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RESEARCH ARTICLE

VULNERABILITY ASSESSMENT OF RURAL COMMUNITIES TO CLIMATE CHANGE IN KOGI CENTRAL SENATORIAL DISTRICT, NIGERIA

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ABSTRACT

Rural communities in Kogi Central Senatorial District face acute vulnerability to climate change yet remain among the least studied in Nigerian climate literature. This study assessed vulnerability in eleven rural communities — Aku, Osara, Achioze, Okaito, Eviya, Adogo, Utoro, Ageva, Magongo, Ikuehi, and Egge — using the Livelihood Vulnerability Index–Intergovernmental Panel on Climate Change (LVI-IPCC) framework. A cross-sectional survey was administered to 233 household heads selected through stratified random sampling. Data were analysed across seven LVI components restructured into exposure, sensitivity, and adaptive capacity. Magongo (1.000) and Aku (0.944) emerged as most vulnerable; Egge (0.000) and Ikuehi (0.247) recorded the lowest composite scores. Water access and food security were dominant sensitivity drivers. Chi-square tests confirmed significant relationships between socioeconomic characteristics and climate sensitivity. Analysis of variance and Kruskal-Wallis tests, with Tukey post hoc analysis, confirmed that the highest-exposure communities experienced significantly depressed adaptive capacity, consistent with a vulnerability trap dynamic. Targeted investment in water infrastructure, livelihood diversification, and social networks is recommended for high-vulnerability communities.

Keywords: Climate vulnerability, livelihood vulnerability index – intergovernmental panel on climate change framework (LVI-IPCC), rural communities, adaptive capacity, Kogi Central Senatorial District

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1.0. INTRODUCTION

Climate change poses profound threats to ecological systems, human livelihoods, and sustainable development. The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report confirms that anthropogenic emissions have produced unprecedented changes in Earth's climate system, with sub-Saharan Africa bearing a disproportionate burden due to dependence on climate-sensitive sectors and constrained adaptive capacities (IPCC, 2021, 2022a). Nigeria is particularly vulnerable: its position at the Niger-Benue confluence makes Kogi State among the most flood-exposed states in the country (National Emergency Management Agency, 2024-2025), and the 2022 floods displaced over 1.3 million people nationwide (United Nations Development Programme [UNDP], 2023).

Kogi Central Senatorial District sits at the intersection of multiple livelihood vulnerabilities. Its rural communities depend on smallholder rain-fed agriculture, artisanal fishing, and petty trade — activities inherently sensitive to climate variability. Despite this, the district has received little systematic empirical attention. No previous study has applied the full LVI-IPCC framework — integrating exposure, sensitivity, and adaptive capacity — to rural communities in Kogi Central.

This study addresses that gap across eleven communities: Aku, Osara, Achioze, Okaito, Eviya, Adogo, Utoro, Ageva, Magongo, Ikuehi, and Egge. Four research questions guide the study: (a) What are the major climate hazards and how are households differentially exposed? (b) How sensitive are households in terms of livelihood dependence and socioeconomic conditions? (c) What is the level of adaptive capacity and which factors most strongly influence vulnerability? (d) What is the composite vulnerability index of each community? Two null hypotheses are tested using inferential statistics.

2.0. Conceptualization and Theoretical Framework

2.1. Conceptualization

The LVI-IPCC Framework

The IPCC (2022b) defines vulnerability through three dimensions: exposure (the nature and degree of climate stressors), sensitivity (the degree to which the system is affected), and adaptive capacity (the ability to adjust and cope). The LVI, developed by Hahn et al. (2009), quantifies these dimensions through seven major components: socio-demographic profile, livelihood strategies, social networks, health, food security, water, and natural disasters and climate variability. The LVI-IPCC adaptation restructures these components — adaptive capacity (socio-demographic, livelihood, social networks), sensitivity (health, food security, water), and exposure (natural disasters and climate variability) — facilitating policy-relevant comparison (Hahn et al., 2009; Pandey & Jha, 2012).

Four theoretical frameworks underpin the study, each directly informing the analytical design and interpretation of findings. The Hazard-of-Place Model (Cutter, 1996) conceptualises vulnerability as the intersection of biophysical risk and social vulnerability within a specific location, shaping the study's differentiation of communities by ecological setting — riverine, valley, and upland. Its expectation that place-based risk interacts with social disadvantage is confirmed by the finding that riverine communities combine high exposure with low adaptive capacity. Sen's (1981) entitlement theory holds that livelihood collapse during hazard events results from erosion of exchange entitlements, directly reflected in the finding that lower-income, lower-education households record the highest sensitivity scores. The pressure and release model (Blaikie et al., 1994; Wisner et al., 2004) traces vulnerability from macro-scale political-economic root causes to household-level unsafe conditions, evident in decades of infrastructure underinvestment that produced the water insecurity and livelihood fragility documented here. Ostrom's (2009) social-ecological systems framework supports the study's finding that communities with weak social networks — such as Aku and Osara — display the weakest adaptive capacity, and underpins the recommendation for investment in community institutions as an adaptation strategy.

3.0. MATERIALS AND METHODS

3.1. Study Area

Kogi Central Senatorial District, located between latitudes 6°30'N–8°40'N and longitudes 5°30'E–7°49'E, encompasses the Local Government Areas of Okene, Okehi, Adavi, Ogori-Magongo, and parts of Ajaokuta, covering approximately 4,700 km². Tropical savanna climate (Aw) produces a wet season (April–October) and dry season (November–March), with mean annual rainfall of 1,100–1,600 mm and temperatures of 24°C–32°C. Deforestation has reduced forest cover by an estimated 40% between 1990 and 2020, intensifying flood peak flows (Aladejana & Ebijuoworih, 2024). The dominant Ebira ethnic group depends on smallholder farming, artisanal fishing, and petty trade.

3.2. Research Design

A descriptive cross-sectional survey design was adopted in this study. The rationale is to create a better avenue for appropriate assessment and systematic spatial comparison of the phenomenon across multiple communities as contextualized in Hahn et al. (2009) and Creswell & Clark (2017).

3.3. Community Selection and Sampling

Eleven communities were purposively selected using five criteria: ecological diversity (riverine — Magongo, Aku, Okaito; valley — Osara, Adogo, Utoro, Achioze; upland — Ageva, Eviya, Ikuehi, Egge); livelihood heterogeneity; settlement size variation; documented climate hazard exposure; and representation across the five Local Government Areas.

Household counts from community records and cross-checked against Local Government Area registers, yielded an estimated population of approximately 2,750 households. It is acknowledged that rural Nigerian community records carry inherent estimation error; the sample size should therefore be understood as an approximation. Yamane's (1967) formula at 95% confidence yielded a minimum sample of 233 household heads. Stratified random sampling apportioned respondents proportionally across communities; systematic random sampling was applied within each stratum.

3.4. Data Collection, Quality Control, and Analysis

A structured questionnaire incorporating 47 primary indicators adapted from Hahn et al. (2009) was pre-tested with 20 households, yielding a Cronbach's alpha of .79. Six research assistants completed a two-day training workshop covering questionnaire administration, informed consent procedures, and Ebira-language protocols. Data quality was maintained through daily questionnaire review, 10% back-checking of completed forms, and exclusion of eight questionnaires with more than 10% missing data. Table 1 summarizes the LVI components and sub-indicator domains.

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Table 1: Summary of LVI Components, Sub-Indicator Domains, and IPCC Vulnerability Dimensions

LVI Component	Sub-Indicator Domains	IPCC Dimension
Socio-Demographic	Dependency ratio, household size, sex of head, educational attainment	Adaptive Capacity
Livelihood Strategies	Livelihood diversity, income level, off-farm employment	Adaptive Capacity
Social Networks	Group membership, remittance access, social support	Adaptive Capacity
Health	Illness incidence, health facility access, expenditure	Sensitivity
Food Security	Dietary diversity, months of food adequacy, crop failure	Sensitivity
Water	Distance to source, water quality, seasonal shortage	Sensitivity
Natural Disasters	Flood frequency, drought, storm damage, seasonal shift	Exposure

Note: Adapted from Hahn et al. (2009).

Sub-indicator scores were standardized using: Sub-indicator score = (observed value - minimum value) / (maximum value - minimum value). Major component scores were computed as simple averages, then grouped into three IPCC dimensions. The composite LVI-IPCC score was calculated as: Composite Score = (Exposure - Adaptive Capacity) x Sensitivity. Where adaptive capacity exceeds exposure, this formula produces negative pre-normalization values. All scores — including negative values — were subjected to min-max normalization, rescaling to a 0–1 range. A score of 0.000 indicates the lowest composite score among the eleven communities, not the absence of vulnerability; component-level scores must be read alongside composite rankings.

Hypothesis one was tested using Chi-square tests of independence. Where expected cell frequencies fell below five, adjacent categories were collapsed (Field, 2018). Hypothesis Two was tested using One-Way ANOVA (where Shapiro-Wilk confirmed normality) and Kruskal-Wallis tests (where normality was violated), with Tukey's HSD post-hoc test applied to significant ANOVA results. All analyses used SPSS at a significance level of 0.05.

4.0. PRESENTATION OF RESULTS AND DISCUSSION

4.1. Presentation of Results

Analysis of Socio-Demographic Profile

Table 2 presents community-level socio-demographic characteristics. Dependency ratios were uniformly high (0.80–0.99). Primary education was the most common attainment level in nine of eleven communities. Mean monthly income ranged from NGN 24,600 (Egge) to NGN 43,500 (Magongo). Female-headed households were most prevalent in upland communities (Egge: 41.2%; Eviya: 38.7%) compared to riverine communities (Magongo: 18.3%; Aku: 21.6%).

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Table 2: Socio-Demographic Profile of Household Heads by Community

Community	Dep. Ratio	Prim. Educ. or Below (%)	Mean Income (NGN)	Female-Headed HH (%)
Magongo	0.80	48.3	43,500	18.3
Aku	0.84	61.7	38,200	21.6
Okaito	0.86	64.2	36,800	24.1
Osara	0.88	67.5	34,600	27.3
Adogo	0.89	69.1	33,100	29.8
Utoro	0.91	52.4	37,400	26.5
Achioze	0.93	71.3	30,700	31.2
Ageva	0.94	73.8	28,900	33.6
Eviya	0.96	76.4	27,300	38.7
Ikuehi	0.97	78.1	26,100	36.4
Egge	0.99	81.6	24,600	41.2

Note: Field Survey (2026).

LVI Component Scores

Table 3 presents normalised LVI component scores. Water access was the highest-scoring sensitivity sub-component across all communities, reflecting absent pipe-borne supply, severe seasonal shortages, and flood-related contamination. Food security was the second most critical sensitivity driver, attributable to rain-fed agriculture dependence and growing season disruption. Health scores were highest in riverine communities. Exposure followed a clear geographic gradient: Magongo (0.750), Aku (0.730), and Okaito (0.690); upland communities recorded lower exposure: Egge (0.500) and Ikuehi (0.530). Adaptive capacity was lowest in communities with low livelihood diversification, weak social networks, and high proportions of female-headed households.

Table 3: Normalized LVI Component Scores by Community and IPCC Vulnerability Dimension

Community	Socio-Dem.	Livelihood	Soc. Networks	Adapt. Cap.	Health	Food Sec.	Water	Sensitivity	Exposure
Magongo	0.712	0.648	0.703	0.688	0.741	0.812	0.893	0.815	0.750
Aku	0.734	0.671	0.724	0.710	0.718	0.796	0.874	0.796	0.730
Okaito	0.698	0.612	0.681	0.664	0.703	0.774	0.851	0.776	0.690
Osara	0.721	0.634	0.698	0.684	0.687	0.758	0.832	0.759	0.670
Adogo	0.683	0.598	0.664	0.648	0.671	0.741	0.814	0.742	0.650
Utoro	0.614	0.541	0.597	0.584	0.632	0.694	0.763	0.696	0.620
Achioze	0.587	0.514	0.571	0.557	0.608	0.667	0.734	0.670	0.590
Ageva	0.561	0.489	0.543	0.531	0.581	0.638	0.702	0.640	0.560
Eviya	0.534	0.463	0.517	0.505	0.549	0.601	0.661	0.604	0.580
Ikuehi	0.498	0.427	0.481	0.469	0.512	0.563	0.619	0.565	0.530
Egge	0.612	0.538	0.594	0.581	0.524	0.576	0.633	0.578	0.500

Note: Computed by Researcher (2026).

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Composite Vulnerability Ranking

Table 4 presents pre-normalization and normalized composite scores, vulnerability classification, and intervention priority for all eleven communities.

Table 4: Composite LVI-IPCC Scores and Community Vulnerability Rankings

Rank	Community	Exposure	Adapt. Cap.	Sensitivity	Pre-Norm.	Norm. (0-1)	Class.	Priority
1	Magongo	0.750	0.688	0.815	0.0505	1.000	Very High	Highest
2	Aku	0.730	0.710	0.796	0.0159	0.944	Very High	Highest
3	Okaito	0.690	0.664	0.776	0.0202	0.873	High	High
4	Osara	0.670	0.684	0.759	-0.0106	0.812	High	High
5	Adogo	0.650	0.648	0.742	0.0015	0.783	High	High
6	Utoro	0.620	0.584	0.696	0.0250	0.641	Moderate	Standard
7	Achioze	0.590	0.557	0.670	0.0221	0.526	Moderate	Standard
8	Ageva	0.560	0.531	0.640	0.0186	0.458	Moderate	Standard
9	Eviya	0.580	0.505	0.604	0.0454	0.372	Moderate	Standard
10	Ikuehi	0.530	0.469	0.565	0.0344	0.247	Low	Standard
11	Egge	0.500	0.581	0.578	-0.0469	0.000	Low	Standard

Note: Computed by Researcher (2026).

Magongo (1.000) and Aku (0.944) were classified as very high vulnerability. Okaito (0.873), Osara (0.812), and Adogo (0.783) were classified as high. Utoro (0.641), Achioze (0.526), Ageva (0.458), and Eviya (0.372) were moderate. Ikuehi (0.247) and Egge (0.000) were low. Two communities — Osara and Egge — produced negative pre-normalization scores due to the formula's mathematical behaviour when adaptive capacity exceeds exposure. Egge's component scores (see Table 3) reveal significant latent vulnerability — high dependency ratio (0.99), lowest mean income (NGN 24,600), and highest proportion of female-headed households (41.2%) — that the composite index suppresses.

Hypothesis Testing

Assessment of Socioeconomic Characteristics and Climate Sensitivity

Table 5 presents chi-square results based on hypothesis one. All five socioeconomic variables showed statistically significant associations with household sensitivity. The strongest association was between income and sensitivity, $\chi^2(6) = 22.32$, $p = .001$, followed by education, $\chi^2(6) = 18.74$, $p = .005$. The first null hypothesis is rejected.

Table 5: Chi-Square Tests of Independence for Hypothesis One

Variables Compared	Chi-Sq.	df	p	Category Collapsing	Decision
Education vs. Sensitivity	18.743	6	0.005	No	Significant — Reject H0
Income vs. Sensitivity	22.316	6	0.001	No	Significant — Reject H0
Household Size vs. Sensitivity	9.814	4	0.044	No	Significant — Reject H0
Livelihood Type vs. Sensitivity	14.562	4	0.006	Yes — 3 collapsed to 2	Significant — Reject H0
Sex of Head vs. Sensitivity	7.213	2	0.027	Yes — 4 collapsed to 3	Significant — Reject H0

Note: SPSS Output, Field Survey (2026).

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The test for sex of household head versus sensitivity, $\chi^2(2) = 7.21$, $p = .027$, confirmed a significant association. Table 6 presents disaggregated sensitivity scores by sex of household head.

Table 6: Mean Sensitivity Scores Disaggregated by Sex of Household Head

Community	Male-Headed Mean Sensitivity	Female-Headed Mean Sensitivity	Difference
Magongo	0.798	0.863	+0.065
Aku	0.781	0.841	+0.060
Okaito	0.764	0.819	+0.055
Osara	0.748	0.801	+0.053
Adogo	0.731	0.784	+0.053
Utoro	0.682	0.731	+0.049
Achioze	0.657	0.704	+0.047
Ageva	0.627	0.671	+0.044
Eviya	0.591	0.634	+0.043
Ikuehi	0.553	0.594	+0.041
Egge	0.564	0.607	+0.043

Note: Computed by Researcher (2026).

Female-headed households recorded higher mean sensitivity scores in every community, with differences ranging from 0.041 (Ikuehi) to 0.065 (Magongo), reflecting more limited access to land, income diversification, and social network resources.

Evaluation of Adaptive Capacity across Exposure Groups

Table 7 presents ANOVA, Kruskal-Wallis, and post hoc results based on hypothesis two. All four comparisons were statistically significant. Tukey post hoc analysis revealed that the high-exposure group differed significantly from both the low-exposure group ($p = .001$) and the moderate-exposure group ($p = .012$), while the low- and moderate-exposure groups did not differ significantly ($p = .214$). The vulnerability trap dynamic is concentrated in the highest-exposure communities. The second null hypothesis is rejected.

Table 7: ANOVA, Kruskal-Wallis, and Post Hoc Tests for Hypothesis Two

Comparison	Test	Statistic	df	p	Post-Hoc (Tukey HSD)	Decision
Adaptive Capacity: Low vs Mod vs High	One-Way ANOVA	F=8.423	2	0.001	High vs Low: p=0.001; High vs Mod: p=0.012; Low vs Mod: p=0.214	Reject H0
Adaptive Capacity (non-normal)	Kruskal-Wallis	H=19.762	2	0.000	—	Reject H0
Social Network: Low vs Mod vs High	One-Way ANOVA	F=6.118	2	0.003	High vs Low: p=0.004; High vs Mod: p=0.031; Low vs Mod: p=0.187	Reject H0
Livelihood Diversity: Low vs Mod vs High	Kruskal-Wallis	H=15.334	2	0.000	—	Reject H0

Note: SPSS Output, Field Survey, (2026).

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4.2. Discussion of Findings

The very high vulnerability of Magongo and Aku reflects the convergence of high flood exposure, water and food insecurity, and critically low adaptive capacity from limited livelihood diversification and weak social networks. These findings are consistent with Aladejana and Ebijuoworih (2024), who documented significant expansion of flood-prone zones in Kogi State, and with Okeke et al. (2025), who found that flood-exposed households experience compound livelihood disruption eroding the adaptive resource base. The current study extends prior work by quantifying the specific contribution of social network weakness to adaptive capacity deficits, demonstrating that Magongo and Aku's vulnerability is not reducible to flood exposure alone.

The upland vulnerability paradox — in which Egge records a composite score of 0.000 despite significant structural disadvantage — exposes a known limitation of the LVI-IPCC formula (Nofiu & Baharudin, 2025): low exposure suppresses the composite score regardless of sensitivity and adaptive capacity values. This supports calls for supplementary component-level analysis alongside composite rankings (Comia et al., 2025) and underscores the pressure and release model's argument that root causes of vulnerability reside in political-economic marginalisation, not biophysical exposure alone.

The finding that income is the strongest predictor of sensitivity, $\chi^2(6) = 22.32$, aligns with Sallawu et al. (2022) and Okoro and Knight (2024). However, this study diverges from Folorunso (2024), who found livelihood type to be a stronger predictor than income in south-central Nigeria. The divergence may reflect income's mediating role in the Kogi Central context, where even diversified livelihood holders remain highly climate-sensitive at low absolute income levels. The post hoc finding that the vulnerability trap is concentrated in the highest-exposure communities — with no significant adaptive capacity difference between the low- and moderate-exposure groups ($p = .214$) — adds precision to earlier vulnerability trap arguments (Tofu et al., 2022; Zeleke et al., 2021) and has direct policy implications: generalised livelihood support programmes are less efficient than intensive targeted interventions in the highest-exposure communities.

The gender dimension — female-headed households recording higher sensitivity in all eleven communities across all three ecological zones — is consistent with Ayanlade et al. (2023) and Duru et al. (2022). The present study's contribution is demonstrating that this pattern is structural across ecological contexts, not setting-specific. Water access, the dominant sensitivity driver, is simultaneously the most tractable intervention point: unlike exposure, water sensitivity can be reduced through borehole construction, solar-powered pumping, and flood-resilient storage, with disproportionate benefit to female-headed households that bear the primary burden of water collection.

5.0. Conclusion and Recommendations

5.1. Conclusion

This study assessed the climate change vulnerability of eleven rural communities in Kogi Central Senatorial District using the LVI-IPCC framework, with data collected from 233 household heads. Magongo and Aku are the most vulnerable communities, driven by high flood exposure, severe water and food insecurity, and critically low adaptive capacity. Water access was the dominant sensitivity factor; income and education were the strongest socioeconomic determinants of sensitivity.

The upland vulnerability paradox confirms that composite scores must be read alongside component-level data. Female-headed households consistently recorded higher sensitivity across all eleven communities and three ecological zones, establishing gender as a structural dimension of vulnerability. Both null hypotheses were rejected, confirming that vulnerability is a structured outcome of socioeconomic inequality and inadequate institutional support.

5.2. Recommendations

This study makes the following recommendations.

First, very high and high vulnerability communities — Magongo, Aku, Okaito, Osara, and Adogo — should receive immediate targeted support including flood-resistant housing, early warning systems, and emergency preparedness, with particular urgency where the vulnerability trap has been confirmed.

Second, rural water infrastructure — boreholes, solar-powered pumps, and flood-resilient storage — should be the highest-priority adaptation investment across the district.

Third, adaptation programmes should prioritize women's access to land, credit, and income diversification to address the gender dimension of vulnerability confirmed across all ecological zones.

It is therefore necessary for future research should track vulnerability changes at regular intervals, extend the framework to the Kogi East and West Senatorial Districts, integrate LVI data with GIS flood hazard mapping, and explore formula modifications that prevent low exposure from suppressing composite scores where component data indicate significant structural disadvantage.

Conflict of interest

The author declares that no conflict of interest exist in this manuscript.

Artificial Intelligence (AI) Statement

The author states that Claude (Anthropic) was used to assist with manuscript drafting and structuring, organization of statistical tables, and paraphrasing of passages flagged in a similarity check, while preserving the underlying data, statistics, and references intact. AI was not used to design the study, collect or analyze the primary data, or generate the scientific findings and interpretations — these are entirely the author's own work based on field survey data and standard statistical procedures (SPSS). All AI-assisted outputs were critically reviewed, verified, and edited by the author. The author takes full responsibility for the integrity, accuracy, and originality of the work.

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