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Climate Change Indicators and their Effects on Agricultural and Pastoral Activities of Farmers and Herders in Plateau State, Nigeria

***Nokshuwan Emmanuel Jidauna; **Olarewaju Oluseyi Ifatimehin; **Olatunde Adewale Francis; & **Folorunsho, Alex**

*Federal University of Education Pankshin. **Federal University Lokoja
Corresponding Author: emmyjiddy@gmail.com
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Abstract

Farmer–herder conflict has become a persistent environmental, resource and socioeconomic challenge in Nigeria, particularly in the Middle Belt, where farming and pastoral livelihoods depend on shared land, water and grazing resources. Climate variability can alter the availability and distribution of these resources and may intensify competition among resource users. This study examined the relationship between climate variability and the spatial distribution of farmer–herder conflict in Plateau State, Nigeria. The study adopted a quantitative longitudinal and spatial research design and used data from 600 respondents alongside rainfall, temperature and farmer–herder conflict records covering 1995–2024. Descriptive statistics, trend analysis, Pearson correlation and spatial analysis were employed. The findings revealed substantial rainfall variability, ranging from 37.5 mm in 1999 to 397.2 mm in 2019, while temperature ranged from 21.60°C in 2022 to 26.09°C in 2005. Farmer–herder conflict incidents increased from 27 in 1995 to 73 in both 2023 and 2024. Spatial analysis showed that conflict was unevenly distributed, with Bassa, Riyom and Barkin Ladi recording high conflict concentrations, Mangu and Bokkos showing moderate concentrations, and Wase, Shendam and Dengi recording relatively low concentrations. Pearson correlation analysis based on the 600 respondents revealed a significant positive relationship between climate variability and the spatial distribution of farmer–herder conflict ($r = 0.684$, $p < .001$). Consequently, the null hypothesis was rejected. The findings indicate that climate variability is significantly associated with farmer–herder conflict, although it does not independently determine the occurrence or geographical concentration of conflict. Rather, climatic pressures interact with land-use competition, resource availability, pastoral mobility and institutional conditions to influence conflict vulnerability. The study concludes that farmer–herder conflict in Plateau State requires climate-informed, spatially targeted and resource-sensitive interventions, particularly in identified conflict hotspots.

Keywords: Climate Variability, Farmer–Herder Conflict, Spatial Distribution, Conflict Hotspots, Rainfall and Temperature.

Introduction

Background to the Study

The relationship between humans and the environment is fundamental to the survival, development and organization of societies. Humans depend on the environment for essential resources such as land, water, vegetation, soil and other natural resources that support food production, settlement and economic activities. At the same time, human activities continuously modify environmental systems through agriculture, livestock production, urbanization, deforestation, mining and other forms of land use. This interaction is dynamic because changes in environmental conditions influence human activities, while human actions can also alter environmental processes. The quality, availability and distribution of environmental resources therefore have important implications for livelihoods and human well-being. Where communities depend heavily on natural resources, environmental changes can directly affect their productive activities and capacity to sustain their livelihoods.

Climate is one of the most important components of the environment influencing human activities. Temperature, rainfall, humidity, wind and other climatic elements determine the suitability of different areas for agriculture, livestock production and other economic activities. Agriculture and pastoralism are particularly dependent on climatic conditions because crop growth, pasture development, livestock health and water availability are closely linked to temperature and precipitation. When climatic conditions remain relatively stable, farmers and herders can organize their activities around established seasonal patterns. However, substantial changes in these conditions can disrupt production calendars, alter resource availability and increase livelihood uncertainty.

Climate change has increasingly altered the relationship between human societies and their environment. It is manifested through long-term changes in temperature, rainfall patterns, drought conditions, flooding, dry-season duration and other climatic and environmental characteristics. The Intergovernmental Panel on Climate Change (IPCC, 2022) reports that human-induced climate change is already affecting ecosystems, food systems, water resources and human livelihoods across the world. These effects are particularly significant in developing regions where communities depend heavily on climate-sensitive natural resources and have limited capacity to adapt. Climate change therefore represents not only an environmental problem but also a livelihood, economic and development challenge. Agriculture is among the human activities most directly influenced by climatic conditions. Crop production depends on adequate rainfall, suitable temperatures, soil moisture and a sufficiently long growing season. Changes in rainfall onset, cessation, amount and distribution can affect planting and harvesting decisions, crop growth and productivity. Excessive rainfall can result in flooding, erosion and waterlogging, whereas inadequate rainfall can produce drought, soil-moisture deficits and crop failure. Rising temperatures may further increase evapotranspiration and affect crop development. These changes can increase production costs, reduce yields and threaten household food security, particularly among smallholder farmers who depend heavily on rain-fed agriculture.

Pastoralism is likewise closely connected to environmental conditions. Herders depend on pasture, water and suitable climatic conditions for livestock production. Changes in rainfall and temperature can influence vegetation growth, the availability of surface water and the quality of grazing resources. Prolonged dry periods may reduce pasture and water availability and require herders to increase livestock mobility in search of suitable resources. Changes in environmental conditions may therefore influence livestock feeding, watering, health, reproduction and productivity. Pastoral households with limited access to alternative water supplies, veterinary services and improved livestock infrastructure may be particularly vulnerable to these changes.

The impacts of climate change are not determined by climatic conditions alone. They are influenced by the interaction between environmental exposure, livelihood dependence, socioeconomic conditions and adaptive capacity. Farmers and herders differ in their access to land, water, finance, technology, extension services, infrastructure and climate information. These differences determine their ability to anticipate and respond to climatic changes. Consequently, the same climate event may have different effects on different communities or livelihood groups. Understanding climate change impacts therefore requires attention to both the environmental indicators of change and the socioeconomic circumstances within which people experience them.

The problem is particularly important in sub-Saharan Africa, where agriculture and pastoralism remain important livelihood systems. A large proportion of rural households depend directly on rainfall, soil, vegetation and water resources for their livelihoods. However, limited irrigation, inadequate infrastructure, land degradation, poverty and restricted access to climate information can constrain adaptive capacity. The IPCC (2022) identifies Africa as highly vulnerable to climate change because of its exposure to climatic hazards and existing socioeconomic vulnerabilities. Consequently, changes in rainfall, temperature, drought, flooding and water availability may have substantial consequences for agricultural and pastoral communities.

Nigeria reflects many of these challenges. Climatic variability across the country has implications for crop production, livestock production and natural-resource management. Changes in rainfall distribution, increasing temperatures, flooding, drought and changing seasonal patterns can affect agricultural calendars, crop productivity, pasture availability and livestock management. The World Bank Group (2021) identifies agriculture and water resources among the sectors particularly vulnerable to climate-related impacts in Nigeria. These challenges are especially important in rural communities where farming and pastoralism remain central to household livelihoods.

Within Nigeria, Plateau State provides an important geographical setting for examining the relationship between climate change and livelihood activities. The state is characterized by varied topography, ecological conditions and agricultural systems that support both crop farming and livestock production. Rural communities depend substantially on rainfall, fertile soils, vegetation, surface water and other environmental resources. Changes in the availability and condition of these resources can consequently affect agricultural and pastoral activities. Evidence from Plateau State has identified changing rainfall patterns, water shortages, flooding and altered stream flow among environmental challenges affecting local livelihoods (Gomos & Dung, 2021).

Farmers and herders in Plateau State may experience climate change through different but interconnected indicators. Farmers may observe irregular rainfall, changes in planting seasons, prolonged dry periods, flooding, increasing temperatures and declining crop productivity. Herders may experience reduced pasture availability, drying water sources, changes in vegetation conditions, increased temperatures and greater livestock mobility. These experiences provide an important connection between measurable climate change and everyday livelihood activities. Examining such

indicators can therefore provide a clearer understanding of how climatic changes affect agricultural and pastoral production at the local level.

Although existing studies have examined climate change, agricultural vulnerability, pastoralism and farmer–herder relations in Nigeria, there remains limited empirical evidence that simultaneously examines specific climate change indicators and their effects on the agricultural and pastoral activities of farmers and herders in Plateau State. Many studies emphasize either agricultural production, pastoral vulnerability or farmer–herder conflict, leaving a need for an integrated assessment of how farmers and herders experience climate-related changes within the same geographical environment. This gap limits the availability of location-specific evidence needed to design appropriate adaptation interventions for the two livelihood systems.

It is against this background that this study examines climate change indicators and their effects on agricultural and pastoral activities of farmers and herders in Plateau State, Nigeria. The study focuses on the major climatic and environmental indicators experienced by farmers and herders and assesses their effects on crop and livestock activities. The findings are expected to provide empirical evidence for strengthening climate adaptation, agricultural extension, livestock services, water-resource management, pasture development and sustainable livelihood planning in Plateau State.

RESEARCH QUESTION

The study was guided by the following research question:

i. What are the major indicators of climate change experienced in Plateau State, and how do they affect the agricultural and pastoral activities of farmers and herders?

OBJECTIVES OF THE STUDY

The objective of the study sought to:

i. identify the major indicators of climate change experienced by farmers and herders in Plateau State; and

RESEARCH HYPOTHESIS

The null hypothesis was formulated and tested at the 0.05 level of significance:

Hypothesis One H_0: There is no significant relationship between prolonged dry seasons and the frequency of farmer–herder conflicts in Plateau State.

RESEARCH DESIGN

The study adopted a descriptive survey design because it was appropriate for obtaining information directly from farmers and herders about their experiences of climate change and its effects on agricultural and pastoral activities without manipulating the study variables.

STUDY AREA AND SAMPLE

The study was conducted in nine LGAs of Plateau State: Bassa, Riyom, Barkin Ladi, Bokkos, Mangu, Kanam, Shendam, Wase and Langtang South. These LGAs were selected because agricultural and pastoral activities are prominent in the areas, making them suitable for examining climate-related livelihood effects. A total of 600 farmers and herders participated in the study, providing adequate responses for assessing the experiences of the two livelihood groups.

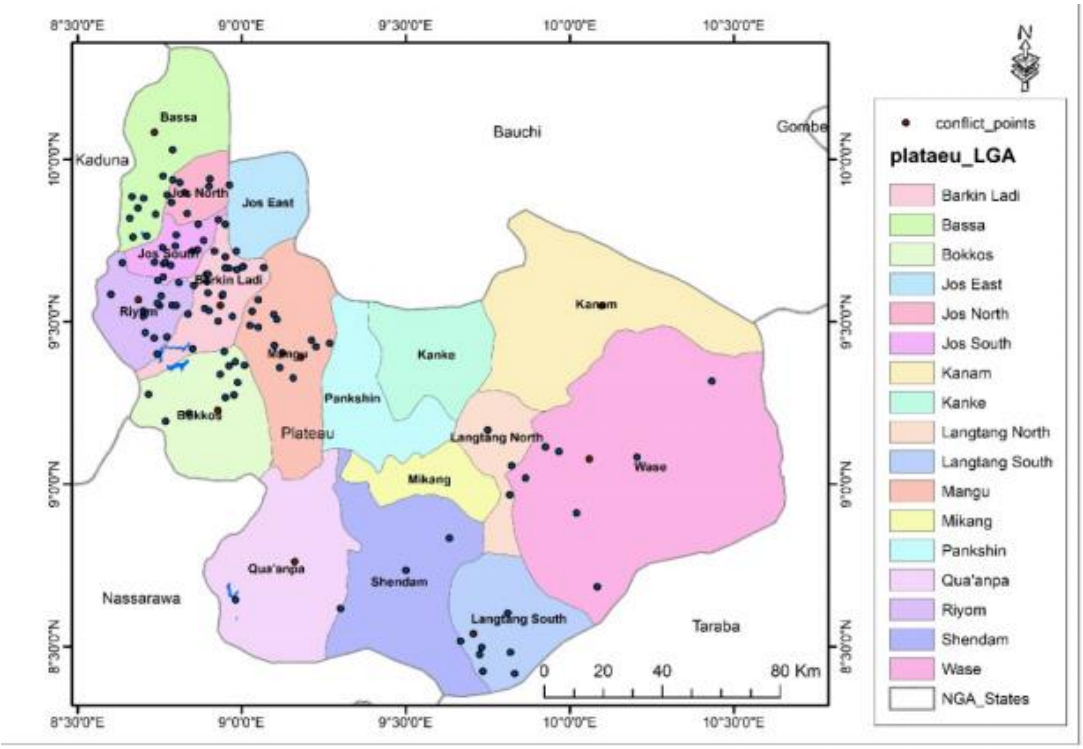


Figure 1: Map of Plateau State showing the nine selected LGAs.

SAMPLING PROCEDURE

A multistage sampling procedure was used because the study covered several LGAs and communities and involved two major livelihood groups. The selected LGAs were identified based on the prominence of farming and pastoral activities, followed by the selection of relevant communities and eligible farmers and herders. This procedure enabled respondents from different locations and livelihood groups to be represented.

INSTRUMENT FOR DATA COLLECTION

Data were collected using a structured questionnaire because it allowed the researcher to obtain standardized information from a relatively large number of respondents. The questionnaire covered climate change indicators, effects on agricultural activities, effects on pastoral activities, and prolonged dry seasons and farmer–herder conflict frequency.

Validity and Reliability

The questionnaire was subjected to face and content validation to ensure that the items were clear, relevant and adequately represented the study variables. It was also pilot-tested among respondents outside the study sample to assess its reliability and identify ambiguous or unsuitable items before the main survey.

Instrumentation

A four-point Likert scale of Strongly Agree (4), Agree (3), Disagree (2), and Strongly Disagree (1) was used to measure respondents' perceptions of climate change and its effects on agricultural and pastoral

activities. The four-point scale was adopted to encourage respondents to indicate a clear position without a neutral option. A criterion mean of 2.50 was used for decision-making; mean scores of 2.50 and above indicated agreement, while scores below 2.50 indicated disagreement.

METHOD DATA ANALYSIS

The data were analysed using frequencies, percentages, mean scores, grand means and Chi-square statistics. Frequencies and percentages were used to identify and rank the major climate change indicators reported by respondents. Mean scores and grand means were used to assess the perceived effects of climate change on agricultural and pastoral activities. The Chi-square test was used to determine the relationship between prolonged dry seasons and farmer–herder conflict frequency because the variables were categorical. The hypothesis was tested at the 0.05 level of significance.

Table 4.1: Major Indicators of Climate Change Reported by Farmers and Herders in Plateau State

S/N	Indicator	Frequency	Percentage (%)	Rank
1	Poor harvests	140	23.3	1st
2	Prolonged dry seasons	124	20.7	2nd
3	Irregular rainfall	101	16.8	3rd
4	Crop and livestock diseases	82	13.7	4th
5	Reduced productivity	71	11.8	5th
6	Reduced labour output	48	8.0	6th
7	Heat-related illnesses	34	5.7	7th
Total		**600**	**100.0**	

Source: Field Survey, 2025.

Table 4.1 shows that poor harvests were the most frequently reported indicator of climate change, accounting for 140 respondents (23.3%). This was followed by prolonged dry seasons, reported by 124 respondents (20.7%), and irregular rainfall, reported by 101 respondents (16.8%). Crop and livestock diseases accounted for 82 respondents (13.7%), while reduced productivity was reported by 71 respondents (11.8%). Reduced labour output and heat-related illnesses were reported by 48 (8.0%) and 34 (5.7%) respondents, respectively.

The predominance of poor harvests, prolonged dry seasons and irregular rainfall is important because these three indicators accounted for 365 respondents, representing 60.8% of the total responses. This suggests that farmers and herders primarily experience climate change through changes in rainfall and moisture conditions and their consequences for livelihood production. The finding is consistent with the broader evidence that climate change is increasingly affecting climate-sensitive livelihoods through changes in temperature, rainfall patterns, water availability and agricultural productivity (Intergovernmental Panel on Climate Change [IPCC], 2022; Suleiman & Kasimu, 2022).

The prominence of poor harvests is particularly significant because it represents a direct livelihood consequence rather than simply an environmental observation. Farmers may experience changing climatic conditions through declining agricultural production, increased uncertainty and reduced household food availability. This supports the argument that the effects of climate change should be examined not only through meteorological measurements but also through observable livelihood outcomes. The finding is consistent with research showing that climatic variability can affect

agricultural productivity and the economic security of rural households (Otaida & Yusufu, 2023; Wang & Patel, 2023).

The relatively high frequency of prolonged dry seasons further indicates the importance of moisture stress in the study area. Prolonged dry periods can reduce soil moisture and water availability and may consequently affect both crop production and livestock management. This finding reinforces the importance of adaptation measures that respond to rainfall uncertainty and water scarcity rather than focusing exclusively on long-term changes in temperature.

Table 4.2: Effects of Climate Change on Agricultural Activities in Plateau State

S/N	Agricultural Effect	Mean	Decision	Rank
1	Reduced crop yields	3.05	Accepted	4th
2	Disruption of planting and harvesting periods	3.15	Accepted	1st
3	Increased crop failure and poor harvests	3.13	Accepted	2nd
4	Increased crop pests and diseases	2.98	Accepted	5th
5	Increased production costs and livelihood insecurity	3.02	Accepted	3rd
Grand Mean		**3.07**	**Accepted**	

Source: Field Survey, 2025. Criterion mean = 2.50.

Table 4.2 indicates that all five agricultural effects recorded mean scores above the criterion mean of 2.50. The grand mean of 3.07 indicates that respondents generally agreed that climate change has considerable effects on agricultural activities. Disruption of planting and harvesting periods recorded the highest mean score of 3.15, followed by increased crop failure and poor harvests (3.13). Increased production costs and livelihood insecurity recorded a mean of 3.02, reduced crop yields recorded 3.05, while increased crop pests and diseases recorded the lowest mean of 2.98.

The high mean score for disruption of planting and harvesting periods suggests that climatic uncertainty affects agricultural activities through changes in the timing and predictability of farming seasons. Farmers who depend substantially on rainfall may find it increasingly difficult to rely on established seasonal patterns when determining when to plant, weed and harvest. Such uncertainty can increase production risks and contribute to poor harvests.

The finding corresponds with Table 4.1, where poor harvests and irregular rainfall were among the most frequently reported indicators. It also agrees with the broader evidence that agricultural systems are particularly vulnerable to changes in rainfall, temperature, soil moisture and growing-season conditions (IPCC, 2022; Suleiman & Kasimu, 2022).

The relatively high mean score for increased crop failure and poor harvests further demonstrates the livelihood consequences of climate variability. Poor harvests may reduce household food availability and agricultural income while increasing the need for additional expenditure on food and farm inputs. The finding is therefore consistent with the argument that climate change presents both an environmental and socioeconomic challenge to agricultural households (Otaida & Yusufu, 2023; Wang & Patel, 2023).

The mean score of 3.02 for increased production costs and livelihood insecurity also indicates that climate-related effects extend beyond the physical production of crops. Farmers may incur additional costs when responding to changing climatic conditions through replanting, purchasing inputs, controlling pests and diseases or seeking alternative sources of water. Consequently, adaptation planning should consider both agricultural productivity and household economic resilience.

Table 4.3: Effects of Climate Change on Pastoral Activities in Plateau State

S/N	Pastoral Effect	Mean	Decision	Rank
1	Reduced availability of natural pasture	3.17	Accepted	2nd
2	Reduced availability of water for livestock	3.19	Accepted	1st
3	Increased distance travelled for pasture and water	3.16	Accepted	3rd
4	Increased livestock diseases and health problems	3.02	Accepted	5th
5	Increased pressure on grazing areas	3.17	Accepted	2nd
Grand Mean		**3.14**	**Accepted**	

Source: Field Survey, 2025. Criterion mean = 2.50.

Table 4.3 shows that all five effects of climate change on pastoral activities recorded mean scores above the criterion mean of 2.50, with a grand mean of 3.14, indicating substantial effects on pastoral livelihoods. Reduced availability of water for livestock ranked first (3.19), followed by reduced natural pasture and increased pressure on grazing areas (3.17 each). Increased distance travelled for pasture and water recorded 3.16, while livestock diseases and health problems ranked lowest (3.02).

The predominance of water and pasture constraints underscores the sensitivity of pastoral production to climatic variability. Reduced availability of these resources can increase livestock mobility and pressure on grazing areas, consistent with evidence that climate variability affects climate-dependent livelihoods through changes in water availability and environmental productivity (IPCC, 2022; Suleiman & Kasimu, 2022).

The relatively high score for increased distance travelled for pasture and water (3.16) suggests that resource scarcity may alter pastoral mobility and increase interaction with other land users. However, mobility should not be equated with conflict; rather, it represents a potential pathway through which climatic stress may intensify competition over shared resources.

The study therefore concludes that climate change constitutes a significant constraint on pastoral livelihoods in Plateau State, particularly through water scarcity, pasture reduction and increased livestock mobility, while the resulting resource pressures are shaped by land-use arrangements, institutional capacity and resource governance.

Table 4.4: Comparative Effects of Climate Change on Agricultural and Pastoral Activities in Plateau State

S/N	Livelihood System	Grand Mean	Decision	Rank
1	Pastoral activities	3.14	Accepted	1st
2	Agricultural activities	3.07	Accepted	2nd

Source: Field Survey, 2025. Criterion mean = 2.50.

Table 4.4 indicates that both agricultural and pastoral activities are substantially affected by climate change, with pastoral activities recording a marginally higher mean (3.14) than agricultural activities (3.07). The small difference of 0.07 suggests comparable vulnerability, although the pathways differ: farmers are more exposed to rainfall variability and declining crop productivity, while herders face greater constraints related to water, pasture and livestock mobility.

Across Tables 4.1–4.4, poor harvests, prolonged dry seasons and irregular rainfall emerge as the dominant climate indicators, while disruption of farming seasons, water scarcity and reduced pasture constitute major livelihood effects. This pattern reinforces evidence of the vulnerability of climate-

dependent livelihoods to climatic variability and limited adaptive capacity (IPCC, 2022; Suleiman & Kasimu, 2022).

The significant association between prolonged dry seasons and farmer–herder conflict frequency ($\chi^2(2, N = 600) = 25.30$, $p < .001$; Cramer's V = 0.205) further indicates that climatic stress is relevant to conflict vulnerability. Nevertheless, the modest effect size cautions against attributing conflict directly to climate change. Rather, prolonged dryness may intensify competition over land, water and pasture, with outcomes conditioned by socioeconomic circumstances, institutional capacity and resource governance (Suleiman & Kasimu, 2022; Kim & Ferré Garcia, 2023).

Overall, the evidence demonstrates that climate change constitutes a significant livelihood challenge for both farmers and herders in Plateau State. The appropriate response is therefore an integrated adaptation strategy combining climate information and early-warning systems, climate-resilient agriculture, livestock water provision, pasture management, veterinary services and effective governance of shared resources (FAO, 2023; WMO, 2024). Although based primarily on reported experiences rather than direct meteorological measurements, the consistency of the findings across livelihood indicators provides useful empirical evidence for strengthening climate resilience and reducing resource-related pressures in the study area.

Table 4.5: Chi-square Test of the Relationship Between Prolonged Dry Seasons and Farmer–Herder Conflict Frequency in Plateau State

Prolonged dry season	Low conflict	Moderate conflict	High conflict	Total
Yes	25	42	57	124
No	180	180	116	476
Total	**205**	**222**	**173**	**600**

Source: Field Survey, 2025.

Table 4.5 shows a clear difference in conflict frequency between respondents who reported prolonged dry seasons and those who did not. Among the 124 respondents reporting prolonged dry seasons, 57 recorded high conflict, compared with 42 moderate and 25 low conflicts.

The Chi-square test in Table 4.5 indicates a significant association between prolonged dry seasons and farmer–herder conflict frequency ($\chi^2(2, N = 600) = 25.30$, $p < .001$). However, the Cramer's V of 0.205 indicates a modest association, suggesting that other factors also influence conflict occurrence and intensity. The observed high-conflict frequency (57) exceeded the expected 35.75, while low conflict (25) was below the expected 42.37.

This finding is consistent with the earlier results, where prolonged dry seasons accounted for 20.7% of reported climate indicators, while reduced livestock water availability (3.19) and increased travel for pasture and water (3.16) were prominent pastoral effects. These conditions may increase pressure on shared resources and livestock mobility, thereby intensifying interaction between farming and pastoral communities.

Nevertheless, the result does not establish that prolonged dry seasons independently cause conflict. Climate change may act as a stress multiplier, with conflict outcomes also shaped by land-use pressures, migration, resource governance and institutional conditions (Suleiman & Kasimu, 2022; Kim & Ferré Garcia, 2023).

The study demonstrates that prolonged dry seasons constitute an important climate-related pressure on farmer–herder relations in Plateau State. Strengthening livestock water supply, pasture management,

grazing routes, climate information, early-warning systems and community-based resource governance can enhance livelihood resilience and reduce resource-related tensions.

Conclusion

The study concludes that climate change significantly affects agricultural and pastoral activities in Plateau State. Poor harvests, prolonged dry seasons and irregular rainfall were major climate change indicators, while disrupted farming seasons, reduced crop productivity, water scarcity and declining pasture were important livelihood effects. The study also found a significant association between prolonged dry seasons and farmer–herder conflict frequency, although the strength of the relationship was modest. This indicates that prolonged dry seasons contribute to conflict but are not the sole determinant. Effective adaptation therefore requires improved climate information services, sustainable water and pasture management, appropriate land-use practices, and stronger farmer–herder resource-management institutions.

Recommendations

Based on the findings, the study recommends that:

- Climate information services should be strengthened to enable farmers and herders respond effectively to prolonged dry seasons and irregular rainfall.
- Climate-smart agricultural practices should be promoted to reduce poor harvests, crop failure and disruption of planting and harvesting periods.
- Livestock water and pasture facilities should be improved, particularly in areas affected by water scarcity, declining pasture and increased livestock movement.
- Agricultural and veterinary extension services should be strengthened to address crop and livestock diseases and improve adaptation to climate-related production challenges.
- Farmer–herder resource-management mechanisms should be strengthened, particularly because prolonged dry seasons were significantly associated with conflict frequency. Local institutions should promote the peaceful management of land, pasture and water resources.

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