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IMPACT OF CLIMATE CHANGE ON FOOD SECURITY AMONG SMALLHOLDER FARMERS IN TARABA STATE: A REVIEW

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ABSTRACT

Climate change refers to any variation in climate over time, weather due to natural variability or as a result of human activities. Climate change and variability is a major threat to food security in many parts of Taraba State and the country which are largely dependent on rain fed and labour-intensive agricultural production. This work is therefore poised to examine the effects of climate change on food security among smallholder farmers in Taraba State, Nigeria. Presently, Taraba state and Nigeria as a whole are experiencing one form of problem or the other that are climate change related. Common occurrences in most part of Taraba are, flood disaster, late onset of rains and early cessation of rainfall, increasing temperature, reduced river flow, declining water table, loss of some plants and animal species and outbreak of some climate related diseases such as malaria, meningitis etc., which affects human lives and livelihoods. Presently, Taraba state and Nigeria as a whole are experiencing one form of problem or the other that are climate change related. Common occurrences in most part of Taraba are, flood disaster, late onset of rains and early cessation of rainfall, increasing temperature, reduced river flow, declining water table, loss of some plants and animal species and outbreak of some climate related diseases such as malaria, meningitis etc., which affects human lives and livelihoods. The review work shows that the relationship between food insecurity and climate change extreme events in Taraba State is highly significant. There is an increasing trend in the mean annual temperature and rainfall data in the state from 1983 – 2012. Sustainable agricultural intensification, climate smart agriculture (CSA) and policies and actions that addresses vulnerabilities and risks of climate change and promote agricultural system that are resilient and sustainable were recommended as measures to mitigate climate change weather extreme events and food insecurity in the State.

Keywords: Climate change; agriculture; vulnerabilities; Sustainable; smallholder farmers

INTRODUCTION

Climate change and variability is a major threat to food security in many parts of Taraba State and the country which are largely dependent on rain fed and labor-intensive agricultural production (Ahmed *et al*., 2016). Climate change refers to any variation in climate over time, weather due to natural variability or as a result of human activities (IPCC, 2001a; 2001b). Climate change and agriculture are interrelated processes, both of which takes place on a global scale. The main climate elements in agriculture are temperature, moisture, sunlight, wind and evaporation. Warming of the climate system is unequivocal as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising sea level consequently leads to increased rainfall and increased rainfall would lead to frequent flood and drought resulting in variability in crop yields in different ecological systems. Climate change in the form of higher temperatures, reduced rainfall and increased rainfall variability, reduces crop yields, reduces net farm revenues and threatens food security in low income-based economies including African countries (Achike, 2014).

Evidence has shown that climate change is already affecting crop yields in many countries. This is particularly true in low-income countries where climate is primarily determinant of agricultural productivity and adaptive capacities are low. (Apata, 2010). Eighty-five percent of Nigerian agriculture is rain fed, and many crops are sensitive to tiny shifts in rainfall and temperature. Available evidence shows that Nigeria (Taraba State) is already being plagued with diverse ecological problems which have been directly linked to the on-going climate change. The Southern ecological zone of Nigeria largely known for high rainfall is currently confronted by irregularity in the rainfall pattern, while the Northern zone faces the threat of desert encroachment at a very fast rate per year occasioned by fast reduction in the amount of surface water, flora and fauna resources on land (Bello *et al,* 2013). All of these occur as production of staples like maize and yam is already stagnant. Productivity per hectare is low by commercial standards. With nearly 70% of Nigeria's population dependent on agriculture and the sector contributing nearly 40% of the country's GDP, Nigeria remains vulnerable to climate variability and long-term climate change. A decline in rain fed agriculture could be as high as 50% in some parts of Nigeria, (Ahmed *et al*, 2016).

Food security is an essential element of overall wellbeing. Increasingly, in the last decade, attention has been focused on means of eliminating food insecurity and hunger worldwide. The idea of food security was presented for the first time in the World Food Conference in 1974 and viewed solely from the perspective of having adequate availability of food on a national scale. Today it is a condition in which all people have access at all times to enough food of an adequate nutritional quality for a healthy and active life (Adebayo, 2010). FOA's vision of a world without hunger is one which most people are able by themselves to obtain the food they need for an active and healthy life and where social safety nets ensure that those who lack resources will get enough to eat" (FOA, 2007). Agriculture is the main source of food, industrial raw materials in Nigeria. It is predominantly a rain fed system and hence vulnerable to climate changes (Ibrahim *et al.,* 2010). This work is therefore poised to examine the effects of climate change on food security in Taraba State, Nigeria.

2. TARABA STATE AND CLIMATE CHANGE.

Taraba state is located at the North eastern part of Nigeria. It lies between 6^o25\` and $9^o30$\` North and between longitude 9^o30\` and $11^o45$\` East of the Greenwich Meridian. The State shares boundaries with Bauchi and Gombe States in the North, Adamawa State in the east and Cameroon Republic in the south. The State is bounded along its western side by Plateau, Nassarawa and Benue States (Terlumum *et al*, 2023). The major occupation of the people of Taraba State is Agriculture. Cash crops produced in the State include coffee, tea, groundnuts and cotton. Crops such as maize, rice, sorghum, millet, cassava, and yam are also produced in commercial quantity (Ahmed *et al*, 2016).

Presently, Taraba State and Nigeria as a whole are experiencing one form of problem or the other that are climate change related. Common occurrences in most part of Taraba are, flood disaster, late onset of rains and early cessation of rainfall, increasing temperature, reduced river flow, declining water table, loss of some plants and animal species and outbreak of some climate related diseases such as malaria, meningitis etc., which affects human lives and livelihoods (Oruonye, 2011). FEWS NET (2011), predicted increase in rainfall that will lead to flood in the north east zone of Nigeria which will affect crop production. Taraba State has experienced so many cases of environmental disaster that can be linked to climate change. A case of eight hours' heavy rain on 7th August 2005 that caused a flood, which led to the collapse of the Jalingo bridge, displacing 50,000 people from their homes and killing over 100 people. Another flood washed away Tella bridge on the federal high way in September 2011 which is the shortest route that connects the North eastern states to other parts of the country through Jalingo, the Taraba State capital. This led to untold hardship for the people of north east, by, restricting the movement of goods to and from other States of the Federation. Gashaka bridge that connects Saduana local government to other part of the state also collapsed in the same month of September, this is a pointer to the existence of climate change crises (Chinweoke and Patience, 2017).

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There is urgent need for a better understanding of the changing climate pattern and how they affect extreme weather events. With this initiative, Taraba State was the second State in Nigeria to implement Reduction of Deforestation and Land Degradation (REDD) after Cross River State. Notwithstanding the environmental degradation ravaging the world today, Taraba State still has large amount of standing natural forests that have been maintained and preserved over the years. As part of its intervention strategies aimed at mitigating the adverse effects of climate change in the northern part of the country, the Nigerian Conservation Foundation in partnership with the Canadian International Development Agency, has commenced activities towards the implementation of emission reduction through REDD in Taraba State (NEXT, 2011).

Response to climate change extreme events in Taraba State.

The household food insecurity access status (HFIAS) indicator was adapted and used in ascertaining the prevalence of food insecurity in the state (Table 1). HFIAS 1 – high/marginal food security, HFIAS 2 - low food security, and HFIAS 3 - very low food security.

Household food security status varies in terms of the socio-economic status of households as reported in Table 2. Food insecurity prevalence was high among females headed households, having a greater proportion of them in HFIAS 3 than their male colleagues, although the difference between the food security of the female- and male headed households was statistically insignificant. This result corresponds to the findings of Battersby (2011) that food insecurity for male or female headed households may not be statistically different.

Table 1: Description of the three HFIAS categories

HFIAS 1n=32	HFIAS 2n= 95	HFIAS 3 n=282
Category 1 and 2 (High food security and Marginal food insecurity) - this group is made up of households with little/no problem or anxiety most of the time in accessing adequate food. Their food intake quantity, quality, and variety are not significantly reduced.	Category 3 (Low food security) – the quality, variety, and desirability of the food taken by these households are significantly disrupted, but the quantity and eating pattern of their meals are not significantly disrupted .	Category 4 (Very low food security) – the eating pattern of one or more household members are disrupted at times during the survey period. Also, the quantity of their food is reduced due to lack of resources or money for food.

Adapted from United States Department of Agriculture 2014; United Nations 2014.

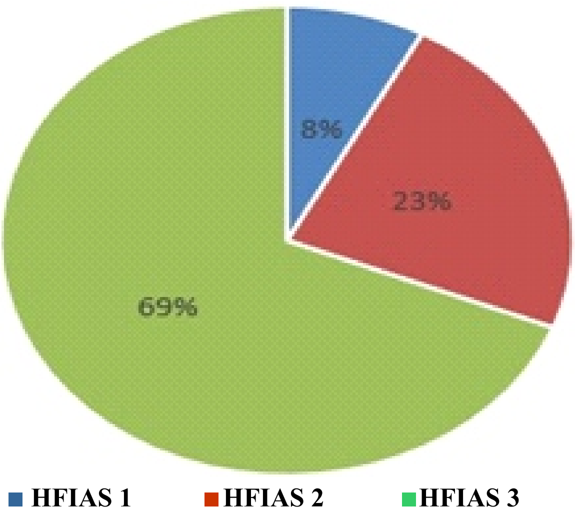

Figure 1: The distribution of household base on food security status in Taraba State.
Source: Chinweoke and Patience (2017)

The result presented in figure 1 shows that greater proportion of the households (69%) in Taraba state had very low food insecurity status. According to household food insecurity access status (HFIAS) analysis. Only 8% of the respondent could be considered food secure or marginally food secure. This result shows that there is high level of food insecurity in Taraba State.

Food Security Status of Farming Households in Taraba State (Southern Taraba)

The frequency distribution of the food security index of rural cassava farmers in Southern Taraba is presented in Table 2. Out of 160 respondents, only 20.63% met the criteria of being food secure. The remaining 79.38% were therefore considered to be food insecure households. In accordance to the 2006 United States Department of Agriculture (USDA) classification by ranges of severity of food insecurity, food insecure households were classified into three groups namely; mildly food insecure, moderately food insecure and severely food insecure which represents 25.63%, 41.25% and 12.5% respectively. This result implies a high level of food insecurity which suggests the detrimental effect of flooding or drought on the livelihood of respondents in Taraba State Ahmed *et al*, (2016).

Table 2: Food Security Index of Farming Households

Food Security Index	Frequency	Percentage
Food secure (0)	33	20.63
Mildly food insecure (-1)	41	25.63
Moderately food insecure (-2)	66	41.25
Severely food insecure (-3)	20	12.5
Total	160	100

Source: Ahmed et al. (2016)

2.3 Trends of Temperature and Rainfall in Taraba South

Temperature data from Ibi Meteorological Station between 1983 and 2012 showed an increasing trend with a trend coefficient of 0.025^{0}C per year (Table 3). Annual mean temperature in Southern Taraba state rose by 0.025^{0}C per unit change in time (Figure 2). The trend analysis results revealed an increasing trend in mean annual temperature in the region. The increasing trend in temperature is a reflection of the global warming resulting into general increase in earth's temperature. Consequently, crops were smothered by excessive heat thereby reducing food production in Taraba state Ahmed *et al,* (2016).

Rainfall record from Ibi Meteorological Station, between 1983–2012 is presented in Table 3. Annual mean rainfall in the Southern part of Taraba State rose by 0.129mm per unit change in time (Figure 2). This revealed an increasing trend with the positive value of the trend coefficient of rainfall in the region. The positive trend in mean annual rainfall might be due to the topography of the region. Taraba State's topography is largely made up of undulating plains and rising hills. Mountains have a strong influence on the atmosphere: they alter the flow of air and respond to solar radiation differently than the surrounding atmosphere. Consequently, in mountainous environments, precipitation is enhanced in some regions and decreased in others. The persistent increase in rainfall in this region exposes it to risk of frequent flooding Ahmed *et al,* (2016).

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Trends of Temperature and Rainfall in Taraba South

Table 3: Trends of Temperature and Rainfall

	Temperature (^{0}C)	**Rainfall (mm)**
Mean	33.67	104.7
Maximum Value	34.48	129.02
Minimum Value	32.94	47
Standard Deviation	0.42	18.75
Coefficient	0.025	0.129

Source: NIMET, (2015).

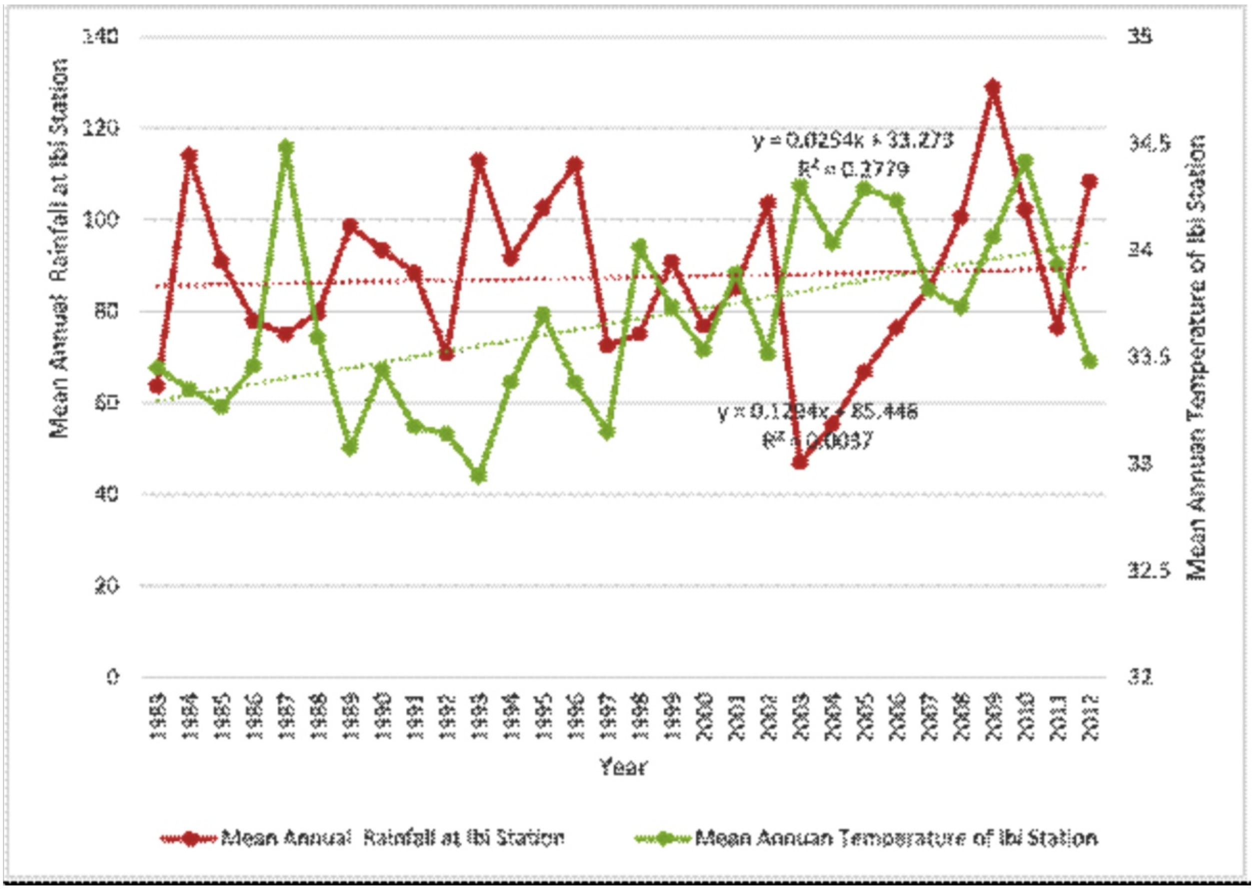

Figure 2: Trends of Temperature and Rainfall in the Southern Part of Taraba State
Source: Ibi Meteorological Station

2.4 The Implications of Climate Change on Farm Yields in Taraba State

Pearson correlation coefficient was used to determine the relationship between yield, temperature and rainfall. The results are presented in Table 4. The correlation analysis showed that there was a significant positive relationship between yield and temperature with (r= 0.56) which implied that as temperature increased the yields of cassava produced also increased in the region. The result of the correlation matrix between rainfall and cassava yields also exhibited a positive and significant relationship with (r=0.65) implying that as rainfall increases cassava yields increased as well in the region. The review work, however, noted that the right temperature and rainfall will boost production of food crops which ultimately improves food security status. The effect of flooding or drought is a setback to agricultural production which is a reflection of the food insecurity level in Taraba State.

Contrary to the *a priori* expectation, cassava yields were expected to decrease as temperature increased. Study has shown that cassava grows best in areas with a mean temperature of 25^0C–29^0C and a soil temperature of about 30^0C, below 10^0C the plant stops growing. Judging from the trend of temperature above, the Southern part of Taraba State, exhibited a maximum annual mean temperature of 31^0C and a minimum annual mean temperature of 30.8^0C. This shows that the temperature in the area is greater than the mean temperature required to grow cassava. Studies have shown that cassava can withstand periods of drought (FAO, 2013). Although the crop can withstand periods of drought, but the increasing trend of temperature may cause the crops to be smothered by heat. Figure 3 revealed that cassava yields were increasing with the prevailing level of temperature in the Southern Taraba. Temperature might not be the only reason for the changes in the growth of cassava yields, but it is definitely one of the factors affecting the growth of cassava in the area. Increase in temperature can cause dry spells. If a long dry spell occurs, the seedlings die (false start) and the farmers are compelled to replant. This can lead to a shorter growing season due to replanting or late onset and/or early cessation of the rains. This will consequently lead to increased spending on cassava stalks in other to meet production levels. Once production levels are not met, food availability decreases and this in turn affects the food security status of rural households.

Table 4: Correlation Matrix between Cassava yields, Temperature and Rainfall

	Yields	Temperature	Rainfall
Yields	1.00		
Temperature	0.5637***	1.0	
Rainfall	0.6521 ***	0.1217	
			1.00

Note: *** = significant at 1%
Source: Computer Generated Analysis, 2015.

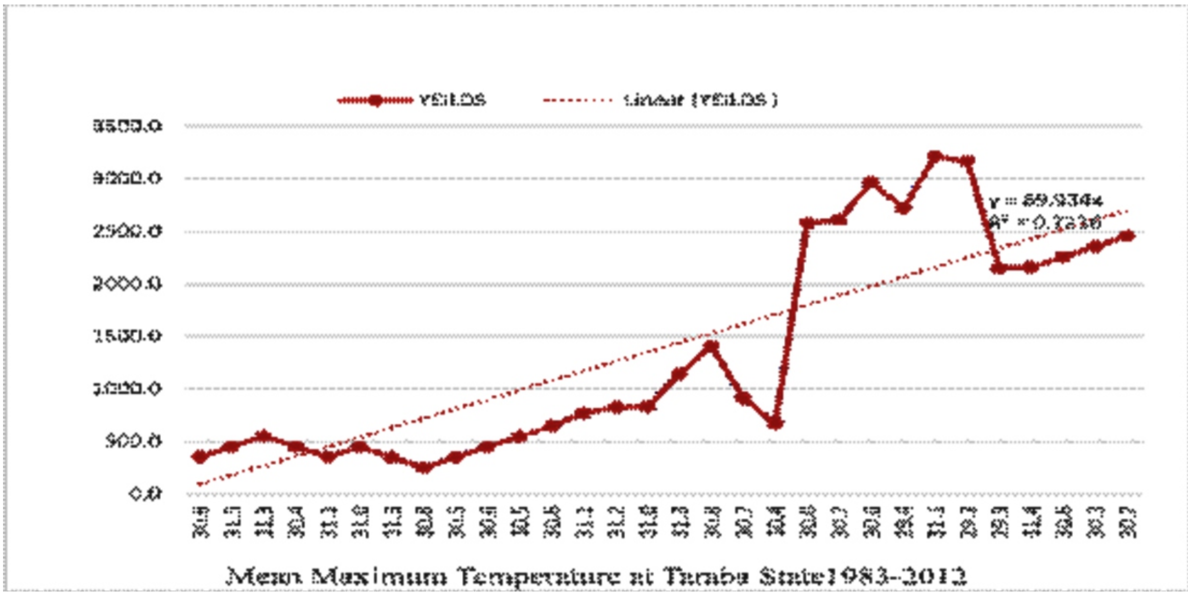

Figure 3: Line Graph Showing Relationship between Cassava Yields and Temperature in Taraba State from 1983 - 2012

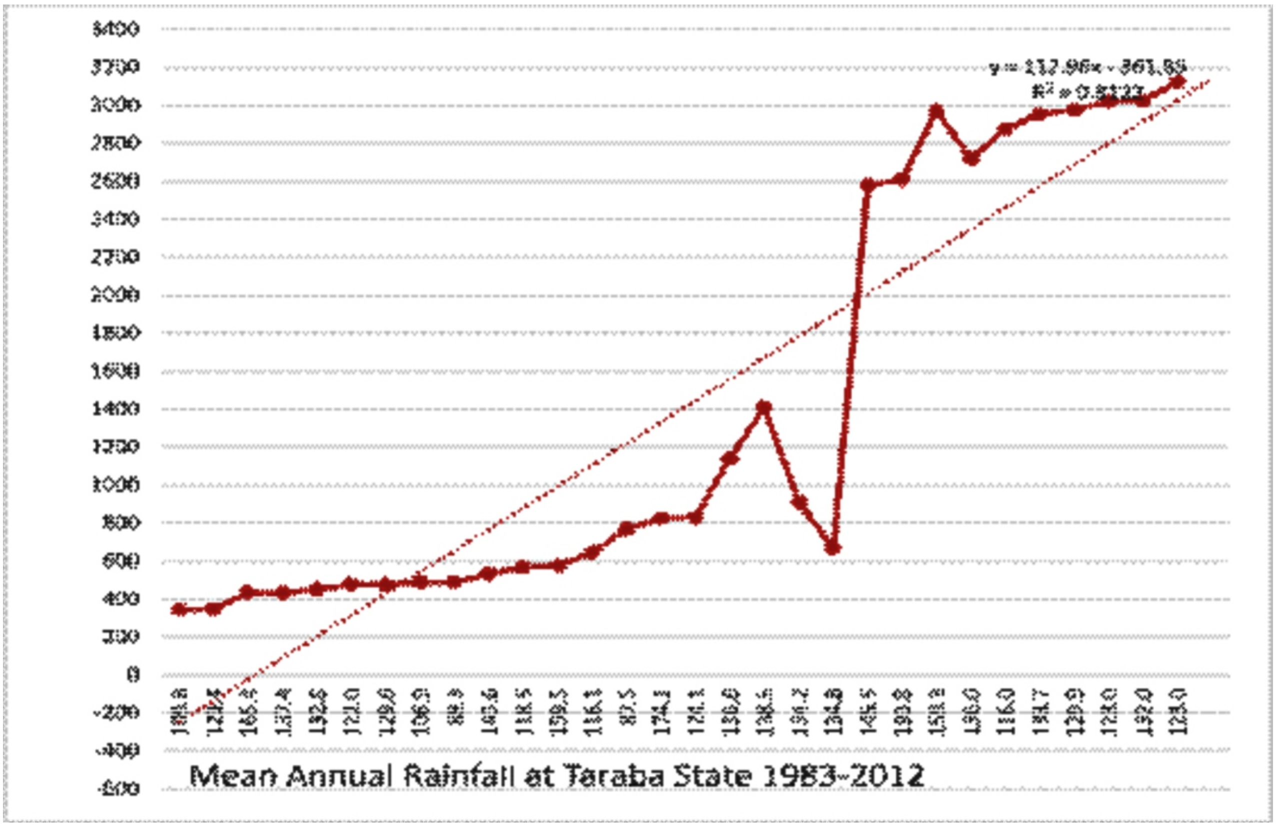

Figure 4: Line Graph showing Relationship between Cassava Yields and Rainfall in Taraba State from 1983 – 2012

As *a priori* expected, cassava yields were expected to increase as rainfall increases. Cassava can grow in areas that receive just 400mm of average annual rainfall but much higher yields can be obtained with higher levels of water supply (FAO, 2013). Table 4 showed that Taraba South had a mean annual rainfall of about 104.0mm. This is more than enough rainfall needed for cassava growth in the area. Crops generally require certain amount of rainfall during growth periods for maximum yield and when this becomes excessive it leads to flooding which in turn leads to poor harvest if at all. Fig 4 showed that production of cassava is increasing even with the prevailing amount of rainfall. But the increasing trend of rainfall inevitably leads to flooding of the area, which is caused by the release of excess water from Lagdo dam in the Republic of Cameroon and aided by the presence of the River Benue passing through some of the communities in Southern Taraba. Although cassava can withstand periods of drought, it is very sensitive to soil water deficit during the first three months after planting. Water stress at any time in that early period reduces significantly the growth of roots, and impairs subsequent development of the storage roots. (FAO, 2013).
Taraba State has suffered from periodical extreme climate events, manifested in the form of frequent flooding (Oruonye, 2012; Oruonye 2014). Those any change in climate mostly manifested as an increase in frequency and severity of extreme weather events such as flood, has a potential to significantly reduce agricultural production and household food security. It should be noted that climate is not the single determinant of yield, nor is the physical environment the only decisive factor in shaping food security, but climate change would severely compromise agricultural production and access to food (IPCC, 2001a).

Temperature and Precipitation Variability

An analysis of meteorological data from Ibi Station (1983–2012) reveals significant climatic shifts with profound agricultural implications. The documented annual temperature increase of 0.025°C (NIMET, 2015) has altered crop phenology, particularly for temperature-sensitive staples such as maize (*Zea mays*) and cassava (*Manihot esculenta*). Concurrently, rainfall has increased at a rate of 0.129 mm per year, but this change manifests as more intense precipitation events rather than consistent gains, creating paradoxical water stress conditions. These modified precipitation patterns have led to an increased frequency of dry spells during critical crop growth stages, more intense rainfall events causing soil erosion (averaging 35–40 tons/ha/yr), and disrupted planting calendars, with 72% of farmers reporting delayed seasons (Taraba Agricultural Development Project, 2018). The combined effects of rising temperatures and erratic rainfall have reduced cassava yields by 18–22% and maize productivity by 25–30% across the state's major agroecological zones. According to Household Food Insecurity Access Scale (HFIAS) data, 69% of farming households now experience 'very low food security' (Category 3), marking a 23% increase from baseline measurements (Chinweoke and Patience).

Emerging phytosanitary challenges

Climate variability has created favorable conditions for the proliferation of pests and diseases, leading to emerging phytosanitary challenges. Key impacts include the expansion of cassava mosaic virus (CMV) incidence, which rose from 35% to 58% of fields between 2010 and 2018, as well as increased whitefly (*Bemisia tabaci*) vector populations due to warmer nighttime temperatures. Additionally, new generations of maize stem borer (*Busseola fusca*) are now emerging per cropping cycle, compounding pressure on staple crops. Aflatoxin contamination in stored groundnuts has also increased by 40%, further threatening food safety and marketability. According to Legg et al. (2014), CMV-affected cassava systems experience yield losses of 30–50%, with complete crop failure occurring in 12% of cases during extreme drought years.

Gender-differentiated impacts

Climate shocks disproportionately affect female agricultural producers due to structural inequalities, revealing clear gender-differentiated impacts. Only 28% of women farmers have access to formal credit, compared to 52% of male farmers, limiting their ability to invest in resilience measures. Additionally, adoption rates of climate-smart technologies—such as drought-resistant crop varieties and micro-irrigation—are 35% lower among women-headed households, further exacerbating their vulnerability. Time poverty also severely restricts adaptive capacity, as women spend an estimated 4–6 hours daily on water collection during droughts (Njuki *et al*, 2014). These compounded constraints reduce the average farm productivity of women by 25–30% compared to male-managed plots under similar climatic conditions, deepening socioeconomic disparities in climate-affected agricultural systems.

Market disruptions and food price volatility

Climate extremes have significantly destabilized local and regional food systems through multiple pathways, including a 40-60% reduction in marketable surplus during flood years and transportation disruptions that increase post-harvest losses to 35-45%. These shocks have triggered extreme seasonal price fluctuations, exceeding 300% for staples like maize (Bryan et al., 2013). For instance, the 2012 floods caused a 78% surge in cassava prices and a 65% increase in maize prices across Taraba's major markets, with these elevated prices persisting for 9-12 months post-event.

An assessment of adaptive capacity reveals that current coping strategies remain largely reactive rather than transformative. Approximately 62% of farmers resort to distress sales of livestock during climate shocks, while 45% adopt harmful consumption smoothing strategies like reducing meal frequency or portion sizes. Notably, only 18% of farmers utilize formal insurance mechanisms, highlighting a critical gap in proactive risk management and long-term resilience building Reuben & Samuel, (2025).

Climate change and food insecurity mitigation in Taraba State

"Agriculture is probably the most climate dependent human activity and is both victim and responsible for climate change, while it can also be a solution to the climate change crisis". In this context, sustainable agricultural intensification is presented as a win-win strategy to combine food security and climate change mitigation (Ayantunde *et al*., 2020; Descheemaeker *et al*., 2016; van Loon *et al*., 2019). However, referring to cereal cropping in Sub Saharan Africa van Loon et al. (2019) conclude that while "intensification scenarios are clearly superior to expansion scenarios in terms of climate change mitigation. "Intensification will come, depending on the nutrient use efficiency achieved, with large increases in nutrient inputs and associated GHG emissions. Many scholars highlighted the benefits of climate-smart agriculture (CSA) (Abegunde *et al*., 2019; García de Jalón *et al*., 2017) both for climate change mitigation and adaptation. Loboguerrero et al. (2019) argue that "Climate-smart agriculture can help foster synergies between productivity, adaptation, and mitigation". In this context, FAO (2016) suggests that "Food and agriculture must be central to global efforts to adapt to climate change, through policies and actions that address vulnerabilities and risks and promote agricultural systems that are resilient and sustainable.

Climate-smart agricultural interventions

1. **Agroecological Approaches:** The integration of agroforestry systems with drought-resistant crop varieties has demonstrated measurable improvements in agricultural resilience. Zougmoré et al. (2018) documented that intercropping maize (Zea mays) with nitrogen-fixing Gliricidia sepium increased soil moisture retention by 18-22% while boosting yields by 30-35% compared to monoculture systems. This symbiotic relationship enhances both hydrological cycling and nutrient availability through improved organic matter decomposition rates.
2. **Adoption constraints:** Despite proven efficacy, significant barriers impede widespread Climate-Smart Agriculture (CSA) adoption among smallholder farmers in Taraba State. Aryal et al. (2020) identified two primary constraints: (1) prohibitive initial investment costs exceeding 40% of average seasonal income, and (2) inadequate extension service coverage, with only 1 agricultural officer per 5,000 farming households. These structural limitations create an adoption gap particularly acute among resource-poor farmers managing <2 hectare plots.
3. **Indigenous adaptation strategies:** Farmers have developed empirically-based coping mechanisms to address rainfall variability. Comparative studies in analogous East African agroecologies (Bryan *et al*., 2013) reveal three effective indigenous practices such as community seed banking preserving 15-20 landrace varieties, phased planting schedules spanning 4-6 week windows and micro-catchment water harvesting techniques.
4. **Policy implementation challenges:** While Taraba participates in the Reducing Emissions from Deforestation and Forest Degradation (REDD+) program, institutional analyses (Ebele & Emodi, 2016) highlight systemic governance deficiencies such as inconsistent enforcement of sustainable land use policies, limited benefit-sharing mechanisms for participating communities and monitoring, Reporting and Verification (MRV) capacity gaps.

CONCLUSION

The review work shows that the relationship between food insecurity and climate change extreme events in Taraba State is highly significant. There is an increasing trend in the mean annual temperature and rainfall data in the state from 1983 – 2012. This increasing trend in the mean annual temperature in the state is an indication of global warming occurring in the state, which consequently lead to crop smothering by excessive heat and reduction of food production in the State. The persistent increase in rainfall in the State also exposes the

State to frequent flooding. There was more climate change affected households (more than three times the non - affected ones) in Taraba State (Southern Taraba) and they had very low food security status. Sustainable agricultural intensification, climate smart agriculture (CSA) and policies and actions that addresses vulnerabilities and risks of climate change and promote agricultural system that are resilient and sustainable were recommended as measures to mitigate climate change weather extreme events and food insecurity in the State.

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