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Climate Variability and River Benue Discharge in Jimeta, Yola Area, Nigeria

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Abstract

It is glaring that climate change is true and has become a monster that every effort must be targeted towards its elimination. Every sector of the economic has been affected by climate change. The impact has been intensified of recent, with the increase in world's population and her quest for survival. In northern Nigeria, its effect among others range from increase in dry spells, heat stress, drop in water tables and consequent shortage of water. To overcome the problems, many have resulted in planting on the river bed, diging of river bed and sinking of bore hole on the bed not only for agricultural purposes but for domestic need. Using climatic (rainfall and temperature) and hydrological data (river discharge) for the period of 49 years, an attempt was made to examine the response of river Benue discharge to climate change. The result shows great fluctuations of the elements about the mean. Both runoff and rainfall total has decreased but the rate of decrease of rainfall is about 14 times that of runoff. Monthly analysis of runoff in some years of the study revealed increase in runoff above the mean but this additional runoff do not add to water availability for use because they occur during the wet season and there are no specific storage to hold the water through to the dry season. For every 0.01mm increase in rainfall there is 1 Million m^3 increase in discharge and vice versa. The discharge between 1980 and 1999 decreased noticeably, because the discharge was well below actual mean of 20.419 Million m^3. The simple correlation analysis revealed that, 24% and 31% association strength to the variation was accounted for by rainfall and temperature respectively. There was an inverse relation between the temperature and runoff as expected from 1980-1990, when pronounced increase in temperature above the mean coincided with the sharpest drop in runoff. The paper recommended that effort should be geared towards programs that will bring to the consciousness of the community as regard the changing climate pattern so as to prepare for the challenges and the right adaptation techniques to the impacts of climate change on water resources.

Key words: Climatic variability; water availability, river discharge, rainfall, temperature, River Benue

Introduction

In recent years, rainfall and temperature change in output have being major breaking news in many parts of the world. The influence is seen in many sectors of life. Water resources are scarce in many regions while some loom in floods. Analysis of the causative agents have shown that several gases such as carbon dioxide, chloroflorocarbon, methane, and Nitrous oxide are trapped on the earth surfaces, strong correlation exist between increase in temperature and the concentration of the listed green house gases. Botkin and keller (1997) noted that over the last 100 years, average global temperature had increased by 0.5 ºC to 0.7 ºC. And scientists have predicted further warming of 1.4 to 5.8 ºC by the year 2100. The prediction has generated considerable debate regarding the possible effect on future climate. Of recent, the debate extended beyond the influence on future climate change but the impact of such changes on the society. The effect on the environ and the people of Yola, which is located within the tropics on latitude 9º 14^1 and longitude 12 º 38^1 are significant (Annex 1). The location of the town within the tropics makes the area receives high incidence of solar radiation for a greater part of the year as a result of dual passage of the sun over the town (Adebayo, 1999). Moreover, preliminary study in jimeta: assessment of

environmental radioactivity levels shows that high temperature experienced in the area is associated with the dual passage of the zenithal sun (Osita et al, 2006). The increase in temperature, apart from the discomfort in human physiological functions and the attended outbreak of several illnesses in man (Adebayo, 2000), can reduce crop yields and change plant growth pattern (Bello, 1987). With the predicted increment of 1.4 to 5.8 ºC by the year 2100, increase in temperature will have serious implication on water resources and could potentially threaten future supplies of food and water; the basic necessities of life.

Several studies have stressed the necessity of management of water resources in Nigeria (Kowal and Adeoye, 1972; Orkuma, 1997; Deve, 2000; Ojo et al.2003). However, much is still required for water availability studies of river basins at local level in arid and semi arid region especially as aridity is spreading its tentacles southward. Knowledge of climate change impacts will improve the management of River Basin Development Authorities in Nigeria, the institutions enacted for water development and distribution to urban and rural areas.

This paper is a part of the study that assessed climatic variability and water availability in Yola area. Focusing on climatic (rainfall and temperature) change observed in Yola and hydrological response of the river basin.

Materials and Method

With the intention to trace the long term fluctuations in climatic parameters over the years and to establish the relationship with discharge (water availability) as climate changes, monthly rainfall, temperature and discharge data covering a period of 49 years (1960- 2008) were collected and analyzed. The data were obtained from the archive of Upper Benue River Basin Development Authority. Other climatic data like evaporation, sunshine and humidity are incomplete for any reliable prediction.The world meteorological standard stipulated a minimum of 35 years. The Meteorological station is located at Yola town while the gauging station is located at Bajabure Bridge.

The rainfall and temperature data collected in upper Benue were first augmented for missing data. The few missing records in the upper Benue station were checked up and interpolated from the data collected from Yola Airport Meteorological Station. Both the climatic and the hydrological records were then normalized for any meaningful comparism. The following formula was used:

$$X_n = (\mathbf{X} - \bar{\mathbf{X}})/\sigma \quad (1)$$

where

X_n = Normalized values

X = Monthly value

X = Mean Monthly value for a period N

σ = Standard deviation

The temperature and rainfall data were correlated with the river discharge (annual runoff) using correlation analysis to show the degree of relationship. The runoff was further regressed with the climatic elements of rainfall and temperature using the linear regression

analytical technique. The regression analysis raveled the data sequence for projection and prediction of future event in the basin.

Results and Discussion

Climatic variability and river Benue discharge in Jimeta Yola was assessed using regression and correlation analysis to spot the trend. The analysis of the rainfall revealed annual mean of 912.8 mm with standard deviation from the mean of 146mm (Table 1). Rainfall distributions through out the years have been with regular fluctuation. The result revealed maximum of 1356mm in 1963 with a progressive drop to minimum rainfall total of 657mm in 2002 with the coefficient of variation of 15.9% (Table 1). The variation depicts downward trend with the early years of study except the early seventies, wetter. There is a comparative but progressive variation in temperature from year to year with incremental change of 0.0069 (Figure 1). Coefficient of temperature is low (0.003%) with maximum of 29.7°C (Table 1). The 49 years of discharge measurements, like that of rainfall, depicts a cyclical trend. The maximal occurred in 1969 with a discharge of 35.280 Million m^3. The minimum was 8.150 Million m^3, a decrease of about 71%, which occurred 20 years after the maximum (Table 1).

The catchments display large spread of rainfall not only annual deviation but also monthly variation. In Figure 4, the early years of study, 1960 to1967, depicts positive deviation from the mean. More rainfall is experienced at the early years than the later years from 2000 to 2008. Similarly, trend line of positive deviation from the mean was observed from 1960 to 1984, with the exception of 1968, 1973, 1978, and 1980 in runoff (Figure 5). From 1980 till 2008, a pronounced progressive drop in discharge occurred relative to early years of study. It should be noted that even though there is pronounced fluctuations in volume, the broad pattern of change in runoff are reasonably consistent. The timing of river flows in the region however needs further investigation.

In terms of correlation coefficient, about 0.24 indicates that it is not only the rainfall of the station that is decisive for the change observed in discharge. The influence of temperature increase is greater. For every 3°C increase in temperature,a 1 Million m^3 decrease in discharge is expected and vice versa (Table 2). There is a comparative but progressive increase in temperature from year to year with incremental change of 0.0069. 1988 witnessed the sharpest increase with 1.4°C above the mean. The pronounced increase, interestingly, concide with the sharpest drop in runoff during the period under study. The study further revealed that 24% and 31% association strength to the variation of runoff is contributed by rainfall and temperature respectively. The two variables considered controlled more than 50 percent vote to water variability in the State.

Other decisive elements could be evapo-transpiration, sunshine, relative humidity, wind speed and as a result of the dam upstream of the study area. The present Lagdo dam is infringing serious stress on the river hydrology in Yola.. The dam which became operational in 1983, created a large artificial lake, which according to Bernard et al., (1994) will reduce the variation in the flow rate. In fact, George, (2007) in Adamawa State noted a sharp decrease in flow from 1984 the beginning of its operational years.

Table 1: Summary of the climatic and hydrological parameters in Yola, Nigeria (1960- 2008)

Index	Rainfall (mm)	Temperature ºC	Discharge(m^3)
Mean	912.8	28.3	20.419
S. Deviation	146.0	0.685	6.228
Coefficient (%)	15.9	0.003	30.5
Minimum	657.0	26.4	8.150
Maximum	1356.0	29.7	35.280

Source: UBRBDA, Yola

Table 2: Regression of temperature and rainfall with discharge in Yola, Nigeria

Variables(X)	Correlation Coefficient®	Regression Equation
Rainfall and discharge	0.243	Y= 11.0+ 0.0104X
Temperature and discharge	-0.309	Y= 99.9- 2.81X

Table 3: Correlation of temperature and rainfall with discharge in Yola, Nigeria

Relationship between variables	Df	Correlation Coefficient (r)	Remark
Rainfall and Discharge	47	0.243*	* Significant at 10%
Temperature and Discharge	47	- 0.309**	** Significant at 5%

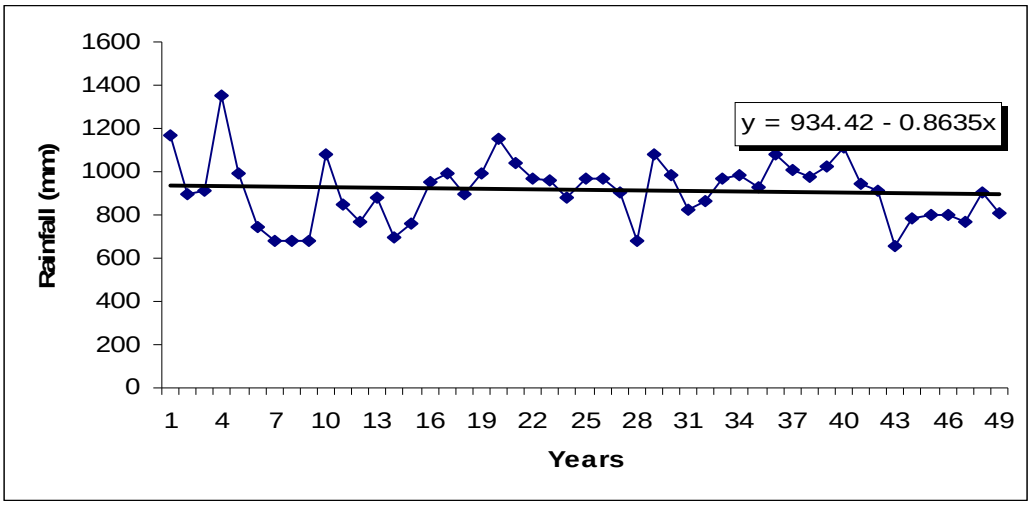

Figure 1: Trend analysis of rainfall in Yola, Nigeria (1960 – 2008)

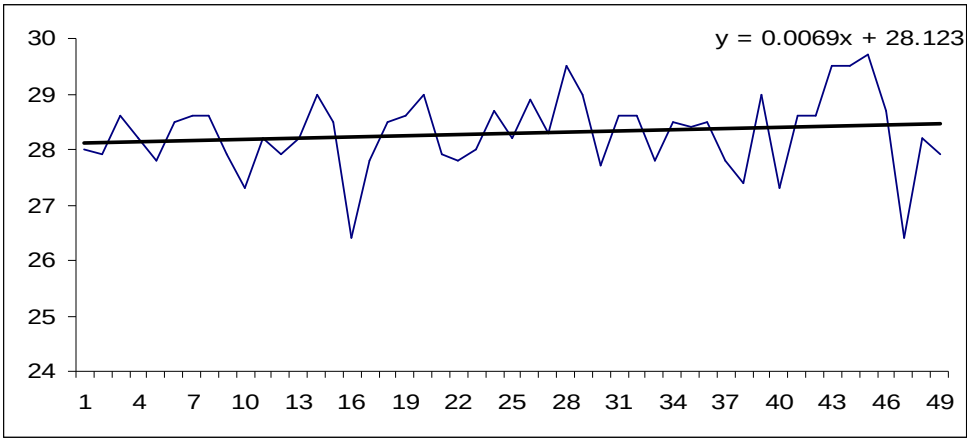

Figure 2: Trend analysis of temperature in Yola, Nigeria (1960 – 2008)

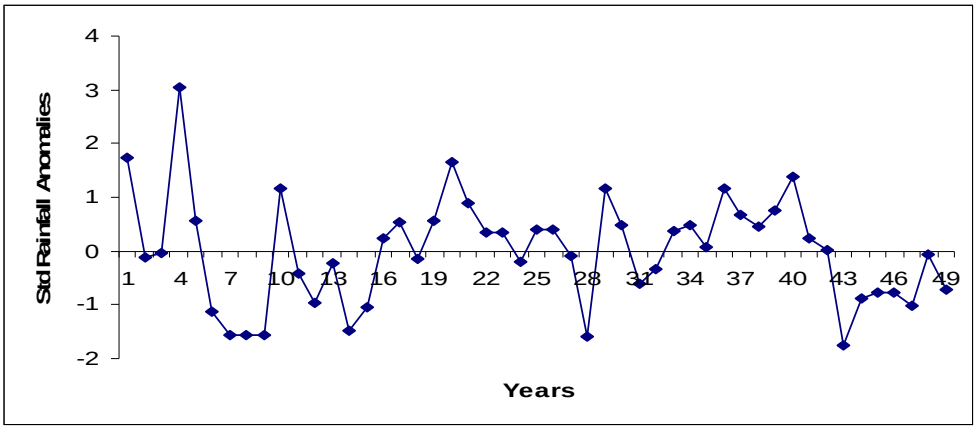

Figure 4: Rainfall anomaly at Bajabure River gauging Station (1960- 2008)

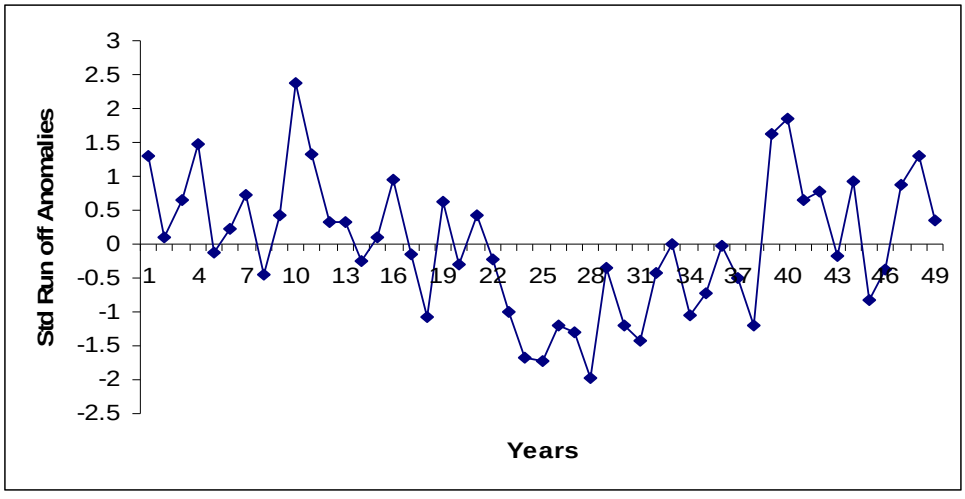

Figure 5: Runoff anomaly at Bajabure River gauging Station (1960- 2008)

Conclusion

It is evident that water depletion from both the surface and underground is in a continuous increase as a result of continuous increase in global population and human socio- economic activities. The case is exacerbated as a result of climate change. It is also obvious that the characteristic of rainfall over an area exert a lot of influence on the water availability in the area. In fact, climate determines not only the total volume of runoff from a catchment but also the temporary behaviour of such runoff.

Though, it is not a simple matter to figure out how regional changes in precipitation, as a result of global climate change, affect water availability (Jim, 2009) but trend analysis, as attempted in this study showed marked fall in annual total of rainfall (10 % compared to present). Even though there is little seasonal contrast in temperature, the trend tends to increase with corresponding decrease in runoff. Both temporal and long term fluctuation in climatic parameters with strong relationship with the river discharge has been noted. The reduced flow co varies with temperature. Relatively small changes in temperature seem to cause relatively large changes in runoff. These finding corroborated the assertion by UCLA, (2011) that as the climate warms the atmosphere, earth hydrology will shift with potential to make flood in some region and drought more extreme in another. NSF, (2002) also submitted that reduced flows are associated with climate change and could potentially threaten future supply of food and water. It is unfortunate that people of Adamawa State, fall into the category of the 1.5 billion people, out of a total world population of around 6 billion who live in watershed where average River runoff is less than 1000 m^3/ Capital/year. The projected values of this variation reveal an alarming result. Falkenmark (1995) has stated that frustration over scarcity of water and over dependent of water supply upon upstream countries may develop into dispute and contributing factor to armed conflict. As the weather becomes intense and reduce the flow substantially, upstream users may come up with policy that will affect downstream users. Such policy has the potential to increase existing tension or create new ones - serving as a threat multiplier. It can be a catalyst for violent conflict and threat to international security. Consequently, the proposed dam on the river Benue by the Federal Government sometime ago is a welcome idea but thorough investigation must be done as to where the dam should be sited. The merit and demerit of the project should also be reviewed so as not to add to the present stress.

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Annex 1

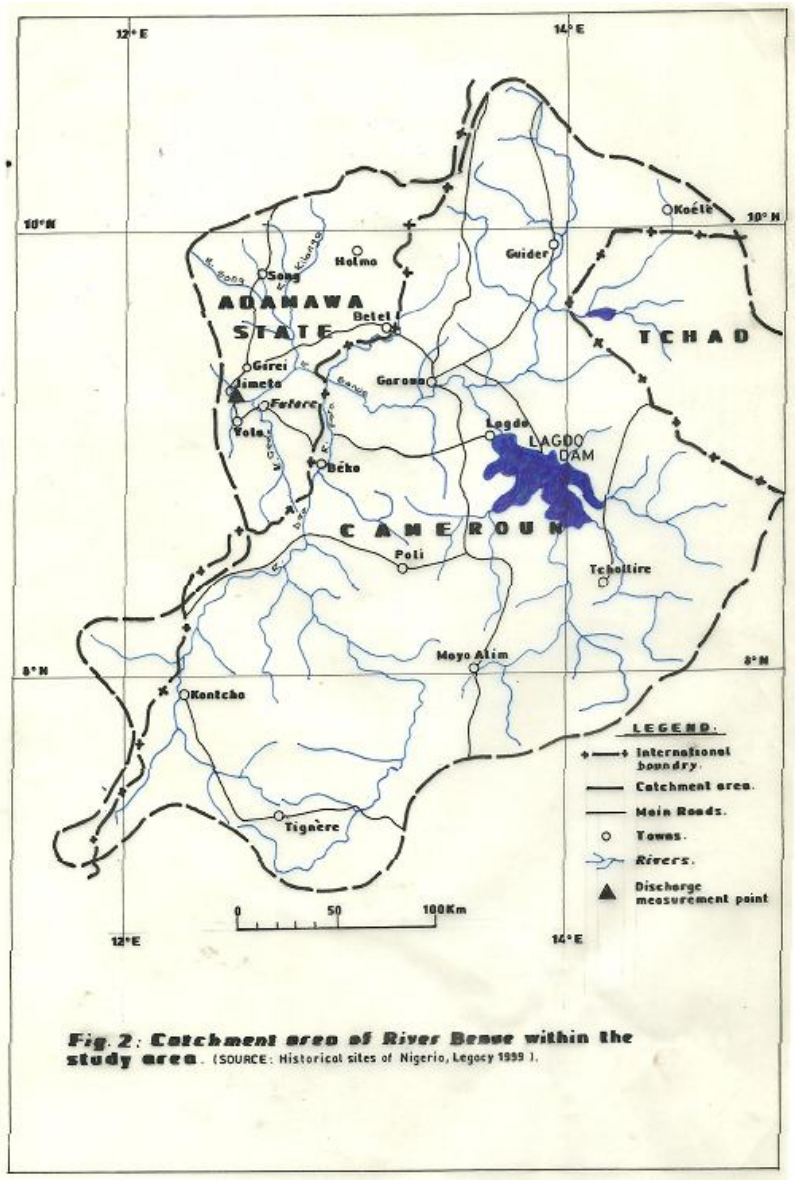

***Fig. 2*: Catchment area of River Benue within the study area**. (SOURCE: Historical sites of Nigeria, Legacy 1999).