



## IMPACTS OF CLIMATE CHANGE AND VARIABILITY ON CROP PRODUCTION IN OYO STATE, SOUTH-WEST, NIGERIA

<sup>1</sup>Adetayo, A. O., <sup>2</sup>Owolade, E. O., <sup>1</sup>Adeyeye, J. A., <sup>1</sup>Faloye, O. T. and <sup>3</sup>Eruola, A. O.

<sup>1</sup>Department of Water Resources Management and Agrometeorology,  
Federal University Oye-Ekiti, Nigeria.

<sup>2</sup>Federal College of Animal Health and Production Technology, P.M.B. 5029, Ibadan, Nigeria.

<sup>3</sup>Department of Water Resources Management and Agrometeorology,  
Federal University of Agriculture Abeokuta.

**Corresponding Author's Email:** wale\_agromet@yahoo.com

### ABSTRACT

The study examined the impacts of climate change and variability on crop production in Oyo State, Nigeria. A systematic random sampling technique was used in selecting 240 respondents. Data were collected through the administration of questionnaire. Meteorological data were obtained from the archives of the Nigerian Meteorological Agency (NIMET) for a period of 35 years (1990-2024). Thirty-five years data on annual agricultural production were also collected from the State Agricultural Development Project (ADP) and the Central Bank (CBN) agricultural annual survey. The results obtained from the study showed that climate change does have a significant effect on crop production in the study area, as most farmers interviewed have noticed significant changes in the climatic conditions as manifested in different forms. There are positive correlations between climatic characteristics and the yield of crops. Pearson's Product Correlation Coefficient ( $r$ ) for maize, cowpea, okro, sorghum, melon and pepper are 0.51, 0.50, 0.12, 0.30, 0.26 and 0.20 respectively at  $p \leq 0.05$ . The mean rainfall cessation, length of raining season and rainfall onset are 320.14th day, 235.31 days and 91.63th day respectively. Based on rainfall distribution pattern observed the study recommends that farmers should switch to crop varieties that would be accommodated by the present annual amount and duration of growing season.

**Key words:** Climate, Change, Variability, Crop, Production, Mitigation.

### INTRODUCTION

Climate change is defined as a difference over a period of time (with respect to a baseline or a reference period) and corresponds to a statistically significant trend of mean climate or its variability, persistent over a long period of time (Chiezey *et al*, 2016). It involves changes in the variability or average state of the atmosphere over durations ranging from decades to millions of years. Climate change is now a household word all over the world. Everyone knows that something has gone amiss with the world's weather and climate patterns. Climate variability and change have a direct, often adverse influence on the quantity and quality of agricultural production. Climate change and its implications on human existence remained a great challenge for agricultural production across the globe. Sub-Saharan Africa has been reported to be one of the most susceptible, vulnerable and most hit regions by climate change and variability (Turrall *et al*, 2021).

In Nigeria, changing rainfall patterns have been reported by researchers such as Nnaji (2011), Ulor (2016), Boko *et al.*, (2017) and Odjugo (2020). Annual decadal and inter-decadal variations in rainfall have been reported by Ulor (2016), observable reduction in precipitation in some parts of Nigeria was noticed by Boko *et al.*, (2017) while Odjugo (2020) observed a decline in rainfall amount in some other parts. Changes in the onset and cessation dates of the wet season have been recorded with more areas of the country experiencing rainfall instabilities. There are strong indications that climate change has adversely affected the agricultural system as well as the food chain in all phases of human endeavours including food security. Similar to other forms of life, the manner in which human beings respond to climate change is critical not only to survival, but also to well-being (IPCC, 2017). Climate-related risks are the major causes of human suffering, poverty and reduced opportunity, which will lead to large-scale human development reversal (Okunade and Ademiluyi, 2019).



Unfortunately, just as the climatic changes are affecting crop productivity, the steadily increasing human population has led to a rise in the demand for food, therefore, more land comes under agricultural cultivation and hence more pressure on natural ecosystem (Ajaga, 2014). IPCC (2017) observed that overall agricultural productivity could decrease during the next century, leading to hunger and malnutrition in vulnerable areas. Thus, there is a need to ensure that agriculture and agricultural practices adapt to changing climate to ensure food security for human survival. Accordingly, there is the need to gain as much information as possible, investigate the positions of rural farmers, their needs, and what they know about climate change, in order to offer adaptation practices that meet their needs. This will help to have a better understanding of the communities' perception and mitigation/adaptation strategies to changing climate. This study seeks to fill in research gaps by examining the consequences of climate change on crop production in Oyo State Nigeria.

This study is aimed at determining the effects of climate change and variability on crop production in Oyo State and suggests possible adaptation measures to adopt to the impacts and make recommendations for improvements.

## **MATERIALS AND METHODS**

### **The Study Area**

The study was carried out in Oyo State, Nigeria. Oyo State ([8°00'N; 4°00'E](#)) was created in February, 1976 out of the old Western region. Located in south-west Nigeria. The State has a population of 5,580,894 based on NPC 2006 and a land mass of 28,454 square kilometers. Agriculture is the main occupation of the people of the state. 6 out of 33 local governments of Oyo state were selected based on their classification as rural areas. Rainfall in the zone can be described as humid to sub-humid tropical with distinct dry and wet seasons. There are two rainfall peaks in June and September, with a dry spell in August (August break) which produces the bimodal rainfall pattern. The mean monthly maximum temperature ranges between 28 and 35°C, while the mean monthly minimum temperature ranges between 22.6 °C and 26.7 °C. It is characterized by minimal temperature fluctuations, usually less than 5°C throughout the year. It is referred to as iso-hyperthermic temperature regime (Ayoade, 2012). The highest mean monthly maximum temperature is recorded in the months of February and March (35°C), while the least monthly maximum temperature is about 28 °C in August for the same period. The highest mean monthly minimum temperature is about 26.7°C in March/April, while the lowest mean monthly minimum temperature is between 22.6 and 22.9°C in August/September for the same period. February and March have the highest evaporation rate, and it is as high as 6.9 mm. The least evapotranspiration rate (2.6 mm) is recorded in June/July. This pattern is directly related to the pattern of rainfall, cloud cover and atmospheric temperature. The relative humidity is relatively high throughout the year. It ranges from 64.5 % in February to 91 % in June, while the lowest values occur during the dry months (Ayoade, 2012; NIMET, 2017).

### **Sampling Techniques and Size**

The selected local government are Itesiwaju, Orire, Irepo, Ido, Egbeda and Saki east. The local governments were selected based on their classification as an agrarian communities. Systematic random sampling techniques was deployed to select the respondents to whom questionnaires were administered. A house was selected at every five houses until the required number of houses of the respondents (240) were achieved.

### **Data Collection**

Data were collected through the administration of questionnaire to the respondents selected from the study area. The survey questionnaires elicit information on the type of farming activity the farmers are engaged in, the type of crop planted and the purpose of engaging in the production of such crops, the total coverage of farmland being cultivated, the type of technology being used to carry out their farming activities, years of cultivating the land, the quantity being produced per year by each farmer and ownership of land cultivated will be obtained from farmers. Also, information will be collected on farmers perception on climate change, the perceived implication on their crop production, techniques put in place to mitigate/adapt to climate change impact, their opinion on their productivity

level over time and reason behind such opinion, means of averting shortage of food production and other information such as climatic situation at present compared with the past.

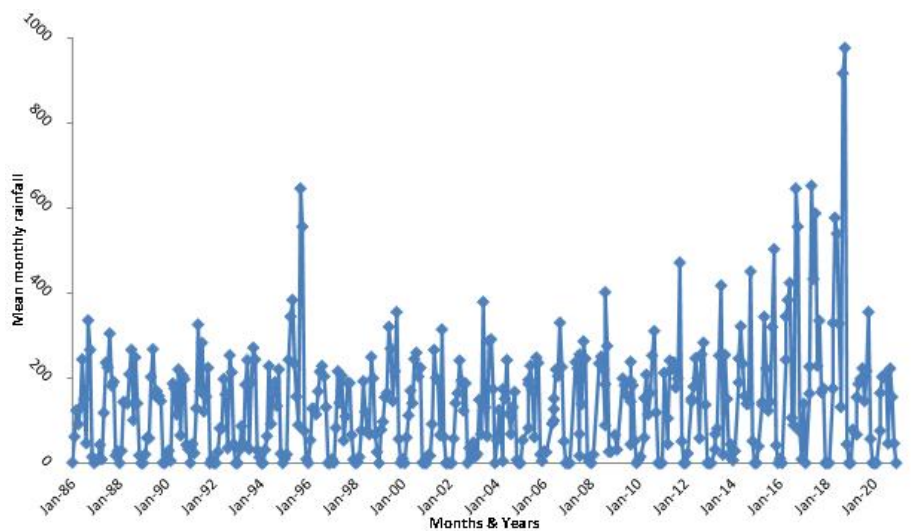
Selected meteorological data (rainfall and relative humidity) were obtained from the archives of the Nigerian Meteorological Agency (NIMET) for a period of 35 years (1986-2020). Thirty-five years data on annual agricultural production shall be collected from State Agricultural Development Project (ADP) and Central Bank (CBN) agricultural annual survey.

### Data Analysis

Descriptive and Inferential statistical analysis were carried out on the collected data. A time series plot is the determination of the data trending over time (randomness or patterned series). Time plots of the rainfall for the period of 30 years were plotted and the period of shift of the series were marked. The rainfall data for each of the sites were stratified into decadal rainfall (consisting of 10 years annual rainfall) and time plot of these decadal rainfall were plotted against the periods.

## RESULT AND DISCUSSION

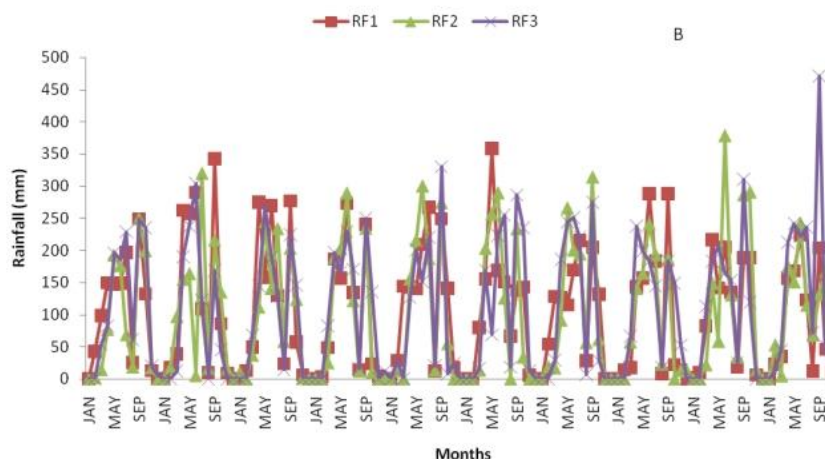
Rainfall is the most important factor in which the amount, duration and distribution pattern directly or indirectly affect the types of crops to be grown, the farming system, the growing season and other farm operations. The time series plot of Oyo State rainfall (Figure 1) showed that rainfall pattern for the site was irregular over the period of thirty-five years (1986-2020). It was shown that rainfall usually peak around June, September and with the least (0), was usually obtained around December, January and February. The irregular pattern however shifted up between February 2018 and October 2020.



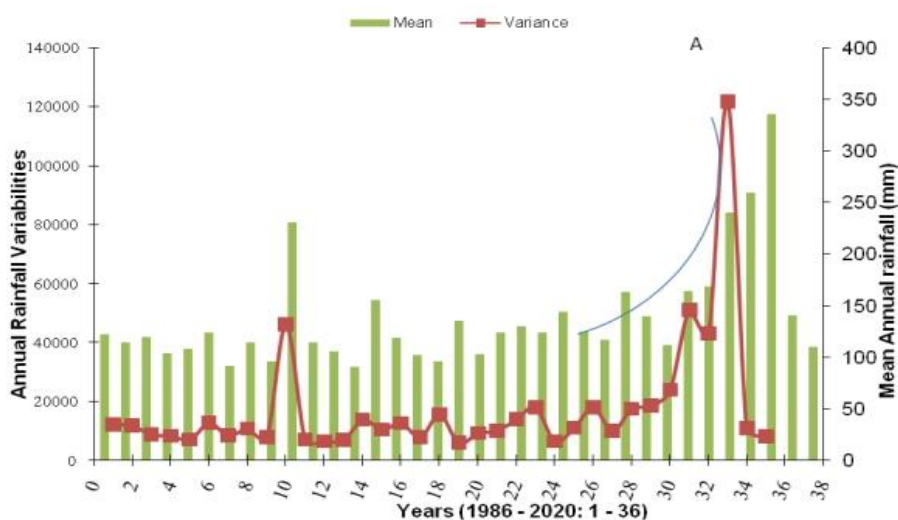
**Figure 1:** Time Plots of the Rainfall for Oyo State (1986-2020)

The decadal rainfall for Oyo State indicated a similar but cyclical pattern for the first three (3) decadal rainfalls (Figure 2). The last decadal rainfall was however different from the earlier one. This falls in line with the time series plot of the entire period where latter year period shifted up.

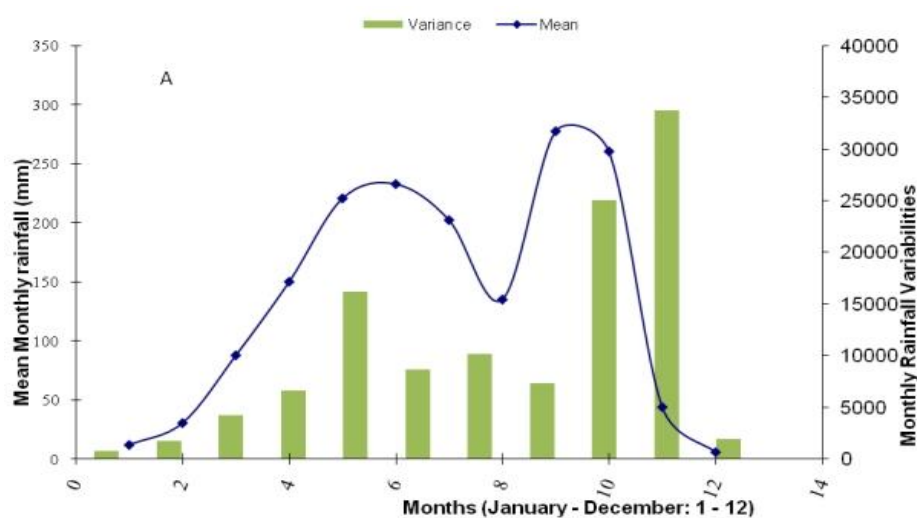
It is also important to add that no two mean annual rainfall gave the same variability (Figure 3). The mean annual rainfall also followed an irregular cyclical pattern and it ranged between 83.3mm (for 1999) and 130.36mm (2019). The variance which could be described as heteroscedastic ranged from 6,244 in 2009 to 21,530.99 in 2019. Mean monthly rainfall for Oyo State returned an irregularly increasing mean ranging from 5.289mm (December) to 277.803mm (September). Mean monthly rainfall followed an irregularly increasing trend which drops at the 6th month (June) and it (mean monthly rainfall) ranged between 83.3mm and 130.36mm. It is explicit from the mean monthly rainfall of the two sites that two rainfall peaks can be noticed in June and September (Figure 4).



**Figure 2:** 35 Years (1986-2020) Time Plots of the Decadal Rainfall Oyo State (RF1-First decade; RF2-Second decade; RF3-Third decade)



**Figure 3:** Mean Annual Rainfall and Annual Rainfall Variability for Oyo State



**Figure 4:** Mean Monthly Rainfall and Monthly Rainfall Variability for Oyo State





### **Descriptive Statistics and Stationarity Test of Rainfall Parameters**

The results of the descriptive and stationarity analysis for Oyo State rainfall indicated that mean rainfall cessation, length of raining season and rainfall onset are 320.14th day, 235.31days and 91.63th day respectively (Table 1 ). The variance does not follow the trend of the means where variance for rainfall cessation is 203.49, rainfall onset 59.66 and length of raining season 51.19. The unit root test statistics of -3.05, -2.84 and -3.49 were obtained for rainfall cessation, length of raining season and rainfall onset and were all significant ( $P < 0.05$ ). It is thus advisable to reject the null hypothesis of stationary of the data set in each of the cases.

**Table 1:** Descriptive Statistics and Stationary Test for Oyo State Rainfall Indices

	<b>Options</b>	<b>Cessation</b>	<b>Length</b>	<b>Onset</b>
<b>Stability Test</b>	Unit root Test	-3.05**	-2.84*	-3.49**
	ADF	3.07**	2.83**	3.53**
	Mean	320.14	235.31	91.63
<b>Covariance</b>	Cessation	203.49	74.73	21.25
	Length		51.19	-17.71
	Onset			59.66

The results obtained from the study of impacts of climate change on crop production shows that climate change does have significant effect on crop production in the study area as most farmers interviewed have noticed significant changes in the climatic condition as manifested in different forms. Table 2 shows socioeconomic characteristics of the respondents. Most of the respondents are male (81.7%). This shows that men are more involved in farming activities while most women are involved in post-harvest activities. The active age of farmers is between 30 and 60 years, while those below the age of 30 years are either pursuing their educational career, in politics, transportation business or petty trading. This also contributed to low agricultural production in the region as the active ages (15-30 years) developed nonchalant attitudes towards farming. Majority of the respondents are Muslim (51.3%) and are married (90%). Primary school was shown to having the highest percentage (53.3%) in terms of educational qualification of the respondents. The table also shows the primary occupation of the respondents with farming having the highest percentage (43%).



**Table 2:** Social economic characteristics of the respondents

	Frequency	Percentage
<b>Gender</b>		
Male	196	81.7
female	44	18.3
Total	240	100
<b>Age distribution (Years)</b>		
20-30	6	2.5
31-40	84	35
41-50	73	30.4
51- 60	77	32.1
Total	240	100
<b>Religion</b>		
Christian	103	42.9
Muslim	123	51.3
Traditional worshiper	14	5.8
Total	240	100
<b>Marital status distribution</b>		
Single	22	9.2
Married	216	90
Divorced	2	0.8
Total	240	100
<b>Educational level</b>		
Tertiary	42	6.7
Secondary	48	20
Primary	128	53.3
Adult education	16	17.5
Arabic education	6	2.5
Total	240	100
<b>Occupation</b>		
Farmers	104	43.3
Artisan	72	30.0
Trader	48	20.0
Unemployed	16	6.7
Students	02	0.8
Total	240	100

The perception of the respondents about climate change is as shown in table 3. Most farmers in the study area seem to have noticed significant changes in the climatic conditions and claimed such climate effects have manifested in different forms. From the list of problem encountered in the communities, temperature and rainfall differences are the foremost problems. Other problems mentioned are bad roads, ill health, pollution and insecurity. In the communities, 87.5% of the respondents have heard about climate change at a time or the other. Some refer to it as change in weather conditions at a particular time (40%), some, just weather conditions (17.5%) and others have no response. On the question ‘do you think the problem of climate change can be solved at all’, 83.3% of the respondents said yes, 12.5% said no and others, no response. Almost all (92.9%) of the respondents agreed that the problem of climate change is affecting them. How they feel the impact differs, some complained of excessive heat (20.8%), to some it is the reduction in rainfall amount received.

On mitigation strategies, many of the respondents are of the opinion that stopping air pollution (35%) is the solution, some suggested enlightenment campaign (15%), intensifying research efforts (23.3%), prayers (8.8%) and being religiously committed (3.8%). The coping strategies adopted by the respondents include, construction of drainage channels (21.7%), children staying indoors (15.8%), use of local herbs and drugs (30%), raising the level of household properties (15.8%) and 16.7% no response. 14.6% of the respondents believed climate change is the factor responsible



for their increased in body temperature. Some laments climate change to be responsible for their ill health (18.3%), some, changes in environmental conditions (17.5%), excessive heating (20.8), reduced rainfall (15%) and 1.3% laments that climate change causes environmental pollution.

**Table 3:** Response on climate change

Response	Frequent	Percentage
<b>Have you ever heard about climate change?</b>		
Yes	210	87.5
No	30	12.5
Total	240	100
<b>What do you know about climate change?</b>		
It is the weather condition	42	17.5
It is the change of weather at a particular time	96	40
No response	102	42.5
Total	240	100
<b>Do you think the problem of climate change can be solved at all?</b>		
Yes	200	83.3
No	30	12.5
No response	10	4.2
Total	240	100
<b>Do you think the problem of climate change affects you as a person?</b>		
Yes	223	92.9
No	17	7.1
Total	240	100
<b>How does the problem of climate change affect you?</b>		
Leads to hotness of the body	35	14.6
Causes ill-health	44	18.3
Leads to changing of environment	42	17.5
Excessive heating	50	20.8
It reduces the amount of rainfall	36	15
It affects human skin	12	5
It causes pollution of the environment	18	7.5
No response	03	1.3
Total	240	100
<b>How do you think an individual can help to Overcome the problem of climate change?</b>		
By prayer	21	8.8
By being religiously committed	09	3.8
By being religiously committed	36	15
Enlightenment campaign	24	10
Be prepared to face it	56	23.3
Intensify research efforts	86	35
Stop air pollution	02	0.8
Making sacrifice to the gods	08	3.3
No response	240	100
Total		
<b>Coping Strategies</b>		
Construction of drainage channels	53	21.7
Children staying indoors	38	15.8
Use of local herbs and drugs	72	30.0
Raising the level of household properties	38	15.8
No response	39	16.3
Total	240	100

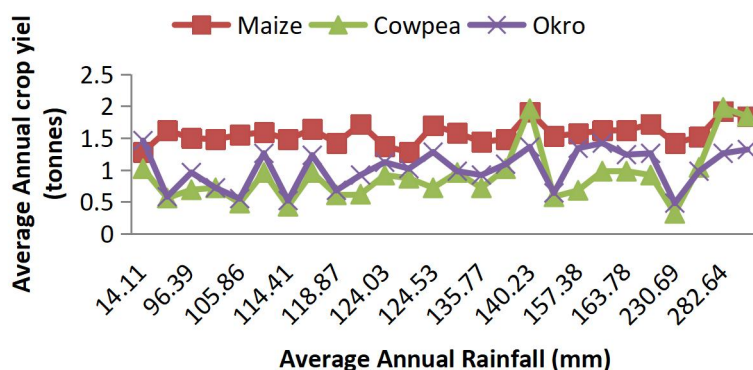
The perception of the respondents to differences in rainfall and temperature was shown in Table 4. 53.4% of the respondents perceived that rainfall has increased steadily while 36.7% viewed

rainfall to have decreased, 4.1%, no change and others are indifferent. Similar opinion about temperature variation was also noticed.

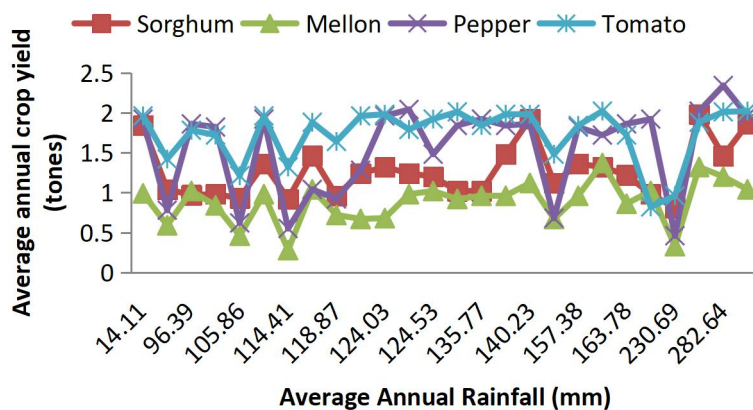
**Table 4: Perception on Rainfall and Temperature differences**

<b>Rainfall differences</b>	Frequency	Percentage
Increasing	128	53.4
Reducing	88	36.7
No change	10	4.1
Don't know	14	5.8
<b>Temperature differences</b>		
Increasing	130	54.2
Reducing	87	36.3
No change	12	5.0
Don't know	11	4.6

Figures 5 and 6 showed the relationship between the selected crops and rainfall distribution pattern in Oyo State. The climatic parameters obtained from the Nigeria Meteorological Agency (NIMET) are used to define their relationships with crop yield for twenty six years. Observation revealed that rainfall has marked variability within the period. According to the studies reported by Singh et al. (2017), drought will be on the increase due to expected warming even during growing season. This implies that there may be little opportunity to adopt longer season varieties of crops to gain back the portion of the season (and radiation capture) lost due to accelerated development.



**Figure 5: Graph of Annual Rainfall and Average Annual Maize, Cowpea and Okro Yield**



**Figure 6: Graph of Annual Rainfall and Average Annual Sorghum, Mellon, Pepper and Tomato Yield**





## CONCLUSION AND RECOMMENDATION

Understanding crop response towards projected changes in climate is required for formulating and disseminating mitigation and adaptation strategies for crop yield improvement in a water-limited environment. Although farmers may be coping with the menace, there is an urgent need for more researches on climate change especially in developing countries that are more vulnerable to the impacts. This study concludes that climate change has impacts on crop yield. There are shifts in the rainfall distribution pattern though favourable for some crops. There may be little opportunity to adopt late maturing crops. The new rainfall regime observed will warrant farmers to switch to crops that would be accommodated by the present annual amount and duration of growing season. Farmers also need more information and enlightenments on how to adapt and mitigate the effects of climate change. The results obtained from this study are of inestimable value for planning, organization and execution of farming systems. Policy makers and other stakeholders in the agricultural sectors have major roles to play in order to achieve sustainable agricultural development goals.

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