EFFECT OF CLIMATE VARIABILITY ON SOME TUBER CROP YIELDS IN THE FEDERAL CAPITAL TERRITORY (FCT), NIGERIA

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Abstract
Climate is the most important factor that determines crops distribution, cultivation, growth and yield in Nigeria. This study aimed at looking at the effect of climate variability on Yam and Cassava yields in the Federal Capital Territory (FCT), Nigeria. Rainfall and temperature data for 32 years as well as yam and cassava yields data for 15 years were collected from the Nigerian Meteorological Agency (NIMET), Abuja and Agricultural Development Programme (ADP), Gwagwalada, Abuja and used for the study. Results were presented in both figures and tables. The data were subjected to various statistical analyses such as mean, kurtosis, skewness, coefficient of variation, time series, correlation, regression analysis, standard deviation and percentage change. Findings revealed that the study area observes two (2) seasons namely, rainy and dry with April (mean rainfall of about 79.5 mm) as the onset and October (mean rainfall of about 187.6 mm) as the cessation of rains. August has the highest mean rainfall of about 355.6 mm, while January has the least mean monthly rainfall of about 3.0 mm. The inter-annual temperatures range between 32^oC-34^oC. Also, a significant positive change in yam yield of 6.33Mt/Ha and 3.17 Mt/Ha for cassava occurred between year 2000 and 2014. Further findings revealed weak positive relationship of 0.3 each between rainfall and temperature with yam yield as well as weak negative relationship of -0.2 and -0.3 between rainfall and temperature with cassava yield. The R^2 for both yam and cassava are84.2% and 73%, while the p-value is <0.001 which is less than the significant level of 0.05.The study recommends the use of hybrid varieties by farmers so as to help in sustaining and improving the yields of yam and cassava, continuous weather monitoring as well as irrigation.

Keywords: Climate variability, rainfall, temperature, yam yield, cassava yield

Introduction
Many African countries which have their economies largely based on weather-sensitive agricultural productions systems like Nigeria are particularly vulnerable to climate change(Dinar *et al.*, 2006). The vulnerability of the Nigeria's agricultural sector to climate change is of particular interest since it is a key sector in the economy which account for 60-70% of the labour force and contributing 30-40% of the nation's gross domestic product(GDP). The sector is also the source of food crops, raw materials for agro–allied industries as well as a source of foreign exchange earnings. According to Balogun (2001), agriculture is regarded as an essential way of life of the indigenous people in the Federal Capital Territory, Nigeria and practiced by about 85% of the indigenous inhabitants. Most of the crops produced by these farmers are cereals and tubers (yam and cassava).

Agricultural practice in Nigeria is mainly rain-fed (Hassan *et al.*, 2011;Audu*et al.*, 2018a) and so, is vulnerable to the effects of climate change and variability particularly, tuber and cereal crops which are the major crops produced in the north of the confluence of Rivers Niger and Benue (Etiosa & Matthew, 2007). The performance of the agricultural sector is determined by crop production which depends on a large number of important climatic factors such as rainfall, temperature and relative humidity (Bello *et al.,* 2012).High temperatures during crop reproductive development are particularly injurious (Aliyu *et al.*, 2012).According to Muyiola *et al.* (2016), Nigeria is a tropical country with high annual temperature which is favourable to crop production (Audu *et al.*, 2014).

Variability in intra and inter annual rainfall is very common in Nigeria. Ayanlade *et al.* (2010) reported that rainfall variability is very high in most part of northern Guinea Savanna (Yola, Minna, and Kaduna) except Jos which has a unique pattern and a significant relationship with tuber yield (cassava and yam). Rainfall, being the most important source of soil moisture is possibly the most important factor determining the productivity of crops (Aliyu *et al.*, 2012). Recent short-term climatic variability and most particularly rainfall fluctuations are becoming increasingly of concern to the government and the people because its variability determines the planning zones of agriculture (Yusuf and Mohammed, 2011). Yakubu *et al.* (2015) stated that rainfall is the climatic variable of primary importance in shaping the spatial and temporal variations of agriculture in the tropics. According to Ibrahim *et al.* (2018), rainfall agriculture remains the most important economic activity in Nigeria and a key barrier to its success has remained largely irregular rainfall regime.

In a research conducted by Duru (2011) on global warming and its impact on subsistence agriculture in Orlu LGA, Imo State, Nigeria using data on temperature and rainfall, it was discovered that increasing temperature led to decrease in yields of cassava and yam. The study of Eze *et al.* (2014) on the effects of rainfall variability on crop yield in Niger Sate, Nigeria using rainfall data showed that yields of most crops are negatively affected by rainfall variability.

There seems to be several researches conducted on climate variability and crop yields in Nigeria. However, none of these researches covered the Federal Capital Territory (FCT) and particularly yam and cassava. The aim of this study is to look at the effect of climate variability on yam and cassava yields in FCT, Nigeria.

Research Questions

(i) What are the attributes of mean monthly rainfall and temperature in the study area?
(ii) What are the trends of yam and cassava yields in the study area?
(iii) What are the relationships between rainfall and temperature with yam and cassava yields over the study area?

Study Area

The study area is the Federal Capital Territory (FCT), Nigeria which is located between longitudes $6^{o}45^{1}$-$7^{o}45^{1}$east and latitudes $8^{o}25^{1}$-$9^{o}25^{1}$ north. It covers about 8000km^2 and occupies about 0.87% of Nigeria. It is bordered by Nasarawa, Niger, Kogi and Kaduna States (Balogun, 2001). It consists of six (6) Area Councils namely; Abuja Municipal, Kuje, Gwagwalada, Bwari, Abaji and Kwali. The hydrological growing days (HGD) or length of growing season is about 220 days. It has high temperature of about 31^{o}C. Its vegetation is Guinea Savanna (Balogun, 2001).

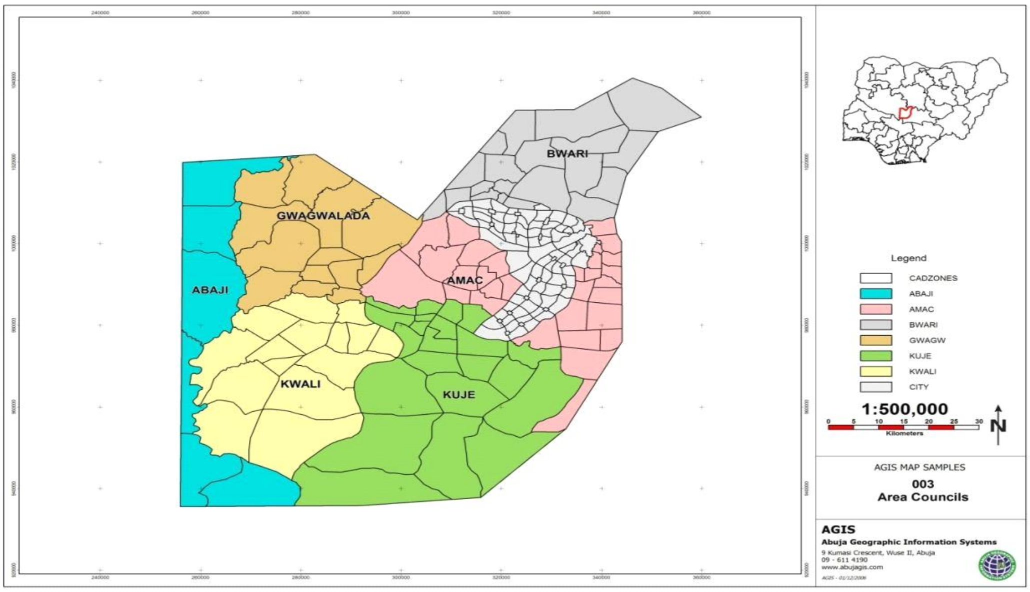

Figure 1: Map of the study area
Source: Abuja Geographic Information System (2019)

Methodology

Mean monthly rainfall and temperature data used for this study were collected from Nigerian Meteorological Agency (NIMET), Abuja. It covered a period of thirty two years (1983-2014). Data on yields of yam and cassava (Mt/Ha) for a period of fifteen (15) years (2000-2014) were collected from Agricultural Development Programme, (ADP), Gwagwalada, FCT. This corresponds with the years that data were available.

Monthly mean rainfall was used to determine the major attributes of rainfall as well as temperature and was calculated thus:

$\bar{x} = \sum \frac{xi}{n}$ eqn. 1

Where: $\bar{x} = mean,$ $\sum$= summation, *xi*= rainfall and temperature values*, n*=no of years.

Percentage (%) change was used to determine the rate of trends either positive or negative of both cassava and yam yields and was calculated thus:

Let y^1= year 1, $y^2 = \text{year } 2$; % change = $y^2 - y^1$ eqn.2

The extent of variability in relation to the mean was calculated after Ismail (2014) as thus:

CV=$\frac{\sigma}{\bar{x}} * 100$ eqn. 3

Where: $\sigma = \text{standard deviation}, \bar{x} = \text{mean}$

The standardized coefficient of skewness (G_1) and kurtosis (G_2) were usedto determine if the data collected were normally distributed in order to use the parametric statistics in their further analysis (Adakayi *et al.*, 2016).

Standard deviation (δ) was used to measure the spread of the data about the mean value and was calculated thus:

$\sigma = \sqrt{\frac{\sum(x-\bar{x})^2}{n}}$ eqn. 4

Where: σ = standard deviation, $\sum$= summation, $\bar{x}$= mean, *x*= any number

Time series analysis was used to show the temporal and spatial distribution of mean monthly and inter-annual temperature.

To determine the relationships between rainfall and temperature with the yields of yam and cassava, the Pearson (*r*) correlation coefficient was used as shown in equation 5.

$r = \frac{n(\sum xy)-(\sum x)(\sum y)}{\sqrt{[n\sum x^2-(\sum x)^2][n\sum y^2-(\sum y)^2]}}$ eqn. 5

Where: r = Pearson Correlation Coefficient., n = number of the pairs of the stocks., $\sum xy$ = sum of products of the paired stock., $\sum x$= sum of the x scores., $\sum y$= sum of the y scores., $\sum x^2$= sum of the squared x scores., $\sum y^2$= sum of the squared y scores

To test the goodness of fitness of the relationships between rainfall and temperature with the yields of yam and cassava, coefficient of determination R^2 or r^2 was used as shown in equation 6 after Enders (2013).

$R^2 = {}^{MSS}/_{TSS} = (TSS - RSS)/TSS$ eqn. 6

Where: MSS= model sum square, TSS= total sum of squares associated, RSS= the residual sum of squares of the measurements minus the prediction from the linear regression. High R^2 values indicate that the model is a good fit.

Results and Discussions

Figure 2 shows the mean monthly rainfall over the study area, 1983-2014.

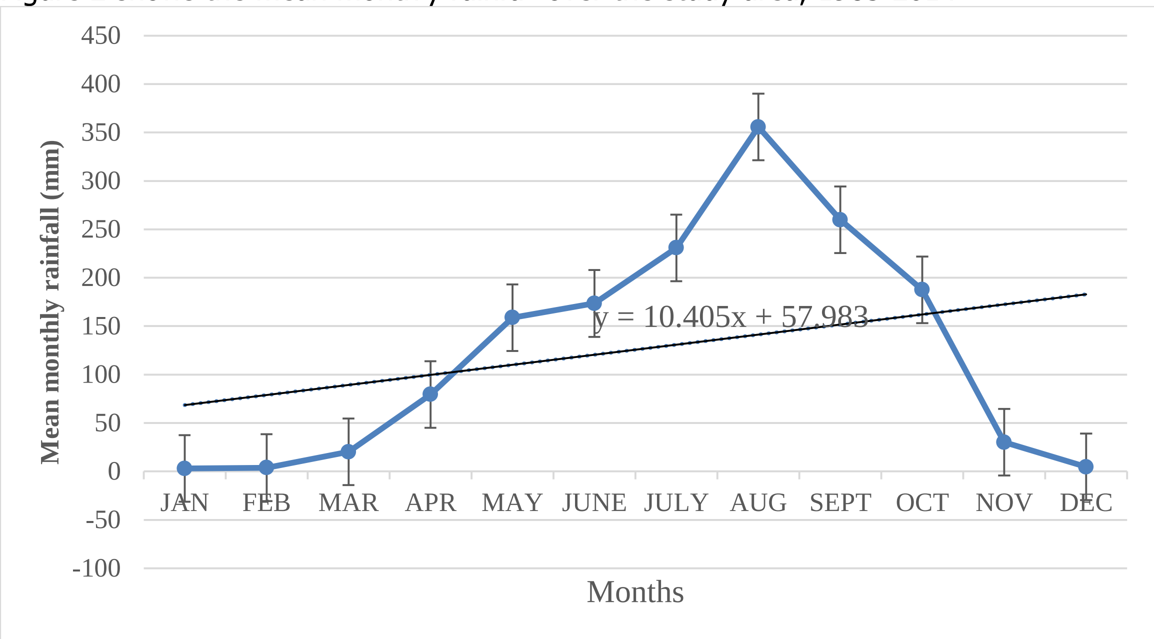

Figure 2: Mean monthly rainfall over the study area, 1983-2014

The findings in Figure 2 indicate that the study area experiences two (2) seasons such as rainy and dry seasons with the months experiencing different amount of mean rainfall with the lowest in January (3.0 mm), February (3.9 mm), March (20.1 mm), November (30.2 mm) and December (4.6 mm) which are dry season months. According to Audu *et al.* (2018b), in the tropics; rainfall is seasonal occurring mostly in wet season. The highest mean monthly rainfall of about 355.6 mm occurs in August. April and October are the onset and cessation of rain in the study area with mean of 79.5 mm and 187.6 mm. This result agrees with the study of Umar (2010) which opined that the onset of rain is that month in which accumulated total rainfall is in excess of 51 mm. Cessation of rain on the other hand is the date after which no more than 51 mm of rain is expected. Over the study area, the derived rainfall parameters are probably the most important agro-climatological factors. According to Yahaya and Abubakar (2012), rainfall onset, duration and cessation are useful in agricultural decision. So, April which marks the onset of wet season corresponds with the planting period for yam and cassava.

Figure3 shows that temperature is generally high and favourable for crop production over the study area. Highest mean annual temperature (34^o C) was recorded in 1995, while the lowest (32^o C) was 1986 with an increasing trend. This result agrees with the study of Odjugo (2010) which observed an increasing temperature over the semi-arid region of Nigeria.

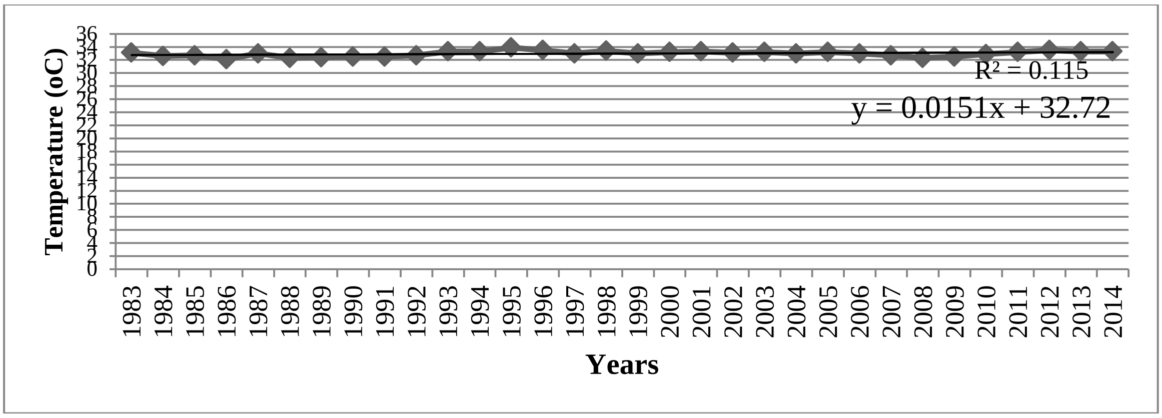

Figure 3: Inter annual temperature of Abuja, 1983 -2014 (32 years)

Table 1showsthat there is a significant positive change in both yam and cassava yields. In year 2000, the yield of yam was 14.07 (Mt/Ha) while it increased to 20.40 (Mt/Ha) in 2014 indicating a significant change of 6.33 (Mt/Ha). The percentage change of yam, 2005–2007 was negative with 2005 having the highest value of -223. All other years have positive values with 2008 having the highest positive change of 360. In the case of cassava, in year 2000, the yield was 8.39 (Mt/Ha) while it increased to 11.56 (Mt/Ha) indicating a change of 3.17 (Mt/Ha).Percentage change for cassava shows that, three (3) years recorded negative change that is, 2004, 2005 and 2008 in which 2008 has the highest negative change of -245. Other years have positive change with 2003 having the highest positive change of 170. According to Olanrewaju (2010a), rainfall amount plays the strongest positive relationship with yam yield in Kwara State of 0.66 which is significant at 99.9% confidence level.

Table 1:Yam and cassava yields in Federal Capital Territory, Nigeria, 2000-2014

Year	*Yam yield(Mt/Ha)	% change in yam yield	*Cassava yield(Mt/Ha)	% change in Cassava yield
2000	14.07	-	8.39	-
2001	14.42	35	9.63	124
2002	14.98	56	9.95	32
2003	15.23	25	11.65	170
2004	15.84	61	11.48	-17
2005	13.61	-223	10.93	-55
2006	12.55	-106	12.51	158
2007	12.42	-13	13.66	115
2008	16.02	360	11.21	-245
2009	16.09	7	11.28	7
2010	17.31	122	11.32	4
2011	17.35	4	11.37	5
2012	18.18	83	11.41	4
2013	18.81	63	11.46	5
2014	20.4	159	11.56	10

**Sources: ***Agricultural Development Programme, (ADP), Gwagwalada, FCT(2017).

In table 2, highest annual rainfall was observed in year 2002 (2011.1 mm), lowest annual was in 2015 (1096.20 mm),long term mean is 1421.1mm, standard deviation is 194.50mm and coefficient of variability is 13.17, kurtosis and skewness values are 1.197 and 0.098 respectively. The result on lowest mean rainfall slightly contradicted Nigerian Meteorological Agency(NiMet, 2018) which observed that Abuja recorded total annual rainfall of 1003 mm in 2018. The long-term mean temperature is 33^{o}C with standard deviation of 0.41^{o}C. The lowest and highest inter-annual values of temperature are about 32^{o}C and 34^{o}C respectively while temperature trend seems to be rising. The rise in temperature could be attributed to anthropogenic activities which have been identified as one of the two factors and the main factor causing global warming, climate variability and climate change (Yahaya *et al.*, 2011).

These anthropogenic activities are mostly urbanization, deforestation, bush burning, road constructions and burning of fossil fuel. These attributes of rainfall and temperature are favourable for yam and cassava productions. -0.32 and -0.19 are the values of the Kurtosis and Skewness. The average yam yield is 15.81Mt/Ha with standard deviation of 2.29. The minimum and maximum yam yields are 12.42 and 20.40Mt/Ha. The kurtosis and skewness are –0.38 and -0.34 respectively. Cassava has a mean yield of 11.19Mt/Ha with standard deviation value of 1.21Mt/Ha. The minimum and maximum values are 8.39 and 13.66Mt/Ha respectively. According to Olanrewau (2010a), temperature displays weak positive relationship with yam yield in Kwara State. The kurtosis value is 1.97 while the skewness value is -0.47.All the variables have relatively low variability, while their coefficient of variability suggests that the variables show low deviation relative to their means. The implication of these results is that, mean values of yam and cassava yields are high with that of yam higher.

Table 2: Descriptive statistics of climate variables with yam and cassava yields

Descriptive Statistic	Rainfall (mm)	Temperature (^{o}C)	Yam yield (Mt/Ha)	Cassava yield (Mt/Ha)
Mean	1421.1	32.97	15.81	11.19
Standard Deviation	194.50	0.41	2.29	1.21
Coefficient of variability	13.17	1.24	14.49	10.81
Minimum	1096.20	32.10	12.42	8.39
Maximum	2011.70	33.90	20.40	13.66
Range	915.50	1.80	7.99	5.27
Kurtosis	1.197	-0.32	-0.38	1.97
Skewness	0.798	-0.19	0.34	-0.47
N	32	32	15	15

In figure 4, it was observed that there were increases in the yearly yields of the two (2) tuber crops over the study period. Yam yield (20.4 Mt/Ha) was higher than cassava (11.6 Mt/Ha) except for 2006 when the yields were almost equal (yam 12.6 Mt/Ha and cassava, 12.5 Mt/Ha)and 2007 when cassava yield (13.7 Mt/Ha) rose higher than yam (12.4 Mt/Ha). Yam yield is on the increase except for 2005–2007 when a decline occurred. Cassava yield isalso on the increase especially between 2000 and 2007 thereby resulting in positive trend. This result agrees with the findings of Thompson and Amos (2010) which observed increases in both cassava and yam yields in Nigeria.

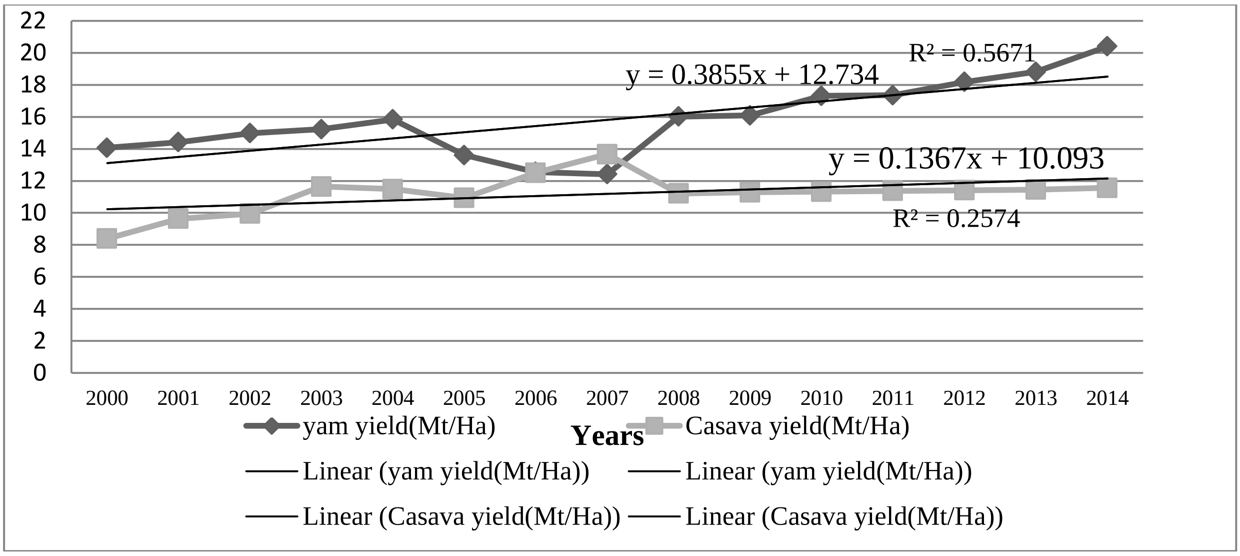

Figure 4:The time series plot of yam and cassava yields in Abuja (2000-2014)

Result on Pearson Correlations Coefficient (*r*) in table 3 shows that the correlation coefficient of rainfall with Yam yield is approximately 0.3. This means that there is a weak positive relationship between rainfall and yam yield. This result agrees with the findings of Olanrewaju (2010b) on rice production in Edu and Lafiagi LGA, Kwara State, Nigeria. In order words, an increase in this climate parameter will result in an increase in yield. The R^2 for both yam and cassava yields are 56.7% and 25.7%. There is a weak positive relationship between temperature and yam yields because the correlation coefficient between temperature and Yam yield is about 0.3. According to Ibrahim *et al.* (2016), increasing temperature has been associated with pests and diseases which also affects yield of crops greatly. Further analysis revealed that rainfall and cassava yields have negative weak relationship of approximately -0.2. The correlation coefficient for temperature and cassava yield is approximately -0.3. This means that, there exists a weak negative correlation between temperature and cassava yields.

Table 3:Correlation of yam and cassava yields with rainfall and temperature 2000-2014

		Rainfall	Temperature
Yam yield	Pearson Correlation	0.3	0.3
	Sig. (2-tailed)	0.91	0.31
	N	15	15
Cassava yield	Pearson Correlation	-0.2	-0.3
	Sig. (2-tailed)	0.94	0.30
	N	15	15

Table 4 shows the coefficient of determination (R^2) for testing goodness of fit of the relationship between rainfall, temperature and yields of yam and cassava in FCT.In the case of yam yields, the R^2 =0.842, R= 0.908 and adjusted R^2 = 0.823. There is quite considerable significance of the model and it indicates that the regression model is of a good fit. The R^2shows that 84.2% of total variability in yam yield is as a result of the effect of the climatic parameters, while other climatic variables like relative humidity may also play an important role since there is remaining 15.8%.

For cassava yield, the R^2 =0.730, R= 0.854 and adjusted R^2 = 0.702. Also, these results show the significance of the model and it indicates that the regression model is of a good fit.The adjusted R^2 of 73% shows that the total variability in yield of cassava is as a result of the effect of the climatic parameters since there is remaining 27%.Similarly, the analysis of variance (F-statistic) at 0.05 level of significance with the degree of freedom shows that the regression result is significant. Hence, the p-values (<0.001) is less than the level of significance (0.05). Therefore, it can be concluded that the model is a good fit for the data. The result of this study concurred with the findings of Ishaya*, et al.*(2014) which observed that tuber crops such as cassava, yams and sweets potatoes may not be negatively impacted by climate variability.

Table 4: Model Summary

Crops	R	R Square	AdjustedR Square	Std. Error of the Estimate	F	Sig.
Yam yield	0.908[a]	0.842	0.823	58.70004	281.900	<0.001
Cassava yield	0.854[a]	0.730	0.702	53.46092	226.303	<0.001

a. Predictors: (Constant), temperature, rainfall

Conclusion and Recommendations

The study looked into the effect of climate variability on some tuber crop yields in the Federal Capital Territory, Nigeria. Data on rainfall, temperature for 32 years and yields of yam and cassava (MtHa) for 15 years were obtained from the Nigerian Meteorological Agency, (NiMet) and Agricultural Development Programme (ADP), Gwagwalada and used for the study. Descriptive statistics such as mean, percentage, variability and standard deviation were used to analysed the results. Findings revealed that the study area observes two (2) seasons namely, rainy and dry with April (mean rainfall of about 79.5 mm) as the onset and October (mean rainfall of about 187.6 mm) as the cessation of rains. August with the mean of about 355.6 mm has the highest mean monthly rainfall while January with the mean rainfall of about 3.0 mm is the driest month. The inter-annual temperatures range between 32^oC-34^oC. The study also revealed a significant positive change in yam yield from 14.07 (Mt/Ha) in 2000 to 20.4 (Mt/Ha) in 2014 with a significant change of 6.33 (MtHa). Cassava witnessed a significant positive change from 8.39 (Mt/Ha) in year 2000 to 11.56 (Mt/Ha) in 2014 with a significant change of 3.17 (Mt/Ha). Further findings revealed weak positive relationship of 0.3and 0.3 between rainfall and temperature with yam yield as well as weak negative relationship of -0.2 and -0.3 between rainfall and temperature with cassava yield. The R^2 for both yam and cassava are84.2% and 73%, while the p-value is <0.001 which is less than the significant level of 0.05. The study recommends the use of hybrid varieties by farmers so as to help in sustaining and improving the yield of yam and cassava, continuous weather monitoring as well as irrigation.

References

Abuja Geographic Information System (2017). *Map of the study area*.

Adakayi, P. E., Sunday, S., & Eziashi, A. L. (2016). Annual trend in maximum temperature in Northern Nigeria. *Journal of Development and Society*, 3(1), 56-71.

Agricultural development project, Gwagwalada (2017). yam and cassava yields.

Aliyu, U., Shamaki, M. A., Ibrahim, K., & Tahir, M. B. (2012). Climate change and sustainable crop production in Sokoto State. Vulnerability and adaptation. In M. A. Iliya., M. A. Abdulrahim., I. M. Dankani., & A. Opponkumi (eds). *Climate change and sustainable development.* Department of Geography, Usumanu Danfodio University, Sokoto and Association of Nigerian Geographer. Pg. 16.

Audu, E. B., Muhammed, A. Y., Umar, A., & Audu, H. O. (2014). Climate change impact on rainfall pattern and the implication on food security in Lokoja Local Government Area of Kogi State, Nigeria. *Development Journal of Science and Technology Research (DJOSTER)*, *3*(1),48-59.

Audu, E. B., Abubakar, A. S., Ojoye, S., Muhammed, M., & Mohammed, S. Y. (2018a). Characteristics of annual rainfall over Guinea Savanna Zone, Nigeria. *Journal of Information, Education, Science and Technology (JIEST)*, *5*(1), 87-94.

Audu, E. B., Abubakar, A. S., Ojoye, S., Muhammed, M., & Abenu, A. (2018b). Trend in heavy rainfall over the Guinea Savanna Zone, Nigeria. *Journal of Information, Education, Science and Technology (JIEST)*, *5*(1),95-102.

Ayanlade, A., Odekunle, T. O., & Orimoogunje, O. O. I. (2010). Impact of climate change variability on tuber crops in guinea savannah part of Nigeria. *AGIS Approach, 2*(1),27-35.

Balogun, O. (2001). *The federal capital territory of Nigeria: A Geography of its development.*Ibadan:University of Ibadan Press Limited. Pp.1–15.

Bello, O. B., Ganiyu, O. T., Wahab, M.K.A., Afolabi, M. S., Oluleye, F., Ig, S. A., Mahmud, J., Azeez, M. A., & Abdulmaliq, S. Y. (2012). Evidence of climate change impacts on agriculture and food security in Nigeria. *Int. J. Agric. and Forestry, 2*(2),49-55DOI.

Dinar, A., Hasan, R., Kurukulasuriya, P., Benhin, J., & Mendelsohn, R. (2016). The policy nexus between agriculture and climate change in Africa. *A Synthesis of the investigation under the GEF/WB Project: Regional Climate. Water and Agriculture: Impacts and Adaptation of Agro-Ecological Systems in Africa*. CEEPA Discussion Paper No. 39. Centre for Environmental Economics and Policy in Africa, University of Pretoria.

Duru, P. (2011). Global warming and its impact on subsistence agriculture in Orlu LGA, Imo State, Nigeria. *Journal of Geography and the Environment*. Department of Geography, University of Nigeria, Nsukka. *2*(1&2),30-236.

Enders, F. B. (2013). Coefficient of determination. *Encyclopedia Britannica, n.p.*

Etiosa, U., & Matthew, A. (2007). Coping with climate change and environmental degradation in the Niger delta of southern Nigeria. *Community Research and Development Center, Benin, Edo State, Nigeria. Pg. 11*

Eze, J. N., Aliyu, U., & Ogunremi, L. T. (2014). The effects of rainfall variability on crop yield in Niger State, Nigeria. In B. T. Tyubee, M. I. Ocheri and Mage, J. O. (eds). *Nigerian Meteorological Society Book of Conference Proceedings*. International Conference on Climate Change and Sustainable Economic Development. Pg. 40.

Hassan, S. M., Celestine, E. I., Abdullahi, J., Gerald, N., & Timothy, S. T. (2011) Assessing the vulnerability of agriculture to climate change in Nigeria. *Draft of strategies for adaptation to climate change in rural sub-Saharan Africa*: Targeting the Most Vulnerable. Pp1-2.

Ibrahim, H. K., Ojediran, E. O., Adeloye, A. A., Ojediran, D. I., & Audu, R. O. (2016). Assessment of the impact of climate change on irish potato yield in Nigeria. *Book of Proceedings of Nigerian Meteorological Society (nimets) Conference on Climate Variability and Change*: Impact, Science, Innovation and Policy. Pg. 99-100.

Ibrahim, I., Emigilati, M.A., Suleiman, Y. M., Ojoye, S., & Yahaya, T. I. (2018). Effectiveness of early warning methodology and standardized precipitation index for drought monitoring over Guinea Savanna Zone, Nigeria. *Journal of Science, Technology, Mathematics and Education (JOSTMED),14*(2),1-8.

Ishaya, S., Hassan, S. M., & James, S. E. (2014). Post adaptive vulnerability of cereals to rainfall and temperature variability in the Federal Capital Territory. *Ethiopian Journal of Environmental Studies and Management,* 7(50),532-547.

Ismail, A. (2014). A comparative study of fire outbreaks in Sokoto, Kebbi and Gusau metropolis. In B. T. Tyubee, M. I. Ocheri, & J. O. Mage, (eds). *Nigerian Meteorological Society Book of Conference Proceedings. International Conference on Climate Change and Sustainable Economic Development. Pg. 34*

Muyiolu, S. K., Oladipo, E. O., Omojola, A. S., Oni, F. O., Adeaga, O. A., & Adedayo, V. (2013). Variability of temperature and rainfall in Nigeria.*Variability of temperature and rainfall in Nigeria. In climate variability and change*: Impact, science, innovation and policy. Nigerian Meteorological Society (NMets). Book of Conference Proceedings. Pg. 489.

Nigerian Meteorological Agency (2018). *Climate Review Bulletin. Pg*. 48.

Odjugo, P. A. O. (2010). Shift in crops production as a means of adaptation to climate change in the semi-arid region of Nigeria. *Journal of Meteorology and Climate Science, 8*(1),1-6.

Olanrewaju, R. M. (2010a). The effect of climate on yam production in Kwara State, Nigeria. *Environmental Issues*. Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria, 3(1),30-34.

Olanrewaju, R. M. (2010b). Climate and rice production in part of the Niger River BasinDevelopment Area (NRBDA). A case study of Edu and Lafiagi Local Government Areas of Kwara State, Nigeria. *Journal of Meteorology and Climate Science*. 8(2),102-110.

Thompson, O.A. and Amos, T.T. (2010). Climate change and food security in Nigeria. *Journal of Meteorology and Climate Science*, 8(2),91-101.

Umar, A.T. (2010). Recent trends and variability in the length of growing season in Northern Nigeria. *Journal of Meteorology and Climate Science*, 8(1),40-52.

Yahaya, T. I., Abdul-Lateef, A. O., &Abdulfatai, O. S. (2011). Why is climate change? Is there any remedy in law? In O. E. Wahab, A. E. Muhtar, & A. O. Olugbenga, (eds). *Law and Climate Change in Nigeria*. Faculty of Law, University of Ilorin. Pg. 426.

Yahaya, T.I., & Abubakar, A. S., (2012). Determination of seasonal rainfall variability and their agro-climatic implication in Ilorin, Kwara State, Nigeria. *INTERNET AFPREV: An International Online Multi-disciplinary Journal,* 1(2),41-51.

Yakubu, H. G., Musa, Y., & Bich, A. A. (2015). Climate change and trends in monthly rainfall profile for Maiduguri (1946-2005).*Book of proceedings, Nigerian Association of Hydrologic Sciences 6th International Conference and Annual General Meeting on Sustainable Water Management in a Challenging Environment.* Pg. 306.

Yusuf, Y. O., & Mohammed, N. A. (2011). An assessment of Spatial distribution of rainfall amount in Zaria, Kaduna State. In M. A. Iliya, M. A. Abdulrahim, I. M. Dankani, & A. Opponkumi (eds). *Climate Change and Sustainable Development. Department of Geography, Usumanu Danfodio University, Sokoto and Association of Nigerian Geographer. Pg. 69.*