An Evaluation of the Effects of Drought on Groundnut Yields in Kano

by

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Abstract

This study undertook an evaluation of the effects of drought on groundnut yields in Kano. The study was conducted using drought index, rainfall characteristics and groundnut yields. Twenty-nine years rainfall and groundnut yields data were used for the study. The relationship between drought index and groundnut yields was determined via the use of correlation coefficient which reveals a significant correlation between both parameters. The study reveals that the nature and magnitude of the drought index affect the various yields of groundnuts in Kano especially among the years with episodic cases of drought in the study area. These findings have important implications on the crop yields of the study area. Drought frequency which constitutes decline in groundnut yields and other crops in general, would have serious socio-economic impact on Kano and Nigeria in general. Thus, it becomes necessary to put appropriate measures in place using the findings of this research to check the effects of drought index on groundnut yields among other crops in the study area.

Introduction

The antithesis of flood is drought, and both are as disastrous as they can be properly ameliorated or managed (Faniran, 1992). Drought means different things to various people, depending on their specific interest (Palmer, 1965). Thus, there is no agreed definition of drought. Specialists in meteorology, agriculture, hydrology, engineering and socio-economic studies who have differing perspectives have suggested at least 150 different definitions (Purtill, 2003, Wilhite and Glantz,1985,). For instance, 'according to U.S National Weather service, drought is "a period of abnormally dry weather which persists long enough to produce a serious hydrologic imbalance". However on a general note, various definitions include, rainfall indicators, such as a reduction of water availability over a certain period, over a certain area, or a lengthy period in which no significant precipitation is recorded (Richard, *et al* 2004; etc)

Droughts are more difficult to predict than flood events (McVigar, *et al* 1998). Studies have shown that, any region can experience drought it is not always the areas with the lowest effective rainfall, as socio-economic factors means that even wettest areas are susceptible to drought due to high demand from large population and irrigated agriculture (Richard, *et al* 2004). Drought is not a recent phenomenon in Nigeria. Historical record indicates 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 abandoned their settlements and resettle where agricultural conditions where more favorable (Ayoade, 1988).

Consequently, Adefolalu (1983) rightly pointed out that plants do not only depend on the amount of rainfall received for growth development and yield but on how much water is available to them as soil moisture. When these amount becomes available within the length of the days and months to which the soil is able to retain enough moisture required it would enhance good yield. In addition, in the tropical environment, temperature and rainfall are the most important determinants of vegetation, as temperatures are high all the year round, they are non-limiting to plant growth but determine what plants will grow (Asiedu,1992). Similarly, Adefolalu (1991), observed that climate, particularly, precipitation has not been accorded the deserved priority in agricultural planning in Nigeria. Thus, the general neglect of this natural resource may be based on the impression that the tropical climate is equitable. Consequently, Ati and Iguisi (2007) observed that the longer duration means more rain fed crops can be cultivated and more rain water can be harvested for water resources development. However, experiences have shown that several attempts to boost food production are being foiled by persistent drought spells.

Thus, not all rainfall is effective but only the portion that contributes to evapotranspiration could be considered as effective. Areas with populations that depend on subsistence farming as a major food source are vulnerable to droughts - triggered famine. At the end of 1987 grazing periods extensive crop losses to droughts were reportedly incurred in many parts of northern Nigeria. For example, Kano State estimated that the crop yield in the state in 1987 ranged between 56% and 75% of the 1986 totals (Mortimore, 1989).

Declining groundnut production in Nigeria

Export to Europe started in the late 19th century when Margarine was introduced in the European markets. The demand for groundnut boomed in the early 20th century when the time the hydrogenation process was developed. That was also the time the railway line was built from Lagos to Kano which made evacuation of the produce to the coast very easy (Paul *et al* 1997).

The favourable climatic conditions with good rainfall, abundant sunshine, availability of a well drained light loose and friable sandy loam well supplied with calcium have encouraged the practice and cultivation of groundnut in the Sudan and Guinea Savannah ecological zones. Nigeria enjoyed a strong comparative advantage in the world scene as evidenced by dissolving of groundnut production from the mid 1950's to the 1960's despite direct taxes, in comparison with other countries where subsidies have prevailed.

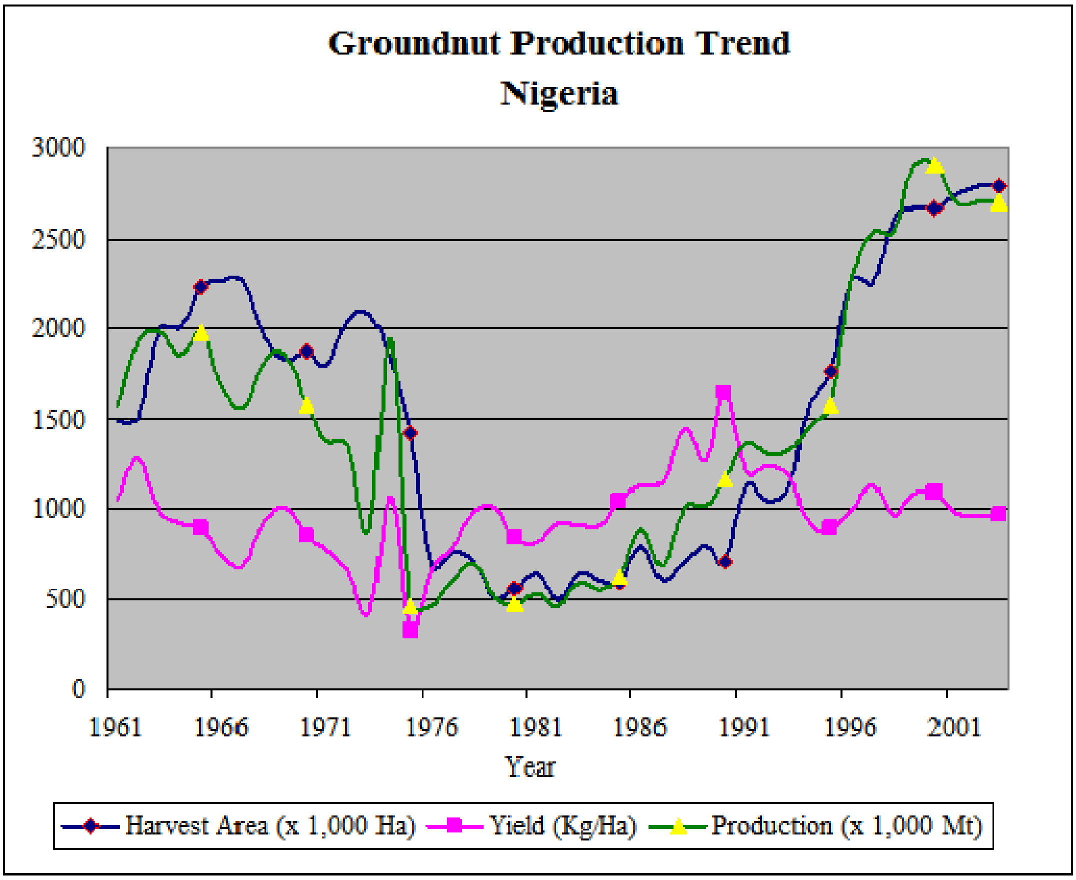
Groundnuts production in Nigeria rose to a record of about 1.2 million tonnes in the mid 1960's when Nigeria was the world's 3rd largest producer after India and China. In terms of export, Nigeria was the largest exporter of groundnut, followed by Senegal (Tanimu, 1982).

Over the years, the trend of groundnut production in Nigeria in terms of yield and harvested area is shown below:

Year	Harvested Area (Ha)	Yield (Kg/Ha)
1961	1,488,000	1,052
1962	1,501,000	1,281
1963	1,992,000	993
1964	2,000,000	925
1965	2,229,000	887
1966	2,254,000	751
1967	2,256,000	691
1968	1,941,000	934
1969	1,833,000	1,007
1970	1,870,000	846
1971	1,795,000	769
1972	2,033,000	664
1973	2,076,000	423
1974	1,815,000	1,066
1975	1,418,000	323
1976	684,000	671
1977	763,000	790
1978	710,000	987
1979	504,000	1,006
1980	563,000	837
1981	650,000	815
1982	497,000	922
1983	650,000	909
1984	600,000	910
1985	594,000	1,046
1986	793,000	1,130
1987	597,000	1,151
1988	707,000	1,437
1989	800,000	1,271
1990	707,000	1,649
1991	1,127,000	1,208
1992	1,046,000	1,240
1993	1,121,000	1,180
1994	1,571,000	925
1995	1,767,000	894
1996	2,266,000	1,005

1997	2,251,500	1,124
1998	2,604,700	973
1999	2,662,000	1,087
2000	2,668,000	1,087
2001	2,738,000	980
2002	2,782,000	970
2003	2,782,000	970

Source : FAO (2003)



A noticeable change in weather conditions since 1970 towards a long dry spell in the middle of the growing season and the resulting loss in yields was one of the major factors that led to the decline in groundnut production in Nigeria. Another factor was the sudden and thereafter repeated outbreak of a rosette virus disease throughout the major producing areas, causing an almost complete crop failure in 1975, after which the once famous groundnut pyramids of Northern Nigeria had completely disappeared (Nnaji, 1999). In areas where the rainfall pattern and the growing season were not seriously affected, the major pests and diseases have been on the increase. While, the main pests are the termites and millipedes, the diseases are the rosette virus transmitted by its vector, aphis craccivora, the foliar disease, notably the early leafspot and the late leafspot groundnut disease. However, both Tanimu (1982) and NPC (1990), concluded that moisture may be a major cause of all these diseases in the sense that their inadequacy is believed to result in low mineralization and availability of such nutrient element as calcium and magnesium which are important in yielding development. Coincidentally, areas where the problems of these diseases seem most widespread and severest are those with inadequate and unpredictable rainfall.

In line with this, Daily Trust (January 2, 2009) expressed views concerning the shortage of groundnut in Kano to be due to natural cause. Since there was drought last year, in which the rainfall stopped earlier than the time it naturally ceases. As a result of this, there were no enough groundnuts, soya, among others. It is dismaying to note that there are many complaints in December and there are still about ten months ahead to reach another October – which is the usual harvesting period. This is a very big problem that the government has to do something about.

Consequently, the aim of this study is to evaluate the effects of drought index on groundnut yields in Kano. This aim will be achieved through the following objectives: to

a. examine rainfall characteristics of Kano
b. identify drought years in the study area
c. determine drought frequency in Kano.
d. examine groundnut yield in Kano
e. assess the relationship between drought occurrence and groundnut yield in the study area.

Study Area

Kano is found in Northern Nigeria. It is located between Latitude 10^0 38' N and 12^o 28' N and Longitude 8^o 04' E to 9^0 10'E. Bounded to Kaduna and Bauchi States, to the South West and South East respectively. Thus, the state composes of forty four local Government areas.

The Kano region occupies the southern east rim of the Chad depression and share physiographic divides with the Niger and Benue River systems to the south and with the Niger systems to the southeast and West as the Chad – Sokoto divide. The elevation of Kano above mean Sea level ranges from about 400 metres to 1200 meters of north and south tip. The Kano region is part of the popular high plains of Hausa land except for the section east of the Hydro-Geographic divide. The rock structure, the relief, and the landforms of the region are closely linked. Generally, the area lies within the wet and dry Climate with more dry than wet months (Olofin, 1987) which is coded as Aw in Koppen's classification. Although, climatic changes are believed to have occurred in the past, the characteristics of the major elements of the present climate are described below. The climate of northern Nigeria is divided into the following: (a) A warm rainy season from June to September (b) A cool dry season from October to February (c) A hot dry season from March to May.

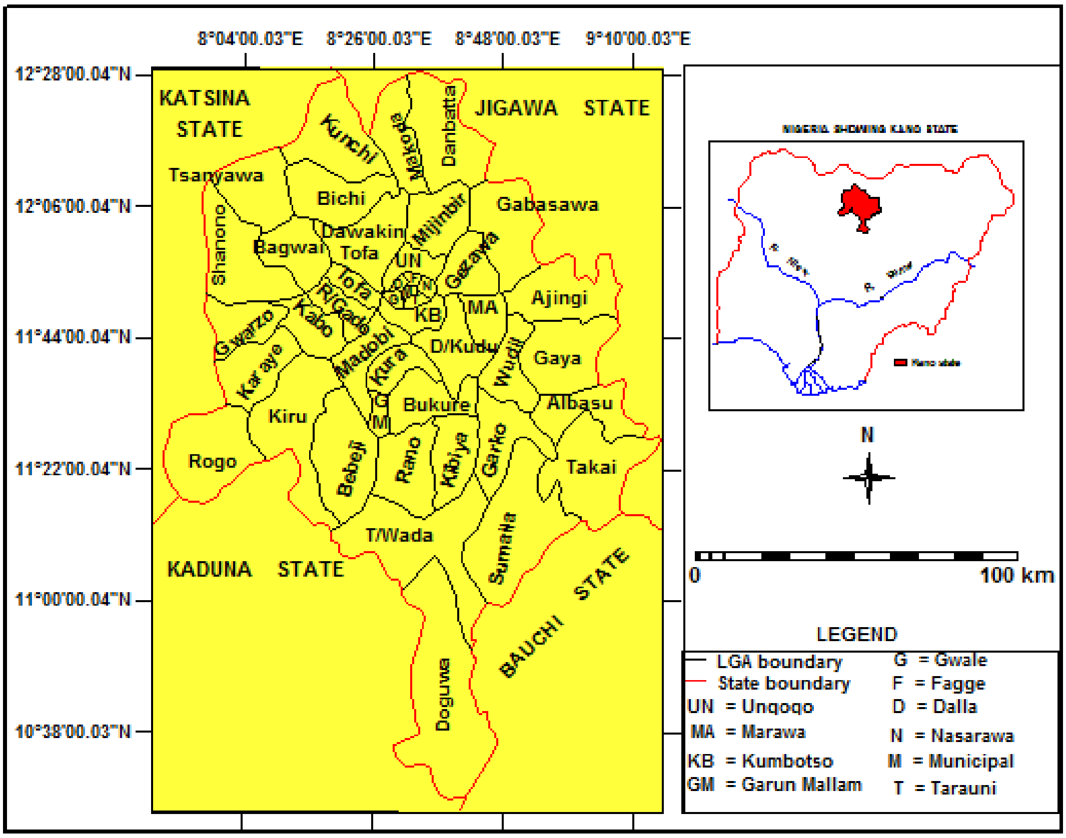


FIGURE 1.1 : ADMINISTRATIVE MAP OF KANO STATE

Source : Lands and Surveys, Kano State

Methodology

Groundnut yield data of Kano State for the period 1982 to 2009 were used in this study. These are secondary data that were obtained from the archive of Kano State Agriculture and Rural Development Authority (KNARDA).

Similarly, rainfall data for 29 years spanning a period of 1982 to 2009 was also obtained from Institute of Agricultural Research Kano, Kano State. These methods are:

(i) Normalized Rainfall Index (NRI):

$$A_{sy} = \frac{R_{sy} - R_s}{S_s} \quad \text{...} \quad (4.2.1)$$

Where : Rsy = the rainfall total for the station s during a year (or a season).

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

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

(ii)Rainfall Anomaly Index (RAI):

$$RAI = 3[(p - \bar{p})/(\bar{m} - \bar{p})] \text{........................} (4.2.2)$$

For positive anomalies and

$$RAI = -3[(p - \bar{p})/(\bar{x} - \bar{p})] \text{.....................................} (4.2.3)$$

For negative anomalies, where p is the actual, *p* is the long term average rainfall, *m* is the mean of the ten highest values of *p* on record and *x* is the mean of the ten lowest values of p on record. The arbitrary threshold values of +3 and -3 have been assigned to the mean of the ten most extreme positive and negative anomalies respectively. Nine abnormal classes ranging from extremely wet to extremely dry conditions are then given against a scale of numerical values of the relative rainfall anomalies index.

In this very study, a modified classification of RAI and NRI were therefore adopted. This is because extreme values, that is, greater than or equal to 4 and less than or equal to -4 for RAI and then greater than or equal to 1.76 and less than or equal to -1.76 for NRI are very infrequent throughout the period of study. These modified classifications are presented in table 4.5 and 4.6 for RAI and NRI respectively.

Table 1 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

Table 2 Modified RAI Classification Values

Index	Character of the weather
3.00 to more	Very wet
2.00 to 2.99	Moderately wet
1.00 to 1.99	Slightly wet
0.99 to -0.99	Near normal
-1.00 to -1.99	Mild drought
-2.00 to -2.99	Moderately drought
-3.00 or less	Severe drought

Rainfall Characteristics

In order to examine the rainfall characteristics of the zone, the following techniques were employed.

(i) The annual and monthly rainfall mean (x), Standard Deviation (SD) and Coefficient of Variation (CV) were calculated. The following formulae were used;

$$\bar{x} = \frac{\sum x}{n} \quad (4.1.1)$$

Where; x = the value of rainfall observation.
n= the number of rainfall observations of sample

$$SD = \frac{\sqrt{\sum (x-\bar{x})^2}}{n} \quad (4.1.2)$$

Relationship between Drought Occurrence and Groundnut Yields

In order to determine the relationship between drought index and groundnuts yield in the zone, the technique of correlation coefficient was used. This is the measure of relationship that exists between two variables X and Y.

Results And Discussion

Rainfall Characteristics

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The mean and standard deviation of variation of the rainfall for the 29 years under review are presented in the appendix. Monthly analysis of the results show that rainfall increases gradually from a mean value of 0mm in January to the highest value of 245.37549mm in August at the peak of the wet season. This is followed by a gradual decrease amount in July (203.552mm) to a low value of 0mm in December. It is obvious from the above analysis, that the standard deviation has a direct relationship with the mean rainfall because it increases with an increase in the mean rainfall and vice versa.

Drought Frequency and Drought Years

The characteristics of drought are expressed in terms of drought index, drought intensity, duration and frequency. The result of analysis of Rainfall Anomaly Index (RAI) and Normalized Rainfall Index (NRI) of the study area are presented on table 5.1 and 5.2 and graphically in figures 5.1 and 5.2 respectively

The results of the analysis of rainfall anomaly index and normalized rainfall index (Tables 3 and 4) for the rainfall data reveal that the zone has experienced mild, moderate and severe drought during the study period.

Table 3 NRI Values

Years	NRI Values
1982	-0.65094
1983	-1.57088
1984	-1.36742
1985	0.221163
1986	-0.82525
1987	-1.53788
1988	1.203788
1989	-0.21599
1990	-1.18486
1991	0.817777
1992	0.895309
1993	0.253056
1994	0.123286
1995	-1.10128
1996	0.057301
1997	-0.50742
1998	2.713743
1999	0.19312
2000	-0.61849
2001	1.242279
2002	-1.17277
2003	0.706152
2004	-0.01638
2005	0.839772
2006	0.153529
2007	0.341036
2008	-0.26548
2009	-0.16485
2010	1.440784

Table 4 RAI Values

Years	RAI Values
1982	-1.85326
1983	-4.47238
1984	-3.89314
1985	0.629665
1986	-2.34953
1987	-4.37845
1988	3.427258
1989	-0.61493
1990	-3.37338
1991	2.32826
1992	2.548999
1993	0.720466
1994	0.351002
1995	-3.13542
1996	0.163139
1997	-1.44466
1998	7.72619
1999	0.549823
2000	-1.76089
2001	3.536845
2002	-3.33894
2003	2.010458
2004	-0.04664
2005	2.390881
2006	0.437106
2007	0.97095
2008	-0.75582
2009	-0.46933
2010	4.102

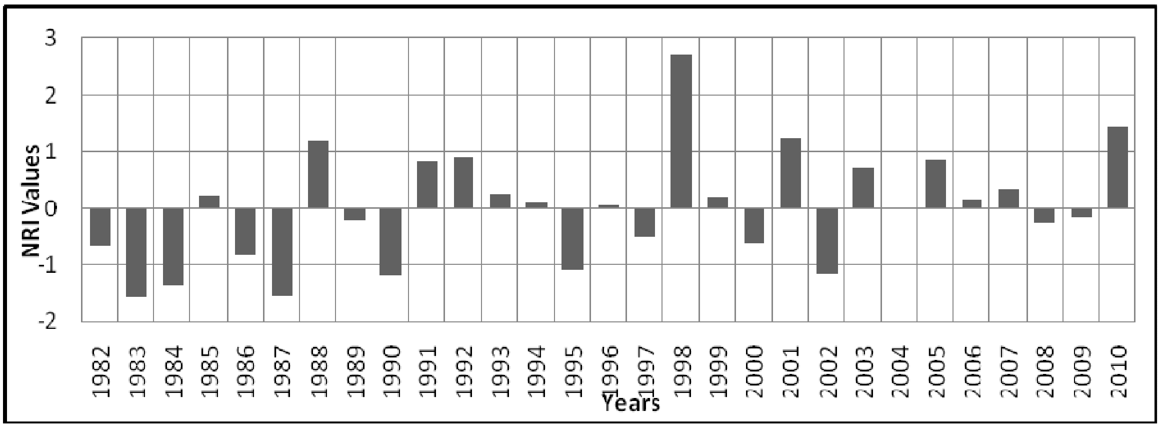

Figure 1 Normalized Rainfall Index

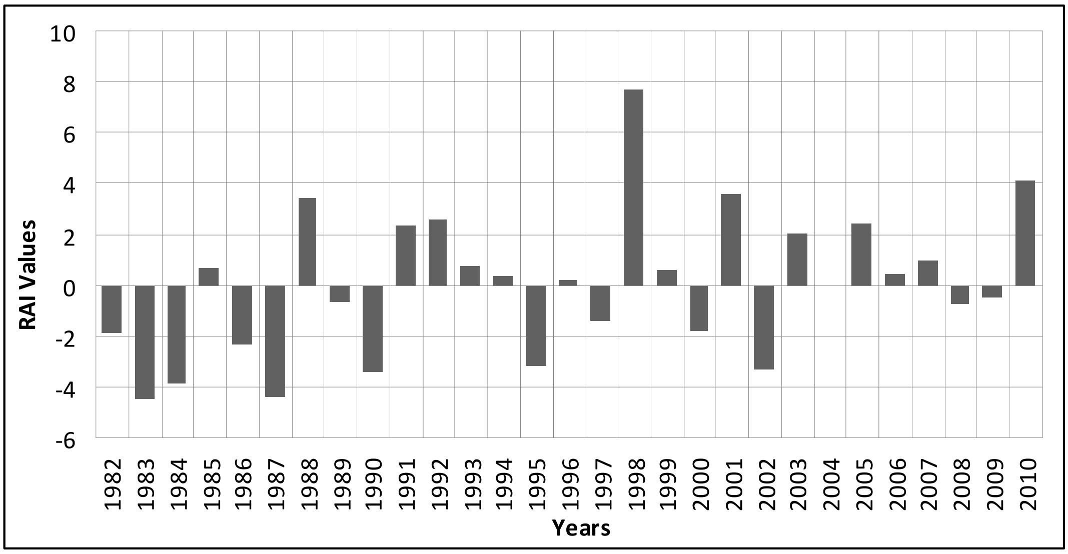

Figure 2 Anomaly Rainfall Index

Table 5 Drought Years in the study area using NRI

Intensity	**Drought Years**	**Frequency**
Mild Drought	1982, 1986, 2000	3 Years
Moderate Drought	1984,1990,1995,2002	4 Years
Severe Drought	1983, 1987	2 Years

Table 6 Drought Years in the Study Area Using RAI

Intensity	Drought Years	Frequency
Mild Drought	1982, 1997, 2000	3 Years
Moderate Drought	1986	1 Year
Severe Drought	1983,1984,1987,1990,1995, 2002	6 Years

The results of the two indices appear to be effective in detecting drought period as they reveal almost the same number of years with moderate to severe drought conditions for the study area. The two methods are therefore suitable for describing metrological drought in the study area. This is because all previously identified drought period in the study area are presented by the two drought indices. For example, the well known extensive great drought of 1968 to 1973 and the moderate to severe drought in each of the years between 1982 and 1987 as described by Oladipo (1993a) are qualitatively well depicted by the two metrological drought indices. Even though the results of the two indices appear to be effective in detecting drought periods, some exceptions founds in the result of analysis are a few years that the RAI values registered 6 years for severe drought.

Another difference found in the results of the two indices is in the detection of moderate drought. For example, while the RAI was able to detect only 1 year of moderate drought year, the NRI detected 4 moderate drought years (Table 5 and 6). The above comparisons of the performances of these two indices reveal certain advantages as observed in the study: The first primary advantage NRI over RAI is through the calculation; Calculation of NRI is much easier than the RAI. It therefore, facilitates the detection and monitoring of drought.

The NRI is to a great extent more suitable for describing meteorological drought in the tropical environment. This is because all previously identified severe drought periods in the study area were all presented by this drought index.

Another advantage is that the NRI on the average performs better than the RAI in terms of detecting severe drought conditions which is very important in drought studies. These findings correlate with previous findings by Abaje 2010, Iweagbu 1993, and Oladipo 1993 whose findings stated that comparative analysis of drought indices present a better understanding of drought episodes.

Table 7 above shows that the highest groundnut yields was 2202 (10.54%). This has the fifth highest annual rainfall of 904.7mm. This is followed by 1233.99 (5.9%) yields with the tenth highest annual rainfall and 1169.77 (5.6%) being the third highest value. Although the period with the third highest yield is the smallest hectare of land, that is, 31.1ha, it was able to produce such high yield (1169.77) due to the effective concentration and distribution of the high annual rainfall on the relatively small hectare of land compared with other large hectare of land not proportionate to the quantity of rainfall.

The above findings are in agreement with Nnaji (1999), and Tanimu (1982) who observed that for groundnut, when rainfall is high yield is also high; not necessarily due to high rainfall but its distribution. Since groundnut does not require heavy rainfall to be successfully established; high rainfall will rather encourage vigorous vegetative growth without any corresponding increase in yields. This implies that high rainfall adequately distributed on a small hectare of land will produce high yields.

Table 7 Groundnut Yields in Kano State

Year	Harvested Area/Ha	Yield(Kg/Ha)	Production(tons)	Percentage(%) of Yields
1982	485,000	461.85	224,000	2.21
1983	657,000	566.21	372,000	2.71
1984	545,000	379.81	20,700	1.81
1985	334,000	353.29	118,000	1.70
1986	542,000	291.51	158,000	1.40
1987	941,000	371.94	350,000	1.80
1988	610,000	375.40	229,000	1.80
1989	694,000	358.78	249,000	1.71
1990	758,000	154.29	117,102	0.73
1991	44993	2202	99088	10.54
1992	256470	231.44	59358	1.10
1993	286042	656.54	187799	3.14
1994	1081040	840.15	908237	4.02
1995	489167	556.90	272418	2.70
1996	346021	1161.29	401832	5.56
1997	241000	800	192800	3.83
1998	553520	910.91	504210	4.36
1999	135230	688.30	93080	3.30
2000	236651	703	116381	3.40
2001	240470	1139.43	274000	5.45
2002	333330	729.99	243330	3.50
2003	443328	769.99	341360	3.68
2004	425595	779.99	331960	3.73
2005	418085	1030	430580	4.93
2006	422060	1233.99	520820	5.91
2007	93260	811	75640	3.88
2008	19.1	1150.26	21.97	5.50
2009	31.1	1169.77	36.38	5.60
TOTAL		20878.03		100

Source: Cropped Area and Yield Survey (C.A.Y.S) and Agricultural Production Survey (A.P.S.), KNARDA

Relationship Between Drought Index and Groundnut Yields

Table 8 Showing the relationship values

Predictor	Coefficient	Standard deviation	t-ratio	P
Constant	754.74	76.12	9.92	0.000
NRI	164.58	79.11	2.08	0.047
	s = 402.2 R-sq = 14.3% R-sq(adj) = 11.0%			
RAI	57.81	27.78	2.08	0.047
	s = 402.2 R-sq = 14.3% R-sq(adj) = 11.0%			

The result of the analysis of drought index and groundnut yields for the years between 1982 to 2009 above shows that there is significant difference between the drought index and ground nut yield. This is because the p value (0.047) is less than the significant level (0.05). This implies that, about 47% of groundnut yield were affected by drought within the study period. These findings are in agreement with Issa and Barbara (2005) who observed that when p. value of a variable is too high (in general more than 0.10), the preserve of that variable is consider to have no value for the equation.

Conclusion

In conclusion, the frequency of droughts in the study area has since led to an unstable groundnut production. Groundnut shortage results from an abnormal reduction in yield, such that it is insufficient to meet the nutritional or economic needs of the community. Thus, the results of the correlation coefficient, NRI and RAI reveal that; the study area has experienced Very wet and moderately wets conditions in the past especially in 1988, 1998 and 2001. However, recurrent droughts still persist in almost every 2 to 4 years, ranging from mild, moderate to severe. Hence, results to serious loss in agricultural yields in the study area. For instance, the periods 1982, 1987 and 1990 witnessed severe and moderate drought. While the groundnut yields are 461. 371 (2.21%), 371.94 (1.80%) and 154.29 (0.73%) respectively. This yields totals are relatively low. The implication 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 (sever, moderate and mild) were experienced. Rainfall characteristics reveal relationship between groundnut yields and rainfall intensity. Most of the years with high rainfall experience high groundnut yields.

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