ANALYSIS OF DROUGHT DYNAMICS IN BIDA ENVIRONS, NIGER STATE, NIGERIA

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Abstract

Drought is a weather related natural disaster. It cause may be due to insufficient rainfall, or prolong dry spells and or lack of rainfall. Crop production in Bida environs is rain fed and it is characterized by drought incidences, the attributes which is reducing the Farmers' zeal for crops farming because of the resultant wastage of capital. The Study analyzed Drought dynamics in Bida environs. A data set of 51 years (1965-2015) of monthly rainfall, and two types of comparable drought index; the Rainfall Anomaly index (RAI) and Standardized Precipitation Anomaly taking the average as normal were used to investigate the fluctuating pattern and intensity of drought. Result shows that drought occurrences of the area are highly variable from year to year. The RAI shows that there was drought of varying degrees in 21 years out of 51 years of the studied period, with the peak value of -4.6 in 1972. The SPA also corroborated the occurrence of erratic dry spells at the planting season with the worst in the year 2015. The crux of the problems as claimed by the Farmers is their inability to determine the best time of farming input from planting to fertilizer application which also usually result to multiple inputs and thus waste of resources as a result of this fluctuations. Since Drought is beyond the Farmers control, suggestion was made that NiMet be encouraged to provide timely and accurate weather and drought forecast on her part, while farmers be informed through all effective means, accept and plan their crop production activities with it on their own part to reduce risk and loss due to this natural event of potential hazard.

Key words:, Drought, Rainfall Anomaly Index, Dry spell, Standardized Precipitation Anomaly.

Introduction

Drought is a weather related natural disaster. It is a very less understood and complex phenomenon. The causes of this natural phenomenon may be due to insufficient rainfall, rainfall variability or prolong dry spell. Drought has been ranked as the third most costly geophysical phenomena (Haas, 1978). This is because of its devastating impact on food production and the socio-economic activities of any country it affect. Drought however is a creeping phenomenon with insidious characteristics (Shuaibu and Oladipo,1993). This imply that drought do not just occur without an underlining factors.

Large area of northern Nigeria falling within the sahel and sudan ecological zone between latitude 9^0N and 14^0N are prone to recurrent drought in one way or the other and the probability of drought at the onset and toward the end of the raining season is usually very high in northern Nigeria (Abubakar, and Yamusa, 2013) “Over the years a consistent shift in the climate and weather condition in Nigeria has become noticeable. This may be attributed to the general change in the global climate conditions as a result of global warming, for instance the onset of the raining season on the average is expected to commence in northern Nigeria between late March and April, but the current weather condition show a deviation from this trend particularly in the year 2015” (Babs Iwalewa 2015).

Agricultural crops production in Bida and environs still depends largely on rain water. Amongst the several problems facing agriculture in Bida and environs is large-inter annual variability of rainfall with dry spells within the rainfall regime.

In reality, it is not only lack of rain or its insufficiency and the consequent drought that determines agricultural crop yields and productions, other agro-climatic parameters such as temperature, soil moisture and soil fertility also count. However, it is only rainfall characteristics, a function of drought occurrences that is mostly noticeable or apparent to farmers’ understanding and hence an important factor that dictate their decisions on agricultural planning.

Bida and particularly the immediate environs’ habitants are predominantly Farmers. Very large percentage of the able population relies or depends on agricultural sector for survival and each years at the onset of the rainfall also set to make a significant impact for an expected bountiful harvest but at the end, majority are still being disappointed as a result of prolong and erratic dry spells. It is important to monitor drought because droughts is one of the most costly natural hazard on year -to- year basis, their impacts are significant and wide spread, affecting many sector of and People at any all-time (IDMP 2016). Threat to food security which may result to hunger and poverty among the farmers who solely depends on agricultural resources for livelihoods may occur in a severe drought.

The aim of this study is to assess the drought dynamic, with a specific objective of analyzing the temporal variations of drought in the study area. This will serve a great benefits in reducing loses and vulnerability due to drought incidences.

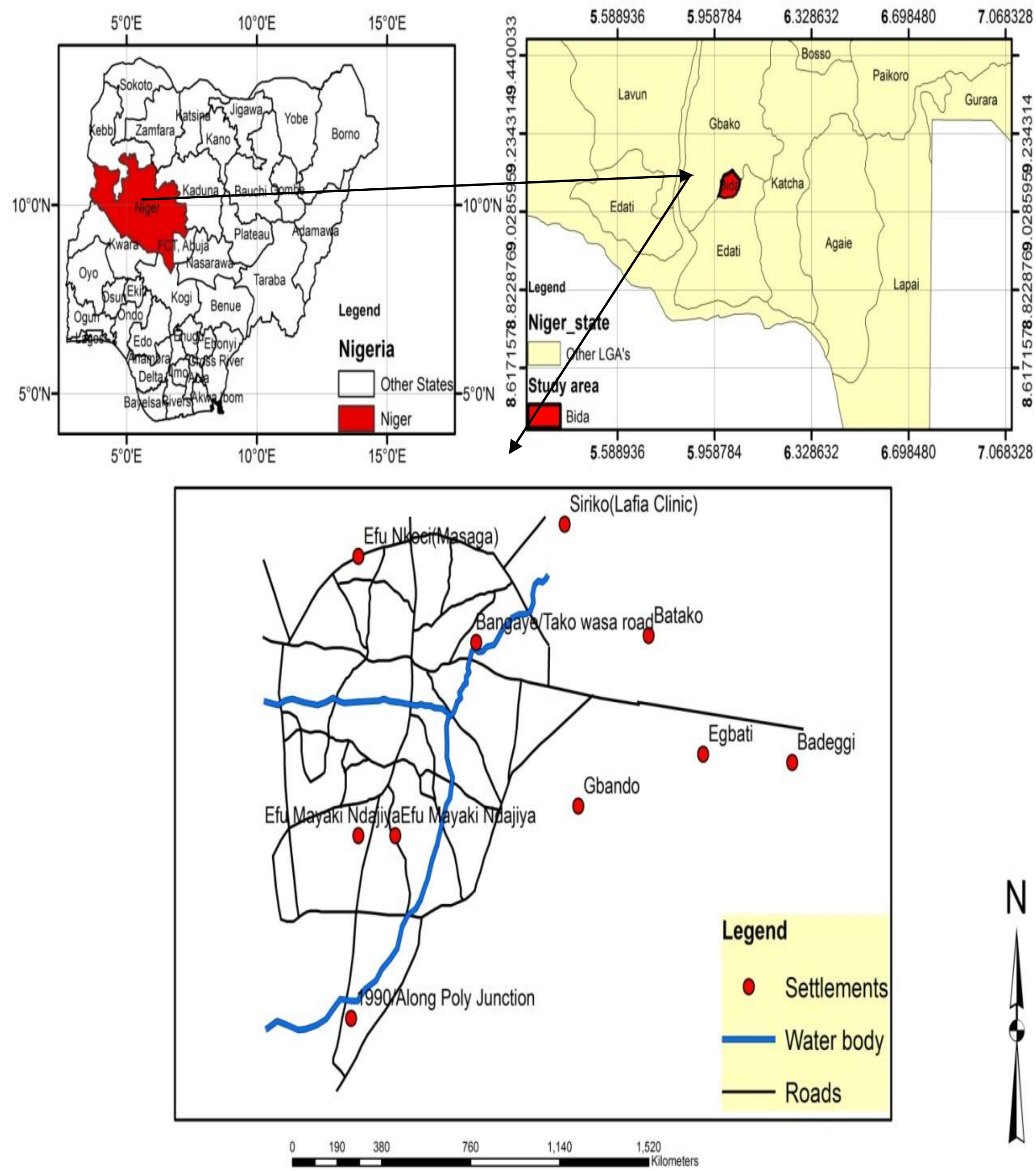
Study Area

Bida is located at about 87km southwest of Minna, capital of Niger State. It lies within latitude 09°05'N - 09°083'Nand longitude 06°01E - 06°017E. It has a population of188, 181(2009National Population Census). However, with the addition of the population of the people of the immediate neighborhood and the increasing population over time, the study area's population may now be over 300000 comprises of the native tribe- the Nupes, which make the bulk of the population, and other major ethnic groups; the Hausa, Yoruba, Igbo and other minority tribes. The town is known for its traditional craft, notably metal and brass wares, but agricultural activities constitute major occupation especially in the neighborhood.

The typical climate of the area is Tropical Monsoon type. It is marked with distinct dry and wet seasons, the raining season which is the crop production regime, spans from April to October with the maximum rainfall in the month of September and the mean annual rainfall of about 1150mm (NiMet Bida, 2015). The dry season spans from November to March, the driest period is within the month of January which record the lowest relative humidity. The season is hottest in the month of March which records a maximum temperature of above 38°c and coldest in the months of December through early part of January with average minimum temperature of about 21°c, and lowest mean relative humidity and occasional negative dew point temperature. The closest major river of micro-climatic impact is the downstream tributary of river Kaduna at Wuya, about 25 kilometers along Bida- Mokwa Road. The vegetation is more of characteristic of southern guinea savanna (Physical setting, Niger State, 2003). It is cover by expanse of annual grasses interspersed with tall dense species and weeds and sparsely distributed within are Shrubs and Trees, of various species and economic values which includes Shear butter, Mango, Locust bean Trees etc.

The soil

The soil is typical of ferruginous tropical soil types which are formed from the basement complex or sedimentary rocks over varying period of time (Physical setting- Niger State, 2003). The surface soils are loamy- sand, alluvial deposit and sand stones.



Figure

1: The Study Area (Bida and its Environs, Niger State, Nigeria)

Source: Remote Sensing and GIS Laboratory, Federal University of Technology, Minna (2016)

Materials and Methods

The study utilized secondary data. This is the rainfall data of the study area for consecutive 51 years (1965-2015) obtained from the archive of the Nigerian Meteorological Agency,Bida Aerodrome. The conventional rain gauge used for the measurement is located at 142.3m above mean sea level (MSL) and has been unchanged for those years there by provided a good tool of comparison in assessing the rainfall trend and its variability in determining the Drought incidences without positional bias. Rainfall Anomaly Index and Standardized Precipitation Index were employed for the analysis.

Rainfall Anomaly Index (RAI).

The rainfall anomaly index developed by Van-Rooy (1965) was used to evaluate the annual rainfall variability. It employed the use of rainfall measurement of the area for a period of 51 years (1965-2015). The rainfall data for those years were arranged in descending order of magnitude with the highest rainfall values ranked first and the lowest rainfall values ranked last. Also, the average values of the ten highest rainfall measurements connoting the maximal average of the first ten extrema and the average values of the ten lowest rainfall measurements connoting the minimal average of the last ten extrema for the period understudy were computed respectively.

The values of these respective ten extrema represent the positive and negative anomalies respectively based on the average rainfall values of the ten extreme as, with the upper been the positive and the lower been the negative. These were used to calculate the Rainfall Anomalies for both positive and negative anomalies for all the years involved. The technique is given by the equations (i) and (ii):

$$RAI = +3\left[\frac{R_{t-M_{Rt}}}{M_{H10-M_{Rt}}}\right], \text{ for positive RAI} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(i)}$$

$$RAI = -3\left[\frac{R_{t-M_{Rt}}}{M_{L10-M_{Rt}}}\right], \text{ for negative RAI} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(ii)}$$

Where:RAI = the annual Rainfall Anomaly Index for a particular year.

Rt = total annual rainfall for a particular year.

M_{Rt} = long term mean rainfall of the years under study.

M_{H10} = mean value of the 10 highest (ranked) rainfall.

M_{L10} = mean value of the 10 lowest (ranked) rainfall

+/-3 = constant for both positive and negative anomalies respectively.

Standardized Precipitation Index (SPI) for the months of April and May.

Standardized Precipitation Index developed by Mckee *et al* (1965) and as employed by Akeh *et al* (2000) normally used to compute the number of standard deviation a value is above or below the mean of the data set. It gives meaningful information about each data point or value and where it falls relative to the mean of the distribution.

This is obtained using equation (iii):

$$x_s = \frac{x - x_m}{x_{sd}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(iii)}$$

Where:

x_s= standardised anomaly

x = rainfall variable

x_m= average of all the sampled rainfall $= \frac{\sum x}{N}$

N = number of the variable sampled.

x_{sd}= standard deviation of all the rainfall sampled $= \frac{\sqrt{\Sigma(x - x_m)^2}}{N}$

The positive SPI values are indicative of absence of drought while the negative values showed the occurrence of drought (Akeh*et al*., 2000). The rainfall values of the months of April and May of the years for this study was used to calculate the rainfall anomaly; this was because these months are crucial in the seasonal planting regime.

Results and Discussion

Rainfall Anomaly Index

The careful observation of the RAI shows that there were some degrees of slight drought of less than -1 in relative to the mean in 1976, 1977, 1981, 1986, 1987, 1990, 1999, 2008 and 2011. For 1979 and 2006, the deficit was between -1 and -2 while in 1965, 1972, 1982, 1983, 1992, 1994, 1998, 2002, 2003, and 2014 was in moderate of higher than -2 to this negative side with the peak value of -4.6 in 1972 indicating the greatest drought year among the studied years. In this context, 21 out of the 51 years used in the study which is about 41% of the time period had some levels of drought.

The temporal variability of drought is conspicuous from the annual RAI. The patterns of fluctuation can be adjudged erratic as the there was no period of consecutive five years other than between 1966 and 1971 without water deficit. Some other years were characterized by moderate intermittent drought which means that farmers will find it difficult on their own to literally know the trends of occurrence, and plan made based on immediate past year may be fruitless, thus scientific drought forecast will be the better and reliable technique of guide to greater yield.

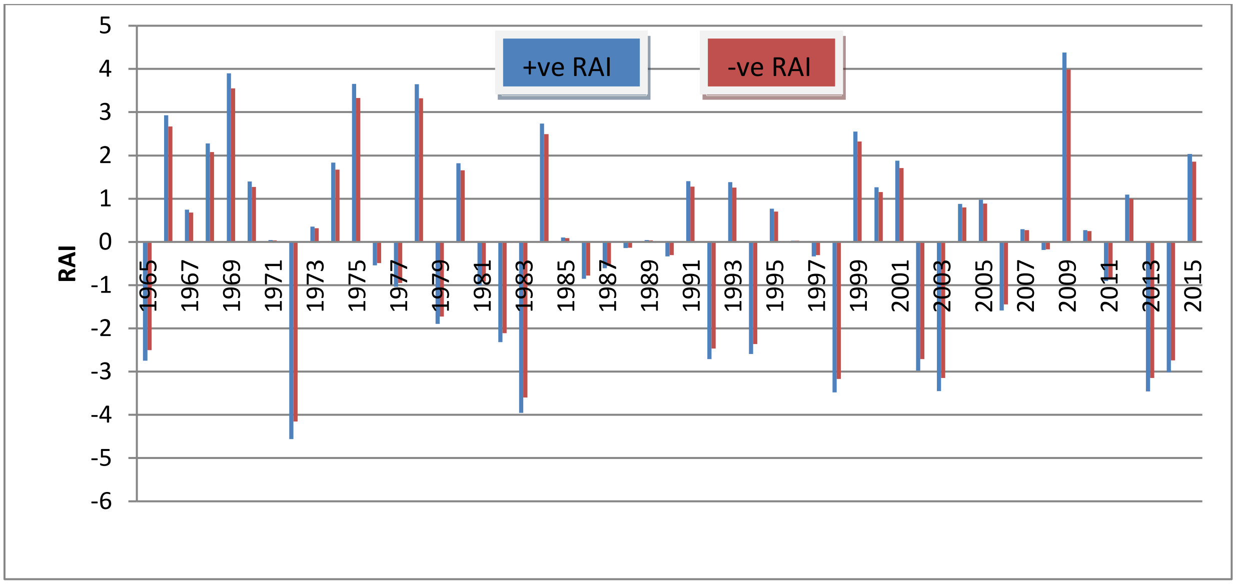


Figure 2: Annual Rainfall Anomaly Index
Source: Author's computation (2016)

Table 1: Rainfall Anomaly Index

S/N	Years	Deviation from mean(X-mX)	Positive. RAI	Negative. RAI
1	1965	-189.98	-2.7475	-2.50215
2	1966	202.7196	2.931739	2.669935
3	1967	51.61961	0.746525	0.67986
4	1968	157.5196	2.278055	2.074625
5	1969	269.7196	3.900696	3.552364
6	1970	96.51961	1.39587	1.271219
7	1971	2.719608	0.039331	0.035819

8	1972	-315.38	-4.56104	-4.15374
9	1973	24.31961	0.351711	0.320303
10	1974	126.8196	1.83407	1.670288
11	1975	252.9196	3.657734	3.331098
12	1976	-37.4804	-0.54204	-0.49364
13	1977	-71.9804	-1.04098	-0.94802
14	1978	252.3196	3.649056	3.323196
15	1979	-130.88	-1.8928	-1.72377
16	1980	125.7196	1.818162	1.6558
17	1981	-69.6804	-1.00772	-0.91773
18	1982	-160.28	-2.31798	-2.11099
19	1983	-273.48	-3.95508	-3.6019
20	1984	189.3196	2.737948	2.493449
21	1985	6.819608	0.098625	0.089818
22	1986	-59.1804	-0.85587	-0.77944
23	1987	-42.1804	-0.61001	-0.55554
24	1988	-9.98039	-0.14434	-0.13145
25	1989	2.919608	0.042223	0.038453
26	1990	-23.1804	-0.33524	-0.3053
27	1991	97.31961	1.40744	1.281756
28	1992	-187.28	-2.70846	-2.46659
29	1993	95.51961	1.381408	1.258049
30	1994	-179.28	-2.59276	-2.36123
31	1995	53.21961	0.769664	0.700933
32	1996	2.019608	0.029208	0.026599
33	1997	-23.0804	-0.33379	-0.30398
34	1998	-240.48	-3.47784	-3.16727
35	1999	176.4196	2.551388	2.323549
36	2000	87.61961	1.267158	1.154001
37	2001	129.9196	1.878903	1.711117
38	2002	-205.98	-2.9789	-2.71288
39	2003	-238.78	-3.45325	-3.14488
40	2004	60.81961	0.879576	0.80103
41	2005	67.21961	0.972133	0.885321
42	2006	-109.88	-1.58909	-1.44719
43	2007	20.61961	0.298202	0.271572
44	2008	-12.7804	-0.18483	-0.16833
45	2009	302.7196	4.377943	3.986993
46	2010	18.91961	0.273616	0.249182
47	2011	-62.5804	-0.90504	-0.82422
48	2012	75.81961	1.096506	0.998588
49	2013	-238.98	-3.45614	-3.14751
50	2014	-208.18	-3.01071	-2.74186
51	2015	140.8196	2.036539	1.854676

Source: Author's computation(2016)

Inter-annual variability of rainfall for the months of April and May

A synoptic view of Figure 3 gave a clear pattern of the deviation from mean of the values of rainfall for the months of April and May with years; 1965, 1967, 1973, 1977, 1988, 1993, 2000, 2001 and 2003 recorded a rainfall deficit of bellow 50mm from the mean, while 1982, 2002, 2008, and 2015 deviated above minus 100mm with the highest in 2015 of minus 151.1mm amount to 74.2% deviation to the negative side of the mean. This suggested a drought period in the crop sowing regime which usually is the month of April through the month of May. The year 2015 as a typical example amongst the studied years, it had a good annual rainfall value of 1296.0mm but have a deficit rainfall value of 151.1mm in the earlier 61 days (April and May) of the growing season. This lead to crop wilt, dried off, crop lose and multiple planting. This in part accounted for non-optimum production of maize and melon (Egusi) in the study area in that year.

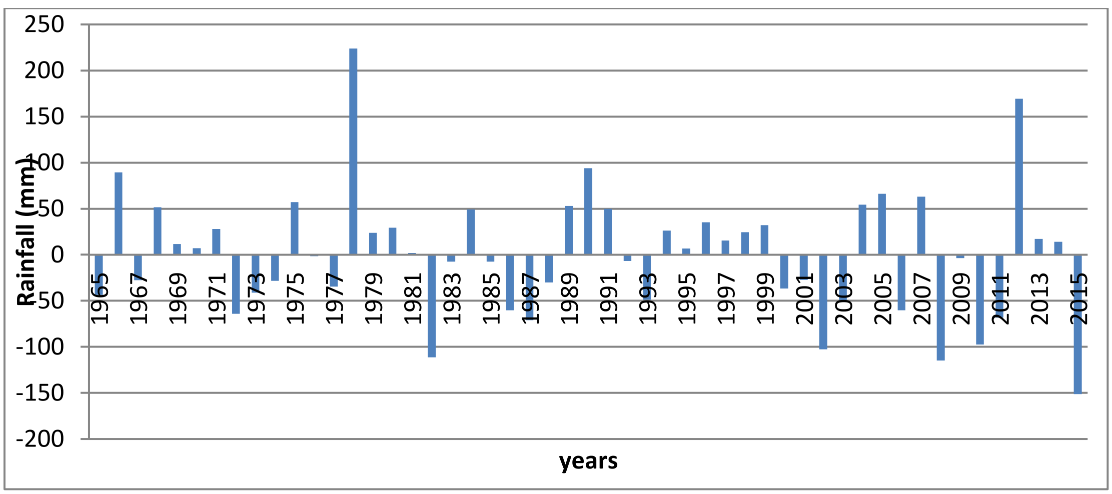


Figure 3: Patterns of Rainfall deviation from mean for the months April and May
Source: Author's computation (2016)

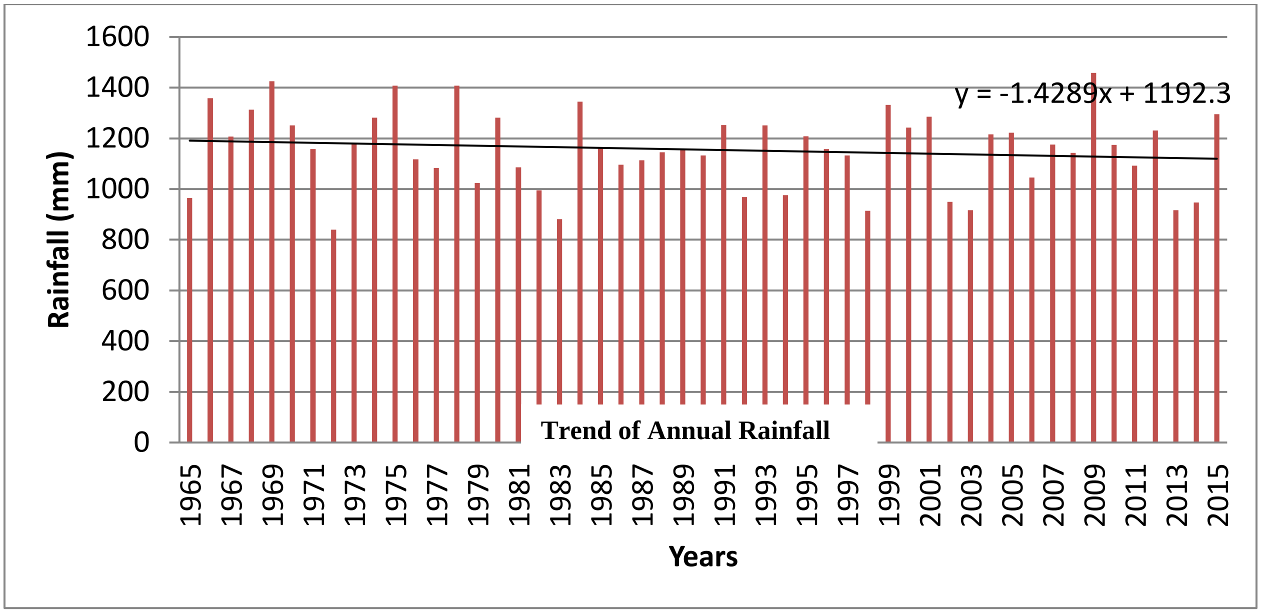


Figure 4: Patterns of Annual Rainfall
Source: Author's computation (2016)

Comparison of patterns of mean rainfall deviations for the months of April and May (Figure 2) and the trend of annual rainfall (Figure 3) shows that there were some years of high annual rainfall of above 1200mm but with drought at the early growing phase of Crops. This occurred in the years: 1967, 1973, 1974, 1985, 1993, 2000, 2001, 2010, and recently the year 2015. This stressed further the fact that, there may be optimum annual rainfall but yet characterized by intermittent drought within the Crop growing season, sufficient enough to affect Crop production negatively.

Standardized Precipitation Index

The patterns of rainfall values indicated the occurrence of some levels of anomalies to the two sides. To the negative side, constituting dry spells in different degrees were years: 1965, 1967, 1972 – 1974, 1977, 1982, 1986 – 1988, 1993, 2000 – 2003, 2006, 2008, 2010, 2011, and 2015 been the worst drought s year at the early season – April and May.

Table 2: Standardized Precipitation Anomaly for the months of April and May.

Year	Sum Rainfall: April and May(mm)	Deviation from mean	SPI for April and May
1965	160.1	-43.7	-0.6
1966	293.1	89.3	1.3
1967	176.3	-27.5	-0.4
1968	255.5	51.7	0.8
1969	215.4	11.6	0.2
1970	211.0	7.2	0.1
1971	231.9	28.1	0.4
1972	139.7	-64.1	-1.0
1973	162.8	-41.0	-0.6
1974	175.5	-28.3	-0.4
1975	260.8	57	0.8
1976	202.4	-1.4	0.0
1977	169.2	-34.6	-0.5
1978	427.6	223.8	3.3
1979	227.7	23.9	0.4
1980	233.0	29.2	0.4
1981	205.7	1.9	0.0
1982	92.3	-111.5	-1.7
1983	196.4	-7.4	-0.1
1984	252.9	49.1	0.7
1985	196.2	-7.6	-0.1
1986	143.7	-60.1	-0.9
1987	132.6	-71.2	-1.1
1988	173.8	-30.0	-0.4
1989	256.6	52.8	0.8
1990	297.6	93.8	1.4
1991	253.5	49.7	0.7
1992	196.9	-6.9	-0.1
1993	155.0	-48.8	-0.7
1994	230.1	26.3	0-4
1995	210.6	6.8	0.1
1996	239.0	35.2	0-5
1997	219.1	15.3	0.2
1998	228.4	24.6	0.4
1999	236.0	32.2	0.5
2000	167.2	-36.6	-0.5
2001	176.6	-27.2	-0.4
2002	101.0	-102.8	-1.5
2003	154.6	-49.2	-0.7

2004	258.1	54.3	0.8
2005	270.0	66.2	1.0
2006	143.6	-60.2	-0.9
2007	266.8	63	0.9
2008	88.9	-114.9	-1.7
2009	200.1	-3.7	-0.1
2010	106.5	-97.3	-1.4
2011	135.6	-68.2	-1.0
2012	373.1	169.3	2.5
2013	221.0	17.2	0.3
2014	217.9	14.1	0.2
1015	52.7	-151.1	-2.2
Sum	**10392.1**		
Mean	**203.8**		

Source: Author's computation (2016)

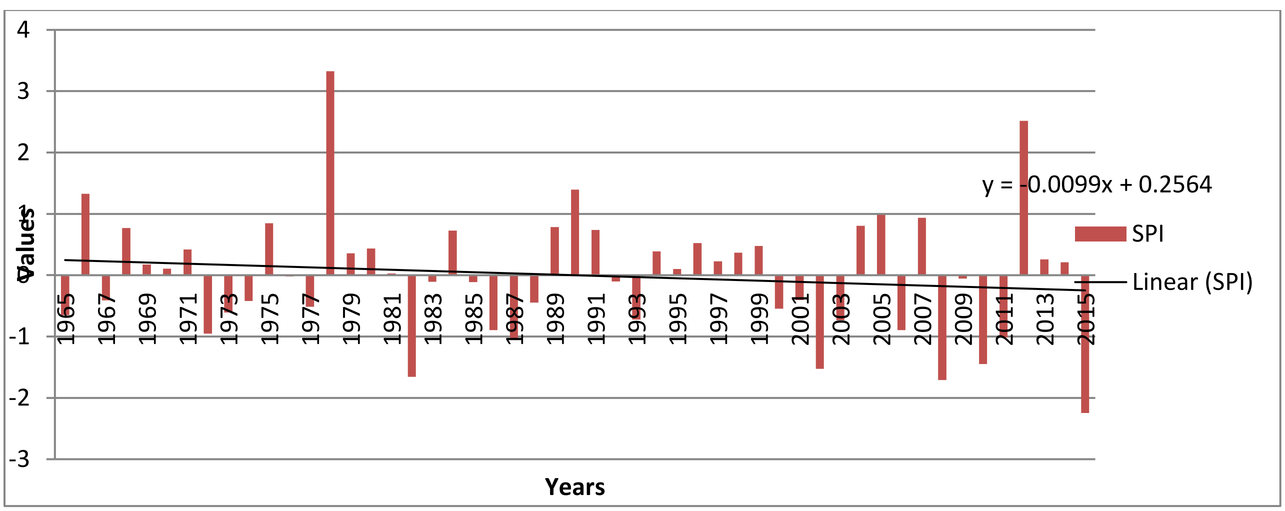


Figure 5: Standardized Precipitation Index (April and May)
Source: Author's computation (2016)

Conclusion and Recommendations

The overall analysis shows that drought is not an alien phenomenon in the study area. The drought characteristic of the area in terms of intensity is not too high to have caused untold level of damages and lose of capital. The temporal pattern of occurrence is that which is causing significant crop failure, resulting to loss of capital, particularly at the onset of the season where the farmers have to plant and replant before rainfall steadiness.

There are some years which recorded early sufficient rainy days that could be taken to be onset of rain by the farmers, and thereafter dry spell for up to a month. This happened recently in the year 2015, and it’s perhaps one of the factors that accounted for individual low production of maize and melon in the study area in that said year.

Crop productions in this micro climatic zone rely mainly on rain fed. Drought intensity, temporality or perpetuity may come under the influence of the unarguable climate change phenomenon, it is therefore important to be constantly acquainted with the patterns the rainfall of the area will take. Irrigation scheme is not readily feasible to these set of farmers, also drought is a natural phenomenon not readily preventable, while the exact patterns of drought may as well be tricky and difficult to predict. However the assertion that “Prevention is better than cure” seem to be the only feasible option applicable now, therefore crop production planning based on available weather and drought forecast will still serve no small measure to reduce crop failure.

Specific measure to achieve this is to fund well the Nigerian Meteorological Agency (NiMet) which has the statutory function of providing information about weather and climate. This will enable her to better achieve her mandate of monitoring, forecasting and issuance of early warning of drought fore stakeholders’ consumption using both meteorological and satellite based indicators.

Also, information dissemination on drought forecast should be improved through social media and in local languages of the area and also through improved Agriculture Extension Workers which is very necessary for effective communication that will enhance questions, answers, feedback and direct guidance as to the best time of impute and suitable crop varieties to plant.

Also, all other related research institutes should collaborate with NiMet in any other areas necessary that can help her to provide qualitative drought predictions.

National Cereal Research Institute (NCRI) Badeggi Niger state, should not cease in finding improved, suitable and drought resistant varieties are made to be known and be available to farmers at affordable prices.

Drought insurance Scheme should be established and farmers to be sufficiently convinced about its importance and its roles it can be made to provide a bail out to farmers who drought is genuinely the culprit for his lose.

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