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Return Periods of Drought Intensities in Some Stations in Northern Nigeria

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ABSTRACT

This study was on the return periods of the various drought intensities. This study was done with the intension of highlighting the likely return periods of these intensities (invisible, mild, moderate, severe and extreme) and call attention of the various stakeholders like farmers, herders and government at various levels to these. This situation will enable them to put in place individual and collective policies and measures in place to combat the droughts when they arrive. The Bhalme and Mooley Drought Index (**BMDI**) was used to indentify the intensities for the drought years in eight selected stations in the study area. It also showed the number of times that all intensities appeared during the study period. Thereafter the Return Period statistical tool was applied to the result from the **BMDI**. The outcome of the application of the return statistical tool being the likely years that all the intensities are to return to the study area. The result showed that the lesser the intensity the higher the likely rate of return. Results also indicated that drought of all intensities are likely to reoccur at faster rates in the region as a whole than within stations without extreme droughts.

KEY WORDS: Return Periods, Invisible, Mild, Moderate, Severe, Extreme, BMDI

INTRODUCTION

Drought is a hazard. Drought has devastating effects and impacts on the area it affects. These effects on the environment, people and economy of the affected area ranges from little or low volume of water in rivers, soil to low yield from crops. Other effects include depopulation of rural areas, death of animals due to scanty pasture, poverty perpetuation and so on (Aremu *et al*, (2)). These effects notwithstanding, the return period of drought is very important. This is because it will determine whether the people and environment have recovered substantially before they face another round of drought. It is more so with the various drought intensities. That is the various drought intensities of invisible, mild, moderate, severe and extreme return periods are important(Aremu and olatunde,(2); Olatunde, (9)). The percentages of occurrences of the drought intensities over the years have been looked at in some studies (Aremu and Olatunde,(2); Olatunde,(9); Olatunde and Aremu,(10)) This study however is on the return or reoccurrence periods of the various drought intensities mentioned earlier. Suggestions will also be given on how to ameliorate the returning droughts in the study area.

The study area lies north of latitude 9^0 00^1 N and extend to latitude 14^0 00^1 N within the Savanna region of Nigeria (Fig 1). The vegetation of the study area has been grouped into the Sudan-Sahel Savanna and Northern Guinea Savanna (Olaniran, (8); Olatunde *et al*, (10)). The Tropical Hinterland climate dominates in the Sudan and Northern Guinea areas, while Tropical Continental climate prevail in the Sahel zone of the study area. The study region produces a huge percentage of the grains consumed in the country. The outputs of these crops (millet, maize, sorghum and so on) are affected by drought. The grasses that cows also graze on in the region are also affected. Occupations of the inhabitants of the study area apart from agricultural activities include fishing, mining, leather works, pottery works, brass and silver works. Other people work in offices, industries and in the informal sector of the economy like driving and trading.

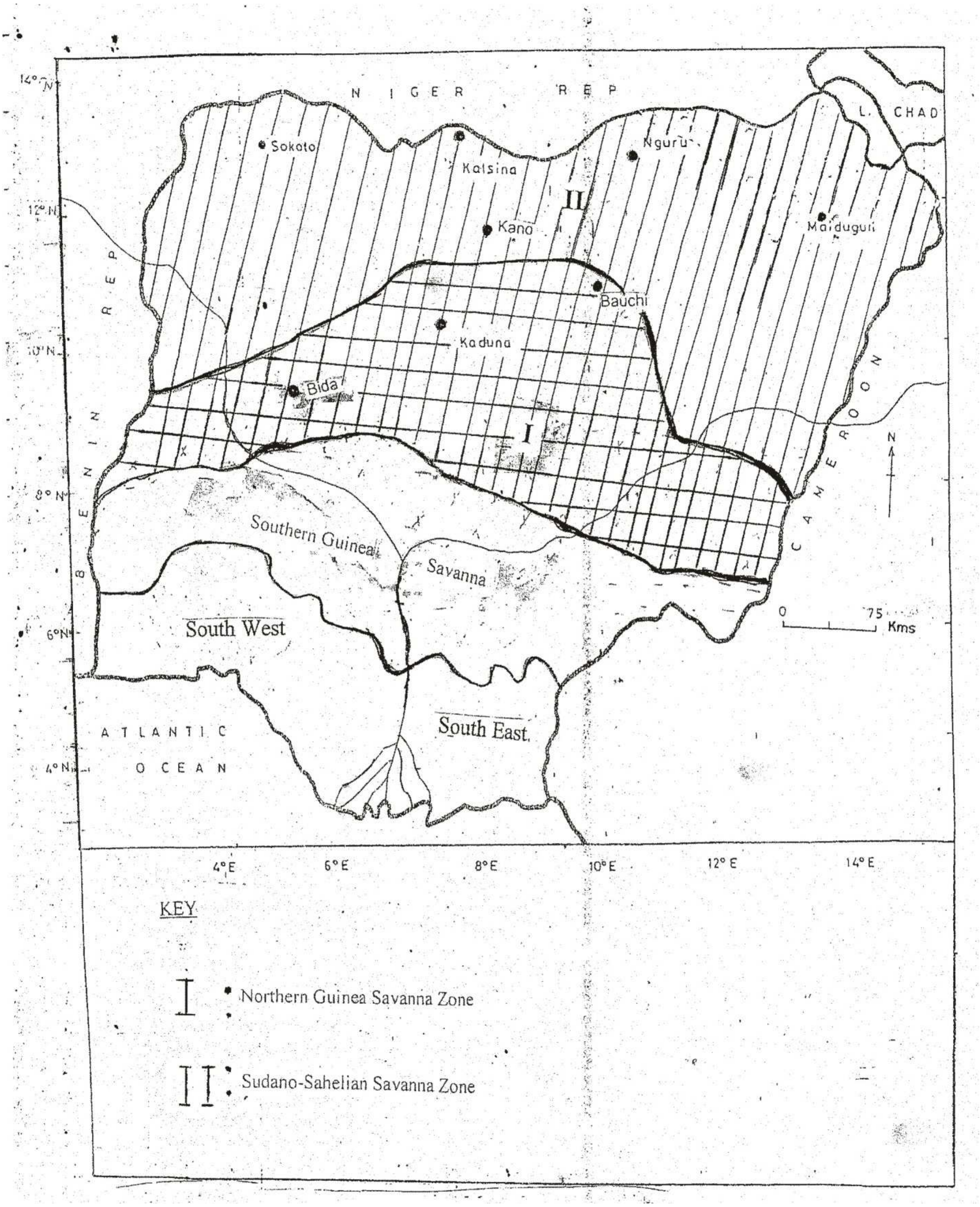

Fig 1.0: Map Showing the Study Region with the Stations Used.

MATERIALS AND METHODOLOGY

The materials and the method for determining the severity of drought are the same as those used by Aremu and Olatunde,(2); Olatunde,(9); Olatunde and Aremu,(10). However, the method for the determination of the return periods of the drought intensities is different and as given by Springhall, (12). Both methods are explained below. The basic research data used for this study was rainfall occurrence in the Sudan-Sahel region of Nigeria. The data were obtained from the Nigerian Meteorological Agency (NIMET) Oshodi, Lagos and covered a period of 70 years (1941-2010) for eight selected drought prone stations (Table 1). These stations were also selected because they are in the drought prone areas of the region. Efforts were made to ensure that stations selected were from those with long and continuous period of daily, monthly and annual rainfall record data of at least 70 years.

Table 1: Stations Used and Their Locations

NO	STATIONS	LATITUDES	LONGITUDES
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, Oshodi 2011.

The method used for classifying droughts into intensities in this study is by Bhalme and Mooley Drought Index (BMDI). This method has been used earlier by Aremu and Olatunde,(2); Olatunde,(9); Olatunde and Aremu,(10). It was used to assess the severity of drought over a period of 70 year. Details of this method are given in Bhalme and Mooley (5) and below, while it's general applicability is given in Shuaibu and Oladipo (11). 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, (7)).

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, (11)). 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, (3)).

In its general form, the **BMDI** for a given month **K** is calculated using this formula $\mathbf{I_K} = (MK / d) + (1 + C) I_K$ ………………………….(3). Where;

C is a constant
d is a constant
$\mathbf{I_K}$ = drought intensity for the **Kth** month.
$\mathbf{I_{k-1}}$= drought intensity for the **(K-1)** month.
M, the moisture index is given by
$\mathbf{M} = 100 (X – \ddot{X}) / S$ …………………………………………….(4)

In equation (4),
X = the monthly rainfall value,
$\ddot{\mathbf{X}}$ = the long term mean monthly rainfall,
S = the standard deviation for the initial month under consideration **(K-1).**

. Equation (3) is then given as;

$\mathbf{I} = M /d$ ……………………………………………………………….(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, (11)).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, (11)).

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, (11).

The negative parts of near normal were taken as invisible droughts according to the explanation of Ayoade (4).

The method used for determining the return periods of the various drought intensities was the Return or Reoccurrence Statistical Tool. It has the formula;

$$\frac{N + 1}{r} \quad \text{...}(14)$$

Where;

N = rank of the smallest occurrence (or total number of events).

1 = rank of the largest occurrence.

r = rank of the occurrence that is to be known (Springhall, (12)).

RESULTS AND DISCUSSIONS

Table 3: Return or Reoccurrence Intervals for Drought Intensities in the Study Area as a Whole.

Drought Intensities	**Return or Reoccurrence Interval**	**Likely Year of Reoccurrence**
Invisible	One year and two months	First quarter 2012
Mild	One year and six months	Half way into 2012
Moderate	Two years	2012
Severe	Three years	2013
Extreme	Six years	2016

Source: Fieldwork, 2012

Extreme drought may likely reoccur in the next six years starting from 2010. That is extreme drought may reoccur in 2016 in the study area. Calculations showed return period for severe drought to be in the next three years starting from 2010. This means the study area might witnessed severe drought in 2013. Analyses showed the return period for moderate drought to be two years stating from 2010, that is moderate drought may reoccur in the study area in 2012. For mild drought the reoccurrence interval is one year and six months starting from 2010, this means mild drought may occur half way into the year 2012. For invisible drought the return period is one year and two months. This means invisible drought may likely reoccur in the study area in the first quarter of 2012 (Table 3).From the above analyses it is clear that the lower the intensity of drought, the higher the likely rate of reoccurrence. That is invisible droughts have shorter years of return than severe and extreme droughts in the study area. This study also further confirms that the return period of drought is much lower than the 10 year cyclical period earlier given by researchers (NIMET, (6)).

These return periods though representing the whole study area, but in reality they are likely to be return periods for those stations where extreme droughts occurred during the period of study using **BMDI** (Maiduguri, Kano and Kaduna). However, for those stations where extreme droughts did not take place (Bida, Bauchi, Kaduna, Sokoto and Nguru), the summary of their return periods are as shown in Table 4.

Table 4: Return/Reoccurrence Intervals of Drought Intensities for Stations without Extreme Droughts during Period of Study.

Drought Intensities	Return or Reoccurrence Interval	Likely Year of Reoccurrence
Invisible	One year and three months	First quarter of 2011
Mild	One year and eight months	Third quarter of 2012
Moderate	Two years and six months	First half of 2013
Severe	Five years	2015

Source: Fieldwork, 2012

Severe droughts are likely to reoccur in those stations that did not experienced extreme drought in the next five years starting from 2010. This therefore indicates severe drought in the year 2015. The return period for moderate drought is two years and six months starting from 2010.This means moderate drought may occur in these stations half way in the year 2013. Mild drought return period in these stations as calculated is one year and eight months starting from 2010.This means mild drought may occur in those stations by third quarter of 2011.For invisible drought the calculated return period is one year and three months stating from 2010, this means invisible drought may occur in these stations by the first quarter of 2011.These return periods (that is for stations that experienced extreme drought and those stations that did not) showed the reoccurrences periods for the drought intensities to be lower or shorter than those given by NIMET (6) and Abaje *et al* (1) in their studies. This situation if and when proven to be true in the light of global warming will be a serious situation for the various stakeholders mentioned earlier as it will be devastating to crops, animals and people. This is because the frequency of occurrence of the effects of drought mentioned earlier will also increase.

Further analyses were carried out by comparing the return periods for drought intensities in stations with extreme drought against those stations without extreme drought (Table 5).

Table 5: Comparing the Return Periods for Stations with Extreme Drought against Those Stations without Extreme Drought

Drought Intensities	Return Periods for the Entire Area	Return Periods for stations without Extreme drought	Differences
Invisible	One year and two months	One year and three months	One month
Mild	One year and six months	One year and eight months	Two months
Moderate	Two years	Two years and six months	Six months
Severe	Three years	Five years	Two years
Extreme	Six years	Not available	Not available

Source: Fieldwork, 2012

Analyses indicated that drought of all intensities are likely to reoccur at faster rates in stations with extreme drought than in stations without extreme droughts (Table 5). Invisible drought is likely to reoccur in stations with extreme drought in the next one year and two months (starting from 2010) while for those stations without extreme drought, it was calculated to be one year and three months showing a difference of one month. For mild drought, it is one year and six months as against one year and eight months indicating a difference of two months. For moderate drought, it is two years against two years and six months, showing a difference of six months. For severe drought, it is three against five years indicating a difference of two years.

It is evident that with increase in intensity of drought (from invisible to severe), the differences in the return periods of the intensities between those of stations with extreme drought and those of stations without extreme drought gradually increases(Table 5). This means that drought of various intensity may likely sets in earlier in other stations (stations with extreme drought- Kano, Maiduguri and Katsina) within the study area apart from those stations without extreme droughts (Bauchi, Bida, Kaduna, Sokoto and Nguru).That is invisible drought may set in a month earlier in other stations before those of these stations, while severe drought may set in two years earlier in other stations before those with out extreme droughts. This proves that the temporal and spatial distribution of drought during the study period vary from place to place and from a period to another in the study area. It also indicates that this trend may likely continue for sometime in the future. This means the intensity of drought in the study area is not the same at every period. This fact the policy formulators and implementers in the study area have to take into consideration in order to have maximum impact in the area as it concerns the tackling of drought and its effects in the study area.

CONCLUSION AND RECOMMENDATIONS

As said earlier what this study has been able to prove is that the return periods of the various drought intensities are getting smaller and that the lower the intensity the higher their rates of reoccurrence in the study area. This situation especially makes the study area prone to low intensity droughts of invisible, mild and moderate. This means the farmers, rearers, governments at all levels will need to be prepared for more droughts in the coming years especially the low intensity ones. Therefore preparations should be geared more towards combating them. This does not mean not being proactive in the preparation against the high intensity droughts of severe and extreme. Some of the measures that can be used to collectively tackle the effects of the expected droughts in the study region include, but are not limited to:

- The 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.
- Installation of drip irrigation that directs water straight to the roots of plants and application of irrigation techniques to extensively cover the area prone to extreme drought.
- The extensive planting of crops and plants that do not require lots of water. These are normally indigenous plants which can survive with low amount of rainfall with out additional watering. In the study area such crops will include drought resistant and short season varieties of cereals like sorghum, maize, millet and rice.
- Modern systems such rotational ranching should be adopted by animal herders in the study region in other to avoid overgrazing and adequately provide pastures for their animals'.
- Farmers in the study area should be encouraged to use organic fertilizers to enhance soil composition and improve water retention thereby combating invisible drought.
- The use of Green Infrastructure (G.I) in cities, towns and villages in the study region will help to reduce the actual and potential impact of radiation especially in reducing evaporation of water from soils and water bodies.
- More boreholes, wells and dams should be dug to reduce water shortages. Also the shallow wells and bad boreholes should be repaired.
- Other measures are, water recycling and rain harvesting.

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