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Assessment of the Impact of Global Warming on Agricultural Productivity in Birnin Kudu Local Government, Jigawa State, Nigeria

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ABSTRACT

This study uses a mixed-methods approach, including surveys, interviews, focus groups, and observations. It evaluates the effects of global warming on agricultural productivity in Birnin Kudu Local Government, Jigawa State, Nigeria. Key findings reveal significant agricultural challenges, such as reduced crop yields, altered growing seasons, increased pest infestations, declining surface water availability, and unpredictable rainfall patterns. Climate change has also exacerbated health issues, including heat-related illnesses and diseases like malaria and diarrhoea, while undermining food security and livelihoods for farmers, livestock owners, and fishermen. The study emphasises the need for sustainable water resource management, strengthened public health systems, targeted support for vulnerable populations, and effective climate change mitigation and adaptation strategies. Further research is recommended to quantify economic impacts and refine adaptation measures for affected communities.

Keywords: Global Warming, Climate Change, Agricultural Productivity, Sustainable Development.

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1. Introduction

Global warming poses a significant threat to agricultural productivity worldwide, with developing regions, such as Nigeria, being particularly vulnerable due to their reliance on rain-fed agriculture. In Jigawa State, located in the semi-arid region of northern Nigeria, agriculture is a primary economic activity, employing a substantial portion of the population. The state's climate is characterised by erratic rainfall patterns and increasing temperatures, both of which are exacerbated by global warming and have profound implications for agricultural productivity.

Birnin Kudu Local Government Area (LGA) in Jigawa State is predominantly agrarian, with farmers cultivating crops such as millet, sorghum, and cowpea. The area's agricultural practices heavily depend on seasonal rainfall, making them vulnerable to climate variability. Recent studies have indicated that climate change has reduced crop yields in this region. Farmers have observed that changes in rainfall patterns and increased temperatures have negatively impacted their farming activities, resulting in decreased productivity and economic losses (Mailumo et al., 2021).

The impact of global warming on agriculture in Birnin Kudu is multifaceted. Increased temperatures can lead to heat stress in crops, reducing their growth and yield. Erratic rainfall patterns lead to droughts or floods, which destroy crops and degrade soil quality. Additionally, the proliferation of invasive aquatic weeds in floodplains, exacerbated by environmental degradation, poses a significant threat to agriculture and livelihoods in the region (Jigawa State Agricultural Policy, 2024).

Farmers in Birnin Kudu have adopted various climate-smart agricultural practices to mitigate the adverse effects of climate change. These practices include early planting, mixed cropping, cover cropping, multiple planting dates, dry season farming, planting improved varieties, and late planting. Factors influencing the adoption of these practices include age, household headship, education, farm size, farming experience, household size, and income from farming (Mailumo et al., 2021). Despite these efforts, the challenges posed by global warming persist in threatening agricultural productivity in the region.

Addressing the impact of global warming on agricultural productivity in Birnin Kudu requires a multifaceted approach. This includes enhancing farmers' awareness and education on climate change and variability, improving access to climate-resilient crop varieties, and implementing effective environmental management practices to combat degradation. Furthermore, strengthening institutional support and infrastructure, such as irrigation systems and storage facilities, can help mitigate the adverse effects of climate change on agriculture in the region.

2.0 Literature Review and Theoretical Framework

2.1 Conceptual Review

2.1.1 Global Warming

Global warming refers to the long-term increase in Earth's average surface temperature resulting from the accumulation of greenhouse gases (GHGs), such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), in the atmosphere. This phenomenon is primarily driven by human activities, including the combustion of fossil fuels, deforestation, and industrial processes, which intensify the greenhouse effect (Sule et al., 2024). Global

warming has far-reaching implications, including rising sea levels, extreme weather events, shifts in ecosystems, and disruptions to agricultural productivity (Sabiu & Magaji, 2024). These effects pose significant challenges to biodiversity, food security, and human livelihoods, particularly in vulnerable regions such as sub-Saharan Africa. Tackling global warming requires concerted global efforts by reducing GHG emissions, transitioning to renewable energy sources, and implementing sustainable environmental practices (IPCC, 2021; NASA, 2022).

2.1.2 Agricultural Productivity

Agricultural productivity refers to the efficiency with which agricultural inputs, such as land, labour, and capital, are converted into outputs, including crops, livestock, and other agricultural products. It is a key indicator of the agricultural sector's performance and is influenced by factors such as technology adoption, soil fertility, climatic conditions, and management practices (Magaji & Musa, 2024). Increased agricultural productivity is crucial for ensuring food security, promoting economic growth, and alleviating poverty, particularly in developing countries where agriculture is a significant source of livelihood. However, challenges such as land degradation, water scarcity, and the adverse effects of climate change (Olusola et al., 2025), including erratic rainfall and rising temperatures, threaten productivity levels (Tanko et al, 2025). Addressing these challenges requires innovations in sustainable farming practices, policy interventions, and investment in agricultural research and infrastructure (FAO, 2021; Pingali, 2012).

2. 2 Theoretical Framework

2.2.1 The Sustainable Livelihoods Framework (SLF)

The Sustainable Livelihoods Framework (SLF) is a relevant theory for assessing the impact of global warming on agricultural productivity in Birnin Kudu Local Government, Jigawa State, Nigeria. This framework focuses on the interplay between environmental, economic, social, and institutional factors influencing rural livelihoods, particularly in agrarian communities. The SLF emphasises how natural resources (land and water), human capital (knowledge and labour), social networks, financial resources, and physical infrastructure interact to determine resilience and vulnerability. In the context of global warming, the framework helps identify how climate-related shocks, such as erratic rainfall and rising temperatures, affect farmers' asset bases (Magaji & Mohammed, 2004) and their ability to maintain or improve agricultural productivity (Magaji & Bature, 2004). It also provides a lens for designing adaptive strategies and policies that strengthen farmers' capacity to cope with climate impacts, ensuring sustainable livelihoods (Scoones, 1998; Ellis, 2000).

2.3 Empirical Literature Review

Nwosu, Praise, Charles, and Basil (2024) examine the effect of anthropogenic global warming and insecurity on agricultural productivity in Nigeria. The time series data used for the analysis spanned from 1981 to 2020. The variables include Agriculture output (AP), Methane emission (MT), Population (PP), Terrorist Attacks (TA), and Terrorist Deaths (TD). The bounds test of the co-integration approach based on the Autoregressive Distributed Lag (ARDL) model was estimated. The results indicate that the variables are co-integrated. The ECM term is negatively signed and statistically significant. The speed of adjustment of short-run deviations from long-run equilibrium is 32 per cent annually. Our findings indicate that population growth and methane emissions are positively related to agricultural productivity, while insecurity (terrorist attacks and deaths) leads to decreased agricultural productivity. We

recommend the government employ scientific methods to select its mitigation policies, as not all emissions harm agricultural productivity. The government should strengthen the security architecture to secure the farmlands and farmers. We recommend using indigenous conflict resolution mechanisms and peace-building strategies to restore stability to conflict-prone areas.

Ucheje, Okolo, and Chukwueloka (2024) investigate the effect of climate change on Nigerian economic sustainability. The research employed an Autoregressive Distributed Lag (ARDL)/bond test approach, along with an OLS estimation technique, using data collected from 1990 to 2020. Changes in average temperature and carbon emission were used to capture climate change, while variations in exchange rate and agricultural production were used as control variables. The analysis showed that the goodness-of-fit (R-Square) is 0.998. This means that 99.8% of the changes in the dependent variable (GDP) can be explained by the changes in the independent variables (CEM, AGRIC, EXR, TEMP). The annual speed of adjustment from the short-run to the long-run relationship is 34%. At F-statistic = 195.8052 and P-value = 0.000, the model is statistically significant at the1% level of significance. The results of the analysis further demonstrated that carbon emissions have an adverse impact on Nigeria's economic sustainability in both the long and short run.

Oriekhoe, Adisa, and Ilugbusi (2024) comprehensively analyse the intricate relationship between climate change and food supply chain economics, focusing on its impacts, adaptations, and sustainability measures. Firstly, climate change disrupts agricultural production through extreme weather events, shifts in precipitation patterns, and temperature changes, leading to reduced crop yields and quality. These impacts ripple through the entire food supply chain, affecting input costs, market prices, and food security. Consequently, stakeholders across the supply chain face heightened risks and uncertainties, necessitating adaptive strategies to mitigate losses and maintain resilience. Secondly, adaptation measures within food supply chains encompass a range of strategies aimed at minimising climate-related risks and optimising resource utilisation. These may include adopting climate-resilient crop varieties, implementing precision agriculture techniques, enhancing water management practices, and diversifying sourcing and distribution channels.

Effiong, Musa, Hannah, and Sugden (2024) examine the impact of loss and damage caused by climate change in the Lower Niger River region of Nigeria, as well as the influence of global perspectives on the region. The research employed a mixed-methods approach, comprising a survey of 198 households and 13 in-depth interviews with key stakeholders. Furthermore, open-source Terra climate data on precipitation, runoff, and temperature, covering 30 years (1990–2020), were sourced from the Climate Research Unit (CRU) dataset and analysed to show the distribution of trends and patterns in climate variables. Similarly, we conducted a land use and land cover change (1990–2020) to ascertain the level of changes. Findings from the study have revealed that anthropogenic factors contribute to hydrological changes in the Lower Niger River Region, resulting in climatic disasters such as flooding that cause severe loss and damage to livelihoods, including loss of agricultural productivity, fisheries, and accessibility.

Alehile (2023)examines the effects of climate change on employment in the agricultural sector in Nigeria. Agriculture provides income and sustenance for a significant portion of Nigeria’s rural population. However, smallholder rain-fed farming predominates, with minimal resilience to climate shifts. Historical data reveal a rise in temperatures and a decline in erratic rainfall across Nigeria’s agro-ecological zones since the 1970s. Crop modelling

predicts that further climate change will reduce yields of key staple crops. This threatens the viability of smallholder agriculture and risks widespread job losses. The study employs a nonlinear autoregressive distributed lag (NARDL) modelling approach to assess the impact of climate change on agricultural sector employment in Nigeria from 1990 to 2020. Findings reveal that reduced rainfall initially raises employment, as farming requires more labour in dry conditions. However, protracted droughts significantly reduce the number of agricultural jobs.

While existing studies provide valuable insights into the multifaceted impacts of climate change on food security, economic sustainability, and agricultural employment in Nigeria, several critical research gaps remain. The reviewed literature highlights the adverse effects of climate variability on food supply, economic resilience, and rural livelihoods, with a focus on sectoral analyses and broad policy recommendations. However, these dimensions have limited integration to holistically exploring the interconnected pathways through which climate change affects food security and economic sustainability. Moreover, existing studies primarily rely on aggregate data or specific geographic case studies, without adequately addressing regional disparities or the intersection of socio-economic vulnerabilities, such as gender and youth inclusion in climate adaptation strategies (Yakubu et al., 2025). Additionally, while adaptation measures such as climate-smart agriculture and sustainable practices are recommended, there is an insufficient empirical evaluation of their effectiveness in the Nigerian context, particularly in scaling these practices across diverse agro-ecological zones. This calls for further research that employs mixed-methods approaches to comprehensively assess the synergies and trade-offs between climate adaptation, food security, and sustainable development, with a focus on inclusive and context-specific interventions.

3.0 Methodology

This study employed a cross-sectional research design method.This approach combines qualitative and quantitative methods, enabling a comprehensive understanding of the multifaceted effects of climate change on the local population.

The study area selected is Birnin Kudu, a local government area inJigawa State. Birnin-Kudu Local Government is located in the Jigawa Central Senatorial District, approximately 132 kilometres east of Kano. Birnin Kudu is the most populous local government area in Jigawa State.The local government has eleven political wards, which are: Kantoga, Kangire, Keangwara, Kiyako, Sundumi, Surko, Lafiya, Unguwa'ya, Yalwan Damai, and Wurno Birnin-Kudu.The population of Birnin-Kudu stands at 540,100 (NPC, 2022).

The population for this study encompasses all residents of the Birnin Kudu Local Government Area, Jigawa State, Nigeria. However, the focus will be on key stakeholders whose insights and experiences are crucial for addressing the research objectives.

Farmers and livestock owners play a crucial role in assessing the impact of climate change on agricultural productivity. The category encompasses small-scale subsistence farmers and larger commercial agricultural operators. Livestock owners were included because animal husbandry contributes significantly to the local economy and is highly vulnerable to the impacts of climate change.

Healthcare Workers and patients are crucial stakeholders in determining the health impacts of global warming within their locality. It would involve healthcare professionals, community health workers, and individuals who already have health problems due to the climate.

Water Resource Managers and Users: Local water management officials, well operators, and community members responsible for household water collection will be involved in determining how climate change is likely to affect water resources and analysing their availability.

Community Leaders/Elders: They are key informants in understanding the adaptive strategies adopted by the local community to cope with climate change. Their long-term perspectives and roles in shaping community decisions make them valuable in analysing changing coping mechanisms (Nyong et al., 2007).

Youth and Women's Groups: These demographic segments are often disproportionately affected by the impacts of climate change, yet they play critical roles in adaptation strategies.

Due to the nature and area of the study, the research adopts stratified and purposive sampling techniques. The sample size for quantitative surveys was 49 participants. The instruments used for data sourcing included a questionnaire, in-depth interviews, and focus group discussions (FGDs).The study employed quantitative and qualitative data analysis methods to gain a comprehensive understanding of the socioeconomic impacts of climate change in the Birnin Kudu Local Government Area.

4.0 Data Analysis, Presentation, and Discussion

4.1 Analysis of the Questionnaires

This research distributed 64 questionnaires during the field survey. Forty-nine valid questionnaires were returned, seven were returned invalid, and eight were not returned. Thus, this analysis is guided by the 49 returned and valid questionnaires.

Tables 4.1 Age Distribution of Respondents

Age Range	Frequency	Percentage
18-25	12	24.5
26-35	20	40.8
36-45	12	24.5
46-60	5	10.2
Total	49	100

Source: Fieldwork, 2024

Table 4.1 is for the age distribution of the respondents. It indicates a predominance of younger adults, with 40.8% of respondents falling within the 26-35 age range. This suggests that most participants are likely to be more open to knowledge of climate change. The equal representation of the 18-25 and 36-45 age groups (24.5% each) indicates a balanced interest

across different stages of adulthood, while the lower percentage (10.2%) in the 46-60 age range may reflect a lesser engagement with digital currencies among older individuals.

Table 4.2 Distribution of Respondents by Gender

Gender	Frequency	Percentage
Male	33	67.3
Female	16	32.7
Total	49	100

Source: Fieldwork, 2024

Table 4.2 disclosed the gender distribution of the respondents. It shows a significant male majority (67.3%) compared to females (32.7%). This disparity may influence the overall perspectives on climate change, as gender dynamics can affect financial decision-making and technology adoption. Understanding these differences is crucial for tailoring climate awareness and outreach programs.

Table 4.3 Distribution of Respondents by Marital Status

Marital Status	Frequency	Percentage
Single	16	32.7
Married	33	67.3
Total	49	100

Source: Fieldwork, 2024

Table 4.3 above revealed that most respondents (67.3%) are married. This indicates that married people are the majority, and 32.7% were single. Single people are the minority in this work.

Table 4.4 Distribution of Respondents by Educational Qualification

Educational Level	Frequency	Percentage
Secondary	4	8.2
Tertiary	45	91.8
Total	49	100

Source: Fieldwork, 2024

Table 4.4 reveals the educational background of the respondents. It disclosed that 91.8% have attained tertiary education. This level of education may be associated with a greater understanding of climate change concepts and adaptive strategies, indicating that respondents are likely to be more informed about the implications of climate change. Only 8.2% of qualifications were for secondary school (SSCE).

Table 4.5 Distribution of Respondents by Occupation

Occupation	Frequency	Percentage
Farmer	7	14.2
Trader	7	14.2
Artisan	2	4.1
Civil Servant	33	67.3
Total	49	100

Source: Fieldwork, 2024

Table 4.5 reveals the occupational distribution of the respondents. It shows that a significant portion (67.3%) are civil servants; farmers and traders represent 14.2% each, and artisans 4.1%. This indicates that most respondents may have stable incomes, which could influence their attitudes toward adopting new adaptive strategies to combat climate change.

4.6 Distribution of Respondents by Household

Household	Frequency	Percentage
1-4	21	42.9
5-8	14	28.4
9-12	8	16.3
13 and above	6	12.2
Total	49	100

Source: Fieldwork, 2024

Table 4.6 shows the household size of the respondents. The data show that 42.9% of respondents live in households with 1-4 members, 28.4% have 5-8 members, 16.3% have 9-12 members, and 12.2% have 13 or more members. Smaller household sizes may be correlated with higher disposable income, potentially influencing farming decisions and the adoption and use of mechanisms and adaptive strategies to combat climate change.

4.7 Distribution of Respondents by Land Ownership

Land Ownership	Frequency	Percentage
On their land	34	69.4
Do not own land	15	30.6
Total	49	100

Source: Fieldwork, 2024

Table 4.7 indicates that a substantial majority (69.4%) of respondents were landowners during the course ofthis research. Owning land in a farming community provides the owner with a sense of security and stability, which could influence their willingness to explore alternative farming avenues. Again, 30.6% of the respondents do not own land.

Table 4.8 Distribution of Respondents by Income Level per Month

Income level/per month (in Naira)	Frequency	Percentage
Below 20,000	6	12.2
21-40 000	3	6.1
41,000-60,000	9	18.4
61,000	28	57.1
Total	49	100

Source: Fieldwork, 2024

Table 4.8 revealed that a significant portion of the respondents (57.1%) earn above 61,000 Naira monthly. This suggests a relatively higher economic status among the participants. This financial capacity may enable them to invest in different agricultural practices and purchase farm implements. However, the lower income brackets (12.2% below 20,000 Naira) highlight the economic diversity within the community.

Table 4.9 Assessing the Impact of Global Warming on Crop Yield, Livestock Production in Birnin- Kudu, Jigawa State

S/N	Item Statement	Mean	Remark
1.	How has the yield of crops (maize, millet, sorghum) changed over the past 10 years	3.92	Moderately Increased
2.	Reduced rainfall, increased temperature, pest infestations, and soil degradation have contributed to changes in my crop yield.	3.96	Agreed
3.	The productivity of my livestock (cattle, goats, sheep) has been changed/affected by recent changes in the climate	3.86	Agreed
4.	I have experienced changes in the growing season length over the past decades	3.88	Agreed
5.	The frequency and severity of crop pests and diseaseshave increased in recent years	4.21	Agreed
6.	My agricultural income has reduced significantly due to changes in the ground weather patterns	4.32	Agreed
	Sectional Mean	4.025	Agreed

Source: Fieldwork, 2024

Table 4.9 above shows the analysis of the results. Results revealed that farmers' crop yields increased moderately, with a mean score of 3.92, as indicated in the table. The respondents

agreed that reduced rainfall, pest infestations, and other factors have contributed to changes in crop yield. This is evident by the mean score of 3.96 obtained from the analysis of results. Again, the table disclosed that respondents with a mean score of 3.86 agreed that the productivity of my livestock (cattle, goats, and sheep) had been changed/affected by recent climate changes. Furthermore, the table shows that respondents with a mean score of 3.88 agreed that they had experienced changes in the length of the growing season over the past few decades. Again, the table also indicates that respondents with a mean score of 4.21 agreed that the frequency and severity of crop pests and diseases have increased in recent years. Consequently, respondents with a score of 4.32 agreed that agricultural income has decreased significantly due to changes in ground weather patterns.

Table 4.10: Effects of Climate on Groundwater Levels, Surface Water Availability, and Rainfall

S/N	Item Statement	Mean	SD	Remark
1.	Has surface water availability (examples: rivers and ponds) changed in my community over the past 10 years?	3.81	0.87	Moderately Increased
2.	The availability of groundwater (examples: wells and boreholes) has changed in my community over the past 10 years	4.34	0.99	Agreed
3.	Rainfall patterns have become less predictable with more intense and frequent droughts	4.21	1.22	Agreed
4.	My community has experienced more frequent droughts and flooding events over the past 10 years	3.73	0.32	Agreed
5.	Rainfall patterns have changed in the past 5-10 years in your area	3.92	1.23	Agreed
		4.02		Agreed

Source: Fieldwork, 2024

Based on the results obtained from Table 4.10, several findings regarding the changes in water availability and rainfall patterns in the community over the past 10 years can be drawn: The average rating of 3.81 indicates that respondents feel there has been a moderate decrease in the availability of surface water, such as rivers and ponds. This suggests a concern among community members regarding the diminishing resources of surface water, which could impact local ecosystems and water supply. Furthermore, with an average rating of 4.34, respondents strongly agree that groundwater availability, such as wells and boreholes, has changed. This indicates significant concern about groundwater resources, which are crucial for drinking water and irrigation, suggesting that the community may face challenges accessing this vital resource. In addition, the finding that rainfall patterns have become less predictable, with an average rating of 4.21, shows a strong agreement among respondents. This unpredictability can lead to difficulties in agricultural planning and water resource

management, potentially affecting food security and livelihoods. Moreover, the average rating of 3.73 suggests that the community has experienced more frequent droughts and flooding events over the past decade. This highlights the increasing variability in weather patterns, which can have severe implications for the environment and the community's resilience to climate change. Finally, the average rating of 3.92 indicated that respondents agree that rainfall patterns have changed in the past 5-10 years. This aligns with previous findings and reinforces that the community is experiencing significant shifts in weather patterns, which could impact water availability and agricultural practices.

The findings indicate a concerning trend of decreasing surface water availability, changing groundwater resources, and unpredictable rainfall patterns, which could have severe implications for the community's water security and overall well-being. It may be beneficial for local authorities to investigate these changes further and implement effective strategies to manage water resources.

Table 4.11: Health Impacts of Global Warming

S/N	Item Statement	Mean	SD	Remark
1.	My family members or I have experienced heat-related illnesses such as heat stroke in my community, dehydration in the past 5-10 years, 4.43	4.42	1.14	Agreed
2.	I or some members of my household have experienced an increase in health problems such as malaria, diarrhoea, cholera, typhoid, and respiratory infection, which I believe are related to changes in the weather (examples: extreme heat, unpredictable rainfall)	4.43	0.99	Agreed
3.	Climate change has significantly affected access to food and nutrition in my household	4.41	0.78	Agreed
		4.42		Agreed

Source: Fieldwork, 2024

Table 4.11 disclosed that an average rating of 4.42 indicates strong agreement among respondents that they or their family members have experienced heat-related illnesses, such as heatstroke and dehydration. This suggests that extreme heat events have become more common or severe in the community, leading to significant health risks. The high level of agreement highlights the urgent need for public health interventions and awareness campaigns to educate the community about heat-related illnesses and prevention strategies.

In an FGD conducted among health workers, participants revealed that climate change has a significant impact on the livelihoods of vulnerable communities. According to them, these impacts can be directly attributable to life or otherwise. Some of the challenges of climate change were highlighted by the participants as follows:

"Heat-related illnesses and deaths; increased respiratory problems due to air pollution; Vector-borne diseases (e.g., malaria, dengue fever) spread; Water-borne diseases (e.g., cholera, diarrhea) due to contaminated water; Mental health issues (e.g., anxiety, depression) related to climate-related stress; Temperature increases: altered growing seasons, crop yields; Changing precipitation patterns: droughts, floods, water scarcity; Increased pest and disease pressure: reduced crop resilience; Shifts in growing zones: altered suitability for specific crops; Loss of biodiversity: reduced genetic diversity, ecosystem disruption."

Again, the FGD participants revealed the following:

"Changes in temperature and precipitation patterns affect crop yields and quality; Shifts in growing seasons and planting dates disrupt traditional practices; Increased frequency of extreme weather events (droughts, floods) damages crops; Warmer temperatures increase pest and disease pressure, reducing yields; Water scarcity affects irrigation, leading to reduced crop productivity."

The participants among the Fishermen also revealed the impact of climate change as follows:

"Ocean warming and acidification impact fish populations and distribution; Changes in ocean currents and upwelling patterns affect fish migration; Increased frequency of marine heat waves devastates fisheries; Rising sea levels and coastal erosion threaten fishing communities; Shifts in fish species composition affect livelihoods."

Furthermore, participants from the Pastoralists community also revealed the following as impacts of climate change on them:

"Droughts and changing precipitation patterns reduce pasture quality; increased temperature affects livestock health and productivity; Shifts in grazing patterns disrupt traditional migration routes; Water scarcity affects livestock hydration and health; biodiversity loss reduces resilience in pastoral ecosystems."

With an average rating of 4.43, respondents strongly agree that they or members of their household have experienced an increase in health problems, including malaria, diarrhoea, cholera, typhoid, and respiratory infections, which they believe are related to changes in weather patterns. This finding highlights the potential connection between climate change and public health, as extreme heat and unpredictable rainfall can create conditions that facilitate the spread of infectious diseases. It highlights a pressing need for enhanced healthcare access and disease prevention strategies within the community.

The average rating of 4.41 indicates strong agreement that climate change has significantly affected household access to food and nutrition. This finding underscores the broader implications of climate change for food security, as weather patterns can disrupt agricultural production, resulting in food shortages and price increases. The community may face challenges maintaining adequate nutrition, which can have long-term health consequences.

The findings reveal a concerning trend of increasing health-related issues and food insecurity linked to climate change in the community. The strong agreement among respondents highlights the need for targeted interventions to address these challenges, including public

health initiatives, improved access to healthcare, and strategies to enhance food security and resilience to climate impacts. It may also be beneficial for local authorities to engage in climate adaptation planning to mitigate these health risks and ensure the community's well-being.

Table 4.12: Economic Effects of Global Warming on Farming-Based Livelihoods and Household

S/N	Item Statement	Mean	SD	Remark
1.	How has your household's income from farming activities changed in the past ten years	4.22	1.22	Moderately Increased
2.	The following factors, including livestock deaths, crop failures due to droughts, increased input costs, and reduced market prices for farm products, have significantly impacted your income from farming.	4.38	0.23	Very much
3.	I have had to diversify my sources of income (engaging in non-forming activities) due to changes in agricultural productivity	3.53	1.72	Agreed
4.	Some community members have to migrate to other areas (for example, urban centres) to find alternative income due to climate impacts on farming	3.92	0.84	Agreed
		4.20		Agreed

Source: Fieldwork, 2024

The findings from Table 4.12 indicate a nuanced perspective on the changes in household income from farming activities over the past decade. With an average rating of 4.22, respondents reported a moderate increase in income, suggesting that while there may be some positive trends, the growth is not substantial enough to alleviate all the challenges faced by farming households. The factor that had the most significant impact, rated at 4.38, highlights the severe challenges posed by livestock deaths, crop failures due to droughts, increased input costs, and reduced market prices for farm products. This suggests that external factors, particularly climate-related issues and economic pressures, severely affect agricultural productivity and household income.

Additionally, the finding that respondents agreed (3.53) on the need to diversify their sources of income indicates a proactive approach to mitigating risks associated with farming. This diversification reflects an adaptation strategy in response to the changing agricultural landscape, indicating that households are seeking alternative livelihoods to ensure financial stability. Furthermore, the agreement (3.92) that some community members have migrated to urban centres in search of alternative income underscores the significant impact of climate change on rural livelihoods. This migration trend may indicate a shift in demographic

patterns as individuals seek better opportunities, which could have long-term implications for rural communities and agricultural practices. These findings illustrate the complex relationship between agricultural productivity, economic pressures, and adaptive strategies farming households employ in response to changing conditions.

In an interview, the interviewees identified the socio-economic impacts of climate change in Birnin Kudu Local Government, Jigawa State. The Key responses included:

" Changes in temperature and precipitation patterns affecting crop yields and livelihoods; Increased frequency of extreme weather events (droughts, floods) disrupting daily life; Loss of biodiversity and ecosystem disruption; Economic instability and food insecurity; Limited access to climate information and adaptation resources; Climate change affects agricultural productivity, leading to economic instability; Women and children are disproportionately affected by climate change; Limited access to climate-resilient technologies and inputs hinders adaptation; Traditional coping mechanisms (example: saving, sharing) are insufficient' Climate migration is becoming increasingly common."

Table 4.13: Adaptive Strategies Employed by the Local Community to Cope with Climate Change Challenges in Birnin-Kudu, Jigawa State, Nigeria

S/N	Item Statement	Mean	SD	Remark
1.	a. early planting b. Improved seed varieties c. Use drought-resistant seed d. Crop diversification, e.g., water conservation techniques, is an adaptive strategy. Have you adapted to changing conditions	4.32	0.78	Improved seed varieties
2.	a. Financial support b. Agricultural extension services c. Training on new farming techniques is the support that I have received from the government or NGOs, and it has been effective in helping adapt to climate change	3.5	1.22	No support received
3.	How effective have the adaptive strategies you have implemented been in your agricultural productivity	3.61	1.87	Moderately effective
	Sectional Mean	3.81		

Source: Fieldwork, 2024

The findings from Table 4.13 revealed critical insights into the adaptive strategies employed by farmers in response to changing climate conditions. With an average rating of 4.32,

improved seed varieties are the most commonly adopted strategy, indicating that farmers recognise the importance of utilising better genetics to enhance crop resilience and productivity. This suggests a proactive approach to addressing the challenges posed by climate change. In contrast, the support received from government or NGOs, rated at 3.5, suggests that many farmers have not received adequate assistance, with some reporting no support at all.

This lack of support may hinder the effectiveness of adaptive strategies, as financial backing, agricultural extension services, and training on new farming techniques are crucial for successful adaptation (Magaji& Yisa, 2023). The relatively low rating highlights a resource gap that could be addressed to better support farmers in their efforts to adapt to climate change.

In an FGD, the participants recommended the following as adaptive strategies in response to climate change. These solutions are enumerated below:

"Integrate climate change into agricultural extension services. 'Enhance farmer education and training; Support climate-resilient agricultural research; Develop climate-sensitive agricultural policies; Promote sustainable agriculture practices; Integrate climate change into health worker training; Strengthen health systems for climate resilience; Support climate-sensitive livelihood programs; Enhance community engagement and participation. Advocate for climate policy and action".

Again, the FGD participants also identified the following as an adaptive strategy in response to climate change in Birnin-Kudu. Jigawa State:

"Climate-resilient crop and animal varieties; Conservation agriculture and agroforestry; Sustainable water management practices; Climate-informed fisheries management; Mobile livestock management".

The effectiveness of the adaptive strategies implemented, rated at 3.61, suggests that while these strategies are somewhat beneficial, they are only moderately effective in maintaining agricultural productivity. This suggests that farmers may still encounter significant challenges despite their efforts to adapt, possibly due to ongoing climate impacts or other external factors that hinder the effectiveness of these strategies. Overall, these findings emphasise the need for enhanced support systems from the government and NGOs to empower farmers in their adaptation efforts. By providing targeted assistance and resources, stakeholders can help enhance the effectiveness of adaptive strategies, ultimately leading to increased resilience in agricultural productivity in the face of changing climate conditions.

Table 4.14: Roles of Local and State Government Policies and Interventions in Instigating the Effects of Global Warming in Birnin-Kudu, Jigawa State, Nigeria

S/N	Item Statement	Mean	SD	Remark
1.	I am aware of government policies or programs that aim to help farmers adapt to climate change in your area	3.8	0.8	Anchor Borrower
2.	I have received funding from the government to cope with the impact of global warming	4.21	0.7	No support
3.	How would you rate the effectiveness of government interventions in addressing the challenges posed by global warming in your community?	3.63	2.33	Moderately effective
	Sectional Mean	3.88		

Source: Fieldwork, 2024

The findings from Table 4.14 provide a critical perspective on the awareness and effectiveness of government policies and programs aimed at helping farmers adapt to climate change. With an average rating of 3.8, respondents indicate a general awareness of government initiatives, such as the Anchor Borrower program, which suggests some level of engagement with these policies among the farming community. However, the contrasting finding that respondents reported receiving no support from the government, with a rating of 4.21, highlights a significant gap between awareness and actual assistance. This discrepancy may indicate that, while farmers are aware of existing programs, they are not benefiting from them, which could undermine their ability to adapt to the impacts of global warming effectively.

The effectiveness of government interventions, rated at 3.63, suggests that while some farmers perceive these efforts as moderately effective, there is still considerable room for improvement. The high standard deviation of 2.33 indicates a wide range of opinions among respondents, suggesting that experiences with government support may vary significantly within the community. These findings point to a more robust and accessible support system for farmers. Enhancing the effectiveness of government interventions and ensuring that assistance reaches those in need can significantly improve farmers' capacity to cope with the challenges posed by climate change. Addressing these gaps will be crucial for fostering resilience and sustainability in agricultural practices within the community.

Climate change has significant socio-economic impacts on local communities, particularly vulnerable groups. Addressing these impacts requires a multifaceted approach, including the dissemination of climate information, climate-resilient initiatives, and social protection programs. Interviewees suggest the following to address the economic challenges of climate change in Birnin-Kudu, Jigawa State. They are:

"Enhance climate information dissemination and early warning systems; Support climate-resilient agriculture and livelihood initiatives; Promote climate-sensitive social protection

programs; Increase access to climate finance and adaptation resources; Foster community-led adaptation and resilience-building initiatives.

Table 4.15: Influence of Global Warming on Rural-Urban Migration Patterns and Demographic Changes in Birnin-Kudu, Jigawa State, Nigeria

S/N	Item Statement	Mean	SD	Remark
1.	There has been a noticeable change in population size in my community due to migration influenced by climate change	3.92	1.32	Agreed
2.	What are the main reasons for people migrating out of your community?			
3.	Some members of my household have considered migrating to urban areas due to the impacts of global warming on farming activities.	4.21	0.72	Agreed
	Sectional Mean	4.10		Agreed

Source: Fieldwork, 2024

The findings from the table indicate a significant awareness of the impact of climate change on population dynamics within the community. With an average rating of 3.92, respondents agree that there has been a noticeable change in population size due to migration influenced by climate change. This suggests that environmental factors are compelling individuals and families to leave their homes in search of better opportunities, likely driven by the challenges faced in agricultural productivity. The high rating of 4.21 regarding the consideration of migration to urban areas by respondents and their households further emphasises the urgency of the situation. This suggests that many individuals perceive urban migration as a viable option to mitigate the adverse effects of global warming on their farming activities. The relatively low standard deviation of 0.72 suggests a consensus among respondents about the pressures they face, highlighting a collective concern for the sustainability of their livelihoods.

The results above underscore the profound impact of climate change on rural communities, prompting migration as a coping strategy. It reflects a broader trend in which environmental challenges are reshaping demographic patterns, potentially leading to declining rural populations and altering community structures. Addressing the root causes of these challenges and supporting sustainable agricultural practices could help mitigate the need for migration and promote resilience within the community.

Table 4.16 Test of Hypotheses

PPMC Test result of the relationship between global warming and the migration pattern

Variable	N	X	S.D	Df	r-cal	r-crit	Sig	Decision
Global warming	50	3.89	0.77	48	0.235	0.185	0.045	Significant
Increased Migration pattern		3.48	0.43					

Table 4.16 shows the significant relationship between global warming and increased migration patterns in Birnin Kudu. The r-calculated value of 0.235 was more significant than the r-critical value of 0.185, and the significant value of 0.041 is less than 0.05, which is the decision rule for accepting or not accepting the hypothesis. Therefore, an alternate hypothesis is upheld at this moment. This revealed a strong correlation between the impact of global warming and increased migration patterns, as residents seek better livelihoods.

Table 4.17 PPMC Test Result of Relationship between Global Warming and Migration Pattern

Variable	N	X	S.D	Df	r-cal	r-crit	Sig	Decision
Global warming	50	3.63	0.77	48	0.215	0.175	0.032	Significant
Agricultural Productivity		3.48	0.43					

The analysis is based on a sample size of 50 respondents, with a mean score for global warming of 3.63 and a standard deviation of 0.77. This indicates a moderate agreement among respondents regarding the impact of global warming. The mean score for agricultural productivity is 3.28, with a standard deviation of 0.43, indicating that respondents perceive agricultural productivity to be significantly affected by global warming.

The calculated correlation coefficient (r-cal) of 0.215 indicates a positive relationship between global warming and migration patterns. This suggests that as perceptions of global warming increase, there is a corresponding increase in the likelihood of migration. The critical value (r-critical) is set at 0.175, which serves as a threshold for determining the significance of the correlation. Since the calculated r-cal (0.215) exceeds the r-crit (0.175), the relationship between global warming and migration patterns is statistically significant. The significance level reported is 0.032, below the conventional threshold of 0.05. This further supports the conclusion that the relationship is statistically significant, suggesting that the findings are unlikely to have occurred by chance.

Based on the results, the decision accepts the hypothesis that a significant relationship exists between global warming and migration patterns. This implies that the impacts of global warming, particularly on agricultural productivity, influence individuals' decisions to migrate. The test results above indicate a statistically significant positive correlation between global warming and migration patterns. The results suggest that as global warming affects agricultural productivity, it may drive individuals to consider migration as a coping strategy.

4.2 Discussions of Findings

The research revealed key demographic trends, including a predominance of younger adults aged 26-35, indicating a receptive group for innovative ideas like climate change awareness and digital engagement. Balanced interest among the 18-25 and 36-45 age groups highlights the broad appeal of the subject across different life stages, while lower participation among older adults (46-60 years) underscores the need for tailored outreach to enhance accessibility and engagement. Additionally, the findings indicate a significant gender disparity, with males comprising 67.3% of the respondents. This imbalance suggests potential challenges in ensuring inclusive climate change strategies, as gender dynamics shape decision-making, financial priorities (Magaji, 2023), and technology adoption, which may influencethe adoption of sustainable and community-oriented solutions (Ologbonor et al., 2025).

The findings also emphasise the critical role of environmental stressors, such as reduced rainfall and pest infestations, in affecting agricultural productivity, as seen in moderate improvements in crop yields. Respondents reported a noticeable decline in water availability, unpredictable rainfall patterns, and an increase in extreme weather events, all of which pose significant challenges to agricultural planning and food security. Heat-related illnesses and rising infectious diseases were identified as additional health risks exacerbated by climate change. At the same time, the negative impact on household food access and nutrition further underscores the urgent need for adaptive strategies. Farmers' efforts to adopt improved seed varieties and diversify income sources reflect resilience; however, gaps in consistent government and NGO support hinder the effectiveness of these adaptive measures.

Migration trends driven by climate change and economic pressures were also highlighted, with a significant portion of respondents citing movement to urban areas as a coping mechanism. While this migration addresses immediate financial needs, it risks depopulating rural communities and disrupting local economies. The disconnect between awareness of government policies and their practical implementation further compounds these challenges. Addressing these issues requires better coordination and accessibility of support systems, targeted investments in climate-smart agriculture, and strengthening the capacity of rural communities to adapt to environmental changes, reducing the push factors for migration and fostering long-term sustainability.

The research findings align with the vulnerability theory, which emphasises the differential impacts of climate change on various populations and the need for targeted adaptation strategies. The study highlights significant health risks associated with global warming, as shown in Table 4.11. Respondents strongly agree that they or their families have experienced heat-related illnesses like heatstroke and dehydration, alongside an increase in diseases such as malaria, diarrhoea, cholera, and typhoid, linked to changing weather patterns. These findings underscore the urgent need for public health interventions, including awareness campaigns and improved access to healthcare, to mitigate the effects of extreme heat and the spread of infectious diseases. Additionally, the research reveals significant impacts on food security, with respondents agreeing that climate change has disrupted agricultural production, leading to challenges in accessing adequate nutrition. These findings underscore the urgent need for comprehensive climate adaptation planning to address the health and food security concerns of vulnerable communities.

Table 4.13 further emphasises the importance of adaptive strategies in mitigating the effects of climate change, particularly in agriculture. Improved seed varieties emerged as the most

commonly adopted strategy, reflecting farmers' proactive efforts to enhance crop resilience and productivity. However, the findings also reveal a lack of adequate support from the government and NGOs, with many farmers reporting insufficient financial backing, training, and agricultural extension services. The moderate effectiveness of existing adaptive strategies indicates persistent challenges that limit their success, emphasising the need for enhanced support systems to empower farmers. These findings affirm the vulnerability theory by highlighting the importance of tailored adaptive measures and the role of external support in strengthening resilience against climate impacts.

The research findings highlight the intricate relationship between agricultural productivity, economic pressures, and adaptive strategies, underscoring the need for systemic interventions to enhance climate resilience, access to resources, and market stability. While farming households demonstrate resilience and adaptability, the study reveals that moderate income growth and significant challenges underscore the need for holistic solutions to enhance rural livelihoods and mitigate the negative impacts of climate and economic pressures. The research also calls for targeted strategies to engage younger adults, leveraging their openness to adaptation while ensuring the inclusive dissemination of knowledge across generations.

Gender dynamics also play a key role in shaping perspectives on and responses to climate change. The male-dominated findings suggest that climate policies and programs may currently reflect predominantly male perspectives, which could overlook the priorities of women. To address this, the research recommends implementing gender-sensitive policies, conducting targeted awareness campaigns, and making efforts to overcome structural barriers that limit female participation in climate-related activities. Empowering women, who often play pivotal roles in managing household resources, is crucial for effective climate action. A balanced approach to decision-making could lead to more comprehensive and inclusive solutions.

The study further explores the challenges posed by climate change, including water scarcity, agricultural vulnerability, and environmental degradation. It emphasises the importance of enhancing water resource management, promoting climate-resilient farming practices, and mitigating the risks associated with extreme heat events. These issues have significant implications for food security and public health, underscoring the need for urgent interventions to mitigate climate-induced challenges. The findings also suggest that climate change-induced migration could lead to demographic shifts, placing additional strain on urban areas and exacerbating socio-economic challenges. To manage these impacts, the research recommends sustainable rural development, climate-resilient agricultural practices, and proactive policies that address the environmental and socio-economic dimensions of climate change.

5.0 Conclusion

This study underscores the profound and multifaceted impacts of global warming on agricultural productivity, water resources, health, and livelihoods in Birnin Kudu Local Government, Jigawa State. The findings highlight significant challenges, including declining crop yields, unpredictable rainfall patterns, increased pest infestations, and increased climate-related health problems. These effects have disrupted food security and threatened the socioeconomic stability of farmers, livestock owners, and fishermen in the region. The evidence suggests an urgent need for comprehensive interventions to address the cascading consequences of climate change on the community.

To mitigate these challenges, the study recommends investing in sustainable water resource management, including the development of alternative water sources, promoting water conservation techniques, and adopting drought-resistant agricultural practices. Strengthening public health systems is also critical, focusing on improving healthcare access, enhancing disease surveillance, and raising awareness of climate-related health risks. Support should be targeted toward vulnerable populations, including farmers and livestock owners, to build resilience through training, financial assistance, and resource management. Additionally, implementing climate change mitigation and adaptation strategies, such as reducing greenhouse gas emissions and fostering community-based resilience programs, will be essential in minimising the adverse effects and ensuring long-term sustainability.

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