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ASSESSING THE RELATIONSHIP OF CLIMATE VARIABILITY AND CROP PRODUCTION IN BAUCHI TOWN AND ENVIRON

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ABSTRACT

The study examines the relationship between climate variability and crop production in Bauchi town and its environs. Climatic elements such as rainfall and temperature were obtained from the Nigerian Meteorological Agency (NIMET) in Bauchi for three decades (1981-2010) and crop yield of some selected crops such as maize, millet, rice, sorghum, groundnut and cowpea were sourced from the Bauchi State Agricultural Development Programme (BSADP) for 30years (1981-2010). These data were analysed using correlation and simple linear regression analysis. The results obtained reveals that rice and cowpea show significant relationship with rainfall at 0.05 level of significant while maize, millet, sorghum and groundnut shows no significant relationship. Temperature and Rainfall explain 10% crop yield of the selected crops but will explain better other crops not included in the study. This implies that other environmental factors such as soil fertility, agricultural inputs may explain better the variation between climatic variable and the selected crop yield. As a result, it was recommended that crop yield should be regressed on other environmental factors such as soil fertility and agricultural inputs. More investment should be made on rain fed agriculture using agricultural extension service.

Keywords: Climate, Crop, Production, Rainfall, Temperature, Variability and Bauchi.

INTRODUCTION

Climate variability and change have a direct often adverse, influence on the quantity and quality of agricultural production. The climate of an area is highly correlated to the vegetation and by extension the type of crop that can be cultivated. Temperature, rainfall, humidity, sunshine (day length) are the important climatic elements that influence crop production. The overall predictability of these climatic elements is imperative for the day-to-day and medium-term planning of farm operations (Akintola, 2009).

According to (Yamusa., et al. 2015) in their work examined the implication of rainfall Variability on some major food crops of the Semi-Arid regions of northern Nigeria in changing climate, Rainfall data for 50 years and grain yield data were both source from NIMET and IAR. Correlation was employed to assess the relationship between crop yield and dry spells, which shows 10 days shift from normal planting period and also showed negative relationship of 1% for Sorghum and Maize while 5% for cowpea and Rice.

(Obioha, 2009) further emphasised that region that was been found to be highly susceptible to climatic anomalies as a result of climate variability and climate change. Most part of the region is increasingly becoming an arid environment as a result of desertification. This problem has been associated by fast reduction of the amount of surface water, flora, and fauna resources, communal conflicts, as well as disruption of natural ecosystems.

According to (Khuram and Ghulam, 2015) in their studies Climatic Variability has direct and adverse impact on the food production and sustainable development especially in rainfed areas. Along the foot-hills of Himalayas, a vast agriculture plain known as Potohar Plateau is isolated. Among climatic factors, the precipitation has great influence on the production of crops. Potohar Plateau is known for its highly variable precipitation characteristics both in terms of frequency and distribution. The study, found that during vegetative and reproductive stages, as the rainfall increases from 100 mm to 250 mm and 50 mm to 200 mm respectively, the yield has been improved resulting in to maximum production i.e. 2400 Kg/Ha at certain amount of precipitation. Maize is generally planted in July with the onset of the monsoon (rainy season) and it attains maturity as the monsoon recedes from Pakistan in September.

The rural population, for whom agriculture is the primary source of food, direct and/or indirect employment and income, noticed long-term changes in temperature and precipitation (Bose., et al. 2014). Food Security is a major issue of concern in the Sahel region as food production and its supply is being threatened by the variations in climatic conditions. Agriculture has been the major source of food supply and forms a significant sector of the nation's economy and also a source of raw materials as well as foreign exchange earnings. Food production in Nigeria is heavily dependent on characteristics of rainfall and temperature. This situation makes the Sahel region particularly vulnerable to climate change. There has been fluctuation in the rainfall pattern coupled with an increase in temperature and evaporation. According to Odiana (2009), evidence of climate change in Bauchi indicated an average mean temperature increase of 0.03^{o}C as well as annual increase of 0.2mm of rainfall. Consequently, the impact of such changes in climatic condition on food production in the area may include; change in forage yield, changes in livestock productivity, changes in ecological processes, alterations in farm level productivity, as well as changes in farm incomes.

Rapid urbanization in addition to climate change can as well cause severe changes in food production and food systems in general. The effects of these changes may include; changes in water availability, land cover changes, altered nitrogen availability and cycling, destruction of vegetation, increased intensification of cropped areas etc. Other environmental changes may include changes in rainfall pattern leading to drought or flood, warmer or cooler temperatures leading to changes in the length of growing seasons, as well as changes in market, food price, and food supply (Gregory, et al. 2005). It was recognized that Nigeria is confronted by major environmental problems, such as climate change, that give rise to shortage of crops, outbreak of diseases, loss of biodiversity, malnutrition and that the Sudan-Sahel region is most susceptible to

the climatic anomalies likely to cause/leads to such problems. Based on current established facts, evidences of climate change in Bauchi and environs, and fluctuations in crop production, it is likely that the two are correlated (Odiana, 2009). (Yamusa., et al. 2013) in their studies concludes that incidence of early season dry spells affects the length of growing season. If this trend persists, there would be greater effect of the variability on Agricultural production. Therefore, efforts are needed to allow societies to adapt to climate variability and climate change in ways that will lead to greater stability in crop production and supply. This brings about the need for research to investigate the relationship between climate variability and crop production in Bauchi and environs.

MATERIALS AND METHODS

Study Area

Bauchi Local Government Area is geographically located and bounded by latitudes10° 19′ 55″ and 10° 20′ 58″ north of the equator and longitudes 9° 50′ 50″ and 9° 51′ 29″ east of Greenwich (Prime) meridian, the study area shares a common boundary with Ganjuwa in the North, Tafawa Balewa in the South, Toro in the West and Alkaleri to the East, which lies also on the Port Harcourt – Maiduguri railway line and covers an area of 3,687 Sqkm. It is connected through good roads and has intra-national boundaries with Kano state and Jigawa state to the north, Yobe state and Gombe state to the east, Kaduna state to the west and the Plateau state and Taraba state to the south. It housed the Yankari Game reserve and Tomb of late Sir Abubakar Tafawa Balewa the first Prime Minister of Nigeria which are of tourism potential to the country (Shuaibu ., et al. 2014).

The climatic condition of the study area is very hot in the months of April and May while December and January are the coldest months. (Climate-data.org, 2013). There are two major seasons in Bauchi i.e. dry and rainy season lasting from October to March and April to September respectively. The annual rainfall ranges from 1,000mm - 1,300mm. The rain starts in the first half of April and finish towards the end of September. The distribution of rainfall is strongly influenced by the presence of the Jos Plateau to the Southwest and west of the area. Here the Toro plains have a mean annual rainfall of 1270mm-1524mm. further east, the Jos Plateau cast a marked rain shadow and the 1,016mm isohyet runs north-south throughout much of the area.

According to (BSADP, 1996) the topography is made up of dissected plain and pediments with cropping hills of intrusive rocks and granites. The soil consists of weakly developed and non-leached ferruginous soils of alluvial and colluvium origins. The soil is thus characterized by sandy-clay texture with low pH, low organic carbon, low nitrogen content, low available phosphorus and high cation exchange capacity (CEC).The study area lies within the northern guinea savannah ecological zone of Nigeria and has two distinctive vegetation zones, namely, the Sudan savannah and the Sahel savannah.

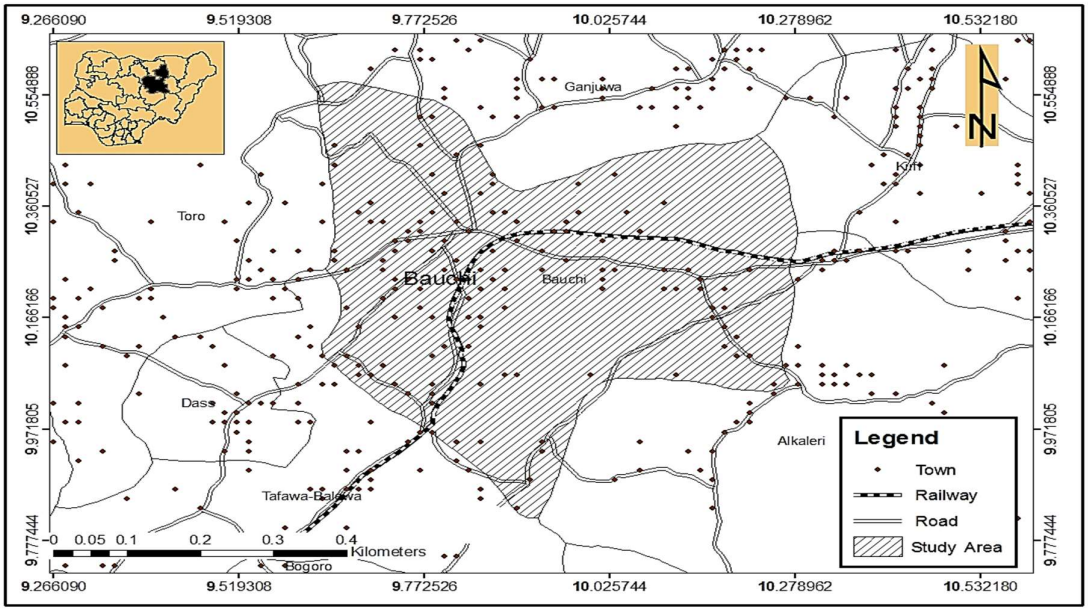

Figure 1: The Study Area: Bauchi L.G.A and Environs
Source: Geographical Map of Nigeria (2014)

The type of data used for this study includes quantitative/secondary data. The data were both sourced from the archive of the Nigerian Meteorological Agency (NIMET) in Bauchi and The Bauchi State Agricultural Development Programme (BSADP). The Rainfall and Temperature data spanning for a period of 30 years (1981-2010) was obtained from the Nigerian Meteorological Agency (NIMET), and Crop production estimate of some selected crops was obtained from Bauchi State Agricultural Development Programme (BSADP) for the period of 30 years (1981-2010) from Bauchi State Agricultural Development Programme (BSADP).

Descriptive statistics of long-term monthly temperature and rainfall were computed for the period under study. Minimum temperature, Maximum temperature, mean monthly temperature and rainfall, standard deviation (a measure of dispersion) and coefficient of variation (measure of variability) and (Correlation analysis to test the level of Relationship between Climates parameters and the selected crops) were also computed for the period under study using SPSS and presented in tabular forms.

RESULTS AND DISCUSSION

Characteristics of Monthly Rainfall Variation (1981-2010)

The study area has its onset of rainfall in May and cessation by September. However, in some year, onset of rainfall is experienced in April and cessation by October. Table 1 show that the highest mean monthly rainfall for Bauchi and Environs is recorded in the month of August with 282.79mm and the lowest mean monthly rainfall is recorded in the month of April with 35.65mm. This is an indication of strong variation between the months of the years under study. The highest minimum and maximum values are recorded in the months of July and August

with 123.1mm and 520.9mm respectively. This implies that August is the wettest month of the year.

There is little variation in standard deviation with the highest standard deviation in the month of September with 92.00, followed by 89.50 in the month of August and 86.70 in the month of July. The lowest standard deviation was found in the month of April with 37.64 followed by 47.47 in October.

Table 1: Mean of monthly rainfall for Bauchi and Environs in the month of August

Month	Minimum	Maximum	Mean	Std. Deviation	CV
Jan	0	0	0	0	0
Feb	0	1.9	0.1	0.37	360.74
Mar	0	33.8	4.27	9.8	229.52
Apr	0	162.6	35.65	37.64	105.58
May	17.3	277.7	99.04	51.77	52.27
Jun	33.7	267	158.89	59.57	37.49
Jul	123.1	446	245.37	86.7	35.34
Aug	54.9	520.9	282.79	89.5	31.65
Sep	4.1	489.3	177.15	92	51.94
Oct	0	186.3	37.91	47.47	125.23
Nov	0	2.7	0.09	0.49	547.72
Dec	0	0	0	0	0

Source: Researchers Computation from SPSS Result

The findings corroborate with Mortimore (2012) which reported rainfall to be variable in the Nigerian Dry lands and that it is difficult to predict.

Characteristics of Annual Rainfall Variation

The total annual rainfall for the period of 30 years ranges from 726 to 1531 mm with a mean annual rainfall value of 1020mm. The yearly variation of 18% however is lower than the average monthly variation of 73.25 % (Table 2).

Table 2: Summary of Intra Annual Rainfall Variation of Bauchi and Environs (1981-2010)

	Minimum	Maximum	Mean	Std. Deviation	CV
Total Rainfall (mm)	725.60	1531.30	1020.16	190.52	18.68

Source: Researchers Computation from SPSS Result

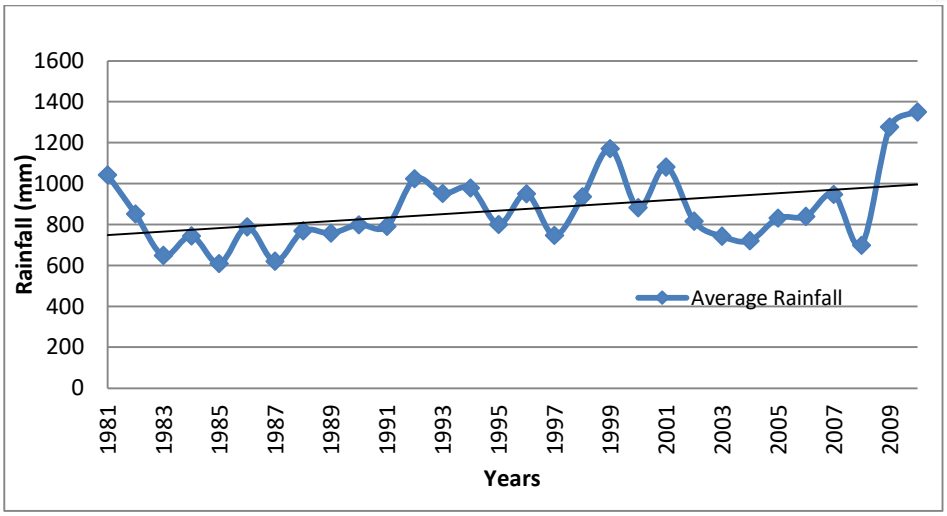

Figure 2: Annual Rainfall Variation of Bauchi and Environs (1981-2010)
Source: Researchers Graphical Representation from Excel

From figure 2, the period from 1981 to 1990 has annual rainfall mostly between 800 and 900mm, 1981 is the wettest year of the period with rainfall amount slightly above 1200mm in the first decade. On the average there is decrease in rainfall from 1981 to 1990. The implication is that, this may have effect on the production of the selected crops within the period because rainfall is one of the most influential determining factors in crop production in the tropics since temperature is always high and sufficient for crop production.

Characteristics of Monthly Temperature Variation (1981-2010)

Temperature is always high in the study area, usually higher than 20^0C. The lowest mean monthly temperatures are recorded in the months of January and December with 22.67^0C and 23.15^0C respectively (Table 3) typical of Northern Hemisphere.

However, the highest temperature is recorded in the month immediately preceding the onset of raining season which can be seen in (Figure 2) and (Table 3) as the month of April with the highest mean monthly temperature of 30.94^0C. This corroborates with condition in Kano Region as observed by Olofin (1987).

The lowest minimum monthly temperature is above 18^0C as recorded in January to be 18.2^0C (Table 3) typical of tropical climate recorded (A Climate) by Koppens. By implication temperature during growing season is relatively high in the study area and also sufficient for plant growth.

Variation in Crop Production (1981-2010)

The crop production in the area shows wide variation with millet being the predominant (accounted for more than 40%) crop produced. Sorghum and maize productions are also significant, account for 22% and 13% respectively. Rice production is the least which account for only 3% of the crop produced in the study area. These can be related to the fact that the climate of the area is relatively dry as such crop like millet, sorghum and groundnut will thrive better in the area.

TABLE 3: Monthly Temperature Variation of Bauchi and Environs (1981-2010) (Station: Bauchi)

Month	Minimum	Maximum	Mean	Std. Deviation	CV
Jan	18.2	27.5	22.67	1.95	8.62
Feb	21.8	29.2	25.19	1.87	7.44
Mar	26.4	31.4	28.92	1.16	4.01
Apr	30	32.5	30.94	0.64	2.06
May	27.5	31.6	29.84	0.94	3.16
Jun	26.6	29.4	27.68	0.69	2.49
Jul	24.7	28.8	26.06	0.92	3.54
Aug	24.5	28.5	25.54	0.82	3.23
Sep	25.1	28.7	26.09	0.74	2.84
Oct	25.5	28.8	26.75	0.8	2.98
Nov	22.9	28	25.27	1.11	4.41
Dec	21.3	27.1	23.15	1.37	5.93

Sources: Researchers Statistical analysis.

Table 4: Crop Production Estimate of some selected crops in Bauchi L.G.A and Environs in Metric tonnes (1981-2010)

Production (metric tonnes)	Min	Max	Mean	STDV	CV
Maize	29208.2	1620093	205520	276997	134.78
Millet	136615	9847137	706043	1740386	246.5
Rice	633.64	134706	40500.6	32143.5	79.37
Sorghum	40473	630183	330882	110276	33.33
Ground nut	10085	636073	124569	122548	98.38
Cowpea	42090	286810	122070	77803.3	63.74

Source: (BSADP, 2012)

Variation in the crops produced in the study area is higher in millet, maize and groundnut and lowest in sorghum. From the Coefficient of Variation, we can determine that the variation is higher in the area, more than fifty percent in most crops except sorghum which has a variation of about 33.3%. This may be attributed to rainfall variation and environment mismanagement as outlined by past studies in some parts of Nigeria's dry land regions.

Relationship between Rainfall and Some Crops in Bauchi and Environs

Correlation analysis was performed to see the relationship between annual rainfall and volume of some crops produced. Annual rainfall data for the period from 1981-2010 was correlated with production data of some crops for the period from 1981-2010 to give the result in table 6 below.

Table 5 reveal that even though there is relationship between total annual rainfall and crop production the relationship has little significance. From the table, rainfall is weakly correlated with millet (-0.299), Sorghum (0.267), maize (-0.016) and groundnut (0.178). This implies that relationship between rainfall and Millet, Sorghum, Maize and Groundnuts in the study area is not significant. The correlation coefficient value of Rice (0.47) and Cowpea (-0.59) are significant at 0.05 level of significance. This implies there is a significant relationship between the crop yield of rice and cowpea rainfall.

Table 5: Correlation Between Rainfall and Some Crops in Bauchi and Environs.

Crops	Correlation Coefficient
Maize	-0.016
Millet	-0.299
Rice	0.47*
Sorghum	0.267
G/nut	0.178
Cowpea	-0.59*

*. Correlation is significant at the 0.05 level (2-tailed).

Sources: Researchers Statistical analysis.

The main and objectives of this research was to examine the relationship between climate variability and crop production in Bauchi town and its environs, using rainfall and temperature data obtained from the Nigerian Meteorological Agency (NIMET) in Bauchi for three decades (1981-2010) and crop yield of some selected crops such as maize, millet, rice, sorghum, groundnut and cowpea were sourced from the Bauchi State Agricultural Development Programme (BSADP) for 30years (1981-2010).

According to (Yamusa., et al. 2015) in their work examined the implication of rainfall Variability on some major food crops of the Semi-Arid regions of northern Nigeria in changing climate, Rainfall data for 50 years and grain yield data were both source from NIMET and IAR. Correlation was employed to assess the relationship between crop yield and dry spells, which shows 10 days shift from normal planting period and also showed negative relationship of 1% for Sorghum and Maize while 5% for cowpea and Rice. Therefore, the findings of (Yamusa., et al. 2015) were in agreement with the study because the study conclude that Rice and Cowpea shows a significant relationship, while Maize and Sorghum shows a negative relationship.

According to (Khuram and Ghulam, 2015) in their studies Climatic Variability has direct and adverse impact on the food production and sustainable development especially in rainfed areas. The study, found that during vegetative and reproductive stages, as the rainfall increases from 100 mm to 250 mm and 50 mm to 200 mm respectively, the yield improves resulting in to maximum production i.e. 2400 Kg/Ha at certain amount of precipitation. Maize is generally planted in July with the onset of the monsoon (rainy season) and it attains maturity as the monsoon recedes from Pakistan in September. Therefore, the study concludes that

The relationship between rainfall and the yield proved true and highly significant correlation has been found at all the four stations i.e. Chakwal, Rawalpindi, Kamra and Jhelum. Well correlated yield with the rainfall amount at early stage of crop development helps to develop a model for yield prediction with a sufficient lead time which may be used by planners and policy makers to manage the probable shortages or surpluses. Curvilinear models have been developed depicting the precipitation amount and maize production for different agricultural zones of Potohar Plateau. Thereby agrees with the study that concludes, Temperature and Rainfall explain 10% crop yield of the selected crops.

CONCLUSION

In this study, the result obtained from the correlation and regression analysis reveal that climatic variables of rainfall and

temperature have little impact on crop production within the years under review. These suggest that variation in the yield of the selected crops and climatic influence on agriculture in Bauchi and environs during the period under review could be as a result of other factors namely soil fertility, seed variety and other environmental factors. This finding is in agreement with the work of Khuram and Ghulam, 2015 on Rainfall Variability and Maize Production over the Potohar Plateau of Pakistan, Yamusa., et al. 2015 on Rainfall Variability and Crop Production in North-Western Semi-Arid Zones of Nigeria and Aondoakaa (2012) on the effect of climate change on agricultural productivity in the Federal Capital Territory Abuja Nigeria which shows a positively significant but weak relationship.

Recommendations

- Effort should be made to regress crop production with other environmental factors such as soil fertility, seed variety etc.
- Improved and or genetically modified crop species that require less consumptive use of moisture and have short growing period should be made available to farmers.
- Monitoring of climatic changes and variations, and dissemination of information to farmers to encourage adaptation should be intensified by respective agencies.

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