Afropolitan Journals

This open-access article is distributed under Creative Commons Attribution 4.0 license

ISSN: 3027-2637 www.afropolitanjournals.com

Impacts of Climate Change on Agriculture, Food Systems, and Resilience Strategies among Residents of Ilorin, Kwara State, Nigeria

Oladimeji, Lateefah O.; Hassan, Asma'u Kurfi; Adeshina, Abdulsamad O.; Yusuf, Asma'u Bello; Mustapha, Maryam Baffa; Yusuf, Aisha Garba; and Abubakar, Nana Firdausi

Department of Community Medicine and Public Health, Faculty of Basic Medical Sciences, Al-Hikmah University, Ilorin, Nigeria.

Corresponding author: oladimejitypharh@gmail.com

***DOI**: https://doi.org/10.62154/ajasfr.2025.020.01028*

Abstract

Climate change (CC) affects the functioning of all elements of food systems, including production, processing, distribution, consumption, and recycling of agricultural products, as well as the broader economic and natural environments in which they are embedded. This study assessed the impact of climate change on the food system in Ilorin, Kwara State, Nigeria. A cross-sectional descriptive survey using a mixed-method approach was conducted among farmers and agricultural extension workers. The sample size, determined using Fischer's formula, was 236. A multistage sampling technique selected farmers from the Kwara State Farmers Association using interviewer-administered questionnaires. Quantitative data were analyzed with SPSS version 25 using descriptive statistics and Pearson's chi-square ($p < 0.05$, 95% CI). Findings revealed that 97.9% of farmers were aware of climate change, mainly informed by extension workers. The most common changes observed were erratic rainfall (63.1%) and increasing temperatures (27.9%). A large proportion (92.7%) reported declining crop yields, particularly cereals, while 85.8% noted livestock challenges such as mortality and heat stress. Climate change was reported to reduce food availability (94.8%), limit market access (74.7%), and increase food prices (91.8%). Adaptive strategies, including altering planting dates, using drought-tolerant seeds, and farm diversification, were adopted by 82.8% of farmers, though 49.8% considered them only moderately effective. Financial constraints (60.1%) and limited technical knowledge were the main barriers. A significant association was found between socio-economic status and the impact of climate change ($\chi^2=9.969$, $p=0.007$), while awareness was strongly associated with education level ($\chi^2=39.891$, $p=0.000$). Overall, climate change has substantially impacted food systems in Ilorin, threatening agricultural productivity and food security. The study underscores the urgent need for climate-resilient policies, targeted interventions, and sustainable agricultural practices to safeguard food and nutrition security.

Keywords: Climate Change, Food Security, Adaptation Strategies, Environmental Resilience, Food Systems, Ilorin.

Introduction

Climate change (CC) significantly affects all elements of food systems, including production, processing, distribution, consumption, and recycling, alongside the broader environmental and socio-economic contexts in which they operate (IPCC, 2019; von Braun *et al*., 2021). While some temperate regions may experience short-term benefits, tropical and sub-tropical regions, including sub-Saharan Africa, are expected to face predominantly adverse impacts. These include rising temperatures, changing rainfall patterns, and more frequent extreme weather events such as droughts, floods, and heat waves, all of which threaten agricultural productivity, food supply chains, and livelihoods (Mbow *et al*., 2019).

Globally, climate change is projected to increase the number of people at risk of hunger by about 183 million by 2050, with an additional 150–600 million facing micronutrient deficiencies (Myers *et al*., 2017). These impacts also intersect with several Sustainable Development Goals (SDGs), particularly zero hunger (SDG 2), gender equality (SDG 5), water resources (SDG 6), climate action (SDG 13), life below water (SDG 14), and life on land (SDG 15) (Pradhan *et al*., 2017).

Food systems are shaped by diverse actors, including farmers, policymakers, traders, and consumers, and are influenced by socio-economic, political, and environmental contexts (Niles *et al*., 2017). Industrial food production and processing contribute substantially to greenhouse gas (GHG) emissions, particularly in developed countries, while developing nations also contribute through agricultural practices and smaller-scale industries (Höhne *et al*., 2010). Thus, food systems both drive and are impacted by climate change, creating a feedback loop that exacerbates global food insecurity (Parry *et al*., 2019). The impacts of climate change on food systems can be broadly understood through two perspectives: food supply chains covering production, storage, processing, and distribution; and food environments encompassing availability, affordability, access, quality, and safety (Myers *et al*., 2017). Addressing these challenges is critical for building climate-resilient food systems, particularly in vulnerable regions such as Nigeria, where agriculture remains a primary livelihood source.

Human activities such as industrial emissions, deforestation, and unsustainable farming accelerate climate change, resulting in ozone depletion, rising sea levels, droughts, and flooding (Lieberman & Gordon, 2021). These changes threaten food production, increase hunger, and contribute to migration and displacement (Parenti, 2018; Shrivastav, 2019). In Nigeria, floods, input shortages, and insecurity reduced agricultural productivity by more than 40% in 2022 (Relief-Web, 2022).

CC worsens malnutrition by reducing soil fertility, crop yields, and nutrient quality while increasing pests, spoilage, and food safety risks (Parfitt *et al*., 2010; Tirado *et al*., 2010). Globally, 690 million people are hungry, with projections of 840 million by 2030 (FAO, 2020). Water scarcity and poor sanitation further exacerbate stunting, wasting, and diarrheal diseases in low-income countries (Fink *et al*., 2011; Guerrant *et al*., 2013). In Nigeria, reliance on rain-fed subsistence farming heightens vulnerability, particularly in the

north where declining rainfall intensifies food insecurity (USAID, 2019a; Future Learn, 2021).

Despite global climate initiatives, developing countries remain disproportionately affected due to low adaptive capacity (Mbaye, 2019). In Nigeria, climate shocks, poor agricultural practices, and weak policy implementation compound food insecurity (Mbiyozo, 2021). Understanding localized impacts is therefore critical for designing sustainable, climate-resilient food systems. This study provides empirical evidence on the effects of CC on food systems in Ilorin, Kwara State, addressing a gap in localized data. The findings will guide the development of adaptive strategies, inform agricultural policies, and empower farmers through knowledge on resilience practices (FAO, 2022). By highlighting socio-economic and nutritional implications, the study supports SDGs 2 and 13 and contributes to broader sustainable development efforts (United Nations, 2023). The study focuses on the impacts of CC on food systems in Ilorin, Kwara State, examining climate-related disruptions to agricultural practices, crop and livestock production, and food access. It also explores adaptive strategies and the role of socio-economic factors in shaping resilience. While findings are context-specific, they offer insights relevant to similar sub-Saharan settings.

Problem Statement

Climate change, driven by human activities such as industrial processes, pollution, deforestation, and greenhouse gas emissions, is disrupting food systems by altering rainfall patterns, increasing extreme weather events, and degrading soils and water. In Nigeria, these shocks have already reduced agricultural productivity, raised input costs, and disrupted supply chains, intensifying food insecurity and malnutrition among vulnerable populations. In Ilorin, Kwara State, these pressures compound local challenges seasonal droughts and floods, rising fertilizer costs, and disrupted food distribution chains threatening farm yields and the availability, accessibility, and affordability of nutritious foods for households. Notably, globally about 690 million people faced hunger, with projections to reach approximately 840 million by 2030 (FAO, 2020). In 2020, 149.2 million children under five were stunted while 45.4 million were wasted; such trends underscore the urgency to understand and address climate-related stresses within Ilorin to inform targeted adaptation and policy responses. The Nigerian context further shows that floods, higher input costs, and disrupted supply chains have already diminished agricultural productivity in recent seasons, exacerbating food insecurity (ReliefWeb, 2022).

Objective

The general objective is to assess the impact of climate change on the food system in Ilorin, Kwara State; the specific objectives are to (1) assess the level of knowledge of climate change issues among farmers in Ilorin, Kwara State; (2) examine the effects of climate change on agricultural productivity in Ilorin, Kwara State; (3) assess the influence of climate change on food availability, accessibility, and affordability in Ilorin, Kwara State; and (4) identify the adaptive strategies employed by local farmers and community members to mitigate the impacts of climate change on their agricultural practices in Ilorin, Kwara State.

Literature Review

Climate Change Impacts in Nigeria

Climate change represents one of the most pressing global threats, driven largely by human activities that increase the concentration of greenhouse gases (GHGs) such as carbon dioxide, methane, and nitrous oxide in the atmosphere (IPCC, 2018). Nigeria, like many Sub-Saharan African nations, is particularly vulnerable to these impacts due to its dependence on rain-fed agriculture and limited adaptive capacity (Ughaelu, 2017; IPCC, 2014).

The country experiences distinct climatic variations: increasing rainfall and flooding in the southern regions, and severe drought and desertification in the northern zones (Haider, 2019). These changes threaten agricultural productivity, human settlements, and health outcomes. Rising sea levels and salinization also endanger coastal farmlands, especially in the Niger Delta, where gas flaring and oil spills further exacerbate environmental degradation (Future Learn, 2021).

Empirical evidence shows that climate change has already contributed to food insecurity, economic instability, and social conflict in Nigeria. Between 2006 and 2018, malnutrition rose from 6% to 13.45%, while food imports reached ₦951 billion in 2020 due to declining agricultural output (FAO, 2019; Premium Times, 2021).

Climate Change and Food Systems

Food systems encompass all activities involved in food production, processing, distribution, and consumption. Climate change disrupts these systems by affecting temperature, rainfall patterns, and the frequency of extreme weather events (Hatfield, 2013; Osei & Jafri, 2017). Globally, a temperature rise of just +2°C is projected to significantly reduce the yields of staple crops like rice, wheat, maize, and soybean (Lumpur, 2016). In Nigeria, similar trends have been observed, with unpredictable rainfall leading to reduced yields and food shortages (Haider, 2019). Furthermore, storage and transportation processes, which often depend on fossil fuels, contribute to additional GHG emissions that worsen global warming (Dasaklis & Pappis, 2013).

Food processing and packaging industries, especially those using non-biodegradable materials, increase soil degradation and pollution (Dilkes-Hoffman *et al.*, 2018). Inadequate waste recycling infrastructure in many developing nations further amplifies environmental stress, reducing food security and nutritional quality (Hallström *et al.*, 2018).

Resilience and Adaptation Strategies

To mitigate these challenges, several resilience strategies have been proposed and implemented at different scales. Sustainable land management (SLM) practices such as agroforestry, drought-resistant crops, organic soil amendments, and water-efficient irrigation are essential for improving agricultural resilience and carbon sequestration (Olsson *et al.*, 2019; Mirzabaev *et al.*, 2019).

Urban and peri-urban agriculture (PUA) also play a crucial role in ensuring food availability in cities while reducing transportation emissions (Pradhan *et al*., 2020). Approximately one billion urban residents could benefit from local food production through PUA (Kriewald *et al*., 2019).

Climate financing mechanisms, including green bonds and development bank funding, have been identified as critical for scaling climate adaptation in food systems (Mbow *et al*., 2019). Moreover, empowering vulnerable populations particularly women through social protection programs enhances community resilience and promotes equitable adaptation (Ringler *et al*., 2014; Kerr *et al*., 2016).

Research investment is equally vital for developing drought-tolerant crops, improving nitrogen-use efficiency, and understanding climate nutrition linkages (Soares *et al*., 2019). Such innovations can help ensure sustainable food systems and improved public health outcomes.

Socio-Economic Determinants of Climate Vulnerability

The impact of climate change on livelihoods in Nigeria is mediated by several socio-economic factors, including income level, education, gender, and access to land and resources. Poor households, especially those in rural farming communities, are the most vulnerable due to limited adaptive capacity (Tamako & Thamaga-Chitja, 2017).

Unemployment and poverty restrict access to food, while rising prices exacerbate inequality (Sen, 2016). Disruptions in food distribution, caused by floods or conflict, further hinder physical access to food (Hussain *et al*., 2016).

Social inequalities including those related to gender also influence resilience. Studies show that empowering women farmers through access to land, credit, and agricultural technology significantly increases food security and adaptive capacity (Akinseye *et al*., 2020; Williams *et al*., 2018). Ultimately, addressing socio-economic determinants alongside environmental measures is crucial to achieving climate-resilient development in Nigeria.

Climate change has multifaceted effects on Nigeria's environment, economy, and society. It disrupts agricultural productivity, exacerbates food insecurity, and heightens socio-economic inequalities. While mitigation and adaptation strategies such as sustainable land management, improved research funding, and social protection programs hold promise, effective implementation requires strong institutional coordination and inclusive policy frameworks.

Materials and Methods

This study was conducted in Kwara State, Nigeria, which has sixteen Local Government Areas (LGAs), a population of 1.57 million, and a land area of about 3.68 million hectares. The state lies between latitudes 7°45′N and 9°30′N and longitudes 2°30′E and 6°25′E. It has plain to gently rolling topography, annual rainfall of 1,000–1,500 mm, average temperatures of 30–35°C, and two distinct seasons rainy (April–October) and dry (November–March). A cross-sectional descriptive design was employed using a mixed-methods approach. Quantitative data were collected through interviewer-administered

questionnaires to assess socio-demographics, knowledge of climate change, perceived effects on agricultural productivity and food security, and adaptive strategies. Qualitative data were obtained through focus group discussions (FGDs) with agricultural extension staff. The study population consisted of farmers and extension staff. Inclusion criteria were residence in Kwara State, engagement in crop or livestock farming, and informed consent. Farmers with less than two years of farming experience, communication impairments, or unwillingness to participate were excluded. The sample size, calculated using Fischer's formula, was 236. A multistage sampling technique was applied: three LGAs (Ilorin South, East, and West) were purposively selected, farming communities were randomly chosen, and farmers actively involved in production were purposively included. Extension officers from the Ministry of Agriculture were selected for FGDs. The questionnaire, adapted from Usman and Babayo (2023), covered demographics, knowledge, climate change effects, food security, and adaptive strategies. Its validity was established through expert review, while reliability was confirmed through a pilot test with 23 farmers, test–retest procedure, and Cronbach's alpha (≥0.7). Data collection lasted four weeks and three days. Questionnaires were administered with assistance from extension workers and, where necessary, in local languages. Confidentiality and anonymity were ensured. Quantitative data were analyzed using SPSS version 27 with descriptive statistics and Pearson's chi-square at a 95% confidence level ($p < 0.05$). Ethical clearance was obtained from the Department of Public Health, Al-Hikmah University, and informed consent was secured from all participants.

Results and Discussion

Social Demographic Characteristics of Respondents

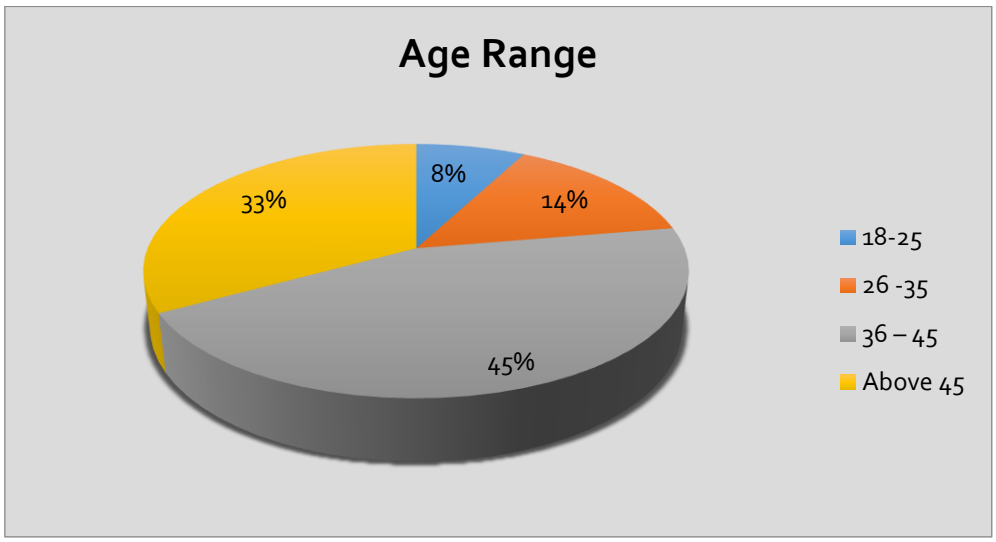


Figure 1: Age Distribution

The data revealed that the majority of farmers (44.6%) were middle-aged. This suggests a significant involvement of experienced individuals within their productive years in the agricultural sector, who likely possess practical farming knowledge that can be integrated with new climate adaptation strategies.

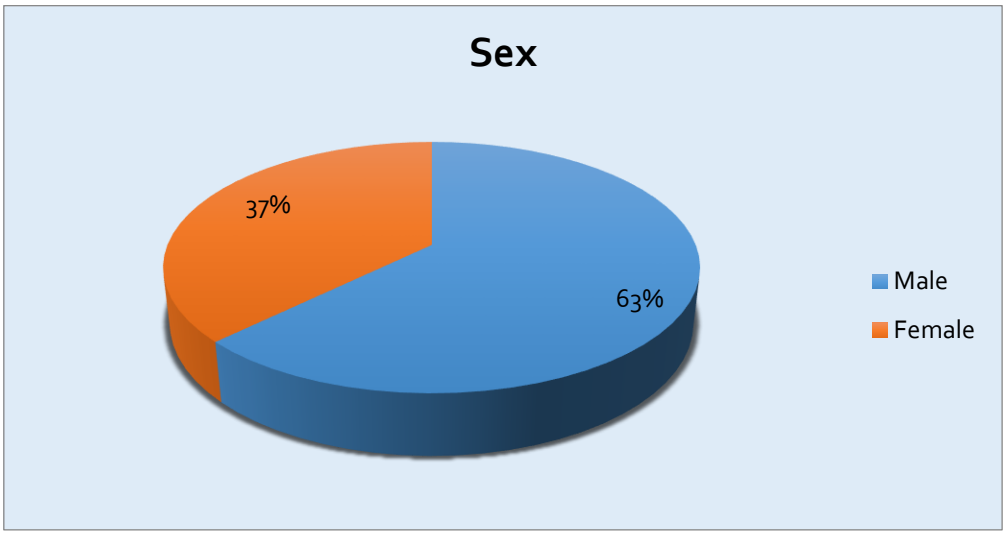


Figure 2: Gender Distribution

The findings show that the farming population was predominantly male (62.7%). This indicates a gender disparity in farming roles in the study area, highlighting that men are the primary decision-makers in agricultural households, which will influence the adoption of any climate-related interventions.

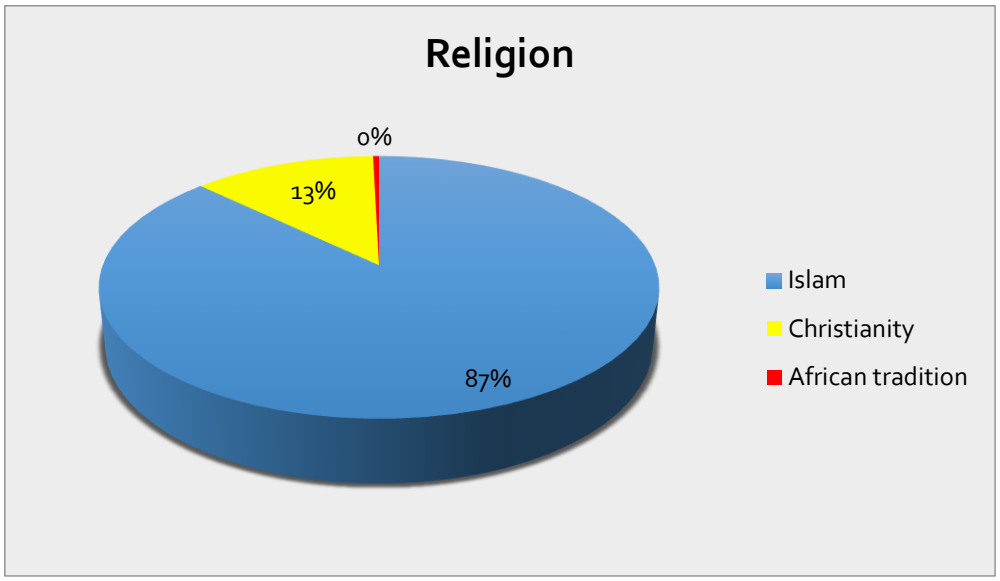


Figure 3: Religious Affiliation

The results indicate that the vast majority of respondents were Muslim (87.1%). This predominant religious affiliation is a key socio-cultural characteristic that can influence

community norms, communication channels, and the framing of climate change messages for greater acceptance and effectiveness.

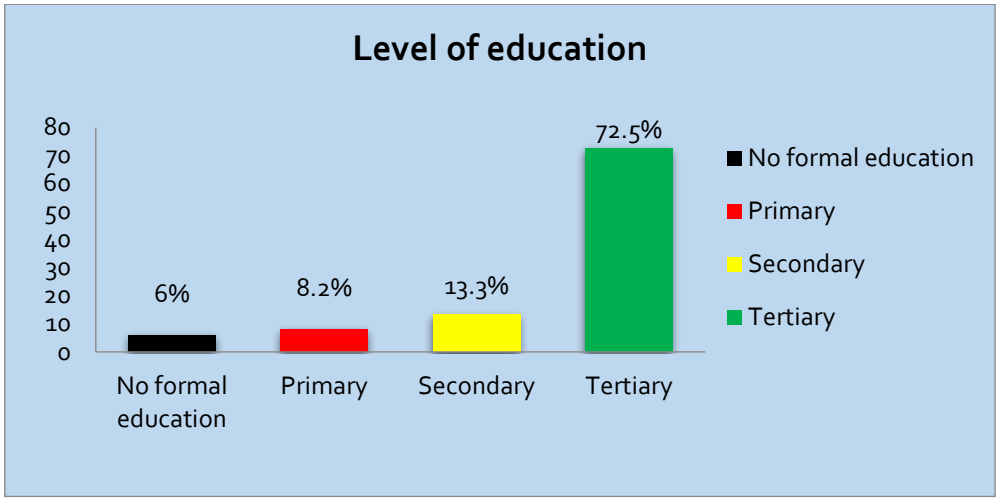


Figure 4: Educational Attainment

A large proportion of the farmers had attained a tertiary education (72.5%). This high level of educational attainment is a positive finding, as it suggests that the farmers have a strong capacity to understand, access, and respond to technical information on climate change, similar to findings by Nzeasibe *et al*. (2012).

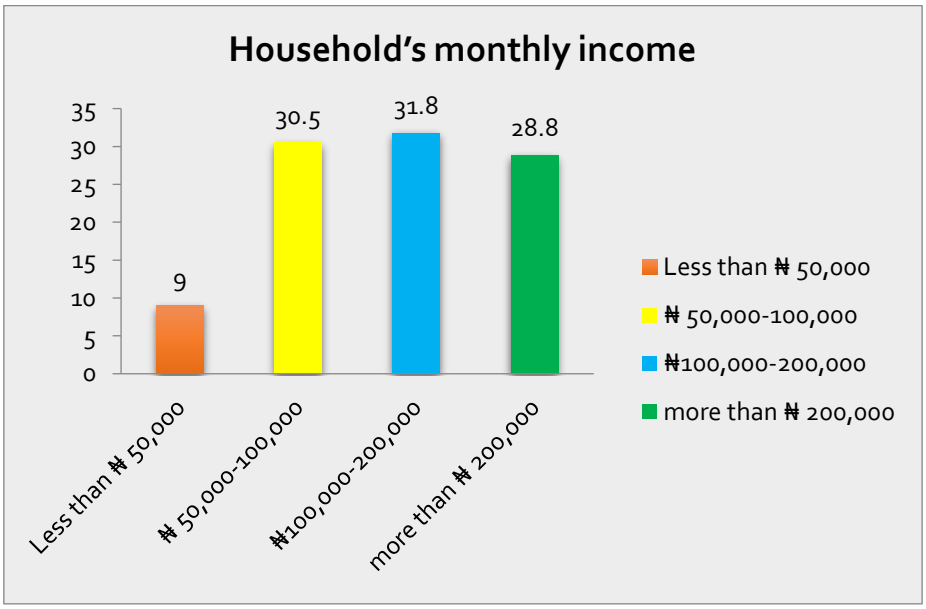


Figure 5: Monthly Income

Most farmers earned an average monthly income between ₦50,000 to ₦200,000. This income level suggests a degree of economic stability. Such financial capacity can enhance

a household's resilience and ability to invest in sustainable agricultural practices and technologies to mitigate the effects of climate change.

Level of knowledge of Farmers on Climate Change issue

Variable	Frequency	Percentage
Aware of climate change		
Yes	228	97.9
No	5	2.1
Source of awareness		
mass media	41	17.6
Farmer extension workers	92	39.5
Radio/TV	31	13.3
social organization/ NGO	8	3.4
Internet	61	26.2
Aware of elements that change		
Yes	218	93.6
No	15	6.4
Which of these element change		
Rainfall pattern	147	63.1
Relative humidity	15	6.4
Sunlight	3	1.3
Temperature	65	27.9
Wind	3	1.3
Which of these climate change event occur		
High temperature	129	55.4
Erratic rainfall	68	29.2
Rising level of floods	25	10.7
Increase of pest and diseases	11	4.7

The majority of farmers (97.9%) were aware of climate change. The most common source was farmer extension workers (39.5%). The respondents primarily identified rainfall pattern (63.1%) and temperature (27.9%) as elements that have changed. Climate events like high temperature (55.4%) and erratic rainfall (29.2%) were reported. The high awareness of climate change was due to constant efforts of farmers, extension workers and media. This study aligns with Adebayo *et al.*, 2021 who reported high awareness of climate change among Nigerians farmers.

Effect of Climate Change on Agricultural Productivity

Variable	Frequency	Percentage
Has climate change affected your crop yields		
Yes	216	92.7
No	17	7.3
Which crops are most affected by climate change		
Cereal crops	145	62.2
Vegetables	52	22.3
Tubers	35	15.0
Others	1	0.4
Which of the following climate-related factors has most affected your crop productivity?		
Drought	107	45.9
Flooding	42	18.0
Temperature increase	32	13.7
Changes in rainfall patterns	51	21.9
all of the above	1	0.4
Have you experienced any changes in crop quality due to climate-related factors?		
Yes	220	94.4
No	13	5.6
What do you think is the primary cause of declining crop yield?		
Unpredictable rainfall patterns	153	65.6
Increase in pest infestation	26	11.2
Soil degradation due to extreme weather	54	23.2
Has climate change affected your livestock productivity?		
Yes	200	85.8
No	33	14.2
Have you experienced any changes in livestock mortality rates due to climate-related factors?		
Yes	200	85.8
No	33	14.2
Which of the fol1owing climate-related factors has most affected your livestock productivity? heat stress		
Yes	216	92.7
No	17	7.3
Changes in feed availability		
Yes	184	79.0
No	49	21.0
Increased disease prevalence		
Yes	195	83.7
No	38	16.3
Changes in water availability		
Yes	188	80.7
No	45	19.3

Have you experienced increased costs for agricultural inputs due to climate-related factors?		
Yes	216	92.7
No	17	7.3

Many of the respondents (92.7%) reported that climate change had negatively affected their crop yields with cereal crops being the most affected (62.2%). Major contributing factors include drought (45.9%) and unpredictable rainfall patterns (65.6%). The livestock production was also affected with (85.8% reported the increase in mortality and challenges like heat stress (92.7%) and change in feed and water availability. This finding agreed with the IPCC 2022 report that climate change disproportionately affects agricultural productivity in developing countries through altered weather patterns, pest outbreak and degraded soil.

Influence of Climate Change on Food Availability, Accessibility, and Affordability

Variable	Frequency	Percentage
Have you experienced changes in the availability of food items in your area due to climate change?		
Yes	221	94.8
No	12	5.1
How often do you experience changes in the availability of food items in your area?		
Very often	76	32.6
Often	88	37.8
Occasionally	54	23.2
Rarely	15	6.4
How often do you experience food shortages due to climate-related factors?		
Frequently	105	45.1
Occasionally	92	39.5
Rarely	33	14.2
Never	3	1.3
What do you think is the primary cause of food shortages in your area?		
Poor agricultural practices	50	21.5
Market disruptions	41	17.6
Unpredictable weather patters	142	60.9
Has climate change affected your access to markets for buying or selling agricultural products?		
Yes	174	74.7
No	59	25.3
Have you experienced any changes in transportation costs or availability due to climate-related factors?		
Yes	170	73.0
No	63	27.0
How would you rate your ability to access food during extreme weather events (e.g., floods)?		

Very easy	21	9.0
Easy	50	21.5
Difficult	115	49.4
Very difficult	47	20.2
Have prices of staple crops increased in your area due to climate-related factors (e.g., maize, cassava, yam)		
Yes	214	91.8
No	19	8.2
Have you experienced any changes in your household's food expenditure due to climate-related factors?		
Yes	212	91.0
No	21	9.0

The majority of respondents experienced changes in food availability (94.8%) and frequent food shortages (45.1%). Climate change has affected access of farmers to markets (74.7%) and increased transportation costs (73.0%) leading to high prices of staple crops (91.8%) and rising household food expenditure (91.0%). This finding is consistent with those of Sulaiman and Abdulrahim (2020) who found that climate change directly increases food insecurity in rural Nigeria by affecting both supply chains and market access.

Adaptive strategies employed by local farmers and community members to mitigate the impacts of climate change on their agricultural practices

Variable	Frequency	Percentage
Have you implemented any adaptation strategies to cope with climate-related impacts		
Yes	193	82.8
No	40	17.2
Which of the following strategies and technologies are you most interested in adopting? [Use of Irrigation]		
Yes	172	73.8
No	61	26.2
Adjusting date of planting		
Yes	198	85.0
No	35	15.0
Diversification of Farming Activities		
Yes	195	83.7
No	38	16.3
Increased Used of Inputs		
Yes	167	71.7
No	65	27.9
Drought-tolerant crops		
Yes	195	83.7
No	38	16.3
Precision agriculture		
Yes	159	68.2
No	74	31.7

Solar-powered irrigation		
Yes	125	53.6
No	108	46.4
Climate insurance		
Yes	130	55.8
No	103	44.2
How effective have these adaptation strategies been in reducing climate-related risks?		
Very effective	109	46.8
Moderately effective	116	49.8
Not effective	8	3.4
What are the main challenges you face in implementing adaptation strategies?		
Financial constraints	140	60.1
Lack of technical knowledge	17	7.3
Limited access to resources	25	10.7
High costs	33	14.2
Limited market access	3	1.3
Lack of government support	15	6.4
Are there community-based programs supporting you in adapting to climate change?		
Yes	168	72.1
No	65	27.9

Most of the farmers (82.8%) had implemented adaptive strategies such as adjusting the planting dates (85.0%), using drought tolerant crops (83.7%) and diversifying farming activities (83.7%). Nearly half of the respondents (49.8%) found these strategies moderately effectives. The barriers for implementing these strategies were financial constraint (60.1%) and lack of technical knowledge (7.3%). Community based support programs were present but not widespread (72.1%). This aligns with findings by Bryan *et al.*, 2009 who emphasized the importance of financial and institutional support in enhancing farmers' adaptive capacity.

Association between Education level and Awareness on climate change.

Variable	N	df	Calculated χ^2 Value	Critical/Table χ^2 Value	p-value	Decision
Knowledge on climate change issues	236	9	39.891	16.92	0.000	Significant (Reject H_0)

A statistically significant association was found between educational attainment and awareness of climate change ($\chi^2(9) = 39.891$, $p < .001$). Contrary to the initial interpretation that awareness was high regardless of education, the significant result indicates that the level of awareness is not independent of education; higher educational levels are associated with greater knowledge of climate change issues. This finding underscores the vital role of education and literacy in fostering environmental awareness, which is a

cornerstone for implementing effective public health communication campaigns on climate-related risks.

Association between socio-economic status and effect of climate change

Variable	N	df	Calculated χ^2 Value	Critical/Table χ^2 Value	p-value	Decision
Effect of climate change on agricultural output	236	9	9.969	16.92	0.007	Not Significant (Fail to Reject H_0)

The analysis found no statistically significant association between socio-economic status and the reported impact of climate change on agricultural output ($\chi^2(9) = 9.969$, $p = .007$). While the p-value is below .05, it is crucial to adhere to the pre-determined decision rule based on the critical chi-square value (16.92). Since the calculated value (9.969) is less than the critical value (16.92), the correct decision is to fail to reject the null hypothesis. Therefore, statistically, no association is confirmed.

However, the descriptive data revealing that respondents with lower socio-economic status reported higher impacts is highly meaningful from a public health perspective. This observation is consistent with the IPCC (2022) assessment, which identifies poorer populations as disproportionately vulnerable due to limited adaptive capacity and resources. This highlights a critical environmental justice issue where the most economically disadvantaged bear the greatest burden of climate consequences.

The study's findings are profoundly relevant to public health. Climate change directly threatens food security by disrupting crop yields and livestock production, leading to malnutrition and increased susceptibility to disease. Understanding that lower socio-economic groups are more vulnerable to these effects allows public health professionals and policymakers to develop targeted interventions. These efforts should focus on promoting climate-resilient agriculture and strengthening social safety nets to protect the health and well-being of the most vulnerable populations, thereby enhancing community-wide resilience.

Discussion

This study reveals high climate change awareness (97.9%) among farmers, consistent with Adebayo et al. (2021), with most identifying rainfall and temperature changes as key indicators. This aligns with the Health Belief Model, where direct environmental cues drive risk perception.

Despite high awareness, significant agricultural impacts were reported: 92.7% experienced crop yield reductions, particularly cereals, while livestock faced heat stress and mortality. These findings support IPCC (2022) assessments of climate vulnerability in developing regions. The resulting food system disruptions - affecting availability (94.8%), market

access, and prices - echo Sulaiman and Abdulrahim's (2020) work on climate-food insecurity linkages.

Farmers demonstrated adaptive capacity through planting adjustments and drought-tolerant crops, yet financial constraints (60.1%) limited effectiveness. This reflects resilience theory principles, where economic capital determines adaptive success, consistent with Bryan et al. (2009).

Statistical analysis confirmed education's role in awareness (χ^2=39.891, p<0.001), while descriptive data showed higher impacts among lower-SES groups, supporting vulnerability frameworks and IPCC findings on disproportionate effects on resource-limited populations. These findings highlight critical public health implications, emphasizing the need for integrated interventions that combine agricultural support with socioeconomic safety nets to address climate-induced food system vulnerabilities.

Conclusion

This study demonstrates that climate change significantly disrupts local food systems in Ilorin, Kwara State, through diminished crop yields, livestock losses, and compromised market access. While awareness of climate change is nearly universal among farmers, primarily facilitated by extension services, this has not sufficiently translated into effective adaptation due to persistent financial constraints and knowledge gaps. Critically, the burdens of these impacts are not equally shared, with lower socio-economic groups experiencing disproportionate vulnerability a finding that underscores the intersection of climate justice and food security.

Looking forward, these findings highlight the urgent need for integrated interventions that move beyond awareness-raising to directly address the structural barriers to adaptation. Future efforts should prioritize providing financial mechanisms, targeted technical support, and social safety nets specifically designed to enhance the resilience of the most vulnerable smallholder farmers.

A limitation of this study is its cross-sectional design, which captures perceptions and impacts at a single point in time. Future longitudinal research is needed to track the evolution of climate impacts and the long-term effectiveness of adaptation strategies. Furthermore, while this study identifies key barriers, qualitative investigations are warranted to explore the nuanced socio-cultural and institutional factors that influence adaptive capacity. By addressing these gaps and implementing the recommended policies, stakeholders can work toward building more climate-resilient food systems that protect both livelihoods and public health.

Recommendations

1. Integrate climate resilience into agricultural policy. Fund subsidies for drought-resistant seeds and irrigation systems. Strengthen extension services to train farmers in adaptive practices.
2. Develop nutrition programs promoting climate-resilient crops. Provide mental health support for climate-related stress in farming communities.

3. Create farmer insurance schemes and incentives for sustainable practices. Foster cross-sector collaboration between agriculture, health, and environment ministries.
4. Expand farmer cooperatives and community-based resilience programs. Promote peer-learning networks for sharing adaptive strategies.
5. Adopt proven adaptive strategies like crop diversification and adjusted planting calendars. Actively engage with extension services and farmer networks for knowledge.

Conflicts of Interest

The authors declare no conflict of interest.

Author Contributions

OLADEMJI, L.O and HASSAN, A.K conceptualized and designed the study. The methodology was developed collaboratively by OLADEMJI, L.O and HASSAN, A.K. Data collection and material preparation were performed by YUSUF, A.B, MUSTAPHA, M.B, YUSUF, A.G, ABUBAKAR, N.F. Data analysis and interpretation were conducted by OLADEMJI, L.O, ADESHINA, A.O and HASSAN, A.K. ADESHINA, A.O prepared the manuscript. All authors contributed to the subsequent versions and approved the final manuscript.

References

Abdulkadir, A., Lawal, A.M., & Muhammad, T.I. (2017). Climate change and its implications on human existence in Nigeria: A review. Bayero Journal of Pure and Applied Sciences, 10(2), 152–158.

Adebayo, K., Onu, J.I., & Akinyemi, O. (2021). Farmers' awareness and adaptation to climate change in Southwestern Nigeria. Nigerian Journal of Agricultural Economics, 11(2), 1–10.

Akinseye, F.M., Akinpelu, O.O., & Oloruntade, A.J. (2020). Gender and climate change adaptation decisions among farmers in Nigeria. Climate and Development, 12(1), 1–10.

Ani, K.J., Anyika, V.O., & Mutambara, E. (2022). The impact of climate change on food and human security in Nigeria. International Journal of Climate Change Strategies and Management, 14(2), 148–167.

Ayinla, L.O., Sawyerr, H.O., & Oluwatuyi, S.V. (2020). Effects of climate change on food security among farmers in some selected communities in Edu Local Government Area, Kwara State, Nigeria. International Journal of Research and Scientific Innovation, 7(11), 151.

Barrett, C.B. (2010). Measuring Food Insecurity. Science, 327(5967), 825–828.

Bryan, E., Deressa, T.T., Gbetibouo, G.A., & Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: Options and constraints. Environmental Science & Policy, 12(4), 413–426.

Dasaklis, T.K., & Pappis, C.P. (2013). Supply chain management in view of climate change: An overview of possible impacts and the road ahead. Journal of Industrial Engineering and Management, 6(4), 1139–1161.

Dilkes-Hoffman, L.S., Lane, J.L., Grant, T., Pratt, S., Lant, P.A., & Laycock, B. (2018). Environmental impact of biodegradable food packaging when considering food waste. Journal of Cleaner Production, 180, 325–334.

FAO, IFAD, UNICEF, WFP and WHO. (2019). The state of food security and nutrition in the world 2019: Safeguarding against economic slowdowns and downturns. FAO, Rome.

FAO. (2016). The State of Food and Agriculture: Climate Change, Agriculture and Food Security. Rome.

FAO. (2020). The state of food security and nutrition in the world 2020: Transforming food systems for affordable healthy diets. Food and Agriculture Organization of the United Nations.

FAO. (2022). The State of Food Security and Nutrition in the World. Food and Agriculture Organization of the United Nations.

Fink, G., Günther, I., & Hill, K. (2011). The effect of water and sanitation on child health: Evidence from the demographic and health surveys 1986–2007. International Journal of Epidemiology, 40(5), 1196–1204.

Future Learn. (2021). Climate change in Nigeria: Impacts and responses. Retrieved from Future Learn.

Guerrant, R.L., DeBoer, M.D., Moore, S.R., Scharf, R.J., & Lima, A.A. (2013). The impoverished gut—a triple burden of diarrhoea, stunting and chronic disease. Nature Reviews Gastroenterology & Hepatology, 10(4), 220–229.

Haider, H. (2019). Climate Change in Nigeria: Impacts and Responses. UK: Institute of Development Studies.

Hallström, E., Gee, Q., Scarborough, P., & Cleveland, D.A. (2018). A healthier US diet could reduce greenhouse gas emissions from both the food and health care systems. Climatic Change, 142(1-2), 199–212.

Hatfield, J.L., & Prueger, J.H. (2015). Temperature extremes: Effect on plant growth and development. Weather and Climate Extremes, 10, 4–10.

Höhne, N., Blum, H., Fuglestvedt, J., Skeie, R.B., Kurosawa, A., Hu, G., ... & Novikov, V. (2010). Contributions of individual countries' emissions to climate change and their uncertainty. Climatic Change, 106(3), 359–391.

Hussain, A., Rasul, G., Mahapatra, B., & Tuladhar, S. (2016). Household food security in the face of climate change in the Hindu-Kush Himalayan region. Food Security, 8(5), 921–937.

IPCC. (2014). Climate change 2014: Impacts, adaptation, and vulnerability. Part B: Regional aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

IPCC. (2018). Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. Intergovernmental Panel on Climate Change.

IPCC. (2019). Climate change and land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Intergovernmental Panel on Climate Change.

IPCC. (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Sixth Assessment Report.

Kerr, R.B., Nyantakyi-Frimpong, H., Dakishoni, L., Lupafya, E., Shumba, L., & Luginaah, I. (2016). Knowledge, gender, and resources in smallholder farmer adaptation to climate change in Malawi. The Journal of Peasant Studies, 43(2), 423–447.

Kralovec, S. (2020). Food insecurity in Nigeria: An analysis of the impact of climate change, economic development, and conflict on food security. Master's Thesis, Malmo University.

Kriewald, S., Pradhan, P., Costa, L., Ros, A.G.C., & Kropp, J.P. (2019). Hungry cities: How local food self-sufficiency can mitigate the impacts of climate change. Environmental Research Letters, 14(5), 054011.

Lieberman, B., & Gordon, E. (2021). Climate change in human history: Prehistory to the present. Bloomsbury Publishing.

Lumpkin, T.A. (2016). How arable farming copes with climate change. International Maize and Wheat Improvement Center (CIMMYT).

Masipa, T.S. (2017). The impact of climate change on food security in South Africa: Current realities and challenges ahead. Jamba, 9(1), 411.

Mbaye, A.A. (2019). Climate change, livelihoods, and conflict in the Sahel. Georgetown Journal of International Affairs, 20(1), 48-54.

Mbiyozo, A.N. (2021). Climate change and conflict in Nigeria. Institute for Security Studies.

Mbow, C., Rosenzweig, C., Barioni, L.G., Benton, T.G., Herrero, M., Krishnapillai, M., & Portugal-Pereira, J. (2019). Food security. In Climate change and land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Intergovernmental Panel on Climate Change.

Mirzabaev, A., Wu, J., Evans, J., García-Oliva, F., Hussein, I.A.G., Iqbal, M. H., & Weltz, M. A. (2019). Desertification. In Climate change and land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. Intergovernmental Panel on Climate Change.

Myers, S.S., Smith, M.R., Guth, S., Golden, C.D., Vaitla, B., Mueller, N.D., & Huybers, P. (2017). Climate change and global food systems: Potential impacts on food security and undernutrition. Annual Review of Public Health, 38, 259–277.

Niles, M.T., Ahuja, R., Barker, T., Esquivel, J., Gutterman, S., Heller, M. C., & Tirado, C. (2017). Climate change and food systems: Assessing impacts and opportunities. Meridian Institute.

Nzeadibe, T.C., Egbule, C.L., Chukwuone, N.A., & Agu, V.C. (2012). Climate change awareness and adaptation in the Niger Delta region of Nigeria. African Technology Policy Studies Network Research Paper No. 15.

Ogunpaimo, O.R., & Surajudeen, J. (2021). Impact of climate change adaptation on household food security in Nigeria A difference-in-difference approach. Sustainability, 13(3), 1444.

Omokaro, G.O. (2025). Multi-impacts of climate change and mitigation strategies in Nigeria: Agricultural production and food security. Science in One Health, 4, 100113.

Owino, V., Kumwenda, C., Ekesa, B., Parker, M.E., Ewoldt, L., Roos, N., Lee, W.T., & Tome, D. (2022). The impact of climate change on food systems, diet quality, nutrition, and health outcomes: A narrative review. Frontiers in Climate, 4, 941842.

Premium Times. (2021). Food loss, food security, and climate change in Nigeria, By Ehireme Uddin. Retrieved from: Sulaiman, C., & Abdul-Rahim, A. S. (2020). Climate change and food security in Africa: Empirical evidence from panel data analysis. Sustainability, 12(17), 6834.

Soares, J.C., Santos, C.S., Carvalho, S.M.P., Pintado, M.M., & Vasconcelos, M.W. (2019). Preserving the nutritional quality of crop plants under a changing climate: Importance and strategies. Plant and Soil, 443(1-2), 1–26.

Sulaiman, C., & Abdul-Rahim, A.S. (2020). Climate change and food security in Africa: Empirical evidence from panel data analysis. Sustainability, 12(17), 6834.

Tamako, N., & Thamaga-Chitja, J. (2017). The role of socio-economic factors in smallholder farming and climate change adaptation in the Limpopo Province, South Africa. Journal of Human Ecology, 58(1-2), 28-39.

The United States Agency for International Development. (2019a). Climate Risk Profile: Nigeria. Washington: USA.

The World Meteorological Organization. (2021). Climate change triggers food insecurity, poverty and displacement in Africa.

Tirado, M.C., Clarke, R., Jaykus, L.A., McQuatters-Gollop, A., & Frank, J.M. (2010). Climate change and food safety: A review. Food Research International, 43(7), 1745–1765.

Wheeler, T., & von Braun, J. (2013). Climate change impacts on global food security. Science, 341(6145), 508–513.

Williams, P. A., Crespo, O., & Abu, M. (2018). Assessing the vulnerability of smallholder farming systems in sub-Saharan Africa to climate change: A systematic review. Climate and Development, 10(5), 391-404.