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Full Length Research Paper

Effects of climatic variables on crop production in Patigi L. G. A., Kwara State, Nigeria

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Agricultural production in Nigeria like other developing countries is highly vulnerable to climate variability. This study used regression and correlation analyses to examine the impacts of temperature, relative humidity, rainfall and number of rainy days on food production in the Patigi Local Government Area (LGA) of Kwara State of Nigeria. The results revealed that maize production correlated highly with rainfall amount (0.73). The other variables namely, relative humidity, number of rainy days, maximum and minimum temperature correlated with the crops but very weak. This means climatic variables examined have impact to a certain limit on the selected crop yield in the study area. The regression analysis revealed that 76, 79, 43, 82, 50 and 35% of the variance in rice, millet, sorghum, groundnut, maize and sweet potato can, respectively be explained by the climatic variables examined. The implication of the findings for sustainable agricultural development is discussed in the concluding part.

Key words: Climate change, crop, agriculture, yield, agricultural zones.

INTRODUCTION

Nigeria is an agrarian country, because about 70% of the population engages in agricultural production at a subsistence level despite the fact that the country depends heavily on the oil industry for its budgetary revenues (National Report, 2006). Agricultural holdings are generally small and scattered. Traditional small-holders, who use simple techniques of production and the bush-fallow system of cultivation, account for around two-thirds of Nigeria's total agricultural production. Nigeria's wide range of climate variation allows it to produce a wide variety of food and cash crops. However, food production could not keep pace with population increase. Food shortage is therefore linked with climate change (Adefolalu, 2004).

Generally, there are many factors influencing crop production and these include soil, relief, climate and diseases among others. In relation to climate, rainfall is the dominant controlling variable in tropical agriculture since it supplies soil moisture for crops and grasses for animals. According to Ayoade (1983), agriculture largely depends on climate to function. Hence, precipitation, solar radiation, wind, temperature, relative humidity and other climatic parameters affect and solely determine the global distribution of crops and livestock as well as their productivity. Kurukulasuriya and Rosenthal (2003) described the four ways in which climate affect agricultural production; changes in temperature and precipitation directly affect crop production and can even alter the distribution of agro-ecological zones; increased CO_2 is expected to have a positive effect on agricultural production due to greater water use efficiency and higher rates of plant photosynthesis; runoff or water availability is critical in determining the impact of climate change on crop production, especially in Africa, and agricultural losses can result from climate variability and the increased frequency of changes in temperatures and precipitation (including drought and floods). Estimation by FAO (2005) is that by 2100, Nigeria and other West African countries are likely to have agricultural losses of up to 4% due to climate change.

Climate to some extent determines the choice of what plant to cultivate, how to cultivate it, the yields of crops and nature of livestock to keep. It can also be seen as one of the environmental factors that affects agricultural

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production. Supporting this, Ayoade (2002) confirms many of the problems facing agricultural products are climate related. For instance, Kowal and Kassam (1973) presented a data to show that groundnut yield begin to decline significantly with reduction of twenty days or more in the length of the growing season for the savannah areas of Nigeria. Ajewole and Iyanda (2010) studied the effect of climate change on cocoa yield with the use of correlation and regression analysis and concluded that optimal temperature and minimal rainfall will give better yield of cocoa in Nigeria.

These findings necessitated the need to carry out a research of this kind. This will reveal whether or not changes in climatic variables have positive or negative effect on crop yield in the study area. It will also reveal the pattern of crop production to be adopted within the study area. The main objective of this investigation is to study the effect of climatic variables on crop production during last the ten years and based on the correlated factors, suggest the crop management plan.

Study area

The study area for this research work is Patigi Local Government Area (LGA), of Kwara State. The Local Government is made up of three districts. It is one of the LGAs and the headquarters for zone B under the Kwara Agricultural Development Project ecological zones. It is located between latitude 8.5 and 9.0° and longitude 5.6 and 6.0° (Figure 1). It is bounded in the north by river Niger and shares boundary with Kogi State in the East. Patigi LGA has a total land area of about 2924.62 sq.km which is about 5% of the total land area of the state. Approximately, 25% of the land area of the LGA is used for farming (Kwara State Agricultural Development Project, 2007). Humid climate prevails within the study area which is characterized by wet and dry seasons each lasting for about six months. The rainy season start towards the end of March and last till October while dry season begin November and ends in early March. Total annual rainfall is between 800 to 1200 mm and mean temperature of about 30 to 35°C. The soil of the study area is red laterite of tropical area formed under seasonal rainfall climatic region. Crops grown include rice, sorghum, millet, groundnut, sweet potato among others. Cultivation of cassava, millet, sorghum, groundnut and maize among others take place on the upland areas while rice cultivation is done on the lowland and floodplain of river Niger. Areas for rice cultivation are known as fadama land.

Rainfall and crops

Rainfall has been seen as the most important factor in crop production in Nigeria. Some of the important factors guiding rainfall in relation to crop include number of rainy days, time of fall, total amount of fall and the type of soil. Rainfall usually determines the type of crop to be grown in different environment as well as the type of agricultural system to be practised in different parts of the country. According to Olaoye (1999), regular occurrence of drought as a result of erratic rainfall distribution and/or cessation of rain during the growing season reduce Nigeria's capability for increased crop production.

Temperature and crops

Temperature affects cereal production by controlling the rate of physio-chemical reaction and rate of evaporation of water from crops and soil surface (Ismaila et al., 2010). Studies have shown that productivity in rice and other tropical crops will decrease with increase in temperatures as a result of global warming. For instance, high temperature for just 1 to 2 h at anthesis (about 9 days before and at heading) causes large percentage of grain sterility in rice (Nguyen, 2006). Effects of heat stress on rice include reduced tilering, reduced height, reduced spikelet number, sterility and reduced grain filling (Nguyen, 2006).

Relative humidity and crops

Plant development depends on high atmospheric humidity in the sense that many plants have the ability to directly absorb moisture from unsaturated air of high humidity. Humidity may again affect the photosynthesis of plant leaves. High humidity at night is beneficial to some plants.

METHODOLOGY

The method of study employed for this work involves the use of secondary sources of data. The Kwara State Agricultural Development Project divided the state into four agricultural/ ecological zones consisting of zones A, B, C and D. Zone B is made up of Edu and Patigi LGAs of which Patigi is the headquarter. Climatic data (rainfall, relative humidity, number of rainy days, maximum and minimum temperature) and agricultural data specifically crop data (rice, millet, sorghum, groundnut, maize and sweet potato) for the zone for a period of ten 10 years (1999 to 2008) were collected from the zonal headquarters of zone B at Kwara State Agricultural Development Project (KWADP). The study employed both descriptive and inferential statistics to analyze the data. Correlation and regression analyses were both employed to analyze the data so as establish a relationship between climatic data and crop yield; and also, to show the percentage contribution of the variables in crop yield.

RESULTS AND DISCUSSION

Table 1 revealed the trend of crop yield in the study area. The highest yield of rice (3.68) was in the year 1999 and 2000 while lowest (2.30) was in the year 2004. The highest

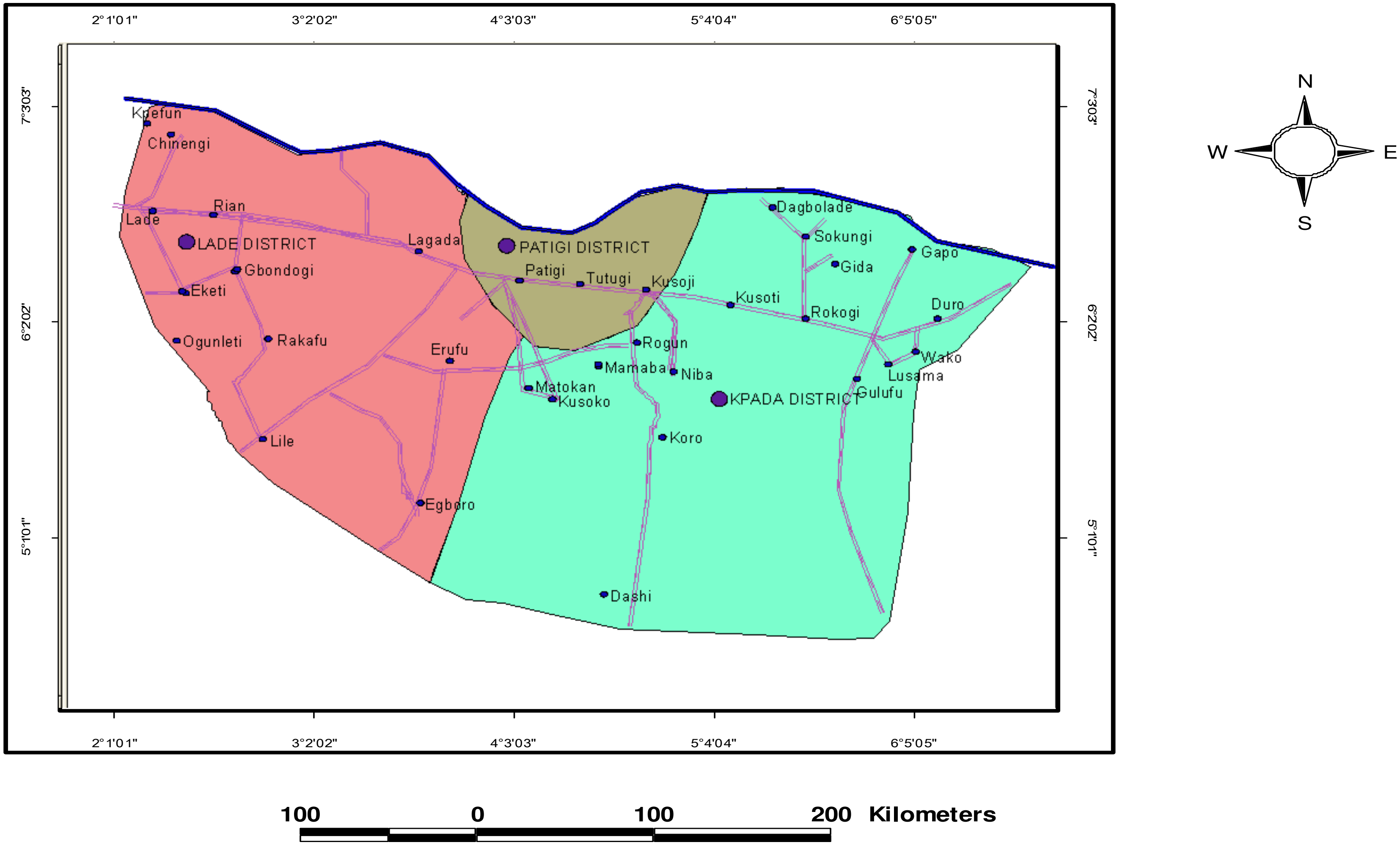

Figure 1. Map of Patigi LGAs.
Source: (Kwara State Ministry of Land and Housing, 1999).

highest yield of maize (1.97) was in the year 2008 while lowest (1.14) was in the year 2001. Millet performed highest (1.98) in 1999 and 2000 and lowest in the year 2002 (1.03). Highest yield (2.18) of sorghum was in the year 1999 and 2000 but lowest in the year 2005. Groundnut was highest in 2006 (2.70) and lowest in 2001 (0.98). Highest yield in sweet potato was recorded in 2007 (8.64) and no production in 1999, 2000, 2001 and 2003.

Table 2 revealed the average climatic data from 1999 to 2008 for the period of growth of crops

Table 1. Crop yield per hectare in zone B (Patigi) 1999 to 2008.

Year	Rice	Maize	Millet	Sorghum	Groundnut	Sweet potato
1999	3.68	1.62	1.98	2.18	1.91	0.00
2000	3.68	1.44	1.98	2.18	2.01	0.00
2001	2.84	1.14	1.60	1.92	0.98	0.00
2002	2.77	1.34	1.03	1.18	1.70	8.23
2003	2.28	1.30	1.04	1.27	1.93	0.00
2004	2.30	1.57	1.74	1.70	2.61	6.49
2005	2.36	1.35	1.75	1.27	2.65	8.50
2006	2.37	1.36	1.82	1.32	2.70	8.49
2007	2.41	1.37	1.89	1.53	1.62	8.64
2008	2.56	1.97	1.89	1.40	1.56	8.41

Source: Kwara Agricultural Development Project.

Table 2. Average climatic data for Patigi (1999 to 2008) during the period of growth of crops.

Year	Rainfall	Maximum	Minimum	Relative humidity	Number of rainy days
1999	162.3	24.7	18.6	55.6	10
2000	65.2	20.1	13.3	34.4	4
2001	90.8	34.7	21.9	80.3	5
2002	110.5	31.6	20.6	80.2	7
2003	94.0	29.3	17.2	75.2	6
2004	170.8	32.3	19.7	73.1	6
2005	65.1	10.4	14.7	56	4
2006	88.7	27.8	16.9	63	5
2007	131.9	36.9	22.8	87.8	10
2008	172.3	32.6	20.1	76	7

Source: Kwara Agricultural Development Project.

Table 3. Correlation analysis.

Crops	Rainfall (mm)	Maximum temperature	Minimum temperature	Relative humidity	Number of rainy days
Rice	-0.035	-0.238	-0.269	-0.622	0.134
Maize	0.727	0.055	0.022	0.051	0.308
Groundnut	-0.467	-0.721	-0.794	-0.709	-0.612
Millet	0.220	-0.217	-0.154	-0.387	0.102
Sorghum	0.152	0.037	-0.180	-0.299	0.067
Sweet potato	-0.130	0.163	0.175	0.363	0.075

Source: Researchers' computation. Correlation is significant at the 0.05 level (2-tailed).

under study. From the table, the average rainfall for the period of the growth of crop was highest (172.3 mm) in 2008 and lowest (65.1 mm) in 2005. Highest in maximum temperature was recorded in 2007 (36.9) and lowest in 2005 (10.1). Minimum temperature was highest in 2007 (22.8) and lowest in 2000 (13.30). Relative humidity was highest in 2007 (87.8) and lowest in 2000 (34.4). Year 2007 had highest number of rainy days (10) while 2005 had 4 days of rain.

Correlation analysis

Table 3 revealed the correlation between climatic variables (for the period of growth of crops under study) and crop yields. From the table, rainfall is highly correlated with maize (0.727), but weakly correlated with millet (0.220) and sorghum (0.152). The implication of this is that the higher the rainfall the higher the yield of maize, while millet and sorghum require minimum rainfall.

Table 4. Regression analysis for the crops and climatic variables.

Crops	R	R^2	Standard error	Regression coefficient	F	P-value
Rice	0.874	0.764	0.39169	1.0111	2.594	0.188
Millet	0.889	0.790	0.15674	1.688	3.017	0.154
Sorghum	0.653	0.427	0.40307	1.498	0.596	0.710
Groundnut	0.903	0.816	0.24464	1.160	3.553	0.122
Maize	0.705	0.496	0.58683	4.003	0.789	0.608
Sweet potato	0.590	0.348	5.13513	-0.234	0.427	0.812

Source: Computer output 2011.

Rainfall is also negatively correlated with rice (-0.068), sweet potato (-0.13) and groundnut (-0.145). The reason may be because of the fadama land present in the study area. Hence, rainfall is not too significant for cultivation of rice in the study area. Maximum temperature has positive weak correlation with maize (0.055), sorghum (0.037) and sweet potato (0.163), but negatively correlated with rice (-0.238), groundnut (-0.721), and millet (-0.217). It means that these crops do not really need maximum temperature to grow. Minimum temperature is weakly correlated with maize (0.022) and with sweet potato (0.175) but negatively correlated with rice (-0.269), groundnut (-0.794), millet (-0.154) and sorghum (-0.180). It means that maize and sweet potato require adequate minimum temperature to survive while rice, millet, groundnut and sorghum do not require much of minimum temperature to grow well. This means that increase in minimum temperature will lead to reduction in the aforementioned crops. The findings corroborate Olanrewaju (2010) findings for rice yield in Edu/Lafiaji. Relative humidity is weakly correlated with maize (0.051) and sweet potato (0.363), while other crops, such as groundnut (-0.707), millet (-0.387), sorghum (-0.299) and rice (-0.622) are negatively correlated with relative humidity. This means that maize and sweet potato require minimum relative humidity to survive in the study area.

Number of rainy days is positive but weakly correlated with rice (0.134), maize (0.308), millet (0.102), sorghum (0.067) and sweet potato (0.075). It is only negatively correlated with groundnut (-0.612).

Regression analysis for the crops and climatic variables

The regression analysis computed for the crops revealed that rice, millet, sorghum, groundnut, maize and sweet potato have coefficient of determination of 0.76, 0.79, 0.43, 0.82, 0.50 and 0.35, respectively. This indicates that 76, 79, 43, 82, 50 and 35% of the variance in rice, millet, sorghum, groundnut, maize and sweet potato can be, respectively explained by the climatic parameters under study (Table 4). The implication is that 24, 21, 57, 18, 50 and 65% of the variance in rice, millet, sorghum, groundnut, maize and sweet potato can be, respectively explained by other factors not included in the study. Climatic variables therefore, have impact on selected crop yield over the years under study except for sweet potato with low percentage. The study has actually revealed that other factors, such as solar radiation, type of soil, soil fertility and farm methods may also be responsible for crop yield.

CONCLUSION AND RECOMMENDATIONS

The study has revealed the effect that climatic variables, such as rainfall, relative humidity, number of rainy days, maximum and minimum temperature have on the yield of rice, millet, sorghum, groundnut, maize and sweet potato in the study area. This will assist in planning ahead in order to avert problems associated with climatic variables in the study area. Factors such as soil fertility, availability of adequate water for crops, suitable temperature, area of land under cultivation, correct timing of planting and good cultural practices (such as spacing of strands), protection of crops from weeds, pests and diseases and planting of high yielding varieties affect crop production in the study area. The following ways can therefore be employed to improve crop yield:

1. Application of fertilizers to maintain adequate level of fertility.
2. Soil conservation by preventing soil erosion, mulching, crop rotation and avoiding bush burning.
3. Plant protection from pests and diseases.
4. Cultivating more land.
5. Plant breeding to develop improved varieties of plants.
6. Use of correct cultural practices.

Furthermore, Smith (2000) observed that diversification of income source is an adaptation strategy including off-farm employment which has the potential to reduce vulnerability to climate related income loss.

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