EFFECTS OF CLIMATE CHANGE ON AGRICULTURAL PRODUCTIVITY IN THE FEDERAL CAPITAL TERRITORY (FCT), ABUJA, NIGERIA.

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http://dx.doi.org/10.4314/ejesm.v5i4.S16

Received 29th September 2012; accepted 18th October 2012

Abstract

The effects of the dynamics of climate on agricultural production are the thrust of this paper. Temperature, rainfall and crops (rice, maize, cassava, groundnut and garden eggs) data were collected for a period of 10 years from the meteorological and agricultural department of the Agricultural development programme(ADP) Gwagwalada. The work assembled and analysed all available data which are needed for evaluating the implication of climate change on agricultural production in the FCT. Some measure of central tendencies were used to critically analyse the parametres such as arithmetic mean, standard deviation, coefficient of variance, simple regression, correlation and multiple regression model to correlate the relationship among rainfall, temperature and crop yield. The paper concludes there exists positive relationship between each climatic element and crop yield but on a very weak significance; there has been constant increase in temperature over the years with 2009 having the highest of 35^{o}C; there is decline in rainfall over the years, and subsequent decline in the productivity of the crops from the correlation carried out in the study. These recommendations were forwarded: Crop yield should be regressed on other environmental factors such as soil fertility etc.; A longer period of data could be collected for better analysis; and data on rainfall, temperature and other crops could be collected and investigated upon to correlate the result with this finding.

Key words: *Agriculture, Climate Change, Crop yield, Federal Capital Territory*

Introduction

Climate change and agriculture are interrelated processes both of which take place on a global scale. Global warming is projected to have significant impact on conditions affecting agriculture, including temperature, Carbon dioxide, glacial runoff, precipitation and the interaction of these elements. These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals. The overall effects of climate change on agriculture will depend on the balance of these effects. Assessment of the effects of climate change on agriculture might help to properly anticipate and adapt farming to maximize agricultural production.

Despite technological advances, such as improved varieties, genetically modified organisms and irrigation systems, weather is still a key factor in agricultural productivity as well as soil properties and natural communities. The effect of climate on agriculture is related to variations in local climate.

Agricultural production is particularly affected by climate change. The occurrences of disasters such as the Sahelian drought of 1963-1973 or the (August) 1980 Ibadan floods remind us of the importance of the climate (Mustapha, 2009). Although the effects of drought and flood have not been experienced in the FCT, the effect of the changes in temperature and rainfall pattern is evident in the decline in crop yield and production.

As a result, these challenges of food crisis and low crop yield in the FCT proper research on the causes and effects of climate change on the agricultural production need to be done which is the basis of this work.

Food crises and other climate change related problems are issues of global concern which is of special urgency to the people of sub Saharan Africa where per capita food availability has declined significantly over the past three decades. All these have created issues of deliberation politically, economically and scientifically these few years. This therefore calls for prompt arrest of the situation or mankind will end up in serious trouble with the trend of the distortion of the

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climate that will be out of control. The phenomenon is evident in the outburst of wild fire, cyclone, and drought, flood and so on. These disasters have rendered many habitats uninhabitable for man and animals. The decrease in crop yield and increase in weed growth, pest and disease, heat wave etc in the FCT calls for attention, therefore the importance of this study may not be far reached for assessment purposes.

Climatic elements like rainfall, temperature, evapotranspiration play key role in crop yield. Vent and Fritze (1957), Agboola (1997) have emphasized that soil moisture through rainfall is very important for plants growth. When the negative aspect of rainfall on crop yield is carefully examined, it shows that rainfall can lead to the development of many pest and diseases even on the crop. Inadequate rainfall on the other hand can cause witting and desiccation. Also sunning/dry period could encourage loss of moisture through evaporation. Vent and Fritze (1957) further pointed out that temperature is very important for accumulation of organic matter as well as ripening of the plants. Rainfall on the other hand is a determinant factor in deciding which type of crop to be grown in different environments in Nigeria, the intensity, amount and duration of rainfall generally decrease from South to North and the Capital Territory yield follows the same pattern. Changes in rainfall patterns could cause soil erosion, storms, floods and drought, affecting agricultural productivity. In light of this, Suleiman (2009) observes that the climate effects would cause deepening food crisis resulting to energy decrease and general breakdown throughout the globe.

Similarly, Intergovernmental Panel on Climate Change (IPCC) has produced several reports about climate change. For instance, the third assessment report published in 2001 reported that poorest countries will be most affected by reduction in crops yields. Evidence of climate change in Nigeria are manifested in the importation of food crops like rice and wheat. Other evidences of climate include increasing evapotranspiration, decreasing rainfall amount in the continental interiors, increasing rainfall in the coastal areas, increasing disruption in climatic pattern and increasing frequency and intensity of unusual or extreme weather related events such as thunder storms, lightening, landslides, floods, drought, bushfire unpredictable rainfall pattern, sea level rise, increase desertification and land degradation, drying up rivers and lakes and constant loss of forest cover and biodiversity (Odjugo, 2010).

Impacts of climate change resulting in a decrease in agricultural production leads to food crisis. World population grows at 3% annually; while yields of major crops grows at only 1% a year (FAO, 2006). The Malthusian theory of population growth and agricultural production is gradually becoming evident in the FCT with the geometric influx of people seeking for "white collar jobs".

The study problem is therefore determined to assess challenges of the dynamics in climatic conditions that influence agricultural production in relation to the growth of population in FCT Abuja. The research has the following objectives:

i. Establish the trend of rainfall in the FCT from year 2000 to 2009
ii. Establish the pattern of temperature from year 2000 to 2009.
iii. To investigate the relationship amongst rainfall, temperature and crop yield.
iv. Identify the effect climate has on agriculture through crop yield.

Scope of the Study

The study will require temperature data, rainfall data, crop yield data, land area covered for farming, from the meteorological department of the Agricultural Development Programme (A.D.P), Gwagwalada office. This data covers the farming seasons from year 2000 to 2009 for the six area councils of the Federal Capital Territory (F.C.T). The crops will only cover randomly selected crops which are Groundnut *Arachis hypogaea;* Garden egg, *Solanum gilol* Cassava, *Manihot esculentus* Maize, *Zea mays* and Rice, *Oryza satival.* These crops are selected because, they are the major ones grown in the region.

Study Area

The study area F.C.T was founded in early 1976 in the quest to have a Federal Capital Territory that is in the centre of the country since Nigerian independence signifies neutrality and National unity. But due to economic and political instability, the initial stage of the city was not completed until the

late 1980s. The original indigenes were the Gwari, Bassa, Nupe, Nok and Ebira people. Migration in the FCT has resulted in composition of the population to include Igbo, Hausa, Yoruba, Igala and so on. The heterogeneity of the town brings together different cultures.

Location and Size

The study area, Federal Capital Territory (FCT) lies between latitude 80° 25' and 9° 25' North of the equator and longitude 6° 45' and 7° 45' East of the Greenwich meridian. It is located in the middle belt of Nigeria. Its size is equivalent to 0.8% of Nigeria (Mabogunje, 1977) it is bordered by four states: Kaduna in the North, Nassarawa in the West, Kogi in the South and Niger in the East. It covers a land mass of 8,000 square kilometers (Km^2) (Abuja master plan, 2000),

Drainage and Geology

The FCT is predominantly underlain by Precambrian magmatites, gneisses, quartz, geamites and schist of crystalline basement complex rocks, the terrain is generally undulating which controls the weather condition of the city. It has an extrusive belt of schist occurring along the south western margin of Gwagwalada. The rocks are the high grade metamorphic and igneous rocks formed in the Precambrian age. The rugged terrain is produced by the older granites. The city is drained by river Usuma, Gurara and other smaller tributaries.

Soil

The soil of the city shows a distinction in type and proportional mixture. The soils are clay silt and sand respectively. The geology produces soil characteristics of alluvial pediments, conbisols and levisols. (Abuja master plan, 2000). These soils influence the vegetation of the region and sustained peasant farming in areas like Zuba, Abaji, Shedda and Kuje.

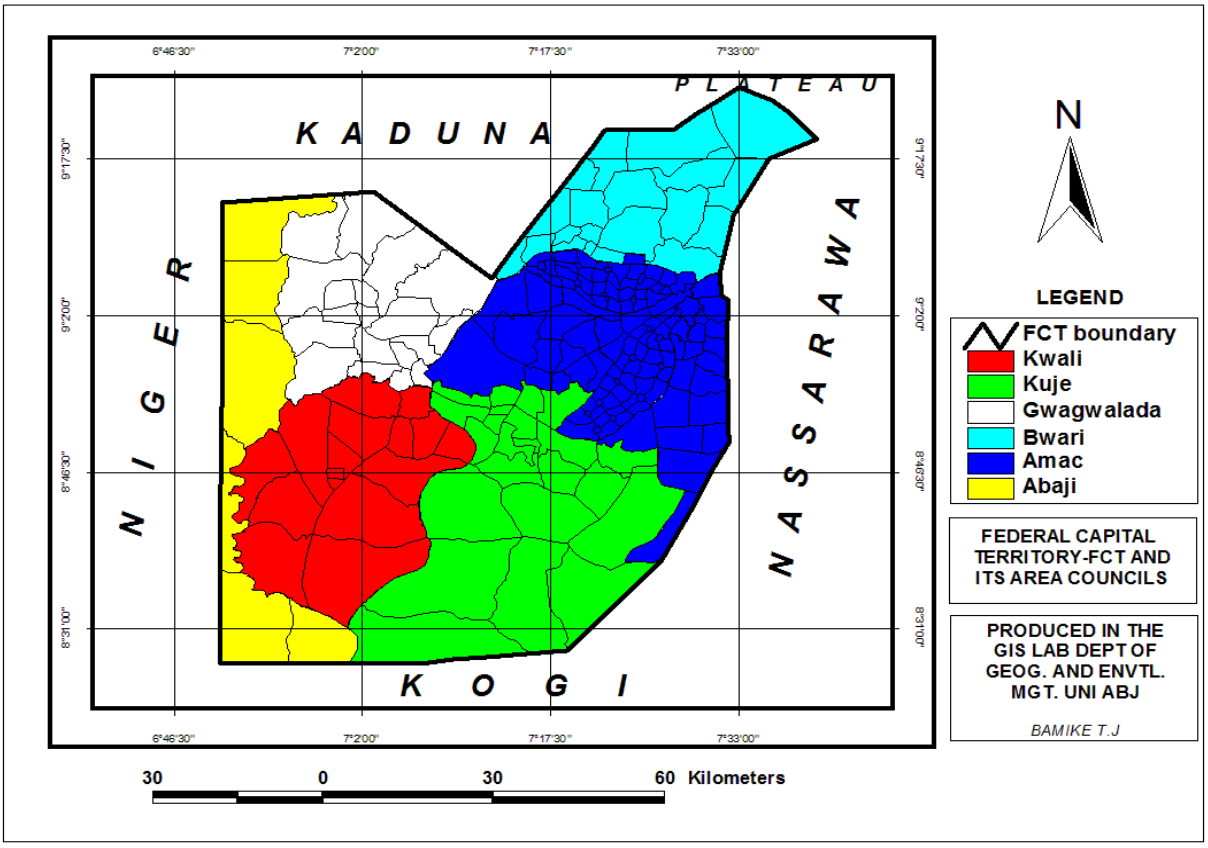

Figure 1 Map of the study area

Climate

The dry seasons record the highest temperature when there are few clouds in the FCT. The location of FCT in the middle belt region of Nigeria rids it of the extreme characteristics of climates of the North and Southern Nigeria. The region experiences two major seasons wet and dry season (Balogun, 2001).

Change in temperature of as much as 17^{o}C have been recorded between the highest and lowest temperature in a single day. During the rainy season the maximum temperature is lower due to dense cloud cover. Diurnal annual range is also much lower sometimes not more than 7^{o}C in July and August. Its temperature ranges from 30.4^{o}C and 35.1^{o}C. During the dry season, relative humidity falls in the afternoons (Abuja master plan, 2000).

The undulating nature of the terrain also affects the temperature patterns in the FCT. The rainy season usually begins in March and ends in the middle of October in the North and early November in the South. Mean annual rainfall is about 1400mm (Abuja master plan, 2000), as the result of it location on the windward side of the Jos Plateau leading to frequent rainfall and a noticeable increase in the mean annual total from the south to the North.

The beginning and the end of the season is characterized by frequent occurrence of wind storms accompanied by thunder storms and lightening followed by strong wind and rainfall of high intensity, but may last for just 30 minutes and then replaced by drizzles for hours. This condition is then replaced by a few days of bright clear skies (Abuja master plan, 2000).

Vegetation

The vegetation of the FCT is normally classified as park savannah, with scattered trees, pockets of guinea savannah, woodland savannah, derived savannah and parkland savannah. The valley of river Iku and Usuma around Gwagwalada and streams in Zuba shows characteristics of riparian vegetation.

Materials and Methods

The data used here were collected from the meteorological and Agricultural Development Programme (A.D.P) Gwagwalada FCT and it covers a period of ten (10) years from 2000 to 2009. The data were collected on some parameters such as annual rainfall and maximum temperature on a yearly basis also products like maize, rice, cassava, garden egg and groundnut and the cultivated land per hectare. The methods of data analysis include: The Multiple Regression Models.

This analysis method operates on assumption that the relationship between one variable, dependent variable y and a host of all other variables x, (1,2,3,4…n) called the independent variables, here the dependent variable is either temperature or rainfall data and the independent variables are the crop yield. These may be expressed by an equation of the form.

$Y=b_o = bx_1 = b_2 \ldots bxn = \sum \equiv$

Where

y	=	dependent variable
b_o	=	constant term
$b_{1,2}$	=	regression coefficient
$\sum$	=	error term that can enter the model

Results

The relationship of some crops and rainfall gave a negative relationship and others positive relationship. The relationship of both rainfall and temperature on most of the crops especially cassava and others showed a strong negative relationship showing that there is variation in the climatic requirement for different crops.

From the Table 1 it can be deduced that there is a constant increase in both the minimum and maximum temperature except for 1^{o}c drop in temperature in 2003, 2007 and 2009. This shows that there is yearly change in temperature that can alter the yield of certain crops in the FCT.

Table 2 shows the annual total and average rainfall in FCT Abuja from 2000-2009. The average rainfalls were gotten from the 10 months estimate of rainfall in a year. The coefficient of variation as seen above of maximum temperature 4.44% and minimum temperature 2.72 shows that there is a consistency in the variation although not too strong.

Table 1 Yearly Minimum and maximum temperature in FCT ABUJA from 2000-2009

Years	Min. Temp (^{o}C)	Max. Temp (^{o}C)
2000	24	32
2001	21	33
2002	23	33
2003	23	32
2004	24	34
2005	24	34
2006	24	34
2007	24	33
2008	25	34
2009	24	35
	$\sum X = 239$	$\sum X = 334$
	X = 23.9	X = 33.4
	STD = 1.06	STD = 0.91
	CV = 4.44	CV = 2.72

Source: FCT ADP weather Data Bank P.M.E sub programme

Table 2 Yearly total and average rainfall in FCT Abuja from 2000-2009

Years	Total Rainfall (mm)	Average rainfall (mm)
2000	1197.4	171.1
2001	1389.5	173.7
2002	1242.9	124.3
2003	1084.7	108.3
2004	1093.4	109.3
2005	911.7	91.2
2006	1340.3	148.9
2007	1401.8	175.3
2008	1304.6	145.3
2009	1470.6	143.0

Source: FCT ADP weather Data Bank PME sub programme

The data on crop yield per tones of cassava garden egg, groundnut, maize and rice covers a period of (10) ten years, that is 2000-2009 and the area cultivated in hectare over the Federal Capital Territory is presented in table 3.

Table 3 Yearly crops yield crop per hectare (C/H) from 2000-2009 in FCT Abuja

Years	Groundnut C/H	Garden egg C/H	Cassava C/H	Maize C/H	Rice C/H
2000	1.1987	6.0860	9.4480	2.1940	2.3970
2001	1.3983	6.1140	9.6390	2.2530	2.1290
2002	1.3438	6.1290	9.9360	2.2940	1.9950
2003	1.1202	6.2250	11.6500	1.6000	2.3200
2004	1.2600	6.3000	11.4800	1.6500	1.9700
2005	1.2881	6.5180	10.9350	1.8310	2.0440
2006	1.2940	6.3640	1.1350	1.9189	2.1210
2007	1.2960	6.6213	6.2029	1.6411	2.1862
2008	1.2979	9.1490	11.2110	1.8560	2.4240
2009	1.3082	10.0640	11.2840	1.8310	2.4370

Source: FCT ADP weather Data Bank PME sub programme

The Trend of Temperature

The table 1 showed the trend of temperature over the years in FCT a close look at the line graph reveals that the temperature from 2000 was constantly increasing except for the fall in 2003 and 2007, but they never went below 32°C in 2003 and 33°C in 2007. The year 2009 experienced the highest temperature of 35°C.

The Pattern of Rainfall

The bar graph in figure 2 displays the pattern of rainfall over the years in FCT. A look at the graph shows that there has not been constant rainfall pattern in the FCT. But the graph has it that 2009 recorded the highest rain fall followed by 2001.

From the graph it is observed that the rainfall pattern fluctuates between 1500mm and 900mm. this is to show that the rainfall pattern was not stable throughout the decade with the highest rainfall in 2009.

The Relationship Between Rainfall And Crop Yield

The bar graph in fig1 showed the rainfall pattern over the years. This shows that there is uneven pattern of rainfall implying that crop yield differs from year to year. This is as a result of the relationship between rainfall and the five crops samples used in this investigation.

It is also noted that the crop yield in FCT is uneven; this is as a result of the area coverage which differ from year to year. This goes a long way to affect the amount of these crops and the coefficient of variation of these crops over the Federal Capital Territory.

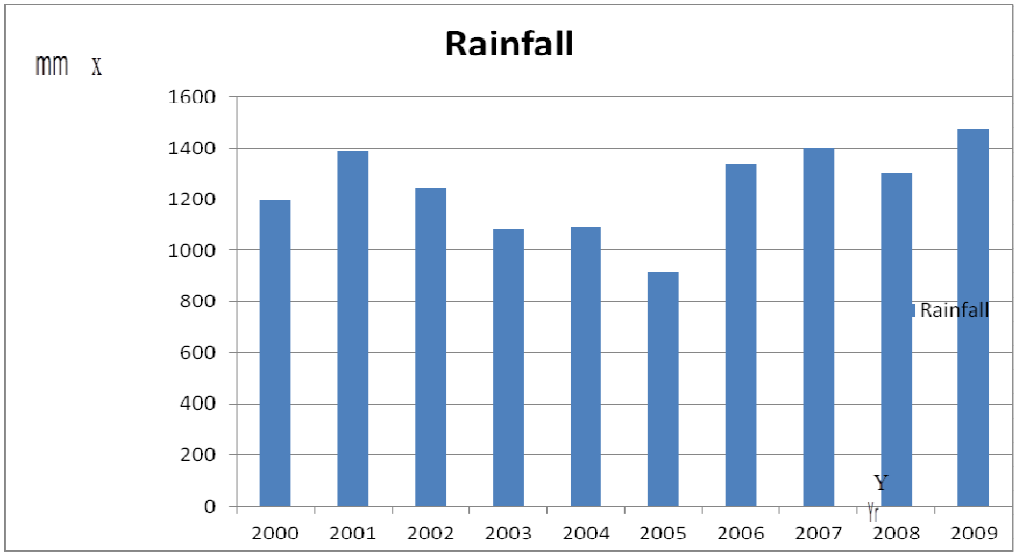

Figure 2 Rainfall pattern

The Relationship Between Temperature and Crop Yield

Table 1 shows maximum temperature over 10 years in the Federal Capital Territory. A closer look shows that 2009 has the highest maximum annual temperature of 35°C and the year 2003 has the least maximum annual temperature of 33°C. This could be explained as a result of presence of cloud cover.

The relationship between temperature and crop yields over the Federal Capital Territory, using the Pearson correlation technique where the crops are the dependent variables and temperature, the independent variable. The mean value of crops against the numbers of hectare of land cultivated and the mean value of temperature were used to determine their relationship.

The Relationship Among Rainfall, Temperature And Crop Yield

In line with the aim of this investigation or research work which is to determine the relationship among rainfall, temperature and crop yield, multiple regression was applied. The annual yield in groundnut, garden egg, cassava, maize and rice were regressed against rainfall and temperature to determine the relationship that exist between them. Thus these results were obtained from the regression, as shown in the table below:

Table 4 Summary of Regression Results

Crop	Regression Value	Remarks
Groundnut	0.37	There exist a weak positive relationship between the variables
Garden egg	0.57	There exist strong positive relationship between the variables
Cassava	0.14	There exist a weak positive relationship between the variables
Maize	0.11	There exist weak positive relationship between the variables
Rice	0.67	There exist a strong positive relationship between the variables.

Discussion

In the relationship between rainfall and the selected crops that is groundnut, garden egg, cassava, maize and rice yield which has a positive relationship means that there exist relationship between the two parameters though weak relationship were obtained like in the case of groundnut having 0.36 and maize 0.41. This could be as a result of the data being a secondary data and the author could not monitor the collection which could have some errors.

It observed that any amount of rainfall above 1800mm will have a negative effect on these two crops that is maize and groundnut. Too much rain could lead to water logging.

The correlation between rainfall, temperature and crop yield all show a positive relationship. This means that combination of rainfall and temperature has a great influence on crop yield and other environment factors such as, soil fertility, seed variety or type etc. So rainfall and temperature are controlling factors of crops yield including other environmental factors listed above. The work of Adakayi (2004) on the effect of climate change on food production in Northern Nigeria shows a strong positive relationship. This difference in result could be as a result of differences in area and source of data.

In summary, the relationship between climatic data (rainfall and temperature) and crop yield of five (5) selected crops that is groundnut, garden egg, cassava, maize and rice for 10 years in ton/hectare is established. The proportion in variation of crop yield that is explained by both rainfall and temperature for ten (10) years considered for the different crops showed above 50%.

Conclusion

We concluded that the relationship between climatic elements and crop yield over the Federal Capital Territory is positively significant but very weak which is not in agreement with works done in other areas. This means that rainfall and temperature influence crop yield but other environmental factor such as soil fertility, type, and temperature technology etc. should also be put into consideration.

Recommendations

Based on the findings of the present research work, we recommend as follows:

- Crop yield should be regressed on other environmental factors such as soil fertility etc.
- A longer period of data could be collected for better analysis
- Data on rainfall, temperature and other crops could be collected and investigated upon to correlate the result with this finding.

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