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Effects of Climate Change on Environmental Security among Vulnerable Groups in Zango Kataf Local Government Area of Kaduna State

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Abstract:

Purpose:
This study explores the impacts of climate change on environmental security among vulnerable populations in the Zangon Kataf Local Government Area of Kaduna State, Nigeria.

Methodology:
Using a cross-sectional survey design, data were collected through a combination of structured questionnaires, in-depth interviews, and the analysis of secondary data sources. The area under study lies within a tropical grassland zone, which has witnessed notable climatic changes in recent decades, particularly concerning temperature and rainfall patterns.

Findings:
Findings reveal a steady increase in annual surface temperature, showing a 12% average rise between 1989 and 2022. At the same time, the annual rainfall in the region has been on a downward trend, decreasing by approximately 4.88% over the same period. These climatic changes pose significant challenges to environmental security in the area, especially for groups that are economically and socially vulnerable.

Implication:
The study emphasizes the urgent need for climate adaptation and mitigation strategies focused on these populations. Policy recommendations include climate-smart agriculture, awareness programs, and the provision of support systems to build resilience and enhance long-term environmental security in the face of ongoing climate change.

INTRODUCTION

Climate change is a critical global challenge that has far-reaching effects on both natural and human systems. Among its most severe consequences is the impact on environmental security, particularly among vulnerable populations. These groups, often characterized by their limited access to resources, low adaptive capacity, and exposure to environmental hazards, are increasingly bearing the brunt of climate-related disruptions. In the context of Nigeria, the Zango Kataf Local Government Area (LGA) in Kaduna State represents a microcosm of the broader challenges faced by vulnerable populations across the country. This region, home to diverse ethnic communities, has been experiencing significant environmental changes, including shifts in rainfall patterns, rising temperatures, and increased frequency of extreme weather events, all of which contribute to the vulnerability of the local population (Kassim & Oguntoyinbo, 2019).

Environmental security refers to the availability of natural resources, the stability of ecosystems, and the capacity of a community or population to manage the consequences of environmental changes. Climate change exacerbates environmental insecurity, particularly for communities that depend on agriculture, livestock, and other natural resources for their livelihoods. In Zango Kataf, environmental degradation, coupled with climate variability, disrupts farming activities, leading to food insecurity, water scarcity, and conflicts over land and resources. These issues disproportionately affect marginalized groups such as women, the elderly, and internally displaced persons (IDPs), who often lack the means to adapt to these environmental stressors (Olabode & Omotayo, 2020).

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Vulnerable groups in Zango Kataf are highly susceptible to the impacts of climate change due to a combination of socio-economic and environmental factors. For instance, the region has witnessed desertification and soil degradation, which undermine agricultural productivity. As a result, rural farmers, particularly those in the southern part of the LGA, are experiencing lower crop yields and reduced income, which further entrenches poverty and exacerbates social inequalities. The local population, largely dependent on subsistence farming, struggles to cope with these changes, resulting in increased migration to urban centers and a growing sense of insecurity (Bamaiyi et al., 2021). Climate-induced conflicts over dwindling resources have also contributed to further instability, creating a cycle of vulnerability for already marginalized communities.

In addition to agricultural impacts, the effects of climate change on water resources are another key concern in Zango Kataf. Water scarcity is increasingly affecting both rural and urban communities in the LGA, leading to competition for access to clean water. This situation is exacerbated by rising temperatures and erratic rainfall patterns, which disrupt water supply systems and strain traditional water sources like wells and rivers. Vulnerable groups, particularly women and children who are responsible for fetching water, face increased hardships as they must travel longer distances to find water. It often exposes them to physical and psychological distress, further heightening the environmental insecurity of these groups (Akinyemi & Asante, 2018).

This study aims to assess the effects of climate change on environmental security among vulnerable groups in Zango Kataf LGA, Kaduna State. By exploring the socio-economic, environmental, and political dimensions of climate vulnerability, this research seeks to provide insights into the ways in which climate change exacerbates existing inequalities and the strategies that can be adopted to mitigate its impacts. Addressing these challenges requires a holistic approach that includes both local and national efforts, focusing on resilience-building and sustainable development practices. Only through a concerted effort can the environmental security of vulnerable groups in Zango Kataf be improved, contributing to broader climate adaptation strategies across Nigeria.

METHODS

Change in the climatic system is arguable, as is now evident from observations of increases in global average air and ocean temperatures, consistent melting of snow and ice and increasing average sea level (IPCC, 2007). The United Nations Framework Convention on Climate Change (UNFCCC, 2005) submitted that climate change is a change of climate that is attributed directly or indirectly to human activity that changes the composition of the global atmosphere and, in addition to natural climate variability, observed over a considerable period. While the Intergovernmental Panel on Climate Change, (IPCC, 2007) defined climate change as any change in climate over time either due to natural variability or as a result of human activity. The most universal concept of climate change, therefore, is a change in the statistical properties of the climate element when observed over a long period, regardless of the cause. Accordingly, fluctuations over periods shorter than a few decades do not represent climate change. The term is sometimes used to refer specifically to climate change caused by human activity, as against changes in climate that may have resulted as part of the earth's natural processes. In this respect, especially in the context of environmental policy and threats to human survival, the term climate change has become synonymous with anthropogenic global warming. However, scientifically, global warming refers to an increase in surface temperature, while climate change includes global warming and every other thing that rising greenhouse gas levels will affect. Thus, Climate change is a long-term shift in the statistical distribution of weather patterns over periods that range from decades to millions of years. It may be a change in the average weather conditions or a change in the distribution of weather events with respect to an average. For example, more or less extreme weather events. Climate change may be limited to a specific region or may occur on a larger scale across the globe. In recent usage, climate change usually refers to changes in modern climate.

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Environmental security refers to the interrelationship between environmental sustainability and the stability of human societies. It focuses on how environmental degradation, resource scarcity, and climate change contribute to social, political, and economic instability, particularly in vulnerable regions. Environmental security encompasses both the protection of natural resources and the resilience of communities to environmental stressors. It involves managing natural resources sustainably to prevent conflicts over water, land, and food while also addressing the broader impacts of environmental changes such as displacement, poverty, and violence. As a concept, it emphasizes the need for adaptive strategies and policies that enhance the capacity of societies to cope with environmental risks and mitigate their consequences (Albrecht, 2020; Homer-Dixon, 1999). By prioritizing environmental security, governments and organizations can work towards creating stable, resilient communities capable of managing environmental challenges and maintaining peace and stability.

Vulnerability and Resilience Theory. Blaikie et al. (1994) proposed Natural Hazards, People's Vulnerability and Disasters theory in 1994. They emphasized how vulnerability results from social, political, and economic conditions rather than just exposure to hazards. It shifted the focus from natural hazards to the structural causes of vulnerability. Piers Blaikie, Ian Davis, Ben Wisner, and Terry Cannon (1994-2012) expanded on vulnerability frameworks in the context of disaster risk reduction, emphasizing marginalized populations' exposure to risks. This theory examines how exposure to climate hazards, sensitivity to impacts, and the capacity to adapt interact to shape vulnerability. It is particularly relevant to Indigenous groups, who are often more exposed to climate risks due to dependence on natural resources and limited adaptive capacity. Indigenous groups in Zangon Kataf LGA rely heavily on agriculture and forest resources, which are highly susceptible to climate variability. Assessing their resilience (adaptive capacity, social networks, and traditional knowledge) helps measure their ability to cope with changing environmental conditions.

Empirical Review. Adger et al. (2021) suggested that migration is a key mechanism linking climate change to violent conflict, particularly through migration increasing the risks of conflict in urban destinations. However, climate change also creates new forms of insecurity through distress migration, immobility and vulnerability that are prevalent in urban destination locations. Here, we examine the extent and nature of human security in migration destinations and test whether insecurity is affected by length of residence and environmental hazards. The study develops an index measure of human security at the individual level to include environmental and climate-related hazards as well as sources of well-being, fear of crime and violence, and mental health outcomes. It examines the elements of human security that explain the prevalence of insecurity among recent and established migrants in low-income urban neighborhoods. The study reports on data collected in Chattogram in Bangladesh through a survey of migrants (N ¼ 447) and from qualitative data derived using photo elicitation techniques with cohorts of city planners and migrants. The results show that environmental hazards represent an increasing source of perceived insecurity to migrant populations over time, with longer-term migrants perceiving greater insecurity than more recent arrivals, suggesting a lack of upward social mobility in low-income slums. Ill health, fear of eviction, and harassment and violence are key elements of how insecurity is experienced, and these are exacerbated by environmental hazards such as flooding. The study expands the concept of security to encompass central elements of personal risk and well-being and outlines the implications of climate change.

Uexkull and Halvard's (2021) study of the security implications of climate change has developed rapidly from a nascent area of academic inquiry into an important and thriving research field that cuts across epistemological and disciplinary boundaries. Here, we take stock of scientific progress by benchmarking the latest decade of empirical research against seven core research priorities collectively emphasized in 35 recent literature reviews. On the basis of this evaluation, we discuss the key contributions of this special issue. Overall, the research community has made important progress in specifying and evaluating plausible indirect links between climatic conditions and a wide set of conflict-related outcomes and the scope conditions that shape this relationship. Contributions to this special issue push the research frontier further along these lines. Jointly, they demonstrate significant climate impacts on social unrest in urban settings; they point to the complexity of the climate–

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migration–unrest link; they identify how agricultural production Patterns shape conflict risk; they investigate understudied outcomes in relation to climate change, such as interstate claims and individual trust; and they discuss the relevance of this research for user groups across academia and beyond. We find that the long-term implications of gradual climate change and the conflict potential of policy responses are important remaining research gaps that should guide future research.

Schnitter and Peter (2019) study climate change, food security and the human health nexus in Canada toward developing a framework to protect population health. They observed that Climate change impacts on the Canadian food system pose risks to human health. Little attention has been paid to climate change, food security, and human health nexus, resulting in a number of knowledge gaps regarding food system components that are most vulnerable to climate change. The lack of understanding of key dynamics and possible future impacts challenges the ability of public health officials and partners in other sectors to prepare Canadians for future health risks. A series of literature reviews were conducted to establish the relationship between climate change, food security, and human health and to identify vulnerabilities within the Canadian food system. Evidence suggests that key activities within the food system are vulnerable to climate change. The pathways in which climate change impacts travel through the food system and affect the critical dimensions of food security to influence human health outcomes are complex. Climate-related disruptions in the food system can indirectly impact human health by diminishing food security, which is a key determinant of health. Human health may also be directly affected by the physical effects of climate change on the food system, primarily related to the impacts on nutrition and foodborne illnesses. In this study, we propose a novel analytical framework to study and respond to the climate change, food security, and human health nexus.

Chin-Yee (2019) studied climate change and human security by linking vulnerable populations to increased security risks in the face of the global climate challenge. Climate change has become ubiquitous in today's socio-economic and political discourse. Being global in scale, climate impacts across ecosystems that state boundaries cannot contain. The actions of one country affect regions on the other side of the world, hence the need for a comprehensive and effective global climate regime. In 2015, the Paris Climate Change Agreement was adopted. In the ensuing years, countries, along with researchers, civil society and industry, have been debating how to implement concrete action to address the climate challenge. The link between climate change and human security was first recognized in the early 2000s. This paper examines how climate change has exacerbated uncertainty and instability in vulnerable populations in different regions. It achieves this by looking at diverse national and local experiences through multiple policy lenses, namely, the proliferation of extreme weather events, coastal erosion and sea level rise, internal displacement, cross-border migration, and climate change as a threat multiplier. It looks at specific cases in Sub-Saharan Africa, the Pacific Islands and the Levant to understand how human (in) security is being affected by climate change. It also addresses the future of global climate policy by assessing the current state of climate policies in light of the Paris Agreement. Global action on climate change is urgent. While many developed countries like to avoid notions of climate justice and differentiated responsibilities, the reality for the most vulnerable countries is that supranational policy is crucial if they are to tackle the climate challenge at home. This paper emphasizes the importance of having meaningful and focused national climate adaptation and mitigation policies in place in order to address both the avoidable and unavoidable impacts of climate change on the economy, the culture and ultimately, the security of a country. This study finds that as climate change plays an increasingly important role in discussions of security, comprehensive strategies are needed to respond to climate-induced security threats and geopolitical ()stability both nationally and around the world. The Paris Agreement was a good first step in driving countries to commit to curbing emissions and drafting climate adaptation action plans. We now need the global climate regime – including countries, industry, and researchers – to step up to the plate and implement effective policies if we are to limit the serious impacts of climate change. The findings in this paper aim to contribute to the global debate around security and climate change.

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The gap in the Literature. Despite extensive studies on climate change impacts in Nigeria, there is a noticeable gap in localized research focusing on Zangon Kataf and its indigenous groups, particularly from the perspective of human security. Existing studies often neglect Indigenous knowledge, social and cultural dimensions, and intersectional vulnerabilities such as gender, age, and socio-economic status. Furthermore, most research relies on quantitative data, overlooking qualitative approaches that explore personal narratives and cultural contexts. Longitudinal studies tracking changes over time, particularly regarding climate-induced migration, food security, and health impacts, are scarce. Additionally, the resilience and adaptation strategies of Indigenous communities, as well as the interplay between climate change, conflict, and displacement within historical and socio-political contexts, are underexplored. Addressing these gaps through more granular and inclusive studies can enhance understanding and inform more effective policy and intervention strategies to support vulnerable populations.

Study Area. Zangon Kataf Local Government Area (LGA) was established in 1987, following the creation of Katsina State and its separation from the old Kaduna State. The LGA is geographically located in southern Kaduna State, bordered by Kachia LGA to the west, Kajuru LGA to the northwest, Kauru LGA to the north and northeast, Kaura LGA to the southeast, Jema'a LGA to the south, and Jaba LGA to the southwest. Its headquarters is in Zonkwa, with other prominent towns including Madakiya, Kamantan, and Samaru Kataf. The LGA spans an area of 2,579 km² and had a population of 318,991 in 2006, projected to grow to 471,300 by 2022 (T'auna, 2023).

The climate in Zangon Kataf LGA is characterized by an annual average temperature of 24.8°C, with highs reaching 28.6°C and lows of 18.8°C. The area experiences minimal rainfall at the year's beginning and end, averaging an annual precipitation of 28.1 mm and a humidity level of 53.7%. The region features prominent geographical landmarks, such as Kacecere Hill, the highest peak at 1,022 meters, along with several other hills like Kankada and Bako, which influence the local climate (Angerbrandt, 2015).

The LGA comprises several administrative wards, including Atak Nfang, Gidan Jatau, and Zango Urban, among others. Its inhabitants predominantly belong to the Atyap ethno-linguistic group, including the Atyap proper, Bajju, Bakulu, Anghan, and Atyecarak peoples, who speak related dialects of the Tyap language. Hausa is also widely spoken due to colonial influences. This diverse linguistic and cultural makeup reflects the area's rich heritage and social complexity (James, 2000).

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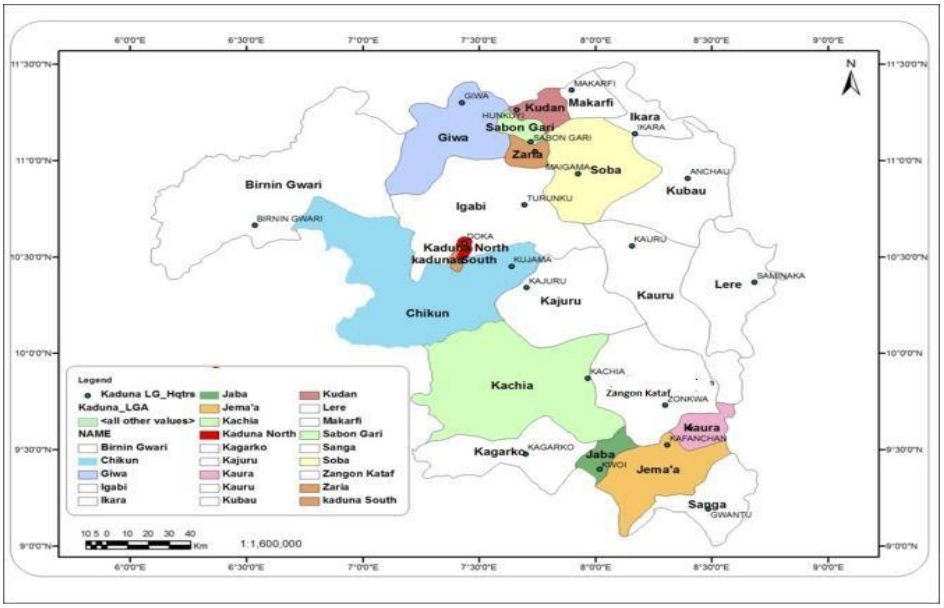

Figure 1. Map of Kaduna State Showing Zango Kataf LGA Source: Adapted from Kaduna State Government, 2023.

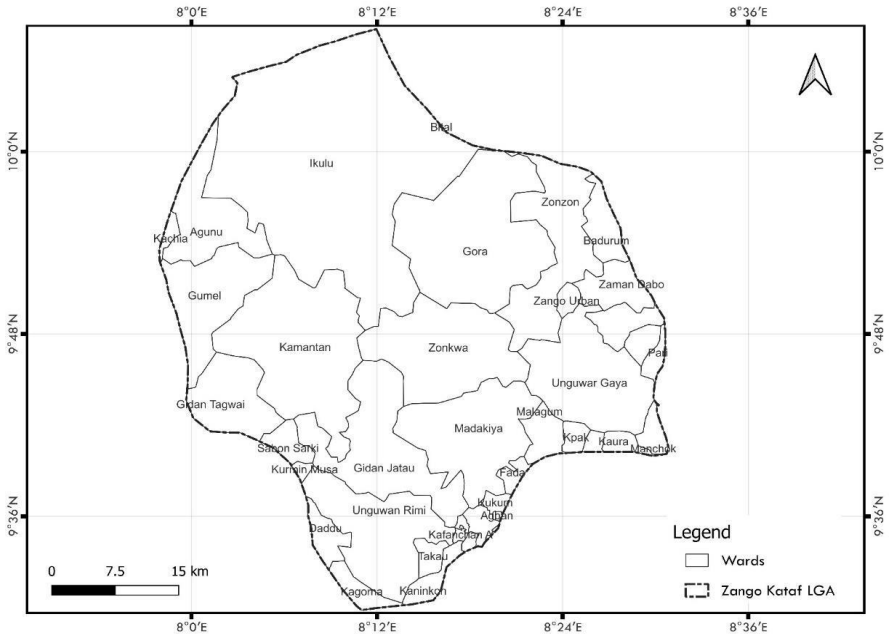

Figure 2. Map of Zangon Kataf LGA showing the various wards Source: Adapted from Kaduna State Government, 2023.

Research Design. The study adopted the cross-sectional survey research design. The design is suitable for collecting data through sampling when the population is too large to be investigated, as in the case of vulnerable

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groups in the Zango Kataf Local Government Area of Kaduna State. To this end, to collect data, the respondents, interviewees and discussants will be sampled from the entire population of the study. Secondly, the survey design made it possible to determine the relationships between climate change and human security in the Zango Kataf Local Government Area of Kaduna State, Nigeria (See Figure 2).

Also, in the use of this research design, both might employ both quantitative and qualitative methods of data gathering, which Plan International (2014) justified as useful tools in reaping the advantages of both methods and improving the study of greater use. Relevant social science research instruments and techniques will be used to gather data from a sample of the study population. To determine the results upon which conclusions were drawn, relevant statistical tools were employed.

Reconnaissance Survey. A reconnaissance survey was carried out in Zango Kataf Local Government Area of Kaduna State. The purpose is to acquaint the researcher with the study area and get first-hand information, particularly the geography of the study area. Also, to ascertain the climatic situation, human security situations, and availability of facilities, which were essential in planning the activities of the researcher and research assistants who will travel to the study area for data collection. The locations of institutions useful for this study for data collection will equally be ascertained. The reconnaissance survey lasted for four days.

Population, Sample and Sampling Techniques. The population of this study includes all men and women aged 40 and above years of Zango Kataf Local Government Area of Kaduna State. This population is considered appropriate because people over 40 years old often have more life experience and have witnessed firsthand environmental changes, giving them a deeper understanding of long-term trends of events. Also, part of the study population community leaders (men and women), religious leaders (both from Christianity, Islam and traditional worshipers), and security personnel (police and military personnel) of Zango Kataf Local Government Area constituted part of the population of the study.

Sample, Sampling Techniques. In this study, a multi-stage sampling technique was employed to select respondents. According to Nworgu (1991), apart from being cost-effective, this technique allows flexibility since several forms of sampling were introduced at various stages. The stages are as follows:

i. In the first stage, five wards that housed Zonkwa, Gora, Bakulu, Kamantan (Anghan) and Madakiya were purposively selected from Zonzon Kataf Local Government Area.
ii. The second stage involved the selection of five settlements in each of the selected wards. Settlements in each ward were randomly selected using a table of random numbers.

To determine the sample size for the study, NPC (2006) population data of people above 40 years were projected for updating the data. From the projections, the population of women and men aged 40 and above in the Zango Kataf Local Government Area was 39,354. Using Taro Yamane's formula with a population size (N) of 39,354 and a margin of error (e) of 0.05. The sample size of the study was therefore determined using Yamane's (1967) formula that states thus:

$$n = \frac{N}{1 + \mathrm{N}\,(e)^2}$$

Where;

n= Sample size required

N= the population size

e= Margin of error (4 percent %) at 95 percent confidence level.

The sample size (396) of the study was distributed among the selected wards based on their population, as indicated in Table 1.

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Table 1. Distribution of sample size among selected wards

Wards	Communities Sampled	Sample size
Zonzon	Ung. Ruhogo	20
	Bafai gora	20
	Wawa rafi	20
	Magamiya	20
Gora	Ung. Gankon	20
	Gora gida	20
	Bakin kogi	20
	Kurmin gandu	20
Anghan	Fadan Kamantan	20
	Kanzir	20
	Fadiya	20
	Kagal	20
Bakulu	Dutsen Bako	20
	Anchuna	20
	Akupal	20
	Ghidol	20
Madakiya	Tsoriyang	20
	Aduwan	20
	Wadon	20
	Ayagan	20

Source: Researcher Computation, 2024.

Households were selected using systematic random sampling, where a sample interval (S.I) was determined and used to select households on an interval basis until the required households for the survey were exhausted in all the selected settlements.

Types of Data and Method of Data Collection. The following data was required to carry out this study;

1. Rainfall and temperature records of Zango Kataf Local Government Area over 30 years (1992-2022) for the authentication of climate change in the study area.
2. Data on the impacts of climate change on economic security among vulnerable groups in Zango Kataf Local Government Area of Kaduna State.
3. Data on the implications of climate change on food security among vulnerable groups in Zango Kataf Local Government Area of Kaduna State.
4. Data on the implications of climate change on health security among vulnerable groups in Zango Kataf Local Government Area of Kaduna State.
5. Data to determine the effects of climate change on environmental security among vulnerable groups in Zango Kataf Local Government Area of Kaduna State.
6. Data to determine the implications of climate change on personal security, community security and political security among vulnerable groups in Zango Kataf Local Government Area of Kaduna State.

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Sources of data. The data for this study were obtained from both primary and secondary sources.

Primary sources of data Survey Questionnaire. The questionnaire is by far the most frequently used instrument in carrying out research, particularly in social science and research. In this study, a structured and semi-structured questionnaire was prepared and administered to the respondents for the purpose of gathering data. A structured and semi-structured questionnaire was designed and administered to the respondents. The questionnaires were administered to females and males aged 40 and above years heads of households. The information in the questionnaire that respondents are required to provide was generally broken down in line with the objectives of the study.

In-depth Interview. In-depth interviews were conducted that involved the interviewer asking interviewee questions for detailed responses. In-depth interview is often used in research to illicit individual opinions on the topic under investigation. Nwogu (1991), in justifying the use of in-depth interviews in research, pointed out that it allows for the collection of in-depth information from the respondents on any issue. Community leaders (men/women), Religious leaders (Christianity/Islam), and Security leaders/experts were the participants in the in-depth interview. The participants were selected on account of their experiences on the topic under investigation.

Ten assistants who were indigenes of the localities were recruited and trained for this study. The training was on how to administer questionnaires, take notes, and record interview sessions. The consent of the interviewees was sought before the process.

Secondary sources of data. Climatic data (rainfall and temperature data) from 1987 to 2023 from weather stations in Zango Kataf Local Government Area State were obtained from NIMET. Other secondary data include population data, which were obtained from the National Population Commission.

Techniques for Data Analysis. In this research, the Statistical Package for Social Science (SPSS) 23 was used in the data analysis. The package was used for the following;

Tabulation and cross-tabulation involving frequencies and percentages were employed to present the demographic and socio-economic characteristics of the respondents.

The Chi-square test of independence (also known as the Pearson Chi-square test or simply the

Chi-square) is one of the most useful statistics for testing hypotheses when the variables are nominal. The Chi-Square Test of Independence was used to test the association between climate change (independent variable) and each dimension of human security (dependent variables: food, environmental, and health security). The analysis was conducted using the formula:

$$X^2 = \sum \frac{(Oij - Eij)^2}{Eij}$$

Where:

Oij = Observed frequency in the i, j-th cell

Eij = Expected frequency in the i,j-th cell, calculated as:

$$Eij = \frac{Ri * Cj}{N}$$

Ri = Row total for the i-th category

Cj = Column total for the jth category

N = Total number of observations.

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The Chi-Square test results were evaluated at a 95% confidence level (α=0.05). A significant result ($p<0.05$) indicates that climate change is associated with the tested dimension of human security. This methodology ensures a rigorous statistical approach to understanding the associations between climate change and food, environmental and health security among the studied population. The data were coded and analyzed using SPSS statistical software.

Testing the Strength of Association Using Phi and Cramer's V. This study further assesses the strength of association between climate change and three dimensions of human security: food security, environmental security and health security using Phi and Cramer's V. These measures complement the Chi-Square Test of Independence by quantifying the degree of association between the variables.

Justification of Methods. According to Usuala (2005), the validity of a questionnaire must be established before its use. The researcher ensures that each question relates to the topic under investigation and provides adequate coverage of the overall topic. In addition, the pre-test exercise is the pilot administration of the questionnaire. Questionnaire survey: Some respondents who were not part of the sampled respondents were for the pre-test exercise. Errors related to the understanding of the questions and grammar by the respondents were noted and adjustments in the questionnaire were carried out.

RESULTS AND DISCUSSION

Climatic Elements Trend Assessment in Zangon Kataf LGA of Kaduna State. Zangon Kataf LGA is located in the Guinea Savannah (tropical grassland region) and is characterized by a mix of wet and dry seasons, with its climate heavily influenced by temperature and rainfall patterns. Assessing climate change/variability is usually achieved by observing the trend of weather elements like temperature, rainfall, relative humidity, and surface soil wetness/moisture that directly impact ecosystems, agriculture, and livelihoods.

Surface Temperature Trend in Zangon Kataf LGA of Kaduna State. In Zangon Kataf Local Government Area of Kaduna State, between 1991 to 2022, the mean annual surface temperature is 24.640C in the range of 22.830C to 26.460C. The year 2022 had the lowest surface temperature (22.830C), while the year 2005 had the highest surface temperature of 26.460C). Figure 3 clearly depicts an increased trend in surface temperature with $y = 0.0355x + 24.015$ and $R^2 = 0.1212$, which signifies a 12% average increase from 1989 to 2022 in Zangon Kataf LGA of Kaduna State. The monthly trend of surface temperature shows that the mean monthly surface temperature is 24.650C in the range of 21.830C to 29.130C. December had the lowest surface temperature at 21.830C, while March had the highest surface temperature at 29.130C. Figure 4 shows a declining monthly trend in surface temperature with $y = -0.5111x + 27.975$ and $R^2 = 0.5249$, which signify a 52% average monthly decrease of surface temperature from January to December in Zangon Kataf LGA of Kaduna State (See Figure 4).

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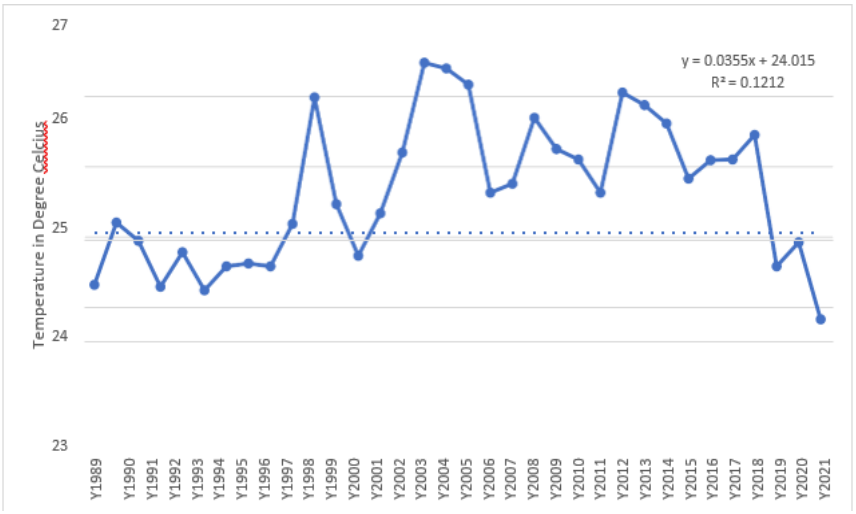
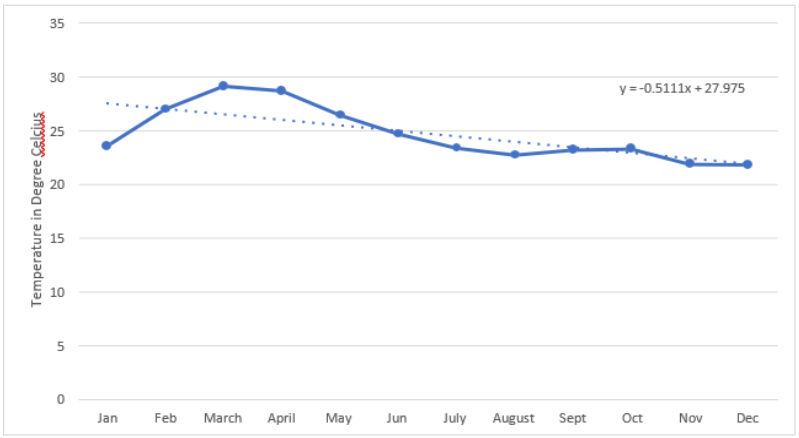


Source: Researcher Analysis 2024

Figure 3. Annual Surface Temperature Trend in Zangon Kataf LGA from 1989 to 2022



Source: Researcher Analysis 2024

Figure 4. Monthly Surface Temperature Trend in Zangon Kataf LGA

The increase in annual surface temperature is not farfetched from the general incidence of global warming. Other studies also show a clear upward trend in surface temperatures in the Guinea Savannah, where Zangon Kataf is located, over recent decades. Oguntunde et al. (2012) and Aremu et al. (2020) note that rising temperatures in the region are consistent with global warming trends, attributed to increasing greenhouse gas emissions and local land-use changes, such as deforestation and agriculture expansion. Seasonal variations in temperature trends could significantly impact the cropping calendar and water availability, which could exacerbate insecurity of various forms in the area (Ojo et al., 2020). Months and years with higher temperatures exacerbate drought stress, affecting food security and rural livelihoods in this predominantly agrarian region (Audu et al., 2019).

Rainfall Trend in Zangon Kataf LGA of Kaduna State. Rainfall in Zangon Kataf LGA depicts decreasing rainfall over the past thirty-three years, with the highest rainfall recorded in the year 2000 (2056.64mm),

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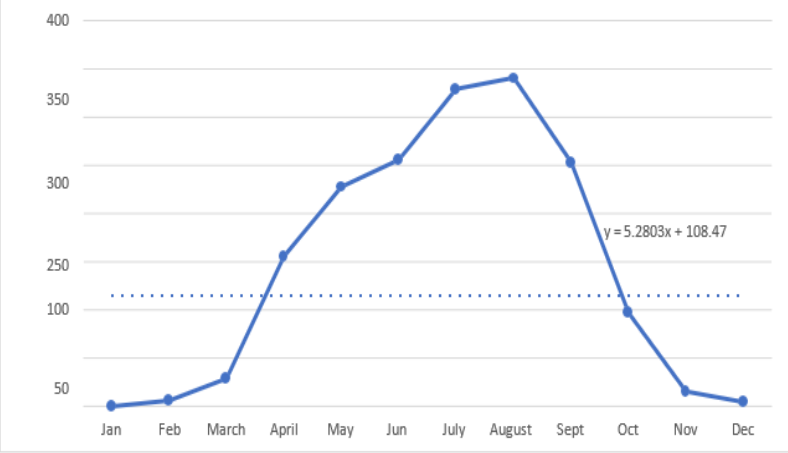
1994 recording 2019.73mm rainfall, and 2020 1907.62mm rainfall. The lowest rainfall values were recorded in the year 1999 with 590.62mm, 2004 with 632.81mm rainfall and 2013 recorded 685.55mm rainfall. Over the past thirty-three years, Figure 4.3 clearly depicts a decreasing trend in annual rainfall with y = -9.3602x + 1553.7 and R^2 = 0.0488, meaning a 4.88% decrease in rainfall within the study period. It could be a result of an increase in temperature that leads to dryness of the atmosphere, thereby reducing cloud formation and, consequently, rainfall in the study area. January had the lowest mean rainfall with 0.29mm, December with 4.68mm and February with 6.15mm. Just like most of the Guinea Savannah, August had the highest mean rainfall of 340.44mm, followed by July with 328.99mm. Figure 4 shows an increasing mean monthly trend in rainfall with y = 5.2803x + 108.47 and R^2 = 0.0204, which signifies a 0.204% average monthly increase in rainfall from January to December in Zangon Kataf LGA of Kaduna State.

Source: Researcher Analysis 2024

Figure 5. The trend of Annual Rainfall in Zangon Kataf LGA from 1989 to 2022



Source: Researcher Analysis 2024

Figure 6. Trend of Mean Monthly Rainfall in Zangon Kataf LGA

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Decreasing rainfall amounts over time in this area have been attributed to climate change and regional atmospheric circulation changes. Oguntunde et al. (2012) linked a significant reduction in total annual rainfall, particularly in the Guinea Savannah of Nigeria, to the southward shift of the Intertropical Convergence Zone (ITCZ). As also observed in this study, rainfall in the region is becoming increasingly erratic, with longer dry spells and shorter, more intense wet periods. The erratic nature of rainfall disrupts planting and harvesting periods, making it difficult for farmers to predict seasonal outcomes, leading to food and economic insecurity in the area.

Oguntunde et al. (2006) affirmed that the region experiences shorter periods of high soil moisture after heavy rainfall, followed by rapid drying due to high temperatures and poor soil structure. This variability poses a significant challenge for rainfed agriculture, which dominates the region's farming systems. Seasonal changes, such as delayed rainfall onset and earlier cessation, shorten the wet season and reduce the duration of soil wetness. The shifts lead to moisture stress during critical crop growth stages, particularly in this region where rainfall is already marginal, affecting crop production and leading to economic insecurity. Human activities, such as deforestation, overgrazing, and expansion of agricultural land, contribute to reduced soil wetness. Deforestation reduces infiltration rates, increases surface runoff, and limits the soil's ability to retain moisture.

Additionally, intensive agriculture without proper soil management leads to soil compaction and reduced porosity, further decreasing surface soil wetness. Climate projections by IPCC, (2021). indicate that the Guinea Savannah will experience further reductions in soil wetness, driven by declining rainfall, higher temperatures, and increased evapotranspiration. IPCC (2021) warns that these trends could exacerbate soil degradation, reduce water availability, and threaten agricultural productivity in the region.

Bio-data of Respondents in Zangon Kataf Local Government Area (LGA). Biodata plays a critical role in assessing the impact of climate change on human security, especially among vulnerable indigenous groups. Human security encompasses a broad spectrum of issues, including access to food, water, shelter, health, and the preservation of livelihoods, all of which are disproportionately affected by climate change in Indigenous communities. Biodata helps provide a detailed understanding of how climate change influences these factors at an individual and community level (Widiatmoko et al., 2023).

Table 2 provides insights into the gender distribution of respondents across study communities in Zangon Kataf Local Government Area of Kaduna State. The gender distribution shows a higher number of male respondents in communities like Kamuru and Fadia, whereas communities like Ungwan-Rimi and Akupal have a higher number of female respondents. Understanding the gender dynamics is crucial because the impacts of climate change can differ significantly between men and women. Women often have different roles and responsibilities, such as water collection and agricultural tasks, which climate change might affect differently. Each community, such as Anchuna-Sarkin and Kamuru, has a unique gender distribution that could influence how climate change impacts are perceived and managed. For instance, communities with more females face different challenges related to health, nutrition and access to resources compared to those with more males.

Table 2. Sex of Respondents in the Study Area

Communities	Sex of Respondents		Total
	Female	Male	
Anchuna-Sarkin	15	35	50
Kamuru	10	40	50
Fadia	15	35	50
Dutsen Bako	25	25	50
Ashafa-Gida	25	25	50

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Ungwan-Rimi	30	20	50
Akupal	30	20	50
Fadan Kamantan	25	25	50
Total	175	225	400

Source: Researcher Fieldwork, 2024.

Understanding marital status is important as it reflects household structures and responsibilities, which influence vulnerability and adaptive capacity to climate change. For instance, married individuals, who form the majority in each community, typically have dependents, making them more susceptible to the impacts of climate change on their livelihoods. Table 4 offers insights into the marital status of the respondents, with most (270) of the respondents being married, 65 being single, and 55 being widows/widowers. The presence of widows and widowers, particularly in communities like Dutsen-Bako and Ungwan-Rimi, suggests a need for targeted support as they might have fewer resources and less social support to cope with climate challenges. Ashafa-Gida and Akupal had a higher proportion of single individuals might indicate different vulnerabilities and strengths. Single individuals might be more mobile and able to adapt quickly, but they could also face challenges related to resource access and social support networks. This demographic profile helps in designing tailored interventions that consider the specific needs of different household types, enhancing resilience and overall human security in the face of climate change.

Table 3. Marital Status of Respondents in Zangon Kataf LGA

Communities	Marital Status of Respondents				Total
	Single	Married	Widow/Widower	Divorced	
Anchuna-Sarkin	5	40	5	0	50
Kamuru	5	35	5	5	50
Fadia	5	40	5	0	50
Dutsen Bako	0	40	10	0	50
Ashafa-Gida	20	30	0	0	50
Ungwan-Rimi	10	25	15	0	50
Akupal	15	25	5	5	50
Fadan Kamantan	5	35	10	0	50
Total	65	270	55	10	400

Source: Researcher Fieldwork, 2024.

The age distribution across communities in Zangon Kataf Local Government Area reveals varying demographic profiles and associated vulnerabilities to climate change impacts. Older adults, predominant in communities like Anchuna-Sarkin, Fadan Kamantan, and Ungwan-Rimi, may face greater health and adaptability challenges. At the same time, younger populations, as seen in Kamuru and Ashafa-Gida, exhibit potential resilience but remain susceptible to livelihood risks. Communities like Fadia and Akupal display balanced age distributions, suggesting mixed levels of vulnerability and resilience. Dutsen Bako's concentration of middle-aged respondents highlights potential workforce disruptions due to climate effects. Overall, the majority of respondents fall into the 41-50 (130 individuals) and 51-60 (125 individuals) age groups, with fewer elderly individuals (61 and above, 15 respondents), underscoring the need for tailored interventions addressing diverse demographic needs.

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Table 4. Age of Respondents

Communities	Age of Respondents					Total
	<30	31-40	41-50	51-60	61 and above	
Anchuna-Sarkin	5	0	15	30	0	50
Kamuru	5	25	15	5	0	50
Fadia	0	15	20	15	0	50
Dutsen Bako	0	5	35	5	5	50
Ashafa-Gida	5	25	10	10	0	50
Ungwan-Rimi	0	15	10	20	5	50
Akupal	5	15	10	15	5	50
Fadan Kamantan	0	10	15	25	0	50
Total	20	110	130	125	15	400

Source: Researcher Fieldwork, 2024.

Education plays a critical role in determining human security amidst climate change. It enhances awareness, facilitates access to information and promotes adaptive behaviors to cope with environmental stressors. Table 4.4 depicts the academic qualifications of respondents across studied communities in Zangon Kataf LGA. Findings revealed that respondents with tertiary education certificates dominate (200 respondents), followed by respondents that had secondary education (155 respondents) compared to 15 with no formal education, 10 with primary education and 20 with Missionary/Qur'anic education. It suggests that a significant portion of respondents possess advanced formal education for climate change and human insecurity-related issues (Mandasari et al., 2023). However, disparities across communities reflect varying degrees of preparedness to address climate change impacts. Anchuna-Sarkin and Kamuru have relatively higher respondents with secondary and tertiary education attainment. It suggests the potential for better awareness and adaptive capacity to climate change challenges due to their access to formal education. Conversely, communities like Fadia, Dutsen Bako and Ashafa-Gida, with some respondents having no formal or only Missionary/Qur'anic education, may experience heightened vulnerabilities. Limited educational attainment in these areas could hinder understanding of climate risks and the adoption of mitigation strategies. In Zangon Kataf LGA, Indigenous groups with lower educational levels may face disproportionate impacts, including reduced livelihood options, poor health outcomes and weakened resilience to climate-induced hazards. Targeted interventions, such as climate education and community capacity-building programs, are necessary to bridge the gaps and enhance the overall human security of these vulnerable populations.

Table 5. Academic Qualification of Respondents

Communities	Academic Qualification of Respondents				
	No Formal Education	Primary	Secondary	Tertiary	Missionary/ Qur'anic
Anchuna-Sarkin	0	0	25	25	0
Kamuru	0	0	25	25	0
Fadia	5	0	10	25	10
Dutsen Bako	5	0	10	30	5
Ashafa-Gida	5	5	20	20	0

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Ungwan-Rimi	0	0	30	20	0
Akupal	0	5	20	20	5
Fadan Kamantan	0	0	15	35	0
Total	15	10	155	200	20

Source: Researcher Fieldwork, 2024.

The occupational distribution in Zangon Kataf LGA highlights the socio-economic dynamics and climate change vulnerabilities of its communities. Farming, involving 155 respondents (38.8%), is the dominant occupation, underscoring a heavy reliance on climate-sensitive agriculture and heightened vulnerability to adverse impacts like erratic rainfall and droughts. Communities such as Kamuru, Fadia, and Dutsen Bako particularly rely on farming. Trading, the second most common occupation with 105 respondents (26.3%), reflects some income diversification, notably in Akupal and Ungwan-Rimi, but remains indirectly affected by agricultural disruptions. Civil servants (95 respondents) with stable incomes may face fewer immediate impacts, while craft workers (45 respondents) dependent on local resources are vulnerable to climate-induced resource scarcity. This occupational mix illustrates varying levels of resilience and exposure to climate change across the population.

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Table 6. Occupation of the Respondents

Communities	Occupation of the Respondents				Total
	Civil Servant	Trading	Farming	Craft Work	
Anchuna-Sarkin	15	5	25	5	50
Kamuru	10	10	30	0	50
Fadia	15	10	25	0	50
Dutsen Bako	10	15	20	5	50
Ashafa-Gida	15	10	15	10	50
Ungwan-Rimi	10	15	20	5	50
Akupal	5	25	15	5	50
Fadan Kamantan	15	15	5	15	50
Total	95	105	155	45	400

Source: Researcher Fieldwork, 2024.

The estimated income distribution of respondents across the communities in Zangon Kataf Local Government Area (LGA) provides critical insights into the socio-economic vulnerabilities of indigenous groups in the context of climate change and its impact on human security. The results in Table 4.6 reveal varying income levels, categorized into six, with a total of 395 respondents. A significant portion of the respondents (95 persons) earn less than ₦20,000 per month, indicating a high prevalence of low-income earners. This group is likely to face heightened vulnerabilities as limited financial resources reduce their capacity to adapt to climate change impacts, such as crop failure, food insecurity and health challenges. Communities like Anchuna-Sarkin (15 respondents) and Ashafa-Gida (20 respondents) exhibit notable concentrations in this income bracket. The income earners of between ₦21,000–₦40,000 and ₦41,000–₦50,000 collectively represent a majority, with 85 and 70 respondents, respectively. These individuals may experience moderate financial security, but they still face substantial risks due to economic constraints that hinder access to adaptive resources, such as improved farming techniques or diversified livelihoods. For instance, Fadia has 20 respondents in the ₦21,000–₦40,000 range, while Dutsen Bako

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has 20 in the ₦41,000–₦50,000 range. High-income brackets above ₦81,000 are relatively rare, with only 35 respondents in the ₦81,000–₦100,000 range and 20 earning over ₦100,000. These higher earners, present in communities like Anchuna-Sarkin and Akupal, may have better access to resources, technologies and information for climate adaptation, thus improving their resilience.

Table 7. Estimated Income of Respondents

Communities	>20,000	21,000-40,000	41,000-50,000	61,000-70,000	81,000-100,000	100,000+	Total
Anchuna-Sarkin	15	10	0	10	0	10	45
Kamuru	20	5	10	5	10	0	50
Fadia	10	20	5	5	5	5	50
Dutsen Bako	10	0	20	20	0	0	50
Ashafa-Gida	20	10	15	5	0	0	50
Ungwan-Rimi	5	15	5	20	5	0	50
Akupal	10	10	10	5	15	0	50
Fadan Kamantan	5	15	5	20	0	5	50
Total	95	85	70	90	35	20	395

Source: Researcher Fieldwork, 2024.

Understanding residency duration is critical for assessing community vulnerability and adaptive capacity to climate change impacts on human security. Longer residency often correlates with deeper knowledge of local environmental changes and more robust social networks, which can influence resilience strategies. Table 9 presents the distribution of respondents' residency durations across communities in Zangon Kataf LGA. Respondents with residency durations of 21–30 years were 111, and respondents with 41 years and above who were 108 dominate the distribution, comprising 27.8% and 27% of the total population, respectively. It indicates that a significant proportion of the population has longstanding ties to their communities (Chukwu, 2023). For example, communities like Anchuna-Sarkin and Fadia have notable numbers of respondents in the "41 years and above" category (15 and 20 individuals, respectively), suggesting that these communities likely have detailed historical knowledge of environmental and climate changes, which can inform adaptive practices. However, long-term residents may also be more vulnerable due to reliance on traditional livelihoods impacted by climate change. The below 20 years category, with 95 respondents (23.8%) and the 31–40 years category, with 86 respondents (21.5%), represent shorter residency durations. Communities like Akupal have a high proportion of short-term residents (25 respondents in "below 20 years"), which might reflect recent migrations or demographic shifts. Shorter residency can indicate lower integration into local adaptive networks, reducing resilience to climate-induced stresses.

Table 8. Residency Duration of Respondents

Communities	Below 20 years	21-30 years	31-40 years	41 years andabove	Total
Anchuna-Sarkin	10	15	10	15	50
Kamuru	20	15	10	5	50
Fadia	5	15	10	20	50

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Dutsen Bako	15	10	15	10	50
Ashafa-Gida	5	20	15	10	50
Ungwan-Rimi	5	15	10	20	50
Akupal	25	16	1	8	50
Fadan Kamantan	10	5	15	20	50
Total	95	111	86	108	400

Source: Researcher Fieldwork, 2024.

Coping Strategies/Traditional Knowledge and Practices. Despite these mixed assessments, community participation in initiatives addressing climate change was minimal, with 385 respondents (96.25%) reporting no involvement. Among the 15 respondents (3.75%) who participated, activities included community awareness programs (310 respondents, constituting 77.5%), resource sharing (215; 53.75%) and advocacy for policy changes (105 respondents, constituting 26.25%). Traditional environmental management practices were widely employed, with 300 respondents (75%) practicing crop rotation, 305 respondents (76.25%) utilizing controlled burns and 105 respondents (26.25%) engaging in sustainable fishing or hunting practices. Similarly, 310 respondents (77.5%) believed traditional knowledge could help address climate change. In terms of resource needs, 335 respondents (83.75%) prioritized financial aid, 310 (77.5%) sought technical assistance, and 190 respondents (47.5%) emphasized capacity building. Notably, food (310 respondents; 77.5%), shelter (255; 63.75%) and water (30; 7.5%) were identified as the most affected community resources. When asked about interest in community workshops on climate change, 320 respondents (80%) expressed willingness to participate, while 15 respondents (3.75%) declined, and 65 respondents (16.25%) were undecided. The findings underscore the multidimensional impacts of climate change on security, emphasizing the importance of integrating traditional knowledge, policy support and community engagement to enhance resilience.

Table 9. Coping Strategies &Traditional Knowledge and Practices at addressing climate change

Question	Have you participated in any political or community initiatives aimed at addressing climate change?			
Options	Yes			No
Freq (%)	**15 (3.75%)**			**385 (96.25%)**
Question	types of activities respondents engaged in when addressing climate change-related issues			
Options	Community Awareness Programs	Resource Sharing	Advocacy for Policy Changes	Others
Freq (%)	**310 (77.5%)**	**215 (53.75%)**	**105 (26.25%)**	**10 (2.5%)**
Question	What external support does your community need to enhance security in the context of climate change?			
Options	Financial Aid	Technical Assistance	Policy Support	Capacity Building
Freq (%)	**335 (83.75%)**	**310 (77.5%)**	**40 (10%)**	**190 (47.5%)**
Question	Traditional environmental management practices among communities			
Options	Crop Rotation	Controlled Burns	Sustainable Fishing/Hunting Practices	Use of Traditional Medicine
Freq (%)	**300 (75%)**	**305 (76.25%)**	**105 (26.25%)**	**90 (22.5%)**
Question	Do you believe traditional knowledge can help in addressing climate change?			
Options	Yes	No	Unsure	
Freq (%)	**310 (77.5%)**	**45 (11.25%)**	**45 (11.25%)**	

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Question	What topics related to climate change would you like to learn more about				
Options	Effects of Climate Change	Mitigation Strategies	Adaptation techniques	Use of Traditional Medicine	Policy Advocacy
Freq (%)	**280 (70%)**	**235 (58.75%)**	**275 (68.75%)**	**45 (11.25%)**	**65 (16.25%)**
Question	Would you be interested in participating in community workshops on climate change?				
Options	Yes	No	Maybe		
Freq (%)	**320 (80%)**	**15 (3.75%)**	**65 (16.25%)**		
Question	Is your community currently involved in any climate action initiatives?				
Options	Yes	No	Unsure		
Freq (%)	**125 (31.25%)**	**170 (42.2%)**	**105 (26.25%)**		
Question	What support does your community need to address climate change?				
Options	Training and Education	Financial Resources	Policy Support	Community Organising	Others
Freq (%)	**315 (78.75%)**	**295 (73.75%)**	**65 (16.25%)**	**275 (68.75%)**	**10 (2.5%)**

Source: Researcher Fieldwork and Analysis, 2024

Test of Hypotheses. Effects of climate change on environmental security among vulnerable groups**:** A chi-square test of independence was conducted to evaluate the relationship between climate change and environmental security among vulnerable groups. The results showed a significant association, $\chi 2(20) = 105.433$, $p<.001$. A linear-by-linear association was also significant, $\chi 2(1) = 6.912$, $p=.009$, indicating a linear trend. Symmetric measures revealed a strong association, with both Phi and Cramer's V at 0.513, $p<.001$. These results highlight the critical impacts of climate change on environmental security, necessitating targeted interventions to protect vulnerable groups.

Table 10. Chi-Square Tests

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	105.433[a]	20	.000
Likelihood Ratio	133.122	20	.000
Linear-by-LinearAssociation	6.912	1	.009
N of Valid Cases	400		

a. 13 cells (31.0%) have an expected count of less than 5. The minimumexpected count is 2.19.

Table 11. Symmetric Measures (Test of Association)

Symmetric Measures (Test of Association)			
		Value	Approximate Significance
Nominal by Nominal	Phi	.513	.000
	Cramer's V	.513	.000

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N of Valid Cases	400

Major Findings. The study highlights significant trends and impacts of climate change in Zangon Kataf LGA of Kaduna State, spanning environmental, economic, and social dimensions. Surface temperature has increased by an average of 12% from 1989 to 2022, with March recording the highest temperatures and December the lowest. Rainfall patterns exhibit a declining trend, with August having the highest mean rainfall. Similarly, surface soil wetness varies across months, peaking in September and August and showing significant annual fluctuations. These environmental shifts underscore the changing climatic conditions affecting the region.

The socio-economic impacts are pronounced, with most respondents noting disruptions to agriculture, food security, and livelihoods. Crop farming is identified as highly sensitive to climate change, with low yields, crop failure, and destruction of farmlands frequently reported. Livestock farming has similarly suffered, with losses of pasture and increased livestock diseases. Climate change exacerbates food insecurity, health issues, and economic vulnerabilities, with significant portions of the population reporting concerns about running out of food and experiencing related health problems such as malaria and typhoid. Despite these challenges, traditional environmental management practices and community-level conservation efforts remain prevalent.

Statistical analyses reveal strong associations between climate change and its impacts on economic, food, health, and environmental security. The results indicate that climate change intensifies vulnerabilities, particularly among economically disadvantaged groups. While many respondents recognize the importance of traditional knowledge and seek financial and technical support to mitigate these impacts, awareness of climate change and active community participation in adaptation initiatives remain limited. These findings highlight the urgent need for comprehensive strategies to address the multi-dimensional effects of climate change on this vulnerable population.

CONCLUSION

The study has demonstrated that climate change is a significant threat to environmental security in Zangon Kataf Local Government Area of Kaduna State, Nigeria. The observed trends of rising temperatures and decreasing rainfall have far-reaching implications for the region's vulnerable communities. These climatic changes have led to increased aridity, soil degradation, and water scarcity, impacting agricultural productivity and livelihoods. The study has also highlighted the disproportionate impact of climate change on vulnerable groups, particularly those with limited resources and low educational attainment. These groups are more susceptible to food insecurity, water stress, and health risks associated with climate change.

To mitigate the adverse effects of climate change on environmental security in the Zangon Kataf Local Government Area, it is crucial to implement a multifaceted approach. Key recommendations include sustainable land management practices, promotion of climate-resilient agriculture, water conservation, early warning systems, renewable energy adoption, and social and economic empowerment of vulnerable groups. Strengthening policy frameworks, inter-sectoral coordination, and public awareness are also essential. By taking these steps, the region can enhance its resilience to climate change and secure a sustainable future for its communities.

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