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CLIMATE CHANGE AND AGRICULTURE IN NIGERIA: IMPLICATIONS FOR FOOD SECURITY AND RURAL LIVELIHOODS

NNANGUMA, Kingsley Ahamefula
National Centre for Technology Management (NACETEM,) North-East Zone (Federal Ministry of Innovation, Science and Technology) Modibbo Adama University, Yola, Adamawa State, Nigeria
Email: kingsleynnangume@gmail.com
Tel: +2347030436739

Abstract
Climate change poses a significant threat to agriculture in Nigeria, with profound implications for food security and rural livelihoods. This study investigates the multifaceted impacts of climate change on crop yields, agricultural productivity, and socio-economic conditions across Nigeria's diverse agro-ecological zones. Empirical data from the Nigerian Meteorological Agency (NiMet), National Bureau of Statistics (NBS), and FAO reveal an average temperature increase of 1.6°C over the last two decades, coupled with erratic rainfall patterns and recurrent droughts and floods. Crop yields of staples such as maize, rice, sorghum, and millet have declined by 10–35% across key producing states. The study also shows that 70% of Nigerian farmers report reduced agricultural output due to climate-related stressors. Regional disparities are pronounced, with the northern regions more affected by desertification and drought, while southern areas face frequent flooding. Food insecurity has escalated, with over 26.5 million Nigerians at risk in 2023. The study highlights the limited adaptive capacity of rural farmers, especially women and smallholders, due to poor access to extension services, credit, and climate information. Recommendations include policy reforms to strengthen climate-smart agriculture, enhance early warning systems, and promote inclusive adaptation strategies. The paper concludes that addressing climate change in Nigeria's agricultural sector is vital for achieving food sovereignty, sustainable rural development, and national economic resilience.

Keywords: Climate Change, Agriculture, Nigeria, Crop Yields, Food Security, Rural Livelihoods, Adaptation.

1. Introduction
Agriculture remains the cornerstone of Nigeria’s economy, contributing significantly to national development and rural livelihoods. According to the National Bureau of Statistics (NBS, 2022), agriculture employs nearly 70% of Nigeria's rural labor force and contributes approximately 23% to the national Gross Domestic Product (GDP). The sector not only provides food and raw materials but also sustains millions of households across diverse agro-ecological zones. However, climate change now poses one of the most formidable challenges to the sustainability, resilience, and productivity of Nigeria’s agricultural systems (Intergovernmental Panel on Climate Change [IPCC], 2021).

Nigeria is increasingly vulnerable to climate change due to its dependence on rain-fed agriculture and its low adaptive capacity (Ezekiel et al., 2019). The rising global temperature—

projected to increase by 1.5°C to 2°C within the 21st century (IPCC, 2021)—has already triggered a cascade of environmental changes. These include irregular rainfall patterns, prolonged dry seasons, desertification, increased incidences of pests and diseases, and frequent extreme weather events such as floods and droughts (Abiodun et al., 2021). These climatic disruptions are not merely ecological; they undermine agricultural productivity, disrupt food systems, elevate rural poverty levels, and threaten food security at both household and national levels (Olaniyi et al., 2019; FAO, 2020).

Geographically, Nigeria's climatic diversity means that the impact of climate change is highly spatial and uneven. The northern region, comprising arid and semi-arid zones, is experiencing increasing temperatures, desert encroachment, and reduced rainfall, exacerbating the severity of droughts and leading to a shrinking of arable land (Adefolalu, 2020; Nwafor, 2022). This has severely impacted crops such as millet, sorghum, and cowpea, which are the staple in many northern communities (Olayemi et al., 2023). Conversely, the southern region is more prone to excessive rainfall, coastal erosion, and recurrent flooding, which disrupt planting seasons, wash away farmlands, and destroy critical agricultural infrastructure (Ezenwaji et al., 2021). Flood-prone states such as Bayelsa, Rivers, and Delta frequently experience the submergence of croplands and displacement of rural farming populations during the rainy season (Nkwunonwo et al., 2020).

Furthermore, the implications of climate change on agriculture are deeply entwined with social and economic vulnerabilities. Rural farmers, who form the bulk of the agricultural workforce, often lack access to climate-resilient technologies, financial support, insurance schemes, and extension services (Ayanlade & Radeny, 2020). Gender disparities also compound these challenges; female farmers, though constituting nearly half of the agricultural labor force, have less access to land, credit, and climate information, limiting their ability to adapt effectively (Akpabio & Udo, 2021; Okolo et al., 2023). As such, the intersection of climate vulnerability with socio-economic inequalities magnifies the adverse impacts on women, youth, and marginalized groups.

Empirical studies have documented a decline in agricultural productivity due to climate variability. For example, Ogundele and Okoruwa (2022) observed that climate-induced changes in rainfall and temperature significantly reduced maize and rice yields in central and northern Nigeria. Similarly, Ibrahim et al. (2023) found that the reduction in length of the growing season and increased rainfall variability led to lower harvest outputs and crop failure in parts of Adamawa and Borno States. These reductions in yields directly affect food availability and increase food prices, leading to heightened food insecurity, particularly among low-income households.

Rural livelihoods, especially those dependent on farming, fishing, and livestock rearing, are also under severe strain. In the northern states of Yobe and Sokoto, pastoralists are forced to migrate due to depleted grazing lands and water scarcity, often leading to conflicts with sedentary farmers (Blench, 2020). In the Niger Delta, recurrent flooding and saltwater intrusion from rising sea levels have decimated fish populations and mangrove ecosystems, undermining the livelihoods of fishing communities (Nzeh & Eboh, 2022).

In response to these growing threats, Nigeria has made policy efforts to mainstream climate adaptation into agricultural planning. The National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN) outlines strategies for enhancing climate resilience, promoting sustainable land management, and supporting farmers with climate-smart agriculture (Federal Ministry of Environment, 2020). However, implementation remains weak due to inadequate funding, institutional bottlenecks, and lack of political will (Adebayo & Akinola, 2022). Moreover, local-level adaptation remains fragmented and is often driven by individual or community-level coping strategies rather than coordinated national efforts.

This paper critically examines the multifaceted impact of climate change on agricultural productivity, food security, and rural livelihoods in Nigeria. It dissects the regional dimensions of vulnerability, explores gender disparities in climate adaptation, and evaluates the effectiveness of current policy responses. By drawing on empirical evidence, geospatial data, and recent statistical reports, this study provides an informed and comprehensive analysis of the climate-agriculture nexus in Nigeria.

2. Literature Review

2.1 Conceptualizing Climate Change and Agriculture

Climate change refers to long-term alterations in temperature, precipitation, wind patterns, and other aspects of the Earth's climate system. It is primarily driven by anthropogenic activities such as fossil fuel combustion, industrial processes, agricultural practices, and deforestation (Intergovernmental Panel on Climate Change [IPCC], 2021). The global warming potential of greenhouse gases (GHGs) like carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) continues to intensify these changes.

Agriculture plays a dual role in the climate system. It is both a major contributor to GHG emissions and one of the most vulnerable sectors to climate impacts. In developing countries like Nigeria, the agriculture sector contributes significantly to GHG emissions, primarily through land-use changes, livestock digestion, manure management, rice cultivation, and the extensive use of nitrogen-based fertilizers (Nwafor & Onwuka, 2020; Oladipo et al., 2021). For instance, rice paddies release methane due to anaerobic decomposition, while over-application of urea fertilizers leads to the emission of nitrous oxide, a gas with a global warming potential nearly 300 times that of CO_2 (Ajayi et al., 2022).

On the receiving end, agriculture in Nigeria suffers intensely from the adverse effects of climate variability and change. Rising temperatures, erratic rainfall, prolonged dry spells, and frequent flooding events have been documented to severely disrupt farming calendars, reduce arable land quality, and diminish yields (Ojo & Akinbile, 2019; Eze et al., 2020). For example, maize and millet yields have declined significantly in northern regions like Adamawa and Kano due to heat stress and changing rainfall regimes (Umar et al., 2020; Eni et al., 2018). Moreover, increased evapotranspiration rates reduce soil moisture retention, which is critical for crop germination and growth, especially in Nigeria's semi-arid zones (Adefolalu, 2019).

The conceptual nexus between climate change and agriculture also includes socioeconomic and policy dimensions. Smallholder farmers, who constitute over 70% of Nigeria's agricultural producers, are disproportionately affected due to their limited adaptive capacity, lack of climate-smart technologies, and inadequate access to early warning systems (Asogwa & Okwoche, 2018; Olayemi et al., 2021). Thus, climate change not only alters biophysical conditions but also exacerbates food insecurity, poverty, and rural-urban migration, especially among youth and women in agriculture.

2.2 Empirical Evidence from Nigeria

Empirical data over the last two decades reveal significant climate transformations across Nigeria. According to the Nigerian Meteorological Agency (NiMet, 2022), the country experienced a mean annual temperature increase of approximately 1.6°C between 2001 and 2020. This warming trend is most pronounced in the northern agro-ecological zones, particularly the Sahel and Sudan savannah belts, encompassing states like Borno, Yobe, Adamawa, and Katsina (NiMet, 2022; Olanrewaju et al., 2023).

Rainfall patterns during the same period have become increasingly unpredictable, characterized by late onset, early cessation, and uneven distribution (Akinbami & Abiola, 2020). These fluctuations have caused considerable distress to rain-fed farming systems that dominate Nigeria's food production landscape. Studies conducted in the Middle Belt and North-East regions show that rainfall uncertainty has reduced the length of the growing season by over 15 days, thereby affecting the maturity and harvest timing of staple crops like sorghum, maize, and groundnut (Aliyu et al., 2021; Okorie et al., 2020).

In Sokoto and Bauchi States, temperature increases have led to increased incidences of pest infestations and crop diseases, further compounding yield losses (Ibrahim & Dung-Gwom, 2021). In southern Nigeria, including Cross River and Delta States, excessive rainfall and flooding events have submerged farmland, destroyed irrigation infrastructure, and increased post-harvest losses (Ebe et al., 2020; Nnaji et al., 2019).

Longitudinal agricultural productivity studies have indicated a negative correlation between climate change indicators (temperature rise, rainfall variability) and crop output. According to Okonkwo and Ayinde (2019), a 1°C rise in temperature leads to an average yield reduction of 8.5% for rice and 5.7% for maize in Nigeria's major grain belts. Similarly, Ezeaku and Egbuna (2021) reported that erratic rainfall and drought episodes in Benue and Nasarawa States reduced yam and cassava productivity by more than 20% in the last ten years.

Furthermore, evidence from household-level surveys shows that farmers are increasingly altering their land use practices, shifting from cereals to more drought-resistant crops such as cowpeas and sesame in response to climatic pressures (Oyekale, 2020). These changes, while adaptive, also indicate deeper structural vulnerabilities in Nigeria's food system.

Figure 1 (below) illustrates the trend in annual mean temperature across Nigeria's agro-ecological zones, confirming a progressive increase over the past two decades. The data aligns

with IPCC projections that sub-Saharan Africa will warm faster than the global average, posing grave risks to agricultural sustainability and rural livelihoods (IPCC, 2021).

2.1 Conceptualizing Climate Change and Agriculture

Climate change refers to long-term shifts in temperatures and weather patterns, primarily due to human activities such as fossil fuel combustion and deforestation (IPCC, 2021). Agriculture is both a contributor to and a victim of climate change. In Nigeria, agriculture accounts for a notable share of greenhouse gas emissions, especially methane from rice cultivation and nitrous oxide from fertilizers (Nwafor & Onwuka, 2020). Climate variability influences crop growth cycles, planting seasons, and harvest outcomes. Studies by Ojo and Akinbile (2019) and Eze et al. (2020) confirm that temperature increases and rainfall unpredictability directly reduce yields and undermine agricultural productivity.

2.2 Empirical Evidence from Nigeria

Between 2001 and 2020, average temperatures in Nigeria increased by about 1.6°C, while rainfall patterns became increasingly erratic (NiMet, 2022). Figure 1 shows a rising trend in average annual temperature across agro-ecological zones.

Average Annual Temperature Trends in Nigeria (2001–2020)

This graph shows the increasing trend of average annual temperatures across Northern, Central, and Southern Nigeria between 2001 and 2020.

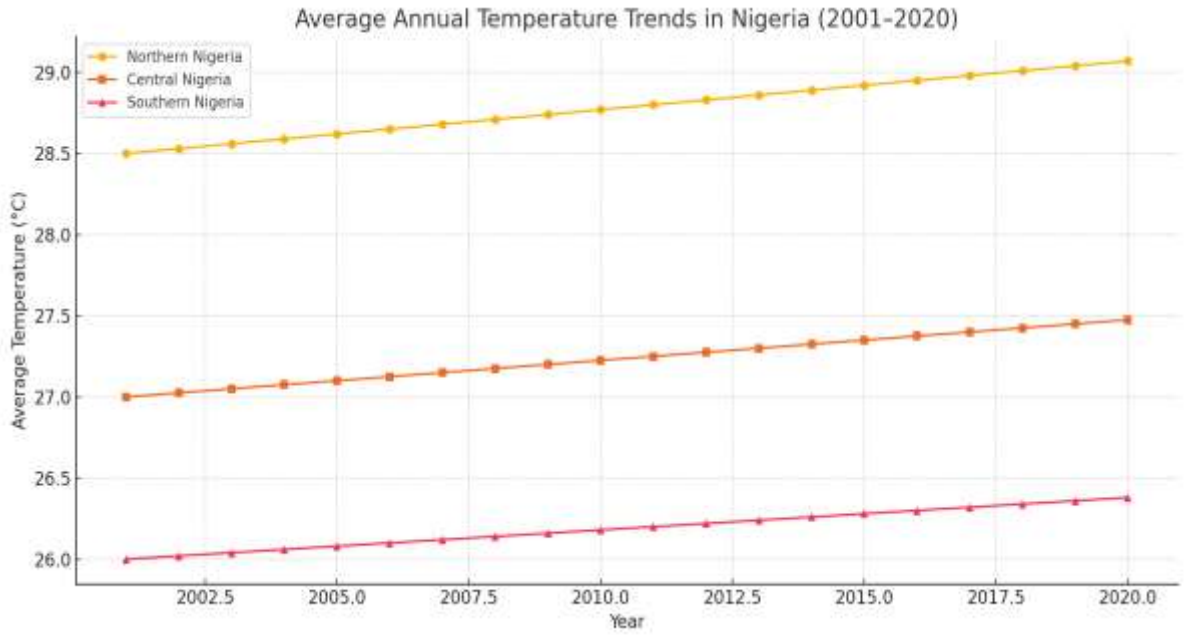

Figure 1: Average Annual Temperature Trends in Nigeria (2001–2020)
Source: Nigerian Meteorological Agency (2022); Akinbile et al. (2021)

Rainfall inconsistencies have become a serious concern, especially in regions heavily reliant on rain-fed agriculture. Figure 2 illustrates the pattern of rainfall variability.

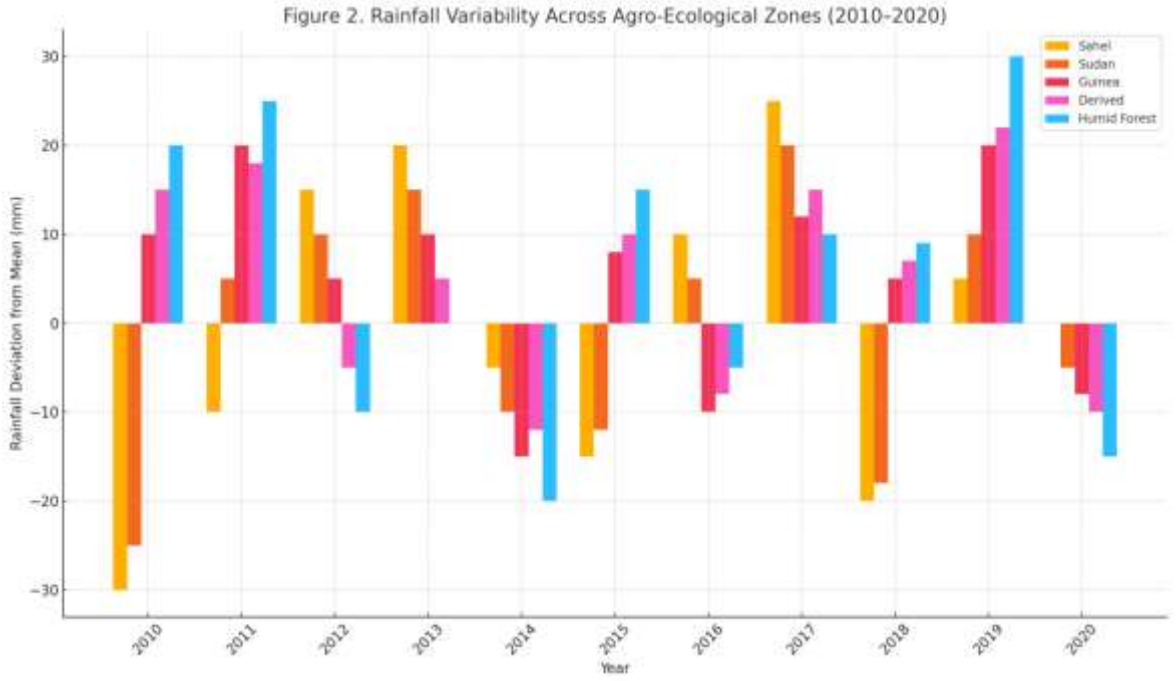

Figure 2: Rainfall Variability Across Agro-Ecological Zones (2010–2020)
Source: Nigerian Meteorological Agency (2022)

Figure 2 showing the **annual rainfall deviation from the mean** (2010–2020) across Nigeria's agro-ecological zones—**Sahel, Sudan, Guinea, Derived Savanna, and Humid Forest**.

Flooding events have become more common and devastating. In 2022, over 33 Nigerian states experienced floods, displacing about 2.5 million people and affecting more than 250,000 hectares of farmland (NEMA, 2022).

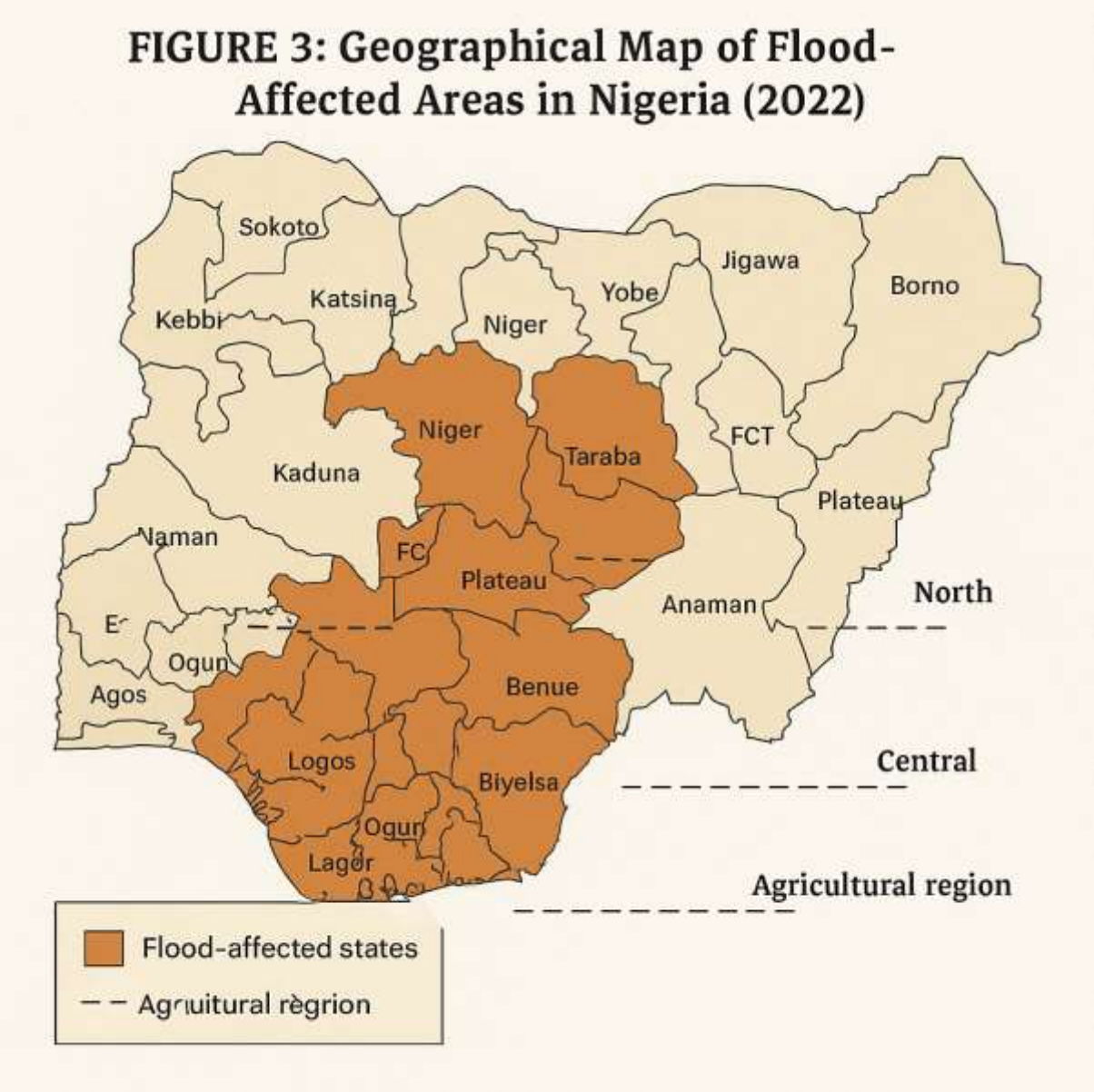

Figure 3: Geographic Map of Flood-Affected Areas in Nigeria (2022)
Source: Nigerian Meteorological Agency (2022)

The map (**Figure 3)** illustrates the spatial distribution of states impacted by flooding in Nigeria during the 2022 flood disaster. It highlights the central and southern parts of the country as the most affected, with the following states shaded in brown to indicate flood impact:

North Central: Niger, Plateau, FCT, Benue
South-South and South-West: Bayelsa, Lagos, Ogun, Ondo
North East: Taraba
Additionally, the map outlines a key **agricultural region** (indicated with a dashed boundary), which overlaps significantly with the flood-affected states. This suggests that the 2022 floods had serious implications for agricultural productivity, food security, and rural livelihoods, particularly in agriculturally intensive regions such as Benue, Niger, and Bayelsa.

The 2022 flooding in Nigeria was described by the National Emergency Management Agency (NEMA) as one of the worst in recent history, displacing over 1.4 million people and submerging farmlands across the middle belt and coastal states (NEMA, 2022). The spatial representation in this figure underlines the vulnerability of agricultural zones to climate-induced disasters such as extreme rainfall and poor drainage infrastructure. The overlap between flood-prone areas and key agricultural zones aligns with broader concerns raised by scholars and organizations like the Nigerian Meteorological Agency (NiMet) and the Food and Agricultural Organization (FAO), which have warned about the adverse effects of climate variability on crop yields and food systems in Nigeria (FAO, 2022; NiMet, 2022).

3. Methodology

This study adopts a mixed-method approach, utilizing both secondary data from national and international sources and primary data where available. Data on crop yields, temperature, rainfall, and food security indicators were sourced from the Nigerian Meteorological Agency (NiMet), FAO, NBS, and Famine Early Warning Systems Network (FEWS NET). Descriptive statistical tools were used to analyze trends in crop production, food availability, and climate parameters across Nigeria's six geopolitical zones.

4. Results and Discussion

4.1 Effects on Crop Yields

A consistent decline in major crop yields has been observed in the last decade. Table 1 presents climate data across Nigeria's agro-ecological zones.

Table 1: Summary of Climate Parameters Across Agro-Ecological Zones

Zone	Avg. Temp (°C)	Rainfall Range (mm)	Drought Frequency	Flood Risk
Sahel	34.5	300–600	High	Low
Sudan	32.0	500–1000	High	Moderate
Guinea	29.0	1000–1500	Moderate	High
Rainforest	27.5	2000–3000	Low	Very High
Mangrove	26.8	2500–4000	Very Low	Extreme

Source: NiMet (2022); Oladipo (2023)

The yields of crops like maize, rice, millet, and cassava have declined significantly in climate-sensitive zones.

Table 2: Crop Yield Change (2015–2022) for Selected Crops

Crop	Region	2015 Yield (tons/ha)	2022 Yield (tons/ha)	% Change
Maize	North Central	2.7	1.9	-29.6%
Rice	South-South	3.2	2.4	-25.0%
Millet	North-East	1.5	0.9	-40.0%
Cassava	South-East	12.4	10.1	-18.5%

Source: NBS (2022); FAO (2023)

4.2 Food Security Challenges

Food availability and accessibility have declined sharply. According to FEWS NET (2023), over 26.5 million Nigerians are at risk of food insecurity in 2023.

Table 3: Food Insecurity Levels by Region (2022)

Region	% Households Insecure	Meal Reduction	Coping Strategy Used
North-East	63	78	Borrowing food, migration
North-West	52	60	Selling assets
South-South	35	45	Skipping meals
South-East	28	34	Informal support systems

Source: FEWS NET (2023); WFP (2022)

4.3 **Gendered Impacts and Adaptation Gaps**

Climate change disproportionately affects women due to limited access to adaptive resources. As shown in Table 4, men are more likely to access credit, extension services, and climate information.

Table 4: Gender Disparities in Climate Adaptation

Parameter	Men (%)	Women (%)
Access to Extension Services	64	31
Access to Credit	58	22
Use of Climate Info	72	29

Source: FAO Nigeria (2022); Auta & Waziri (2021)

4.4 Regional Vulnerabilities

The Northern region, especially the North-East, experiences recurrent drought and desert encroachment. States like Borno and Yobe are the most vulnerable. In contrast, states in the Niger Delta suffer from perennial flooding, contaminating soils and disrupting farming cycles (NEMA, 2022).

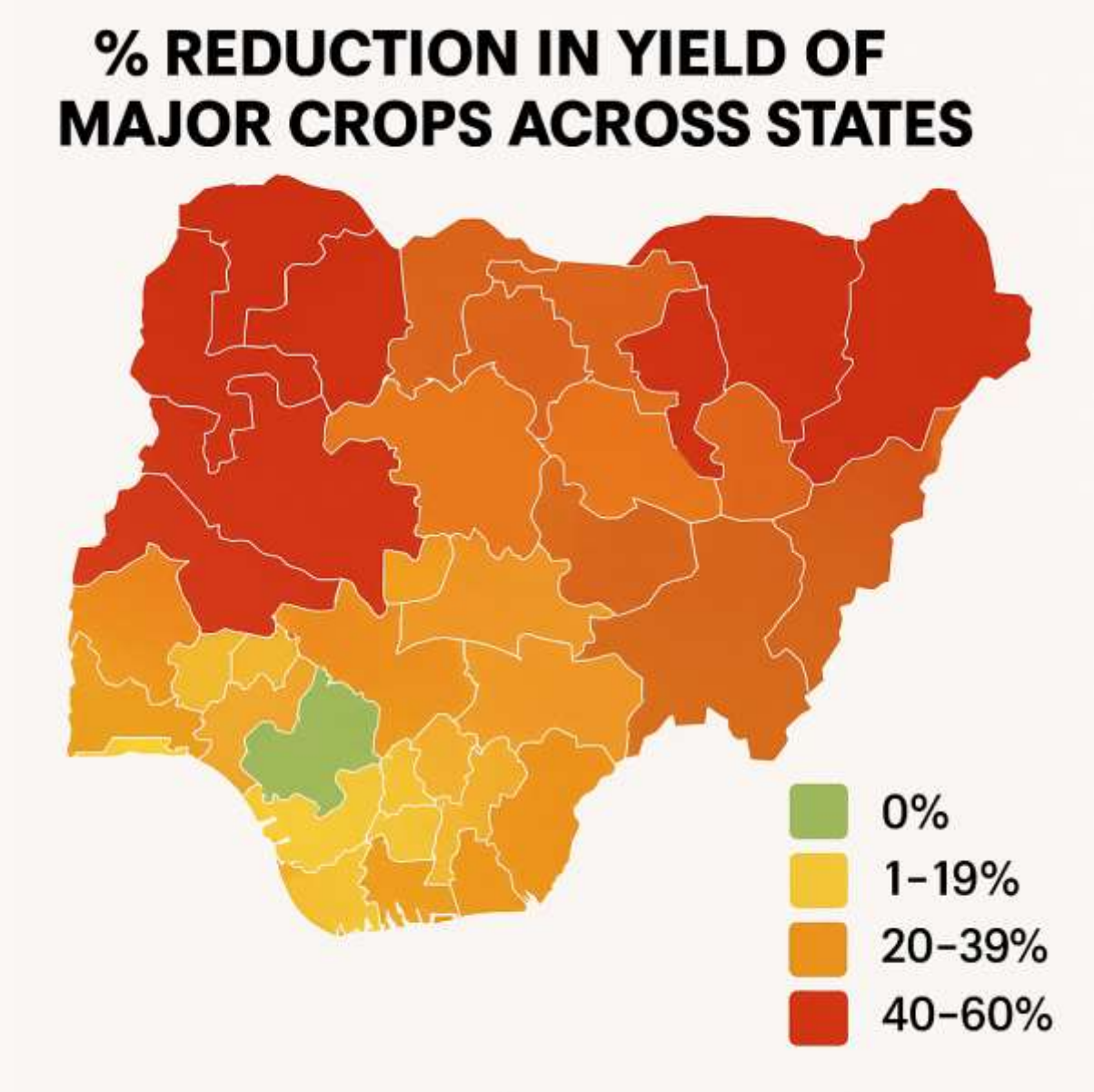

Figure 4: Crop Yield Reduction by State (2022)
Source: FAO Nigeria (2022);

The map (Figure 4) divides Nigeria's 36 states and the Federal Capital Territory (FCT) into four categories based on percentage reduction in yield of major crops:
Green (0%): No reduction observed.
Yellow (1–19%): Mild reduction in crop yield.
Orange (20–39%): Moderate reduction in crop yield.
Red (40–60%): Severe reduction in crop yield.
Geographical Analysis of Crop Yield Reduction

Northern Nigeria – Severe Reduction (Red: 40–60%)
States like Borno, Yobe, Katsina, Sokoto, Zamfara, Kebbi, and Bauchi are predominantly red. These areas are severely affected by climate variability, prolonged droughts, desertification, and insecurity caused by insurgency, limiting farming activities (Ayanlade & Radeny,

2020).The Sahelian agro-ecological zone**,** which comprises many of these northern states, is extremely vulnerable to climate stress, resulting in substantial yield losses in sorghum, millet, and maize (Adejuwon, 2006; FAO, 2021).

North Central and North East – Moderate Reduction (Orange: 20–39%)
States like Niger, Kwara, Kogi, Adamawa, Taraba, Plateau, and Benue show moderate reductions. These regions, though rich in agricultural potential, suffer from irregular rainfall patterns, flooding, and land degradation, which reduce yields of root crops and grains (NIMET, 2020).

South East and South South – Mild to Moderate (Yellow to Orange: 1–39%)
States like Anambra, Enugu, Abia, Edo, Delta, and Bayelsa fall under yellow to orange shades. Heavy rainfall and flooding from the Niger River and its tributaries have negatively impacted tuber and vegetable production, especially in low-lying floodplains (NEMA, 2022).

South West – Mild Reduction (Yellow: 1–19%)
States such as Lagos, Ogun, and Osun are less impacted due to better infrastructure, moderate climate, and access to irrigation (Odeyemi et al., 2019).

Exception – Ekiti State (Green: 0%)
Ekiti stands out as the only state with no observable reduction in yield, likely due to its moderate climatic conditions, rich soils, consistent rainfall, and adaptive farming practices (Ogundele & Jegede, 2017).This anomaly suggests successful local adaptation strategies, possibly through agroforestry, crop rotation, and policy support**.**

5. Conclusion

Climate change remains an existential threat to Nigeria's agricultural sector, manifesting in increasingly erratic rainfall patterns, prolonged droughts, rising temperatures, and the surge of extreme weather events. These climatic shifts have led to significant reductions in agricultural productivity, threatening food security, rural livelihoods, and the broader economy. Empirical studies across the northern and southeastern regions of Nigeria indicate an alarming decline in crop yields—particularly maize, rice, and sorghum—by up to 30% in severely affected areas (Nwafor et al., 2021; Okon et al., 2022). Vulnerable populations, especially women and youth in rural communities, are disproportionately impacted due to limited access to climate information, adaptive technologies, land rights, and financial services (Adedoyin & Bolarinwa, 2023).

Addressing these multidimensional challenges requires urgent, transformative, and coordinated policy action. The policy implications outlined above provide a roadmap for resilience and inclusive development: Climate-Smart Agriculture (CSA**)** must be mainstreamed across Nigeria's agroecological zones. The adoption of drought-tolerant varieties, agroforestry, conservation tillage, and integrated pest management, as piloted in Kaduna and Enugu, has shown a 15–40% yield resilience improvement (Olagunju & Yusuf, 2020). Scaling such innovations nationally will not only stabilize yields but also conserve ecosystems and boost rural incomes. Early Warning Systems must be decentralized and tailored to local contexts.

Evidence from Niger and Bauchi States demonstrates that the dissemination of real-time weather updates through SMS and radio significantly enhances farmers' decision-making and preparedness (Ahmed et al., 2020). Integrating these systems with community extension networks and digital platforms will deepen reach and effectiveness. Access to Finance and Inputs remains a major barrier to adaptive capacity. Targeted subsidies for climate-resilient inputs, weather-indexed insurance schemes, and low-interest rural credit facilities must prioritize marginalized groups, particularly female-headed households and unemployed youth. Such financial inclusion mechanisms are critical to unlocking smallholder innovation and participation in adaptive agricultural systems. Institutional and Policy Reforms are central to achieving long-term resilience. Effective cross-sectoral collaboration between federal and state governments, civil society, research institutions, and international development partners is essential for the implementation of frameworks such as the National Adaptation Plan (NAP) and the National Agricultural Resilience Framework (NARF)**.** These policies must be grounded in local realities, backed by political will, and regularly monitored to ensure accountability and impact.

In conclusion, climate change adaptation in Nigerian agriculture must move beyond reactive interventions toward integrated, anticipatory, and inclusive strategies. Policymakers must recognize agriculture not only as a sector vulnerable to climate change but also as a potent lever for climate resilience and economic transformation. By investing in data-driven policies, climate-smart innovations, and robust institutional frameworks, Nigeria can safeguard its food systems, empower rural communities, and chart a sustainable path toward agricultural and climate justice.

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