Climate Change, Rainfall Variability and Meteorological Droughts in Borno State, Nigeria

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INTRODUCTION

The industrial revolution which began some 150 years ago has been identified as the turning point of mass human induced climate change action (Huq et al, 2008). This position was further buttressed when the Intergovernmental panel on Climate Change (IPCC) published its first assessment report in 1990, which drew the attention of the global community to the significant increases in atmospheric green house gas concentration. Since then climate change issues have been viewed from 3 major perspectives. (1) Climate change and global warming; (2) stratospheric ozone depletion and ultraviolet radiation and (3) significant variation in seasonal climates (Adelekan and Gbadegesin, 2005). The third approach is more favourably discussed in connection to global environmental issues such as desertification, deforestation, land use management and changes of ecosystems and biodiversity. The present study will therefore attempt an in-depth analysis of meteorological drought incidences in Borno state, northeastern Nigeria based on the third approach to climate change study.

Drought impacts in various ways. The effect of drought may be direct or indirect, singular or cumulative, immediate or delayed. Droughts are generally classified into four main types; Meteorological drought, agricultural drought, hydrological drought and socio-economic drought. Though the study of meteorological drought has received greater attention than the others, it was studied using different approaches. For example, the Bhalme-mooley technique has been applied by Shuaibu and Oladipo (1993) cited in Oladipo (1997) and Oladipo (1991). The Palmer Drought Severity Index (PDSI) has been used by Karl (1983), Oladipo (1985), Guttman et al (1992) and Wells et al (2004). Borno state is an agrarian state noted for cereal production and livestock farming, yet its rainfall occurrence is highly variable. Therefore it becomes imperative to critically analyzed drought incidences in Borno state using the Standardized Precipitation Index (SPI) method.

MATERIALS AND METHODS

Study Area:

Borno state is located on latitude 100 05' to 130 55'N and longitude 110 45' to 14 0 48'E. It is bounded in the northeast by Lake Chad, north by republic of Chad, west by Yobe state, south by Gombe and Adamawa state and east by republic of Cameroun. It has its capital in Maiduguri and it is made up of 27 local government areas with a 2006 provisionary census figure of 4,151,193 people.

The climate is characterized by two distinct seasons, wet and dry. The wet season last a period of 4 months (June – September) while the dry season covers the months of October to May. Precipitation is quite low with a mean annual downpour of 630mm. Temperatures are generally high throughout the year with annual average of 29°C. This could be explained partly by the long period of dry season characterized by clear sky without the moderating influence of cloud cover. The Harmattan winds however exercised a moderating effect on temperature between November to February. Mean annual sunshine hours are high in Borno state (10hrs), while mean relative humidity is quite low (20 – 40%).

Data source:

Secondary data in the form of annual rainfall values for Maiduguri was abstracted from Akintola (1983) for the period 1915 to 1983, while the remaining period was obtained from the head office of Nigerian Meteorological Services (NIMET) for the period 1984 to 2005. Annual rainfall figure is preferred for this study because of the analytical technique used.

Data analysis:

The 90 years annual rainfall was divided into 3 climatic periods of 30 years each and their averages found in order to detect any shift in climatic mean values. A 5 year moving average was also introduced to smoothen out extreme values and produce a pattern for the mean annual precipitation. The entire rainfall data was subjected to the Standardized Precipitation Index (SPI) technique in order to detect drought years, magnitude and severity. The SPI technique was developed by McKee et al (1993) for the purpose of defining and monitoring droughts. The technique has been adjudged a good indicator of moisture supply (Wu et al, 2004). The SPI is based on statistical probability and was designed to be a spatially invariant indicator of drought. The nature of the SPI allows an analyst to determine the rarity of a drought or an anomalously wet event at a particular time scale for any location in the world that has precipitation records. This study adopts a 12 months SPI for seasonal drought index in Maiduguri. All negative SPI values are taken to indicate the occurrence of drought, while all positive values show no drought. A table of SPI and cumulative probability is used to determine drought intensity.

RESULTS AND DISCUSSION

Rainfall Variability and Climate Change Signals

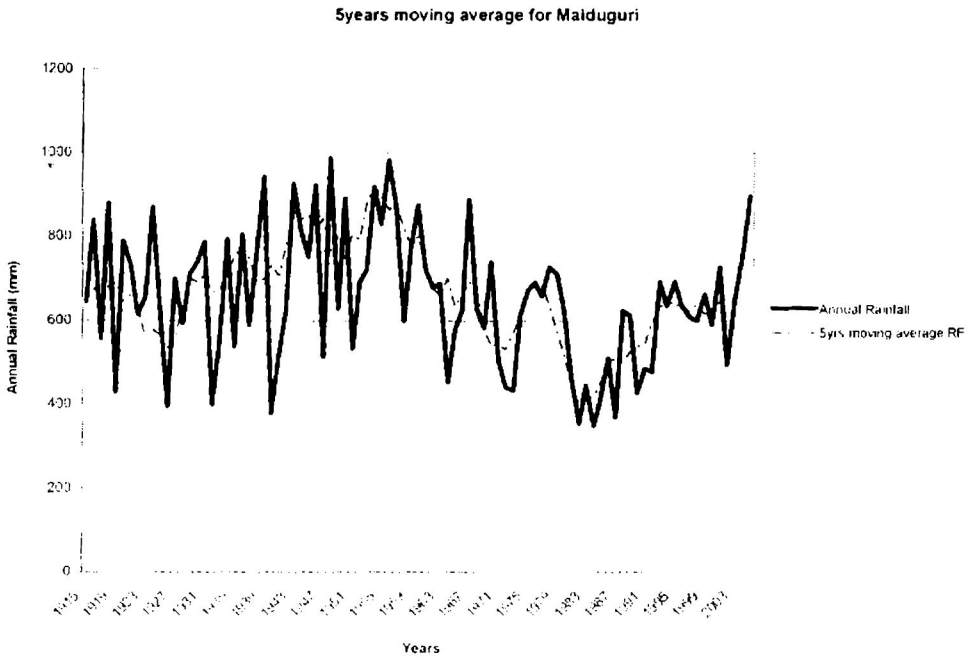
Table 1: Mean rainfall value for climatic period.

Serial No	Climatic period	Mean rainfall value (mm)
1.	1915 to 1944	673.69 mm
2.	1945 to 1974	702.22 mm
3.	1975 to 2004	578.78 mm

Result from table 1 shows that the second climatic period (1945-1974) has a mean annual rainfall of 702.22mm and this is higher than the first and third climatic period. This does not give a definite pattern as to the possible direction of climate change. Therefore it becomes necessary to introduce a five years moving average to the annual rainfall data for the whole period. The result is displayed in figure 1. A close observation of figure 1 shows that since the early 1950s, rainfall has been on the decrease in Borno state. Though there seems to be an appreciable rise by the early 1990s, the general trend seen with the eyes is that of a downward sloping trend. This is indicative of climate change characterized by increasing temperature, high evaporation and reduced rainfall as observed by Ojo (2003). Observations further shows that throughout the period of study, the five years moving average for annual precipitation only rose above the mean annual for the entire period (654.26mm) from 1943 to 1963.

Drought analysis

Temporal analysis shows that 42 drought episodes occurred within the 90 years, this makes an average of a drought event every two years. The 90 years period was divided into 10 year periods know as decades and the number of droughts in each decade was counted. Result shows that after the decade 1940-1949, there was a noticeable decline in drought events through the decades up to the 1980-1989 decade when the figure raised to 9 incidences. Incidentally, this happens to be the decade with the highest drought incidence. This finding goes to support the works of Akeh et. al. (2005) who did a drought frequency count for 21 selected stations across Nigeria including Maiduguri. They found out that all over Nigeria the decade 1980 – 1989 recorded the highest frequency of drought events. Also, Fasola and Omojola (2005) in a study involving 20 stations in the Guinea, Sudan and Sahel savannah region of Nigeria noted that in the overall the 1950 - 1959 decade recorded the highest rainfall, while the decade 1980 - 1989 had the least rainfall from the total decade mean.



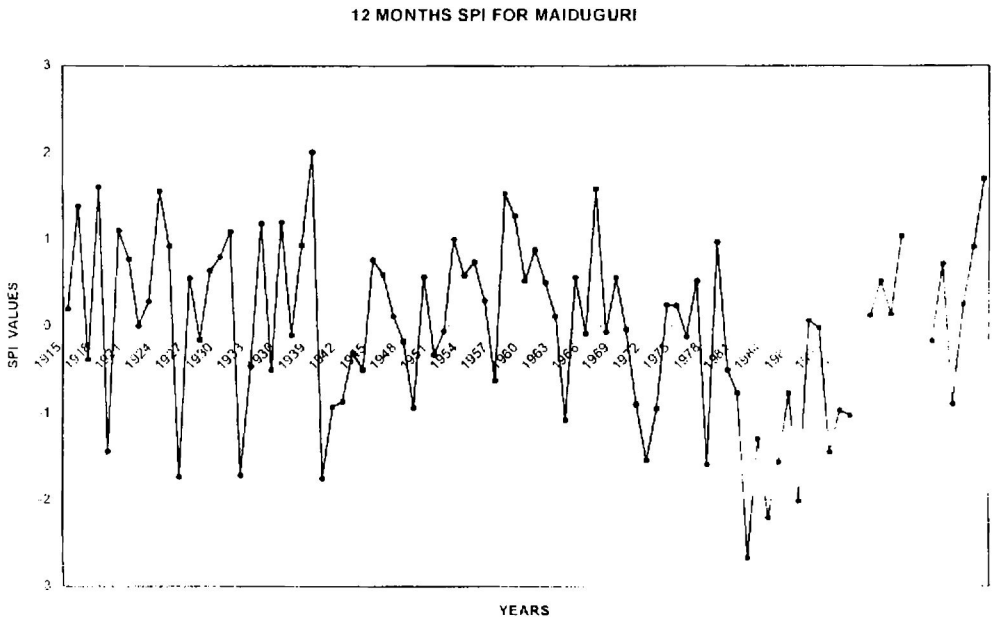
Drought duration analysis shows that out of the 90 years period of study, sporadic (single) drought events occur only 15 times constituting 35.7% of drought episodes in Borno state. There were very few cases of 2 years drought stretch (back to back). It occurred 3 times and constituted 14.3% of total drought events within the study period. A 3 year drought stretch was lacking in Borno state, in place of it were longer duration droughts. There were two episodes of four year drought stretch events occurring between 1970-1973 and 1989-1992. Before then, a much longer 5 years drought stretch had occurred between 1940 to 1944 constituting 11.9% of drought events in Borno state during the study period. The longest drought duration of 8 years at a stretch occurred only once during the year 1980 to 1987. This singular event accounted for 19% of drought incidence in Borno state during the study period.

Drought severity and magnitude was measured using SPI values which indicates degree of departure from annual participation mean. The degree of departure is then read against an SPI prepared index (see McKee et al, 1993). The result of drought severity (magnitude) for Borno state shows that 28 incidence constituting 67% of drought occurrences measured 0 to -0.99 on the SPI scale. This means they were near normal events. The water shortage associated with their occurrences is quite insignificant so that damages caused by this type of drought events do not create panic. Recovery rate from this type of drought event is quite fast if precipitation situation appreciates upwards slightly. This type of drought hardly occurs back to back as the shortage of rainfall in any particular year is easily corrected by normal precipitation the next year.

Table 5; Drought severity/magnitude for Borno state

Station	Study period	Events	SPI scale	Freq (%)	Severity
Maiduguri	90 years	42	0 to -.99	28 (67%)	Near normal
			-1.0 to -1.49	5 (12%)	Moderately dry
			-1.5 to -1.99	6 (14%)	Severely dry
			-2.0 to -3.0	3 (7%)	Extremely dry

The next class of drought with magnitude of -1.0 to -1.49 on the SPI scale is classified as moderate drought. Borno state recorded 5 incidents accounting for 12% of drought events within the study period. There were also droughts of severely dry condition (14%) and extremely dry condition (7%). The highest drought magnitude in Borno state measured -2.67 on the SPI scale. This occurred in 1982 (see figure 3), and because of extremely dry conditions associated with it, recovery can be very difficult. It is belief that this 1982 extremely dry drought set a chain of drought events covering 1982 to 1985 of various scales between moderately dry to extremely dry conditions. The resultant effects of drought of this magnitude are the lost of agricultural output, reduced biomass production and a great reduction in animal quality and quantity. These types of droughts are known to have caused outright migration and abandonment of farmlands (Appa, 1987). Indirectly, it may lead to change in land use practice and create heavy pressure on urban centers thereby putting severe strain on the economy.



CONCLUSION

The issue of climate change in Borno state is real, evidence by noticeable decrease in mean precipitation. Drought analysis in the area also shows that a drought is bound to occur in every two years with different magnitude. Drought of high magnitude, though not so common as near normal situation, have very low recovery rates and high tendency to initiate prolong back to back drought events. This also was observed to impact negatively on the economy of the state and nation at large. The research therefore concludes that in view of the low rainfall values recorded in Borno state, efforts should be intensified to introduce crops of drought resistant varieties in the state. Secondly, the ministry of agriculture should lunch a massive campaign to de-emphasized dependence on rain fed agriculture because of its vulnerability to weather vagaries. Rather, irrigation cultivation should be encouraged as this practice gives the farmer a degree of control on some vital inputs such as moisture. Finally, it is also recommended that drought monitoring and mitigation centers be established for early warnings and provisions of relief materials when the need arise.

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