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ASSESSMENT OF CLIMATE CHANGE VULNERABILITY AMONG HOUSEHOLDS IN KADUNA NORTH SENATORIAL DISTRICT, KADUNA STATE, NIGERIA

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ABSTRACT

Purpose: *This study assessed household vulnerability to climate change in Kaduna North Senatorial District, comprising eight Local Government Areas (LGAs) in Kaduna State. The aim was to identify vulnerability patterns across LGAs and the key socioeconomic and infrastructural factors influencing adaptive capacity.*

Design/methodology/approach: *Primary data were obtained through 385 structured questionnaires administered to household heads across two communities in the selected LGAs using simple random sampling technique. Descriptive statistics were used to analyze socioeconomic characteristics, while a vulnerability index was computed from normalized values of 20 indicators categorized under exposure, sensitivity, and adaptive capacity. Indicators were scaled between 0 and 1 based on their functional relationship to vulnerability.*

Findings: *The analysis revealed that Soba LGA (0.662) was the most vulnerable, followed by Kubau (0.641) and Kudan (0.525) respectively while Zaria (0.325) and Sabon Gari (0.299) were less vulnerable due to better access to infrastructure and essential services. Communities characterized by low literacy, poor access to agricultural inputs, inadequate healthcare and veterinary services, and long distances to markets and credit facilities exhibited higher vulnerability to climate impacts.* ***Research limitations/implications:*** *The study relied on household-level cross-sectional data. Broader longitudinal studies incorporating additional environmental and institutional indicators could provide deeper insights.*

Practical implications: *Findings underscore the need for targeted interventions in LGAs with moderate to high vulnerability, focusing on improving education, agricultural input distribution, healthcare, market access, and credit facilities.*

Originality/value: *The study contributes empirical evidence on household vulnerability using a structured index approach and provides actionable insights for policy and climate adaptation planning in northern Nigeria.*

Keywords: Climate change; vulnerability; impacts; households; assessment

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1.0 INTRODUCTION

Climate change poses one of the most pressing socioeconomic and environmental challenges of our time, as evidenced by extensive observations of its accelerating impacts over recent decades (IPCC, 2022). The concept of vulnerability, rooted in geography and natural hazards research, is applied diversely across academic disciplines, reflecting specialized perspectives and contexts. Vulnerability generally refers to the susceptibility to uncertainties and stresses, encompassing both external exposures to climate-related risks and internal fragility, which denotes the capacity to adapt without incurring harm (Adger et al, 2021). In climate change studies, vulnerability serves to measure the extent of damage or potential damage a region or ecosystem faces from climate impacts (Lim & Vos, 2022).

A vast amount of climate change related research has been conducted by various scholars in northern Nigeria. These are mostly related to perception and adaptation studies related to agriculture. In Kaduna State, important information on vulnerability to climate change is very much needed. This lays the groundwork for this study specifically focusing on the eight Local Government Areas (LGAs) that make up Kaduna North Senatorial District of the State. The research aims to assess the vulnerability of households to climate change in the eight Local Government Areas that make up Kaduna North Senatorial District in Kaduna State.

The potential sectors considered most vulnerable in Nigeria include agriculture, public health, water resources, biodiversity and habitat. The coasts are considered the most vulnerable regions together with erosion and desertification-prone areas of the country. Vulnerable groups include women, children, the elderly, farmers, fishers and poor people living in urban areas. The frequency and intensity of severe weather events are expected to increase because of climate change. An increase in flood and coastal erosion is expected to occur due to sea level rise. The infrastructure needed to adequately respond to such events is lacking in many states in Nigeria. Diseases like malaria and typhoid are likely to have wider extents, affecting more people especially the poor who are at risk already (Adger et al, 2021).

Various research has been conducted in Northern Nigeria on climate change and its impacts especially on agriculture. In Kaduna state, Abaje et al (2015) conducted research assessing rural communities' vulnerability to climate change. The communities sampled in their research were Sanga, Kagarko, Kajuru, Kauru, Soba, and Ikara, which are Local Government Areas across the state. This research however concentrates on one of the three Senatorial Districts in the state, focusing on the eight LGAs that make up the district.

2.0 LITERATURE REVIEW

The Intergovernmental Panel on Climate Change (IPCC, 2021) defines climate change as long-term alterations in temperature and typical weather patterns in a place, which may be due to natural variability or a result of human activities, especially those that increase greenhouse gas concentrations in the atmosphere. These changes can be identified through statistical analysis and tend to persist for decades or longer

Vulnerability refers to the state of being open to injury, harm or damage. A system's capacity to cope or assimilate stress or shocks and to recuperate determines its degree of vulnerability. Climate change presents a significant challenge to Nigeria, exacerbating existing vulnerabilities and posing threats to its economy, environment, and population. Nigeria, with its diverse climate zones ranging from the arid Sahel region in the north to the humid rainforests in the south, is particularly susceptible to the impacts of climate change. The country faces various climate-related risks, including increased temperatures, changing rainfall patterns, and extreme weather events such as floods, droughts, and storms. These changes have profound implications for agriculture, water resources, public health, and infrastructure, putting millions of people at risk of food insecurity, water scarcity, and displacement (World Bank, 2021).

One of the most pressing concerns in Nigeria is the impact of climate change on agriculture, which employs a significant portion of the population and contributes substantially to the country's GDP. Changes in temperature and rainfall patterns are already affecting crop yields, with projections indicating further reductions in the future. Smallholder farmers, who rely heavily on rain-fed agriculture, are particularly vulnerable to these changes. The decrease in agricultural productivity not only threatens food security but also exacerbates poverty and exacerbates rural-urban migration. Additionally, extreme weather events such as floods and droughts lead to the destruction of crops, livestock, and infrastructure, further undermining the resilience of farming communities (Oluwagbemi & Eleyowo, 2020).

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2.1 THE STUDY AREA

The Kaduna North Senatorial District (Figure 1) is a significant administrative division situated in the northern part of Kaduna State, Nigeria. It encompasses eight local government areas which include Ikara, Kubau, Kudan, Lere, Makarfi, Sabon Gari, Soba and Zaria. Geographically, it lies within latitude 10° 20' N to 11° 00' N and longitude 7° 30' E to 7° 52' E. It is bordered by other senatorial districts of the state and sharing boundaries with neighboring states such as Katsina, Kano, Bauchi and Plateau, the district occupies a strategic position in the geopolitical landscape of northern Nigeria (NPC, 2019).

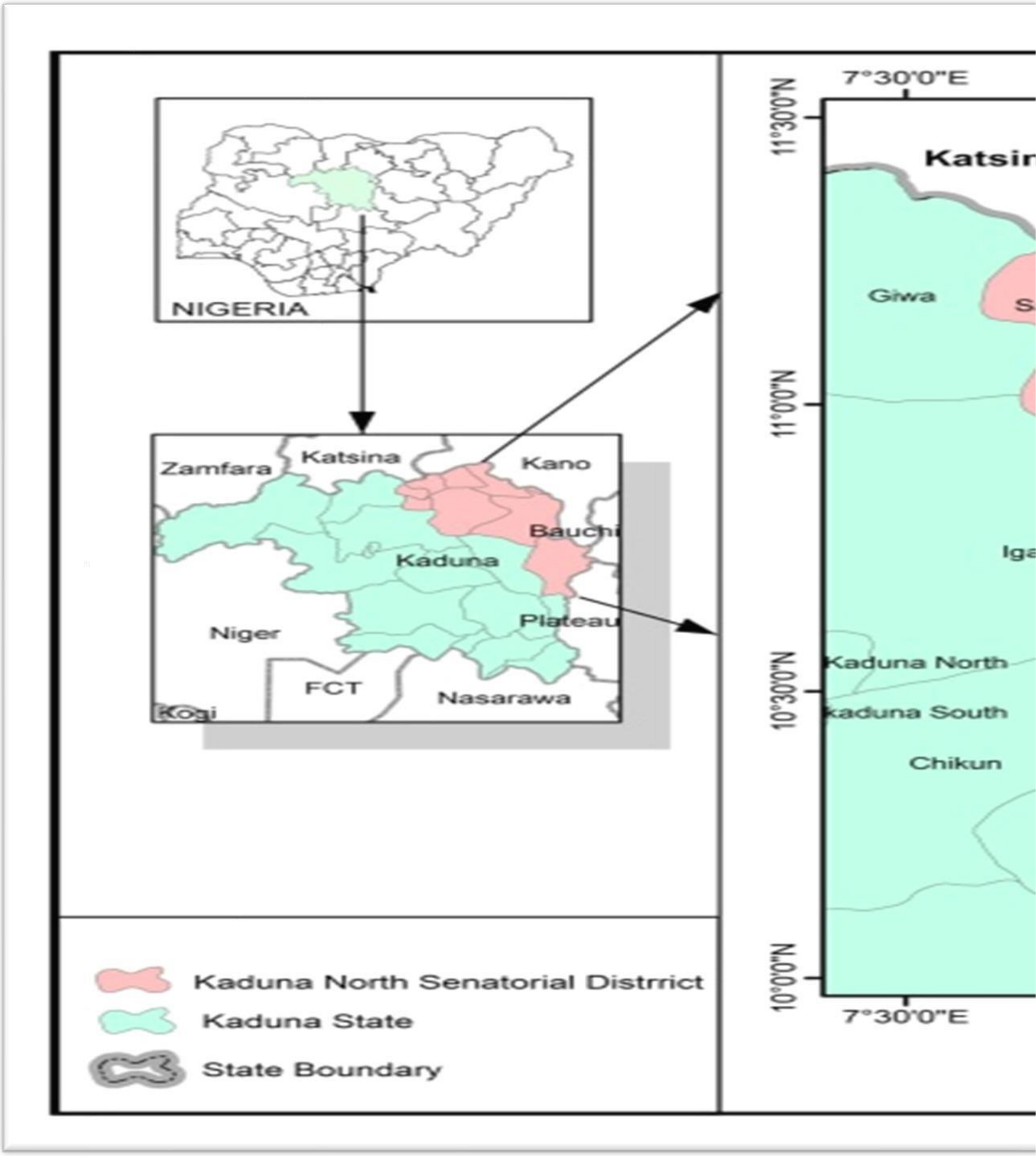

Figure 1: Kaduna State Showing the Study Area Source: Kaduna State Ministry of Lands and Survey

The climate of the region is characterized by a typical tropical savannah climate, featuring distinct wet and dry seasons. The region experiences a rainy season that typically spans from May to October, with the peak rainfall occurring between July and September. During this period, the district receives the majority of its annual precipitation, which ranges from approximately 900mm to 1,100mm. The dry season, on the other hand, extends from November to April, marked by hot and dry weather conditions. Average temperatures in the district range from 25°C to 35°C, with the hottest months usually occurring between February and April (Abaje & Oladipo, 2019).

The geological landscape of Kaduna North Senatorial District is predominantly characterized by crystalline rocks and sedimentary formations. The district is situated within the Nigerian Basement Complex, which comprises rocks dating back to the Precambrian era. These rocks, including granite, gneiss, and schist, form the underlying geological structure of the region. Additionally, sedimentary formations such as sandstones and shale are found in certain areas, especially along the boundaries with neighboring states (Okosun & Okonkwo, 2016).

3.0 METHODOLOGY

The area of study, which consists of the eight LGAs in Kaduna North Senatorial District (Ikara, Kubau, Kudan, Lere, Makarfi, Sabon Gari, Soba and Zaria) of Kaduna State, had a population of 2,090,218 people with an annual growth rate of 2.5% as recorded at the 2006 census (FRN, 2010). The Mehta (2004) method was used to project the figure to the year 2024, giving rise to an estimated total population of 3,260,113 people (Table 1).

This was necessary in determining the number of respondents required. The method is calculated as:

$P_n = P_o(1+R/100)^n$ ……………………..……………………………….…….Eqn.1

where: P_n= present year population

P_o= base year population R=

yearly growth rate n= number of

intermediary years.

Information and data for this study were collected from both primary and secondary sources. In determining the sample size for the questionnaire survey, Krejcie and Morgan (1970) method was used. The formula is given as:

$s = X^2 NP(1-P) \div d^2 (N-1) + X^2 P(1-P)$……………………….……..……..Eqn. 2

where: s = the sample size.

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level

N = the size of population. P = the population proportion

d = the degree of accuracy expressed as a proportion

(.05).

Based on this method, the recommended sample size of a population of 3,260,113, at 95% confidence level, and a margin of error of 5% would be 385.

The proportional distribution of respondents was attained using the formula:

Sample Size = n × 385 / N…………………………………………...………Eqn. 3

Where: n= Population of a community sampled

385 = Total number of sample size

N = Population of the whole communities sampled.

A sum of 385 copies of a questionnaire with 95% anticipated response rate were administered to the eight (8) LGAs of Kaduna North Senatorial District based on simple proportion (Table 1).

Table 1: Number of Respondents (Household Heads) in each LGA

LGA	Population (2006)	Projected Population (2024)	No. of Respondents
Ikara	194,723	303,709	36
Kubau	280,704	437,814	51
Kudan	138,956	216,730	26
Lere	339,740	529,893	63
Makarfi	146,574	228,611	27
Sabon Gari	291,358	454,431	54
Soba	291,173	454,143	53
Zaria	406,990	634,782	75
Total	**2,090,218**	**3,260,113**	**385**

A simple random sampling technique without replacement (SRSWOR) was used in sampling two (2) communities each in the eight LGAs. This was done to ensure equal chance of selection, statistical validity and generalizability. This method was employed by Abaje et al (2015). The structured questionnaires were purposively administered to household heads who are 40 years and above, and must have been residing in the community for at least three (3) decades. The purpose of this is to ascertain that the respondents have experienced the impacts of climate change over the years and are more aware and concerned about its effects on their environment and livelihood assets (Heltberg & Hamilton, 2019). Simple descriptive statistics were used to describe the socioeconomic characteristics of the respondents using Microsoft Excel 2019. In determining the degree of vulnerability of the people in the study area, the vulnerability index approach method as postulated by Ranganathan *et al.*, (2009) was adopted. This is because the method is based on various indicator sets that determine the vulnerability of an area and can be used at any scale to correlate the vulnerability of various places. A set of 20 indicators was selected for all the components of vulnerability (categorized under adaptive capacity, sensitivity and exposure) in each of the LGAs of the study (Table 2). Under this method, two types of functional relationships exist. When the observed values are related positively to the vulnerability, the normalization is achieved by using the formula:

$$Pij = \frac{Xij - Min(Xij)}{Max(Xij) - Min(Xij)} \quad \text{Eqn. 4}$$

But when the values are negatively related to vulnerability, computation of standardized scores was done using the formula:

$$Nij = \frac{Max(Xij) - Xij}{Max(Xij) - Min(Xij)} \quad \text{Eqn. 5}$$

where *Max* = Maximum indicator value
Min = Minimum indicator value
Xij = indicator value *j* corresponding to LGA *i*

Pij = standardized score for values that show a positive correlation with vulnerability
Nij = standardized score for values that show a negative correlation with vulnerability
All the standardized scores for the two types of functional relationships will lie between 0 and 1, with 1 corresponding to the LGA that is most vulnerable and 0 corresponding to the LGA that is least vulnerable. After computing the standardized scores, the *Vulnerability Index (VI)* is established by giving equal weights to all indicators using single mean of all the scores. The formula is given as:

$$VI = \frac{\sum_j Pij + \sum_j Nij}{K} \quad \text{..... Eqn. 6}$$

where VI = Vulnerability Index
Pij = standardized score for values that show a positive correlation with vulnerability
Nij = standardized score for values that show a negative correlation with vulnerability
K = number of indicators

The variables and indicators used to compute vulnerability indices are categorized into exposure, sensitivity, and adaptive capacity. Exposure is measured by the frequency of extreme climatic events, specifically floods and droughts, both of which positively influence vulnerability. Sensitivity factors include population density, civil insecurity, and pest/disease occurrence, which increase vulnerability, while irrigated land and fertilizer use reduce it. Adaptive capacity indicators, which inversely affect vulnerability, encompass farm size, literacy rate, crop production value, livestock ownership, and access to essential resources such as markets, insecticides/pesticides, improved seeds, veterinary, and healthcare services. Functional relationships indicate whether each factor increases (+) or decreases (−) vulnerability. Data on these indicators were sourced using structured questionnaire. The indices of vulnerability were utilized in ranking the LGAs in accordance to their degree of vulnerability. Finally, the vulnerability indices were modified into three classes (Table 2) in order to produce a vulnerability map of the study area.

Table 2: Vulnerability Classification Values

Index value	Vulnerability Degree
0.00 - 0.40	Low
0.41 - 0.60	Medium
0.61 - 1.00	High

Source: (Füssel & Birkmann, 2021).

4.0 DISCUSSION OF RESULTS

4.1 Socioeconomic Characteristics of Respondents

The findings reveal that the majority of respondents were male (94%), while only 6% were female. This male dominance is attributed to the tradition where household heads are usually men unless in cases of widowhood or divorce. In terms of age distribution, most respondents were between 40–49 years (43.1%) and 50–59 years (40.4%), with the average respondent being over 40 years of age. Marital status data shows that 89% of the respondents were married, 5.2% widowed, 3.9% divorced, and only 1.9% single.

Regarding educational attainment, over half (51%) of the respondents had Islamic (religious) education, 22.6% had secondary education, 15.5% had primary education, 7.5% attained tertiary education, and 3.4% had no formal education. The dominant form of schooling in the area is Islamic education, reflecting cultural and religious preferences prevalent in rural Northern Nigeria.

4.2 Vulnerability to Climate Change

The results of the 20 indicators used in assessing climate change vulnerability across the selected LGAs are presented on Table 3. The table reveals the indices and vulnerability ranks of each LGA in the study area. The vulnerability assessment revealed pronounced disparities in climate vulnerability across the LGAs studied. Soba LGA recorded the highest vulnerability index (0.662), making it the most susceptible to climate stressors. This elevated ranking reflects the convergence of high exposure - marked by increased temperatures, erratic rainfall, and frequent drought events as well as heightened sensitivity through densely populated communities and notable civil insecurity. Adaptive capacity indicators reinforce this picture: limited access to health services, veterinary support, and agricultural inputs coincides with reliance on informal microfinance, underscoring institutional fragility consistent with findings by Abaje et al. (2015), who noted similar challenges in infrastructure and input provision in Soba.

Kubau (0.641) and Kudan (0.525) LGAs follow closely in vulnerability ranking. Both areas exhibit moderate to high exposure to climatic extremes such as heatwaves and drought, coupled with restricted access to resources like health care, fertilizers, and veterinary services. This pattern aligns with regional studies demonstrating that limited adaptive capacity among smallholder farming communities amplifies vulnerability (Ogudu, 2018; Abaje et al., 2015), and mirrors trends observed in similar LGAs across the study area.

Table 3: Vulnerability index of the LGA

	Indicators	Local Government Areas								Average Index
		Sabon Gari	**Zaria**	**Lere**	**Makarfi**	**Ikara**	**Kudan**	**Kubau**	**Soba**	
Exposure	Change in Annual Rainfall	0.171	0.312	0.417	0.463	0.510	0.725	0.675	0.842	0.514
	Change in Min. Temp.	0.125	0.294	0.392	0.527	0.420	0.643	0.620	0.716	0.467
	Change in Max. Temp.	0.179	0.315	0.485	0.381	0.680	0.582	0.859	0.953	0.554
	Frequency of Floods	0.590	0.297	0.376	0.612	0.320	0.467	0.529	0.625	0.477
	Frequency of Droughts	0.198	0.284	0.503	0.295	0.590	0.819	0.711	0.578	0.497
Sensitivity	Population Density	0.256	0.298	0.328	0.748	0.240	0.354	0.797	0.491	0.439
	Civil Insecurity	0.093	0.301	0.451	0.334	0.460	0.693	0.366	0.967	0.458
	Occurrence of Pests/ Diseases	0.665	0.289	0.294	0.419	0.370	0.428	0.650	0.384	0.437
	Fertilizer Use	0.415	0.310	0.367	0.556	0.750	0.761	0.892	0.759	0.601
	Irrigated Land	0.296	0.295	0.512	0.203	0.180	0.295	0.425	0.263	0.309
Adaptive Capacity	Farm Holding Size	0.065	0.299	0.439	0.487	0.530	0.536	0.559	0.648	0.445
	Literacy Rate	0.205	0.303	0.283	0.362	0.290	0.672	0.736	0.327	0.397
	Crop Production	0.337	0.296	0.556	0.674	0.420	0.387	0.501	0.895	0.508
	Number of Livestock	0.570	0.302	0.321	0.291	0.360	0.514	0.629	0.412	0.425
	Distance to Nearest Market	0.472	0.292	0.498	0.538	0.610	0.629	0.753	0.536	0.541
	Insecticides/Pesticides Supply	0.198	0.309	0.354	0.127	0.200	0.243	0.780	0.781	0.374
	Improved Seed Supply	0.089	0.300	0.427	0.453	0.340	0.498	0.661	0.159	0.366
	Veterinary Services	0.270	0.288	0.389	0.315	0.470	0.357	0.255	0.924	0.409
	Health Care Services	0.156	0.290	0.465	0.000	0.000	0.000	0.422	0.980	0.289
	Microfinance/Access to Credit	0.630	0.826	0.103	0.455	0.820	0.897	1.000	1.000	0.716
Vulnerability Index		**0.299**	**0.325**	**0.398**	**0.412**	**0.428**	**0.525**	**0.641**	**0.662**	**0.461**
Rank		**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	

Note: 0.00 - 0.40 = Less Vulnerable 0.41 - 0.60 = Moderately Vulnerable 0.61 - 1.00 = Highly Vulnerable Source: Data Analysis (2025)

LGAs occupying the middle ranks (Ikara (0.428) and Makarfi (0.412)) experience moderately elevated vulnerability. Their exposure to temperature variability and pest outbreaks persists, though offset to an extent by somewhat better access to adaptive resources. Nevertheless, studies indicate that Ikara exhibits low adaptive capacity relative to other LGAs, due to limited credit access and low literacy, which constrain resiliencebuilding efforts.

At the lower end of the scale, Zaria (0.325) and Sabon Gari (0.299) LGAs are assessed as the least vulnerable. These areas benefit from relatively lower exposure and sensitivity, supported by stronger adaptive capacities, such as access to literacy, agricultural inputs, and urban health infrastructure—an observation corroborated by Ogudu's (2018) study emphasizing urban-rural health service differences in Zaria.

These findings resonate with the broader literature on climate vulnerability in Nigeria, where exposure, sensitivity, and capacity converge to determine risk profiles (Fothergill & Peek, 2004; Cutter et al., 2009; Smit & Wandel, 2006). Wealth, literacy, and infrastructure consistently emerge as critical determinants of a community's ability to adapt (Gbetibouo et al., 2010; Deressa et al., 2008) and explain much of the spatial heterogeneity observed across LGAs.

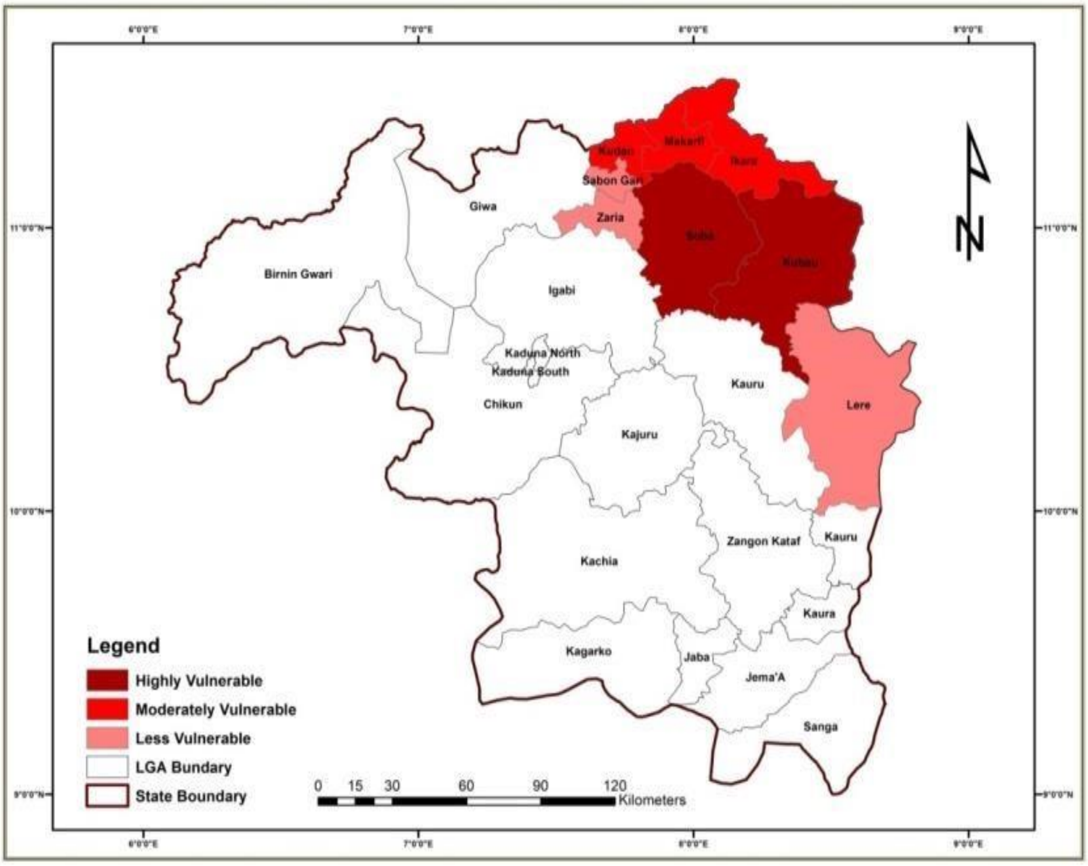

Figure 2: Map of Vulnerability Indices across the Local Government Areas

A detailed breakdown of the three vulnerability components in the study area indicates that exposure indices span from 0.467 to 0.554, averaging 0.502; sensitivity indices range between 0.437 and 0.601, with an average of 0.449; and adaptive capacity indices lie between 0.289 and 0.716, averaging 0.447. This profile suggests that exposure is the dominant factor influencing climate vulnerability in these rural communities. In other words, the primary drivers of their vulnerability are the increased frequency and severity of climatic stressors such as erratic rainfall, higher temperatures, and extreme weather events. This contrasts with earlier research—such as Prasertsak (2011) in Thailand, where adaptive capacity was the leading vulnerability component - and underscores a more pressing need in this region to focus on reducing climatic exposure (Prasertsak, 2011). Instead, the findings align with recent research in Nigeria showing that environmental exposure in rural areas is a major vulnerability driver, overshadowing both social sensitivity and the ability to adapt (Okoro & Knight, 2024).

5.0 CONCLUSION AND RECOMMENDATIONS

Climate change vulnerability in Kaduna North Senatorial District is not uniform across the eight LGAs, with significant variation based on levels of exposure, sensitivity, and adaptive capacity. The study identified Soba, Kubau, and Kudan LGAs as the most vulnerable due to high climatic exposure and limited access to critical resources such as healthcare, veterinary services, improved seeds, and agricultural inputs. The most affected groups are smallholder farmers and rural dwellers with low income, limited formal education, and large household sizes—factors that reduce their ability to adapt to climate-induced shocks.

Conversely, Sabon Gari and Zaria LGAs were found to be the least vulnerable, attributed to better infrastructure, higher literacy levels, and greater access to institutional support. The results underscore that exposure to extreme weather events—particularly erratic rainfall and increasing temperatures—is the most dominant factor influencing vulnerability in the region, more so than social sensitivity or adaptive capacity.

The study recommends prioritizing interventions in the most vulnerable LGAs—Soba, Kubau, and Kudan—by improving infrastructure, expanding healthcare access, and increasing the supply of agricultural inputs. It emphasizes the need for grassroots climate literacy campaigns to enhance community awareness, investment in irrigation and water management to reduce dependence on rain-fed farming, and scaling up access to microfinance, improved seed varieties, and veterinary services to support adaptive practices. Additionally, it calls for community-based adaptation plans that integrate indigenous knowledge and for strengthening early warning systems and disaster risk communication to improve responses to climate hazards. Collectively, these measures aim to reduce rural households' vulnerability and promote sustainable livelihoods amid climate change.

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