THE IMPACT OF DROUGHT AND DESERTIFICATION IN THE LAKE CHAD BASIN REGION

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ABSTRACT

The main purpose of this study was to assess and analyze the climatic trends in the Lake Chad basin region between 1960 and 2002 for which the climatic data is made available. This is because of the impact of drought and desertification in the region which affects socio-economic life of the people in very remarkable ways as virtually every economic activity that the people engaged in is dependent on weather. The data for annual rainfall and temperature were for synoptic meteorological stations within the basin. These included N'Djamena, Mao, Bousso, SARH, Lai (Logone), Djimtilo (near Lake), Bol (Lake). The main findings revealed that the climatic data with respect to rainfall total annual figures show a declining trend until about the early 1980s, there after it begins to show an upward trend. The temperature patterns also varied from one stations to the other although Mao stands out from the other stations. The general trend from the polynomial curve is that of a slight decline from 1960 to 2002. It can be concluded that a proactive allocation of water among the various communities in the basin must be pursued to ensure that everyone has access to water optimally.

Keywords: *Drought, desertification, Lake Chad, climatic trend, socio-economic life*

INTRODUCTION

Drought can be termed as a period when there is little or no rainfall for a long period of time in a place. Desertification on the other hand can be defined as the reduction or spatial reorganization of net primary production in arid and semi arid lands (http://www.evsc.virgnia.ed/desert). At the meeting convened during 1977 in Nairobi, Kenya, United Nations Conference on Desertification (UNCOD) defined the phenomenon as " the diminution or destruction of the biological potential of land, and can lead ultimately to desert-like conditions. It is an aspect of the widespread deterioration of the ecosystems, and has diminished or destroyed the biological potentials, i.e. plant and animal production, for multiple use purposes at a time when increased productivity is needed to support growing populations in the quest of development" (UNEP, 2003 in Adesina, 1993). Desertification is a feature of land in arid semi-arid and dry sub-humid areas where the soils are especially fragile vegetation is sparse and scanty rainfall. About one third of the earth's land surface (4 billion hectares) is threatened by desertification, and over 250 million people are directly affected. From 1991 to 2000, droughts have been responsible for over 280,000 deaths and accounted for 11% of the total water-related disasters (Bohel et al., 1994).

Desertification is influenced by both climatic and human factors. Rainfall and temperature are the most important climatic factors in desertification. Increased temperature accentuates evapotranspiration causing enormous water losses. This coupled with decreased rainfall provide suitable conditions for the establishment of desert conditions. The human factors include uncontrolled land use, farming and overgrazing, poor irrigation practices which contribute to salinity, and sometimes drying up of the rivers that feed large lakes. To these may be added the movement of refugees during periods of conflict and socio-economic and political factors (IPCC, 2007). De-vegetation particularly due to grazing and extraction of firewood destroys the plants that hold the soil together causing further soil deterioration. Firewood extraction is an important anthropogenetic factor as firewood is the main source of domestic energy in the region (IPCC, 2007).

Desertification affects all aspects of life and this underscores the inter-linkage between environment and livelihoods. Desertification leads to vegetation loss and makes affected areas generally more vulnerable to the impact of flash floods that are common in the dry lands of Africa. It also causes salt levels in soils to rise, resulting in deteriorating soil conditions for cropping and water quality both for agriculture and domestic consumption (Shiklomanov, 1993;

Briassoulis, 2001; Adesina, 1993). Drought and desertification affect socio-economic life of the people in very remarkable ways. This is because virtually every economic activity that the people engaged in is wholly dependent on weather. This study therefore attempts to assess and analyze the climatic trends in the region with particular reference to drough and desertification.

METHODOLOGY

The Lake Chad basin is located approximately between latitude 12^{o}N and 14^{o} 30' N and Longitudes 13^{o} E and 15^{o} 30' E, (Figure1) parts of four West African countries namely Chad, Cameron, Nigeria and Niger. In Nigeria's territory the basin covers an area of approximately 200,000km^2 with 720km^2 attenuation westwards from the shores of the lake and a north-south maximum of 300km in width (Thambyahphillay, 1987). The Lake Chad basin comprises five bioclimatic zones, namely: Saharan, sahelo-saharan, sahelo-sudanian, dudano-sahelian and sudano-guinea ecological zones. The south-west humid Atlantic (monsoon) and the north-east Egyptian hot and dry (harmattan) currents influence the climate and consequently the ecological zonation of the basin. The sudano-guinean climate in the south for example has annual rainfall of over 950 millimeters, a rainy season of six to seven months (May-November) with an average annual temperature at Sarh (formerly Fort Archambault in Chad) of 28^{o}C (absolute minimum 10^{o}C, absolute maximum 45^{o}) and annual Piche-recorded evaporation of 2027mm in 1961.

During the winter months the cool, dry, dust-laden "harmattan" blows from the Saharan in the north, bringing low humidity, cool nights and warm days. In summer months, moisture-laden winds blows from the Gulf of Guinea in the south bring high humidity, rains, and more uniform diurnal temperature. The monsoon advances from the south, so that rains start earlier, are heavier and last longer in the southwards, although in general there is high spatial and temporal variability over the entire area. The terrain of the study area is generally flat with a few shallow depressions and a few widely scattered elevated spots. The resulting surface drainage density is low (LCBC, 2007).

The type of available data collected and analyzed for this study is climatic data in the Lake Chad basin. These were obtained from the Lake Chad Basin Commission in N'Djamena Chad. This data set is needed for the evaluation of trends in the dry basin between 1960 and 2002. Data for annual rainfall and temperature were for synoptic meteorological stations within the basin. These included N'Djamena, Mao, Bousso, SARH, Lai (Logone), Djimtilo (near Lake), Bol (Lake) (LCBC, 2007).

The climatic data set for each stations were analyzed using a second order polynomial curve. Technically, the term "polynomial" should only refer to sums of many terms, but the term is used to refer to anything from one term to a zillion terms. However, the shorter polynomials do have their own names:

(a) a one-term polynomial, such as 2x or $4x^2$, may also be called a "mononomial"

(b) a two-term polynomial, such as 2x + y or $x^2 - 4$, may also be called a "binomial"

(c) a three-term polynomial, such as 2x + y + z or $x^4 + 4x^2 - 4$, may also be called a "trinomial"

In mathematics, a polynomial is an expression that is constructed from one or more variables and constants, using only the operations of addition, subtraction, multiplication, and constant positive whole number exponents. For example, $x^2 - 4x + 7$ is a polynomial. A second-degree polynomial, such as $4x^2$, $x^2 - 9$, or $ax^2 + b^x + c$, is also called a "quadratic" curve. Polynomial involves: Partitioning the between-groups sum of squares into trend components. When this option is selected with balanced designs, SPSS 8 package computes the sum of squares for each order polynomial from weighted polynomial contrasts, using the group code as the metric. These contrasts are orthogonal; hence, the sum of squares for each order polynomial is statistically independent. If the design is unbalanced and there is equal spacing between groups, it also computes sums of squares using the unweighted polynomial contrasts, which are orthogonal. The deviation sums of squares are always calculated from the weighted sums of squares. The least squares fit through points are calculated by using the following equation:

$$y = b + c_1 x + c_2 x^2 + c_3 x^3 + \ldots\ldots + c_6 x^6$$

Where

b and $c_1 \ldots c_6$ are constants.

RESULTS AND DISCUSSION

Rainfall is the dominant mode of precipitation in the humid tropics. It is also the main source of available water in general and specific terms. In general terms, rainfall occupies a dominant position in the hydrological cycle, helping to bring water from the oceans to the land. In this way, it supports rain fed agriculture and among other things, recharges underground water sources. In specific terms it keeps rivers flowing even through the desert and builds the water storage in dams used for various purposes. It is therefore a strong indicator of aridity or wetness.

Figures 1-3 show the trend in annual precipitation in the selected stations from 1960 to 2003. In general, the total annual rainfall varies a great deal over the period under consideration. For example, N'Djamena Aero had its highest precipitation in year 2002 and the lowest in 1984 (767mm and 226mm) respectively. Mao recorded its highest precipitation of 1075mm in 1996 and it's lowest of 75mm in 1972. Sarh Meteo recorded the highest precipitation in 1982 (1258mm) and the lowest in 1986 (681mm). This distribution of rainfall trends from 1960 to 2002 in the three stations of the basin revealed that Sarh Meteo station has the highest rainfall among the three stations for which there are comprehensive data.

The smoothened polynomial curves indicating rainfall trends give a more informative picture of the general pattern. For N'Djamena the trend shows a decline in annual rainfall from about 600mm in 1960 to a little below 500mm in 1980. From thence, it shows a steady rise to about 700cm in 2002. The trend is similar for Sarh Meteo. Rainfall from the smoothened polynomial curve declined from about 1100cm in 1960 to a low of about 900cm in 1980. After 1980, the annual total began to show a progressive rise peaking at about 1200cm in 2002. The 2002 figure was higher than that of 1960. In Mao, the pattern is completely different. Using the polynomial curve figures, the annual rainfall was about 300cm in 1960 and rose to above 400cm in 1970 and thereafter nosedives to below 200mm in 2002.

As in the case of water levels in the lake (Dami,2008) the analyses of annual rainfall trends suggest that there are variations in water supplies over the basin. While certain areas appear to be receiving more rains, some others are not. The tentative conclusion is that the basin may in total, be receiving more rainfall at least in some parts. However, more cohort investigations are required to bring out the true picture of changing environment in the basin.

Annual maximum temperature trends in Lake Chad basin 1960 to 2002 indicates that temperature is an important parameter of climate because of its effect on virtually all other parameters of climate. In the arid environment, it is particularly significant in evapo-transpiration and is as such a good measure of aridity in such environments. When the rains are increasing, a corresponding increase in temperature could still cause dryness in the environment (Dami, 2008 and IPCC, 2007).

The available temperature data are the maximum annual temperature for each of the stations. Table 2 shows the temperature figures in the three stations - N'Djamena, Mao and Sarh from 1960 to 2003. In N'Djamena the highest maximum temperature was in 1976 (37.5^{o}C) while the lowest record - 34.4^{o}C was in 1968 In Mao the highest maximum temperature 23.2oC was recorded in 1960 and the lowest (19.5^{o}C) was in 1996. In Sarh CT1161 the highest maximum temperature was recorded in 1966 (37.7^{o}C) while the lowest was in 1960 (32.5^{o}C). The annual maximum temperature distribution from 1960 to 2002 in the three locations shows that Mao station has the lowest records among the three. With respect to temporal patterns, maximum temperature values vary appreciably from year to year. However, what could be described as extremes was recorded in 1966 and 1975.

The polynomial curve fitting shows that temperatures increased gradually from 1960 to 1982, and thereafter began to decline towards 2002. The pattern in Sarh Meteo is similar to that of N'djamena. With the exception of the high figure in 1964, the year to year variation was relatively small. However, the overall trend captured with the polynomial curve indicated a slight gradual increase in temperature up to 1988 and a decline thereafter up to 2002. The pattern in Mao is slightly different. Variations from year to year appear to be fairly regular with the exception of the low of about 19.5^{o}C in 1995. The general trend from the polynomial curve is that of a slight decline from 1960 to 2002. The overall trend in temperature from these records is that higher temperature values reached a peak around the early 1980s but showed a decline from then up to 2002. This trend tends to suggest that although there were high temperatures around the period of the famous Sahelian drought of the 1970s, temperature values may have been reducing since then.

Table 1: Annual Rainfall Around Lake Chad Basin from 1960 to 2002

Year	N'DJAMENA AERO (mm)	MAO (mm)	SARH CT1161 (mm)
1960	533	189	1161
1962	490	441	918
1964	477	323	1064
1966	593	272	829
1968	561	224	1008
1970	653	217	998
1972	603	1096	906
1974	424	287	1079
1976	651	264	970
1978	666	962	891
1980	451	823	924
1982	382	87	1258
1984	226	117	699
1986	556	176	681

1988	627	225	1005
1990	329	186	729
1992	537	178	874
1994	639	195	1113
1996	472	75	1133
1998	731	119	1122
2000	746	122	1154
2002	767	132	1167

Sources: Lake Chad Basin Commission (LCBC) Ndjamena

The Map showing the Lake Chad basin region

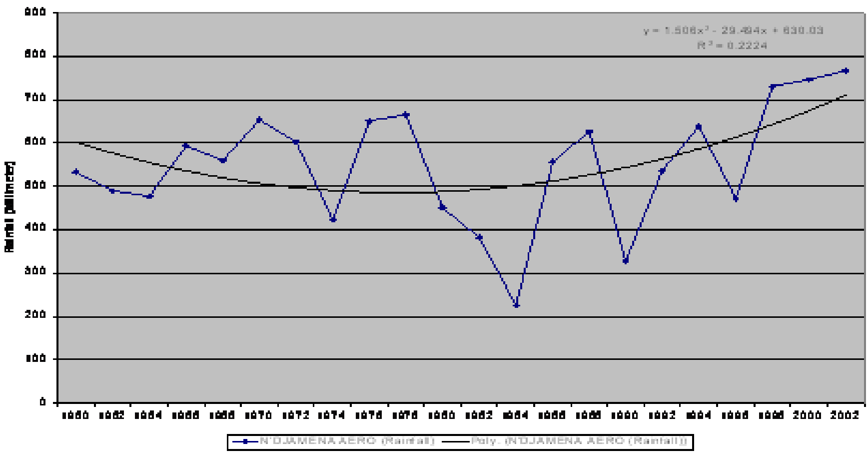

Fig. 1: Annual Rain fall Pattern in N'Djamena Aero from 1960 to 2002. **Source:** Lake Chad Basin Commission, Ndjamena

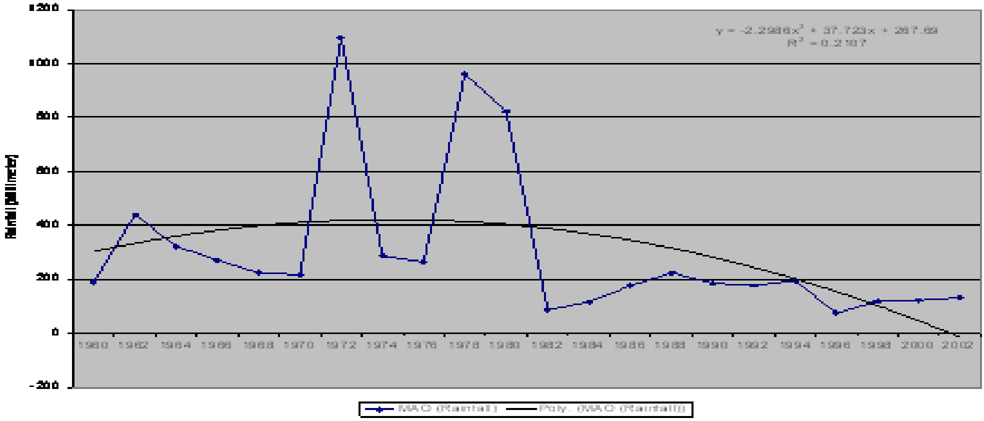

Figure 2: Annual Rainfall Pattern in Mao from 1960 to 2002. **Source:** Lake Chad Basin Commissio, Ndjamena

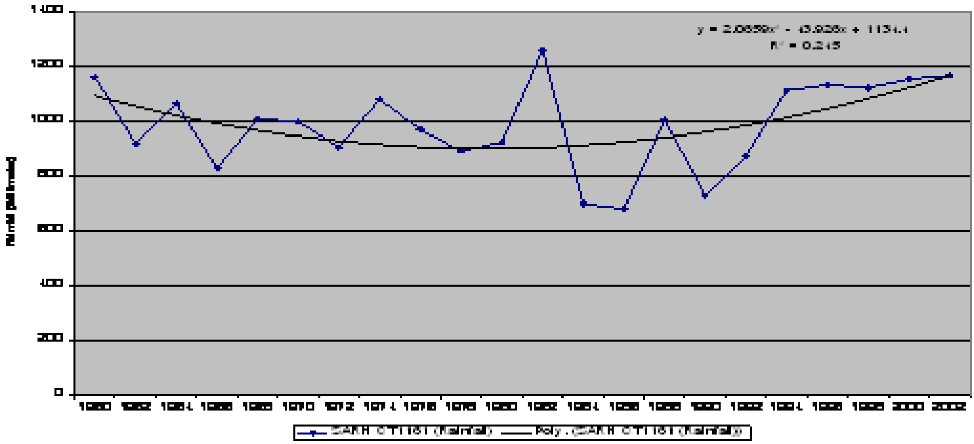

Figure 3: Annual Rainfall Pattern in Sarh Meteo from 1960 to 2002. **Source:** Lake Chad Basin Commission, Ndjamena

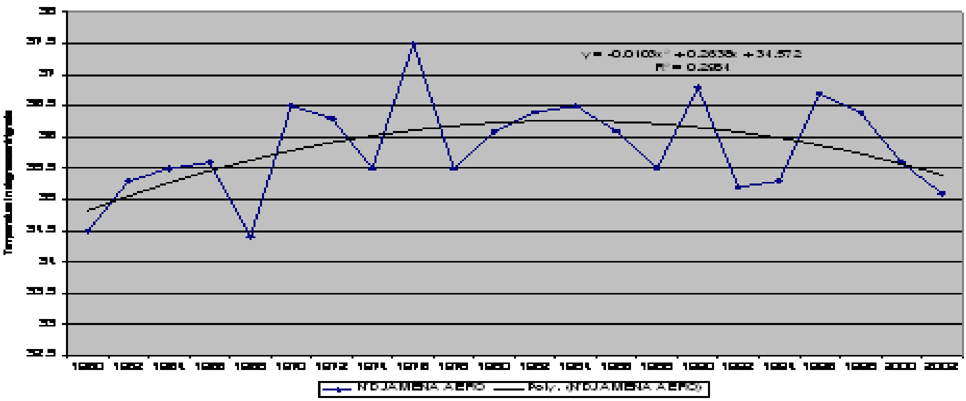

Figure 4: Annual temperature pattern in N'Djamena Aero from 1960 to 2002. **Source:** Lake Chad Basin Commission, Ndjamena

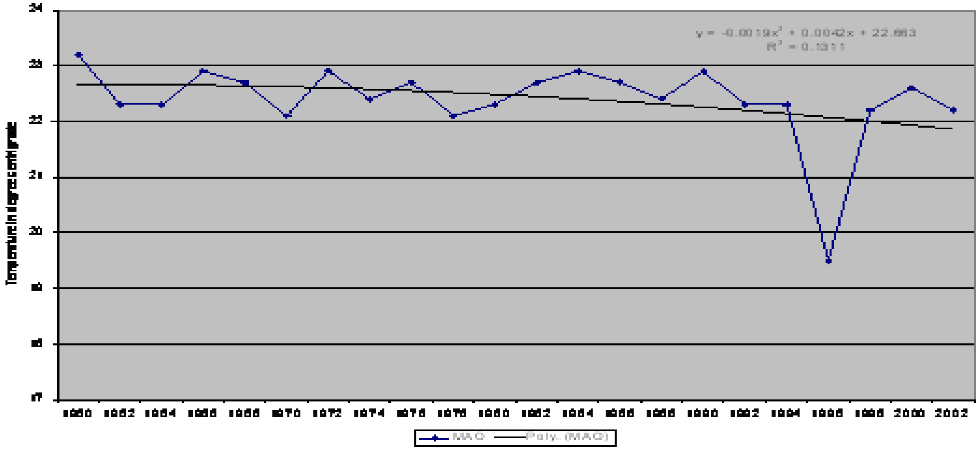

Fig. 5: Annual Temperature Pattern in Mao from 1960 to 2002. **Source:** Lake Chad Basin Commission, Ndjamena

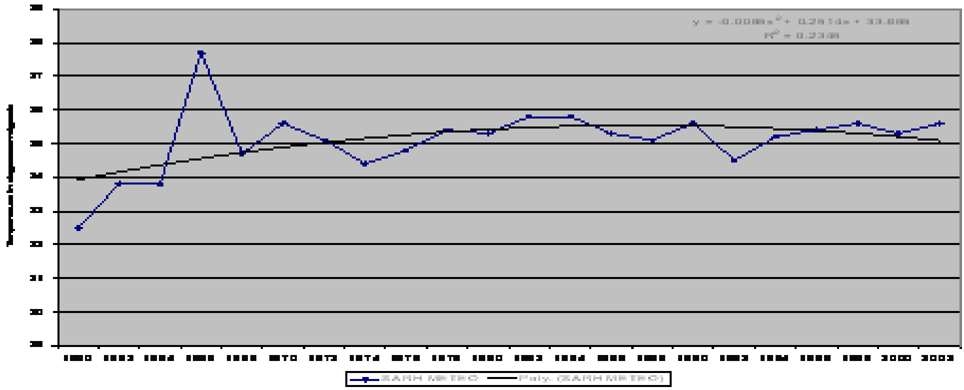

Fig. 6: Annual temperature pattern in Sarh Meteo from 1960 to 2002. **Source:** Lake Chad Basin Commission, Ndjamena

Table 2: Annual maximum temperatures around Lake Chad basin from 1960 to 2002

Year	N'DJAMENA AERO (OC)	MAO (OC)	SARH METEO (OC)
1960	34.5	23.2	32.5
1962	35.3	22.3	33.8
1964	35.5	22.3	33.8
1966	35.6	22.9	37.7
1968	34.4	22.7	34.7
1970	36.5	22.1	35.6
1972	36.3	22.9	35.1
1974	35.5	22.4	34.4
1976	37.5	22.7	34.8
1978	35.5	22.1	35.4
1980	36.1	22.3	35.3
1982	36.4	22.7	35.8

1984	36.5	22.9	35.8
1986	36.1	22.7	35.3
1988	35.5	22.4	35.1
1990	36.8	22.9	35.6
1992	35.2	22.3	34.5
1994	35.3	22.3	35.2
1996	36.7	19.5	35.4
1998	36.4	22.2	35.6
2000	35.6	22.6	35.3
2002	35.1	22.2	35.6

Source: Lake Chad Basin Commission (LCBC) Ndjamena

CONCLUSION

The Lake Chad region will remain a vital region in Africa since many people had their roots there and the restoration of the drying Lake Chad therefore remains a serious concern to many: farmers, fishermen, politicians etc. This study has assessed the trend as well as the possibility that the drought and desertification being experienced in the region may all together be partly a cyclic event that could be passing away given the tendencies towards wetter conditions in the region. What is not known is how fast the natural change will happen to effect a full restoration of socio-economic life in the basin. From this study, it can be concluded that trends in rainfall and temperature of the lake have varied from one point of the basin to another. While some locations appear to be getting wetter, others are getting drier. Thus, although more data are needed to draw a firm conclusion on the trends in the environment of the basin, it is possible that the aridity that had been experienced in the past have not come to stay. Consequently, all the efforts that have been in place geared towards the restoration of the basin must be intensified. Also, a proactive allocation of water among the various communities in the basin must be pursued to ensure that everyone has access to water optimally.

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