International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 3, pp 75-87, March-2022

https://doi.org/10.47001/IRJIET/2022.603012

Drought and Its Intricating Impacts on Some Areas in Northern Nigeria

Dada B.M.

Federal University of Technology, Akure, Ondo State, Nigeria

***Abstract* - Drought which is a prolonged period of abnormally low rainfall leading to shortage of water is a bane to all facets of human activities, especially Agriculture and electricity generation. It cuts across all region but majorly predominant in the Northern part of Nigeria due to its unimodal pattern of rainfall.**

This study presents a comprehensive analysis of the available climatological data and information on droughts to investigate the occurrence of meteorological drought episode over two selected stations in Northern Nigeria by analysing the drought occurrence in the past decades with special focus on drought categories and its impact on the livelihoods and sustainable development of the selected stations. The primary data used for this study were collected from the archive of Nigeria Meteorological Agency (NIMET) for the period of 30 years 1987 to 2016 and the two selected stations are Kano and Maiduguri.

The study reveals the growing importance of precipitation forecasts in Maiduguri, particularly the amount, timing, duration and distribution of rainfall. Rainfall was cited as the major cause of drought by 98 percent of the respondents in the catchment. Whilst meteorological rainfall forecasts are available through various channels they are not readily accessible to rural communities. Effective drought forecasting and warning requires the adoption of a protocol that includes the science of monitoring and forecasting and can give a wealth of information on how different groups can use the forecast in support of their decision making.

The study also established that the annual and seasonal occurrence of drought in the two stations is becoming less frequent for the last 30 years. In annual scale, the major climate character in the two stations changed from dry to wet after 1995; in seasonal scale, most of the drought events happened before the early 2000s.

It was also observed that from 1994 to 2016, the ratio of drought influencing areas and all degrees of drought frequency areas to the two stations have a dramatic decreasing trend, particularly the moderate drought.

Keywords: Drought, Unimodal, Annual, Seasonal, Climate.

I. INTRODUCTION

Drought is as an extended period – a season, a year, or several years of deficient rainfall relative to the long-term average rainfall for a region. It is the inability of rainfall to meet the evapotranspiration demands of crops resulting in general water stress and crop failures. Large areas of Maiduguri falling within the Sahel and Sudan ecological zones between latitude 9-14oN are prone to occurrence of droughts in one form or the other (Glantz and Katz, 1977; Apeldoorn, 1981; Adeoye, 1986; Nyong *et al*., 2007). The probability of drought at the onset and towards the end of the rainy season is usually very high in Maiduguri (ICRISAT, 1984; Adeoye, 1986; Tenkouano *et al*., 1997).

Although drought has several definitions, the central element in these definitions is water deficit. Farmers are struggling, money has been lost, livestock are suffering, and the landscape shows the all-too-familiar brown grasses and cracked earth.

Dry spells at the beginning of the season usually result in multiple plantings and low or no yields leading to low food security index. In the same vein, end of season drought could bring about water stress at critical periods of need during the reproductive stages of most crops thus resulting in crop failures and shrinking of yields. In fact, the 20th century started in the region with droughts and the resultant famines of 1903 and 1911-1914, respectively (Kolawole, 1987).

Large number of inhabitants of the drought prone areas is smallholder farmers, who depend mostly on the highly variable rainfall for crop cultivation and maintenance of their herds.

This study is geared at looking at the causes, effects and ways of reducing the risk of drought in Northern Nigeria.

Drought is at the core of serious challenges and threats facing sustainable, agricultural development in Africa (Andreas, 2005). These problems have far reaching adverse impacts on human health, food security, economic activity, physical infrastructure, natural resources and the environment, and national and global security.

ISSN (online): 2581-3048
Volume 6, Issue 3, pp 75-87, March-2022
https://doi.org/10.47001/IRJIET/2022.603012

The underlying causes of most droughts can be related to changing weather patterns manifested through the excessive build-up of heat on the earth's surface, meteorological changes which result in a reduction of rainfall, and reduced cloud cover, all of which results in greater evaporation rates.

The resultant effects of drought are exacerbated by human activities such as deforestation, bush burning, overgrazing and poor cropping methods, which reduce water retention of the soil, and improper soil conservation techniques, which lead to soil degradation. Between 1950 and 2006, the Nigerian livestock population grew from 6 million to 66 million - an 11-fold increase. The forage needs of livestock exceed the carrying capacity of its grasslands. It is reported that overgrazing and over-cultivating are converting 351,000 hectares of land into desert each year. The rates of land degradation are particularly acute when such farming practices are extended into agriculture on marginal lands such as arid and semi rid lands, hilly and mountainous areas and wetlands (Lester, 2006).

Drought influences water availability, which is projected to be one of the greatest constraints to economic growth in the future. Reduced annual average rainfall and its run-off would increase desertification. Most of the rivers and streams in the drought prone areas flow into Lake Chad. Drought, therefore exacerbate the shrinking of the lake. The rivers in addition to contributing in recharging Lake Chad are catchments to several dams built for irrigation and domestic water supply. This means that the regions will not have sufficient water resources to maintain their current level of per capital food production from irrigated agriculture even at high levels of irrigation efficiency and also to meet reasonable water needs for domestic, industrial, and environmental purposes.

Several animal and plant species are disappearing in the drought prone region of Maiduguri and Kano. The combined effects of drought and bush burning (during dry season) have made the flora to go extinct and the animals to migrate to safer havens. Drought, land degradation and desertification have had serious impact on the richness and diversity of plants and animals in the region. Plant biodiversity will change over time, unpalatable species will dominate, and total biomass production will be reduced.

The impacts of drought on the energy sector are felt primarily through losses in hydropower potential for electricity generation and the effects of increased runoff (and consequent siltation) on hydropower generation. In Nigeria, electricity is largely generated through hydropower thus drought is likely to reduce the volume of water in the dams and rivers and consequently lead to reduction in hydroelectricity generation and hence load shedding of electricity in the state. Load shedding as result of low water volume in Kainji and Jebba electricity projects has become more pronounced during the dry season thus compounding the energy crisis in Maiduguri

Drought which is defined as the protracted absence, deficient or poor distribution of precipitation, is one of the anomalies that have plagued the Northern part of Nigeria, Maiduguri precisely since the beginning of the 20th century.

The Northern region of Nigeria has suffered decrease in rainfall in the range of 3-4 percent per decade since the beginning of the nineteenth century. The Director-General, Nigerian Meteorological Agency highlights that analyses of rainfall data (1911 -2000) in thirty 30 years interval, Empirical Situation and Policy Implications 2000 show that many more places are recording late onset of rains, early cessation of rain, shortened length of the rainy season and reduced annual amount of rain especially in the northern part of the country. He also observed more frequencies of drought, more persistent harmattan haze and increasing temperature trends (Mohammad, 2009).

Over 80% of Nigeria's population depends on rain-fed agriculture and fishing as their primary occupation leading to a high risk of food production system being adversely affected by the variability in timing and amount of rainfall. The lack of reliable communication channels and delays in forecast dissemination has also contributed to increased vulnerability of communities in remote areas to climate related disasters. If there should be appropriate utilization of the abundant knowledge and information on the occurrence of drought on agricultural production systems and human survival. Although Nigeria has made some efforts to adapt and mitigate drought risks. There is therefore need to identify and document the incidence of drought and indigenous innovative adaptation measures used by rural dwellers, in the drier parts of Northern Nigeria, to cushion the drought on their livelihoods, especially as the area is prone to desertification. National studies show that persistent droughts reduce national food production and leads to commitment of massive resources in mitigating their effects (DMC, 2002).

II. METHODOLOGY

Description of study areas

The Coastal Mangrove Swamp Forest, Rain Forest, Southern Guinea, Northern Guinea, Sudan, and Sahel savannah vegetation zones make up Nigeria's six unique vegetation zones. In accordance with the climate trend, the vegetation differs regionally.

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 3, pp 75-87, March-2022

https://doi.org/10.47001/IRJIET/2022.603012

Maiduguri is a city in the Nigerian state of Borno. It is situated at an elevation of 325 meters above sea level and is located at 110 . 85IN latitude and 130.16IE longitude. Maiduguri is the largest city in Borno, with a population of 1,112,449 people. It is based on the WAT time zone. Lake Chad borders it on the northeast, the Republic of Chad on the north, Yobe state on the west, Gombe and Adamawa states on the south, and on the east, there's the Republic of Cameroun. It is made up of 27 local government areas, with a population of 4,151,193 according to the 2006 provisional census. The highest temperature ever recorded was 47 degrees Celsius (117 degrees Fahrenheit) on May 28, 1983, and the lowest temperature ever recorded was 5 degrees Celsius (41 degrees Fahrenheit) on December 26, 1979.

Maiduguri, commonly known as Yerwa by its residents, is the capital and largest city of Borno State, which is located in northern Nigeria. The city is located along the seasonal Ngadda River, which flows into the Firki wetlands in the Lake Chad region. The British established Maiduguri as a military station in 1907, and the city has grown fast since then, with a population of over a million by 2007.

On average, temperatures are always high. April, May, and August are the months with the most rainfall (rainy season). The months of January and July are dry in Maiduguri. April is the warmest month on average. January is the coldest month on average. The wettest month is August. If you don't like a lot of rain, this is the month to avoid. The month of July is the driest of the year.

This is well within the Nigeria's arid or Sahel zone, which has been identified as areas north of latitude 12°N (Adefolalu, 1988). It has a tropical continental (semi-arid) climate with distinct wet and dry seasons (May to September and November to March).

The Inter Tropical Discontinuity (ITD) oscillation is the mechanism that regulates the wet and dry seasons in this region. Its northward movement ushers in the rainy season, whereas its southbound movement ushers in the dry season and the arrival of harmattan dust.

Kano is the state capital of Kano state in Northern West, Nigeria located at 120.00IN, 080.31IE. It is situated in the sahelian geographic region, south of the Sahara.

Kano is 481 metres (1,578 feet) above sea level. Kano features a tropical savanna climate. The city sees on average about 980mm (38.6 in) of precipitation per year, the bulk of which falls from June through September. Kano is typically very hot throughout the year, though from December through February, the city is noticeable cooler. Nighttime temperatures are cool during the months of December, January and February, with average low temperatures of 11 to 15 degrees.

Study Area Map

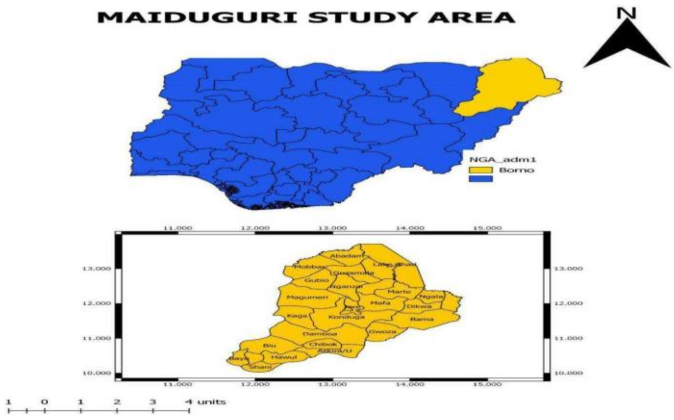

Figure 1(a): Map of Maiduguri

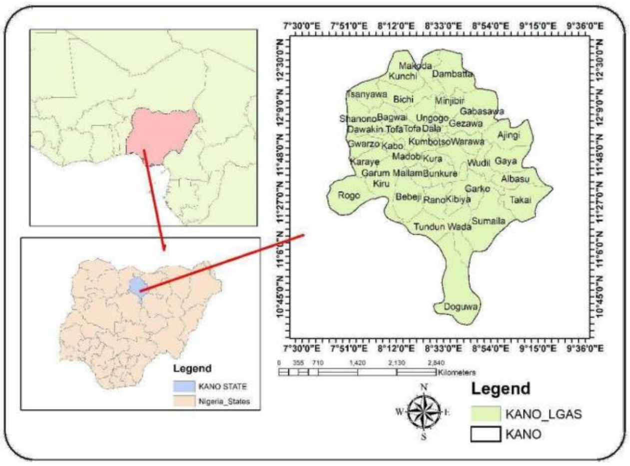

Figure 1(b): Map of Kano

III. METHODS AND PROCEDURES MATERIAL - HISTORICAL DATA

The data used for this study was collected from the archives of Nigeria Meteorological Agency (NIMET). Thirty (30) years monthly rainfall and evaporation over the period of 1987 – 2016 were collected for Maiduguri (110.85I N and 130.16I E) and Kano (120.00I N, 080.31I E).

This data set provides country/ regional/continental level estimates on drought events, people killed and affected and economic damage.

Additionally, a global database on SPI was used to analyze droughts with the aim to substantiate the findings of this review. It is acknowledged that a number of drought indicators are available, each with its own strengths and weaknesses (e.g. Mishra and Singh, 2010; Dai, 2011; Zargar et al., 2013). For example, the decile index (Gibbs and Maher, 1967) is easy to

ISSN (online): 2581-3048
Volume 6, Issue 3, pp 75-87, March-2022
https://doi.org/10.47001/IRJIET/2022.603012

compute; however, it requires a long time series of data to have accurate results. The Palmer Drought Severity Index (PDSI) (Palmer, 1968) can be used to identify abnormalities in agricultural droughts, as well as historical features of current situations.

The disadvantage of this method is that it depends on soil moisture data and its properties which are often very difficult to assess, especially at a larger spatial scale and in spatially distributed manner.

The widely used standardized precipitation index (Mckee et al., 1993; Zargar et al., 2011) appears to offer advantages because it is a straightforward method that only requires a little amount of data (precipitation). The SPEI is a widely used drought indicator which uses precipitation and potential evapotranspiration for its computation. It can track the start, intensity, and length of a drought. The indicator is well-suited to studying drought's geographical and temporal variations, as well as the influence of global warming.

This indicator is primarily concerned with meteorological drought and does not provide estimates for agricultural, hydrological, or socio-economic components of droughts, while it can be used as a proxy for these droughts because they are ultimately caused by a lack of precipitation. The literature has a detailed review of several drought indicators, their comparative core principles, and varied drought perspectives (e.g. Dai, 2011; Mishra and Sing, 2010; Ntale and Gan, 2003; Smakhtin and Schipper, 2008; UNISDR, 2004; Zargar et al., 2011).

Method

The principle of SPEI is using the degree of the difference between precipitation and evapotranspiration which deviates the average status to represent the regional drought. The calculation steps are as follows.

Thornthwaite method, one of the most widely used methods in calculating the potential evapotranspiration (PET), which takes the monthly mean temperature and monthly mean sunshine hour as the key factors, was used based on the following formula:

$$\text{PET} = 16 \times \left(\frac{N}{12}\right) \times \left(\frac{m}{30}\right) \times \left(10 \times \frac{T_i}{I}\right)^{a} \quad (1)$$

Where N is the monthly mean sunshine hour, m is the number of days in a month, Ti is the monthly mean temperature, a is given as formula (2), and I is a cumulative number of 12-month thermal indexes calculated as formula (3):

$$a = 6.75 \times 10^{-7} \times I^{3} - 7.71 \times 10^{-5} \times I^{2} + 1.79 \times 10^{-2} \times I + 0.49 \quad (2)$$

$$I = \sum_{i=1}^{12} \left(\frac{T_i}{5}\right)^{1.514} \quad (3)$$

The SPEI uses the monthly (or weekly) difference between precipitation and PET. This represents a simple climatic water balance (Thornthwaite, 1948) which is calculated at different time scales to obtain the SPEI. We followed the simplest approach to calculate PET (Thornthwaite, 1948), which has the advantage of only requiring data on monthly mean temperature.

With a value for PET, the difference between the precipitation (P) and PET for the month i is calculated according to:

$$D_i = P_i - PET_i \quad (4)$$

Where Di is the difference between precipitation and potential evapotranspiration, Pi is the monthly precipitation, and $PETi$ is the monthly potential evapotranspiration.

The accumulated water profit or loss series with meteorology meaning in different time scales were constructed using the following formula:

$$D_n^k = \sum_{i=0}^{k-1} P_{n-i} - PET_{n-1} \quad (5)$$

Where k (months) is the timescale of the aggregation and n is the calculation month.

Other than SPI that could be calculated with two parameter distribution (e.g., gamma distribution), a three-parameter distribution is needed to calculate the SPEI. Vicente-Serrano found the log- logistic distribution correlates best to the ***D*** series compared with other three selected three parameter distributions (Pearson III, lognormal, and general extreme values).

Therefore, the probability density function of a three parameter Log-logistic distributed variable is expressed as:

$$f(x) = \frac{\beta}{\alpha}\left(\frac{x-\gamma}{\alpha}\right)^{\beta-1}\left(1 + \left(\frac{x-\gamma}{\alpha}\right)^{\beta}\right)^{-2} \quad (6)$$

Where a, β and γ are scale, shape and origin parameters, respectively, for D values in the range (γ> D <∞).

Parameters of the Log-logistic distribution can be obtained following different procedures. Among them, the L-moment procedure is the most robust and easy approach (Ahmad et al., 1988). When L moments are calculated, the parameters of the Pearson III distribution can be obtained following Singh et al. (1993):

$$\beta = \frac{2\omega_1 - \omega_0}{6\omega_1 - \omega_0 - 6\omega_2},$$

ISSN (online): 2581-3048
Volume 6, Issue 3, pp 75-87, March-2022
https://doi.org/10.47001/IRJIET/2022.603012

$$\alpha = \frac{(\omega_0 - 2\omega_1)\beta}{\Gamma\,(1+\frac{1}{\beta})\,\Gamma\,(1-\frac{1}{\beta})}, \quad (7)$$

$$\gamma = \omega_0 - \alpha\Gamma\,(1+\frac{1}{\beta})\Gamma\,\,(1-\frac{1}{\beta}),$$

Where, Γ (1 +1β) is the gamma function of (1 + 1β) , ωs is the probability-weighted moments (PWMs) of order s, and s = 0, 1, 2 (formula (8)). Consider

$$\omega_s = \frac{1}{n}\sum_{i=1}^{n}\left(1-\frac{j-0.35}{n}\right)^s D_i \quad (8)$$

Where n is the number of data points in j is the range of observations in increasing order.

$$F(x) = \left[1+\left(\frac{\alpha}{x-\gamma}\right)^{\beta}\right]^{-1} \quad (9)$$

The SPEI value can be obtained as the standardized value of $\boldsymbol{F}\ (\boldsymbol{x})$ with the following formula:

$$SPEI = W - \frac{c_0 + c_1W + c_2W^2}{1 + d_1W + d_2W^2 + d_3W^3} \quad (10)$$

$$W = \sqrt{-2\ln(P)}\ for\ P \leq 0.5$$

Where P is the probability of exceeding a determined D value and $P = 1 - F\ (x)$; when $P > 0.5$, $P = 1 - P$. And the constants are

c_0=2.515517,

c_1=0.802853,

c_2=0.010328,

d_1=1.432788, (11)

d_2=0.189269,

d_3=0.001308,

The annual scale drought level was defined as five types and each standard of SPEI range was given in Table 1.

This computation was done for each year of the 30 years of study. The values of Standardized Precipitation Index were to analyze drought occurrence while all positive values show no drought (wet).

Table 1: Classification standard of drought based on SPEI

No drought	Light drought	Moderate drought	Severe drought	Extreme drought
−0.5 <SPEI	−1<SPEI≤ −0.5	−1.5<SPEI≤ −1	−2<SPEI≤ −1.5	SPEI≤ −2

Analysis and Computation of data was done using R Statistical Software and Graphical analysis was made using both R graphical tool and Excel graphical tool.

IV. RESULTS AND DISCUSSION

Annual and Seasonal Rainfall distribution in Kano and Maiduguri

There are little or no variation in rainfall amount received during study period of the two locations:

(1) the annual amount of rainfall received in Kano ranges between 500mm to 1900mm while of Maiduguri ranges between 300mm to 1000mm, (2) both locations have an increasing rainfall trend, and (3) both locations have a unimodal seasonal rainfall (i.e they both have one rainfall peak in August), onset and cessation of rainfall is the same April and October respectively.

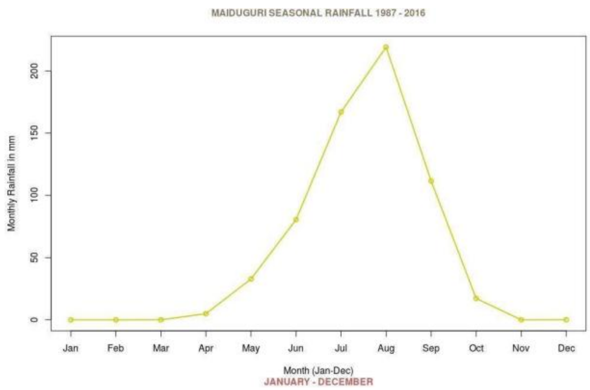

Figure 2(c): Seasonal rainfall variability for Maiduguru (1987- 2016)

ISSN (online): 2581-3048
Volume 6, Issue 3, pp 75-87, March-2022
https://doi.org/10.47001/IRJIET/2022.603012

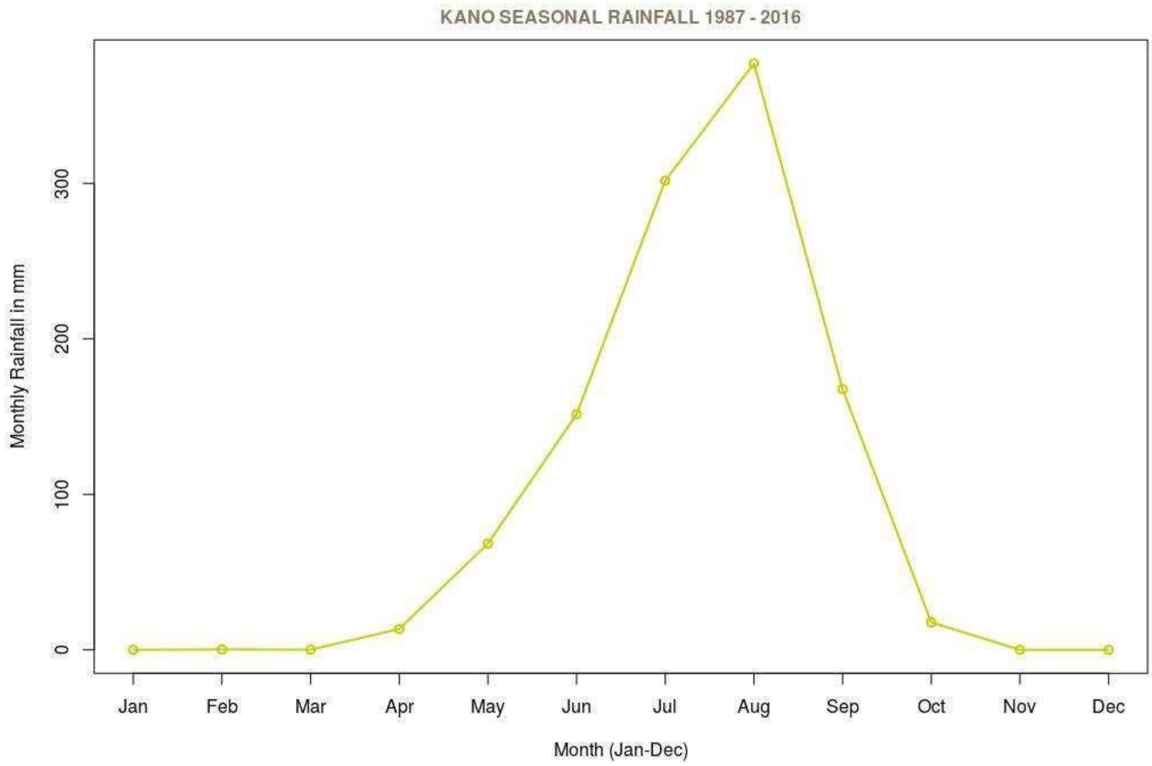

Figure 2(d): Seasonal rainfall variability for Kano (1987 – 2016)

ANOMALIES IN SEASONAL RAIFALL AMOUNT

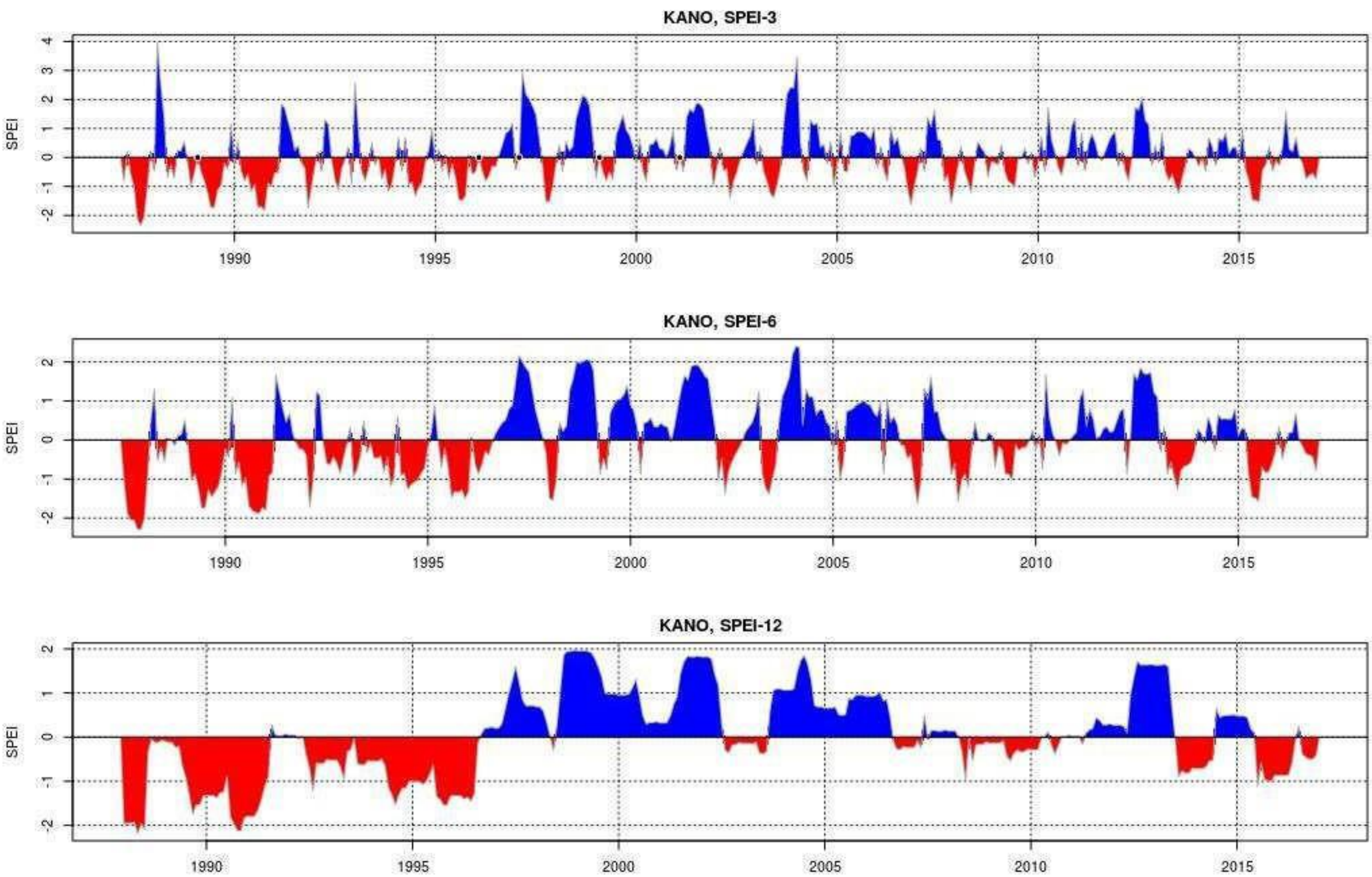

Figure 3(a)

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 3, pp 75-87, March-2022

https://doi.org/10.47001/IRJIET/2022.603012

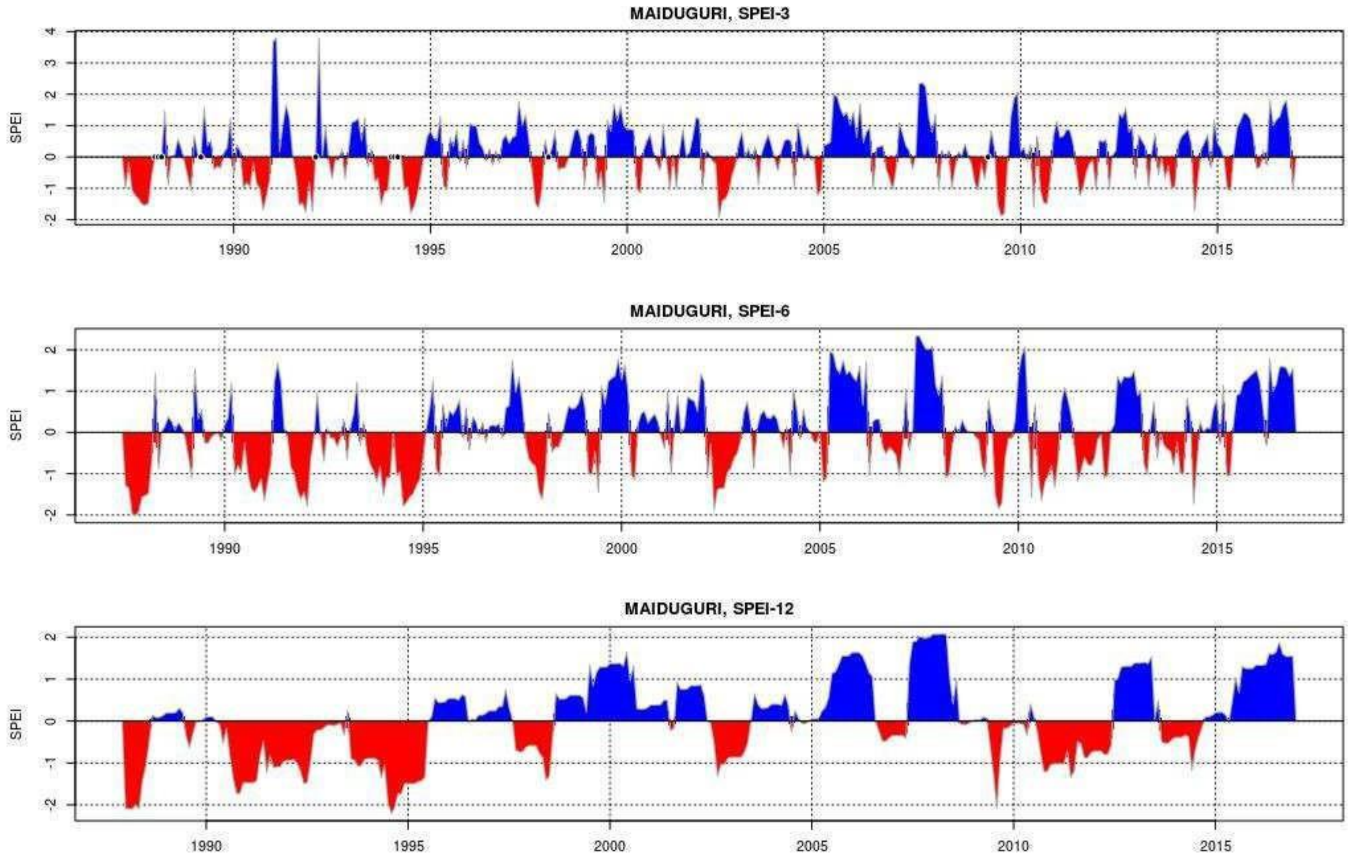

Figure 3(b)

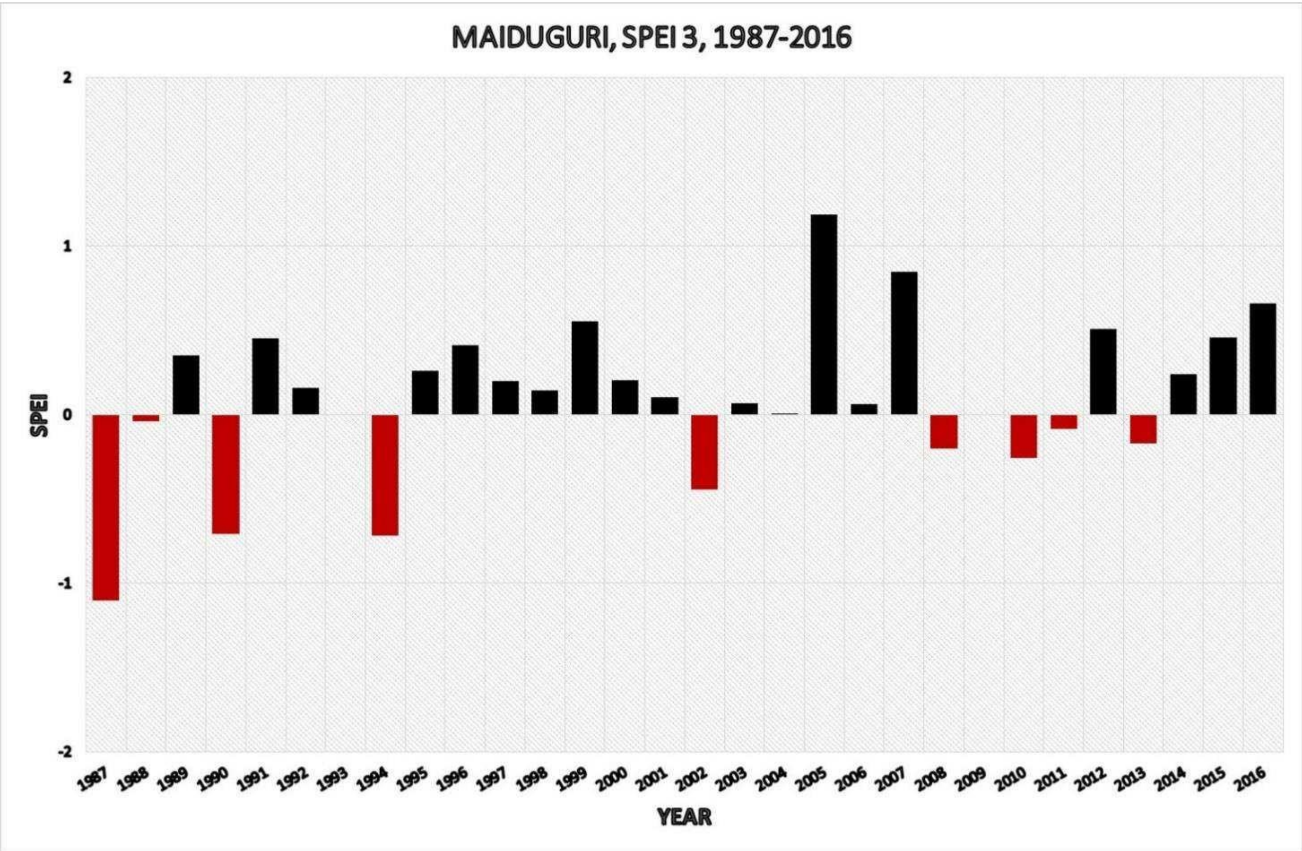

Figure 4(a)

ISSN (online): 2581-3048
Volume 6, Issue 3, pp 75-87, March-2022
https://doi.org/10.47001/IRJIET/2022.603012

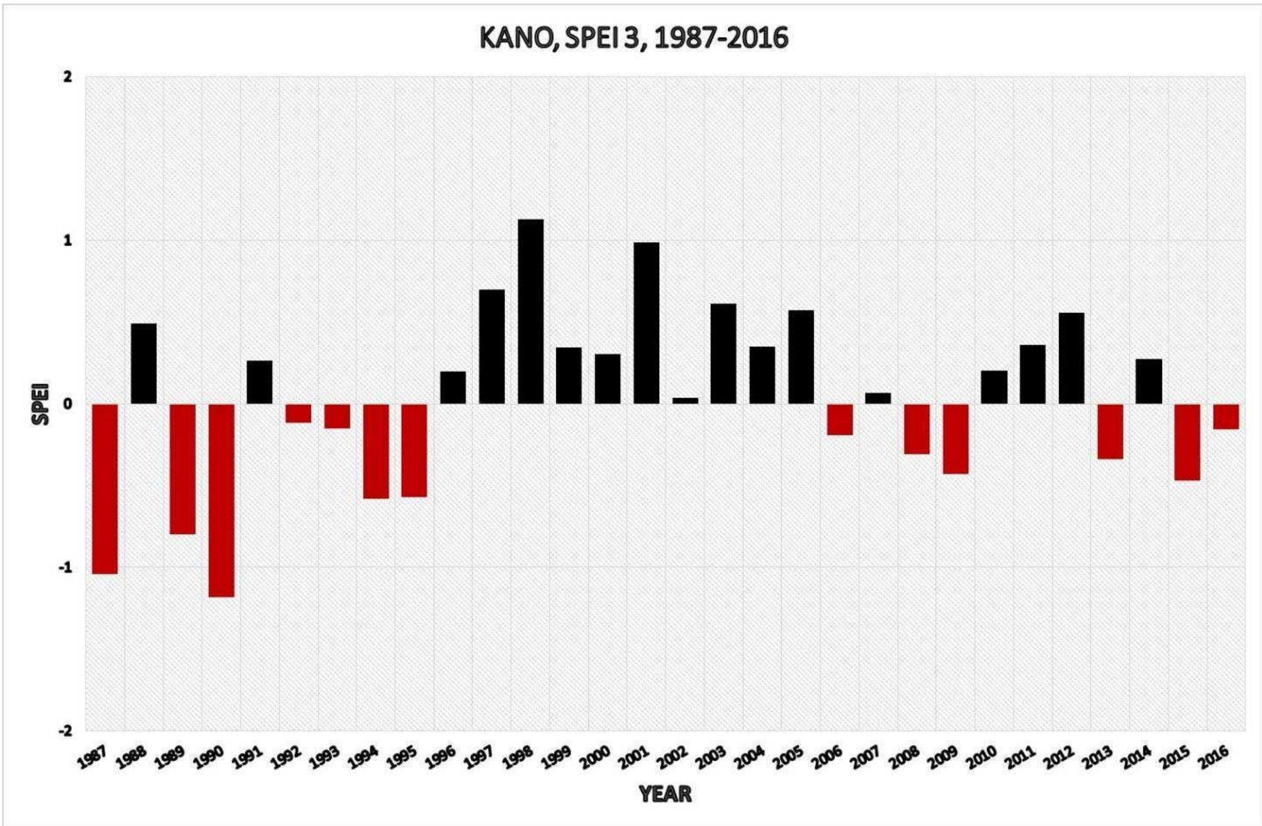

Figure 4(b)

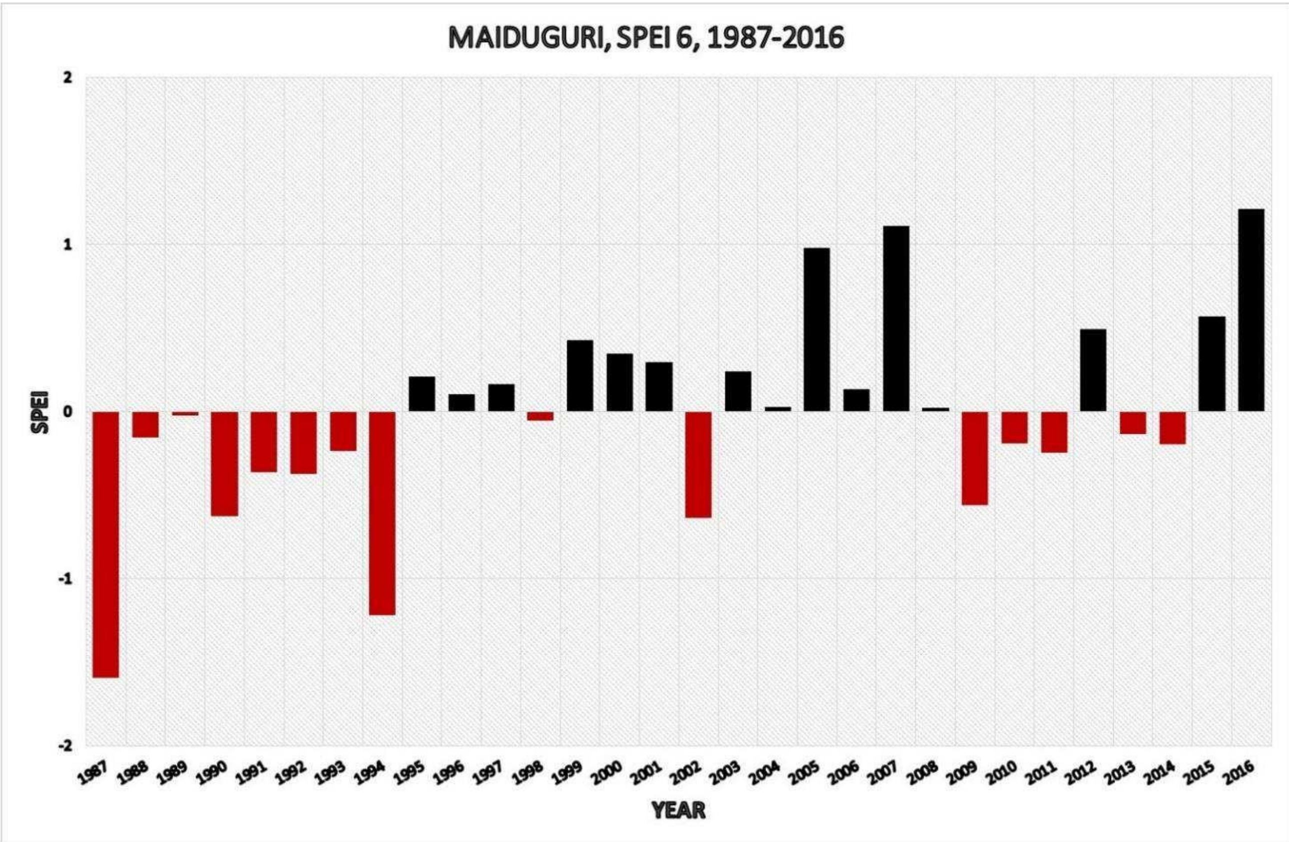

Figure 4(c)

International Research Journal of Innovations in Engineering and Technology (IRJIET)
ISSN (online): 2581-3048
Volume 6, Issue 3, pp 75-87, March-2022
https://doi.org/10.47001/IRJIET/2022.603012

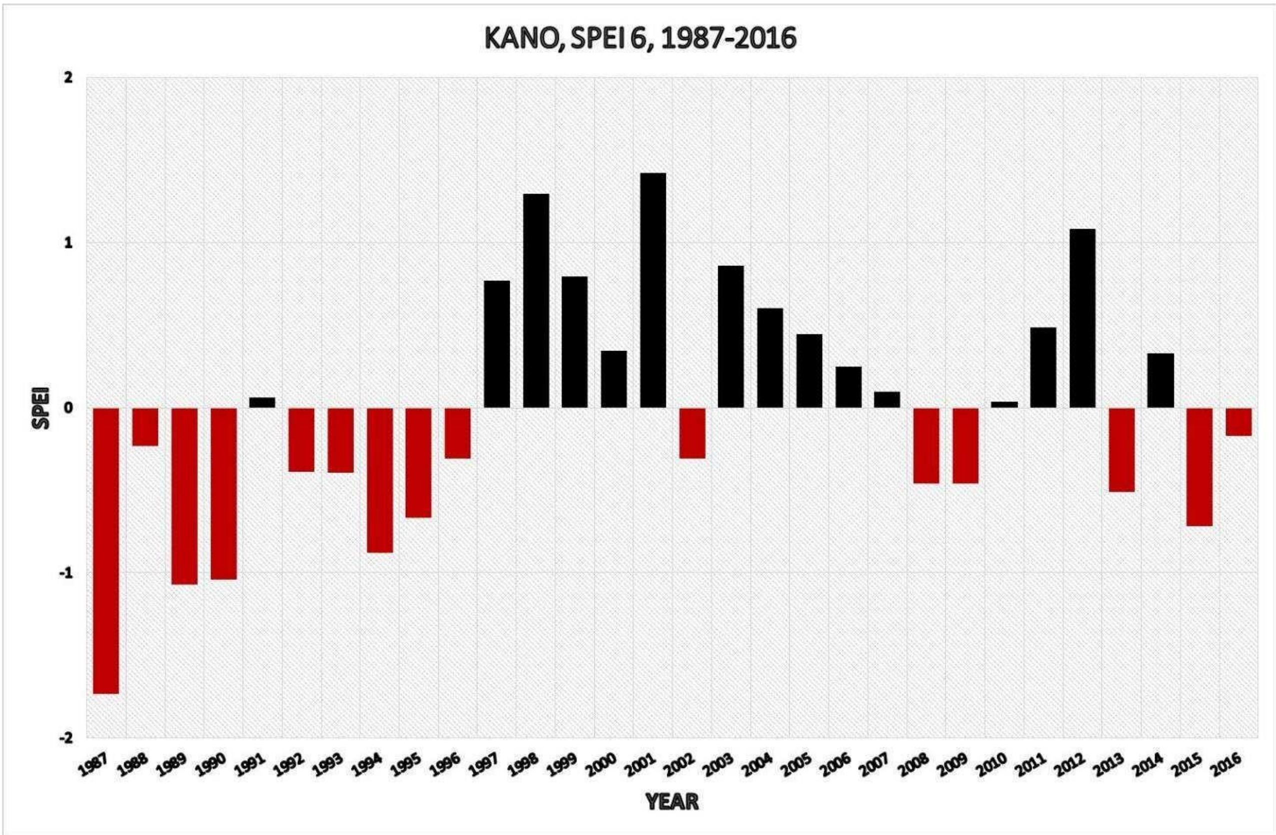

Figure 4(d)

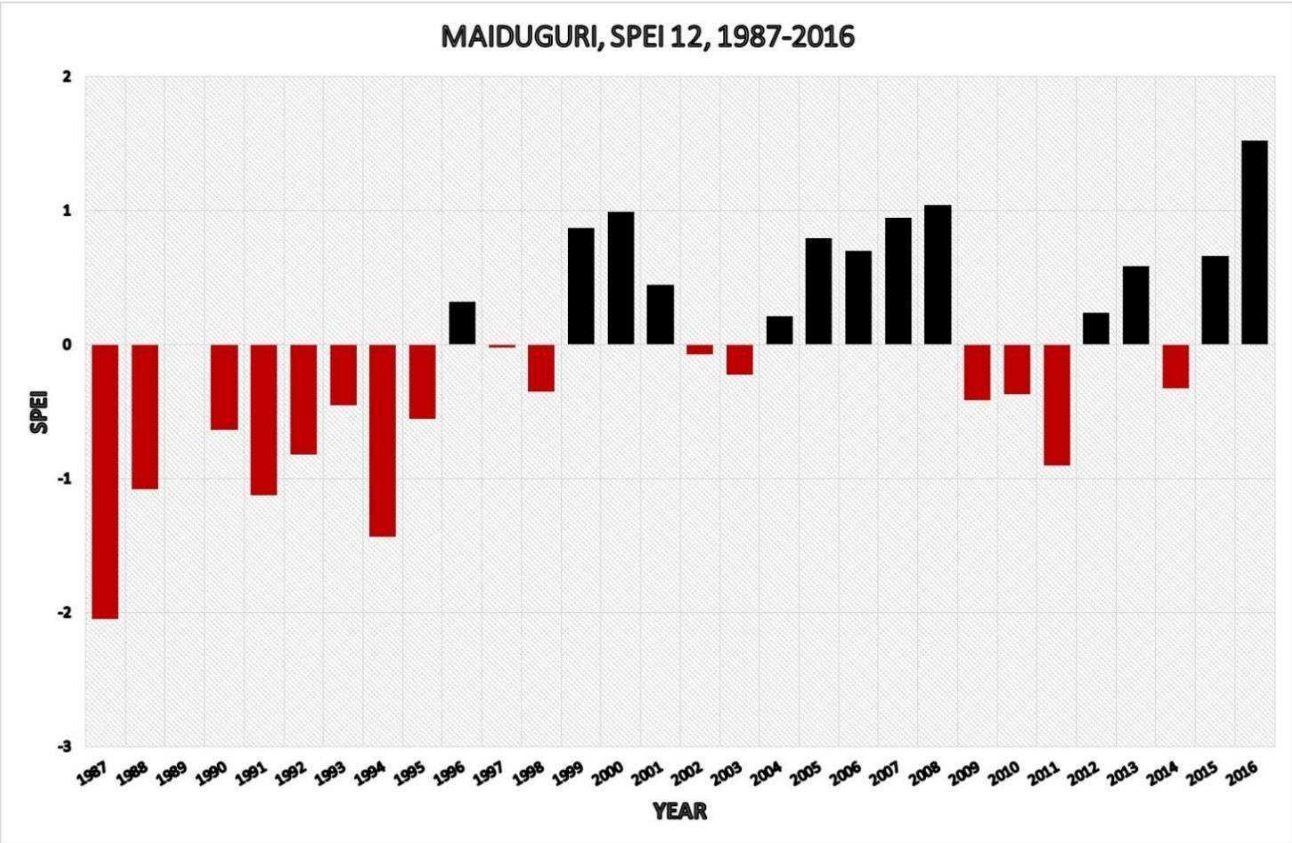

Figure 4(e)

ISSN (online): 2581-3048
Volume 6, Issue 3, pp 75-87, March-2022
https://doi.org/10.47001/IRJIET/2022.603012

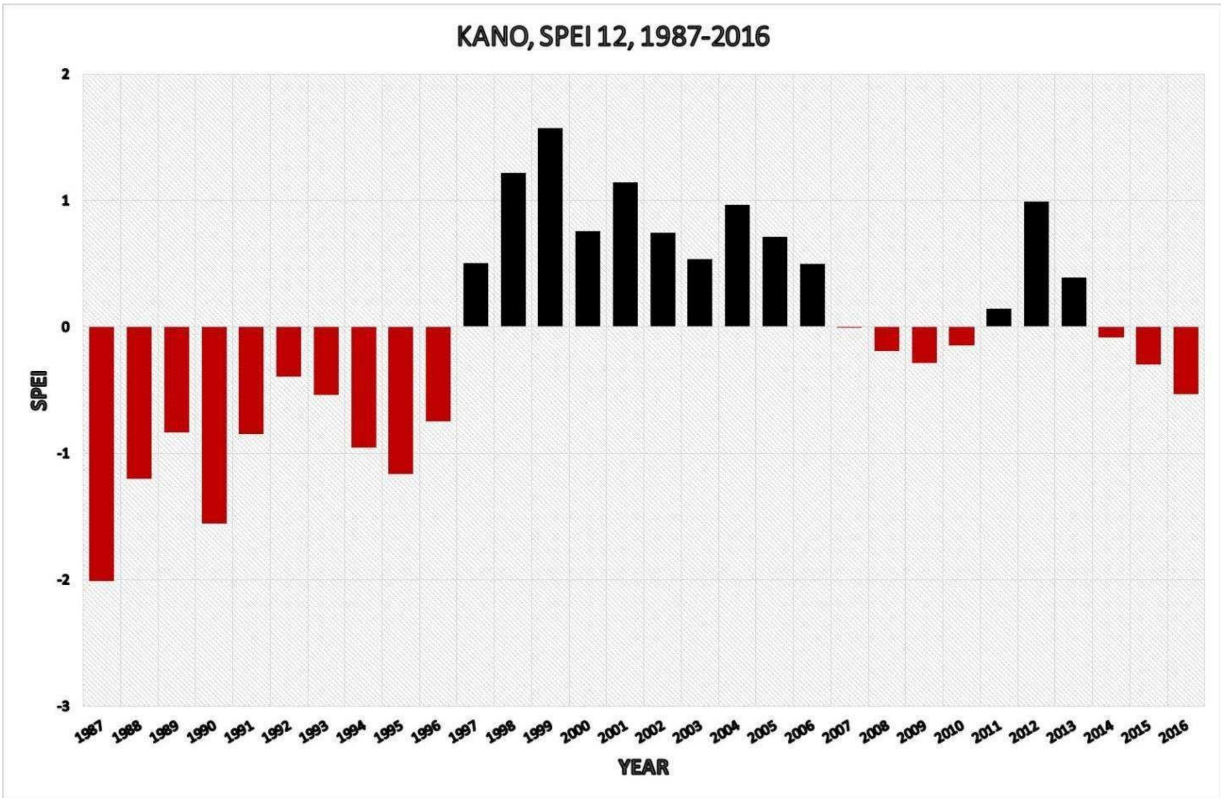

Figure 4(f)

The Inter-annual Variability of SPEI Value in Annual and Seasonal Scale (Anomalies in annual and seasonal rainfall amount).

The standardized precipitation evaporation anomalies (SPEI) results presented in Fig.3a-4f shows the inter-annual variability of the annual SPEI value.

Before 1995, most of the annual SPEI values are negative with some years having a value less than -2.0; however, right after 1995, almost every SPEI value is positive; nearly half of them are greater than 0.5, except a few years with a SPEI value of just above 0. According to Table 2, the drought degree is negatively correlated with the SPEI value, which indicates that the annual drought in the two stations, as shown in Fig.3a-4f is becoming less frequent. The decreasing-increasing trend of the annual rainfall in both stations Fig 2(a-b) shows the climate in the two stations is changing from dry to wet especially after 1995.

Table 2-6 shows that the drought area has an overall decreasing trend during the last 30 years. The ratio of drought occurrence to overall occurrence fluctuates from 1994 to the early 2000s.

Table 2: Table showing No of Drought Occurrence in 360 months of the 30years (1987-2016)

All in all, the variation trends of SPEI value indicate that the drought frequency and degree in two stations are decreasing from 1994 to 2016 both in annual scale and in seasonal scale, which is particularly significant after the early 2000s.

Classification	KANO			MAIDUGURI		
	SPEI3	SPEI6	SPEI12	SPEI3	SPEI6	SPEI12
No drought	256	247	254	259	241	251
Light drought	57	59	48	43	49	49
Moderate drought	28	35	35	35	49	45
Severe drought	11	14	18	14	18	8
Extreme drought	8	5	5	9	3	7

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 3, pp 75-87, March-2022

https://doi.org/10.47001/IRJIET/2022.603012

Table 3: Table showing Percentage of Drought Occurrence in 360 months of the 30years (1987-2016)

Classification	KANO			MAIDUGURI		
	SPEI3	SPEI6	SPEI12	SPEI3	SPEI6	SPEI12
No drought	71	69	71	72	67	70
Light drought	16	16	13	12	14	14
Moderate drought	8	10	10	10	14	13
Severe drought	3	4	5	4	5	2
Extreme drought	2	1	1	3	1	2

Table 4: Table showing No of Drought Occurrence in 30 years (1987-2016)

Classification	KANO			MAIDUGURI		
	SPEI3	SPEI6	SPEI12	SPEI3	SPEI6	SPEI12
No drought	24	21	20	26	25	20
Light drought	4	6	6	3	3	6
Moderate drought	2	3	3	1	2	3
Severe drought	0	0	1	0	0	1
Extreme drought	0	0	0	0	0	0

Table 5: Table showing Percentage of Drought Occurrence in 30 years (1987-2016)

Classification	KANO			MAIDUGURI		
	SPEI3	SPEI6	SPEI12	SPEI3	SPEI6	SPEI12
No drought	80	70	67	87	83	67
Light drought	13	20	20	10	10	20
Moderate drought	7	10	10	3	7	10
Severe drought	0	0	3	0	0	3
Extreme drought	0	0	0	0	0	0

Table 6: Table showing Severity of Drought Occurrence (monthly)

Classification	KANO			MAIDUGURI		
	SPEI3	SPEI6	SPEI12	SPEI3	SPEI6	SPEI12
No drought	1in7months	1in7months	1in7months	1in7months	1in7months	1in7months
Light drought	1In6years	1In6years	1In8years	1In8years	1In7years	1In8years
Moderate drought	1in18years	1in10years	1in10years	1in10years	1in7years	1in7years
Severe drought	1in30years	1in25years	1in20years	1in25years	1in20years	1in50years
Extreme drought	1in50years	1in100years	1in100years	1in30years	1in50years	1in50years

Table 7: Table showing Severity of Drought Occurrence (yearly)

Classification	KANO			MAIDUGURI		
	SPEI3	SPEI6	SPEI12	SPEI3	SPEI6	SPEI12
No drought	1in8months	1in7months	1in7months	1in9months	1in8months	1in7months
Light drought	1In8years	1In5years	1In5years	1In10years	1In10years	1In5years

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 3, pp 75-87, March-2022

https://doi.org/10.47001/IRJIET/2022.603012

Moderate drought	**1in14years**	**1in10years**	**1in10years**	**1in30years**	**1in14years**	**1in10years**
Severe drought			**1in30years**			**1in30years**
Extreme drought						

V. CONCLUSION

The Standardized Precipitation Index calculated for the distinct savannah ecological zones within northern Nigeria reflects how severe to extreme droughts characterized the 1980s, while the 1990s experienced mild droughts, like the years before the 1980s. The Sahel savannah experiences severe droughts with a higher average water deficiency than elsewhere. Drought intensity data also shows that severe to extreme drought characterized the Sudan and Sahel savannah ecological zones.

The Sahel Savannah region is therefore more prone to drought risk and hazard since future drought events may also exceed the "drought of record" and the capacity of the region to respond. Thus, drought preparedness planning should be considered an essential component of integrated water resources management within the savannah ecological zones of northern Nigeria since the magnitude of drought impacts may increase in the future as a result of an increased frequency of occurrence of natural events (i.e., meteorological droughts) as projected by climate change scenarios. The planning should also entail the development of people-oriented national drought policies with options for an early warning signal and regional and international cooperative plans.

REFERENCES

[1] Abubakar, I. U. (2008). Issues on Crop Production in Northern Nigeria: Poor Crop Yields and Irrigation. *Paper presented at the first northern Nigeria submit on Agriculture: Policy and Finance imperatives for vision* 2020 held on 28-30July, 2008 at Kaduna.

[2] Adeaga, O. (2002) Management of drought risk in the Sudano-Sahelian region of Nigeria. In: FRIEND—Regional Hydrology: Bridging the Gap between Research and Practice (ed. by H. A. J. van Lanen & S. Demuth), 157–162. *IAHS Publ 274. IAHS Press, Wallingford, UK.*

[3] Adefolalu, D. O. (1986) Further aspects of Sahelian drought as evidenced from rainfall regime of Nigeria. *Arch. Met. Geophys. Bioclim. Ser. B* 36, 277–295.

[4] Adeoye, K.B. (1986). An Evaluation of Drought Incidence and Hazard in Northern Nigeria. *Paper Presented at the 22nd Annual Conference of the Agricultural Society of Nigeria, Zaria* 1st – 3rd September, 1986.

[5] Apeldoorn, G. J. Van. (1978). Drought in Nigeria Volume2: Lessons of the 1972-74 Disaster. *Center for Social and Economic Research, Ahmadu Bello University, Zaria.*

[6] Apeldoorn, G. J. Van. (1981). Perspectives on Drought and Famines in Nigeria. *George allen and Unwin Ltd, London*. 184p.

[7] Bonaccorso, B., Bordi, I., Cancelliere, A., Rossi, G. & Sutera, A. (2003) Spatial variability of drought: an analysis of SPI in Sicily. *Water Resour. Manage*. 17, 273–296.

[8] EurAqua (2004) Towards a European Drought Policy, 41128e56161b800014456.html. http://www.euraqua.org/content/activities/positionpapers.4.4a4d22a Comparative response of a day-neutral and photoperiod-sensitive sorghum to delayed sowing or transplanting. Drought and Desertification (ed. by V. O. Sagua, E. E. Enabor, P. R. O. Kio, A. U. Ojanuga, M. Mortimore & A. E. Kalu), 11–53. *Federal Ministry of Science and Technology, Lagos, Nigeria.*

[9] FME. (2000). National Action Plan to Combat Desertification. *Federal Ministry of Environment, Abuja*.

[10] Glantz, M. H. and R. W. Katz. (1977). When is drought a Drought. *Nature* 267: 192-193

[11] Guttman, N. B. (1999) Accepting the Standardized Precipitation Index: a calculating algorithm. *J. Am. Water Resour. Assoc*.35(2), 311–323.

[12] ICRISAT, (1984). Agrometereology of sorghum and millet in the semi-arid tropics. Proceedings of an International Symposium, 15-20 November 1982, *ICRISAT Centre, Pantancheru, India*. 322pp.

[13] Ingawa S. A. (1998). National Fadama Development Project (NFDP): Achievements, constraints and prospects. In: Irrigation for sustainable agriculture. *Proceedings of the 12th National Irrigation and Drainage Seminar*, 14-16 April, 1998. Pp 188-201.

[14] Jeon, Y. W. and L. Halos-Kim (1998). Characterising the Desirability of Postharvest Technologies for African Conditions. In Kwarteng, J. (ed.) *Enhancing Post-harvest Technology Generation and*

ISSN (online): 2581-3048
Volume 6, Issue 3, pp 75-87, March-2022
https://doi.org/10.47001/IRJIET/2022.603012

Dissemination in Africa. Mexico City, Sasakawa-Global 2000. P. 36-46.

[15] Jibrin, M. J. (2010). Coping with Droughts in Nigeria's Sudano-Sahelian Zone. *Paper for Presented at the US-Nigeria International Workshop: Exploring Strategies for Managing Drought Using Climate Forecasts and Indigenous Knowledge* Nov 13-16, Bauchi Nigeria.

[16] Kolawole, A. (1987). Responses to Natural and Man-made Hazards in Borno.

[17] Lester R. Brown, (2006): The earth is shrinking: Advancing deserts and rising seas squeezing civilization. *Earth Policy Institute.* http://www.earthpolicy. org/Updates/2006/Update61.html, McGraw Hill Publishing co. New Delhi. pp.397.

[18] Mortimore, M. (1989). Adapting to Drought. Farmers, Famines and Desertification in West Africa. *Cambridge University Press, Cambridge* 299p.

[19] Musa, I. K. (2008). Strategies for Implementing Participatory Irrigation Management (PIM) in Nigeria to Achieve the Millennium Development Goals (MDGs) in the Irrigation Sub-Sector. *Proceedings of National Sensitization workshop on Participatory Irrigation Management for Chief Executives of River Basin Development Authorities (RBDAs) and State Irrigation Departments (SIDs),* 24-25 June, 2008 at Abuja.

[20] Nnaji, A. O. (2001). Forecasting seasonal rainfall for agricultural decision making in northern Nigeria. *Agricultural and Forest Meteorology* 107: 193-205 Northeast Nigeria. Disasters: 59-66.

[21] Nyong, A., F. Adesina and B. O. Elasha. (2007). The Value of Indegenous Knowledge in Climate change Mitigation and Adaptation Strategies in the African Sahel. *Mitigation and Adaptation Stretegies for Global Change* 12 (5): 787-797.

[22] O'Meagher, B., Stafford Smith, M. & White, D. H. (2000) Approaches to integrate drought risk management. In: Drought: AGlobal Assessment, vol. 2 (ed. by D. A. Wilhite), 115–128. *Routledge Publishers, London, UK.*

[23] Obasi, G. O. P. (1994) WMO's role in the international decade for natural disaster reduction. Bull. *Am. Met. Soc.* 75, 1655–1661.

[24] Ojo, O. & Oyebande, L. (1987) Trends in occurrences and severity of droughts in Nigeria. *In: Ecological Diasters in Nigeria.*

[25] Oladipo E. O. (1995) Some statistical characteristics of drought area variations in the savanna region of Nigeria. *Theor. ApplClimatol.* 50, 147–155.

[26] Othman, M. K., A. I. Arab, A. Ibrahim and M. S. Kallah (2010). Mitigating desertification through irrigation opportunities and challenges in Northern Nigeria. *In book of proceedings of the 10th International Conference of the Nigerian Institution of Agricultural Engineering,* 20- 22nd October, 2010. P. 338-352.

[27] Rabiu, A. B. (2009). Farmers Participation for Sustainable Irrigation Management. *Proceedings of zonal workshop for managers of 12 MDG irrigation projects, ABU, Zaria, Nigeria.*

[28] Recurrence of Drought in Nigeria: Causes, Effects and Mitigation179 Sen, S. (1975) Reaping the Green Revolution. *Food and Jobs for All.*

[29] Tata Shaib, B., Aliyu, A. And J. S. Bakshi (1997). Nigeria: National Agricultural Research Strategy Plan 1996-2010. *Research Report of Department of Agricultural Sciences, Federal Ministry of Agriculture and Natural Resources, Abuja*. Pp. 335

[30] Sirdas, S. & Sen, Z. (2001) Application of the standardized precipitation index (SPI) to the Marmara region, Turkey, *In: Integrated Water Resources Management (ed. by M. A. Marino & S. P. Simonovic), 291–296. IAHS Publ. 272. IAHS Press, Wallingford, UK.*

[31] Wilhite, D. A., Hayes, M. J. & Svoboda, M. D. (2000) Drought monitoring and assessment: status and trends in the UnitedStates. *In: Drought and Drought Mitigation in Europe (ed. by J. V. Vogt & F. Somma), 149–160. Kluwer Academic Publishers, Dordrecht, The Netherland.*

Citation of this Article:

Dada B.M., "Drought and Its Intricating Impacts on Some Areas in Northern Nigeria" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 6, Issue 3, pp 75-87, March 2022. Article DOI https://doi.org/10.47001/IRJIET/2022.603012

****