ASSESSMENT OF STRENGTH OF ASSOCIATION BETWEEN CLIMATIC PARAMETERS AND SOME SELECTED CROPS IN FUNTUA, KATSINA STATE, NIGERIA

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Abstract
Agricultural production in Nigeria and particularly Funtua Local Government Area of Katsina State is rain-fed hence it is dependent on weather. This situation threatens food security and leads to poverty, among the farmers in the study area. This eventually leads to shortage of food, increasing importation of "common" foodstuffs especially sorghum, millet and maize, hike in the prices of foodstuffs and mal-nutrition in the study area. This paper assesses the strength of association between climatic parameters and some selected food crops in Funtua, Katsina State, Nigeria. Multiple regression and analysis of variance were adopted for interpretation and analysis. The study revealed that there is correlation coefficient of 1.00 which indicates a sharp increase in the degree of association between sorghum yield, maize yield and annual rainfall and this shows that, the higher the annual rainfall, the higher the crop yields. Correlation coefficient of 0.65 for sorghum and 0.97 for maize indicates an increase in the degree of association between maximum temperature and annual food crop precisely maize and sorghum. The study also revealed that the ratio between the variance estimates (F) was 1.75 and since the calculated F of 1.75 was lower than 3.24, so the predictors (relative humidity, maximum temperature and annual rainfall) does not significantly differ as some independent variables, and any of them can be chosen as the independent variable for the crop yields in the study area. It is recommended that drought resistant and short duration high yielding crops should be developed through research efforts and made available to farmers in the study area.
Keywords: Climate, Climatic variability, Food Security, Food crops, Strength and Association

Introduction

Climate variability is a major environmental problem of our time that is threatening the existence of man and the environment. It is a major threat to agricultural system and food security in many countries in sub-Saharan Africa (Nigeria inclusive). Climate variability refers to all variability in climate as a result of natural variations and human activities. Natural variation is due to increase in the concentration of carbon dioxide and other heat trapping gases (such as methane, ozone, nitrous oxide, carbon monoxide and water vapour) in the atmosphere (Eboh, 2009).

Jones and Thornton (2003) estimate that, due to increased temperatures and erratic rainfall, crop yields in Africa may fall by 10 to 20% by 2050. However, this figure masks variation. In some areas crop reductions will be greater (northern Uganda, southern Sudan, and the semi-arid areas of Kenya and Tanzania) while in other areas crops yields may increase (southern Ethiopia highlands, central and western highlands of Kenya and the Great Lakes Region) Thornton and Smith, (2009). Analysis of climate risk identified maize in southern Africa as one of the most important crops in need of adaptation investments (Lobell *et al.*, 2008). Climate change projections suggest that by 2030 maize yields in southern Africa will be 50% of the average yields achieved at the beginning of this century.(Lobell et al, 2008).

Agricultural production in Nigeria and particularly Funtua Local Government Area of Katsina State is rain-fed hence it is dependent on weather. Climate variation

refers to a change in climatic conditions that is attributable directly or indirectly to natural or human causes. IPCC (2007) assessment reports predicted increased evapotranspiration and lower soil moisture levels in drier areas as a result, some cultivated areas may become increasingly arid. Several factors that directly connect climate variability and agricultural productivity include; average temperature increase, change in rainfall amount and patterns, rising atmospheric concentrations of CO_2 pollution levels and climatic variability with associated extreme events such as drought, flood and storms. All these impact negatively on crop production in the study area.

The location of the study area, in the arid zone makes it vulnerable to the gradual desertification due to the persistent deforestation and overgrazing. This has greatly affected the socio-economic life of the inhabitant. Population pressure and human activities coupled with non-adherence to existing legislation against land degradation problem pose serious threat to humans and livestock in the entire Local Government Area. Every year, farmers in Funtua Area are usually in high spirit to plant their crops in anticipation that yields would be bountiful. Though as it may, this is not usually the case as crop failures are witnessed annually. The situation threatens food security and leads to shortage of food, increasing importation of "common" foodstuffs especially rice, millet and maize, hike in the prices of foodstuffs, mal-nutrition and so on in the study area. The resultant effect is hunger and poverty among the populace. Against this background, the present study is designed to assess the strength of association between climatic parameters and some selected crops in funtua.

Study Area

Funtua is a Local Government Area in Katsina State of Nigeria and is located within latitude 11^0 32'N and 11^0 53N of the equator and longitude 7° 19'E and 7° 31E and it has an area of 448 km² and a population of 225,571 at the 2006 Census (National Population Census, 2006) 420,110 in 2012 estimate. Funtua became a Local Government in 1967 and the inhabitants of the Local Government are predominantly Hausa and Fulani by tribe. The major occupations are Trading, farming and animal rearing.

The geological formation of the area is of the basement complex origin in the south and sedimentary formation in the north giving rise to the clay, loamy and sandy soil in the south and north respectively.

Weather varies according to the season of the year. Maximum temperature ranges from 29^0 – 38^0C. Harmattan season (November – February). Lower temperature from 18^0 - 27^0C. The wind is dry from January to April, signaling the arrival of the rainy season, which last from April to September. The mean average rainfall ranges from 400-1300mm.

Funtua consists largely of shrubs vegetation with some wooded savanna in the south. Due to the vast arable land which nature has bestowed on the state, it is currently playing a leading role in commodity and food production namely, cotton, groundnut, millet, guinea corn, maize, wheat and vegetables.

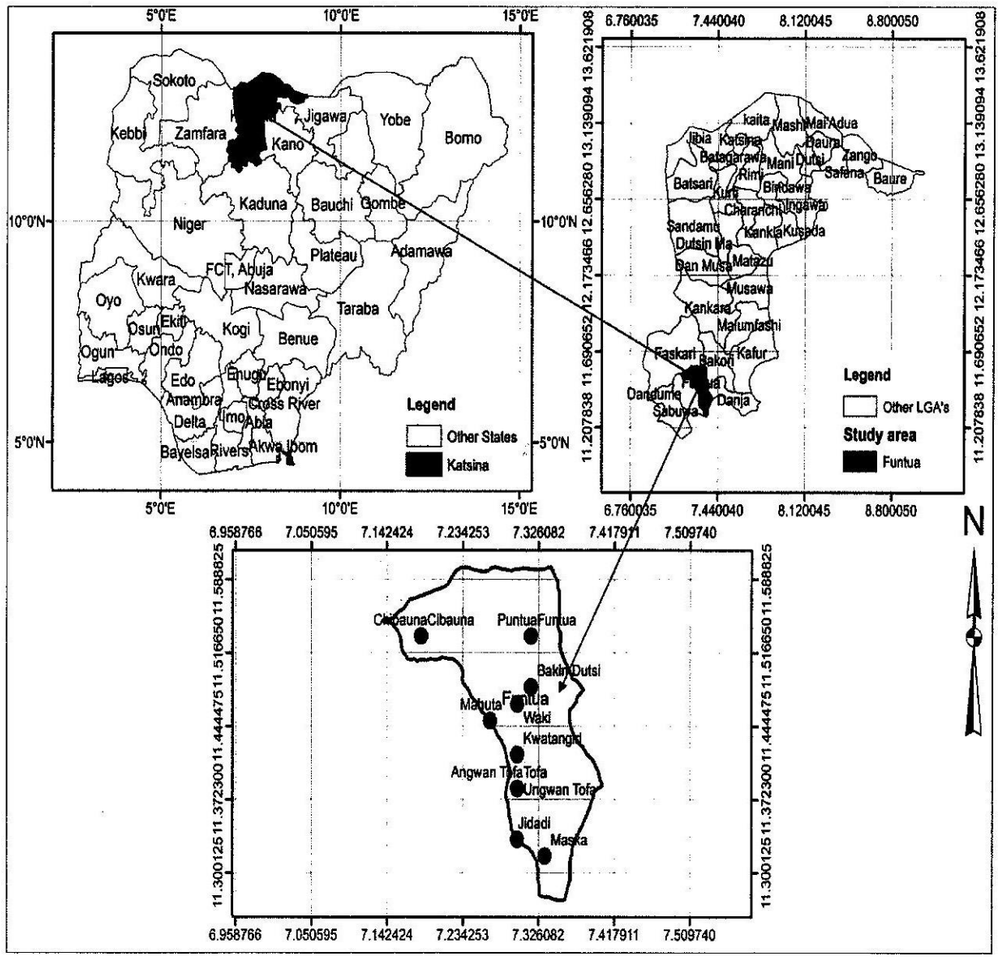

Figure 1: Location of the Study Area (Funtua LGA, Katsina State, Nigeria)

Source: Department of Geography FUT, Minna, (2015)

Materials and Methods

The research work utilized both primary and secondary data. The secondary data collected from KTARDA and NIMET includes crop yield data and climatic parameters data respectively. The crop yields include (maize and sorghum) and climatic parameters include (rainfall, relative humidity and temperature).

The crop yields data covers period of twenty years (1993-2013). The choice of the climatic parameters was based on their importance in determining the time of farm preparations and planting, growth, development and yield of crops in the study area.

Method of Data Analysis

Multiple regressions were used to test the Strength of Association between climatic parameters and crop (Maize and Sorghum) in the study area. The multiple regression equation for the three independents variables of this study include:

$$Y = a + bX_1 + cX_2 + dX_3$$

Y = Dependent variables (Maize and Sorghum yields),

X_1, X_2 and X_3 = Independent variables (annual rainfall, maximum temperature and relative humidity)

a, b, c and **d** = Regression coefficients.

Correlation analysis of weather variables and the crop yield were carried out using the Maize and Sorghum as dependent variables and the weather variable as predictors. Analysis of variance was also used to ascertain how positively or negatively linearly correlated between the weather parameters and crops (Maize and Sorghum).

Results and Discussion

Strength of Association between Climatic Parameters and the Crops

As shown in Table 1.below of this study, there exist a relationship between food crop precisely maize and sorghum in the study area and climatic parameters like annual rainfall, maximum temperature and relative humidity.

Table 1. Correlation Analysis of Weather Variables and Crop Yield

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	33948.618	3	11316.206	1.263	.320[b]
	Residual	143302.225	16	8956.389		
	Total	177250.843	19			
2	Regression	32582.760	2	16291.380	1.914	.178[c]
	Residual	144668.083	17	8509.887		
	Total	177250.843	19			
3	Regression	30629.591	1	30629.591	3.760	.068[d]
	Residual	146621.252	18	8145.625		
	Total	177250.843	19			

a. Dependent Variable: Maize Yield (000 mt)

b. Predictors: (Constant), Relative humidity(%), Annual Rainfall (mm), Max Temp (^{0}C)

c. Predictors: (Constant), Relative humidity(%), Max Temp (^{0}C)

d. Predictors: (Constant), Relative humidity (%)

At 0.05 level of confidence, the critical value of F from table is 3.24. Since the F of 1.26 is less than 3.24, thus, there is a significant linear relationship between annual rainfall and maize yield in the study area. For maximum temperature, the critical value of F from table is 3.59. Since the F of 1.91 is less than 3.59, thus, there is a significant linear relationship between maximum temperature and maize yield in the study area. And for relative humidity, the critical value of F from table is 4.41 since the F of 1.26 is less than 4.41, thus, there is a significant linear relationship between relative humidity and maize yield in the study area.

Table 2: Analysis of Variation (ANOVA) of the Variance

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-129.627	888.203		-.146	.886
	Annual Rainfall (mm)	-.058	.148	-.091	-.391	.701
	Max Temp (0C)	-13.997	29.349	-.114	-.477	.640
	Relative humidity (%)	17.312	8.945	.477	1.935	.071
2	(Constant)	-157.912	862.897		-.183	.857
	Max Temp (0C)	-13.701	28.599	-.112	-.479	.638
	Relative humidity (%)	16.463	8.457	.454	1.947	.068
3	(Constant)	-521.662	401.134		-1.300	.210
	Relative humidity (%)	15.076	7.775	.416	1.939	.068

a. Dependent Variable: Maize Yield (000 mt)

Table 2.revealed that annual rainfall, maximum temperature and relative humidity are positively linearly correlated with maize yield in the study area with 0.70, 0.64 and 0.71.
In this case, our regression equation

$(\mathbf{Y = a + bX_1 + cX_2 + dX_3})$ becomes

$\mathbf{Y = (-129.62) - 0.06 - 13.99 + 17.31}$.

This result shows that there is more of food availability and access in the study area because these food security indicators rely heavily on major climatic parameters analyzed in this study. The study also revealed that there is high strength of association between crops examined as indicators for food security with climatic parameters. With regard to food stability and utilization, there is less food stability and utilization in the study area .

Table 3. Regression between Annual Rainfall, Maximum Temperature, Relative Humidity and Sorghum Yield(ANOVA[a])

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	44288.673	3	14762.891	2.089	.142[b]
	Residual	113086.849	16	7067.928		
	Total	157375.522	19			
2	Regression	41434.528	2	20717.264	3.038	.074[c]
	Residual	115940.994	17	6820.058		
	Total	157375.522	19			
3	Regression	37913.216	1	37913.216	5.713	.028[d]
	Residual	119462.306	18	6636.795		
	Total	157375.522	19			

a. Dependent Variable: Sorghum Yield (000 mt)
b. Predictors: (Constant), Relative humidity (%), Annual Rainfall (mm), Max Temp (^{0}C)
c. Predictors: (Constant), Relative humidity(%), Max Temp (^{0}C)
d. Predictors: (Constant), Relative humidity (%)

At 0.05 level of confidence, the critical value of F from table is 3.24. Since the F of 2.09 is less than 3.24, thus, there is a significant linear relationship between annual rainfall and sorghum yield in the study area. For maximum temperature, the critical value of F from table is 3.59. Since the F of 3.04 is less than 3.59, thus, there is a significant linear relationship between maximum temperature and sorghum yield in the study area. And for relative humidity, the critical value of F from table is 4.41. Since the F of 5.71 is greater than 4.41, thus, there is a significant nonlinear relationship between relative humidity and sorghum yield in the study area.

Table 4: Coefficients between Annual Rainfall, Maximum temperature, Relative Humidity and Sorghum Yield (Coefficients[a])

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	74.814	789.027		.095	.926
	Annual Rainfall (mm)	-.083	.131	-.139	-.635	.534
	Max Temp (0C)	-18.824	26.072	-.163	-.722	.481
	Relative humidity (%)	19.863	7.946	.581	2.500	.024
2	(Constant)	33.927	772.486		.044	.965
	Max Temp (0C)	-18.397	25.602	-.159	-.719	.482
	Relative humidity (%)	18.635	7.571	.545	2.461	.025
3	(Constant)	-454.483	362.081		-1.255	.225
	Relative humidity (%)	16.773	7.018	.491	2.390	.028

a. Dependent Variable: Sorghum Yield (000 mt)

Table 4.revealed that annual rainfall, maximum temperature and relative humidity are positively linearly correlated with sorghum yield in the study area with 0.53, 0.48 and 0.24.
In this case, our regression equation

$(Y = a + bX_1 + cX_2 + dX_3)$ becomes

$Y = 74.81 - 0.83 - 18.82 + 19.86$.

As depicted above, Climatic parameters have been the most important determinant of the climate and crop yields in Funtua Local Government Area as well as in other part of Katsina State. Inter-monthly variability in the parameters has been the key weather element that determines the success of agriculture in the study area. Crop yields in Funtua area is strongly linked to climate variability because farmers rely on rain-fed agriculture. This related with the findings of Nwajiuba, (2012) that Climate variability has been identified as one of the most crucial factors that affect sustainable agricultural production and the scope for reducing poverty in Nigeria. Therefore, any variability in climate is bound to impact on the agricultural sector in particular and other socio-economic activities in general. The impacts could be measured in terms of effects on crop growth, availability of soil water, health and availability of farm labour, soil fertility, soil erosion, incidents of pests and diseases, and sea level rise.

Conclusion

The study revealed the major climatic problems encountered by the farmers in Funtua Local Government Area which are drought, inadequate adaptation strategies, and socio-economic challenges. A strong relationship between crop yields and climatic variability, particularly the temporal change in annual rainfall, maximum temperature and relative humidity has been established. Any particular year preceded by a very wet season, high relative humidity had very high yield for maize and sorghum in the study area. Food crops such as maize and sorghum are highly sensitive to climate variability especially drought.

Therefore, it can be concluded that impact of climate variability on food crops is real and its manifestations are felt across the study area. The negative consequences of the impact of climate variability on food crops are severe among poor and vulnerable communities in Katsina State, especially Funtua Local Government which is the study area.

Recommendations

1) The need to utilize irrigation potential as subsistence or alternative to rain fed.
2) Government to embark on continuous monitoring and application of result of weather variables especially rainfall and temperature.
3) As they affect crop production, and resistant and short duration high yielding crops should be developed through research effort are made available to farmers in the study area.

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