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## Climate and water resources management

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## Climate and water resources management

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17 OF THE 52 major international rivers of the world are in sub Saharan Africa. Most of the rivers and some lakes such as Lake Chad (located in the study area of Nigeria) are already under severe stress, which is projected to continue in the foreseeable future (Obasi, 2000). This would make management of water resources even more difficult. Climate change and variability are natural and induced stress that are generally not usually taken into account (Ojo, 1988). The evaluations of the IPCC also point to temperature increases, precipitation change, increased variability, and sea level rise (IPCC, 1996). All these factors impact directly on the availability of water resources.

In this paper therefore,

- Rainfall for four selected stations (Sokoto, Kano, Katsina and Maiduguri) and water flow for two stations in Hadeija river basins in the NE hydrological area (all in the Sahelian region of Nigeria) are used to study the variability of rainfall in relation to water resources management in that region and
- Level of water flow in Kainji Dam (The biggest reservoir located in the central part of Nigeria) are considered in relation to hydroelectricity generation in Nigeria.

### Results showed that:

- The effective water resources (available water) index for Kainji area indicated negative values for eleven months and a positive value in August for the period 1961- 1998.
- Rainfall at Kano, Katsina, Sokoto and Maiduguri and runoff (at Tiga Dam and Ciroma gauging stations) had been on the decrease since 1961 to Date.

The above factors have been generally responsible for the erratic power failure in the country for the past 5 years. The paper further enumerates other impacts of Climate change on water resources, and finally advocates for other sources of power generation as reliability on Dam construction for energy and water needs has failed this country.

### Introduction

There is overwhelming evidence of climatic change over the past decades in many parts of the world. The reduced rainfall over the country in the areas north of latitude 11°N, especially in the 1970's and 1980's coupled with the high evaporation rates have tasked the ingenuity of water resources Managers in these areas. To ensure that adequate

water is available for human, industrial and agricultural purposes they have embarked on the building of dams. Almost all fields of water resources management need meteorological data. Dams were constructed for such purposes as domestic and industrial water supply, irrigation, hydropower generation, navigation, flood control and fisheries. Kainji dam was constructed for those purposes of which hydropower generation had a higher priority to augment electricity generation (installed capacity is now 760MW). In recent years, due to the paucity of water inflow, it has been difficult to attain the maximum operating head (465 feet) needed for optimum energy generation. This is attributed mainly to climate variation and change. The geographical location of the dam is 09° 55' N 04° 35' E. It is within the NW Hydrological Area 1 (NWA) to the Northwest of Nigeria. River Niger is the main river that drains the area.

In this paper therefore, Some energy and environmental problems, such as low flows and rainfall variability emanating from the effect of climate variation are discussed. This paper also seeks to suggest some likely short term and long term measures to sustainable development.

### Data/Methodology

Monthly rainfall for Kano, Katsina, Maiduguri, Sokoto, Gusau and Yelwa, and evaporation data from 1961 to 1995 were obtained from the Department of Met. Services. While runoff data for Tiga Dam and Chiroma stations on the Kano River from 1964 to 1985 and Kainji reservoir (1961-1990) were obtained from the Department of water Resources.

Areal rainfall and evaporation analyses were carried out using simple arithmetic mean. A similar method was used for runoff. For the rainfall reliability, the coefficient of variation method was employed. The rainfall and runoff records were normalized for any meaningful comparison to be made. The formulae used are:

$$X_n = (X - \bar{X})\delta$$

where

$X_n$  = Normalized rainfall

$X$  = Monthly rainfall

$\bar{X}$  = Mean monthly rainfall for a period  $N$

$\delta$  = Standard deviation

For the rainfall reliability, the coefficient of variation method was implored.

**Table 1. Monthly values of effective water resources (mm) index for North West Hydrological Area 1 (NWA) for the period 1961 - 1990**

Jan.	Feb.	Mar	Apr	May	Jun	Jul	Aug	Sep.	Oct.	Nov.	Dec	Annual
-347.4	-364.8	-425	-400.3	-318.6	-206.	-83.1	8.4	-83.9	-242.7	-306	-319.3	-3108.9

$$CV = (\delta / \bar{R}) 100$$

where

CV = coefficient of variation ( % )

$\delta$  = standard deviation

R = arithmetic mean of rainfall (mm)

Using the hydrologic or water balance equation expressed as:

$$R = RF + ET \pm \Delta S \pm \Delta G$$

where R = rainfall

RF = runoff or discharge

ET = evaporation

$\Delta S$  = change in soil moisture storage

$\Delta G$  = change in groundwater storage

The effective water resources index or available water index (R – ET) for HA 1 can be determined.

### Results and Discussion

The normalized areal rainfall for Sokoto, Kano, Katsina and Maiduguri (fig.2) generally have rainfall surplus in the 1920s and early 1960s and rainfall deficit from late 1960s to date. The Annual runoff for Tiga dam and Ciroma in the NE hydrological area (fig.3) showed general decline in values. Figure 1 depicts high coefficient of rainfall variation values to Northwest, Northeast and Southwest with the highest value of 33% for Sokoto while low values are to the Delta region (14%) and upper Benue (Northeast Central). The effective water resources index of the area (available water index) gives a positive value for only August (8.4mm) while the rest of the months indicate negative values (Table

1). The index for the annual mean is - 3109mm. This implies that the available water for NWA is decreasing rapidly and it is however the main reason for the low flow in the reservoir.

For Kainji, the time lag between rainfall peak and runoff peak is one month (September RF = 2206.8m<sup>3</sup>/s) Runoff decreased from January to a minimum value in June ( 194.5m<sup>3</sup>/s, Fig 5), less than four weeks after the onset of the rains, thereafter it increased to a peak in September. The mean annual runoff for the period under consideration is 1140.5m<sup>3</sup>/s. Hydroelectricity power generated in Kainji dam compared to the total from other sources is given below in percentage at ten years interval. There is an indication that the level of generation is decreasing fast. Figure 4 also shows the rainfall Vs evaporation pattern over Niger North hydrological area (NW). Apart from August, the evaporation was generally higher than the rainfall.

### Conclusion

The runoff is affected by the amount of water available from rainfall. For effective water resources management the amount of water available is a very important factor. The kainji dam hydro power scheme was the best viable and economical alternative means of electricity generation since it is not restrictive in purpose but climate variation has a negative impact on it. It had actually encouraged and enhanced economic development in all sectors of the economy in the nation. With the downward trend of annual rainfall, low reliability, remarkable temporal variations of monthly rainfall and evaporation within the hydrological area (NW), there is need to harvest and store

**Table 2.**

Year	Installed Capacity (MW)	% Hydroelectricity Generated at Kainji Dam
1970	320	49.4
1980	760	27.9
1990	960	9.0

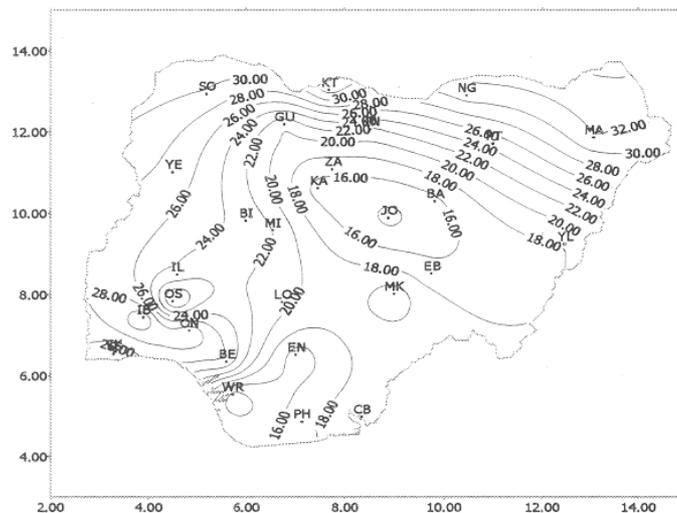


Figure 1. Map of coefficient variation

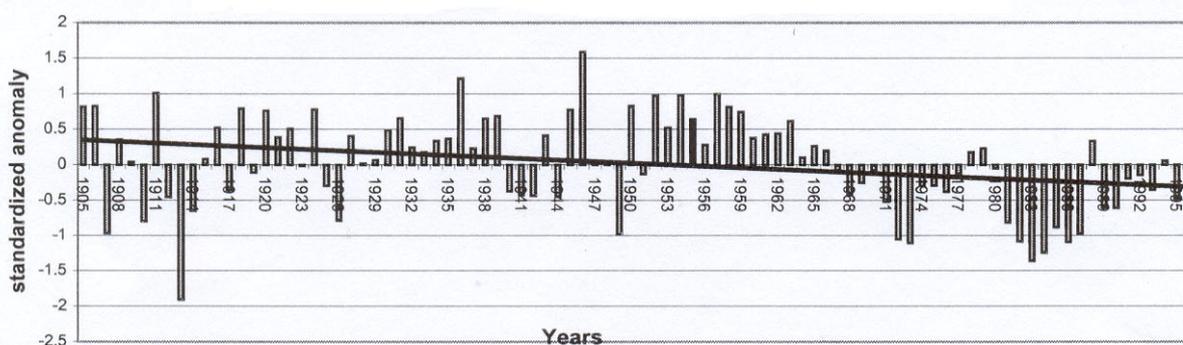


Figure 2. SAHEL normalized mean annual rainfall, averaged for 4 stations

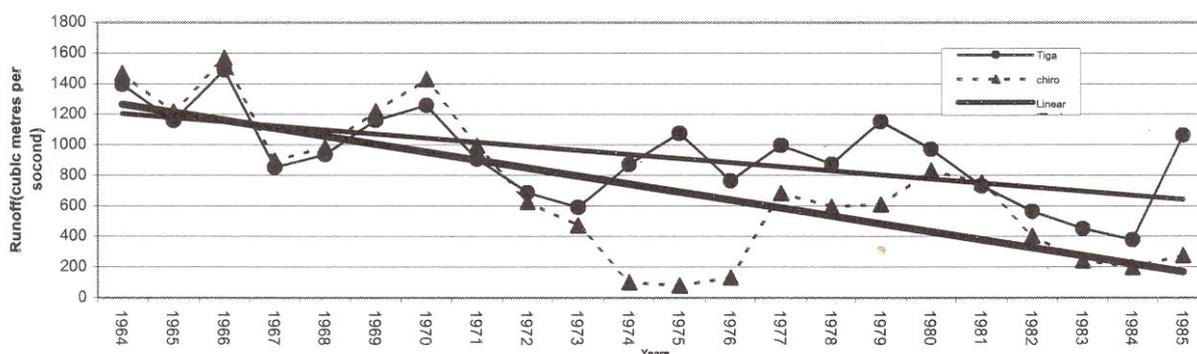


Figure 3. Annual runoff for Tigad and Cirroma gauging stations (in NE hydrological area)

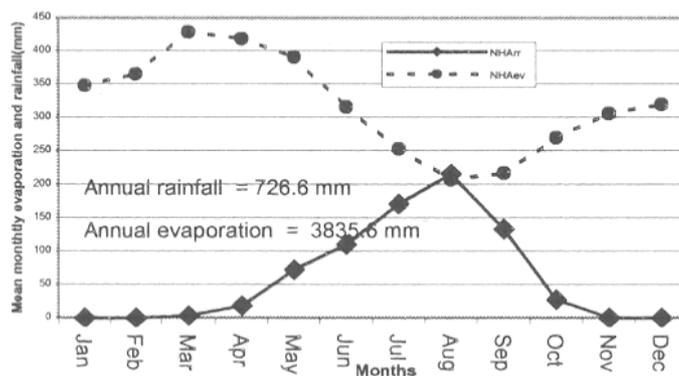


Figure 4. Seasonal evaporation and rainfall patterns for Niger North Hydrological Area (NW) (1961-1990)

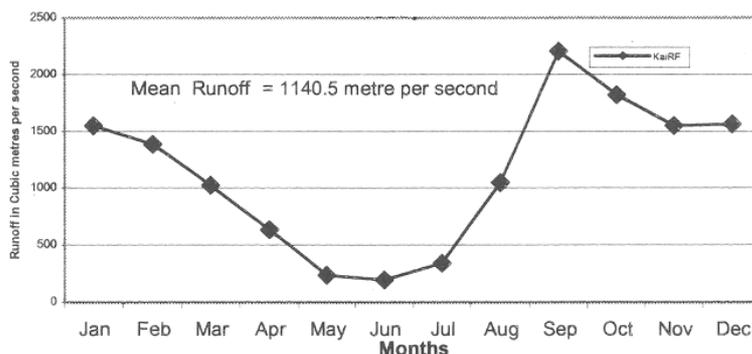


Figure 5. Mean monthly runoff for Kainji Reservoir (1961 - 1990)

flood/rain water during periods of excess, for use during periods of scarcity, in order to increase the reliability of water supply for hydroelectricity power generation. New sources of energy generation like gas and wind power are hereby advocated to compliment the existing hydropower generation system in Nigeria.

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