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Extent and Intensity of Extreme Drought in Some Parts of the Savanna Region of Nigeria

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Abstract
This study is on the extent and intensity of extreme drought in some parts of the Savanna Region of Nigeria. The region is prone to drought occurrences. Data used were from 1941 to 2010 and for eight stations scattered over the region. The Bhalme and Mooley Drought Index (BMDI) was used to depict extreme droughts occurrence. This was with the intention of finding out the percentage of extreme drought occurrences over a 70 year period (1941-2010).Results showed that extreme droughts were confined to stations in the extreme north of the study area and for limited time during the study period. Apart from these, other findings were made and are in the study. Also the effects of droughts especially extreme and the mitigation measures were looked at.
Key Words: Extreme, Drought, Drought Intensity, Percentages, Sub-period

INTRODUCTION

The definition of drought varies depending on scholars, scientists and on what type of drought they are focusing on. However, the various definitions can be grouped under two main heads: (1) conceptual definitions, are those formulated in general terms and help people to understand the concepts of droughts. They are also important in establishing drought policy as in the case of the Australian drought policy. (2) Operational definitions on the other hand, are those that help people identify the beginning, end and degree of severity of a drought. To determine the degree of drought severity, operational definitions specify the degree of departure from an average of precipitation or some other climatic variable over a period. Operational definitions can also be used to analyse drought frequency, severity and duration of drought for a given historical period (NDMC, 2006). Most operational definitions can be classified into meteorological, hydrological, agricultural and socio-economic (Shuaib and Oladipo, 1993).

The expression extreme drought can be found under meteorological drought which itself is under operational definitions. It is a category under the intensity/severity of droughts. It is the most catastrophic of droughts. Its negative effects transcends all the sectors of the economy, be it agriculture, health or transport. The Bhalme and Mooley Drought Index classify it as a drought with a value from -4.00 or less (Shuaib and Oladipo, 1993). Also, in percentage form, it is when there is an abnormal or deficit precipitation to about 60% or more. It is at times known as disastrous or catastrophic drought.

Studies on droughts have tended to focus on the general occurrences of drought without specifically looking at the severity or intensity of the drought. The few studies (Oladipo, 1993; Abaje *et al*,2011 Olatunde,2013; Aremu and Olatunde,2012) carried out on drought intensity in the study area did not concentrate on the occurrence and reoccurrence of extreme drought. This study intends to do this so as to give an insight into its occurrences over the years and decades in parts of the savanna region of Nigeria and also help to proffer solutions to its effects in the strong likelihood that it returns.

The study area is the savanna region of Nigeria. The area is known for subsistence farming and the production of grains like maize, sorghum, millet and rice. The occurrence of any form of drought therefore is a major cause for concern to the people of the area. The advent of climate change in recent years has again raise the fear of the reoccurrence of extreme drought in the area. The objective of this study is to look at the pattern of the occurrence and reoccurrences of extreme drought over the years and decades so as to give the stakeholders the ideas and hindsight into its likely occurrence in the future.

MATERIALS AND METHODOLOGY

The data, period and method used for this study are the same as those used by Aremu and Olatunde, 2012 in their study on drought intensities and Olatunde, 2013 in his study on invisible drought. The data were obtained from the Nigerian Meteorological Agency (NIMET) Oshodi, Lagos and covered a period of 70 years (1941-2010) for eight stations (Table 1). The synoptic stations used were with long and continuous period of daily, monthly and annual rainfall record data of at least 70 years.

The analysis method in this study is that by Bhalme and Mooley (1980). It was used to look at the intensity/severity of drought over a 70 year period. Details of this method can be found in Bhalme and Mooley (1980) and are given below, the applicability of the method can be found in Shuaibu and Oladipo, 1993. The Bhalme and Mooley Drought Index (BMDI) is an empirical one that uses monthly rainfall as the sole climatological input. The index has been shown to perform comparatively well in depicting periods and intensities of drought (Oladipo, 1985).

Monthly growing seasonal rainfall (April to October) values for the eight (8) selected stations were used to derive the Bhalme and Mooley Drought Index (BMDI) for the assessment of drought severity (Shuaibu and Oladipo, 1993). For agricultural purposes, the months of April to October (the growing season) are considered to be the most important in drought study. This is because they are said to be the months when more than 95% of the annual rainfall total is received in the study area and also in the Savanna region of Nigeria (Anyadike,1993).

In its general form, the **BMDI** for a given month **K** is calculated using this formula

IK = (MK / d) + (1 + C) IK …….(3)

Where;

C is a constant

d is a constant

IK = drought intensity for the **Kth** month.

Ik-1= drought intensity for the **(K-1)** month.

M, the moisture index is given by

M = 100 (X – Ẍ) / S …….(4)

In equation (4),

X = the monthly rainfall value,

Ẍ = the long term mean monthly rainfall,

S = the standard deviation for the initial month under consideration **(K-1).**

. Equation (3) is then given as;

I = M /d …….(5)

The values of **C** and **d** in equation (3) for northern Nigeria are **0.43** and **38.84** respectively. These are constant values (Shuaibu and Oladipo, 1993).These values were used in equations (3) and (5) to generate monthly values of BMDI for the stations under study. From these monthly values, the means or seasonal drought index **(SDI)** series were obtained for each year studied in the stations. The seasonal indices were then used to classify a year into any of the following wetness/ dryness categories using B.M.D.I classification chart (Shuaibu and Oladipo, 1993).

RESULTS AND DISCUSSIONS

Results of Analyses of Extreme Droughts Using Decades

In the decades 1941 to 50, 1952 to 60, 1961 to 70 and 2001 to 2010 no station experienced extreme drought (Table 3 and Fig.2). In the decade 1971 to 1980, extreme drought was experienced for one year in Kano, other stations did not experience extreme drought. In the next decade of 1981 to 1990, a year of extreme drought was experienced in Maiduguri with other stations experiencing no extreme drought. The decade 1991 to 2000 also had one year of extreme drought that occurred in Katsina while other stations experienced no extreme drought during the decade (Table 3). These three decades (1971to 1980, 1981 to 1990 and 1991 to 2000) each accounted for about 33.33% of the extreme drought in the study area during the study period. Therefore, extreme droughts were confined to the three decades (Table 3 and Fig.2).

The occurrence of three years of extreme drought out of 282 years (total number of years study for the stations used) means that one month of extreme drought occurred for every 10 years of all drought intensities.

Results of Analyses of Extreme Drought Occurrences Using Overlapping Sub-Periods

At regional level extreme drought occurred for eight years (100%) during the study period using sub-periods. The sub-period 1971 to 2000 experienced the highest number of years of extreme drought at three years (37.50%). Two sub-periods 1961 to 1990 and 1981 to 2010 had two years (25%) each of extreme droughts. The sub-period 1951 to1980 experienced one year (12.50%) of extreme drought while the sub-period 1941 to 1970 experienced no extreme drought at all. This may be due to low intensity of human activities like animal grazing and tree cuttings leading to more biogenic freezing nuclei in the air and therefore more rainfall (Table 4).

Taking all the sub-periods into consideration (that is across the overlapping sub-periods) at regional level, Kano and Maiduguri experienced three (3) years (37.50%) of extreme drought. They were followed by Katsina with 2 years (25%) while other stations recorded no extreme drought during the study period. In Kano, The sub-periods with the three years of extreme drought were 1951 to 1980, 1961 to 1990 and 1971 to 2000 each with a (1)year (33.33%).Other sub-periods did not experienced extreme drought (Table 4). Maiduguri also had years of extreme drought like Kano but the drought sub-periods were 1961 to 1990, 1971 to2000 and 1981 to 2010 all with one (1) year (33.33%) of extreme drought each. Other sub-periods had no extreme drought. Katsina had the last two sub-periods of 1971 to 2000 and 1981 to 2010 with a (1) year (50%) each of extreme drought. Other sub-periods did not experience extreme drought (Table 4)

Results show five (5) stations **Bauchi, Bida,Kaduna, Sokoto** and **Nguru** experienced no extreme drought throughout the studied sub-periods (Table 4). In the three stations with extreme drought, **Maiduguri** and **Katsina** recorded no extreme drought in the first two sub-periods, but had two years of extreme drought in the

last two sub-periods (0:2). **Kano** however, had one year of extreme drought in the first two sub-periods (1941 to 1970 and 1951 to 1980) and another one year in the last two sub-periods (1971 to 2000 and 1981 to 2010) (1:1). This suggests that extreme droughts have been more common in the last 30 or more years than the first 30 years of the study periods in Maiduguri and Katsina. Kano on the other hand recorded a balance in the occurrence of extreme drought (years) in the first 30 years and the last 30 years (Table 4).

Results of Analyses of Extreme Drought Occurrences in Two Non-Overlapping Sub-periods (1941 to 1975 and 1976 to 2010)

The sub-period 1976 to 2010 had two years (66.67%) of extreme drought out of a possible three years of extreme drought during the study period for all the stations. The remaining one year (33.33%) of extreme drought occurred in the sub-period 1941 to 1975(Table 5.40). Extreme drought only occurred in three stations and showed the following ratios, Kano (1:0). Maiduguri (0:1) and Katsina (0:1) for the two non-overlapped sub-periods (Table 5). The sub-period 1976 to 2010 has proved to be the most affected by extreme drought as it had greater numbers of years than those of the earlier sub-period 1941 to 1975 (Table 5).

CONCLUSION AND RECCOMMENDATIONS

This study has been able to prove that only few stations confined to the extreme northern part of the study area experienced extreme drought during the period of study. It has also showed that extreme droughts were experienced in the study region in recent decades. This situation therefore signifies that extreme drought may likely occur not too long in the future in those stations where it occurred in the past. This makes the likelihood of it occurring in those stations where it did not occur lesser. This however, does not eliminate the occurrence of other low intensity droughts like mild, moderate and severe.

The extreme droughts that occurred in the study region have mostly affected negatively the entire sectors of the economy from agriculture to health, tourism, insurance, transportation, industry and others. This means various strategies have to be adopted to combat extreme drought occurrence and its effects. Some of the measures that can be adopted are;

- ✓ Dissemination of information to the farmers, animal herders and other stakeholders should be done regularly and as at when due. This is to inform them of an impending drought, its likely intensity and the measures to be adopted by the citizens to mitigate its effects.
- ✓ Application of irrigation techniques to extensively cover the area prone to extreme drought.
- ✓ Rotational grazing and ranching should be adopted by animal herders in the study region in other to avoid overgrazing and adequately provide pastures for their animals'.
- ✓ More boreholes, wells and dams should be dug to reduce water shortages. Also the shallow wells and bad boreholes should be repaired.
- ✓ Crop rotation system and application of organic manure should be adopted to enhance water retaining capacity of the soil.
- ✓ Green infrastructure on a large scale in the study area will help to reduce the rate of water evaporation and the impact of drought in the region.
- ✓ Other measures are, water recycling and rain harvesting.

All measures above and possibly others not mentioned need to be implemented in the study area collectively so as to mitigate and tackle effectively the effects of extreme drought.

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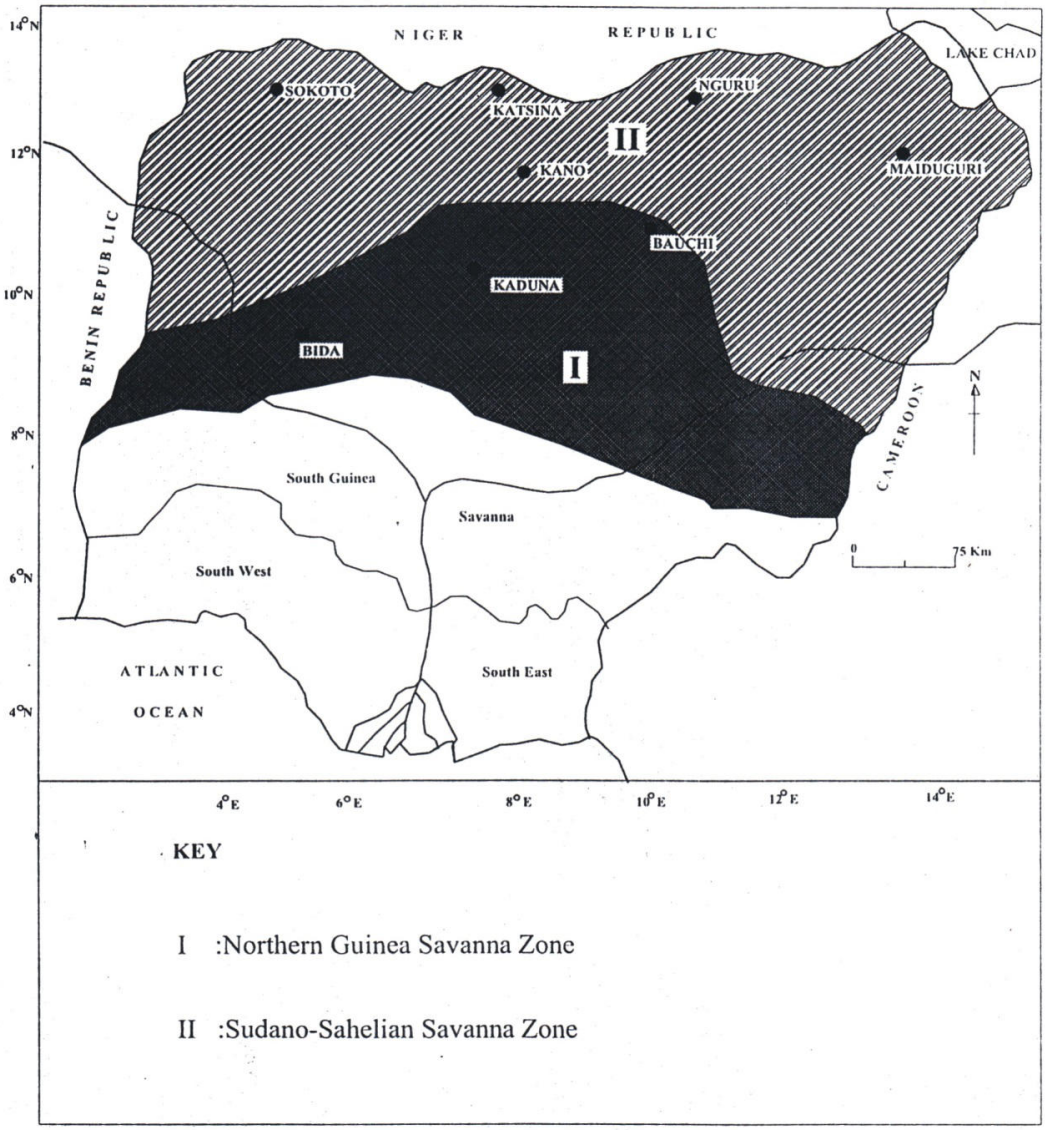

Fig. 1: Study Stations with Vegetation Map of the Study Area.

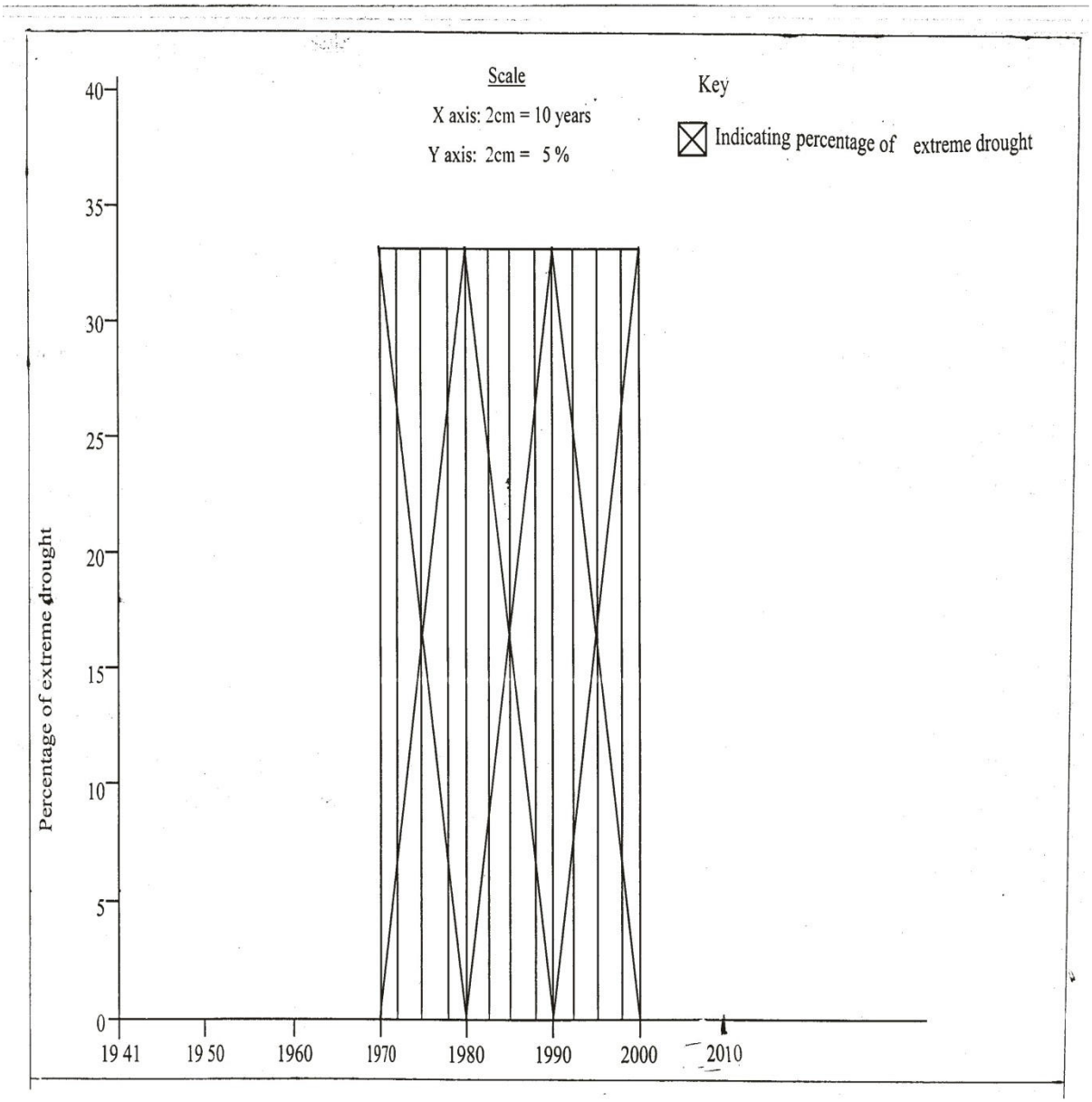

Fig.2: Extreme Drought Occurrences in Decades.

Table 1: Stations Used and Their Locations

NO	STATION	LATITUDE	LONGITUDE
1.	**Bauchi**	10^{0} 17^{1} N	9^{0} 49^{1} E
2.	**Bida**	9^{0} 06^{1} N	5^{0} 38^{1} E
3.	**Kaduna**	10^{0} 35^{1} N	7^{0} 26^{1} E
4.	**Kano**	12^{0} 03^{1} N	8^{0} 32^{1}E
5.	**Maiduguri**	11^{0} 51^{1} N	13^{0} 05^{1} E
6.	**Sokoto**	12^{0} 55^{1} N	5^{0} 16^{1}E
7.	**Nguru**	12^{0} 58^{1} N	10^{0} 28^{1} E
8.	**Katsina**	13^{0} 01^{1} N	7^{0} 41^{1}E

Source: NIMET, 2010.

Table 2: BMDI Classification Chart.

BMDI	CHARACTER OF ANOMALOUS MOISTURE CONDITIONS (CAMC).
4.00 or more	Extremely wet
3.00 to 3.99	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	Moderate drought
-3.00 to -3.99	Severe drought
-4.00 or less	Extreme drought

Source: Shuaibu and Oladipo, 1993.

Table 3: Frequency and Percentages of Extreme Drought during the Decades in stations

STATION	1941-50	1951-60	1961-70	1971-80	1981-90	1991-2000	2001-2010	Total
Bauchi	-	-	-	-	-	-	-	-
Bida	-	-	-	-	-	-	-	-
Kaduna	-	-	-	-	-	-	-	-
Kano	-	-	-	1	-	-	-	1
Maiduguri	-	-	-	-	1	-	-	1
Sokoto	-	-	-	-	-	-	-	-
Nguru	-	-	-	-	-	-	-	-
Katsina	-	-	-	-	-	1	-	1
Total (%)	-	-	-	1(33.33)	1(33.33)	1(33.33)	-	3(100)

Table 4: 30 Year Overlapping Sub-periods for Extreme Drought.

STATION	1941-1970	1951-1980	1961-1990	1971-2000	1981-2010	TOTAL
Bauchi	-	-	-	-	-	-(0.00)
Bida	-	-	-	-	-	-(0.00)
Kaduna	-	-	-	-	-	-(0.00)
Kano	-	1	1	1	-	3(37.50)
Maiduguri	-	-	1	1	1	3(37.50)
Sokoto	-	-	-	-	-	-(0.00)
Nguru	-	-	-	-	-	-(0.00)
Katsina	-	-	-	1	1	2(25.00)
Total	-	1	2	3	2	8(100.00)

Table 5: Years and Percentages of Extreme Drought in Two Sub-periods (1941 to 1975 and 1976 to 2010)(Non-Overlap)

Station	1941 to 1975	1976 to 2010	Total
Bauchi	--	-	-
Bida	-	-	-
Kaduna	-	-	-
Kano	1	-	1
Maiduguri	-	1	1
Sokoto	-	-	-
Nguru	-	-	-
Katsina	-	1	1
Total	**1 (33.33%)**	**2 (66.67%)**	**3 (100%)**

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