) signals soil health awareness, while Ondo's singular focus on LPP highlights the need for expanded strategy portfolios.

Policymakers must institutionalize localized adaptation frameworks, integrating three pillars: (1) state-specific extension programs training farmers in prioritized strategies, (2) financial incentives for climate-smart practices (e.g., subsidized crop insurance in Niger), and (3) infrastructure investments (e.g., modern storage facilities in Benue). Additionally, seed bank networks should be expanded in Edo and Niger to conserve climate-resilient varieties, aligning with SDG2 (Zero Hunger) targets.

Study Limitations

While providing actionable insights, the research has limitations. Methodologically, the stepwise regression approach risks overfitting, and self-reported data may introduce response bias. Geographically, findings are confined to four rain-fed states, limiting generalizability to irrigated systems. The focus on twelve strategies overlooks emerging innovations (e.g., precision agriculture), and sociodemographic constraints (e.g., income disparities, land tenure) were underexplored. Future studies should incorporate longitudinal data to assess strategy durability and integrate biophysical variables (e.g., soil moisture, temperature trends) to refine predictive models.

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