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Temporal Analyses of Drought Intensities Occurrence within Recent Decades in Some Stations in Northern Nigeria

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Abstract

This study was on temporal analyses of drought intensities occurrences in recent decades in some stations in Northern Nigeria. The region experiences drought occurrence often. Data used were from 1941 to 2010. The Bhalme and Mooley Drought Index (BMDI) was used to categorize drought occurrences into invisible, mild, moderate, severe and extreme within the decades used. This was with the intention of finding out their percentages of occurrences over a 70 year period (1941-2010) in those stations. Results show that low intensity drought prevailed in Northern Nigeria during the study period. It also indicated that extreme droughts were confined to the decades between 1971 and 2000 in those stations. Apart from these findings, others were discussed in the study. Measures on how to ameliorate and mitigate the effects of droughts, especially the dominant intensity types on the people, community and environment were suggested.

Keywords: Decades, Drought, Drought Intensities, Extreme, Frequency, Invisible, Mild, Moderate, Percentages, Severe

1.0 INTRODUCTION

Drought definition varies. It also has many types. Among the types are; meteorological drought, hydrological drought, agricultural drought, ecological drought, socio-economic drought among others (National Drought Mitigation Centre, 2006; Mortimore, 1989; Ayoade, 1988). This classification depends very much on the view and perspective of the scholar or scientist concerned. Apart from the types, drought intensity can be categorised into invisible, mild, moderate, severe and extreme (Ayoade,1988; Shuaibu and Oladipo, 1993).Therefore, drought has many attributes. Other attributes apart from those mentioned earlier are; on-set, duration, persistency, return period and termination. However, out of these attributes, the important one is the intensity. This is because it shows the severity degree of the drought. The various intensities mentioned earlier have effects on the environment, agriculture, water availability and human beings in the area of occurrence, the study area inclusive. Drought effects vary with intensity. Therefore, the degree of impact of extreme drought on the environment for example will be greater than that of invisible or mild drought. Droughts of various intensities have been reported in the study region (Mortimore, 1973; James, 1973; Adefolalu, 1986; Oladipo, 1993; Abaje*et al*, 2011; Aremu, 2011) for years. However, few studies concentrated on analysing the occurrences of the various drought intensities within the decades in the study region overtime. Therefore, the objective of this study is to look at the occurrences of the various drought intensities within the decades used in the study stations and to assess variations in their occurrences. This is with the view of recommending measures against the dominant drought intensity as it is likely to reoccur more in future.

2.0 THE STUDY AREA

The study area is north of latitude 9^0 00^1 N and extend to latitude 14^0 $00'^1$ of Northern Nigeria (Olaniran, 1987) (Fig 1).The dominant climatic types in the study region are; Tropical Hinterland (Tropical Wet) climate in the Sudan zone and Tropical Continental (Tropical Dry) climate in the Sahel zone. The vegetation of the study area has been grouped into the Sudan Savanna and Sahel Savanna (Olaniran, 1987).Large percentage of the grains (maize, sorghum, millet and others) consumed in the country are produced in the study area. Occupations of the people in the study region 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.

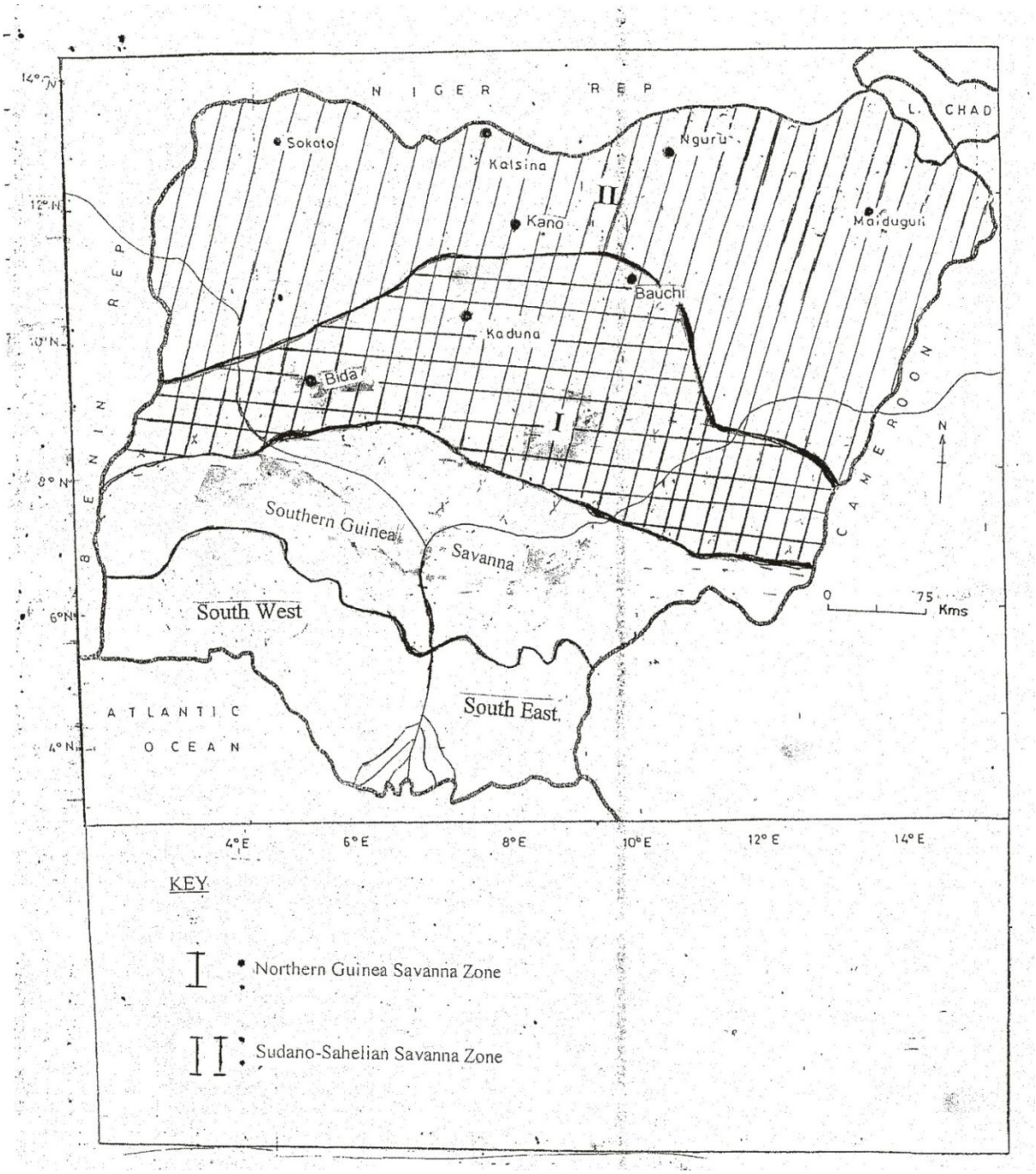

Fig.1: Study Area Showing Vegetation Belts and Stations Used.

3.0 METHODOLOGY

The research data used for this study was rainfall occurrence in the Northern 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 stations (Table 1). These stations were chosen because they are located in the drought prone areas of the region. Efforts were made so that stations selected were 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 analysis in this study is the Bhame and Mooley Drought Index (BMDI). It was used to assess the intensity of drought over a period of 70 year. Details of this method are given in Bhalme and Mooley (1980) and described below, while its general applicability is given 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). It has also been used in this study because of the following advantages; first, it is simpler and less intricate. It uses not terms like soil water capacity, evapo-transpiration for its calculation. These parameters are difficult

to estimate. It is therefore an empirical index that uses monthly rainfall alone as the sole climatological input. The method takes into account the importance of significant seasonal precipitation totals which other methods do not (Shuaibu and Oladipo 1993). In addition, it provides a good measure of the current status of drought. That is, the effects of short periods of dry weather are taken into consideration. This is not so with others which are designed to evaluate degree of severity and frequency of prolonged periods of abnormally dry conditions. Also, once the constant are determined, it is easy to adopt it for different climatic regions and lastly the BMDI index gave good correspondence between historically documented droughts and those depicted by BMDI (Shuaibu and Oladipo, 1993).

Monthly growing seasonal rainfall (April to October) values for the eight (8) chosen stations were used to derive the Bhalme and Mooley Drought Index (BMDI) for the assessment of drought intensity (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 Northern Nigeria (Anyadike, 1993).

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

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 drought indices (**SDI**) were then used to classify a year into any of the following wetness/ dryness categories using **BMDI** classification chart Shuaibu and Oladipo (1993).

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.

The negative parts of near normal were taken as invisible droughts according to the explanation of Ayoade (1988) (Table 2).

4.0 RESULTS AND DISCUSSIONS

From the analyses, each decade results are discussed below for the eight stations used.

4.1 Analyses of All Drought Intensities Occurrence within Each Decade

1941 to 1950

Invisible drought dominated the decade occurring in 17 years (45.95%) out of a total 37 years for all droughts in the decade. Extreme drought did not occur within the decade at all (Table 3 and Fig.2). Other intensities frequency of occurrences and their corresponding percentages are as shown in Table 3 below.

Table 3: Drought Intensities Occurrences within the Decade 1941 to 1950

Drought Intensity	**Frequency of Occurrence**	**%age of Total Occurrence**
Invisible	17	45.95
Mild	14	37.84
Moderate	5	13.51

Severe	1	2.70
Extreme	0	0.00
Total	37	100.00

Source: Fieldwork, 2012

1951 to 1960

In this decade, invisible drought still dominates, occurring in 13 years (56.52%) out of the possible 23 years for all drought intensities in the decade. Extreme drought also did not occur (0%) in this decade. Other drought intensities years of occurrences and the corresponding percentages are as shown in Table 4 below.

Table 4: Drought Intensities Occurrences within the Decade 1951 to 1960

Drought Intensity	**Frequency of Occurrence**	**%age of Total Occurrence**
Invisible	13	56.52
Mild	8	34.78
Moderate	1	4.35
Severe	1	4.35
Extreme	0	0.00
Total	23	100.00

Source: Fieldwork, 2012

1961 to 1970

Invisible drought occurred in 18 years (56.25%) out of a possible 32 years for all drought intensities occurrence in the decade. Mild drought occurred in 10 years (31.25%) and moderate drought in four years (12.5%)(Fig.2). Severe and extreme droughts did not occur in the decade (0%) (Table 5).

Table 5: Drought Intensities Occurrences within the Decade 1961 to 1970

Drought Intensity	Frequency of Occurrence	%age of Total Occurrence
Invisible	18	56.25
Mild	10	31.25
Moderate	4	12.50
Severe	0	0.00
Extreme	0	0.00
Total	32	100.00

Source: Fieldwork, 2012

1971 to 1980

Invisible drought with 20 years (45.45%) still dominates in this decade. The least occurred drought intensity was extreme drought with one year (2.27%) occurrence. During the period of study, this is the first decade of occurrence of extreme drought. Other intensities frequency of occurrence and their corresponding percentages are as shown in Table 6 below and Fig.2.

Table 6: Drought Intensities Occurrences within the Decade 1971 to 1980

Drought Intensity	Frequency of Occurrence	%age of Total Occurrence
Invisible	20	45.45
Mild	12	27.27
Moderate	9	20.45
Severe	2	4.55
Extreme	1	2.27
Total	44	100.00

Source: Fieldwork, 2012

1981 to 1990

This is the first decade where the mild and moderate droughts surpassed the number of years of invisible drought occurrence. In this decade, moderate drought had the highest years of 24 (33.80%), followed by mild drought with 22 years (30.99%). Invisible drought came third in terms of years of occurrence with 19 years (26.27%). Severe drought had five years (7.04%) and extreme drought with one year (1.41%)(Table 7 and Fig.2). This decade coincides with the widely publicized droughts of the 1980's. The very intense nature of the drought then is evident in the reduced percentage accrued to invisible drought and the presence of extreme drought (Table 7).

Table 7: Drought Intensities Occurrences within the Decade 1981 to 1990

Drought Intensity	**Frequency of Occurrence**	**%age of Total Occurrence**
Invisible	19	26.76
Mild	22	30.99
Moderate	24	33.80
Severe	5	7.04
Extreme	1	1.41
Total	71	100.00

Source: Fieldwork, 2012

1991 to 2000

This decade also had more years of mild drought than invisible drought. Invisible drought had 17 years (41.46%) as against 19 years (46.34%) for mild drought. The least occurred drought intensity in this decade was extreme with one year (2.44%). This was also the last decade of extreme drought occurrence during the period of study. Other intensities frequency of occurrence and their corresponding percentages are as shown in Table 8 below and Fig.2.

Table 8: Drought Intensities Occurrences within the Decade 1991 to 2000

Drought Intensity	Frequency of Occurrence	%age of Total Occurrence
Invisible	17	41.46
Mild	19	46.34
Moderate	2	4.88
Severe	2	4.88
Extreme	1	2.44
Total	41	100.00

Source: Fieldwork, 2012

2001 to 2010

This decade reverted back to invisible drought dominating with the highest years of occurrence of 23 years (67.65%) out of a possible 34 years for all drought intensities occurrence in the decade. Extreme drought did not occur. Other intensities frequency of occurrence and their corresponding percentages are as shown in Table 9 below and Fig.2.

Table 9: Drought Intensities Occurrences within the Decade 2001 to 2010

Drought Intensity	Frequency of Occurrence	%age of Total Occurrence
Invisible	23	67.65
Mild	7	20.59
Moderate	2	5.88
Severe	2	5.88
Extreme	0	0.00
Total	34	100.00

Source: Fieldwork, 2012

Table 10: Frequency of Drought Intensities within Each Decade

Drought Intensity	1941-1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	Total
Invisible	17	13	18	20	19	17	23	127
Mild	14	8	10	12	22	19	7	92
Moderate	5	1	4	9	24	2	2	47
Severe	1	1	-	2	5	2	2	13
Extreme	-	-	-	1	1	1	-	3
Total	37	23	32	44	71	41	34	282

Source: Fieldwork, 2012

In the above analyses, apart from the decade 1991 to 2000 where mild drought years exceeded those of invisible drought years and 1981 to 1990 when moderate drought years exceeded mild and mild drought years exceeded invisible drought years, other decades showed decline in drought years from invisible drought to extreme drought (Tables 3 to 10 and Fig. 2) .The most drought prone decade without taking drought intensities occurrence into consideration was 1981 to 1990, with 71 years (25.18%) of drought for all the stations in the study area out of a possible 282 years of drought(Tables 3 to 10 and Fig.3). This was followed by the decade before it, 1971 to 1980 with 44 years (15.60%) of drought. Next was the decade 1991 to 2000 with 41 years (14.54%) of drought. This was followed by 1941 to 1950 with 37 years (13.12%) and 1961 to 1970 with 32 years (11.35%) of drought. Bringing up the rear was the decade 1951 to 1960 with 23 years (8.16%) of drought. Other decade's frequencies of occurrences of the various intensities are as shown in Table 10 below and Fig.3.

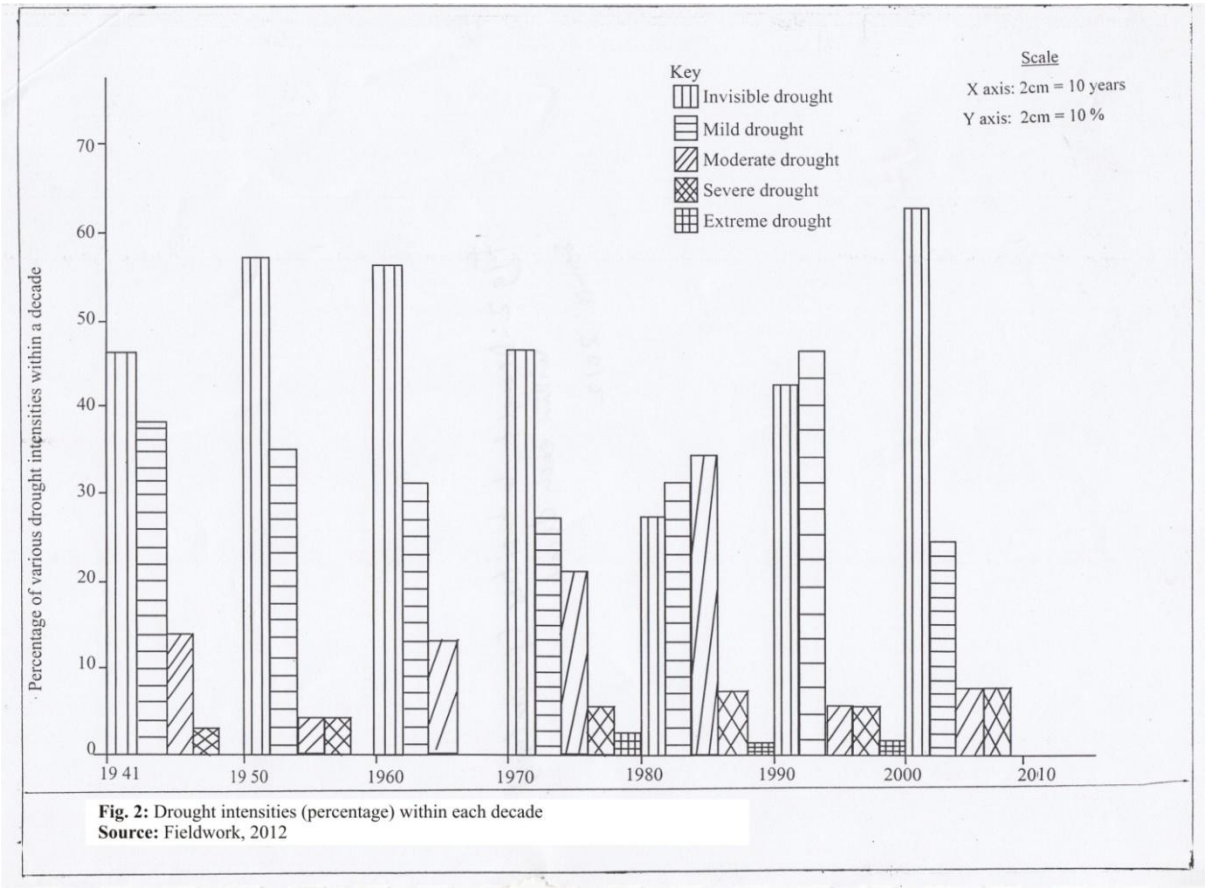

Fig. 2: Drought intensities (percentage) within each decade
Source: Fieldwork, 2012

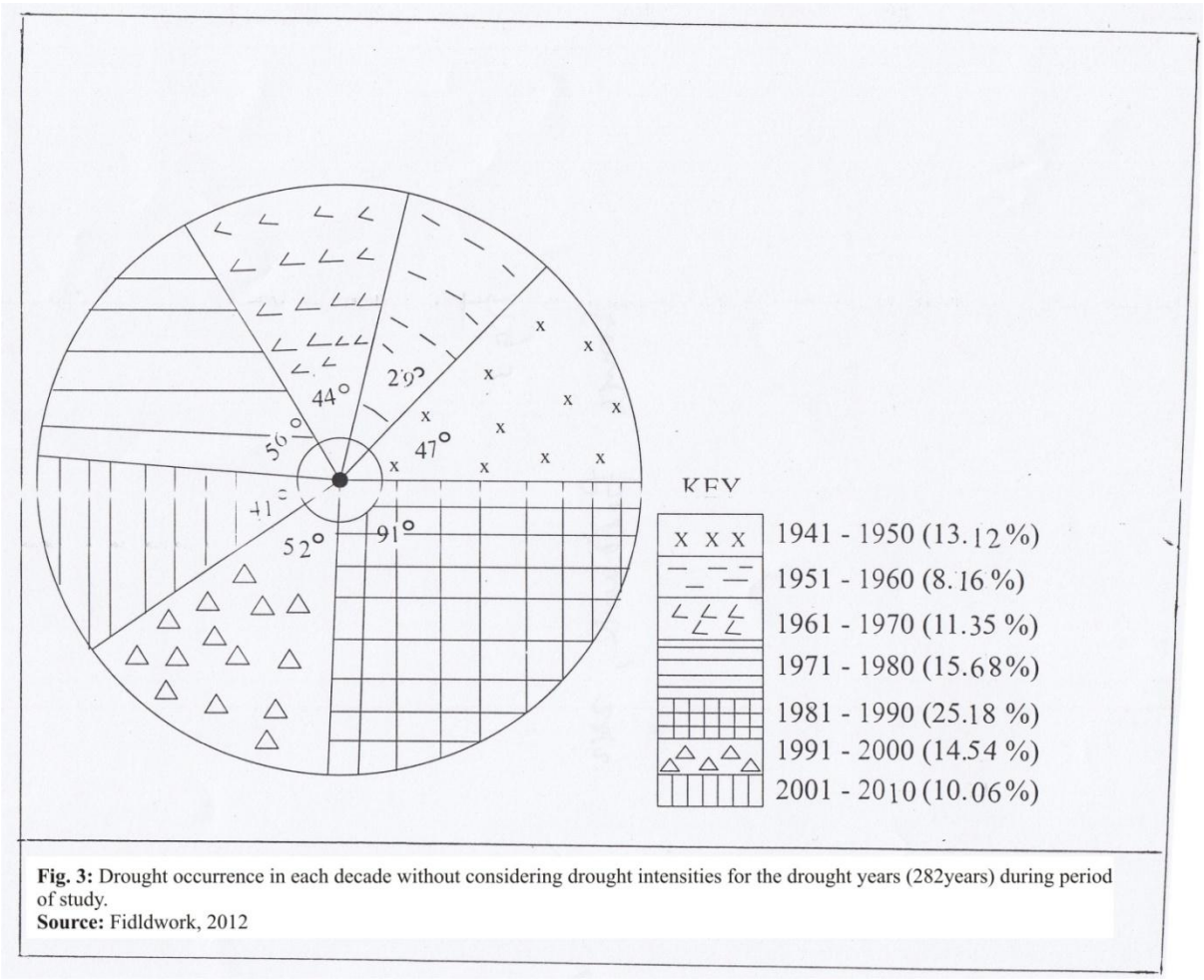

Fig. 3: Drought occurrence in each decade without considering drought intensities for the drought years (282years) during period of study.
Source: Fidldwork, 2012

5.0 CONCLUSIONS

This study shows that low intensities droughts prevailed and dominated the decades studied. It also proved that the recent decades, 1991 to 2000 and 2001 to 2010 share the same experiences with earlier decades in the sense that the lower drought intensities dominated. This is evident in invisible drought consistently having more than 45% in all the decades used for the study. What this means is that mitigation efforts should be directed more at the low intensity droughts (invisible and mild). This is because they are likely to reoccur more in future decades than the highly intense droughts (severe and extreme). Efforts should be geared towards the mitigation of invisible drought as the farmers and other stakeholders affected directly may not even be aware of its existence until after the crops have been affected. This may result in famine and high cost of food.

6.0 RECOMMMENDATIONS

1. There should be constant monitoring of the water available to the crops in the study area. This is to avoid a situation where invisible drought will be present and the farmers will not be aware so as to take remedial measures to correct the situation.

2. There is the need to complete and upgrade the shelter belt programme being implemented in the study area. Furthermore, Green Infrastructure (G.I) should also be established to assist in the reduction of water evaporation from the soil.

3. There is the urgent need to complete and put into use of the various irrigation dams in the study region, so that water will be available for the crops as at when due.

4. The farmers need to always put into use the best practices of agriculture. Some of these are; crop rotation, use of organic manure, minimum tillage and so on. Some of these can be practiced together so as to improve soil composition and water retention.

5. Subsidised and improved seedlings that are able to produce maximum outputs and are the same time drought resistant with short growing season should be procured and distributed to the farmers.

1. This research is part of a PhD Thesis for Nigerian Defence Academy, Kaduna.

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