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Impact of Climate Change on Global Food Security: A study of 2024 Rainfall Shortfall in Taraba State, Nigeria

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Abstract
Climate change poses one of the most significant threats to agricultural production and global food security. Extreme weather events and fluctuating rainfall have contributed to declining global crop yields, pushing many households into poverty and hunger. This paper examines the impact of climate change on food security in Taraba State, using the 2024 rainfall shortfall as a case study. The study employed both primary and secondary sources, with primary data collected through a structured questionnaire. Descriptive statistical tools, such as mean and standard deviation, were used to analyse the data. The findings revealed that most crop farmers understand the concept of climate change and have observed environmental variations due to its effects. The study also found that respondents had long observed and experienced the impacts of climate change, indicating awareness and understanding of its effects. Furthermore, the study discovered that the area has experienced a prolonged dry spell, significantly impacting food production. The paper concludes that the impact of climate change is severe in the study area due to the reliance on rain-fed agriculture, which hinders agricultural commercialisation. Furthermore, the paper recommends the following as solutions to climate change among others: education, sensitisation and enlightenment on early warning signs, climate-Smart Agriculture, crop diversification, drought-resistant crops, drip irrigation system, water-smart crop choice, government policy initiative, community-based adaptation.

Key Words: Climate change, crop production and food security.

Introduction

Climate change represents one of the most significant and pervasive threats confronting our planet today. This issue is omnipresent, impacting every corner of the Earth, influencing all forms of life, and particularly endangering human populations in developing nations (Eze, et al 2020). Agriculture, a vital component of human existence, is particularly vulnerable to the effects of climate change. Rising temperatures and shifting weather patterns can lead to severe and lasting detrimental impacts on agricultural productivity and the viability of farming regions, ultimately diminishing food supplies and creating potential crises for populations in many developing countries (Olaniyan, & Tomori, 2016).

For the majority of rural communities in developing nations, and especially in sub-Saharan Africa, agricultural production continues to be their primary source of income. Approximately 30% of the gross domestic product is generated by agriculture, which employs over 60% of the population (Kandlinkar&Risbey, 2000). Around 97% of all cropland in sub-Saharan Africa is used for rain-fed farming, which exposes agricultural output to significant seasonal rainfall variability (Alvaro, Tingju, Katrin, Richard & Claudia, 2019). Climate change poses a special threat to agriculture in developing nations

(Action Aid, 2018). According to the IPCC, rain-fed agricultural yields in some African nations may drop by as much as 50% by 2030 (Intergovernmental Panel on Climate Change, IPCC, 2017).

The implications of climate change for agriculture and food security are profound, with extreme weather events contributing to a decline in global crop yields. Projections indicate that the average global temperature may increase by 2.0 to 6.4 °C, with sea levels expected to rise by 59 cm by the conclusion of the 21st century (Shaba, et al 2018). This unprecedented temperature rise has resulted in more frequent heat waves, droughts, floods, and erratic precipitation patterns.

Such alterations significantly affect existing agricultural systems, productivity, and food security on both regional and global scales (Okafor, Oladejo, & Ikem, 2019). Changes in climatic conditions also have considerable repercussions for weeds, diseases, insects, and pests, potentially expanding their geographical range, increasing their generational cycles, and enhancing their survival rates during winter (Sharma, 2020).The natural factors contributing to climate change include variations in the Earth's orbit, changes in ocean circulation, fluctuations in the albedo of landmasses, and alterations in solar radiation. In contrast, human-induced factors stem from activities such as deforestation, air pollution, unsustainable agricultural practices like bush burning, excessive and improper use of inorganic fertilizers, fossil fuel combustion, urban expansion, industrial growth, and an inefficient transportation system, among others (Anabaraonye, Okafor &Ikuelogbon, 2019).

Climate change significantly influences soil formation, with critical implications for soil development, utilisation, and management, particularly concerning soil structure, stability, topsoil water retention, nutrient availability, and erosion. Researchers have forecasted that anticipated shifts in temperature, precipitation, and evaporation due to climate change will lead to considerable alterations in organic matter turnover and CO2 dynamics, thereby profoundly affecting soil fertility (Okafor, Oladejo, & Ikem, 2019). In Nigeria, climate change represents a considerable threat to agricultural productivity and food security, adversely affecting crop yields and the livelihoods of millions (Olaniyan & Tomori, 2016).

Although Nigeria is one of Africa's largest agricultural producers, its agricultural sector remains highly susceptible to the detrimental impacts of climate change. Recent research has underscored the rising frequency and severity of extreme weather events, such as droughts, floods, and heatwaves, which are linked to climate change (Ogunjobi, 2020). These extreme weather phenomena disrupt agricultural operations, resulting in diminished crop yields, post-harvest losses, and income instability for farmers (Adejuwon, 2019).

Changes in temperature and precipitation patterns, driven by climate change, have led to alterations in planting seasons and a rise in the prevalence of crop diseases and pests, which further aggravate yield losses (Eze, 2021). In Taraba State, the effects of climate change, including increasing temperatures, shifting rainfall patterns, and a higher occurrence of extreme weather events, present significant threats to agricultural production and overall food security in the region (Zubair &Yahuza, 2019). In 2024,

Taraba state experienced a significant shortfall in rainfall, with a total rainfall of 600 mm, compared to the average annual rainfall of 900 mm (NIMET, 2024). The rainfall shortfall was most severe in June and July, which are critical for crop growth and development (NIMET, 2024). Crop yields were significantly reduced, with maize yields declining by 40% and rice yields declining by 30% (Taraba State Ministry of Agriculture, 2024). The rainfall shortfall also led to a significant increase in crop failures, with over 50% of farmers reporting total crop loss (Taraba State Ministry of Agriculture, 2024).

The impact of the 2024 rainfall shortfall on agricultural production in Taraba state has significant implications for food security. The reduced crop yields and increased crop failures have led to a shortage of staple crops, such as maize and rice, which are critical for food security (FAO, 2017). The shortage of staple crops has also led to an increase in food prices, making it difficult for vulnerable populations to access nutritious food (World Bank, 2019). Therefore, in light of the above problem the study seeks to examine the impact of climate change on Global food security using Taraba State as a case study.

Conceptual Framework/Clarification

Climate change refers to the long-term warming of the planet, which is primarily caused by the increasing levels of greenhouse gases in the Earth's atmosphere. These gases, such as carbon dioxide, methane, and water vapor, trap heat from the sun, leading to a rise in global temperatures.

Climate change can be caused by:

1. **Greenhouse gases**: The burning of fossil fuels, such as coal, oil, and gas, releases large amounts of carbon dioxide into the atmosphere, leading to a trap of heat and a rise in global temperatures.
2. **Deforestation:** The clearing of forests for agriculture, urbanisation, and other purposes releases carbon dioxide and reduces the ability of forests to act as carbon sinks.
3. **Land use changes:** Changes in land use, such as the conversion of natural habitats to agricultural land or urban areas, can lead to the release of stored carbon into the atmosphere.
4. **Industrial processes:** Various industrial processes, such as the production of cement and steel, also release large amounts of greenhouse gases.

Global Food Security

Global food security is a complex and multifaceted issue that refers to the availability, access, utilisation, and stability of food supplies to meet the nutritional needs of all people. Food security is a fundamental human right, and it is essential for human health, well-being, and economic development.

Dimensions of Global Food Security include:

1. **Availability:** The availability of sufficient quantities of food of appropriate quality, supplied through domestic production or imports.
2. **Access:** Access to food, which includes the ability to purchase or produce food, as well as the physical access to markets and distribution systems.

3. **Utilisation:** The proper use of food, including adequate nutrition, safe water, and proper sanitation.
4. **Stability**: The stability of food supplies, which includes the ability to maintain access to food over time, despite shocks and stresses.

Theoretical framework

Vulnerability theory

This work adopts Vulnerability Theory, which was developed by Robert Chambers (1989), focuses on the susceptibility of individuals, households, or communities to harm or damage due to external stressors, such as climate change.

In the context of climate change and food security, Vulnerability Theory can be applied to understand how rainfall shortfall in Taraba State affects the livelihoods of farmers and the overall food security in the region.

Components of Vulnerability Theory Include:

1. **Exposure:** Taraba State's agricultural sector is exposed to climate-related hazards, such as rainfall shortfall, which can lead to crop failure and reduced food production.
2. **Sensitivity**: The sensitivity of farmers in Taraba State to rainfall shortfall is high, as they rely heavily on rainfall for crop cultivation.
3. **Adaptive Capacity:** The adaptive capacity of farmers in Taraba State to respond to rainfall shortfall is limited, due to factors such as lack of access to irrigation facilities, credit, and climate-resilient agricultural practices.

Therefore, the case study of rainfall shortfall in Taraba State can provide valuable insights into the impact of climate change on food security. This theory explores the following:

1. **Food availability:** How does rainfall shortfall affect crop yields and food availability in Taraba State?
2. **Food access**: How does rainfall shortfall affect the ability of households in Taraba State to access food, particularly for vulnerable groups such as women and children?
3. **Food utilisation:** How does rainfall shortfall affect the nutritional quality of food consumed by households in Taraba State?

Therefore, the application of Vulnerability Theory to the case study of rainfall shortfall in Taraba State provides a framework for understanding the impact of climate change on food security. By examining the exposure, sensitivity, and adaptive capacity of farmers in Taraba State, policymakers and stakeholders can develop targeted interventions to enhance the resilience of agricultural systems and improve food security in the region.

Empirical Review

Ogunjobi (2018) conducted an evaluation of how variations in temperature and rainfall affect maize production in Nigeria. By analysing historical climate data alongside

crop yield statistics, the researchers utilised statistical methods to uncover relationships between climatic factors and maize yields. The study's results indicated a notable negative correlation between rising temperatures and maize yields, especially in areas with elevated temperature levels. Furthermore, alterations in rainfall patterns were shown to impact maize productivity, with drought conditions resulting in significant yield declines.

This research highlighted the susceptibility of maize production to the effects of climate change in Nigeria, emphasising the critical need for adaptation strategies to reduce risks and bolster resilience within the agricultural sector. Ajayi (2019) explored the effects of climate variability on rice productivity in Nigeria. Through the application of statistical models and climate data analysis, the study assessed the connections between rainfall, temperature, and rice yields over an extended timeframe.

The findings revealed that variations in rainfall and temperature significantly influenced rice productivity, with extreme weather phenomena such as droughts and floods causing considerable yield losses. The study stressed the necessity of adopting climate-resilient agricultural practices and effective water management strategies to improve rice production amid changing climatic conditions. Additionally, it recommended that policymakers incorporate climate adaptation strategies into agricultural policies to safeguard food security and sustain the livelihoods of rice farmers in Nigeria.

Eze (2020) conducted an assessment of the impact of climate change on cassava production in Nigeria. Through a combination of field surveys and climate data analysis, the research explored the correlation between temperature fluctuations, rainfall patterns, and cassava yields. The findings indicated that increasing temperatures and alterations in precipitation significantly affected cassava productivity, posing challenges for food security and rural livelihoods. The study emphasised the necessity of adopting climate-smart agricultural practices and investing in adaptive strategies to mitigate climate-related risks and bolster cassava resilience. Recommendations included the establishment of early warning systems and the promotion of drought-resistant cassava varieties to facilitate sustainable production amid climate change challenges.

Adejuwon (2017) examined the effects of climate change on yam production in Nigeria. Utilising a blend of field experiments and climate modeling techniques, the study evaluated the sensitivity of yam yields to variations in temperature and rainfall. The results demonstrated that fluctuations in temperature and precipitation patterns had a significant impact on yam productivity, with increased temperatures and unpredictable rainfall contributing to yield declines. The research highlighted the critical need for adaptation strategies, such as crop diversification and improved soil management practices, to enhance yam resilience against climate change effects.

Furthermore, it recommended that policymakers incorporate climate adaptation measures into agricultural development plans to promote sustainable yam production and ensure food security in Nigeria. Olaniyan & Tomori (2016) explored the connection between climate variability and wheat productivity in Nigeria, specifically focusing on Gombe State. By employing remote sensing data and crop modeling techniques, the study

analysed the influence of temperature changes and rainfall variability on wheat yields over time. The findings revealed that rising temperatures and inconsistent rainfall patterns negatively affected wheat productivity.

Oguntunde (2018) investigated the effects of climate change on millet production in Nigeria, specifically in Kano state. Through the use of field surveys and climate modeling techniques, the research evaluated trends in millet yields in relation to temperature fluctuations and alterations in rainfall patterns. The findings revealed that rising temperatures and changes in precipitation adversely impacted millet yields, posing risks to food security and the livelihoods of rural communities.

The study underscored the necessity of adopting adaptation strategies, including the promotion of enhanced agronomic practices and the creation of climate-resilient millet varieties. It recommended that policymakers incorporate climate change adaptation strategies into agricultural policies and programs to foster sustainable millet production and bolster resilience within the agricultural sector. Anyadike (2019) examined the influence of climate variability on cowpea production in Nigeria. By employing a combination of field experiments and climate data analysis, the research explored the connection between temperature extremes, water stress, and cowpea yields. The results demonstrated that variations in temperature and precipitation had a significant impact on cowpea productivity, with extreme weather events resulting in yield reductions. The study highlighted the critical need to promote crops that are resilient to climate change.

Study Area

Taraba State consist of sixteen Local Government Areas with Ardo Kola, Lau, Jalingo, Karim Lamido, Yorro, Zing in the North, Gassol, Kurmi, Gashaka, Bali, Sardauna in the Central and Donga, Wukari, Ibi, Takum, Ussa in the south. The state is bounded in the west by Plateau and Benue states and on the east by the Cameroon. Taraba state lies largely within the tropical zone with an estimated land area of about 54,428 sq. km, the state lies roughly between latitudes 6Â°25'N and 9Â°30'N and between longitudes 9Â°30'E and 11Â°45'E.

It is bordered on the west by Gombe and Plateau States and by Adamawa State to the northeast. It also shares its south western boundary with Benue State and on the east is Republic of Cameroun. The major occupation of the people of Taraba State is agriculture. They produce cash crops such as coffee, tea, groundnuts and cotton (Umar, et al, 2014). Other crops produced are maize, rice, sorghum, millet cassava and yam in commercial quantity. Poultry, rabbit breeding, pig farming, cattle, sheep and goats are reared in large numbers.

Other occupational activities such as pottery, cloth weaving, dyeing, mat-making, carving, embroidery and blacksmithing are also carried out in various parts of the State (Online Nigeria, Community Portal of Nigeria, 2003).The climate is suitable for agriculture. It is characterised by two distinct seasons (dry and wet). The wet season usually starts from April to end in October while the dry season is from November to March. April is the hottest month of the year with a mean maximum temperature of about

28oC. The average yearly rainfall is about 1,350 mm. The mean monthly hours of sunshine is highest in December and lowest in August. The mean relative humidity is highest in August and lowest in February (TED, 1992).

Material and Methods

Methods

The research was carried out in Tarabaa State, located in the northeastern region of Nigeria. A multi-stage sampling method was employed to select crop farmers for this investigation. The initial stage involved a deliberate selection of three local government areas, each corresponding to a senatorial zone within the state.

The chosen local government areas include Donga in the southern zone, Gassol in the central zone, and Zing in the northern zone. These local governments were selected due to their significant role in crop production within the state. The second stage consisted of a targeted sampling of one predominant crop-producing village from each of the selected local government areas. In the third stage, a list of crop farmers was obtained from the Taraba Agricultural and Rural Development Authority (TARDA) for the identified villages. Subsequently, a simple random sampling technique was utilised to select a representative sample of 280 respondents from a total population of 457 identified crop farmers.

The sample size (n = 280) was determined using the Raosoft online sample size calculator, as referenced in Mason et al. (2018) and Orifah et al. (2020), with a 5% margin of error and a 95% confidence interval. Bowley's proportion allocation formula (Bowley, 1926) was then applied to establish the sample proportion from each of the selected villages. Primary data were collected for the study using a validated questionnaire, and the data were analysed using SPSS software (version 20). Descriptive statistics, including frequency, percentage, mean, and standard deviation, were employed for data analysis.

Results and Discussion

Table 1: Socio-demographic characteristics of the respondents

Sex	Frequency	Percentage
Male	235	83.9
Female	45	16.7
Age		
≤ 20	17	6.1
20-39	95	33.9
40-59	127	45.4
60 and above	41	14.6
Educational level		
No Formal Education	38	13.6
Primary	97	34.6
Secondary	101	36.7
Tertiary	44	15.7
Household Size		
Less than 11	43	15.4
11 – 20	121	43.2
21 – 30	85	30.4
31 – 40	31	11.1

Source: Author's field survey

The information in Table 1 indicated the dominance of males (83.9%) in crop production in the area. The majority (42.9%) of crop farmers are between 40 and 59 years old. Most (36.7%) of the crop farmers have a secondary education. The majority (43.2%) of respondents have a family size of between 11 and 20 persons.

Table 2: Awareness of Climate Change

Awareness	Frequency	Percentage
Aware of the climate change		
Yes	236	84.3
No	44	15.7
Observed climatic changes		
Yes	210	75.1
No	70	24.9
Experienced the effect of climate change		
Long ago	197	70.4
Not long ago	83	29.6

Source: Author's field survey

Information in Table 2 reveals that about 84.3% of crop farmers understood what was meant by climate change and also 75.1% observed variations in their environment as a result of climate change. Most respondents (70.4%) had observed and experienced the effect of climate change long ago. Another 29.6% had observed and experienced the effects of climate change not long ago. Thus, it can be concluded that crop farmers in the study area are aware and understand what is meant by climate change and equally experienced the effects associated with climate change.

Table 3: Impact of Climate Change on Food Production in Taraba State

SN	Variables	Frequency	Percentage
1	Due to unfavorable weather conditions, such as high temperatures, farmers have experienced a reduction in crop yields and the emergence of new pests.	201	71.8
2	Due to climate change, the area has experienced a long dry spell session of rainfall in the area	272	97.1
3	Extreme weather such as thunderstorms and heavy wind has led to crop failure in many areas	178	63.6
4	Due to climate change, there are occasional shifting of seasonal rainfall patterns and severe precipitation events	255	91.1
5	The clime changes phenomena increased flooding which led to the destruction of food crops	267	95.4
6	Climate change has resulted in decreases in the crop rotation period, planting and harvesting of plants.	213	76.1
7	Climate change has effects on soil water balance which leads to changes in soil evaporation and plant transpiration which affects crop production	193	68.9
8	It shortened the crop growth period which decreased the crop's yields	188	67.1
9	Changes in temperatures and precipitation patterns have led to changes in the length of growing seasons in the area thereby affecting food production	214	67.4
TOTAL		**280**	**100**

Source: Author's field survey

The analysis in Table 3 presents the findings of this research on the impact of climate change on crop production in Taraba State. The result indicates that the majority (97.1%) of the respondents agreed that due to climate change, the area has experienced a long dry spell session of rainfall which significantly impacted food production negatively in the area. Another significant number (95.4%) of them agreed that the climate change phenomena increased flooding which led to the destruction of food crops across the State. 91.1 % of respondents sampled, indicated that the occasional shifting of seasonal rainfall patterns and severe precipitation events due to climate change has rendered crop production difficult in the area, which invariably affected the food security of the area.

A large number (76.1%) of the respondents have agreed that climate change has resulted in decreases in the crop rotation period, planting and harvesting of plants in the area. Similarly, another significant number (68.9 %), (67.1 %) and (67.4%) of the respondents agreed that climate change has effects on soil water balance which leads to changes in soil evaporation and plant transpiration which affects crop production; It shortened the crop growth period which decreased the crop's yields and changes in temperatures and precipitation patterns have led to changes in the length of growing seasons in the area thereby affecting food production respectively.

Discussion of Findings

The socio-demographic characteristics of the respondents were investigated in the study area and the results are presented in Table 1. The findings revealed the dominance of males (83.9%) in crop production in the area. This agrees with Adesehinwa, et. al. (2014) who reported 70% dominance of males in their study on socio-economic characteristics of ruminant crop production farmers. Most livestock farmers ages have been reported to be between 40-50 years (Ajala and Gefu, 2019; Verbeek, et. al., 2007).

The majority of the crop farmers had secondary education. The majority of respondents had a family size of between 11-20 persons. The study found that most of the crop farmers understood what was meant by climate change and also observed variations in their environment as a result of climate change. The study found that most respondents had observed and experienced the effect of climate change long ago. This also implies that crop farmers in the study area are aware and understand what is meant by climate change and equally experienced the effects associated with climate change. This finding aligns with the idea that awareness is a crucial factor in climate change adaptation (Alem et al., 2017). Farmers who are aware of climate change are more likely to recognise its impact on their farming practices and food security. The analysis in Table 3 presents the findings of this research on the impact of climate change on crop production in Taraba State.

The result found that due to climate change, the area has experienced a long dry spell session of rainfall which significantly impacted food production in the area. It was also found that climate change phenomena increased flooding which led to the destruction of food crops across the State. The finding revealed that the occasional shifting of seasonal rainfall patterns and severe precipitation events due to climate change has

rendered crop production difficult in the area, which invariably affected the food security of the area. This finding was in line with the finding of Jones and Thornton (2019) who reported that the impact of climate change has threatened food security for many households in developing countries

Conclusion

This paper has revealed that climate change is a very serious enemy to agricultural activities in the study area and Nigeria as a whole. Even in the temperate zone where it has been discovered that climate change will elongate the crops' growing season, it would only last for a while, but in the long- -term, crops and animals likewise aquatic creatures would be badly injured. The impact of climate change is severe in the study area due to the over-dependence on rain-fed agriculture which does not encourage the commercialisation of agriculture.

Agricultural production is usually restricted in Nigeria by extreme weather conditions such as drought, desertification and flooding among others. Based on this paper, recommend measures to combat the adverse effect of climate change on agricultural production in the area which includes but not limited to proper education, sensitisation and enlightenment on early warning signs, climate-Smart Agriculture, crop diversification, drought-resistant crops, drip irrigation system, water-smart crop choice, government policy initiative, community-based adaptation, training, continuous education and awareness programmes for farmers to enhance their understanding of climate change and its impacts on food security, to mention but the list continues.

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