



AN ASSESSMENT OF THE IMPACT OF CLIMATE CHANGE ON AGRICULTURE AND FOOD SECURITY IN TANGAZA LOCAL GOVERNMENT AREA, SOKOTO STATE: INSIGHTS FROM FARMER PERCEPTIONS

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ABSTRACT

The survey basically assessed farmers' perceptions of the impact of climate change on agriculture and food security in Tangaza Local Government Area, Sokoto State, Nigeria. Descriptive survey design employing a mixed-methods approach was adopted. Data were collected from 200 respondents, comprising 160 farmers, 20 agricultural extension officers, and 20 household heads, using structured questionnaires, key informant interviews, and secondary data from NiMet and local agricultural offices. Trend analysis of climate and crop data from 2005 to 2024 indicated that mean annual temperature increased from 32.4°C to 35.2°C, while mean annual rainfall declined from 610 mm to 495 mm. Correspondingly, yields of major crops (millet, sorghum, cowpea, and maize) declined substantially during the same period. Farmers reported that unreliable rainfall, shortened growing seasons, heat stress, and increased crop failure negatively affected crop production, a perception corroborated by extension officers. Household food insecurity was prevalent, with 70% of households reporting inadequate food supply throughout the year, 75% experiencing seasonal scarcity, and 80% affected by rising food prices. Farmers primarily relied on low-cost coping and adaptation strategies, including early planting, use of drought-tolerant varieties, and mixed cropping. However, the adoption of capital-intensive measures, such as irrigation and access to extension services, remained low. The findings demonstrated that climate change has significantly undermined agricultural productivity and household food security in Tangaza LGA. The study recommended promoting climate-smart agriculture, improving irrigation and storage facilities, enhancing extension services, providing drought-tolerant crop varieties, and integrating indigenous coping strategies into formal adaptation programs to strengthen local resilience.

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INTRODUCTION

Climate change is one of the most pressing global challenges of the 21st century, with widespread



implications for natural systems, economies, and human well-being. The term climate change refers to long-term alterations in average weather conditions, including temperature, precipitation, and wind patterns, driven largely by anthropogenic greenhouse gas (GHG) emissions from fossil fuel combustion, deforestation, and industrial processes (Intergovernmental Panel on Climate Change [IPCC], 2022). The global average surface temperature has already risen by approximately 1.1°C above pre-industrial levels, and this increase is projected to exceed 1.5°C within the next two decades if current emission trajectories persist (IPCC, 2023). The African continent is particularly vulnerable to climate variability and extremes due to its dependence on rain-fed agriculture, high levels of poverty, and limited adaptive capacity (United Nations Economic Commission for Africa [UNECA], 2022).

Agriculture remains the backbone of Nigeria's economy, employing about 35% of the labor force and contributing significantly to national food supply and livelihoods (National Bureau of Statistics [NBS], 2022). However, the sector is highly climate-sensitive, as temperature fluctuations, erratic rainfall patterns, droughts, and floods directly influence crop yields, livestock productivity, and fisheries. Recent evidence suggests that climate change has already led to substantial yield reductions in staple crops such as maize, sorghum, millet, and rice across sub-Saharan Africa (Lobell et al., 2022; Sultan et al., 2023). In northern Nigeria, recurrent droughts, desertification, and land degradation have compounded food insecurity, undermining household resilience and worsening rural poverty (Okpara et al., 2021). The Food and Agriculture Organization (FAO, 2023) estimates that more than 19 million Nigerians face acute food insecurity, with climate-related shocks being a major driver.

Tangaza Local Government Area (LGA) of Sokoto State represents a typical semi-arid ecological zone in northwestern Nigeria, characterized by low annual rainfall, high evapotranspiration, and fragile soils. Farming constitutes the primary source of livelihood, with crops such as millet, sorghum, maize, and cowpea, alongside livestock rearing, forming the backbone of the rural economy. However, the area is increasingly exposed to climate risks, including shortened rainy seasons, prolonged dry spells, and pest outbreaks. A recent study in Sokoto State indicated that 68% of farmers reported declining crop yields due to unpredictable rainfall patterns, while over 70% expressed concern about food shortages linked to climate variability (Abubakar & Usman, 2022). Similarly, Yusuf et al. (2023) observed that frequent drought episodes in the region have reduced pasture availability, leading to conflicts between farmers and herders over scarce resources. These findings highlight the urgent need for localized assessments of climate change impacts and context-specific adaptation strategies.

Food security, as defined by FAO (2021), is the condition in which all people, at all times, have physical and economic access to sufficient, safe, and nutritious food, is intricately linked to climate conditions. In Tangaza LGA, food security is threatened not only by reduced agricultural productivity but also by



limited storage facilities, weak extension services, and poor access to climate information. As climate extremes intensify, households are compelled to adopt unsustainable coping mechanisms such as selling livestock, reducing meal frequency, or migrating to urban centers (Adamu et al., 2022). These responses, though necessary for short-term survival, often undermine long-term resilience. Furthermore, climate change exacerbates existing socio-economic challenges, including poverty, gender inequality, and limited access to credit and technology, thereby constraining adaptive capacity.

Globally, adaptation in agriculture is increasingly emphasized as an essential strategy to buffer the adverse effects of climate change. Adaptation measures include crop diversification, adoption of drought-resistant crop varieties, improved irrigation systems, and sustainable land management practices (FAO, 2022). In Nigeria, government initiatives such as the National Adaptation Strategy and Plan of Action on Climate Change for Agriculture (NASPA-CCN) aim to mainstream climate adaptation into agricultural policy (Federal Ministry of Agriculture and Rural Development [FMARD], 2021). However, the effectiveness of such strategies at the local level remains uncertain, particularly in rural communities like Tangaza where awareness, resources, and institutional support are limited.

The rationale for this study lies in the urgent need to generate empirical evidence on the extent of climate change impacts on agriculture and food security in Tangaza LGA. While national and regional studies provide broad insights, localized assessments are critical to capture the unique vulnerabilities and adaptive responses of rural households. By evaluating climate change impacts, identifying challenges, and exploring adaptive strategies, this research will contribute to enhancing agricultural resilience and food security in Tangaza. Moreover, the findings will inform policymakers, extension agents, and local stakeholders in designing targeted interventions that align with the socio-cultural and ecological realities of the area.

Objectives of the Study

The study was based on the following objectives:

1. To examine the socio-demographic characteristics of farming households.
2. To analyze trends in average crop yields of major staple crops in from 2005 to 2024.
3. To assess trends in annual rainfall patterns between 2005 and 2024.
4. To examine changes in mean annual temperature over the period of 2005-2024.



5. To assess farmers' perceptions of the effects of climate change on crop production.
6. To document agricultural extension workers' observations on climate change impacts on crop production.
7. To determine the household food security status of farming households under climate stress.
8. To identify the coping and adaptation strategies adopted by farmers in response to climate change impacts on agriculture.

Problem Statement

Climate change has become one of the greatest threats to sustainable development globally, with agriculture being the most vulnerable sector. In Nigeria, especially in semi-arid regions like Sokoto State, farmers heavily depend on rainfall for agricultural production. However, rising temperatures, prolonged dry spells, irregular rainfall distribution, and extreme events such as floods and droughts have continued to undermine agricultural productivity (IPCC, 2023). In Tangaza Local Government Area, the majority of the population relies on subsistence farming and livestock rearing for survival. Recent evidence suggests that crop yields have declined in the area due to shortened rainy seasons, poor soil fertility, and recurrent pest infestations (Abubakar & Usman, 2022). This decline in agricultural productivity directly affects household food availability, dietary diversity, and income levels, thereby aggravating food insecurity.

Despite the visible impacts, there is inadequate localized empirical research on the extent to which climate change is affecting agriculture and food security in Tangaza LGA. Most existing studies in Nigeria focus on broader national or regional levels, which may not capture community-specific vulnerabilities and adaptive strategies. This knowledge gap limits the ability of policymakers, extension workers, and farmers themselves to implement effective climate adaptation practices tailored to local realities. It is against this background that this study seeks to assess the impact of climate change on agriculture and food security in Tangaza LGA, Sokoto State.

In summary, climate change poses a significant threat to agriculture and food security in Sokoto State, with Tangaza LGA serving as a microcosm of the wider challenges facing semi-arid regions of Nigeria. Understanding the interplay between climatic factors, agricultural production, and household food security is essential for developing effective adaptation measures. This study is therefore timely and necessary, as it seeks to provide evidence-based recommendations to mitigate the adverse impacts of climate change while promoting sustainable agricultural practices in Tangaza.

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Methodology

Study Setting

The study was conducted in Tangaza Local Government Area (LGA) of Sokoto State, Nigeria. Tangaza lies within the Sudan Savanna ecological zone and experiences a semi-arid climate characterized by high temperatures, low rainfall, and long dry seasons. Agriculture is the predominant livelihood, consisting of millet, sorghum, maize, and groundnut cultivation, as well as livestock rearing such as cattle, sheep, and goats. The area was selected because of its high vulnerability to climate change impacts including drought, rainfall variability, and advancing desert encroachment.

Study Design

This study adopted descriptive survey design, employing a mixed-methods approach that integrates both quantitative and qualitative data.

Population and Sample

The population of the study comprised all crop and livestock farmers estimated to be over 10,000, fifty (50) agricultural extension officers, and all households in Tangaza Local Government Area (LGA). Given the large size of the population, a total sample of 200 respondents was considered adequate for the study.

A multi-stage sampling technique was adopted. In the first stage, five (5) wards were randomly selected from the ten (10) wards in Tangaza LGA. In the second stage, four (4) communities were randomly selected from each of the selected wards, resulting in a total of twenty (20) communities. In the third stage, eight (8) farmers were purposively selected from each community based on a minimum of five (5) years of farming experience, yielding a total of 160 farmers. The five-year experience threshold was adopted to ensure that selected farmers had sufficient exposure to climate variability.

In the fourth stage, however, twenty (20) agricultural extension officers were purposively selected from the Tangaza LGA agricultural institutions to ensure the inclusion of knowledgeable and experienced agricultural personnel. In the fifth stage, twenty (20) household heads were systematically selected from the selected communities for the administration of the Household Food Insecurity Access Scale (HFIAS). Thus, the sample comprised 160 farmers, 20 agricultural extension officers, and 20 household heads. Random selection at the ward and community levels helped to minimize sampling bias and enhance representativeness, while purposive and systematic sampling ensured the selection of relevant



and information-rich respondents.

Instruments for Data Collection

Five instruments were used in this study:

1. Structured Climate Change and food security Questionnaire (CCAFSQ): A 40-item tool measuring socio-demographics, climate change indicators, crop/livestock impacts, and food security outcomes.
2. Climatic Data Retrieval Sheet: Extracted rainfall and temperature records from NiMet (2014–2023).
3. Crop Yield Extraction Guide: Retrieved annual yields of millet, sorghum, maize, and groundnut from SADP archives.
4. Household Food Security Questionnaire (HFIAS): Standardized tool measuring household food access, frequency, and severity of food insecurity.
5. Key Informant Interview (KII) Guide: Open-ended questions for agricultural officers, community leaders, and extension workers.

Validity of Research Instruments

The validity of the primary data collection instruments used in this study was established through face and content validation. Copies of the questionnaires administered to farmers and households, as well as the interview schedule designed for extension workers, were subjected to expert review by specialists in Agricultural Economics and Educational Measurement. The experts evaluated the instruments for clarity, relevance, and adequacy of the items in addressing the study objectives, particularly those relating to socio-demographic characteristics, climate change impacts, agricultural production, extension services, and household food security. Based on their observations and suggestions, necessary modifications were made, and the revised instruments were finalized before administration.

Reliability of Research Instruments

The reliability of the structured questionnaires administered to farmers and households was established through a pilot study conducted in Gudu Local Government Area. Although outside the main study area, Gudu is located within the same region and shares similar characteristics. Twenty respondents

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participated in the pilot test. The Cronbach's Alpha coefficients obtained were 0.84 for the climate change indicators questionnaire, 0.82 for the agricultural production questionnaire, and 0.86 for the Household Food Insecurity Access Scale (HFIAS), all of which indicate high internal consistency. Reliability testing was not applicable to the interview schedule administered to extension workers because of its qualitative nature.

Methods for Data Analysis

Quantitative Analysis:

1. Descriptive statistics (frequencies, percentages, means) described socio-demographics, climate indicators, and food security variables.
2. Trend analysis assessed 10-year patterns in rainfall, temperature, and crop yields (2014–2023).
3. HFIAS scoring categorized households into food secure/insecure groups.
4. Pearson Product Moment Correlation (PPMC) analyzed relationships between climate variables and crop yields.
5. Chi-square tests examined associations between climate indicators and food security outcomes.

Qualitative Analysis:

1. KII transcripts and observation notes were coded and analyzed using thematic analysis.
2. Themes explored perceptions of climate impacts, community adaptation practices, and institutional responses.



Results

Table 1: Socio-demographic characteristics of respondents

S/N	Variables	Category	Frequency (F)	Percentage (%)
1.	Gender	Male	154	82.2
		Female	32	17.8
2.	Age	Below 30 Years	18	9.7
		31-40	52	28.0
		41-50	68	36.6
		Above 50	48	25.7
3.	Educational Level	No formal Education	58	31.2
		Primary Education	60	32.3
		Secondary Education	46	24.7
		Tertiary Education	22	11.8
4.	Farming Experience (Years)	1-5 Years	14	7.5
		6-10 Years	42	22.6
		11-20 Years	74	39.8
		Above 20 Years	56	30.1
5.	Farm Size (Hectares)	Less than 1	30	16.1
		1-3	88	47.3
		4-6	42	22.6
		Above 6	26	14.0

Source: Field Survey, 2025

The data in Table 1 show that the majority of respondents (82.2%) were male, reflecting the dominance of men in farming activities in the study area. Most respondents (36.6%) were within the age range of 41–50 years, indicating a mature and experienced farming population. Table 1 further shows that 63.5% of respondents had at least primary education, suggesting a moderate literacy level that could influence understanding of climate-related issues. In addition, over 70% of the respondents had more than 10 years of farming experience, which enhances the reliability of their responses regarding long-term climatic trends. Farm size distribution indicates that most farmers (47.3%) cultivated between 1–3 hectares, reflecting smallholder dominance.

**Table 2: Average Crop Yield Trends in Tangaza LGA (2005-2024)**

Year Range	Millet (kg/ha)	Sorghum (kg/ha)	Cowpea (kg/ha)	Maize (kg/ha)
2005–2009	1,450	1,320	1,600	980
2010–2014	1,280	1,150	1,420	900
2015–2019	1,140	1,020	1,260	780
2020–2024	980	860	1,080	650

Source: Sokoto State Ministry of Agriculture (2005–2024).

Table 2 shows a persistent decline in crop yields across all major staples cultivated in Tangaza LGA. Millet yield declined from 1,450 kg/ha in 2005–2009 to 980 kg/ha in 2020–2024, while sorghum decreased from 1,320 kg/ha to 860 kg/ha over the same period. Cowpea yield also declined from 1,600 kg/ha to 1,080 kg/ha, and maize from 980 kg/ha to 650 kg/ha. The consistent downward trend across cereals and legumes suggests systemic production challenges rather than crop-specific constraints.

Table 3: Annual Rainfall Trend in Tangaza LGA (2005-2024)

Year Range	Mean Annual Rainfall (mm)	Notable Trend
2005–2009	610 mm	Stable rainfall pattern
2010–2014	575 mm	Slight decline begins
2015–2019	540 mm	Irregular rainfall; delayed onset
2020–2024	495 mm	Significant decrease; early cessation

Source: Nigerian Meteorological Agency (NIMET), Sokoto station (2005–2024)

Table 3 shows a progressive decline in mean annual rainfall from 610 mm in 2005–2009 to 495 mm in 2020–2024, representing a reduction of about 115 mm. The rainfall pattern shifted from relative stability to irregularity, delayed onset, and early cessation in later periods. These changes reduce the effective length of the growing season and increase the risk of crop failure in the predominantly rain-fed farming system.

Table 4: Mean Annual Temperature Trend in Tangaza LGA (2005–2024)

Year Range	Mean Annual Temperature (°C)	Notable Trend
2005–2009	32.4 °C	Moderate heat
2010–2014	33.1 °C	Increasing temperature
2015–2019	34.0 °C	Frequent heat waves
2020–2024	35.2 °C	Extreme and prolonged hot periods

Source: NIMET Sokoto Station (2005–2024)

Table 4 shows that mean annual temperature increased steadily from 32.4°C in 2005–2009 to 35.2°C in 2020–2024. The period from 2015–2024 was characterized by frequent heat waves and prolonged hot periods. Rising temperatures intensify evapotranspiration and soil moisture loss, thereby worsening crop water stress.

Table 5: Farmers’ Perception of Climate Change Effects on Crop Production

(Farmers = 160)

Perceived Effect	Frequency	Percentage (%)
Declining crop yields	150	93.8
Unreliable rainfall pattern	146	91.3
Shortened growing season	141	88.1
Increased heat stress on crops	143	89.4
Higher incidence of crop failure	144	90.0

Source: Field survey, 2025

Table 5 shows that most farmers perceived climate change as negatively affecting crop production. Specifically, 93.8% reported declining crop yields, 91.3% observed unreliable rainfall patterns, 88.1% reported shortened growing seasons, 89.4% experienced increased heat stress on crops, and 90.0% noted increased incidence of crop failure.

Table 6: Agricultural Extension Workers’ Observations on Climate Change Impacts

(Extension Workers = 20)

Observed Impact	Frequency	Percentage (%)
Reduced crop yields	18	90.0
Delayed onset of rainfall	17	85.0
Increased crop failure risk	16	80.0
Early cessation of rains	15	75.0
Increased pest and disease incidence	12	60.0

Source: Field survey, 2025

Table 6 shows that extension workers largely corroborated farmers’ experiences. Reduced crop yields were reported by 90.0% of extension workers, delayed onset of rainfall by 85.0%, increased crop failure risk by 80.0%, early cessation of rains by 75.0%, and increased pest and disease incidence by 60.0%.

**Table 7: Household Food Security Status under Climate Stress (N = 20)
(Households = 20)**

Food Security Indicator	Yes (Frequency)	Yes (%)	No (Frequency)	No (%)
Adequate food supply year-round	6	30.0	14	70.0
Food scarcity during dry season	15	75.0	5	25.0
Increased food prices due to poor harvest	16	80.0	4	20.0
Reduction in meal frequency	11	55.0	9	45.0

Source: Field survey (HFIAS items), 2025

Table 7 shows that household food insecurity was widespread. Only 30.0% of households reported adequate food supply throughout the year, while 70.0% lacked year-round food sufficiency. Seasonal food scarcity during the dry season was reported by 75.0% of households, and 80.0% indicated increased food prices due to poor harvests. In addition, 55.0% of households reduced meal frequency as a coping strategy.

Table 8: Coping and Adaptation Strategies Adopted by Farmers (N = 160 farmers)

Strategy	Frequency (n)	Percentage (%)
Early planting to utilize early rains	128	80.0
Use of drought-tolerant varieties	115	71.9
Mixed cropping / intercropping	102	63.8
Staggered planting (phased planting)	86	53.8
Mulching to conserve soil moisture	72	45.0
Application of organic manure	69	43.1
Water harvesting (small ponds, zai pits)	52	32.5
Dry-season farming in fadama / irrigation wells	48	30.0
Migration for wage labor	40	25.0
Selling livestock to cope	35	21.9
Indigenous pest control methods	31	19.4
Tree planting / agroforestry	28	17.5
Accessing extension advice	20	12.5
Use of small-scale irrigation pumps	12	7.5



Source: Field survey and KIIs, 2025

Table 8 shows that farmers predominantly relied on low-cost and autonomous adaptation strategies. Early planting was the most widely adopted strategy (80.0%), followed by the use of drought-tolerant varieties (71.9%) and mixed cropping or intercropping (63.8%). Soil and moisture conservation practices such as mulching (45.0%) and application of organic manure (43.1%) were moderately adopted. In contrast, adoption of capital-intensive strategies such as water harvesting (32.5%), dry-season irrigation (30.0%), use of irrigation pumps (7.5%), and access to extension services (12.5%) remained low, reflecting financial and institutional constraints.

Discussions

Local and Regional Agreement

The Tangaza trends declining rainfall totals, later onset and earlier cessation of rains, rising mean temperatures, and falling staple crop yields are consistent with national and regional analyses for the Sahel and Sudan savanna (NIMET, 2023; Adefolalu, 2022). Farmers' perceptions match instrumental records, demonstrating convergence of indigenous knowledge and meteorological data (Ibrahim & Garba, 2021).

Comparisons with West African and Sahelian Studies

Studies from neighbouring Sahelian contexts report analogous patterns of reduced rainfall reliability and declining yields for millet, sorghum, and cowpea (Sultan & Gaetani, 2016; Nwafor et al., 2021). The coping strategies recorded in Tangaza (early planting, drought-tolerant varieties, mixed cropping, mulching) mirror those documented across West Africa (FAO, 2022; Mustapha et al., 2020).

Global Evidence from Other Semi-arid and Tropical Regions

Global evidence similarly links rising temperatures and rainfall variability to reduced crop productivity and heightened food insecurity:

In South Asia, studies show wheat and rice yields decline with increased heat stress and irregular monsoon onset (Lobell et al., 2011; Challinor et al., 2014).

In parts of East Africa, increased rainfall variability has produced decreased maize yields and raised food insecurity, with smallholders adopting comparable adaptation measures such as drought-tolerant



varieties and staggered planting (Thornton et al., 2014; Wheeler & von Braun, 2013).

Australian and Mediterranean analyses report yield and phenological shifts under warming scenarios, leading to earlier maturation and reduced grain filling—mechanisms also plausible in Tangaza’s observed yield declines (IPCC, 2023).

Mechanistic Consistency

The correlations between lower rainfall, higher temperatures, and reduced yields observed in Tangaza are mechanistically consistent with crop-physiology and climate literature: reduced soil moisture and increased evapotranspiration impair germination, flowering and grain filling; heat stress accelerates crop development and reduces biomass accumulation (Lobell & Gourdj, 2012; Challinor et al., 2014).

Distinct Contribution of the Tangaza Study

While global and regional studies provide broad patterns, this study contributes localized, 20-year empirical evidence (climate and yield series) for Tangaza LGA, demonstrating the magnitude of local climatic change and its direct alignment with farmers’ lived experience and household food security outcomes.

Conclusion

This chapter has presented and analyzed data collected on the impact of climate change on agriculture and food security in Tangaza LGA. The findings reveal clear evidence of climatic shifts that negatively affect crop and livestock production, leading to reduced food availability and heightened vulnerability. Statistical analysis confirmed significant relationships between climate change and both agricultural productivity and food security indicators.

Recommendations

1. Government and development partners should promote climate-smart agriculture (CSA) through wider dissemination of drought-tolerant and early-maturing crop varieties, and by encouraging intercropping, mixed cropping, mulching, and organic soil fertility management practices suitable for semi-arid environments.



2. Investments should be made in small-scale irrigation technologies, such as shallow tube wells, treadle pumps, and solar-powered pumps, and rainwater harvesting structures (zai pits, contour bunds, small earth dams) should be scaled up through community-based projects.
3. The Sokoto State Government should recruit, train, and deploy more extension workers in Tangaza LGA, and extension programs should integrate climate information services, including seasonal rainfall forecasts and early-warning systems.
4. Collaboration between NiMet, extension services, and local institutions should be strengthened to provide timely, localized weather forecasts and improve farmers' capacity to make informed planting and harvesting decisions.
5. Improved storage facilities should be introduced to reduce post-harvest losses, and nutrition-sensitive agriculture programs should promote crop diversification, including legumes and vegetables, to enhance dietary diversity.
6. Micro-credit schemes and agricultural insurance products tailored to smallholder farmers should be expanded, and government and NGOs should subsidize climate-resilient inputs such as improved seeds and irrigation equipment.
7. Indigenous coping strategies should be incorporated into formal adaptation programs, and participatory planning involving farmers, extension agents, and local leaders should be encouraged.
8. Climate change adaptation should be mainstreamed into local agricultural development plans, and national frameworks such as NASPA-CCN should be localized to reflect the socio-ecological realities of Tangaza LGA.

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