

Climate Change Anomalies and its Prospects on Agriculture in Cross Rivers State, Nigeria

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Abstract: The changes that occurred in the climate systems have become a global challenge. Climate change has impacted on different sectors including agriculture and this calls for urgent attention as food security is of great importance to the economy of a nation and its challenges and prospects differ from different geographical locations. Therefore, this work examined the monthly, annual and decadal distribution, pattern, trends, anomalies of rainfall and temperature in Cross River State, Nigeria. The rainfall and temperature data were obtained from Nigerian Meteorological Agency (NIMET) for a period of 30 years (1997-2016). The measure of dispersion, trend, anomalies was used to analyze the work and results showed the highest monthly mean rainfall was in July with 491.97mm and lowest rainfall was in December with 33.84mm and no august-break was recorded while mean temperature is 28.7°C, the anomalies for rainfall and temperature trend fluctuated greatly with a positive trend. Findings in this study showed that temperature and rainfall are on the increase and such rise in rainfall can result to flooding which can affect agriculture. The study recommends a proper climate monitoring system for farmers to practice early dry season planting to ensure a profitable agricultural practice for food sustainability.

Keywords: Climate Change, Temperature, Rainfall, Agriculture, Cross River State

I. INTRODUCTION

Climate change is a current issue that is affecting all the nations of the world. It has become one of the most discussed and researched topics because of its visible impact on different sectors of the economy such as agriculture, health, transportation etc. Agricultural sector is very important in the Nigeria economy and the world; consequently, the change occurring in the climate pattern is a threat to the development of agriculture (Chikezie *et al.*, 2015; IPCC, 2007). Climate change in IPCC usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean or the variability of its properties which persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC 2007). Climate change happens in different ways, ranging from increased climate variability and gradual changes in temperature and precipitation, to increased frequency and intensity of extreme events. The concept of climate change is inevitably resulting

in changes in climate variability and in the frequency, intensity, spatial extent, duration and timing of extreme weather and climate events (IPCC, 2014). The climate system is continually changing due to the interactions between the components as well as external factors such as volcanic eruptions or solar variations and human-induced factors such as changes to the atmosphere and changes in land use. Changes in the climate systems are caused by two factors: namely through the natural processes and through anthropogenic actions. Furthermore, there is the opinion that internal changes to the climate system such as variations in ocean currents or atmospheric circulation which is the natural process, can also result in climate variability or change (National Research Council., 2010). The warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen (IPCC, 2014). The observed changes and causes are due to human influence on the climate system. Recent anthropogenic emissions of greenhouse gases are the highest in history and recent climate changes have had widespread impacts on human and natural systems (IPCC, 2014).

Agriculture is vulnerable to harsh weather conditions and climatic activities; in as much as we have improved seedlings and irrigation support systems, climate and weather still remain the main causal factor for agricultural production and sustainability. In the tropical environment where rain-fed agriculture is predominant, the onset and cessation of the rains ascertain the cultural practices of farmers, such as land preparation, crop variety selection and planting to harvesting (Odekunle, 2004; Umar, 2010). However, high rainfall and temperature with extreme weather conditions such as drought, flooding can affect or prevent crops from growing, and thereby reduce crop production (IPCC 2007). Trend, anomalies in rainfall and temperatures could be both positive and negative for rainfall, the positive anomalies indicate wetter than normal rainfall which can result to flooding while the negative anomalies are indicators of drier than normal rainfall which can result to drought and in temperature we have different periods of warming and cooling phases. NIMET (2016) shows that climate change threatens our ability to ensure global food security, eradicate poverty and

achieve sustainable development. Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. The Food and Agriculture Organization (FAO) of the UN has warned that hunger in Africa is being made worse by the impacts of climate change. Climate change is already beginning to transform life on earth. In Nigeria and indeed all over the globe, seasons are shifting, temperatures are rising, landscapes are changing and sea levels are soaring. Among the consequences of climate change impacts on agriculture are that, it could potentially interrupt progress in the economy of a nation; also a hungry population is a volatile population. In Nigeria the change in pattern of extreme high or low rainfall are very important for agriculture as well as the economy of a nation (Igwenagu, 2015) most especially in the southern Nigeria where agriculture is dependent on rain.

II. MATERIALS AND METHOD

Location

Cross River state derives its name from the Cross River which passes through the State. It is a coastal state located in the Niger Delta region, and occupies 20,156 square kilometers. It shares boundaries with Benue state to the north, Ebonyi and Abia states in the west, in the east by Cameroon Republic and to the south by Akwa Ibom and the Atlantic Ocean.

The secondary data were the monthly rainfall and temperature of Calabar in Cross River state of south-eastern Nigeria for a period of 30 years (1987-2016) which was collected from the Federal Meteorological Services Oshodi in Lagos State. The monthly rainfall and temperature data collected were further converted to annual values. The monthly, annual, rainfall and temperature averages, anomalies, trends obtained were used to determine the general pattern and characteristics of rainfall and temperature in the study area.

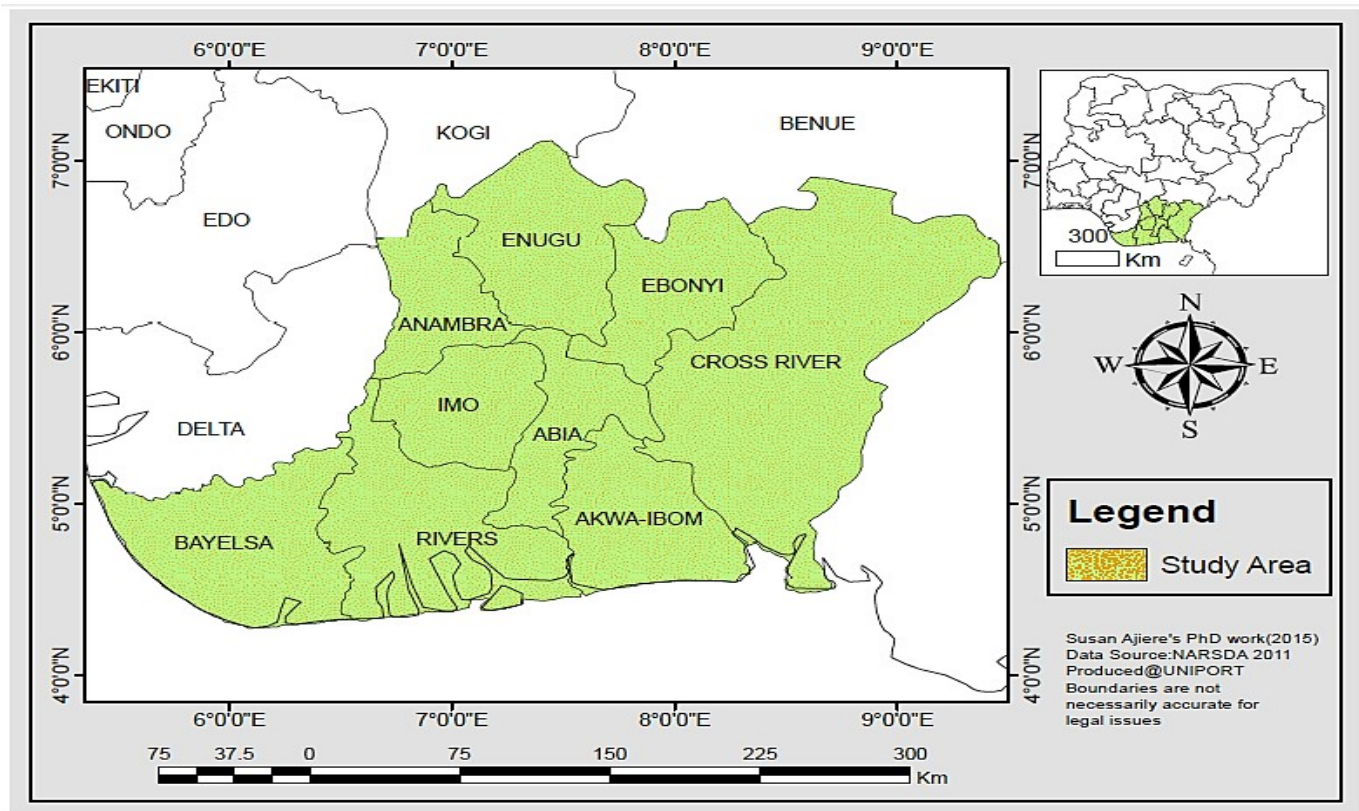


Figure 1. South Eastern Nigeria showing Cross River State

III. RESULTS AND DISCUSSION

This study examines the distribution of rainfall and temperature in Cross River state. This shows the basic properties of all the variables in this study, the mean monthly and annual rainfall totals, mean temperature, minimum, maximum temperature for the period of study from 1987 to 2016.

The Mean monthly rainfall (Table 1) shows a general change in the seasonal rainfall regime, the month with the highest rainfall in Cross River state was July with mean of 491.97mm while the months with the lowest rainfall was December with mean of 33.84mm. Also, the known August break was not observed in August but recorded a very high amount of rainfall. Thus, it was observed that June, July, August and September experienced heavy rainfall.

Table 1: Mean Monthly Rainfall for Cross River State of South Eastern Nigeria (1987-2016)

MONTHS	RAINFALL (mm)
January	35.88
February	62.37
March	172.92
April	238.45
May	302.89
June	416.23
July	491.97

August	449.05
September	390.98
October	307.94
November	171.11
December	33.84

The mean monthly maximum temperature across in Table 2, showed that the month with the highest maximum temperature in Cross River state was February with mean temperature of 33.55°C, while the lowest maximum temperature in was 28.07°C in august. The results reveal that the highest temperature was at the peak of the dry season in February.

Table 2: Mean Monthly Maximum Temperature in Cross River State of South Eastern Nigeria (1987-2016)

State	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Lowest	Highest
Cross river	32.28	33.55	32.74	31.90	31.24	29.91	28.67	28.07	29.00	29.86	31.04	31.82	28.07 (Aug)	33.55 (Feb)

The mean monthly minimum temperature (Table 3) showed that the month of March in Cross River state had 23.91°C, while the month with the lowest value of minimum temperature was July with mean of 22.56°C. It can be noted

that temperature was increased in the period. This result further reveals that Cross River state experienced its lowest minimum temperature in July and coincidentally that was also when it experienced its highest rainfall.

Table 4 Mean Monthly Minimum Temperature in Cross River State of South Eastern Nigeria (1987-2016)

State	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Lowest	Highest
Cross River	22.68	23.91	23.91	23.63	23.34	23.07	22.56	22.81	22.85	22.85	23.14	23.01	22.56 (July)	23.91 (mar)

The mean monthly temperature (Table 5) showed that February in Cross River state had temperature of 28.73°C while the month with the lowest mean temperature was

August with mean of 25.44°C. The result showed an increased temperature in the state.

Table 5. Mean Monthly Temperature in Cross River State of South Eastern Nigeria (1987-2016)

State	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Lowest	Highest
Cross river	27.48	28.73	28.33	27.76	27.29	26.49	25.61	25.44	25.92	26.36	27.09	27.42	25.44 (Aug)	28.73 (Feb)

The annual rainfall total for the period of study as in Table 6 showed that the years with the highest rainfall total in Cross River state were 2012 and 2016 with 4044.9mm and 3862.1mm respectively. While the years with the lowest

rainfall total were 2004 and 2015 with records of 2324.5mm and 2324.5mm. The results showed that there were changes in the rainfall pattern and there was an increased rainfall in the state.

Table 6. Annual Rainfall Total in Cross River State of South Eastern Nigeria (1987-2016)

State	Annual highest Rainfall (mm)	Annual Lowest Rainfall (mm)
Cross River	2012, /4044.9mm	2004 / 2324.5mm
	2016/ 3862.1mm	2015 /2324

The trend of rainfall total for Cross River state (Figure 2) showed that rainfall fluctuated greatly with an increasing upward positive trend and the highest rainfall was recorded in

2012 with 4044.9mm values. The lowest rainfall was recorded in 2004 and 2015 with 2324.5mm values. The trend line showed that rainfall was on the increase in this state.

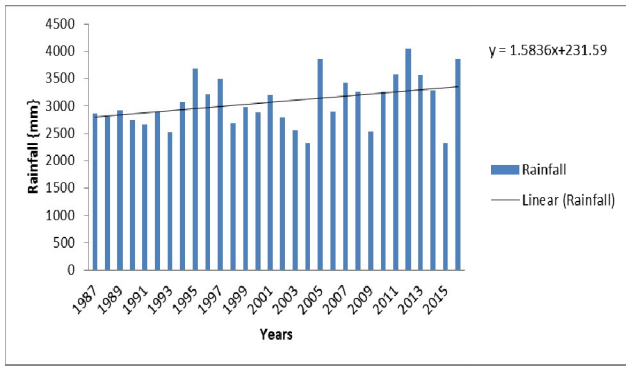


Figure 2 Annual Rainfall Total Trend of Cross River State

In Cross River state the maximum temperature trend analysis (Figure 3) showed that it fluctuated greatly and showed an increased upward trend with highest maximum temperature in 1998 having value of 31.5°C and lowest point in 2006 with the value of 30.1°C. Thus, 1993 to 2003 showed that for 10 years temperature rose on the increase, but in 2004 it dropped and got to the lowest in 2006 with the value of 30.1°C and started rising in 2007. It showed a positive trend which was an increased maximum temperature. However Figure 4 showed the minimum temperature with upward trend highest in 1990 having value of 23.8°C and lowest value in 1995 at 22.2°C. However, a decrease occurred in 2013 with the temperature value of 22.9°C. An increase occurred in 2014 with temperature value of 23.1°C. The year showed a positive trend which was an increased minimum temperature.

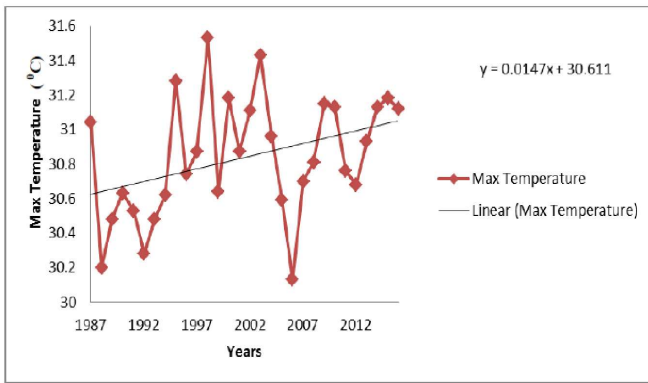


Figure 3 Annual Trend of mean maximum temperature of Cross River State

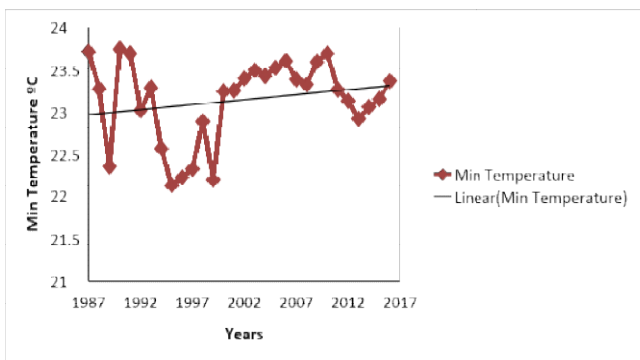


Figure 4. Annual Trend of mean minimum temperature of Cross River state

The trend analysis for mean temperature fluctuated in Figure 5 showing an increased upward trend with highest temperature value of 28.05°C in 2012 and lowest point in 1999 with the value of 26.4°C. This showed a positive trend which was an increased mean temperature.

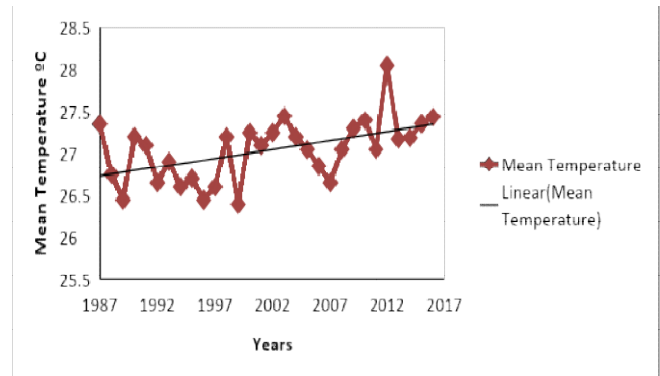


Figure 5 Annual mean temperature trend of Cross River State

Cross River state experienced some anomalies in temperature. The mean annual temperature anomalies from 1987 to 2016 as shown in Figure 6 showed that there was a persistent increase in temperature in the state since 2001 and 2002 for mean temperature. This signifies a warming climate and evidence that the mean annual temperature anomalies had been increasing with time.

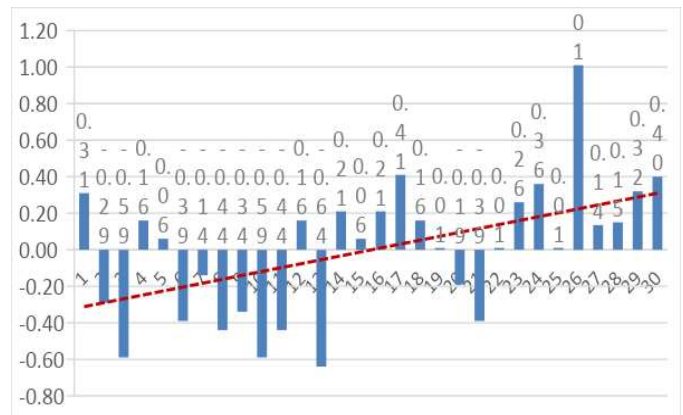


Figure 6. Anomalies of annual mean temperature over Cross River State 1987-2016

In the state, mean annual rainfall anomalies from 1987 to 2016 is depicted in Figure 6. The figure showed that both positive and negative anomalies were observed within the period of study which was consistent from 2002. The positive anomalies indicate wetter than normal rainfall which could result to flooding while the negative anomalies were indicators of drier than normal rainfall which could result to drought. The last two decades showed more positive anomalies which corresponded to the wet but flood years recorded in Nigeria while the negative anomalies correspond to the dry drought years observed in Nigeria (NIMET, 2016).

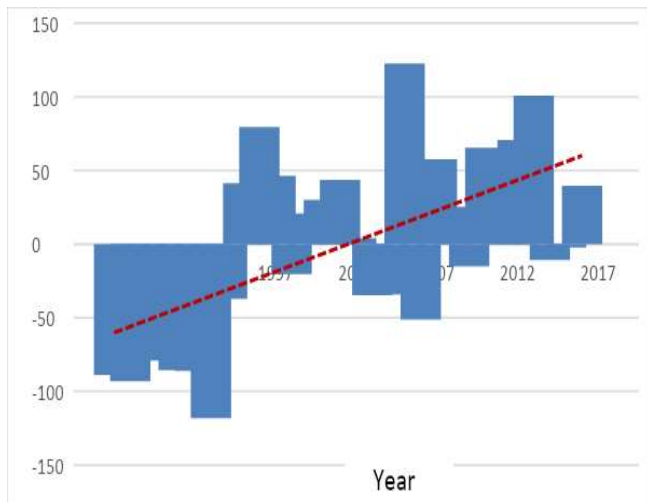


Figure 6. Anomalies of annual Mean Rainfall over Cross River State 1987-2016

IV. CONCLUSION

There are notable changes in rainfall and temperature patterns, visible fluctuations in the trend lines. Rainfall showed positive trend while minimum, maximum and mean temperature showed positive trend which means that there was increased rainfall and temperature in the period in Cross Rivers state. The Anomalies in rainfall and temperatures showed positive trend and for rainfall this could result to flooding which can affect agriculture in the state while in temperature we had different periods of warming and cooling phases. Warm climate is evidence that the mean annual temperature anomalies have been increasing with time. The high rainfall experienced in the state can be attributed to rising atmospheric temperature which have increased evapo-transpiration and consequently increased condensation precipitation. Studies have shown that the global warming has increased the water holding capacity of the atmosphere and thus the risk of more precipitation. This work has shown that there is an evidence of

climate change in Cross Rivers state and its prospects in agricultural needs serious attention. This study therefore recommends the setting up of a proper weather monitoring system and farmers should be encourage to practice early and dry season farming to ensure a profitable agricultural practice for food sustainability.

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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