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Analysis of Rainfall and Temperature Variability On Crop Yield in Lere Local Government Area of Kaduna State, Nigeria

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Abstract: *Climatic variability is one of the major problems of Nigeria's agricultural system and production. This paper examines the effects of rainfall and temperature variability on the yield of millet and cowpea in Lere Local Government Area of Kaduna State, Nigeria. Thus, information on yields of millet and cowpea, temperature and rainfall spanning the period of thirty years (1988-2018) were obtained for this study. The yield data for millet and cowpea were obtained from National Agricultural Extension and Research Liaisons Service (NAERLS), Ahmadu Bello University, Zaria, while data for rainfall and temperature were derived from Nigerian Metrological Agency (NiMet) Abuja. Trend analysis of climatic and yield data was carried out using Microsoft Excel Tool (2017). The relationship between rainfall and temperature data, millet and cowpea data were tested using bivariate correlation analysis. The result of the trend analysis showed that rainfall increases from 1988-2018 but yield rate declines. The results of the correlation analysis showed a weak relationship between rainfall data and yield. In view of this, it was recommended that, there is need for the development of a comprehensive agricultural and climate change policy that considers the risks associated with millet and cowpea production among farmers of the study area and Nigeria as a whole.*

Keywords*:* climate change, correlation, cowpea, millet, rainfall, temperature.

INTRODUCTION

Rainfall is considered as the leading climatic factor that has effects on crop productivity. Variability of rainfall is progressively becoming a thing of concern, most especially in the agricultural rain-fed places of the world; because of its distributions, pattern and seasonality. In areas where rain-fed agriculture is being practiced, the erratic nature of water and its irregularities

in both the amount received and its spread, remains a major threat to agricultural production as yields are increasingly becoming poorer and there is high variability in yearly crop production. Therefore, the unpredictable pattern of the onset of rainfall, cessation and length of growing season in a location can negatively affect the farmers in an area that depends on rainfall for their farming activities (Agidi, 2017). In Nigeria, rainfall variability affects the rain-fed agriculture in which many of the population depend.

Rainfall Variability is defined as the degree to which rainfall amounts vary across an area or through time. It is the fluctuations of rainfall occurrence annually or seasonally above or below a long-term normal value. Every year, the rainfall of a location can be different in a specific period, either above or below normal (Intergovernmental Panel on Climate Change [IPCC], 2022). Rainfall values in last decade reduced drastically and affected crop yields across Nigeria (Iornongo, 2021). These posed threats to food security in many developing nations including Nigeria because of the climate-dependent nature of agricultural systems and lack of viable Smart Climate Agricultural Practices (Ikpe et al. 2022). Agriculture which is one of the major areas of socio- economic as well as National Gross Domestic Product (GDP) in most countries in Africa is more vulnerable to rainfall variability.

Millet production depends almost entirely on rainfall as its moisture supply. Therefore, the amount and distribution of rainfall are important factors in determining the ultimate productivity of the millet. Millet is a crop of hot and dry climates and can be grown in areas where rainfall is not sufficient (200-600 mm), millet development begins at a base temperature around 12^{o}C, an optimum temperature of between 30-35^{o}C and a lethal temperature of around 45^{o}C). The base temperature has been shown to be constant regardless of the stage of development (Ong, 1993a).

At present, Nigeria is the largest producer and the consumer of cowpea worldwide with about 5 million hectares and over 2 million tons production annually with per capita consumption of about 25 to 30 kg per annum (Apata et al. 2009). Adewuyi et al. (2015) observed that the survival of agriculture is dependent on climate, and the two are inter-related because they both take place globally. Recent research has shown that grains can be used to offset the major impacts of climate change because of their unique position as staple for the growing populations (Ortiz, 1998).

Cowpea is considered more tolerant to climate change because of its tendency to form a deep taproot (Food and Agriculture Organisation [FAO], 2004). This leads to the interest of this work on cowpea. In Nigeria, particularly Kaduna State, cowpea is of major importance to the livelihoods of millions of people providing nourishment and an opportunity to generate income. Trading fresh produce and processed food and snacks provides rural and urban women with the opportunity for earning cash income; and as a major source of protein, minerals and vitamins in daily diets, its positive impacts on the health of women and children (Ole et al. 2009; Madu, 2016).

Despite the importance of millet and cowpea, its production is beset with constraints such as drought, flooding, salt-stress and extreme temperatures, all of which are expected to worsen with

climate change (Apata et al. 2009). Yield is mainly determined by ecological factors including climate, soil and pests and diseases. Thus, any changes in these factors could lead to changes in yield and therefore contribute to inter-annual changes in crop yield (Adejumon, 2006). Manu et al. (2017) rightly pointed out that plants do not only depend on the amount of rainfall receive for growth, development and yield but on how much water is available to them as soil moisture. When this amount becomes available within the length of the days and months to which the soil is able to retain enough moisture required, it would enhance good yield. In addition, in the tropical environment, temperature and rainfall are the most important determinants of vegetation, as temperatures are high all the year round, they are non-limiting to plant growth but determine the types of plants to be grown (Nwafor, 1982; Asiedu, 1992, Dovers and Hezri, 2010; Malhi et al. 2021). Similarly, Adefolalu (1991), and Medugu and Majid (2014) observed that climate, particularly precipitation has not been accorded the deserved priority in agricultural planning in Nigeria. Thus, the general neglect of this natural resource may be based on the impression that the tropical climate is equitable. In view of this, Ati et al. (2007), and Ojo et al. (2018) observed that, the longer duration means more rainfed crops can be cultivated and more rainwater can be harvested for water resources development.

Thus, not all rainfall is effective but only the portion that contributes to evapo-transpiration could be considered as effective (Abubakar and Yamusa, 2013; Adeoti et al. 2016). An important prerequisite for efficient intensification of agricultural production is an understanding of climate – crop relationships. Although, the effects of short – term weather fluctuations on cowpea yields have been well recognized for a long time, but they have not been well studied and understood in Nigeria, especially in Kaduna State where it is generally believed that the weather is somehow favourable for crop production. Some studies have been conducted to assess the impact of climate change on agriculture in developing countries (notably studies conducted by IPCC 2007; Timko and Singh 2008; Brown 2009; Ayinde 2010; Oyerinde et al. 2013; Eze, Aliyu et al. 2018; Chikezie et al. 2019; Ikpe et al. 2016; Ariko et al. 2024). These studies point to the concern for the present and future climate observations, weather trends and their implications for agriculture that continue to inspire researchers as well as public and policy level interests regarding the analysis of climate change in relation to agricultural productivity. This study therefore seeks to investigate the effects of climate change on cowpea and millet production in Kaduna State. This is the thrust of this present study.

THE STUDY AREA

Being an administrative Local Government Area and town in Kaduna State of Nigeria, Lere have its headquarters in the town of Saminaka. Geographically, the coordinates of Lere are Latitudes 10.386 ^{o} and Longitude 8.573. This is a region that is characterized with tropical wet-and-dry type (Koppen's Aw climate). In Lere, the wet season lasts from April through October with a peak in August, while the dry season extends from November of one calendar-year to April of the next (Abaje et al. 2012). According to National Bureau of Statistics, the town and its environs have an estimated population of about 93,290 in 2016 whereas the Lere Local Government has an area of 2,634 km2 and a population of 339,740 at the 2006 census.

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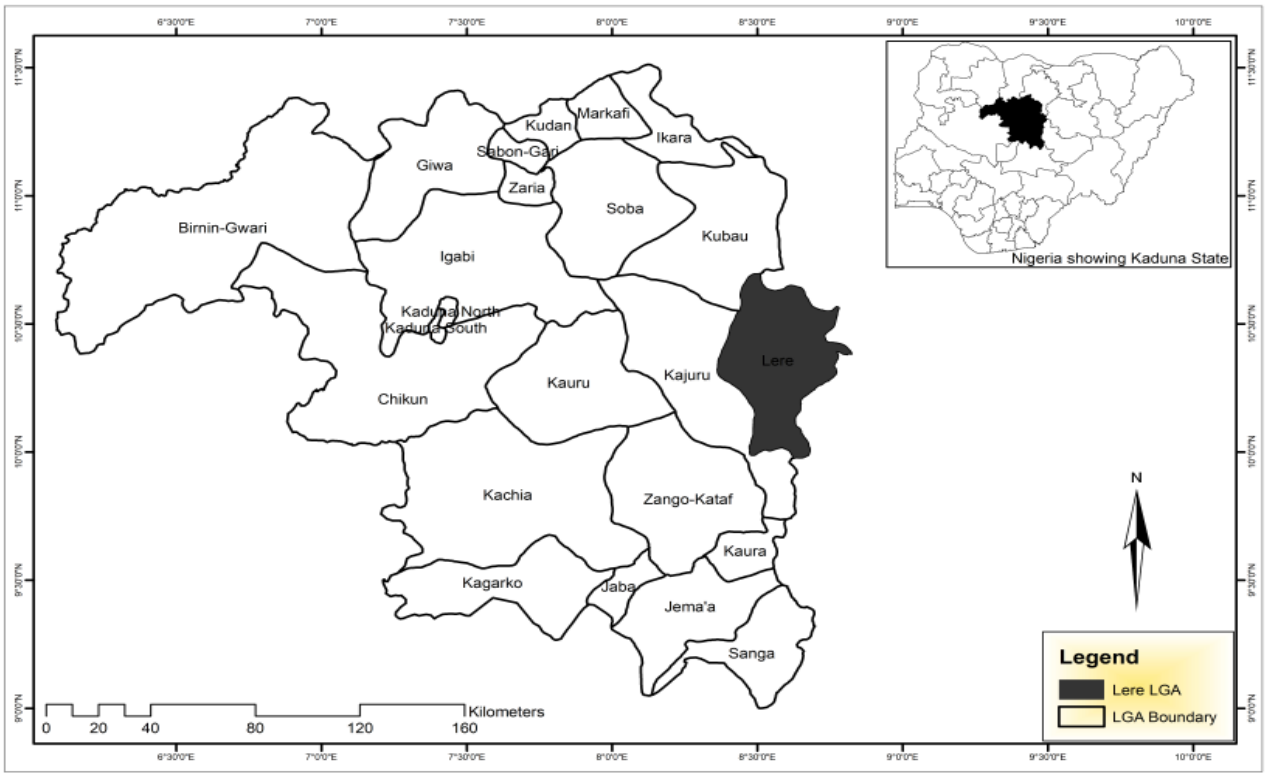

Figure 1: The Study Area

The wet season in the study area is oppressive and overcast whereas the dry season is partly cloudy and hot all year round. During the wet season, a wet day can vary significantly throughout the year and can be characterized with at least 0.02 inches of liquid precipitation. Moreover, the wet season can easily last up to 5.4 months (from ending of April to early October) (Abaje et al. 2016; Ikpe et al. 2020). The rainfall intensity is very high between the months of July and August (ranging from 60 mm hour-1 to 99 mm hour-1) (Oladipo, 1993). The pattern of rainfall in this region is highly variable in spatial and temporal dimensions with an inter-annual variability of between 15 and 20 percent (Oladipo, 1993; Abaje, 2016). Over the course the year, the temperature varies from 13^{o}C to 36^{o}C and rarely below 11^{o}C or above 39^{o}C. The hot season mostly last for only 2.4 months (mid-February to ending-April) whereas the cool season last for 2.9 months (ending-July to early-October) with average daily high temperature below 29^{o}C.

METHODOLOGY

This research work was solemnly based on secondary data. Millet and cowpea production data (yield/hectare) covering a period of thirty years (1988-2018) and was obtained from National Agricultural Extension and Research Liaisons Service (NAERLS), Zaria, Kaduna State, while monthly rainfall/temperature data for the same period was obtained from the archive of the Nigerian Meteorological Agency (NiMet), Abuja. Trend analysis of temperature, rainfall, millet

and cowpea were carried out using Microsoft Excel Tool (2017). Similarly, the relationships between rainfall and the yield of Millet and cowpea, and temperature and yield of Millet and cowpea in the study area were tested using bivariate correlation analysis.

Two types of test statistics were used for this study, the descriptive statistics and the inferential statistics. Pearson Product Moment Correlation (PPMC) was used to correlate rainfall, temperature and cowpea production in Kaduna State. Abubakar (2019) view Pearson Product Moment Correlation (PPMC) as coefficient of correlation used to measure the degree of association between bivariate variables. When a researcher is interested in measuring two variables on a single experimental unit, the resulting data becomes bivariate data. The coefficient of correlation is a single number that indicates the strength and direction of the relationship between two variables.

RESULTS AND DISCUSSIONS

The results of the study generally revealed that as the region is becoming wetter in terms of the climatic elements like rainfall and temperature, the production rate for millet and cowpea decreased from 1988-2018.

General Statistics of Rainfall and Temperature Data

The general statistics of rainfall and average temperature of Lere (1988-2018) is presented in Table 1. The results of the standardized coefficient of Skewness (Z1) and Kurtosis (Z2) for the station was accepted as normal at 95 percent confidence level. Therefore, no transformation was made to the rainfall and temperature series.

Table. 1: General Statistics of the Rainfall and Average Temperature of Study Area (1988-2018)

Statistics	Rainfall (mm)	Temperature ^{o}C
Skewness (Z1)	1.65	-3.66
Kurtosis (Z2)	5.21	17.31
Standard Deviation	442.1	0.14
Range	2196.18	0.8
Minimum	680.02	32.1
Maximum	2876.2	32.9

Source: *Fieldwork (2018).*

The minimum amount of rainfall (680.02 mm) was recorded in 2008 while the maximum amount (2876 mm) was recorded in 2018. The standard deviation was 442.1 which is an indication of high rainfall variability in the study area. On the other hand, the study area recorded its annual minimum temperature of 32.1ºC in 1989 while the maximum temperature (32.9ºC) was recorded in 2009.

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Trends of Rainfall with Millet/Cowpea Yields in Kaduna

The result of the trend analysis of annual rainfall with millet and cowpea yield is presented in Figure 2. The result shows that millet and cowpea yields appear to be influenced by rainfall during the study period. This result agrees with the findings of Ikpe (2021) which reported that there is a relationship between rainfall and the yield of millet. The increasing rainfall trend is in concurrence with the result of Abaje *et al.* (2012) that most of the synoptic stations in northern Nigeria have been witnessing increasing annual rainfall in recent years. This result further confirms the findings of Ariko et al (2020) which reported rainfall has positive relationship with crop yield in northern Nigeria. Nnachi, et al. (2018) reiterated that Nigerian agricultural system is at the mercy of rainfall since most of the agricultural practices are rainfed.

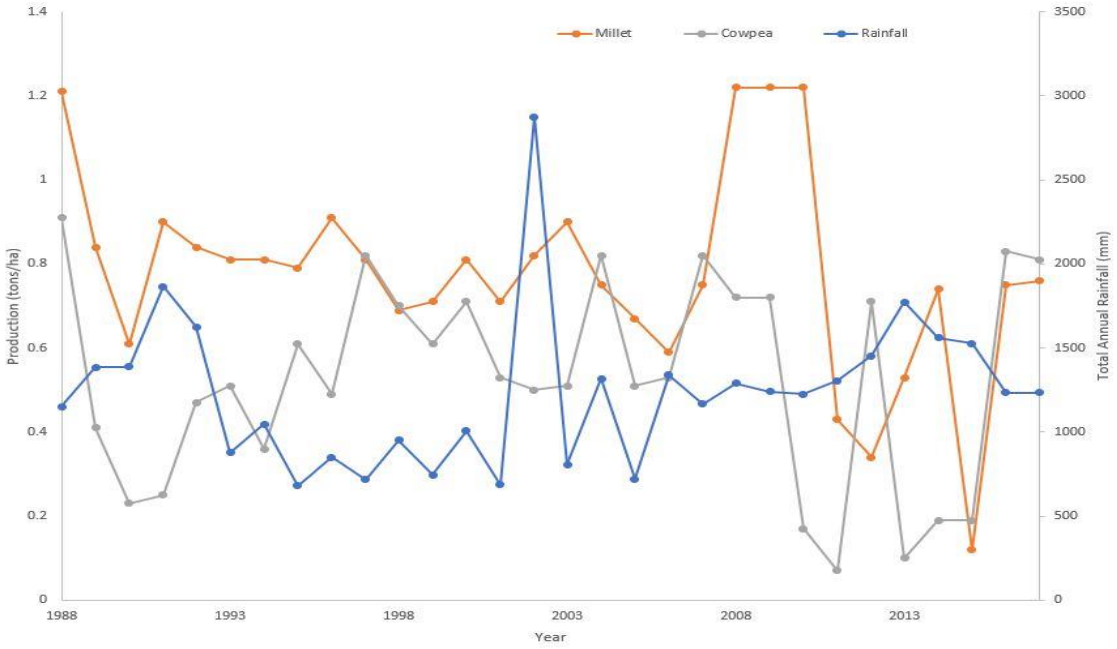

Figure 2: Trends of Rainfall with Millet and Cowpea Yield in Kaduna (1988-2018)

Figure 2 shows that there is an increase in millet production and cowpea with decrease in rainfall amount especially in the eighties and nineties, from 2007 to 2011 there is other years of increase in millet with decrease in cowpea production and from there rainfall begin to rises with decrease in both of the two staple crop production.

Trends of Temperature with Millet and Cowpea Yields in Kaduna

Figure 3 (shows that in Kaduna) there is decrease in temperature from eighties to nineties with an increased tempo of cowpea and millet production and from 2000s to date there is another increase in temperature with increase in cowpea production with slightly decrease in millet production, The linear trend lines for both the average temperature and annual cowpea yield showed an increasing

trend. The increasing temperature in recent years agrees with the findings of Abaje et al. (2016) using temperature data spanning a period of forty years (1975-2014). This reiterate the precipitation and temperature animalities in the period observed with an increase in both parameters. The result further agrees with the findings of Nnachi et al. (2016) and Suleiman et al. (2023) which reported a decrease in temperature at Gusau station, Zamfara State.

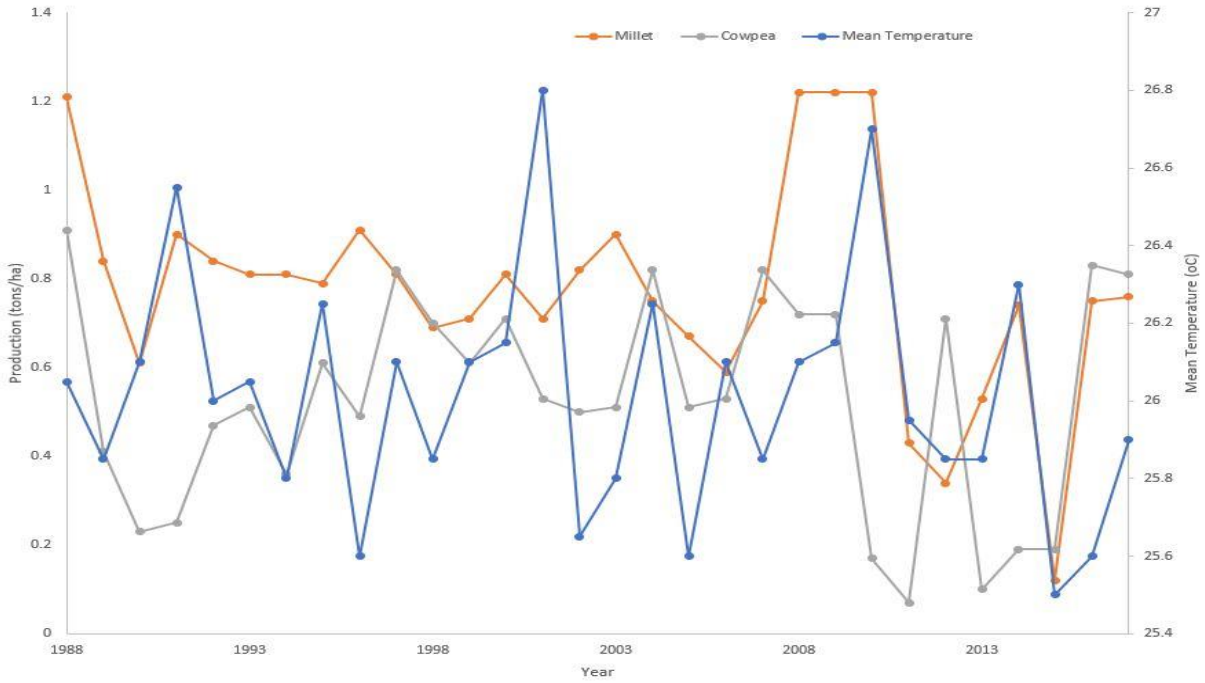

Figure 3: Trends of Temperature with Millet and Cowpea Yield in Kaduna (1988-2018)

Relationships between Climate Data (Rainfall and Temperature) and Millet/Cowpea Yield.

Table 4 provides the correlation coefficient of annual rainfall/average temperature on millet and cowpea yields in Kaduna State between (1988-2018).

Table 2. Statistical Summary Output

Climatic variables	r-value	
	Millet	Cowpea
Annual rainfall	-0.106	-0.317
Average temperature	0.373	-0.096

Source: *Fieldwork (2018).*

The P value of almost all the items tested is greater than 0.05 level of significance; this is an indication that the test is not significant at 0.05 level of significance, and as such the null hypothesis is accepted and concludes that there is no significant relationship between rainfall in Lere with

millet/cowpea production. Also, the analysis further shows that there is no significant relationship between temperature and millet/cowpea productions in Lere, Kaduna. This is to say that as rainfall and temperature in the region increases, millet and cowpea production decreases.

CONCLUSION

This study has examined analysis of rainfall and temperature variability on crop yield in Lere Local government area of Kaduna State, Nigeria. The result shows increase in rainfall and temperature while decrease in millet and cowpea yield. The study concluded that millet and cowpea yields was influenced by rainfall during the study period.

RECOMMENDATIONS

1. The Nigerian Meteorological Agency (NiMET) can do more in issuing seasonal forecasts of onset and cessation dates of rainy season and annual number of rain days each year. Considering the sensitivity of crop yields to these variables, farmers should be encouraged to avail themselves of these services and apply such information in grain production;
2. Agricultural Extension Officers (AEOs) should be deployed to guide farmers through routine visits, sensitization programmes on variability in rainfall characteristics and use of viable adaptation strategies in other to achieve improved and sustained crop yield;

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