Analysis of Agricultural Drought Occurrences in Northwestern Nigeria

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ABSTRACT- Drought is one of the most important natural disasters. It shows its influences slowly over time and is one of the most costliest natural disasters of the world that affects more people than any other. It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another. The aim of this research was to analyse the occurrences of agricultural drought events in Northwestern Nigeria. Rainfall data from Nigerian Meteorological Agency was used in establishing the occurrences of drought events in the study area using the Monsoon Quality Index (MQI). The results revealed the notable drought occurrences within the years of study and how it varied from one station to the other. Recommendations include; channeling more studies towards identifying drought resistant crops as well as farming strategies that will alleviate possible drought disasters. Early warning system to be incorporated into an application software that could be accessible and easily usable by stakeholders both within and without the agro-meteorological industry since this will bring about a massive awareness and preparedness to drought events on the part of government as well as individuals. There should be regular awareness and enlightenment campaigns to the general public on the causes of drought as well as coping mechanisms to drought events, in various parts of the country.

INDEX TERMS- Drought, Agricultural drought, Monsoon Quality Index

1 INTRODUCTION

Drought is a condition of extreme but short climatic variation that results in insufficient rainfall to meet the socio-economic demands of a region in terms of water supply for domestic and industrial uses, agriculture and ecosystem. Drought is one of the most important natural disasters. It show its influences slowly over time and is one of the costliest natural disasters of the world that affects more people than any other [1][2].

It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another. Drought is a temporary aberration; it differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate [3]. There is no universally adopted definition of drought due to the wide variety of sectors affected by it, its diverse geographical and temporal distribution, and the demand placed on water supply by human-use systems [1].

Drought is a recurring environmental hazard in dry sub-humid and semi –arid regions where people's livelihood depends largely on subsistence agriculture and animal husbandry.

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Drought, in all its forms, is injurious to the wellbeing of the people and hampers attempts by all concerned to achieve sustainable development in the region. Agricultural drought is the most common of all the drought types in Nigeria and represents the most challenging to track and forecast owing to its ease of occurrence. The 1969-1973 drought remains topical because it had a serious impact on the agriculture sector in Nigeria [4].

According to [5], the most important kind of drought is agricultural drought which can cause serious disaster for food security, since crop yields are directly affected by soil moisture shortage. Drought assessment and monitoring should be considered essential components of integrated water resources management systems as mentioned by [6], to reduce societal vulnerability to future droughts events. This study thus analysed the spatio-temporal trends of drought occurrences in Northwestern Nigeria.

2 STUDY AREA

This study was carried out in Northwestern Nigeria. The location, position and size of the study area is bounded by latitudes $10^0\ 00^1$N and $13^0\ 58^1$N and longitudes $4^0\ 8^1$E and $6^0\ 54^1$E of the Greenwich meridian. It has a population of about 35, 786,944 according to 2006 census figures. The major climatic feature of the region is the alternating wet and dry seasons called, rainy and dry seasons [7]. This is as a result of the migration of the ITD or ITCZ. This line is formed by the meeting of the Tropical Maritime Airmass (TM) which is wet and the Tropical Continental Airmass (TC) which is dry. While looking at temperature variations in the region, the average temperature of the year is 27.7°C.The warmest month on the average is April with an average temperature of 31.7°C.The coolest month month on

the average is January with an average temperature of 21.7^{0}C.The highest recorded temperature is 41.1^{0}C which was recorded in April and the lowest recorded temperature is 8.9^{o}C in January.This region of the country is also characterised with high evaporation during the dry season, however it creates water shortage problems. Figure 1 shows the political boundary of Northwestern Nigeria.

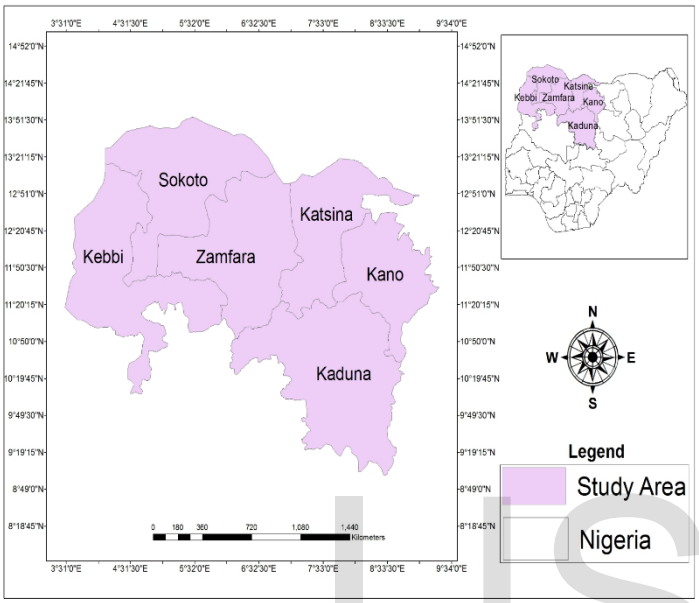

Figure 1: The Study Areas (North-western Nigeria)

Source: Kano State Land and Survey (2015)

3 MATERIALS AND METHODS

The Monsoon Quality Index was used in this study. It gives us the quality of water spread and the occurrences of agricultural drought events across the study area. The index is small if the annual amount is high and the rains are not concentrated in any one month. Thus, the smaller the index the better the season quality-wise.

$$MQI = \frac{(rmmi \times Nbi)}{R_i^2} \quad (1)$$

Where: i = Year Identifier, rmm = Highest Monthly rainfall total, R = Annual Rainfall total,

Nb = Number of breaks in rainfall. A break is taken as any pentad period with less than 5mm of rain.

The index is classified as follows:

MQI- Ranges	Quality	Intensity
> 0.015	Very Poor	Very Severe Drought
≥ 0.01 < 0.015	Poor	Severe Drought
≥ 0.005 < 0.01	Fair	Mild Drought
≥ 0.001 < 0.005	Good	No Floods no Drought
<0.00	Very good	Floods

Adopted from [8]

4 RESULTS AND DISCUSSION

The MQI was used to examine the quality of the rainfall distributions across the Northwestern part of Nigeria for the years put under consideration in this study.

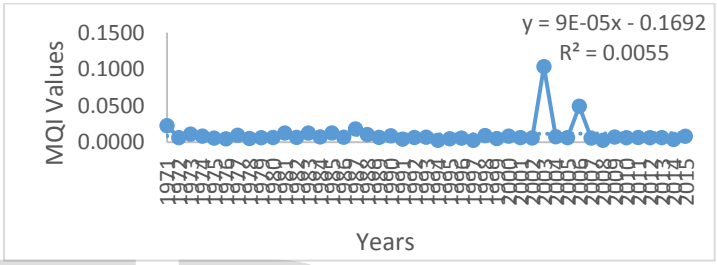

Figure 8: Drought Events over Yelwa from 1971-2015

The research of this study revealed that a very severe droughts was reported in 1971 with an annual value of about 0.022. The drought of 1973 signifies a declining severity of the drought to that of severe drought with an intensity of about 0.011. Very severe droughts were experienced in 1987 and 2003 with annual values of about 0.018 and 0.103 respectively. The trend line equation is decreasing at 0.00004 annually.

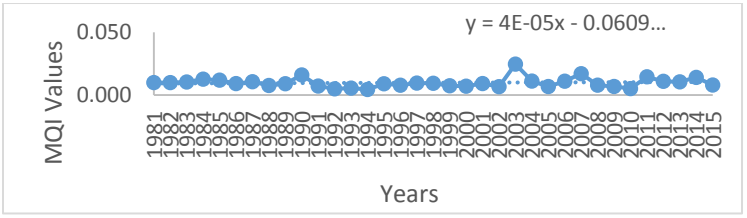

Figure 9: Drought Events over Gusau from 1981-2015

Based on the availability of data over Gusau station, a severe drought was observed from 1981 to 1985 whose respective annual values were 0.010, 0.010, 0.010, 0.013 and 0.012. A fair water quality was experienced in 1986 while a severe drought have returned in 1987 with an annual value of about 0.011. In 1990, a very severe drought was experienced in the station with a value of 0.016. In 2004, a severe drought was also revealed in the study area and consequently a very severe one in 2007.

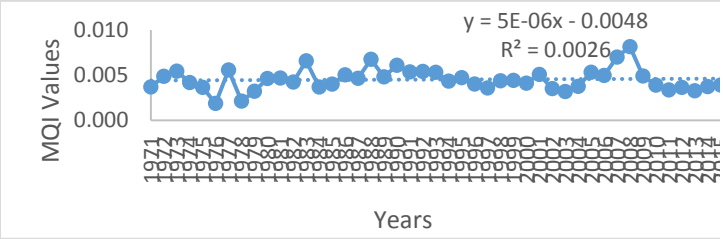

Figure 10: Drought Events over Kaduna from 1971-2015

The drought occurrences over Kaduna was that of a fair quality indicating a mild drought in the study area. The years 1972, 1973 and 2005 indicate the occurrence of a mild drought in Kaduna station on a magnitude of 0.005. In 1983, 1988 and 2006 mild droughts were also experienced with a value of 0.007. Other years with mild drought occurrences include 1987, 1989, 1990, 1991, 1992, and 1993 while the remaining years show an improvement in quality of water spread with a good quality. The trend line equation is decreasing at y =5E-06x-0.0048.

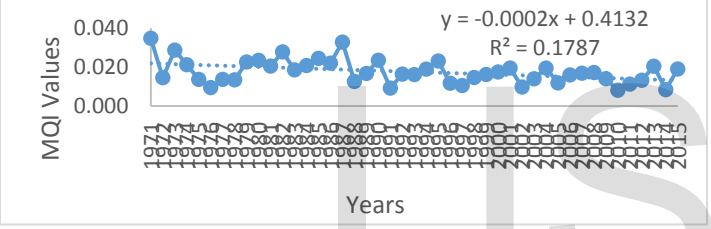

Figure 11: Drought Events over Sokoto from 1971-2015

The occurrences of very severe drought in Sokoto were observed in 1971,1972,1973,1974 with an annual values of 0.035, 0.015, 0.029 and 0.029 respectively. The intensity of the drought reduced in 1975 to a severe drought with a magnitude 0.014. A very severe drought returned from 1979 to 1987.The severity of the drought reduced in 1988 to a severe drought as against the earlier very severe drought. This research also revealed the occurrences of very severe agricultural drought of 1992, 1993, 1994 and 1995 with values 0.016, 0.016, 0.019 and 0.023 respectively. The drought of 1998 and 1999 was also very evident in this research. The trend line equation is decreasing at y =-0.0002x +0.4132

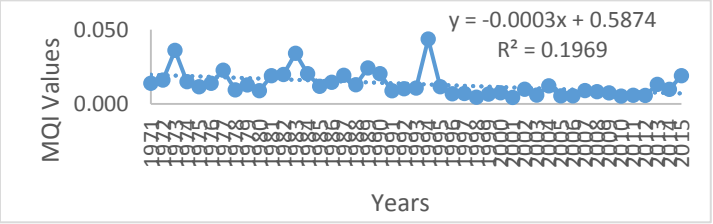

Figure 12: Drought Events over Kano from 1971-2015

A severe drought was observed in 1971 with annual value of 0.014 while a very severe drought was noticed from 1972, 1973 and 1974 with annual values of 0.016, 0.036 and 0.015 respectively. The intensity of the drought reduced in 1975 and 1976 to a severe drought with annual values of 0.012 and 0.014 respectively. A very severe drought returned in 1977 with annual value of 0.023.The drought of 1982 and 1983 were also very severe drought with annual values of 0.020 and 0.034 respectively. A very severe drought was also observed in 1986 and 1987.The Intensity of the drought reduced to a severe droughts in 1988 with an annual value of 0.013. The droughts of 1989, 1990 and 1994was a very severe one with annual values of 0.024, 0.020 and 0.044 respectively. The trend line equation is decreasing at y =-0.0003x + 0.5874.

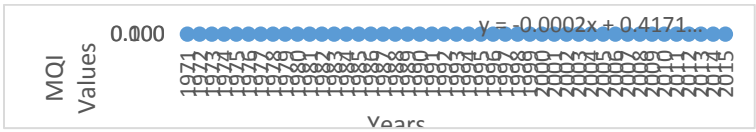

Figure 13: Drought Events over Katsina from 1971-2015

A very severe drought was observed from 1971, 1972, 1973, 1974, 1975, 1976, 1977 and 1978 with annual values of 0.035, 0.027, 0.041, 0.018, 0.017, 0.017, 0.022 and 0.020 respectively. The drought intensity reduced in 1979 to a severe drought with an annual value of 0.012.

A very severe drought returned from 1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1994, 1995, 1996, 1997, 1998, 1999 and 2000 with annual values of 0.015, 0.018, 0.026, 0.020, 0.026, 0.021, 0.033, 0.031, 0.015, 0.019, 0.025, 0.044, 0.031, 0.015, 0.015, 0.019, 0.025, 0.044, 0.031, 0.051, 0.024, 0.025, 0.032, 0.021, 0.020, 0.030 and 0.021 respectively. The trend line equation is decreasing at y =-0.002x+0.4171.

5 CONCLUSION AND RECOMMENDATIONS

The MQI portrayed the quality of spread of precipitation across the different stations within the years of study and there have been differences of moisture quality with some locations having fair or good quality in some years and poor quality in others which corresponds to different drought severity. Generally, the drought occurrences have been on the declined.

Recommendations include:

i. Since there are possibilities for further drought occurrences, more drought studies should be channeled towards identifying drought resistant crops as well as farming strategies that will alleviate possible drought disasters

ii. It will really be of advantage to the society at large if the early warning system can be incorporated into an application software that could be accessible and easily usable by stakeholders both within and without the agro-meteorological industry since this will bring about a massive awareness and preparedness to drought events on the part of government as well as individuals.

iii. There should be regular awareness and enlightenment campaigns to the general public on the causes of drought as well as coping mechanisms to drought events, in various parts of the country.

REFERENCES

[1] Loukas, A. & Vasiliades, L. (2004). Probabilistic analysis of drought spatiotemporal characteristics in Thessaly region, Greece. Natural Hazards and Earth System Sciences. European Geosciences Union. Available from http://hal.archives-ouvertes.fr/docs-/00/29/92/22/PDF/nhess-4-719-2004.pdf (accessed: 5 February 2009).

[2] Bacanli, U.G., Dikbas, F., & Baran, T. (2008).Drought Analysis and a Sample Study of Aegean Region. Ethics and Climate Change. Scenarios for Justice and Sustainability. Sixth International Conference on Ethics and Environmental Policies, Padova, 23-25 October 2008.

[3] National Drought Mitigation Center, NDMC. (2006).What is Drought? Understanding and Defining Drought Available from http://drought.unl.edu/whatis/ concept.\htm (accessed: 12 December 2007).

[4] Usman M.T. (2000). An instability index for monsoon onset characterization over Nigerian Sahel. Environ.Rev,3(1):367-379

[5] Boken V.K. (2005). Monitoring and Predicting Agricultural Drought. Oxford University Press: Oxford; 472 pp.

[6] Wilhite, D.A 2005. Drought as hazard: Understanding the natural and social context.chapter1 in Drought and water crisis, Science,technology and mansgement issues CRCPress,Boca Raton,Florida.

[7] Ekpoh, I. J. (2005). Climate and Society in Northern Nigeria: Rainfall variability and farming. The International Journal Series on Tropical issues, 8(3), 157-162.

[8] Usman M.T. & Abdulkadir .A, (2014). An experiment in intra-seasonal agricultural drought monitoring and early warning in the Sudano-sahelian Belt of Nigeria. *International journal of climatology*, 34, 2129-2135,doi:10.1002/joe.3840