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TREND ANALYSIS OF CLIMATE PARAMETERS ACROSS THIRTY YEARS OF ARABLE CROP PRODUCTION IN OGOJA, CROSS RIVER STATE, NIGERIA.

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AUTHORS CONTRIBUTION:

1 Okang, A. O –conceived the idea and participated in writing the paper.
2 Egbai, Oruk Ohon -Framed and designed the methodology
3 Asor, Love Joseph - Conducted the laboratory analysis
4 Ambe, Benjamin Ayua –Performed field analysis
5 Diminyi, C. A – carry out statistical analysis
6 Agbor, C. E. – Did a thorough literature search..

CONFLICT OF INTEREST STATEMENT:

The authors hereby declare that there is no conflict of interest.

ABSTRACT

The study focused on trend analysis of climate parameters (Rainfall, Temperature and Relative humidity) viewed across years of crop production in the Ogoja, Cross River State, Nigeria. The purpose of the study was to examine the trend pattern of climate parameters in relation to crop production over thirty years of period. The study adopted the use of participatory research method in addition to data obtained from Nigeria meteorological Agency (NIMET) Ogoja. Hypothesis was tested using regression analysis. The result of regression analysis revealed that there is a significant relationship between climate parameters (rainfall, temperature and relative humidity) and years at 0.05 level of significance. This implies that the area experience heavy amount of rainfall from year to year, but the uncertainty in the rainfall pattern (timing and amount) at the study area influenced crop production. Temperature has significant positive relationship with time. Normally, increase in temperature should have positive impact on crop yield in the tropical or near tropical zone, because normal high temperature enhances high rates of bio-chemical reaction in plants. Therefore significant increase in temperature may result in accelerated physiological development, leading to increase yield and maturation. The study recommends the cultivation of crops with natural adjustment potentials to climate oscillations.

Key words: Climate parameters, Crop production, Food security, Trend analysis, Yield,.

1. INTRODUCTION

Climate variability may be limited to specific region or occur across the whole world. Although it is not a new phenomenon, the usage recently especially in the context of environmental policies, refers to

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changes or variability in modern or prevailing climate, particularly since the 20th century. The increase in greenhouse gas concentrations in the atmosphere has made many scientist to conclude that the temperature of the earth will increase by several degrees over the next century [1]. Some are beginning to conclude that the increase greenhouse gas by the anthropogenic effect has concentrations on global climate are already evident [2]. According to CGIAR, [3]. Climate variability may be caused by internal or external processes such as changes in solar radiation, volcanism, orbital variations, and human influences through industrial revolution, agriculture and deforestation resulting in greenhouse gas emissions. Physical evidences of climate variability can be seen from historical or archeological changes, insects and sea levels IPCC [4] reported that mean atmospheric temperature increase by 1.3^{0}c over the past century with a predicted 3.2^{0}c to 7.2^{0}c increase in the 21st century. Increasing surface temperature has been linked with lengthening of the growing season in temperate region while shortening the growing season in tropical environment with very high chances of drought [5].

Atmospheric patterns of circulation arise primarily as a consequence of heating contrasts between the poles and the equator, moderated by seasonality and because land and water absurd and release heat at different rates, resulting in a patch work of warmer and cooler regions characterized by a number of patterns of atmospheric circulation with different persistence. Based on the [6] projection, the humid tropical zone of Southern Nigeria is already too hot and too wet. It is characterized by increase in both temperature and precipitation. Already, temperature increase of about 0.2 degree to 0.3d per decade have been observed in the various ecological zone of the country, while drought persistence has characterized the Sudan-Sahel regions , particularly since the 1960s [7]. For the tropical humid zones of Nigeria, precipitation increase of about 2-3 percent for each degree of global warming may be expected [8]. Thus, it is reasonable to expect that the precipitation would probably increase by approximately 5-20 percent in the humid areas of the forest regions and southern savannah areas. The increase in temperature in these areas would also possibly increase evaporation, reducing the effectiveness of the increase in precipitation.

Projections of rainfall in the very humid regions of southern Nigeria where Cross River State belong is expected to rise. This may be accompanied by increase in cloudiness and rainfall intensity, particularly with severe storms. It could also result in shift in geographical patterns of precipitation and changes in the sustainability of the environment and management of resources. However, since the increase in temperature could increase evaporation and potential evapotranspiration, there would be tendency towards 'drought' in parts of these humid areas of the country. In fact, recent studies have shown that precipitation decrease in the humid regions of West Africa, including Southern Nigeria, since the beginning of the last century is about 10-20 percent or about 2-5 percent per decade [8]. If this trend persists, rainfall in the humid regions of Southen Nigeria may be about 50 percent to 80 percent of the 1900 values by 2100 [7] with increase in ocean temperature, however, there could be increase in the frequency of storms in the coastal zones of the country.

In contrast to the humid areas of Southern Nigeria, the savanna areas of Northern Nigeria have less rainfall has in the case of some areas in the Northern senatorial district of Cross River State, which coupled with temperature increases, would reduced soil moisture availability [7]. According to [6], the Sudan-Sahel zone of Nigeria has suffered decrease in rainfall in the range of about 30-40 percent or about 3-4 percent per decade since the beginning of the nineteenth century. Already, these savannah and semi-arid areas suffer from seasonal and inter annual climate variability, and there have been drought and effective desertification processes, particularly, since the 1960s [7]. This situation may be worsened by the expected decrease in rainfall with greater drought probabilities and more rainfall variability and unreliability. Unarguably, a number of extreme climatic events will increase in frequency and severity due to changes or variability of climate. Some of this event will have negative impact on crop yield. The impacts of climate change as it relates to agriculture are found evident in the tropical climatic condition as well as frequent natural calamities like cyclones, floods, and drought.

However, climate change exacerbates the climatic condition by causing various natural hazards. Though agriculture achieved an immense progress technologically but still, is susceptible to unfavourable climate conditions [9]. Agricultural productivity entirely depends on climatic factors such as, rainfall, temperature, relative humidity and others. The agricultural sector becomes more vulnerable to climate variability as the climatic factors are changing and it seems that in the near future they will be more erratic [9]. Increase temperature, changing rainfall patterns and sea level rise, coupled with increased flooding, frequent cyclones, rising salinity in coastal belts and recurrent drought in the Northern part of Nigeria and the study area are likely to reduce crop yields and crop production. An IPCC estimation showed that rice and wheat production would be declined by 8 and 32 percent, respectively by 32 percent by 2050 (against the base year of 1990) in Bangladesh [10]. This is not different from the situation in the study area.

Understanding meteorological conditions is essential to any agricultural work and in particular with livestock industry. Apart from the rainfall and temperature factors, wind velocity and relative humidity also affects livestock has it affect crop production [11]. While natural variability continues to play a key role in weather, climate change has shifted the odds and changed the natural limits, making certain types of extreme weather more frequent and more intense[12]. The kinds of weather events that would be expected to occur more often in a warming world are indeed increasing. Due to chaotic nature of the atmosphere, the massive computational power is required to predict and forecast atmospheric processes [13].Weather forecast systems are among the most complex equation. A great quantity of data from satellites through ground stations and sectors located around our planet send daily information and they are used to foresee the weather situation in next hours and days all around the world [14].

Climate variability is affecting the temperatures, as well as rainfall patterns in the densely populated regions that would have enormous significance for livelihood and well-being of the people of the region. It will have environmental and social impacts that will likely increase uncertainty in water supplies and agricultural production for people across .The cascading effects of rising temperatures are already affecting water availability, biodiversity, ecosystem boundaries, and global feedbacks [15]. Normally, global warming should have positive impacts on crop yield in the tropical areas because higher temperature means higher rates of chemical reaction. High temperatures may result in accelerated physiological development, leading to hastened maturation and reduced yield [16]. There is no doubt that in tropical regions, increased temperatures may accelerate the rate at which plants release carbon dioxide in the process of gaseous exchange, underminding optimal conditions for net growth. When temperatures exceed the optimal for biological processes, crops often respond negatively with a steep drop in net growth and yield [7]. If night-time temperature minima rise more than a day-time maxima – as is expected from greenhouse warming projections – heat stress during the day may be less severe than otherwise, but increased night time respiration may also reduce potential yields. In middle and higher latitudes, the projections are for a general increase in agricultural productivity with global warming [17]**.** For one thing the growing season may be extended as a result of earlier onset of spring and a delayed arrival of winter. Crops could be planted earlier in spring and harvested later in autumn. There is thus two or more cropping cycles during the same season. Also agricultural land could be extended to areas formerly considered too cold for agriculture and the

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various agricultural belts could be extended towards the Polar Regions. The relatively poorer soils at the higher latitudes in Russia, Europe and North America may impose limits on such expansion [7].

Water demand and water supply to crop plants will be modified to the detriment of crop yield as global warming progresses. [18] and Egbai et al [19] emphasized the use of resilient crops that withstand adverse soil condition. With the same level of perceptible rainfall, a higher temperature will reduce the relative humidity and increase the sink strength of the atmosphere. As a consequence, more rainfall will be withdrawn from the soil through evaporation and less water will be available to be absorbed by crop plants [7]. According to him, higher atmospheric sink strength will also increase the rate at which water passes through the crop plants from the hair roots to the leaf surfaces. In much healthy plant, water is pulled through tubular columns by the tension created by evaporation at the leaf surface [17]. It is this water that keeps the living cells turgid, a condition required for optimum functioning. The amount of water and the rate it passes through the plants is determined by the evaporative power of the atmosphere, which can be enhanced by a higher atmospheric temperature [7]. The problems of trend of climate parameters such as rainfall, temperature and relative humidity which is related to crop yield can cause uncertainties of the farming seasons, that can lead to unusual sequence, for example crop planting and replanting which can result in food shortage due to harvest failure [20]. Extreme weather and climate events such as droughts, flood, thunderstorm and heavy winds, devastate farmlands and soil quality, which can also lead to crop failure .Pest and disease migrate in responds to climate variability [21]. Oko et al [22] adduced that extreme weather perturbation can lead to adverse effect on land cover due to formation of rill erosion channel in the tropics.

2. STUDY AREA

The study area includes Yala Local Government Area, Bekwara Local Government, Obanliku Local Government, Ogoja Local Government and Obudu Local Government Area, all of North-East zone of Cross River State, South-south Nigeria. It is bounded in the North by Benue State, bounded in the West by Ebonyi State, bounded in the East by the Republic of Cameroon and bounded in the South by Ikom and Boki Local Government Area of Cross River State. Fig. (1 and 2). The area is located between longitude 8^{0} 17^{c} E and 9^{0} 30” E and latitude $6^{0}15^{c}$ N and 6^{0} 51 N.

The population density of North-East zone of Cross River State is approximately 789, 774 from 2006 census with land mass of about 4994km. There are ten political wards in four local government and thirteen political wards in one local government which made a total of 53 political wards in the five local government area of the North-East zone of Cross River State. Many languages spoken in many communities in the five local government area of the study. Soil in zone differs in their physical –chemical characteristics. The soil varies from brown, brownish yellow to yellowish red and the texture varies from sandy loam to sandy clay to clay sub-soil. The soil pH ranges from 5.0 and below with low cation exchange capacity less than 10mcg/100g [23] the soil mention above are commonly found in Bekwara, Yala, Ogoja and part of Obudu. The mountain soils of Obudu as [24] explain has 40 to 98 percent sand, 10 to 26 percent silt and 10 to 44 percent clay. The pH of the soil ranging from 4:52 to 5:93 are acidic and can be used for tree crops cultivation or forest species [24] The type of crops found in the study area are both tree and arable crops. The tree crops found there are: cocoa, oil palm, coffee, bush mango, kolanut, cashew, guava, moringa, grape, citrus and almond etc. while arable crops are; yam, cassava, rice maize, groundnut, banana, plantain, soya beans, cocoyam, pineapple, pumpkin, melon and okra etc. others are livestock, cattle rearing, fishing and wildlife such as monkey, rabbits, chimpanzee, birds and snakes etc [23].

ISSN- 2394-5125 VOL 10, ISSUE 06, 2023

Climate information of major climatic element such as temperature and rainfall states that temperature in the North-East Cross River State varies from 22.25^0c to $28^0.32^0$ during the year 1986 to 2015 while rainfall varies from 1251.40mm to 3347.30mm during the year 1986 to 2015. Which also lead to the variability of daily and monthly raining and dry season in the study area. Topography/drainage of the study area includes mountains with attitudes of 1300 – 1400m in Obudu and Obanliku local government areas. Bekwara, Ogoja and Yala local government areas has lowland with small areas with undulating land with elevation of 150 – 300m. the are many river formation taking their source from Obudu river, Obudu ranch water fall, Abatepa river and Ikangbanga river [23].

3. METHODOLOGY

The study was carried out in the North-East zone of Cross river State which involved five local government out of eighteen local government of the state. The five local government include Yala local government, Bekwara local government, Obanliku local government, Obudu local government and Ogoja local government. Table of random numbers were adopted to selected two communities from each local government used for field observation and supplemented for details using the participatory observations provided more background information on climatic parameter in temperature, rainfall and relative humidity and years in the North-East zone of Cross River State. Data on rainfall, temperature and relative humidity were obtained annually for the period of 30 years from Nigeria metrological station (NiMet Ogoja).

Data for this study were based on the analysis using both descriptive and inferential statistics. The inferential statistics were the time series analysis.

4. RESULTS AND DISCUSSION

Table 1: Data on climatic parameters for the North-East (Ogoja) Agricultural Zone of Cross River State from 1986 – 2015

Years	Temp O.C	RH %	Rainfall MM
1986	27.49	75.00	1516.50
1987	22.25	75.00	1445.70
1988	27.53	75.00	1581.20
1989	27.15	70.00	2197.60
1990	23.35	72.00	1506.50
1991	27.79	74.00	1948.10
1992	27.37	70.00	1594.60
1993	26.92	71.00	1597.00
1994	25.57	69.00	1435.80
1995	27.91	70.00	2180.70
1996	28.05	75.00	1441.50
1997	27.28	69.00	2239.80
1998	20.34	69.00	2150.40
1999	24.85	75.00	1698.10
2000	26.57	66.00	1712.70
2001	26.88	70.00	1251.40
2002	27.70	70.00	2220.10
2003	28.08	73.00	1815.80

ISSN- 2394-5125 VOL 10, ISSUE 06, 2023

2004	28.12	72.00	1513.90
2005	28.23	73.00	1781.50
2006	28.13	73.00	1816.30
2007	27.78	72.00	23.73.10
2008	27.75	67.00	2355.00
2009	27.96	75.00	2737.90
2010	28.29	74.00	2398.70
2011	27.76	73.00	2640.20
2012	27.99	75.00	3347.30
2013	27.78	75.00	2669.40
2014	28.18	74.00	2038.00
2015	28.32	72.00	1868.10

Source: Nigeria Metrological station (NIMET) Ogoja.

Hypothesis

Ho: There is no significant variation in climatic parameters (rainfall, temperature and relative humidity) and years (1986 – 2015) in the North – East Agricultural Zone of Cross River State.

H1: There is a significant variation in climatic parameters (rainfall, temperature and relative humidity) and years (1986 – 2015) in the North – East Agricultural Zone of Cross River State.

Table 2 shows the model summary of the linear regression for rainfall, where r = 0.599 and table 3 indicates that b = 33.06 and a = -64164.76. This shows that the strength in the time series is approximately 0.60 in the positive direction. The rate of this change is indicated by the slope of the regression (b) = 33.06 as shown in Fig. 2

From table 3, t = 3.962, $p < 0.05$. Hence, the trend is significant. This means that there is a significant trend in the time series. The trend equation is therefore given as: Rainfall = 64164.76 + 33.06 years.

This means that, given a unit increase in years, rainfall increases by 33.06 units.

Table 2:Regression model summary for the relationship between rainfall and year

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.599[a]	.359	.336	395.57943

a. Predictors: (Constant), Years

Table 3: Coefficients for the relationship between rainfall and year

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-64164.763	16692.695		-3.844	.001
	Years	33.059	8.344	.599	3.962	.000

a. Dependent variable: Rainfall

Table 4 shows the model summary of the linear regression for temperature, where r = 0.433 and table 5 indicates that b = 0.09 and a = 160.31. This shows that the strength in the time series is approximately 0.43 in the positive direction. The rate of this change is indicated by the slope of the regression (b) = 0.09 as shown in Fig. 3

From table 5, t = 2.541, p = 0.017. Hence, the trend is significant. This means that there is a significant trend in the time series. The trend equation is therefore given as:

Temperature = -160.31 + 0.09 years

This means that, given a unit increase in years, temperature increases by 0.09 units.

Table 4: Regression model summary for the relationship between temperature and year

Model	R	R. Square	Adjusted R Square	Std. Error of the Estimate
1	.433[a]	.187	.158	1.74684

a. Predictors: (Constant), Years

Table 5: Coefficients for the relationship between temperature and year

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
1. (Constant)	-160.306	73.713		-2.175	.038
Years	.094	.037	.433	2.541	.017

a. Dependent Variable: Temperature

Table 6 shows the model summary of the linear regression relative humidity, where r = 0.10 and table 7, indicate that b = 0.03 and a = 13.798. This shows that the strength in the time series is approximately 0.87 in the positive direction. The rate of this change is indicated by the slope of the regression (b) = 0.03 as shown in Fig.4

Hence, Table 7, t = 0.524, p > 0.05, the trend is not significant. This means that there is no significant trend in the time series.

Table 6:Regression model summary for the relationship between relative humidity and year

Model	R	R. Square	Adjusted R Square	Std. Error of the Estimate
1	.0.99[a]	.010	-.026	2.63758

a. Predictors: (Constant), Years

ISSN- 2394-5125 VOL 10, ISSUE 06, 2023

Table 7: Coefficients for the relationship between humidity and year

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-64164.763	16692.695		-3.844	.001
	Years	33.059	8.344	.599	3.962	.000

a. Dependent Variable: Relative humidity

The discussion of findings captures the data result based on the hhypothesis of the study. The hypothesis state that there is a significant variation in climatic parameters (rainfall, temperature and relative humidity) and year (1986 – 2015) in the North-East Agricultural Zone of Cross River State. Statistical record of rainfall in the North-East Agricultural Zone of Cross River state of Nigeria between 1986 – 2015 shows both decreasing and increasing trend with the highest and lowest amount of rainfall records (Table 1).

The highest amount of rainfall recorded between 1986 – 1995 is in 1989 and 1995 with (2197.60mm and 2180.70mm) while the lowest is indicated in 1982 and 1994 with (1445mm and 1436.80mm) has indicated in the trend. Between 1996 – 2005, the highest rainfall recorded is in 1997 and 2002 with the record of (2239.80mm and 1251.40mm) accordingly. Between 2006 – 2015, the highest amount of rainfall is recorded in 2012 and 2013 with the records of (3347.30mm and 1868.10mm) respectively. Annual mean volume of rainfall in the study area was relatively high as compared to the lowest amount of rainfall between period of years, this is because the location of the zone is close to the tropical zone of central cross river state and the type of vegetation found in the area is montane forest/grassland-d and derive savannah which you can still experience high amount of rainfall [25] The regression between rainfall and year as indicated by the slope of regression with 64164.76 + 33.06 years which shows that there is significant trend in variation in the amount of rainfall from year to year in the study area. This implies that the area experienced heavy amount of rainfall from year to year, but the uncertainty in the rainfall pattern (timing and amount) at the study area affect crop yield, has the study revealed through the farmers and the researcher. Agidi etal [25] predicted that climate variability will pose serious threat to food security. This is because agriculture especially crop yield at the study area is highly dependent on rain, therefore changes in pattern of rainfall have greatly affected crop yield in communities of the. The intermittent dry spell during farming season also contributes to the loss of some farm produce at-- the study area. This is because farmers who plant after the first or second rain may run at huge loss because the rains might be delayed beyond the expected period and this will result by the crops being scotched by the heat of the sun causing economic loss. More so, majority of the respondent posit that before this time farmers use to predict the time for wet season and they know precisely when to plant their crops. Presently, many farmers cannot predict the amount and time for wet season again because of the extent of changes in climate. The severe crop failure and loss of yields due to false start of the rains, frequ-ent intervening dry spells during the growing seasons, early cessation of rains thereby curtailing the growing season in the area.

Data on tem--perature from 1986 – 2015 shows an increase and decrease trend. Trend betwe-en 1986 – 2000 indicates that 1996 recorded (28.05^0 and 1997 recorded ($27.\text{-}91^0$c) as the highest temperature while the lowest recorded (22.25^0c) in 1987 an-d (20.34^0c). in 1998 respectively. While between 2001 and 2015

ISSN- 2394-5125 VOL 10, ISSUE 06, 2023

the data record-ed the highest temperature in 2015 with (28.32^{0}c) and the lowest temperature in- 2001 with (26.88^{0}c) and 2002 with (27.70^{0}c) .

The coefficient --of correlations of temperature and time is – 64164.76 and is statistically significant, implying that temperature has significant positive relationship with time. Normally, increase in temperature should have positive impact on crop yield in the tropical zone or near tropical zone, because high temperature enhances high rates of bio-chemical reaction in plants. Therefore, the significant increase in temperature may result in accelerated physiological development, leading to hastened decrease yield and maturation. [16] reported that increase temperature may accelerate the rate at which plant releases carbon dioxide in the process of respiration, resulting in less than optimum conditions for net growth. When temperature exceed the optimal for biological processes steep drop in net growth and yield [7]. The most important climatic element determining the occurrence and localization pest and disease appear to be temperature. In general, pests and disease vectors do better when the temperature is high under optimum water supply conditions [7].

Higher temperature is therefore likely to extend the range of distribution of certain pest and disease of crops. The gains expected from longer growing seasons might not be realizable because of greater infestation by pest and disease. Also high moisture level recorded in the study area might benefit pest and disease rather than increase the yield of crops. This evidence suggests that longer growing seasons will enable insects such as grasshoppers to complete a greater number of reproductive cycle during the wet season. Also, the higher temperatures observed in the area may also allow larvae to multiply exceedingly thus causing greater infestation during the following cropping season. [17] observed that altered wind patterns may change the spread of both wind-borne pests and of the bacteria and fungi that are the agent of crop disease. Crop pest interactions may shift as the timing of development stages in both host and pest is altered [7].

Relative humidity record in northern cross river state from 1986 – 2015 shows an increasing and decreasing trend with the highest between 1986 – 2000 which indicate 1986, 1987 and 1988 with the record of (75 percent) and the lowest recorded (66 percent) in 2000 while between 2001 – 2015 the data indicated that 2009, 2012 and 2013 recorded the highest value with (75 percent) in 2008 respectively.

The model summary of linear regression, in table 4.2.7, shows that the strength in the time series is approximately 0.87 in the positive direction. The rate of this change is indicated by the slope of the regression (b) = 0.03. From table 4.2.8, t = 0.524, p>0.05, Relative humidity (RH) directly influences the water relationship of plant and indirectly affect leaf growth, photosynthesis, pollination, occurrence of disease and finally economic yield. This dryness of the atmosphere reduces dry matter production through stomatal control and water potential [26] reported that turgor pressure is high under RH due to less transpiration. Thus high relative humidity enhances leaf enlargement. Also incidence of insect pest and disease is high under high humidity conditions, and high relative humidity favours easy germination of fungal spores on plant leaves. NAS [27], observed the blight disease of potato, cassava and tea spread more rapidly under humid condition, and several insects such as aphids and Jassids thrive better under moist conditions. However, relevant point were suggested as the effect of high values of relative humidity areas follows: reduces evapotranspiration, increase heat load of plant, stomatal closure, reduces C02 up take;

Reduced transpiration, influences translocation of food materials and nutrients; moderately high RH of 60 – 70 percent is beneficial and low RH increase the evaporation.

Furthermore, it was revealed that the climatic trend of rainfall, temperature and relative humidity has changed significantly. This is supported by the secondary data gathered from the meteorological agency (Nimet) Ogoja and literature reviewed in this study such as [24], [28], [29], [30] and [31] who supported that trend of climatic variability and change has significant relationship with years. Therefore, there is a significant relationship between climatic parameters (rainfall, temperature and Relative humidity) and years in Northern Senatorial District of Cross River State.

5. CONCLUSION

The study has important contribution to food production in view of the established relationship between crop production and climate parameters. The study examined the trend pattern of climatic variables over thirty years from 1986-2015 in relation to crop production in the study area. It's crystal clear that variability and oscillation in weather parameters is capable of influencing crop production dynamics already a review of literature proved that similar result were revealed from a variety of related studies implying that there is a significant relationship between climatic parameters (rainfall, temperature and Relative humidity) and years in Northern Senatorial District of Cross River State.

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