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Impacts of Climate Change Variability on Livelihoods of Rural Households in Agroecological Zones of Taraba State Nigeria

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ABSTRACT

This study examines the impacts of climate change variability on the livelihoods of rural households across the agroecological zones of Taraba State, Nigeria. The state's ecological diversity, spanning Sudan Savannah, Guinea Savannah, and Montane zones, provides a critical context for understanding differentiated climate risks. Using a mixed-methods approach, data were collected through household surveys (n=1,067), focus group discussions, key informant interviews, field observations, and secondary meteorological records. Findings reveal significant shifts in rainfall onset, cessation, and distribution, alongside rising temperatures, with marked implications for agricultural productivity and rural welfare. Perceived impacts varied across zones, with the Sudan and Northern Guinea Savannahs reporting the highest livelihood disruptions, including crop yield decline, property damage, flooding, and transportation challenges. Decline in crop yields emerged as the most severe impact, while increased temperatures and altered livelihood patterns were also widely acknowledged. Statistical analyses (Chi-square and ANOVA) confirmed significant associations between ecological zones and climate impacts, underscoring the heterogeneity of vulnerabilities. Despite widespread awareness, adaptive responses remain constrained by limited access to extension services, climate information, and financial resources. The study highlights the urgent need for zone-specific, evidence-based policies to strengthen resilience, safeguard food security, and reduce poverty among rural households in Taraba State.

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Introduction

Climate change has emerged as one of the most pressing global environmental challenges, with far-reaching impacts on human livelihoods, ecosystems, and sustainable development. The Intergovernmental Panel on Climate Change notes with high confidence that Africa is warming faster than the global average, and that changes in rainfall patterns, increased frequency of extreme events, and rising mean temperatures will disproportionately affect the continent because of its high dependence on climate-sensitive sectors and limited adaptive capacity [1]. Rural livelihoods in sub-Saharan Africa are especially vulnerable, given their reliance on rain-fed agriculture, fragile ecosystems, and low levels of socioeconomic resilience [2].

Nigeria is no exception. As the largest economy in Africa and home to a rapidly growing population, the country's food security, health, and economic stability remain highly exposed to climate variability. Agriculture contributes significantly to rural employment and income, yet the sector faces multiple stressors, including erratic rainfall, rising temperatures, desertification, flooding, and soil fertility decline [3]. The interplay of these climate-induced risks with pre-existing socioeconomic challenges such as poverty, weak infrastructure, and limited access to credit and technology further aggravates vulnerability among smallholder farmers [4].

Taraba State in northeastern Nigeria represents a microcosm of these dynamics. The state is endowed with diverse agroecological zones including derived savanna, Sudan savanna, and montane/highland systems each defined by distinct climatic and ecological characteristics [5]. This ecological diversity underpins rural livelihood activities such as crop cultivation (maize, yam, rice, cassava), livestock rearing, fishing, and non-farm enterprises. However, emerging evidence points to considerable variability in rainfall onset, cessation, and distribution across the state, alongside rising minimum and maximum temperatures [6]. In Central Taraba, rainfall patterns have become increasingly erratic, with prolonged dry spells and frequent flooding disrupting planting cycles and reducing agricultural yields [7]. In Wukari, rainfall variability analyses reveal statistically significant increases in late-season precipitation, complicating farmers' traditional cropping calendars [8].

Equally important are farmers' perceptions and adaptive responses. Studies show that farmers in Taraba generally recognize shifting rainfall and temperature patterns, associating them with low crop yields, pest outbreaks, and reduced livestock productivity [9]. However, adaptive responses remain constrained by low access to extension services, inadequate climate information, limited financial resources, and socio-cultural barriers [3]. These findings underscore that while awareness of climate change is widespread, the ability to translate this awareness into effective adaptation strategies remains weak [5,10].

Beyond agriculture, climate variability also exacerbates food insecurity in Taraba State. Ike (n.d.) reported that over 90% of households in the state were food insecure, with households exposed to extreme climate events being three times more likely to suffer acute food shortages than those unaffected. These realities highlight how climate shocks cascade through agricultural production, income streams, and household welfare, deepening poverty and undermining resilience.

Problem Statement

Although there is growing evidence of climate variability and its impacts on agriculture in Taraba State, knowledge gaps remain concerning how these changes are experienced across the state's distinct agroecological zones. Existing studies have largely focused on climatic trend detection in specific locations (e.g., Gembu, Wukari, or Central Taraba), or on farmer perceptions of climate change, without integrating these perspectives into a comprehensive understanding of livelihood outcomes across ecological gradients [3,5,7-9]. Few studies have systematically linked observed climatic trends with household-level livelihood vulnerabilities, coping mechanisms, and adaptive responses in Taraba's agroecological zones.

This gap is critical because climate impacts are not uniform: the derived savanna, Sudan savanna, and highland zones experience distinct rainfall and temperature dynamics, leading to differentiated vulnerabilities and adaptive capacities. Without robust, zone-specific evidence, policy interventions risk being generic, poorly targeted, or ineffective in addressing localized challenges. In particular, interventions that fail to account for agroecological diversity may reinforce existing inequalities, leaving the most vulnerable households behind.

Therefore, there is an urgent need for research that integrates climatic trend analyses with household-level livelihood assessments across Taraba State's agroecological zones. Such research will provide spatially explicit insights into how climate variability shapes rural livelihoods, highlight adaptation gaps, and inform targeted policy and development interventions. This study addresses that need by examining the impacts of climate change variability on the livelihoods of rural households across Taraba's agroecological zones, thereby contributing evidence to support context-specific resilience strategies.

Conceptual Framework

The conceptual framework (Figure 1) illustrates the linkages between climate variability, livelihood systems, adaptation strategies, and the role of institutions in shaping resilience among rural households in the agroecological zones of Taraba State, Nigeria. It draws on the Sustainable Livelihoods Framework and integrates insights from climate livelihoods literature in Sub-Saharan Africa [11,12].

Climate variability is the primary external stressor influencing livelihoods. Key manifestations include rising temperatures, shifts in rainfall onset and cessation, and the increased frequency of extreme events such as droughts, floods, and dry spells. These climatic changes disrupt ecological balance, agricultural productivity, and water availability [1]. In Nigeria, rainfall variability has become more pronounced, particularly in agroecological transition zones, exposing rural farming communities to recurrent shocks [12,13].

Climate variability undermines livelihood capitals in multiple ways. Natural capital is degraded by soil erosion, deforestation, drought, and flooding. Physical capital, such as irrigation infrastructure, storage facilities, and farm tools, is damaged during extreme weather events, further limiting productive capacity [14]. Human capital, including knowledge, skills, and health, is affected by climate-induced diseases and reduced labor productivity. Financial capital diminishes as crop failures reduce income, savings, and access to credit [15]. Social capital, expressed through community networks and traditional institutions, is strained under climate stress but can also serve as a buffer against vulnerability [16].

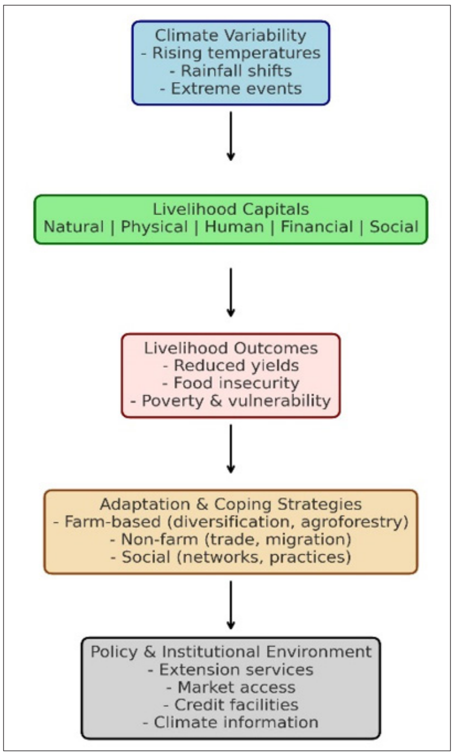

Figure 1: Conceptual Framework Linking Climate Variability, Livelihoods, and Adaptation in Taraba State

The erosion of livelihood capitals translates into negative livelihood outcomes. These include reduced agricultural yields due to erratic rainfall, food insecurity as harvests decline, and increased poverty and vulnerability among rural households [17]. Such outcomes reinforce a cycle of exposure and sensitivity to climate risks, leaving resource-poor households with limited adaptive capacity [18].

In response, households employ various adaptation and coping strategies. Farm-based strategies include changing planting dates, adopting drought-tolerant crops, intercropping, and practicing agroforestry [19]. Non-farm strategies such as petty trade, wage labor, and migration provide alternative income streams when agriculture fails. Social strategies include reliance on kinship ties, informal savings groups, and indigenous coping practices [20]. While these strategies help households cope in the short term, their effectiveness is often constrained by limited access to climate information, extension services, and financial support. The policy and institutional environment play a critical mediating role. Extension services provide technical support and disseminate climate-smart practices. Market access enables households to generate income and reinvest in resilience measures. Access to credit facilities enhances financial capacity for adaptation investments. Climate information systems improve decision-making by providing timely forecasts [21]. Effective institutional support transforms household adaptation from reactive coping into proactive resilience building, while weak institutions exacerbate vulnerability and poverty traps [16].

Overall, the framework emphasizes that climate variability is not only an environmental issue but also a multidimensional challenge that interacts with household assets, livelihood activities, and governance systems. Adaptation pathways are shaped by both internal capacities (livelihood capitals) and external enablers (policies and institutions). Understanding these linkages within Taraba's agroecological zones provides critical insights into how climate shocks affect rural livelihoods and where interventions are most urgently needed.

Methodology

The study was conducted across seven Local Government Areas (LGAs) of Taraba State, Nigeria: Lau, Karim Lamido, Gassol, Gashaka, Bali, Kurmi, and Sardauna. These LGAs were purposively selected to capture the ecological diversity of the state, ranging from the Sudan Savannah through the Guinea Savannah to the Montane zone. The area is predominantly agrarian, with livelihoods heavily dependent on rain-fed agriculture, making it highly sensitive to climate variability.

Primary Data were Obtained through Three Complementary Approaches

- **Focus Group Discussions (FGDs):** Conducted in each of the seven LGAs, with a minimum of six participants in each session. Participants included community leaders and household heads who had resided in the communities for at least 30 years. Both men and women were included to ensure gender-balanced perspectives. Discussions focused on historical and current climate change patterns, past environmental disasters, livelihood vulnerability, resilience, and local adaptation strategies.
- **Key Informant Interviews (KIIs):** Conducted with selected stakeholders, including government and non-governmental organizations, community-based organizations, traditional leaders, and academics. These interviews explored institutional roles, policy interventions, and local coping mechanisms in addressing climate variability.
- **Field Observations:** A systematic reconnaissance survey was carried out in all study LGAs to establish baseline information on socio-economic conditions, livelihood activities, and environmental challenges. Observations focused on visible climate change impacts, available resources, and adaptive capacities within communities.

Secondary data were obtained from existing population records, published literature, institutional reports, and meteorological data. These complemented primary data by providing historical records of temperature and rainfall trends, as well as demographic and ecological profiles of the study areas.

The total projected population of the selected LGAs for 2023 was 1,961,136, based on National Population Commission data [22]. Table 1 presents the population distribution by LGA, ecological zone, and the corresponding sample sizes.

Table 1: Population of the Study Areas [22].

Agro-ecological Zone	LGA	2006 Population	2023 Projected Population	Sample Size
Sudan Savannah	Karim Lamido	193,924	331,273	180
	Lau	95,190	162,610	88
Northern Guinea Sav.	Gassol	245,086	418,671	228
	Gashaka	87,166	148,902	81
Southern Guinea Sav.	Bali	211,024	360,485	196
	Kurmi	91,282	155,934	85
Montane	Sardauna	224,357	383,261	209
Total		1,148,029	1,961,136	1,067

Population projections were made using Mehta's growth model, which adjusts base-year population by applying the annual growth rate [23]. A sample size of 1,067 household heads was adopted, based on a 5% margin of error at a 95% confidence level, as recommended by Saunders [24]. This ensured adequate representation of the population across the LGAs. The study employed proportional allocation sampling to ensure that the number of respondents drawn from each LGA reflected its share of the total population. The formula used was:
each LGA. The formula used is:
$Qi = (Fi / P) \times N$ (2)
Where:
Qi = The number of respondents selected from each LGA
Fi = Population of each LGA (see Table below)
P = Total population of all LGAs
N = Total required sample size (384)
By substituting the values in equation 2, the sample size for each LGA is calculated as follows:
Lau = (162,610/1,961,136) × 1,067 = 88 respondents
Karim Lamido = (331,273/1,961,136) × 1,067 = 180 respondents
Gassol = (418,671/1,961,136) × 1,067 = 228 respondents
Gashaka = (148,902/1,961,136) × 1,067 = 81 respondents
Bali = (360,485/1,961,136) × 1,067 = 196 respondents
Kurmi = (155,934/1,961,136) × 1,067 = 85 respondents
Sardauna = (383,261/ 1,961,136) × 1,067 = 209 respondents
Total Sample Size: 1,067 respondents

Data were collected using structured questionnaires, FGDs, and KIIs. The questionnaires included both closed- and open-ended items and targeted household heads aged 40 years and above with at least 30 years of residency. A reconnaissance survey was conducted prior to the main data collection to familiarize the researcher with the socio-economic, cultural, and ecological context, and to build rapport with community leaders and organizations.

Meteorological data (rainfall and temperature) covering the study period were analyzed using Microsoft Excel (2013) and SPSS v21.

- **Trend Analysis:** Linear trend lines and equations were generated to examine changes in rainfall and temperature over time.
- **Onset, Cessation and Length of Rainy Season:** Determined using Walter's method, considered suitable for Nigerian rainfall patterns [25,26].
- **Seasonality Index:** Calculated following Walsh and Lawler to capture the spread and variability of rainfall during the wet season [27].

- **Standard Deviation Analysis:** Used to assess deviations from mean rainfall and temperature, thereby highlighting climate anomalies.

To assess community perceptions of climate change impacts, a five-point Likert Scale (LS) was employed, ranging from *strongly agree (5) to strongly disagree (1)*. A mean score of 3.0 was used as the threshold: values below 3.0 indicated lesser impacts, while values equal to or above 3.0 indicated greater perceived impacts of climate change.

Result of the Findings

Perceived Impacts of Climate Variability on Rural Livelihoods

Table 2 presents the perceived impacts of climate change variability across the four agroecological zones of Taraba State. The Northern Guinea Savannah recorded the highest mean perception score (3.94), closely followed by the Sudan Savannah (3.89). By contrast, the Southern Guinea (3.15) and Montane zones (3.22) reported relatively lower mean scores.

Table 2: Perceived Impacts of Climate Change Variability on the Livelihoods of Rural Households

	Sudan Savannah	Northern Guinea Savannah	Southern Guinea Savannah	Montane	Mean	Rank
Climate change has resulted to decline in crop yields	4.6245	4.3398	4.2740	4.3493	4.3969	1st
Climate change has led to increase temperature	3.6989	4.1133	3.1851	3.3158	3.5782	2nd
Climate change has led to changes in livelihood pattern	3.8587	3.9159	3.1032	2.9569	3.4587	3rd
Climate change led to damage to buildings and other property	4.1970	3.7735	2.8078	2.9904	3.4422	4th
Climate change has led to disruption of transportation	3.4349	3.8997	3.1317	3.1244	3.3977	5th
Frequent occurrences of drought during the raining season	3.5688	3.7994	2.9110	2.9043	3.2959	6th
Frequent occurrences of floods during the raining season	3.8773	3.7184	2.6584	2.8660	3.2800	7th
Mean	3.8943	3.9371	3.1530	3.2153		
Rank	2nd	1st	4th	3rd		

Across all zones, the most significant impact was the decline in crop yields, with the highest average score of 4.40, suggesting that reduced productivity is the most widely recognized livelihood challenge. Other high-ranking impacts included increased temperature (mean = 3.58) and changes in livelihood patterns (mean = 3.46). Impacts such as damage to buildings and other property (mean = 3.44) and disruption of transportation (mean = 3.40) were particularly pronounced in the Sudan and Northern Guinea zones. Although less strongly perceived overall, the frequent occurrence of droughts (mean = 3.30) and floods (mean = 3.28) during the rainy season were still significant concerns, especially in the Sudan and Northern Guinea Savannahs.

These results highlight the uneven distribution of climate impacts, with households in the Sudan and Northern Guinea zones perceiving higher levels of livelihood disruption compared to their Southern and Montane counterparts.

Association Between Perceived Impacts and Agroecological Zones

Table 3. reports the results of Chi-square tests assessing the association between perceived climate impacts and agroecological zones. All listed impacts showed statistically significant associations ($p < 0.001$), indicating that experiences of climate change vary significantly by ecological context.

Table 3: Test of Association between the Impacts of Climate Change Variability on the livelihoods of rural households and the Agroecological Zones

	Value	Df	Asymp. Sig. (2-sided)
Climate change has resulted to decline in crop yields	75.355a	12	.000
Climate change has led to increase temperature	219.829a	12	.000
Climate change has led to disruption of transportation	175.044a	12	.000
Frequent occurrences of floods during the raining season	198.621a	12	.000
Frequent occurrences of drought during the raining season	148.337a	12	.000
Climate change has led to changes in livelihood pattern	167.538a	12	.000
Climate change led to damage to buildings and other property	205.999a	12	.000

The strongest associations were observed for increased temperature ($\chi^2 = 219.83$), damage to property ($\chi^2 = 205.99$), and flood occurrences ($\chi^2 = 198.62$). These results suggest that while all zones experience climate-related impacts, the intensity and type of impacts differ. For example, increased temperature and property damage were more strongly perceived in the Northern Guinea Savannah, whereas crop yield declines were more prominent in the Sudan Savannah. This finding confirms that ecological diversity plays a critical role in shaping household experiences of climate variability in Taraba State.

Variation in Perceptions of Climate Impacts Across Zones

The results of the ANOVA test (Table 4) further demonstrate statistically significant variations in perceived climate impacts among agroecological zones. All impact variables reported F-values significant at either the 0.05 or 0.01 level.

Table 4: Test of Variation on The Impacts of Climate Change Variability on the Livelihoods of Rural Households among the Agroecological Zones

	Climate change has resulted to decline in crop yields	Climate change has led to increase temperature	Climate change has led to disruption of transportation	Frequent occurrences of floods during the raining season	Frequent occurrences of drought during the raining season	Climate change has led to changes in livelihood pattern	Climate change led to damage to buildings and other property
Sudan Savannah	4.6343a	3.7052a	3.4403a	3.8843a	3.5784a	3.8694a	4.2052a
Northern Guinea Savannah	4.3398b	4.1133b	3.8997b	3.7184a	3.7994a	3.9159a	3.7735b
Southern Guinea Savannah	4.2740b	3.1851c	3.1317c	2.6584b	2.9110b	3.1032b	2.8078c
Montane	4.3493b	3.3158c	3.1244c	2.8660c	2.9043b	2.9569b	2.9904c
F-Value	9.124	45.742	23.156	70.626	33.156	43.739	67.033

Note: Means with different letters (a, b, c and d) are significantly different while those with the same letters are not significant
*F-Value is significant at 0.05
**F-Value is significant at 0.01
Ns=Not Significant Variation

The Sudan Savannah consistently reported the highest mean perception scores for impacts such as crop yield decline (4.63), property damage (4.21), and flood occurrences (3.88). The Northern Guinea Savannah showed the highest concern for increased temperature (4.11) and disruption of transportation (3.90). In contrast, the Southern Guinea Savannah and Montane zones reported significantly lower mean values across most impacts, suggesting either reduced exposure or lower perception of climate stressors in those areas. These results affirm that climate variability impacts are not uniform across Taraba State. Instead, they are strongly shaped by ecological conditions, with the Sudan and Northern Guinea zones facing the greatest livelihood vulnerabilities.

Discussion of Findings

This study found that declining crop yields are the most significant impact of climate variability across Taraba State. This outcome is consistent with global and regional studies that highlight the vulnerability of smallholder agriculture in sub-Saharan Africa to rainfall variability and temperature increases [2,17]. The IPCC also reported that climate-induced stressors, such as erratic rainfall and extreme heat, disproportionately undermine agricultural productivity in Africa [1]. These findings underscore the centrality of agriculture as the sector most at risk from climate variability, confirming earlier studies that smallholder farming systems remain highly sensitive to environmental change.

The results revealed heterogeneous impacts across Taraba's agroecological zones, with the Sudan and Northern Guinea Savannahs experiencing greater livelihood disruptions than the Southern Guinea and Montane zones. This finding corroborates earlier evidence that ecological transition zones often face the most pronounced climatic variability and livelihood risks [8,12]. The differences observed can be attributed to variations in rainfall distribution, soil fertility, and exposure to extreme events, highlighting the need for spatially nuanced adaptation strategies.

The close alignment between farmer perceptions and observed meteorological data in this study confirms that rural households accurately perceive climate variability. Farmers reported delayed rainfall, prolonged dry spells, and rising temperatures, which are consistent with empirical climate trend analyses in Taraba and neighboring regions [3,9]. This agreement demonstrates that local knowledge is a reliable source of climate information, validating earlier studies that emphasized farmers' capacity to observe and interpret environmental changes.

Unlike previous studies that emphasized widespread vulnerability across all ecological settings, this research recorded relatively lower perception scores in the Southern Guinea and Montane zones. Several factors may explain this divergence. Ecological buffering due to higher elevation and cooler climates likely reduces the perceived intensity of climate shocks in the Montane zone, while diversified livelihoods in the Southern Guinea zone may cushion households from agricultural losses [1,18]. These findings highlight the importance of recognizing localized ecological and socio-economic contexts when assessing vulnerability.

The study confirmed that although climate change awareness is widespread, adaptive capacity remains constrained by weak institutional support, inadequate extension services, poor access to credit, and limited climate information. These results are consistent with findings from Ethiopia, South Africa, and Nigeria, where enabling conditions such as finance, technology, and extension services strongly influence adaptation outcomes [14,19]. The persistence of these constraints underscores the need for targeted interventions that link awareness with actionable strategies to build resilience among rural households [28,29].

Conclusion

This study has shown that climate change variability poses significant threats to rural livelihoods across the diverse agroecological zones of Taraba State. The findings revealed that while all zones are affected, the Sudan and Northern Guinea Savannahs are the most vulnerable, experiencing severe declines in crop yields, increased temperatures, flooding, and property damage. The Southern Guinea and Montane zones, though relatively less affected, are not insulated from these impacts. These variations highlight that climate risks are unevenly distributed and closely linked to ecological conditions. Importantly, although farmers are aware of changing climate patterns, their capacity to adapt remains limited due to weak institutional support, poor access to credit, inadequate extension services, and insufficient climate information. Strengthening resilience therefore requires context-specific interventions that integrate local knowledge with climate-smart practices, improve access to resources, and enhance institutional frameworks. Such measures are critical to safeguarding food security, reducing poverty, and sustaining rural livelihoods in Taraba State.

Recommendations

Based on the findings of the study, the following recommendations were made;

- Promote Zone-Specific Adaptation Strategies: Policies and interventions should recognize the ecological diversity of Taraba State. Tailored climate-smart practices such as drought-tolerant crops in the Sudan Savannah and flood-resistant farming techniques in the Northern Guinea Savannah should be promoted to address localized vulnerabilities.
- Strengthen Institutional and Extension Services: Government and development agencies should enhance agricultural extension services to improve farmers' access to timely climate information, training, and modern technologies. Strengthening institutions at community and state levels will improve farmers' adaptive capacity.
- Facilitate Access to Financial and Resource Support: Expanding credit facilities, subsidizing farm inputs, and providing insurance schemes against climate risks will enable rural households to invest in adaptive measures, diversify income sources, and recover more quickly from climate shocks.
- Enhance Community-Based Resilience and Knowledge Sharing: Building on local knowledge systems, community-led adaptation initiatives should be encouraged, including cooperative farming, water resource management, and indigenous coping strategies. Supporting social networks will help households collectively manage risks and strengthen resilience.

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