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ASSESSMENT OF THE EFFECTS OF INTRA-SEASONAL DROUGHT EPISODES ON GROUNGNUT YIELD IN NORTHWESTERN NIGERIA

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ABSTRACT
This study attempted to assess the effects of intra-seasonal drought episodes on groundnut yield in Northwestern Nigeria spanning a period of 60 years (1956-2015). In order to achieve this, rainfall data for Kaduna, Kano, Yelwa, Katsina, Sokoto and Gusau sourced from Nigerian Meteorological Agency (NIMETS) were used. Similarly, groundnut yield data for same period were obtained from the office of National Bureau of Statistics (NBS) and National Agricultural Extension and Liasons Service (NAERLS). Standardized Coefficients of Skewness (Z_1) and Kurtosis (Z_2) for the six meteorological stations were employed to test for the normality of the data. Similarly, Cramer's test was also employed to examine temporal trend and variability of groundnut yield into 10-year non-overlapping sub-periods in the study area. Besides, the Normalized Rainfall Index (NRI) was used to determine the frequency of occurrence and intensity of drought. The relationship between the drought values and the yields of groundnut in the study area was tested using Bivariate correlation analysis. The results revealed, the sub-periods 1966 to 1995 recorded about 70% of the total drought occurrence in the study area. The results also revealed that groundnut yield has shown gradual increase in recent years (margin of *tk* values were 0.01 and 0.02), compare to the margin of *tk* values of 3.81 in the 70s and 80s. The results of the correlation analysis indicated a positive (weak) relationship between drought occurrence and groundnut yields in the study area (Kaduna R^2=.014; Kano R^2=.063; Kebbi R^2 =.016; Katsina R^2 =.048; Sokoto R^2 =.317 and Zamfara R^2 =.019. In view of this, it was recommended among other measures, the need for the development of a Response Farming Technique and longitudinal approach for comprehensive measures to address the shock and destruction that comes with re-occurrence of drought.

KEYWORDS: Drought, Correlation, Groundnut yield, Occurrence and Cramers' test

1. INTRODUCTION

Thus, there is no agreed definition of drought. Specialists who have differing perspectives have suggested at least 150 different definitions (Wilhite, 2000). For instance according to U.S. National Weather Service [NWS], (2008), drought is a period of abnormally dry weather which persists long enough to produce a serious hydrologic imbalance. However, in the most general sense, drought originated from a deficiency of precipitation over an extended period – usually a season or more – resulting in a water shortage for some activity, group or environmental sector (NDMC, 2016).

In addition, based on disciplinary perspectives and interest, the following drought types were identified: meteorological, agricultural, hydrological drought and socio-economic or famine droughts (Richard, Lindley, Gavin and Richardson, 2004).The frequency of occurrences of extreme weather events such as floods, hurricanes, blizzards, droughts and heat and cold waves experienced in different parts of the world in recent years and the devastating effects of these severe weather events on human lives and property as well as national economies, constitute the most important environmental problem that mankind faces (USAID, 2007). The effects of intra-seasonal drought episodes events on crops will be either direct or indirect, or both (Gwary, 2006). Extreme weather and climate events have attracted considerable attention in recent years because of the large losses of life as well as tremendous increase in economic losses caused by the extreme events (Easterling et al. 2000).

Available literature on Nigeria shows the existence of spatial differences in the nature of disasters (Daura, 2014). While oil and gas pollution is largely a Niger Delta problem, drought and quelea birds infestation occur in the Northern Sates (National Emergency Management Agency, 2012). Literature has also shown that the Sahel and Sudan savanna are drought prone areas (Odekunle, 2010). Reddy, Reddy and Anbumozhi (2003) observed that groundnut is grown on 35.5 million ha across 82 countries in the world. However, more than half of the production areas are frequently subjected to drought episodic stresses for different durations and intensities. Thus, Blankenship, Cole, Sanders and Hill (1984) and Cole, Sanders, Dorner and Blankenship (1989) reported that groundnut yield losses due to drought episodes are highly variable in nature, depending on timing, intensity and duration, coupled with other location-specific environmental stress. IFAD [International Fund for Agricultural Development] (2012) observed that majority of the countries affected by agricultural drought are found in the drylands of the world, which includes the arid, semiarid and sub-humid regions, where crop production is largely determined by climatic features.

Drought is not a recent phenomenon in Nigeria. Historical records indicate that drought has occurred frequently in the past. Some of these droughts were severe and accompanied by famines, arising from crop failures. Drought-induced famines compelled people in the past to abandon their settlements and resettle where agricultural conditions where more favourable (Ayoade, 1988). It has been quantified that in 1987, about 5 million metric tonnes of grains (valued at over about $400 million) were reportedly lost to drought (Oladipo, 1993). Similarly, an analysis of drought during 1900 – 2013 indicated that the severe droughts in Sahel (during; 1910’s, 1940’s, 1960’s, 1970’s and 1980’s) caused huge socio-economic and environmental impacts in this region (Masih, Maskey, Musa and Trambauer, 2014).In 2011, the Horn of Africa experienced its worst drought spell in 60 years, with a total of more than 15 million people requiring assistance [WMO] (2010). In addition, Zeng (2003) concluded that between 1968 and 1972, the Sahelian area of Africa experienced one of the worst droughts in living memory.

Groundnut which traditionally has constituted an important component of Nigeria's export has shown a decline from 18 percent in 1968 to virtually no exports at all in 1975 (Nnaji, 1999). Afterwards, the production ranges from 400,000 to 890,000 tones (FAO, 2005). Also, NAERLS (2015) observed increase in groundnut yields from 0.76 Percent in 2014 to 2.9 Percent in 2015. Groundnut is grown in most parts of Nigeria but the climate North of latitude 11^0 $11^{'}$ is most suited for its production (Muktar, 2009). In spite of climate conditions, there has been a steady decline in the production of groundnut. For instance, it was observed by Ahmed, Rafay, Singh and Verma (2010) that groundnut yields from farmers' field are low averaging about 800kg ha^{-1}, less than one third the potential yield of 3000kg ha^{-1}. In view of this, Yusif (2009) concluded that scarcity of eggs has hit Northern Nigeria due to scarcity of groundnut which translates into growing rise of prices of poultry feed.

Drought stress has a strong effect on biocompetitive (*Phytoalexins*, antifungal proteins) or protective compounds (phenols), which influence the growth of Aspergillus fungus and aflatoxin synthesis, as well as the proper maturation of peanut seeds. Aflatoxin contamination threat increases during drought, the capacity of seed to produce *phytoalexins* decreases resulting in aspergillus invasion and aflatoxin production. Some of the enzymes that are induced in response to gungal attack such as *chitinases, osmotins, peroxidases,* and *proteases* are also adversely affected during drought stress through cell membrane-mediated mechanisms

An important prerequisite for efficient intensification of agricultural production is an understanding of climate – crop relationships. Although, the effects of short – term weather fluctuations on groundnut yields have been well recognized for a long time, they have not been well studied and understood in Nigeria, especially in the Northwestern zone of Nigeria, where it is generally believed that the climate is favourable for crop production. This is the thrust of this research

2. STUDY AREA

North West region of Nigeria is located between Latitudes 9^0 $02^{'}$N and 13^0 $58^{'}$N and Longitudes 3^0 $08^{'}$E and 10^0 $15^{'}$E (Fig.1). The area so defined covers a land area approximately 212,350km2 (Table 1). Northwestern Nigeria shares borders with Niger Republic in the northern part, Benin and Niger Republic in the Western part, Niger State and FCT to the south, and Yobe, Bauchi and Plateau States to the East.

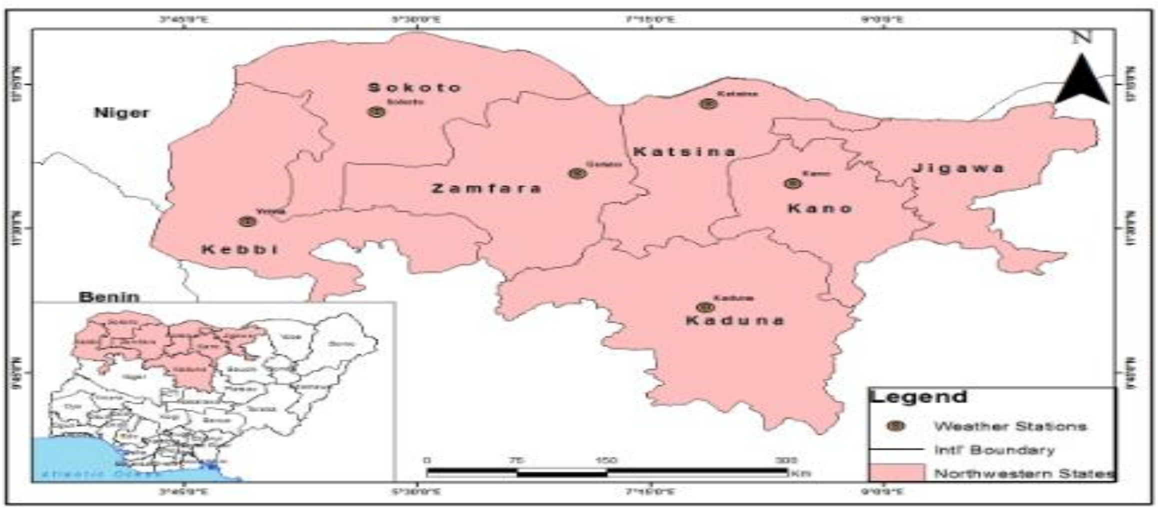

Figure 1: Study Area Source: Lands and Survey, Jigawa State (2017)

Table 1**:** Land Area of Northwestern Nigeria by States

States	Square kilometers
Jigawa	23,287
Kaduna	42,481
Kano	20,280
Katsina	23,561
Kebbi	36,985
Sokoto	27,825
Zamfara	37,931
Total	212,350

Source: Office of the Surveyor-General of Nigeria

Thus, Imo and Ekpenyong (2011) observed that with an annual average temperature of 38.3^{0}C, Sokoko is one of the hottest cities in Nigeria, with maximum daytime temperatures hovering between 35^{0}C and 40^{0}C which this area quite unbearable to the people. However, in the study area, average temperature is 29^{0}C; average minimum temperature is 13^{0}C in January, while, average maximum temperature is 38^{0}C in April, the average sunlight duration is 9 hours (Oyediran, 1977). The highest temperatures are experienced about April in the study area. Minimum temperatures are usually in December. Maximum temperature could be as much as 40.6^{0}C while the minimum could be as little as 12.8^{0}C (Abdulkarim and Sarki, 2013). Similarly, constant elements such as relative humidity and rainfall are heavily relied on to differentiate between the season and climatic zones. Besides, Northwest Nigeria has about 19 kcalcm^{-2} of radiation on annual basis. The annual radiation varies greatly in the study areas, monthly values which show little seasonal variations.

The major rivers traversing the place are Niger at the Southern boundaries and Rivers Rima, Hadejia and Sokoto. Groundwater is highly used in the study area, often to a depth of 100 metres for a borehole. Static water could be found at the depths of 40 metres. The study area has about three of the River Basins in Nigeria, namely; Upper Benue River Basin, Hadejia-Jamare River Basin and Sokoto-Rima River Basin (Oguntoyinbo, Areola and Filani, 1978).Among all these Rivers, River Sokoto is the most important in the area. The total population of the study area is about 22,913,412, 35,915,467 and 48,942,300 according to the 1991 and 2006 National Population Census, as well as the 2016 projected population figures.

3. METHODOLOGY

Reconnaissance Survey

A reconnaissance survey was carried out in the study area. The main objective of this survey was to become familiar with the study area in terms of various agricultural authorities and agencies in each of the states in Northwestern part of Nigeria.

Types and Sources of Data

The research was based on secondary source of data. Groundnut yield data was obtained from the National Bureau of Statistics (NBS), Abuja, National Agricultural Extension and Research Liaison Services (NAERLS), Zaria, Kaduna State. The data series of interest covered the period 1956-2015 (Table 2).

Table 2: Groundnut Yield Data Required

Source	Data Description	Period
NBS and NAERLS	Yield of groundnut for Northwestern Nigeria	1956-2015
NBS and NAERLS	Yield of groundnut for Individual states in Northwestern Nigeria	2006-2015

In addition, monthly rainfall data for the period of 60 years (1956-2015) was obtained from the archive of Nigerian Meteorological Agency. The data were collected for six synoptic stations namely: Kano, Gusau, Sokoto, Katsina, Kaduna and Yelwa in the Northwestern Nigeria (Table 3).These stations were selected because they are synoptic stations in the drought prone region of the country (Abaje, Ati and Iguisi, 2012). The stations equally satisfied the general criteria used by the European Climate Support Network (2014) that: data must be available for at least 40 years, missing data must not be more than 10% of the total, missing data from each year must not exceed 20%, more than three months consecutive missing values are not allowed, and lastly, the data be tested and found to be normally distributed.

Table 3**:** Meteorological Stations in the Northwestern Nigeria

Stations	Station No.	Latitude	Longitude	Altitude	Period	No. of years
Kano	1206.03	12°03'N	08°32'E	475.80m	1956-2015	60
Gusau	1206.14	12°10'N	06°42'E	468.00m	1956-2015	60
Sokoto	1205.51	12°55'N	05°12'E	309.00m	1956-2015	60
Katsina	1307.04	13°01'N	07°41'E	516.63m	1956-2015	60
Yelwa	1004.54	10°53'N	04°45'E	224.00m	1956-2015	60
Kaduna	1007.34	10°36'N	07°27'E	644.96m	1956-2015	60

Source: Nigeria Meteorological Agency (NIMET).

Techniques of Data Analysis

The standardized coefficients of Skewness (Z_1) and Kurtosis (Z_2) statistics as defined by (Brazel and Balling, 1986) was used to test for the normality in the seasonal (May to October) rainfall series for each of the stations. These are the months during which most of the stations in the region receive over 85% of their annual rainfall totals (Ati, Stigter, Iguisi and Afolayan 2009). The standardized coefficient of Skewness (Z_1) was calculated using:

$$Z_1 = \left[\left(\sum_{i=1}^{N} (x_i - \bar{x})^{3}/N \right) \Big/ \left(\sum_{i=1}^{N} (x_i - \bar{x})^{2}/N \right)^{3/2} \right]^{1/2} \Big/ \left(6/N\right)^{1/2} \text{ .... } 1$$

and the standardized coefficient of Kurtosis (Z_2) was determined as:

$$Z_2 = \left[\left(\sum_{i=1}^{N} (x_i - \bar{x})^{4}/N \right) \Big/ \left(\sum_{i=1}^{N} (x_i - \bar{x})^{2}/N \right)^{2} \right] - 3 \Big/ \left(24/N\right)^{1/2} \text{ .... } 2$$

Where $\bar{x}$ is the long term mean of x_i values, and N is the number of years in the sample. If the absolute value of Z_1 or Z_2 is greater than 1.96, a significant deviation from the normal curve is indicated at 95% confidence level.

In this study, meteorological indication was used in depicting periods of different drought frequency and intensities in the study area. This method was based only on rainfall input. This is because rainfall has been considered as the most important variable in drought indices that also include data of temperature or evapo-transpiration. Moreover, rainfall is the variable that mainly determines the duration, magnitude and intensity of drought (Vicente-Serrano and L'opez-Moreno, 2005). The choice of this method is justified enough when one considers the fact that it is only rainfall records that are available in many parts of the study area. This method is:

(i) Normalized Rainfall Index (NRI): The normalized rainfall index is a measure of intensity of drought using annual or seasonal rainfall totals and the standard deviation to indicate the shortage of water of any given season. The normalized rainfall index for a given station as defined by Turkes (1996), Turkes, Koc and Saris (2009) was computed as:

$$A_{sy} = \frac{R_{sy} - \bar{R}_s}{S_s} \text{ ----------------------------------3}$$

Where: R_{sy} = the rainfall total for the stations during a year (or a season).

R = the long term mean (of the period specified for the station) and,

S_s = standard deviation of the annual (or seasonal) rainfall total for that station.

This was achieved using description and classifications of index as defined by Turkes (2009). This is shown in Table 4.

Table 4: NRI Classification Values

Limit of Index	Character of Rainfall
1.76 or more	Extremely wet
1.31 to1.75	Very wet
0.86 to 1.30	Moderately wet
0.51 to 0.85	Mildly wet
0.50 to -0.50	Near normal
-0.51 to 0.85	Mild drought
-0.86 to 1.30	Moderate drought
-1.31 to 1.75	Severe drought
-1.76 or less	Extreme drought

Source: Turkes, (2009)

In this very study, a modified classification of NRI was therefore adopted. This is because extreme values, that is, greater than or equal to 1.76, and less than or equal to -1.76 for NRI values. These are infrequent throughout the period of study. Previous studies from Oladipo (1993), Abaje, Ati and Iguisi (2012) lend credence to this fact. These modified classifications are presented in Table 5.

Table 5 Modified Classes of NRI Values

Index	Character of Rainfall
1.31 or more	Very wet
0.86 to 1.30	Moderately wet
0.51 to 0.85	Mildly wet
0.50 to -0.50	Near Normal
0.50 to -0.85	Mild drought
-0.86 to -1.30	Moderate drought
-1.31 or less	Severe drought

Source: Abaje, Ati and Iguisi, 2012

In order to examine trend of groundnut yield in the study area, the Cramer's test (Lawson, Balling, Peters and Rundquist, 1981) was used to compare the means of the sub-period (in year) with the mean of the whole record period (N-year).

Similarly, to examine the nature of trend, linear trend lines and moving mean were calculated and plotted using Microsoft Excel Statistical tool (2016) for the annual groundnut yield in the study area. Thus, 10 – year moving mean was used in order to smoothing the time series.

To establish the relationship between drought occurrence and groundnut yields in the study area. The relationship between drought occurrence and crop yield has been a subject of longstanding interest (Gote, Khodiar, Sadhu and Shekhar, 2010). Thus, the relationships between the drought occurrence and the yield of groundnut in the study area were tested using bivariate correlation analysis. This is represented as:

$$r = \frac{\Sigma\,(x-x)(y-y)}{\sqrt{\Sigma(x-x)^2(y-y)^2}} \quad \text{---------------------------- 4}$$

r = Correlation coefficient

Where x and y = individual observations of dependent and independent variables respectively

$\bar{x}$ and y = Mean of dependent *(x)* and independent *(y)* variables respectively

The groundnut yields value was used as dependent variables and groundnut value as the independent variable. This has been used in similar studies on the relationship between climate and agricultural yields by James and Amor (2004) and Ananthoju and Rajini (2014).

3. RESULTS AND DISCUSSION

Rainfall Normality

The results of the Standardized Coefficient of Skewness (Z_I) and Kurtosis (Z_2) for the six stations are presented in Table 6. The results of Z_1 and Z_2 of data for the stations revealed that the rainfall data of all the stations were normally distributed at 95% confidence level with exception of Z_2 for Kaduna and Yelwa. Therefore, no transformation was made to the rainfall series.

Table 6: Standardized Coefficients of Skewness and Kurtosis for the Six Meteorological Stations

Statistics		Kaduna	Kano	Yelwa	Katsina	Sokoto	Gusau
Mean ($\bar{x}$)		1244.19	929.42	981.37	595.18	651.43	910.19
Standard Dev. (δ)		231.86	325.43	183.31	162.21	146.74	170.29
Skewness (Z_1)		1.26	0.78	0.51	0.20	0.74	1.21
Kurtosis (Z_2)		4.61*	0.12	2.19*	-0.36	1.19	1.84
Minimum Value		848.9	434	496.25	262	373.2	675.7
Maximum Value		2246.9	1869.3	1556.2	979	1150.6	1507.1

Source**:** Fieldwork (2017) *Significant at 95% confidence level

Occurrence and Intensity of Drought

The occurrence and intensity of drought are expressed in terms of drought index and drought frequency. The results of the analysis of Normalized Rainfall Index (NRI) for the six (6) stations in the study area are presented below: Thus, during the periods under study, there were 51 cases of mild droughts, 42 cases of moderate drought and 21 cases of severe drought. In addition, the occurrence of drought based on 10-years non over-lapping sub-periods revealed that the sub-periods 1966 to 1995 recorded about 70 percent (that is, 79 droughts occurrences) of the 114 total drought occurrence in the study area (Table 7).

Table 7: Summary of Drought Occurrence Based on Sub-Periods

Sub-Periods	Kaduna	Kano	Yelwa	Katsina	Sokoto	Gusau	Total Occurrence of Drought	Percentage (%)
1956-1965	4	5	-	-	1	2	12	10.53
1966-1975	2	6	4	4	7	4	27	23.68
1976-1985	2	8	2	4	5	4	25	21.93
1986-1995	6	4	2	7	4	4	27	23.68
1996-2005	2	-	-	4	-	3	9	7.89
2006-2015	3	1	1	2	3	4	14	12.29
Total	19	24	9	21	20	21	114	100%

Source**:** Fieldwork (2017)

Similarly, the sub-periods 1956-1965, 1996-2005 and 2006-2015 recorded about 30% (that is, 35 drought occurrences) of the 114 total drought occurrence in the study area. It could be concluded particularly in this zone that the occurrence of droughts in this zone already has a long history, which is not likely to disappear in the near future. These findings agrees with the studies conducted by Imo and Ekponyong (2011) who observed that in the last 40 years, this zone has witnessed severe drought. Also studies by Adefolalu (1986), Tarhule and Woo (1998) revealed recurrence, persistence and periodicity of droughts (in one form or the other) in Northwest zone of Nigeria. However, despite the increase rainfall witnessed in recent years in the study area, this study differ from previous studies through its finding that some areas still experienced drought conditions despite the increase rainfall.

Temporal Trends of Groundnut Yields

Nigeria was prominent among world producers of groundnut especially in the 1950s and 1960s. However, since then, there has been upward and downward trends in terms of groundnut yields in Nigeria especially Northwest zone of the country which produces over 60 Percent of its total output. Thus, Table 8 shows the results of 10-year non-overlapping sub-period analysis of groundnut yields and trends in the study area while, Table 9 shows drought occurrence and the variability in 10-Year non-overlapping sub-period analysis of groundnut yield (*tk)*

Table 8: 10-Year Non-Overlapping Sub-Period Analysis of Groundnut Yield in Northwestern Nigeria

Sub-period	t*k* values
1956-1965	2.85*
1966-1975	2.21*
1976-1985	-1.60
1986-1995	-1.79
1996-2005	-1.78
2006-2015	-1.80

Source**:** Fieldwork (2017) *Significant at 95% confidence level

Table 9: Drought Occurrence and the Variability in 10-Year Non-Overlapping Sub-Period Analysis of Groundnut Yield (*tk)*

Sub-Periods	**Total Occurrence of Drought**	**Percentage (%) of Drought Occurrence**	**Variability in 10-Year Non-Overlapping Sub-Period Analysis of Groundnut Yield (*tk)***
1956-1965	12	10.53%	2.85
1966-1975	27	23.68%	2.21
1976-1985	25	21.93%	-1.60
1986-1995	27	23.68%	-1.79
1996-2005	9	7.89%	-1.78
2006-2015	14	12.29%	-1.80
Total	114	100%	

Source**:** Fieldwork (2017)

Table 8 revealed from the sub-periods 1976 to 2015, groundnut yield were on the negative, while from the sub-periods 1956 to 1975, yields of groundnut were positive. However, Table 9 was more detailed in terms of the variations within each of these sub-periods. From Table 9, it could be seen clearly that, the more the occurrence of drought the lower the yields in groundnut. For instance, the sub-periods 1956 to 1965 witnessed 12 drought occurrences and the yield in groundnut was 2.85 (positive). However, between the sub-periods 1966 to 1975, drought occurrences increased to 27 and the yields of groundnut decreased. Interestingly, between the sub-periods 1996-2005, drought occurrences reduce drastically to 9 and the yields in groundnut increased (although negative).

Consequently, the results in Figure 4.14 show upward trends between: 1956-1977 and downward trends between: 1978-2015 of groundnut yield in the study area, while, the results in Figure 4.15 and 4.16 provide more detail trends of groundnut yields within two climatic periods of thirty years each, (that is, 1956-1985 and 1986-2015) in the Northwestern Nigeria. It could be seen that, groundnut yields rose from about 366,000 Units output in 1956 to over 1million in 1966. Unfortunately, yields dropped from about 693,000 (in 1967) to as low as 44,039 in 1973. Similarly, yields rose to about 162,000 in 1974 and also fell to about 140,000 in 1977. However, yields dropped for the periods of 14 years to less than 1,000 from 1978 to 1991. Interestingly, yield rise to between: 2,000 to 3,000 from 1992 to 2005. But, from the period 2006 to 2015 yields fell to 1,000.

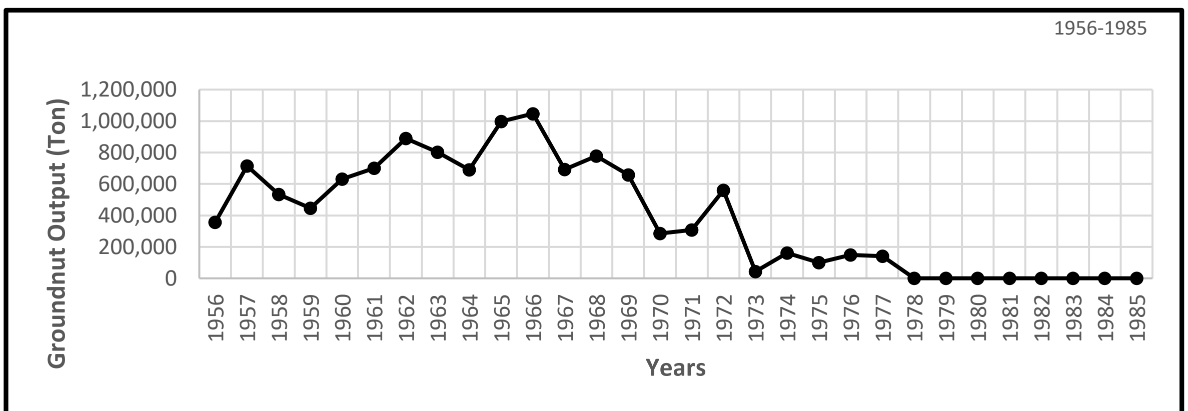

Figure.4.14Temporal Trend of Groundnut Yield Between the periods 1956- 1985

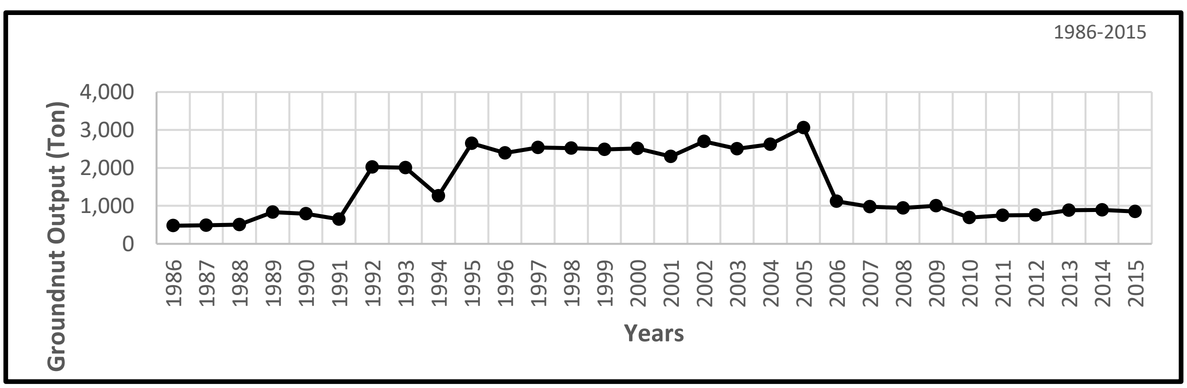

Figure: 4.15: Temporal Trend of Groundnut Yield between the Periods 1986-2015

From the foregoing, the decline of groundnut yields in the study especially in the last four decades (1976-2015) coincided with the periods of drought (1970s and 1980s) in the zone. This finding relates with previous studies conducted by Okorie (2003), Alatise and Ikumawoyi (2007) that crop yield have dropped by about 60 Percent in the zone. Similarly, Iliya and Sakwah (2006) observed that drought forced about 68 Percent of the farmers to replace most crops with grains such as millet believed to be early maturing and more resistant to aridity. In addition, Nfare, Waiyar, Ramouch, Masters and Ndejunga (2005) and Yusif (2009) concluded that drought of 1974/75 growing season, which brought with it aphid infestation wiped more than 750,000 hectares of groundnut fields, brought tremendous loss to both farmers and merchants. This study, however, differ with previous studies through its finding that there has been gradual increase in groundnut yields in recent years particularly in the last twenty years of this study (that is, 1996-2015). This agrees with findings conducted by F.A.O. (2005); Taphee and Jongur (2014); FAO, (2015) and NAERLS, (2015).

Table 10: Summary of Correlation Results for Drought Occurrence Values and Groundnut Yields in the Study Area.

Kaduna	Kano	Kebbi	Katsina	Sokoto	Zamfara	Northwest Nigeria
.014	.063	.016	.048	.317	.019	.022

*Significant at 0.05% confidence level

Based on the foregoing, there are grounds to conclude that before ascribing annual variations of a particular crop to drought, it must be assumed that some other climatic and biophysical factors remain constant (Adejuwon and Ogunkoya, 2006). In view of this, it could be concluded from these results that there are fluctuations in groundnut yields in the study area. As a whole, in the study area, drought occurrence and yields of groundnut revealed positive relationships (1956-2015). In addition, individual states in the study area within the last 10 years (2006-2015) drought occurrence and groundnut yields revealed moderate relationship in Sokoto State and weak relationships in Zamfara, Kano, Kaduna, Katsina and Kebbi States. Moreso, it was further observed that Sokoto recorded lowest drought within the last 10 years (2006-2015). To some extent, groundnut yield depends on water availability which may improve its yield. This could justify the increase in groundnut yield in the area. In almost all the states, the highest correlation co-efficients are for Sokoto State, followed by Kano, Katsina, Kebbi, Zamfara and Kaduna States, and a positive correlation coefficient for the whole study area (60 years) as well.

This result reveals an unmistakable contrast with previous research by Nautiyal (1999) and Nnaji (1999) which shows relationships were negative. On the other hand, this finding was in agreement with conclusion drawn from Binbol, Adebayo and Kwon-Ndung (2006), Ananthoju and Rajini (2014), NAERLS (2015) which shows relationships are positive. This could be attributed to: first, the drought occurrence values in the study area in recent years were dominated by mild and moderate droughts, also because drought experienced during the last decade did not remarkably impact on groundnut yields as likely factor for positive relationships in the study area. These classes of drought are not associated with high water deficit. Mc Williams (2005) has shown that the effect of drought depends on growth stages, deficiency level and environmental changes during drought conditions. Mc Williams (2005) concluded that during later productive stages, yield losses from drought decreases as crop nears physiological maturity. Secondly, farmer's interest to cultivate more of groundnuts that requires less fertilization and groundnut farming is becoming more profitable venture in recent years (Taphee and Jongur, 2014).

CONCLUSION AND RECOMMENDATION

In conclusion, the occurrence and intensity of droughts of about 70% that dominated the study area between 1966 to 1995 and about 30% in between 1996 t0 2015 has since led to an unstable groundnut production. Groundnut shortage results from an abnormal reduction in yield from 1976 to 1995. Thus, the result of the NRI and Crammers' test shows recurrent droughts still persist in the study area, ranging from mild, moderate to severe. Furthermore, groundnut yields were relatively low. The implication of this is that there exist severe, moderate and mild droughts as indicated in the variations in groundnut yields in years in which drought of diverse intensities (severe, moderate and mild) were experienced. Thus, drought occurrence values revealed positive correlations coefficients with groundnut yields in the study area. It was however recommended among other measures, the need for the development of a Response Farming Technique and longitudinal approach for comprehensive measures to address the shock and destruction that comes with re-occurrence of drought.

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