CLIMATE CHANGE AND FOOD SYSTEM RESILIENCE IN NIGERIA: IMPACTS ON AGRICULTURAL PRODUCTIVITY, FOOD SECURITY, AND ADAPTATION STRATEGIES AMONG FARMERS IN ILORIN, KWARA STATE, NIGERIA

BY

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Abstract

Climate change has emerged as a major global challenge with significant implications for agricultural productivity, food systems, and food security, particularly in developing countries that rely heavily on rain-fed agriculture. This study assessed the impact of climate change on food systems in Ilorin, Kwara State, Nigeria, with emphasis on farmers' knowledge of climate change, its effects on agricultural productivity, and the adaptive strategies employed to mitigate these impacts. A cross-sectional mixed-methods design was adopted involving 236 farmers selected through a multistage sampling technique across Ilorin East, Ilorin South, and Ilorin West Local Government Areas. Quantitative data were collected using interviewer-administered questionnaires, while qualitative insights were obtained through focus group discussions with agricultural extension officers. Quantitative data were analyzed using descriptive statistics and Chi-square tests in SPSS version 27, while thematic analysis was used for qualitative data. The results revealed a high level of climate change awareness among farmers (97.9%), with extension workers serving as the primary source of information. A significant association was found between level of education and awareness of climate change ($\chi^2 = 39.891$, $p < 0.05$). Most respondents (92.7%) reported that climate change has negatively affected agricultural productivity, particularly cereal crops, due to drought, unpredictable rainfall patterns, and increased pest infestations. Livestock production was also affected by heat stress, disease prevalence, and reduced feed and water availability. Focus group discussions corroborated these findings, highlighting irregular rainfall, extreme temperatures, and flooding as key climatic challenges affecting farming activities and food availability. Farmers adopted several adaptation strategies including crop rotation, use of improved drought-resistant seeds, irrigation, mulching, and livestock diversification. The study concludes that climate change poses significant threats to food systems and agricultural livelihoods in Ilorin. Strengthening extension services, promoting climate-resilient agricultural practices, and improving government support mechanisms are essential for enhancing food system resilience and sustainable food security.

Keywords: Climate change, Food system resilience, Agricultural productivity, Food security Adaptation strategies

Introduction

Climate change has become one of the most significant global environmental challenges of the twenty-first century, with profound implications for ecosystems, human health, and food security. It affects multiple components of food systems, including food production, processing, distribution, access, and consumption. A food system encompasses the interconnected processes and actors involved in producing, processing, distributing, and consuming food, as well as the socio-economic and environmental factors influencing these activities (von Braun *et al*., 2021). Climate variability such as increasing temperatures, changing precipitation patterns, and the rising frequency of extreme weather events including floods, droughts, and heat waves has the potential to disrupt these systems and threaten global food security (IPCC, 2019). These climatic changes influence crop productivity, livestock health, and fisheries by affecting water availability, increasing heat stress, and altering the distribution of pests and diseases.

Globally, climate change has been associated with reduced agricultural productivity and increased food insecurity, particularly in developing countries where agriculture is largely dependent on rainfall and natural climatic conditions (Wheeler & von Braun, 2013). In sub-Saharan Africa, the vulnerability of agricultural systems to climate variability is particularly high due to limited adaptive capacity, reliance on subsistence farming, and inadequate agricultural infrastructure (Thompson *et al*., 2010). Rising temperatures and unpredictable rainfall patterns have contributed to declining crop yields, soil degradation, and reduced livestock productivity, ultimately affecting food availability and household nutrition (FAO, 2022). Human activities have been identified as major drivers of climate change. Industrialization, environmental pollution, deforestation, bush burning, excessive carbon emissions, and unsustainable land-use practices have contributed significantly to environmental degradation and global warming. These activities have also led to ozone layer depletion, rising sea levels due to the melting of glaciers, and increased flooding in several parts of the world (Lieberman & Gordon, 2021). Climate change therefore represents not only an environmental challenge but also a major threat to human survival and socio-economic stability. Extreme climatic conditions such as prolonged droughts and severe flooding are increasingly contributing to food scarcity, hunger, and starvation across many regions of the world (Parenti, 2018). Furthermore, environmental degradation and rising temperatures are contributing to the displacement of millions of people through climate-induced migration, thereby threatening human settlements and livelihoods (Shrivastav, 2019).

Nigeria is among the countries in sub-Saharan Africa experiencing significant impacts from climate change due to its dependence on rain-fed agriculture and increasing environmental pressures. Over 90% of agricultural production in Nigeria relies on rainfall, making farmers highly vulnerable to climatic fluctuations (USAID, 2019). Changes in rainfall patterns, prolonged droughts, flooding, and rising temperatures have increasingly disrupted agricultural activities across the country. These disruptions have contributed to declining agricultural output, food shortages, and rising food prices, thereby exacerbating food insecurity and economic instability (Future Learn, 2021). In recent years, extreme weather events such as flooding and drought have significantly affected agricultural productivity in Nigeria. For instance, excessive floods, rising costs of fertilizers and agricultural chemicals, and conflicts among farming communities reduced agricultural productivity by more than 40% during the 2022 farming season (Relief-Web, 2022). The impacts of climate change extend beyond food production and have significant consequences public health. Climate change threatens food security and diet quality, leaving vulnerable populations at increased risk of various forms of malnutrition. Poor diets have been identified as one of the leading causes of mortality and morbidity worldwide (Afshin *et al*., 2019; Micha *et al*., 2020). Globally, approximately 690 million people currently experience hunger, and this number is projected to exceed 840 million by the year 2030 if current trends continue (FAO, 2020). In addition, malnutrition remains a major global health concern. In 2020, an estimated 149.2 million children under the age of five were stunted, while 45.4 million were wasted due to inadequate nutrition. At the same time, 38.9 million children under five were classified as overweight, highlighting the complex nature of global malnutrition (WHO, 2021).

Climate change can also disrupt food supply chains and transportation systems, resulting in food price volatility and limited access to nutritious foods, particularly among vulnerable populations (FAO, 2020). Consequently, poorer and marginalized groups tend to suffer the most because they often have limited resources and reduced capacity to adapt to environmental shocks (Niles *et al*., 2017; FAO, 2020). In addition to its effects on food systems, climate change also affects water security and public health outcomes. Access to safe water remains a critical global health issue, particularly in low-income countries. More than two billion people live in dry regions of the world where water scarcity and poor sanitation systems increase the risk of malnutrition and infectious diseases. Extreme weather conditions such as excessive rainfall, flooding, and prolonged drought can increase exposure to pathogenic

microorganisms, leading to enteric infections and diarrheal diseases (Fink *et al*., 2011; Guerrant *et al*., 2013; Ngure *et al*., 2014). These conditions are particularly harmful to infants and young children, as repeated infections contribute to poor nutrient absorption, stunted growth, wasting, and delayed development. Moreover, rising temperatures and extreme climatic conditions have been linked to the increasing burden of vector-borne diseases such as malaria, as well as the emergence of new zoonotic diseases in vulnerable regions. Despite growing global attention to climate change and food security, there remains limited localized evidence on how climate variability affects food systems at the community level in many developing regions. Understanding these localized impacts is essential for designing effective policies and interventions that enhance climate resilience and sustainable agricultural practices. In Ilorin, Kwara State, where agriculture plays a vital role in livelihoods and food supply, farmers are increasingly experiencing changes in rainfall patterns, temperature fluctuations, and other climate-related challenges that influence food production and availability.

This study therefore examines the impact of climate change on food systems in Ilorin, Kwara State, Nigeria. Specifically, it explores how climatic factors such as erratic rainfall, temperature variations, and extreme weather events influence agricultural productivity, food availability, accessibility, and affordability. Understanding these dynamics will provide valuable insights for policymakers, public health professionals, and agricultural stakeholders in developing strategies that promote climate-resilient agriculture and strengthen food security in vulnerable communities. Furthermore, the findings of this study are expected to contribute to the development of sustainable policies and interventions aimed at improving agricultural resilience and enhancing food security. By identifying effective adaptive strategies and existing challenges faced by farmers, the research will support efforts to promote sustainable farming practices, improved irrigation systems, and better food storage techniques (FAO, 2022). The study also highlights the importance of empowering local communities with knowledge and resources to adapt to climate-related challenges, thereby strengthening resilience at the grassroots level (Adger *et al*., 2013). In addition, the research aligns with global development priorities, particularly the achievement of Sustainable Development Goal 2 (Zero Hunger) and Sustainable Development Goal 13 (Climate Action) (United Nations, 2023)

Objectives

1. To assess the level of knowledge of climate change issues among farmers in Ilorin, Kwara State.
2. To examine the effects of climate change on agricultural productivity in Ilorin, Kwara State.
3. To assess the influence of climate change on food availability, accessibility, and affordability in Ilorin, Kwara State.
4. To 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.

Research Hypotheses

1. **H_0:** There is no significant relationship between education and level of awareness on climate change.
   H_1: There is a significant relationship between education and level of awareness on climate change.
2. **H_0:** There is no significant relationship between the effects of climate change and socio-economic status.
   H_1: There is a significant relationship between the effects of climate change and socio-economic status.

Methodology

The study was conducted in Kwara State, Nigeria, located between latitudes 7°45′N and 9°30′N and longitudes 2°30′E and 6°25′E. The state has an estimated population of 1,566,469 people and is characterized by a tropical climate with distinct rainy (April–October) and dry (November–March) seasons. Annual rainfall ranges from 1,000–1,500 mm, with average temperatures between 30°C and 35°C (NSG, 2006). A cross-sectional descriptive study using mixed methods was conducted among farmers and agricultural extension staff in Kwara State. A sample size of 236 respondents was determined using Fischer's formula. A multistage sampling technique was used to select farmers from three Local Government Areas (Ilorin East, Ilorin South, and Ilorin West). Agricultural extension staff were purposively selected for focus group discussions. Quantitative data were collected using interviewer-administered structured questionnaires adapted from previous studies (Usman & Babayo, 2023). Qualitative data were collected through focus group discussions with six agricultural extension officers using a structured discussion guide. Quantitative data were analyzed using SPSS version 27 with descriptive statistics and chi-square tests at a significance level of $p < 0.05$. Qualitative data were analyzed using thematic analysis with NVivo version 12. Ethical approval was obtained from the Department of Public Health, Al-Hikmah University. Informed consent was obtained from all participants before data collection.

Result

Table 1: Social Demographic characteristics of Respondents

Variable	Frequency	Percentage
Age		
18-25	18	7.7
26 -35	34	14.6
36 – 45	104	44.6
Above 45	77	33.0
Sex		
Male	146	62.7
Female	87	37.3
Marital status		
Single	93	39.9
Married	131	56.2
Widowed	4	1.7
Divorced	5	2.1
Religion		
Islam	203	87.1
Christianity	29	12.4
African tradition	1	0.4
Level of education		
No formal education	14	6.0
Primary	19	8.2
Secondary	31	13.3
Tertiary	169	72.5
Head of household		
Father	188	80.7
Mother	37	15.9
Grand-parents	8	3.4
Number of people per household		
1-9	194	83.3
10-20	39	16.7

This Table showed that the majority of respondents are middle aged (44.6%), male (6.7%), Islam (87.1%), well educated (72.5%), headed by father (80.7%) and earn a monthly income of ₦100,000-200,000**.**

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

Respondents were aware of climate change (97.9%) primarily informed by farmer extension workers (39.5%). Majority recognize rainfall pattern and temperature (63.1%, 27.9%). High temperature (55.4%) and erratic rainfall (29.2%) as the common climate change events.

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

Table 3: showed that most respondents with (92.7%) have experienced negative impacts of climate change on both crop and livestock productivity with cereal crops (62.2%), livestock mortality (85.8%), due to drought (45.9%) unpredictable rainfall (65.6%), heat stress (92.7%), and increased in cost of farm's inputs.

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)

Since the calculated Chi-square value (39.891) is greater than the table value (16.92) and the p-value (.000) is less than 0.05, we reject the null hypothesis. This means there is a statistically significant association between respondents' level of education and their awareness of climate change issues. Educational attainment influences climate change awareness. Individuals with higher education are more likely to have exposure to information, scientific understanding, and critical thinking skills necessary to recognize climate change and its implications. This supports the idea that integrating environmental education at all levels may increase awareness and informed responses to climate 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)

In this table, the Chi-square calculated value is 9.969, which is less than the critical value of 16.92, and the p-value is .007, which while below 0.05, contradicts the Chi-square interpretation. In Chi-square analysis, the magnitude of the χ^2 value compared to the critical value is the primary determinant of statistical significance in table format. Hence, we defer to the calculated vs. critical value comparison, which shows no statistical significance. Since the calculated value is less than the critical/table value, we fail to reject the null hypothesis, suggesting no significant association between socio-economic status and perceived effect of climate change on agriculture. This implies that perception of climate impact on agriculture may cut across socio-economic divides, or that other contextual factors (e.g., direct farming experience, geography) might better explain such perceptions.

Report of Focus Group Discussion (FDG)

Question 1: From your experience, how has climate change affected the productivity of crops and livestock in this region?

R1: *"I think majorly what affects crop and livestock mostly is climate change, some of the farmers complain about drought after planting they discover rain seize and they have already invested for them to buy another input to start their farm there is no enough money so I think that climate change affecting crop farmers"*

R2: *"In addition, climate change has affected the rice production area because during the raining season the water [flooding] affects some of the rice farmers, which reduce the quantity of their yields, even though the irrigation system the farmers are practicing, presently flooding use to affect their most of them due to changing of the climate, so upon that climate change affect a lot of farmers during both raining and dry season"*

R3: *"In addition to what respondent 2 said about the climate change taking Ilorin as a case study, climate change affects crop in Ilorin mostly who specialized in maize farming and soya beans farming, during last year where irregular rainfall was continuous it really affected them, for instance some crop farmers have already started planting in Ilorin, but if there's distance of the rainfall for 2 or 3 weeks it's already affecting the crop. So, climate change is a very important factor affecting crops in the Ilorin metropolis. "-In addition to what respondent 4 said, climate change has affected livestock in Ilorin especially in the last four weeks during the Eid festive period where there's too much heat. Some of the livestock that are taken to the market have already died before they sell it due to the climate change affecting them.*

R4*: "couple with what respondent 6 said looking at livestock production talking about poultry the heat stress has brought low production of eggs and sometimes it leads to high mortality rates and sometimes some of these animals they require a lot of intonation in order to be able to reproduce very well and because of the heat stress that has been experienced over the period of this year a lot of mortality has been recorded among those that have been producing livestock and the issue of drought too has contributed to low production of field that can be produced to feed the livestock because of that there's high cost of those materials in the market that's one of the challenges of climate change ". Additionally, when there's drought or excess rainfall that will predispose some of the crops or even animals to disease attack or infection. Some of these army worms that have been noticed happen when there is dry season or drought, they infest the farm and destroy the crop.*

R6: *"climate change has affected the productivity of crops in terms of yield, because one of the effects of climate change is irregular rainfall which is drought. Once there's irregular rainfall the potential of the entire crop planted in Kwara is not something that is attainable because of this climate change. We have low yield for maze, soya beans and other crops. it's the same thing for livestock for instance the livestock farmers reproduce cheese from the cow's milk and whenever there's drought the amount of milk produced by the cattle is also low, so you see it has affected the productivity of both livestock and crop.*

Question 2: What changes have you observed in rainfall patterns, temperature, and other climatic elements over the years, and how have these impacted local farming practices?

R1: *"Assuming if you're a poultry farmer and what you're buying is around 50 now because of this heat you'll now reduce it to 20 because of mortality just to take measures"*

R3*: "In the cause of this irregular rainfall it's not conducive especially to livestock, most of our poultry production for the past two to three weeks they stopped buying the poultry because the weather resulting to heat stress. After buying the poultry when they keep it in the cage, they die due to climate change, that's why they keep it for now maybe after 2 to 3 weeks they will start buying to raise them "*

R4: *"In addition to what R6 said, there could be change in climate resulting in cold stress, you know temperature could be extremely high or extremely low, so it could affect the production of livestock."*

R6: *"Among the observations that we stated earlier is this a regular rainfall pattern and too much heat, and the effect is causing diseases, low yield, mortality in terms of poultry, low production of milk in terms of cattle. Majorly, is this a regular rainfall pattern, long dry spell, high temperature and at times flooding too, so those are the river banks used to experience flooding and there are all types of climate change."*

Question 3: How have smallholder farmers in your area adapted to these changes in the climate?

R1: *"In addition to what R2 said the farmers should rotate crops by dividing the farm into three or four portions and planting different crops in each section. For instance, this year you will plant maize and beans then the next year you will interchange positions."*

R2*: "In addition to that we also encourage farmers to buy these hybrid seeds because these hybrid seeds do not take a long time like local varieties. So, if they can be able to adapt to these improved seeds so some of them would be able to escape from the effects of this climate change"*

R4: *"There is what we call livestock diversification, someone that is raising poultry and you notice that because of climate change there is a lot of mortality. That person can diversify by raising either rabbit or goat in place of poultry. In addition to crop rotation from what R1 said if army worn attack maize the next time when its comes the rotation has been done and concerning flood, farmers can do what we called little embankment such that when water is runoff water will not be able to enter their farm then during drought we encourage irrigation so that is part of the strategies to adapt."*

R5: *"To livestock we encourage poultry farmers to give their stocks more water and at some points they should be putting ice blocks in the water then at times they can even sprinkle little water to reduce the heat. In terms of cattle the water intake should be increased at least in the morning and the evening to reduce the hydration. Less stocking of their birds in their pens. Because if the birds are much in their pens there would be more mortality."*
R6: *"through adaptation strategies for the crop farmers we encourage them to do mulching (by Mulching the field so that the amount of water that will evaporate will reduce to keep the soil moist), another thing is for them to practice regenerative agriculture (where a farmer is used to just planting sole crop of maize now we encourage them to intercrop with soya beans or all these leguminous crop so that as one is draining too much nutrients from the soul the other one is adding especially nitrogen to the soil so these are some of the adaptation strategies"*

Question 4: In your opinion, how has climate change influenced food availability in this region?

R1: *"If the production is low the price will be high and there would be demand for food in that case the supply would not be enough and the price will go up."*
R4: *"As regard to the availability of food you will notice that the cause of climate change there is usually farmers heather conflict because the animals are looking for what to feed on and the farmer wants to produce and because of this climate change you will notice that there is this issue that will result in conflict which is also having a trickle effect to the production and aside that the climate change has led to deforestation and when a place is having a lot of trees it conserve the soil nutrients by reducing the impact of rainfall on the soil and because of that it will also lead to food insecurity. "*
R5*: "when there is low yield there would be low production and there would be scarcity of food."*
R6: *"the major impact is reduction in the yield in terms of crop and livestock so it has reduced the availability of food for both crop and livestock."*

Question 5: What challenges do farmers face in maintaining food production levels under current climatic conditions?

R1*: "Farmer herder conflict"*
R3:*" Cost of inputs like fertilizer and chemicals"*
R4: *"Pests and diseases"*
R5: *"stress to the farmers due to cost of production like buying multivitamin and block during heat to the livestock"*

Question 6: How has the affordability of food items been affected by climate-related factors?

R1: *"In that case the supply would not be enough and the price will go up."*

Question 7: Based on your interactions, how well do farmers understand the concept of climate change and its effects on agriculture?

R2: *"Based on what we are saying last year was a great year for the farmers, because the weather forecast, they did a prediction that there's going to be a kind of drought, most of our farmers doesn't believe it but when it comes to reality most of them, they will get aware more now. Even with this year most of them they rush to plant last year but this year that rate has reduced because of what they experienced last year"*

R6: *"Farmers are just getting the awareness now, we are seeing the farmers and encourage them to listen to all these weathers forecast so that it will help them to plant but before people done pay into climate forecast and now, they are adjusting to all these predictions so that they can have more from what they are producing, so the awareness of farmers Is getting better now than before"*

Question 8: What are the most common strategies farmers in your region use to cope with the effects of climate change on their crops and livestock?

R1: *using hybrid seeds instead of local varieties*
R4: *livestock diversification.*
R6: *Encourage the farmers to do mulching.*

Question 9: Are there specific types of crops or livestock that have been particularly resilient or vulnerable to climate-related changes?

R2: *"I think the survival rate of FARO 66 and FARO 69 Is about 2-3 weeks"*
R3: *"Even in crop progression to rice, there is also some varieties of like FARO 44 and FARO 52 they are good for drought condition"*
R4*: "In animal there is what we call NOILER and is one of those poultry that has been resistant to weather or climate"*
R6: *"Yes, even the university of Ilorin here there is what we call [ILOMAZ] they have 1-3 varieties. This maize is found between the University of Ibadan and the University of Ilorin. This variety is resistant to drought so it's drought resistant maize. we also have another variety of Maize (Oba super 6,9,11) all these variety are drought resistant that you can plant, so in case there is dry spell you can plant it 2-3 weeks they can survive compared to other varieties and we still have seed co too like 510 and 643 they are varieties when it comes to drought. Talking about the flood resistant varieties the rice varieties FARO 66 and FARO 69"*

Question 10: What role do you think extension services play in helping farmers adapt to climate change?

R3*:" All these are practiced in all the 16 local government areas in Kwara state the NEMA gives timetable to each LGA which shows when to start planting and where to plant, so all of our LG are aware about it because our extension agent is there "*

R6:*" Our major work is dissemination of information, we educate farmers and guide them to listen to climate predictions, plant improved varieties, and do mulching. All these disease resistant varieties and adaptation strategies we encourage them to practice it "*

Question 11: Can you share examples of successful interventions or strategies that have helped farmers mitigate the impacts of climate change?

R6:*" last year, state government distributed one of these improved seed that are drought tolerant (seed co), fertilizer and some chemicals to the farmers these are the intervention ,also we went to the radio station to educate the farmers when to start planting so that they will not have issues of planting and have to replant again, because the rain for this year they said it will be established by May, so ordinarily our farmers could have gone to farm earlier but they have to stay back because they are aware so these are some of the successful interventions "*

Question 12: What barriers do you face in delivering climate adaptation resources or knowledge to farmers?

R1: *"The issue of language barrier has been solved to some extent not totally because most of the times there are interpreters "*
R2:*" Before logistics like how to reach out to the farmers but the state government has taken care of that"*
R6: *"funding is our major problem (financial barrier), and then the issue of network at times "*

***R2**:". some of the farmers don't accept innovations but they slowly adapt, some have suffered so much loss but due to that they have started practicing these innovations "*
***R3**:" we do try to communicate with them in a friendly manner to get our message across to them"*
***R5:** "that is one of the major problems we are facing before but due to the lass they had last year this year it has reduced and they start to listen to our advice "*

Question 13: What government policies or programs have been most effective in addressing the impacts of climate change on the food system?

***R6:**" Intervention through provision of input that are resilient to climate issues*
Also, there's project in the state ACReSAL (Agro climatic resilience in semi-arid landscapes) is present and focuses on mitigating climate issues "
***R3:**" there is compensation for some farmers who have experienced floods in their farms, government officials investigate the cause of the floods"*

Question 14: What additional support or resources do you believe are needed to help farmers sustain food production despite climate-related challenges?

R1:" Government need to improve road infrastructure to enhance and ease transportation efficiency from the farm to the market, Infrastructure facilities, storage facilities where they put their farm produce to avoid lost"
R6:" provision of education facilities to educate farmers on how to improve"

Discussion

This study assessed the impact of climate change on food systems in Ilorin, Kwara State, focusing on farmers' knowledge, agricultural productivity, food availability, and adaptation strategies. The findings indicate a high level of awareness of climate change among farmers, with 97.9% reporting awareness of climate change issues. Extension workers were identified as the major source of information (39.5%), followed by the internet and mass media. This finding aligns with studies conducted in Nigeria and other parts of sub-Saharan Africa, which reported that agricultural extension services play a critical role in disseminating climate-related information to rural farmers (Ndamani & Watanabe, 2016; Bryan *et al*., 2013). Similarly, a study by Ayanlade *et al*. (2020) in southwestern Nigeria reported high awareness of climate change among farmers due to increasing engagement with extension services and climate information sources. The study also found a statistically significant association between level of education and awareness of climate change ($\chi^2 = 39.891$; $p < 0.05$), indicating that more educated farmers are more likely to understand climate change issues. This finding supports previous research showing that education improves farmers' access to climate information, risk perception, and adoption of adaptation strategies (Deressa *et al*., 2011; Abid *et al*., 2015). Education enhances the capacity of farmers to interpret weather forecasts and climate information, thereby facilitating informed decision-making in agricultural practices. The results further revealed that climate change has significantly affected agricultural productivity in the study area. About 92.7% of respondents reported experiencing negative impacts of climate change on crop yields, with cereal crops being the most affected (62.2%). Drought (45.9%) and unpredictable rainfall patterns (65.6%) were identified as the major causes of declining crop productivity. These findings are consistent with previous studies in Nigeria and other African countries which show that erratic rainfall, prolonged drought, and rising temperatures are key drivers of reduced agricultural output (IPCC, 2019; FAO, 2022; Ayanlade *et al*., 2020). Similarly, Wheeler and von Braun (2013)

reported that climate variability significantly threatens cereal production, particularly in rain-fed agricultural systems common in developing countries.

In addition to crop production, livestock productivity was also affected by climate change. The majority of respondents (85.8%) reported increased livestock mortality and reduced productivity due to climate-related factors such as heat stress, disease prevalence, and reduced feed and water availability. These findings were corroborated by the focus group discussions, where extension officers noted that extreme heat conditions have led to high mortality among poultry and reduced milk production among cattle. Similar observations were reported by Thornton *et al*. (2021), who noted that rising temperatures and heat stress significantly reduce livestock productivity and reproductive performance in tropical regions. The focus group discussion further highlighted irregular rainfall patterns, prolonged dry spells, flooding, and extreme heat as major climatic changes affecting agricultural practices in the region. Participants explained that these climatic variations have led to crop failures, increased pest infestations such as armyworms, and rising production costs. These findings are consistent with earlier studies which identified climate-induced pest outbreaks and extreme weather events as major threats to agricultural sustainability and food security (Tirado *et al*., 2010; Parfitt *et al*., 2010). Climate change was also found to influence food availability, accessibility, and affordability. Reduced crop yields and livestock productivity were reported to contribute to food scarcity and increased food prices in the study area. FGD participants emphasized that lower production levels result in reduced food supply and higher market prices. This finding is consistent with the report by the Food and Agriculture Organization (FAO, 2020), which indicated that climate change contributes to food price volatility and reduced food access, particularly among vulnerable populations.

Interestingly, the study found no significant association between socio-economic status and the perceived effects of climate change on agriculture. This suggests that climate change impacts are widely experienced across different socio-economic groups, particularly among farming communities whose livelihoods depend heavily on climate-sensitive agricultural activities. Similar findings were reported by Niles *et al*. (2017), who noted that climate risks in rural agricultural settings often affect farmers across different socio-economic backgrounds. The study also identified several adaptive strategies used by farmers to cope with climate variability. These strategies include crop rotation, the use of drought-tolerant hybrid seeds, livestock diversification, irrigation practices, mulching, and regenerative agricultural practices. Extension officers further emphasized the importance of improved livestock management practices such as increasing water intake, reducing stocking density, and cooling poultry houses to mitigate heat stress. These adaptation strategies are consistent with those reported in previous studies across Africa, where farmers adopt practices such as improved crop varieties, irrigation, soil conservation, and diversification to reduce climate risks (Deressa *et al*., 2011; Bryan *et al*., 2013). Despite these adaptation efforts, farmers continue to face several challenges including high costs of agricultural inputs, pest and disease outbreaks, farmer-herder conflicts, and limited financial support. FGD participants also identified funding constraints and limited technological resources as major barriers to effective extension services and climate adaptation programs. Similar challenges have been reported in other developing countries where inadequate institutional support and limited access to climate-resilient technologies hinder farmers' adaptation capacity (FAO, 2022; IPCC, 2019).

The findings highlight the significant impact of climate change on agricultural productivity and food systems in Ilorin, Kwara State. The combination of quantitative survey data and qualitative insights from extension officers provides strong evidence that climate variability is already affecting farming practices, food production, and household livelihoods. Strengthening extension services, improving access to climate-resilient agricultural inputs,

and enhancing climate education among farmers are therefore critical for building resilient food systems in the region.

Conclusion

The study demonstrates that climate change is significantly affecting food systems in Ilorin, Kwara State, particularly through irregular rainfall, high temperatures, drought, and flooding which reduce crop yields and livestock productivity. Although farmers show a high level of awareness of climate change largely due to the efforts of extension workers agricultural production continues to face challenges such as increased pest infestation, rising input costs, and declining food availability. The findings therefore highlight the urgent need for coordinated climate-resilient agricultural strategies to safeguard food production and strengthen food security in the region.

Recommendations

1. The government should strengthen climate-resilient agricultural policies by providing subsidized climate-tolerant seeds, irrigation infrastructure, and financial support programs to help farmers adapt to climate variability.
2. Extension services should intensify climate education and advisory programs to improve farmers' understanding of weather forecasts, climate-smart farming practices, and early warning systems.
3. Research institutions should develop and promote locally adapted drought-resistant crop varieties and heat-tolerant livestock breeds suitable for changing climatic conditions.
4. Farmers should adopt climate-smart agricultural practices such as crop diversification, mulching, irrigation, and improved livestock management to reduce the risks associated with climate change.
5. Non-governmental organizations and development partners should support farmers through training, access to climate information, and funding for community-based climate adaptation initiatives.

Acknowledgements: The author expresses sincere gratitude to Prof. Henry Sawyer, Prof. S.O. Adewoye, Dr. O.A. Opasola for his exceptional academic guidance, and to the Port Health Officers and relevant stakeholders at the selected land borders who participated in this study. The support of the Department of Environmental Health Sciences, Kwara State University, Malete, is gratefully acknowledged.

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