DROUGHT INCIDENCE AND ITS EFFECTS ON AGRICULTURAL PRODUCTION IN KANO METROPOLIS, KANO STATE, NIGERIA

S.Y. Mohammed, Samsudeen O. and Mukhail A, I. A. Tanko, Garba, M and Eze V. N.
Department of Geography, Federal University of Technology, Minna

ABSTRACT

Drought is caused by a deficiency in precipitation for a period of time. This may cause widespread crop failure, death of livestock, water shortages, famine and other hardships that may result in the loss of human lives and this is an inherent characteristic of Africa. The aim of this study was to assess drought incidence in Kano metropolis and its impacts on agricultural production. The data utilised for this study inçluded; rainfall and temperature data as from 1981 to 2014 for Kano metropolis which was sourced from the Nigerian Meteorological Agency (NIMET) and groundnut, sorghum and millet yield data as from 1996 to 2013 for Kano metropolis which was sourced from Kano State Agricultural Development Agency (KNARDA). To derive the climatic trend of rainfall and temperature, as well as the identification of the drought years, the Standardized Precipitation Index (SPI) was used and this clearly showed the irregular trend of rainfall, as well as the drought years. For the crop yield trend, a simple polygon was used, where the mean annual yield of each crop was computed and the polygon was plotted for the various years under concern. The results indicates that there is very strong positive relationship between climatic parameters and the crop yield. The multiple regression model summary for each of the crops study gave coefficient of determination-square as 0.71, 0.90 and 0.97 respectively indicating a strong positive correlation between the climatic elements and crop yield. This implies that about 71%, 90% and 97% of any changes in groundnut, sorghum and millet yields respectively was accounted for by rainfall and temperature. The study recommended early drought monitoring and warning systems for the study area. There should be regular awareness and enlightenment campaigns to the general public on the causes of drought as well as coping mechanisms to drought events.

Key words; Drought, Precipitation, Agriculture, Environment, Incidence

1. Introduction

A drought is a period of below-average precipitation in a given region, resulting in prolonged shortages of water supply, whether atmospheric, surface or ground water. A drought can last for months or years, or even few days (Irish Independent, 2013). It can have a substantial impact on the ecosystem and agriculture of the affected region. Although droughts can persist for several years, even a short, intense drought can cause significant damage and harm to the local economy (ADCC, 2007). Drought is a recurring environmental hazard in dry sub-humid and semi –arid regions where people's livelihood depends largely on subsistence agriculture and animal husbandry. Drought, in all its forms, is injurious to the wellbeing of the people and hampers attempts by all concerned to achieve sustainable development in the region. Agricultural drought is the most common of all the drought types in Nigeria and represents the most challenging to track and forecast owing to its ease of occurrence. The 1969-1973 drought remains topical because it had a serious impact on the agriculture sector in Nigeria (Usman, 2000). The aim of this study was to assess the incidence of drought in Kano metropolis as well as its impacts on agricultural production.

2. Study Area

The study domain is Kano metropolis, Kano State Nigeria, located between latitude 11°55′ N and 12°3′N and longitude 8°27′E and 8°36′E of the Greenwich meridian, with an elevation of 1549 feet above sea level. Kano metropolis is a conurbation of eight Local Government Areas around the main city which includes; Dala, Fagge, Kano Municipal, Nassarawa, Tarauni, Kumbotso, Gwale and Ungogo. Kano metropolis registered a population of approximately 10 million people in the year 2006 National Population Census (National Population Commission [NPC], 2006).

The city is the trade nerve center of West Africa and a major industrial center of Northern Nigeria. Figure 1 shows the administrative boundary of Kano state and the Kano metropolis. The state is bordered by Jigawa State in the north-east, Katsina State in the north-west, Bauchi in the south-east and Kaduna State is on the south-western boundary.

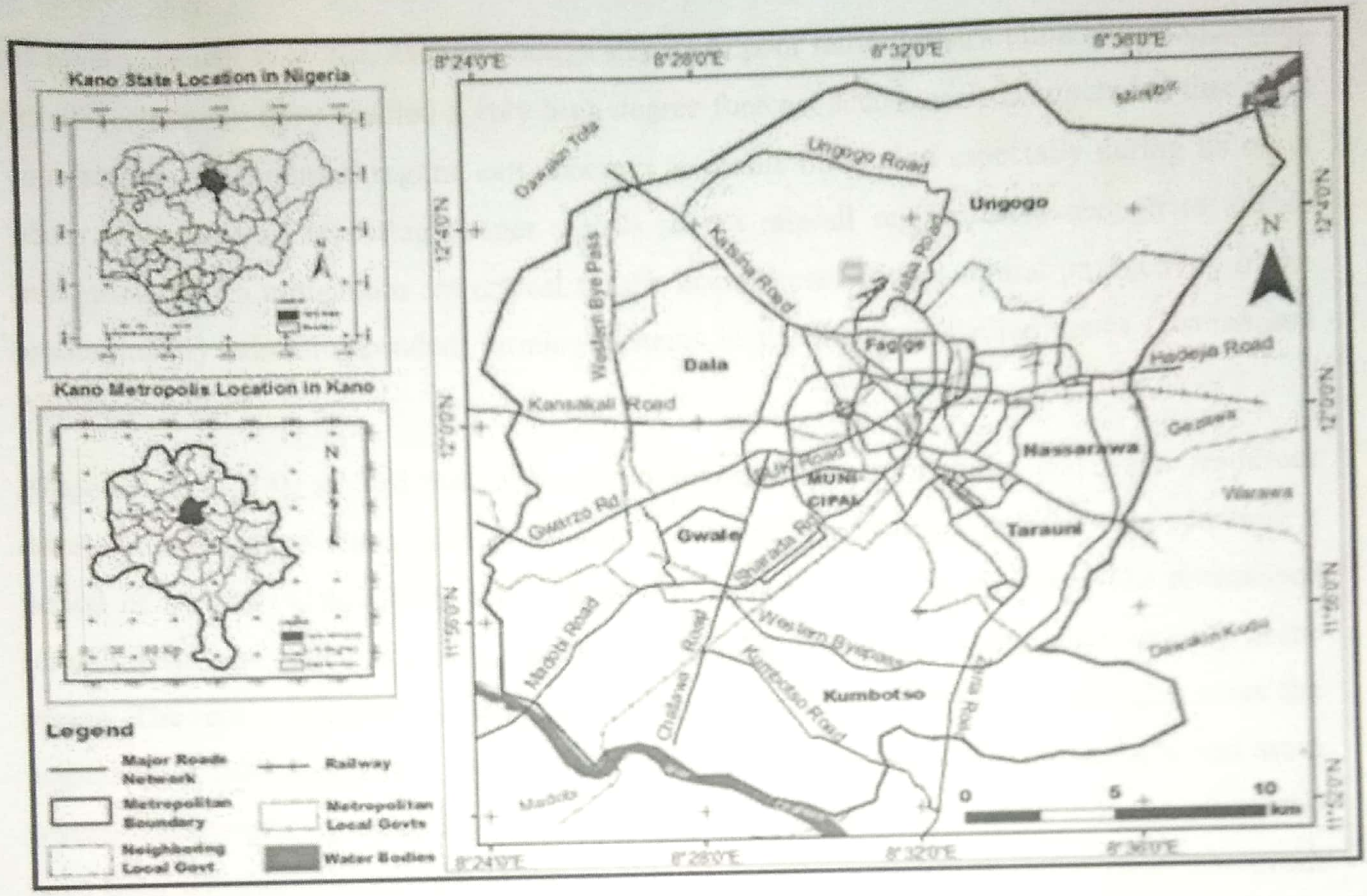

Figure 1: The Study Area (Kano metropolis, Kano State, Nigeria).

Source: Hexagon Geospatial Technology Limited (2016).

Literature Review

Usman and Abdulkadir (2014) reviewed an experiment in intra-seasonal agricultural drought monitoring and early warning in the Sudano- Sahelian Belt of Nigeria. The study revealed that the highly variable rainfall and recurring drought in dry sub-humid and semi-arid regions constitute a major socio-economic problem partly because it is the most challenging to track and forecast owing to its ease of occurrence and impact on socio-economic sustainability. The study proposes a simple drought monitoring and early warning methodology based on experiment over Kano, Nigeria, hinged on intra-seasonal rainfall monitoring index determined for each pentad, using daily rainfall totals for a period of 30 years. The onset dates and drought intensity levels were used to define early warning statements at three levels; advisory, alert and emergency. The result of the research revealed that the years between 1970 and 1990 over Kano, Nigeria, which ended as years of severe drought or worse, showed enough signals of poor rainfall distribution at the beginning, for the scheme to have enabled a very high degree forecast accuracy. It is concluded that strict monitoring of the rainfall regime early enough to enable mitigation especially during its onset phase is capable of revealing danger signals in the rainfall regime early enough to enable mitigations. Such mitigations are critical for the management of agricultural productivity in the predominantly rainfall-dependent farming systems in the Sudano-Sahelian zones (Usman and Abdulkadir, 2014).

Abaje *et al.* (2013), studied the implications of drought for agricultural and water resources development in the Sudano-sahelian ecological zone of Nigeria using rainfall data spanning a period of 60 years (1949-2008) for eight meteorological stations in the zone. The normalised rainfall index was used in depicting periods of different (meteorological) drought intensities in the region. The results revealed that the zone was characterized by larger extent droughts since the beginning of 1968 through the early 1970's and then the 1980's in which the drought was more severe than any other decade in the study period. The late 1990's and the 2000's on the other hand have been witnessing a decrease in the number of drought occurrences in the zone. The mean absolute probability of mild, moderate and severe droughts for the zone was 0.13 (recurrence interval of 7.7 years) and 0.11 (recurrence of 9.1years) and 0.08 (recurrence interval of 12.5 years). The findings revealed that this zone is generally replete with severe and prolonged droughts events and did not start simultaneously in the whole of the region. It started in the northern part of West African Sahel in 1968 and retreated southwards until 1973 when the whole study area was affected by droughts. The findings further revealed that the decade (1980-1989) witnessed the persistence of drought in the zone. The late 1990's and the 2000's on the other hand have been witnessing decrease in the number of drought occurrences in the zone (Abaje *et al.*, 2013).

Results and Discussion

Figure 2 shows the rainfall distribution over Kano metropolis for the past thirty one years (1984 – 2014). From the figure, the rainfall trend pattern has been fluctuating, inconsistent and irregular. The lowest rainfall amount occurred in 1984 with an amount of 473.7mm while the highest rainfall was recorded in 2001 with an amount of 1789.4mm. The overall mean annual rainfall from 1984 - 2014 is 1069.0mm.

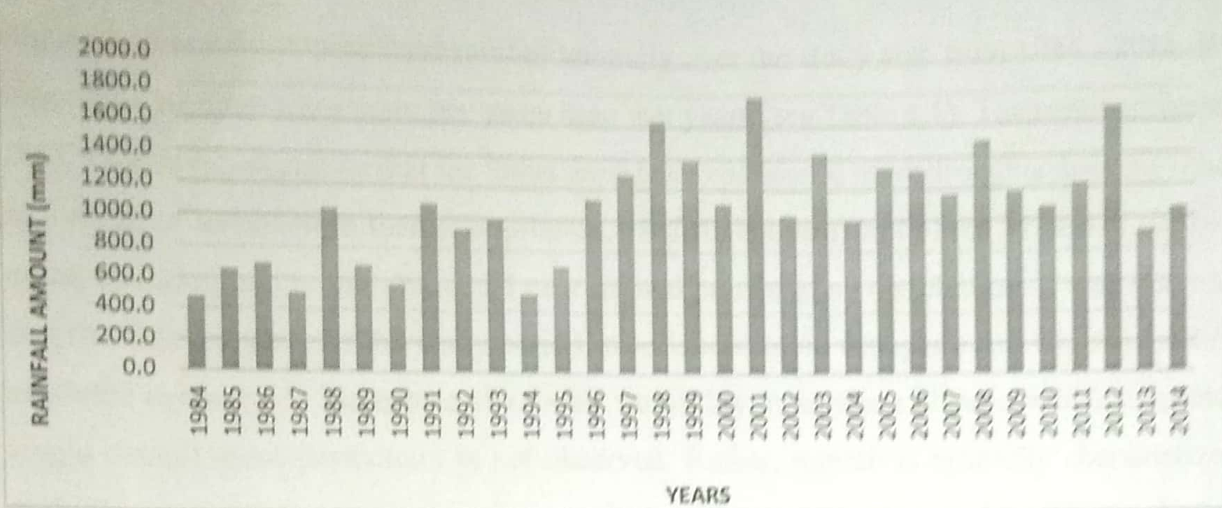

Figure 2: Rainfall trend of Kano metropolis (1984 – 2014)

The Standardised Precipitation Index (SPI) calculation used in Table 1 was based on the long-term precipitation record for a desired period. This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero (Edwards and McKee, 1997). Positive SPI values indicate greater than median precipitation, and negative values indicate less than median precipitation and similarly for temperature. Because the SPI is normalised, wetter and drier climates can be represented in the same way, and wet periods can also be monitored using the SPI. Figure 3 thus presents the standardised rainfall trend over the study area.

Table 1: Wet, Dry and Extreme Rainfall Occurrences over Kano (Based on Standardised Precipitation Index

Station		Kano
Range	**Range Meaning**	**Number of occurrence**
-0.99 to 0.99	Near normal	18
1.00 to 1.49	Moderately wet years	02
-1.00 to 1.49	Moderately dry years	05
1.55 to 1.99	Very wet years	02
-1.55 to 1.49	Very dry years	03
2 and above	Extremely wet	01
-2 and less	Extremely dry	0

Figure 3 shows the standardised rainfall anomaly over the study area from 1984 - 2014. It can be observed that there were more dry years than wet years (see Table 4.1). The result corresponds to IPCC (2005) report stating that the Sahel zone has experienced more droughts than any other zone as a result of reduction in total precipitation. 18 different years out of the 31 years (1984 – 2014) under consideration in this study had near normal precipitation distribution. It was also observed that the first ten years of the study period experienced more drought years which is in line with available evidence on the nature of rainfall variability in northern Nigeria which suggests that a single overall mean periodicity is not observed. Rather, rainfall is primarily characterized by a multiple, non-symmetric cycle of anomalies with varying magnitudes. These observations confirmed earlier findings by Bunting *et al.* (1976). The cycles vary from 3 to 5 years in some locations, and from 10, 20, and 30 to 40 years in others (Kalu, 1987).

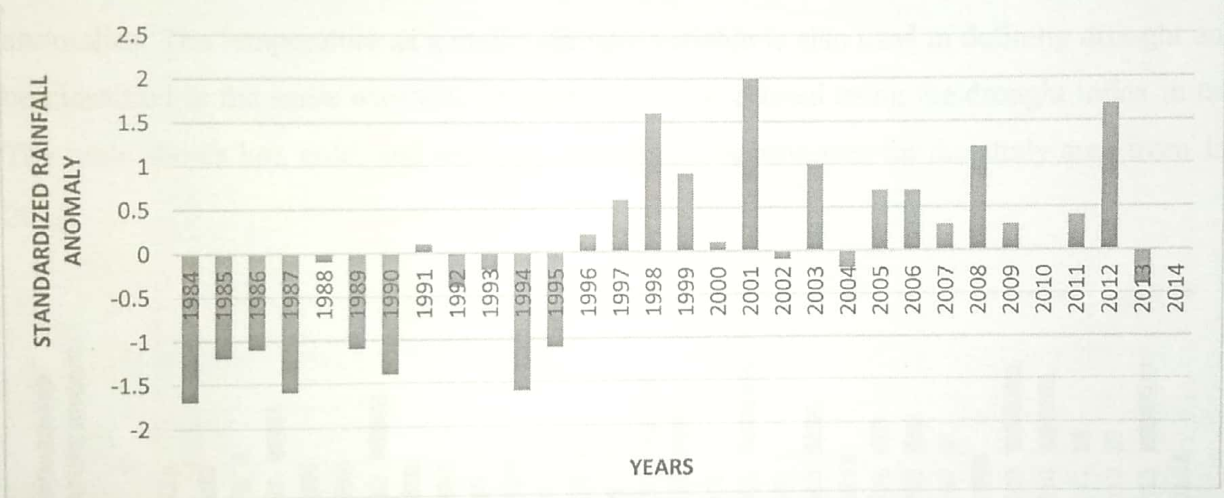

Figure 3: Standardised Rainfall Trend over the study area

Figure 4 depicts the mean temperature trend of Kano metropolis from 1984 – 2014. The mean temperature trend of Kano metropolis for the past thirty one (31) years shows that temperature has been very variable (fluctuating and irregular) which was also confirmed by many of the residents. The lowest annual mean temperature was recorded in the year 1989 with an average value of 32.3°C, while the highest annual mean temperature was recorded in the years of 2009 and 2013 with an average value of 34.4°C. Indeed, even the lowest recorded temperature value of 32.3°C is still not comfortable for proper human metabolism.

Figure 4: Mean Temperature Trend of Kano Metropolis (1984 – 2014)

Figure 5 depicts the standardised temperature anomaly for the study area from the year 1984 - 2014 with 11 years having negative temperature anomalies (1984, 1985, 1988, 1989, 1991, 1992, 1994, 2002, 2004, 2008 and 2014), while the remainder of the 18 years have positive temperature anomalies. The temperature as a major climatic variable is also used in defining drought and can be classified in the same way with as the rainfall was classed using the drought index in table 2. The table shows hot, cold, and extreme temperature occurrences for the study area from 1984 – 2014.

Figure 5: Standardised Temperature Anomaly (1984 – 2014)

Table 2: Hot, cold and extreme temperature Occurrences over Kano (Based on Standardized Precipitation Index).

	Station	Kano
Range	**Range Meaning**	**Number of occurrence**
-0.99 to 0.99	Near normal	17
1.00 to 1.49	Moderately hot years	02
-1.00 to 1.49	Moderately cool years	05
1.55 to 1.99	Very hot years	02
-1.55 to 1.49	Very cold years	03
2 and above	Extremely hot	01
-2 and less	Extremely cold	01

From figure 5 and table 2, the analysis of the drought index using SPI gives the same result as that of rainfall except for 1989 which is characterized as an extremely cold year as interpreted in table 2.

Figure 6 shows the millet, sorghum and groundnut yield trend in tons per hectare from 1996 – 2013. From the figure, the trend was an irregular one for all the three crops under consideration. The yield trend was a mixture of increasing (upward) and decreasing (downward) trends. Although, sorghum appears to have recorded the highest yield during the time under consideration, followed by millet and then groundnut.

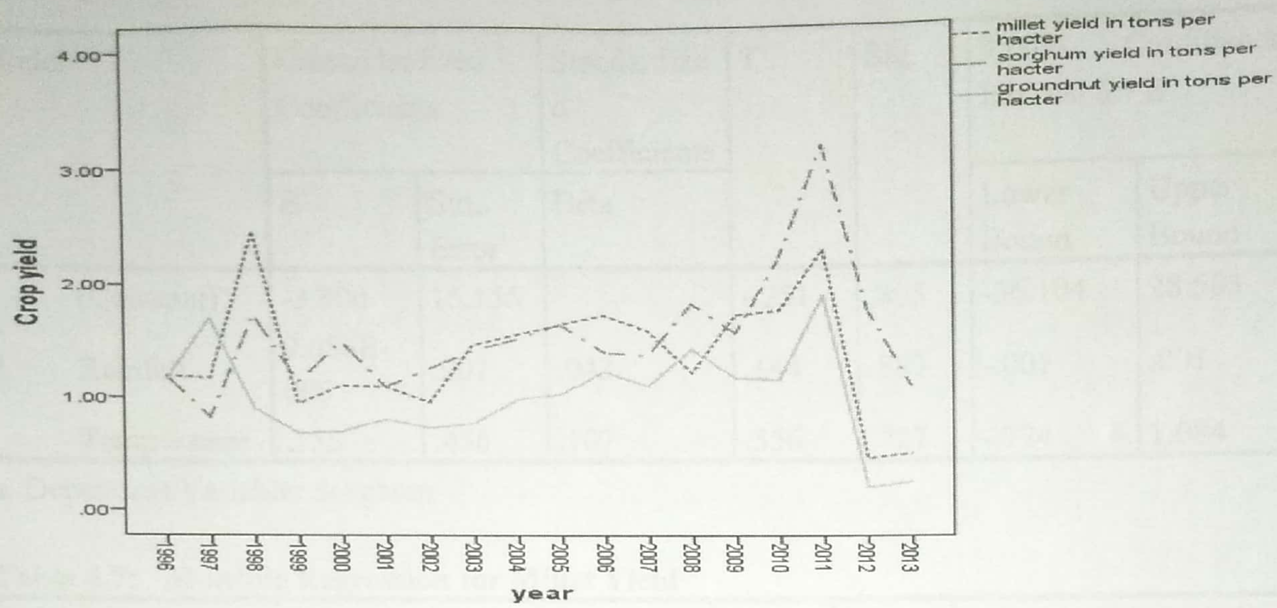

Figure 6: Millet, Sorghum and Groundnut yield trend in tons per hectare from 1996 – 2013

The effects of climatic drought was evaluated using multiple linear regression. The multiple regression model summary from tables 3, 4, and 5 for each of the crops under study (groundnut, sorghum and millet) gave coefficient of determination, R- square as 0.71, 0.90 and 0.97 respectively indicating a strong positive correlation between the climatic elements and crop yield. These implies that about 71%, 90% and 97% of any change in groundnut, sorghum and millet respectively is accounted for by climatic variables while the remaining percentages are explained by other factors that influence crop production. The result have revealed that climatic variables have more effect on crop production in the study area than any other factor.

Table 3: Multiple Regression Model for Groundnut Yield

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	4.341	11.893		.365	.720	-21.008	29.689
	Rainfall	.000	.000	-.152	-.507	.620	-.001	.001
	Temperature	-.088	.342	-.077	-.259	.799	-.817	.640

a. Dependent Variable: Groundnut

Table 4: Multiple Regression Model for Sorghum Yield

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-3.800	15.155		-.251	.805	-36.104	28.503
	Rainfall	9.086E-005	.001	.043	.144	.887	-.001	.001
	Temperature	.155	.436	.107	.356	.727	-.774	1.084

a. Dependent Variable: Sorghum

Table 4.7: Multiple Regression for Millet Yield

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-4.169	16.072		-.259	.799	-38.426	30.088
	Rainfall	.000	.001	.097	.322	.752	-.001	.002
	Temperature	.155	.462	.101	.336	.741	-.829	1.140

a. Dependent Variable: Millet

The standardized beta coefficient for the independent variables (rainfall and temperature) in tables 3, 4 and 5 respectively revealed that rainfall influences groundnut, sorghum and millet yields 50%, 4.3% and 9.7% respectively, while temperature influences groundnut yield by about 80% and 10% each for sorghum and millet.

The unstandardized coefficients from the tables gives the multiple regression equation for the independent (climate) variables contributions on the dependent variables (groundnut, sorghum and millet) as follows;

$Y_{groundnut} = 4.341 + 0.00P + 0.088T$ Equation 1

$Y_{sorghum} = 0.00009P + 0.155T - 3.800$ Equation 2

$Y_{millet} = 0.00P + 0.155T - 4.169$ Equation 3

Where Y_i is crop yield; P is precipitation; T is temperature and 4.341, -4.169 and -3.800 are constant for the study area.

Conclusion and Recommendations

The rainfall distribution of Kano metropolis from 1984 - 2014 had an irregular increasing and decreasing trend. The temperature distribution of Kano metropolis for the same period has also shown almost similar trend with the rainfall. There have also been drought events in Kano within the years considered for this study, and this was ascertained through the standardized precipitation/temperature index. The crop yields of groundnut, sorghum and millet has also shown an irregular increasing and decreasing trend. A close examination of the yield of the three crops revealed that the most cultivated crop in Kano metropolis is sorghum followed by millet, and then groundnut.

The regression model revealed a very strong positive relationship between drought events, as well as climatic variables (temperature and rainfall) with crop yield output in Kano metropolis, suggesting that a greater percentage of the crop yields output was controlled by temperature and rainfall, while the remaining percentages could be accounted by other factors such as soil fertility, fertilizer and pesticide applications as well as farming techniques used.

Based on the major findings of this study, the following recommendations were put forward towards ensuring sustainable agricultural production especially in northern Nigeria:

i. There should arise early drought monitoring and warning systems for every agro-ecological zone of Nigeria.

ii. Farmers should be trained to come up with adaptive and mitigation techniques towards crop production in drought years in order to sustainably drive the economy to ensure that food security is guaranteed.

iii. There should be regular awareness and enlightenment campaigns to the general public on the causes of drought as well as coping mechanisms to drought events, in various parts of the country.

iv. This research also recommends further studies on the mitigation and adaptive measures to drought events, especially with respect to agricultural activities.

References

Abaje, I. B., Ati, O. F., Iguisi, E. O., & Jidanna, G. G. (2013). Droughts in the Sudano-Sahelian Ecological Zone of Nigeria: Implications for Agriculture and water resources Development. *Global Journal of Human Social Science Geography, Geosciences and Environmental*, 13 (2). ISSN: 2249-4604.

Avoiding Dangerous Climate Change (ADCC, 2007). Climate Emergency Institute 2007 publication.

Bunting, A. H., Dennet, M. D., Elston, J., & Milford, J. R. (1976). Rainfall Trends in the West African Sahel. *Quarterly Journal of Royal Meteorological Society*, 102, 59. doi:10.1002/qj.49710243105, http://dx.doi.org/10.1002/qj.49710243105

Edwards, D. C., & T. B. McKee. (1997). Characteristics of 20th century Drought in the United States at Multiple Time Scales. *Climatology Report,* 97 (2), Colorado State University, Fort Collins, Colorado

Inter-governmental Panel on Climate Change [IPCC]. (2005). Climate Change Working Group1; The Physical Science Basic Contribution of Working Group1 to the Assessment Report of the Intergovernmental panel on Climate Change (eds. S .Solomon, D. Gin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor & H. L . Miller), Cambridge University Press, Cambridge.

Irish Independent (2013). It is a scorcher and Ireland is officially in drought. *Irish Independent,* 2013-07-18.

Kalu, A. E. (1987). The Recurrence of Severe Droughts in Northern Nigeria. Proceedings of the 1985 Commonwealth Meteorologists Conference. Meteorological Office College, Reading.

Usman M. T & Abdulkadir. A. (2014). An Experiment in Intra-seasonal Agricultural Drought Monitoring and Early-warning in the Sudano-sahelian Belt of Nigeria. *International Journal of Climatology*, 34, 2129-2135. doi:10.1002/joe.3840.

Usman M. T. (2000). An Instability Index for Monsoon Onset Characterization over Nigerian Sahel. *Environmental Revised,* 3 (1): 367-379.