

RAINFALL RESPONSE TO DAM/IRRIGATION PROJECTS IN NORTHERN NIGERIA

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ABSTRACT

In this paper, we examine the possibility that the increasing number and size of dam/irrigation projects in northern Nigeria are having a corresponding increase in rainfall in spite of the threat of climate change. We modeled the rainfall trends over 11 meteorological stations over a period of 34 years (1971 - 2004). The trends were compared with each other based on the closeness of the meteorological stations with dam/irrigation projects. Results obtained showed a compelling evidence of a direct relationship between rainfall and dam/irrigation projects. The results indicated that the average rate of change in rainfall trends for the 11 stations ranged from – 4.08 to 24.83mm per annum. Kano area had 24.83mm while Jos area had - 4.08. Results obtained in this study thus provide evidence as to the extent that rainfall has responded to dam/irrigation projects.

KEYWORDS: Dam/Irrigation projects; climate change; trend modeling; and rainfall trends.

1. INTRODUCTION

Temperature which is presently increasing globally is not only an element of climate and weather but also a factor of climate. As a factor, any change in it is nearly always reflected in changes in the other climatic elements. For instance, an increase in temperature can result in dryness in some areas, and for others it could result in increased rainfall. As temperature increases, evapo-transpiration also increases. In other words, the molecules of water that leave from plants and other wet surfaces such as dams, lakes, rivers, seas, oceans, etc., to the atmosphere increase with increasing temperature. With this, more molecules of water are added to the atmosphere and such will encourage condensation and subsequently and/or possibly precipitation.

The present increasing temperature of the globe commonly known as global warming has caused a change in the world's climate (Obasi, 1992; Barry and Chorley, 1992; Kaser, 1999; IPCC, 1996, 2001; Desanker and Justice, 2001;

and Goudie, 2002). Basically, components of the climatic system, as with other systems, respond to perturbations either from within or from without the system. (Meyer 1996; Danielson *et al.*, 1998; and Pidwirny, 2004). This implies that the other elements of climate should be changing in response to increasing temperature. Precipitation (rainfall in this case) is one of such elements being affected. For example, Nicholson, (2001) has noted a long-term reduction in the rainfall of semi-arid regions of West Africa, and increased aridity in most of the Africa region particularly since the 1980's. Similarly, Obioha (2005) reported that the sahelian zone of north-eastern Nigeria has been experiencing a change in its climate characterized by reduction in rainfall, increase in the rate of dryness and heat. Meanwhile, rainfall has increased over the last 50years over the north-western Australia (Australian Greenhouse Office, 2003). Looking at these two conditions, it could be speculated that the likely reason for the increased dryness in the Sahel regions of West Africa with increasing temperature is the influence of the

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Sahara Desert which borders the area in the north. The Sahara desert is generally a dry area with little or no evaporation occurring over it to encourage rainfall. Conversely, the increase in rainfall over north-western Australia probably due to global warming could be attributed to the Indian Ocean and the moisture bearing wind from it that blows into the country through that part.

Dam/irrigation projects provide wet surfaces from which evapo-transpiration occurs. The number and sizes of such projects are increasing in Northern Nigeria (the study area) with increasing demand for food and water as the population increases. There is therefore the likelihood that these projects will have some impact on the project areas' rainfall. This paper therefore examines the extent that rainfall has responded to the dam/irrigation projects in Northern Nigeria.

Northern Nigeria is situated between latitudes 7 and 14°N and longitudes 3° and 15°E (Fig.1). It has common borders with arid areas namely Niger Republic in the north and north-west, northern part of Benin Republic in the west, northern Cameroon in the east, with the exception of the south where it shares boundaries with southern Nigeria which is wetter. Northern Nigeria covers about 75 percent of the area of Nigeria. It has an area of about 692, 826 square kilometres and more than 400,000 square kilometres of it are arable land (Nnaji, 2001).

The productivity of this arable land has been enhanced through the development of numerous dam/irrigation projects thus making it an important producer of much of Nigeria's food needs. The closeness of the northern fringes of the study area to the Sahara Desert and its south being bordered by the wetter

2. STUDY AREA

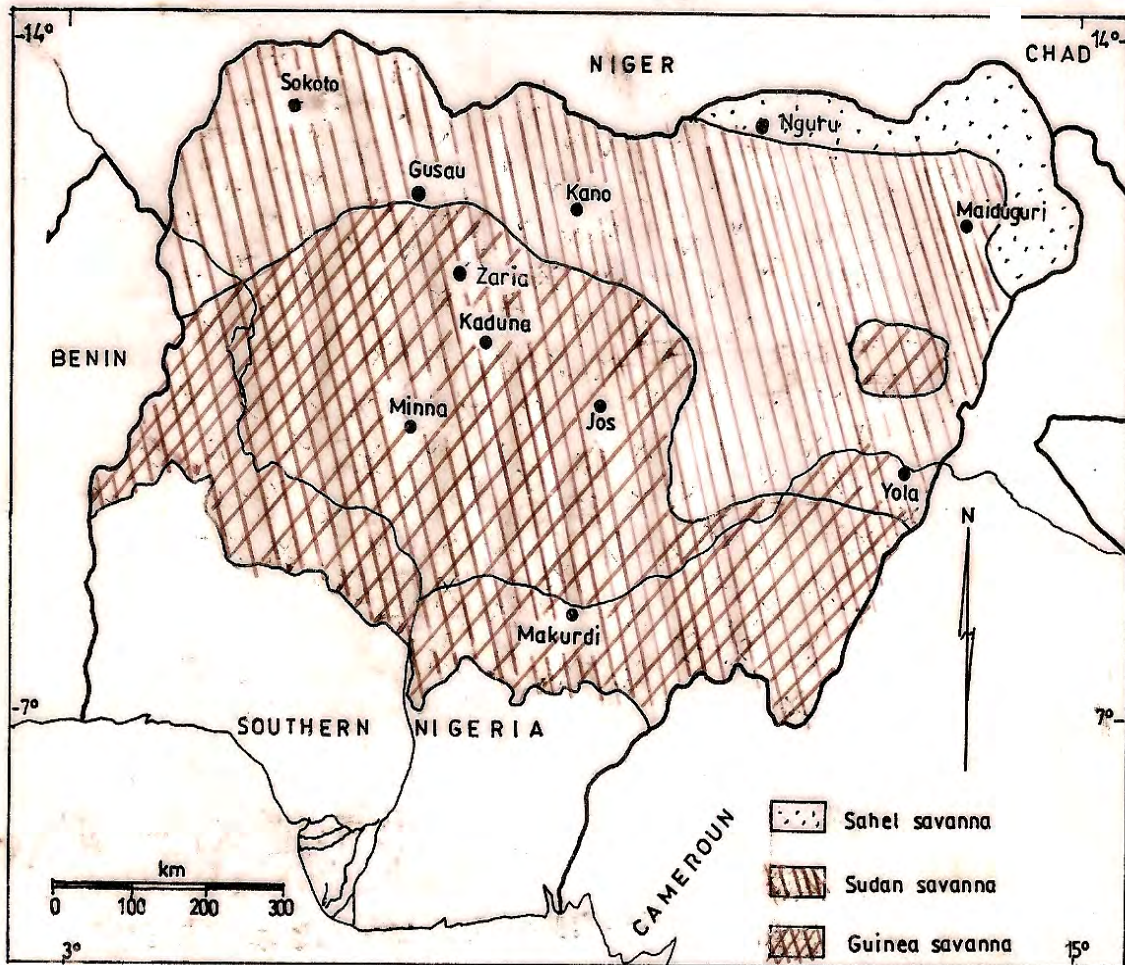


Fig.1: Northern Nigeria: Vegetation zones and selected meteorological stations

southern Nigeria makes rainfall to vary significantly over the year. This is due to the interaction between the Tropical Maritime Air mass (mT) and Tropical Continental Air mass (cT) whose extent of influence depends on the position of the Inter-Tropical Discontinuity (ITD). The north and back movements of the ITD over Northern Nigeria determine the Air mass whose characteristics prevail over the region. As a result, when the mT dominates, it brings rain due to its source region, the Atlantic

Ocean. while dry season with harmattan comes in. Irrigation projects keep crops alive.

Fig.1: Study Area (Northern Nigeria): Vegetation Zones and Selected Meteorological Stations

rain, and Katsina in the extreme north with a rainy season of between 3 and 4 months, and 80 days of rain (Nnaji, 2001 and Nwagbara, 2008). Equally, the average annual rainfall has a mean of more than 1200mm in the south and less than 300mm in the far north with exception in high altitude areas (Nnaji, 2001 and Nwagbara, 2008). This rainfall pattern is the product of the interaction between the Tropical Maritime Air mass (mT) and Tropical Continental Air mass (cT) whose extent of influence depends on the position of the Inter-Tropical Discontinuity (ITD). The forth and back movements of the ITD over Northern Nigeria determine the Air mass whose characteristics prevail over the region. As a result, when the mT dominates, it brings rain due to its source region, the Atlantic

3. MATERIALS AND METHODS

Data Used

Monthly rainfall data covering 34 years (i.e. 1971 to 2004) for 11 meteorological stations in the study area (Fig.2) were collected for this study. There were no missing data as data for the 4488 months in the 34 years for the 11 stations were available. The data were sourced from the Nigeria Meteorological Agency, Oshodi, Lagos. The 11 meteorological stations namely, Gusau, Jos, Kaduna, Kano, Maiduguri, Makurdi, Minna, Nguru, Sokoto, Yola and Zaria were selected based on their spatial distribution in the

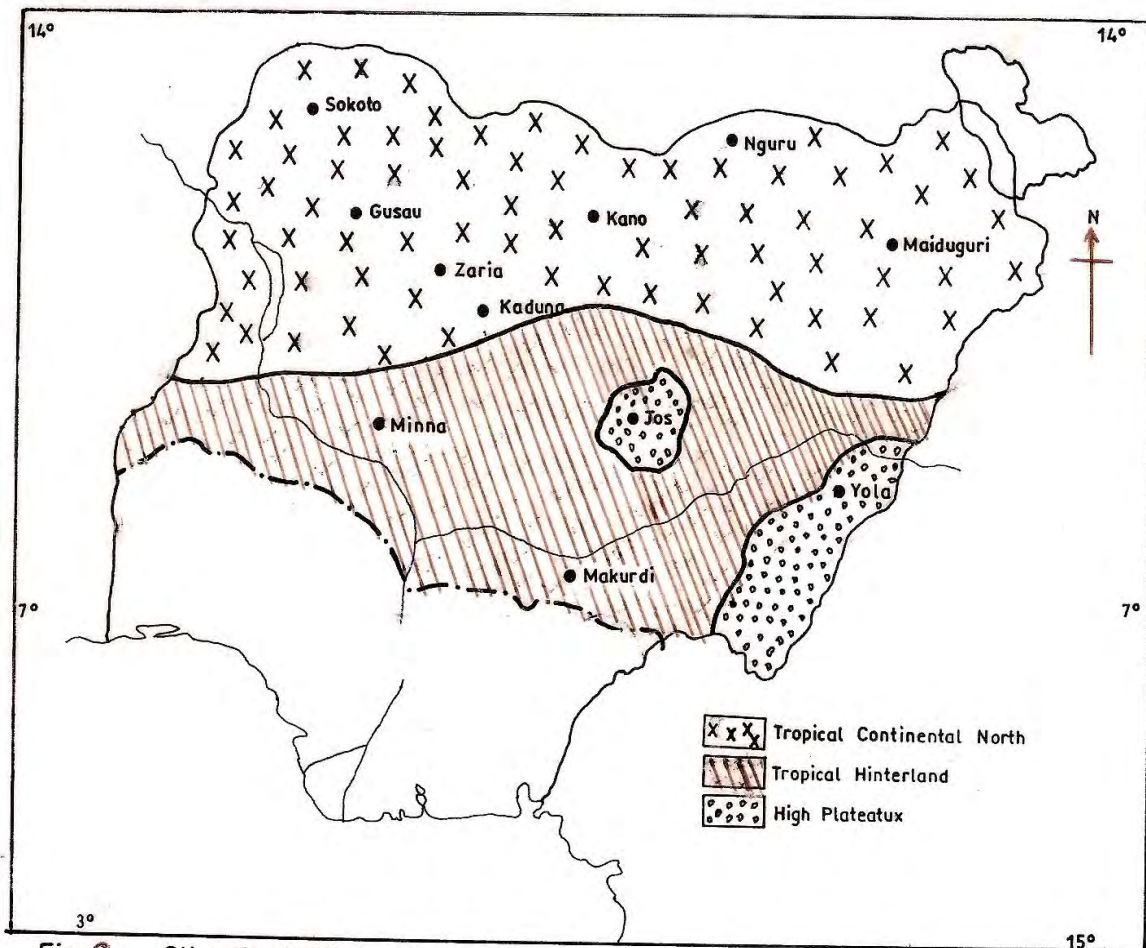


Fig. 2 : Climatic Regions of Northern Nigeria

three major climatic regions of the study area: Tropical Hinterland, Tropical Continental North and High Plateau, and completeness of data required.

3.2 Technique of Data Analysis

The linear regression statistical technique was used to model the trends in rainfall data over the period of 34 years in the stations and study area as a whole. In applying this statistic to the data, the equation of the least squares line was first of all determined and then plotted. This technique can be expressed in the form:

$$Y = a + bx \quad (1)$$

$$\text{where } b = \frac{n \sum xy - (\sum x)(\sum y)}{n \sum x^2 - (\sum x)^2} \quad (2)$$

$$a = \frac{\sum y}{n} - b \frac{\sum x}{n} = y - bx \quad (3)$$

a is the intercept; b the regression coefficient (slope); y the rainfall value; x the time in years; \bar{x} the mean time; and \bar{y} the mean rainfall values.

Results obtained from the application of the statistical technique were used to compare with each other based on stations and the extent of dam/irrigation projects around them.

4. RESULTS

Table 1 shows the results of the application of linear regression to annual rainfall totals. The results are further shown as linear trends in Figs. 3A – D, 4A – D, and 5A – D.

In Table 1, only Jos station out of the 11 and General (i.e. the stations are grouped as one to represent the study area) stations possesses negative slope. It implies that all the other.

Table 1: Intercepts, Slopes and Regression Line Equation for Annual Rainfall Totals

S/N	Station	a (Intercept)	b (Slope)	Regression Line Equation
1	Gusau	386.10	5.88	$Y = 386.10 + 5.88x$
2	Jos	1611.70	-4.08	$Y = 1611.70 - 4.08x$
3	Kaduna	1198.67	0.38	$Y = 1198.67 + 0.38x$
4	Kano	-1293.33	24.83	$Y = -1293.33 + 24.83x$
5	Maiduguri	414.90	1.79	$Y = 414.90 + 1.79x$
6	Makurdi	1167.47	0.14	$Y = 1167.47 + 0.14x$
7	Minna	1018.38	1.90	$Y = 1018.38 + 1.90x$
8	Nguru	407.71	0.01	$Y = 407.71 + 0.01x$
9	Sokoto	90.14	6.07	$Y = 90.14 + 6.07x$
10	Yola	816.46	0.95	$Y = 816.46 + 0.95x$
11	Zaria	497.99	5.76	$Y = 497.99 + 5.76x$
12	General	569.76	4.03	$Y = 569.76 + 4.03x$

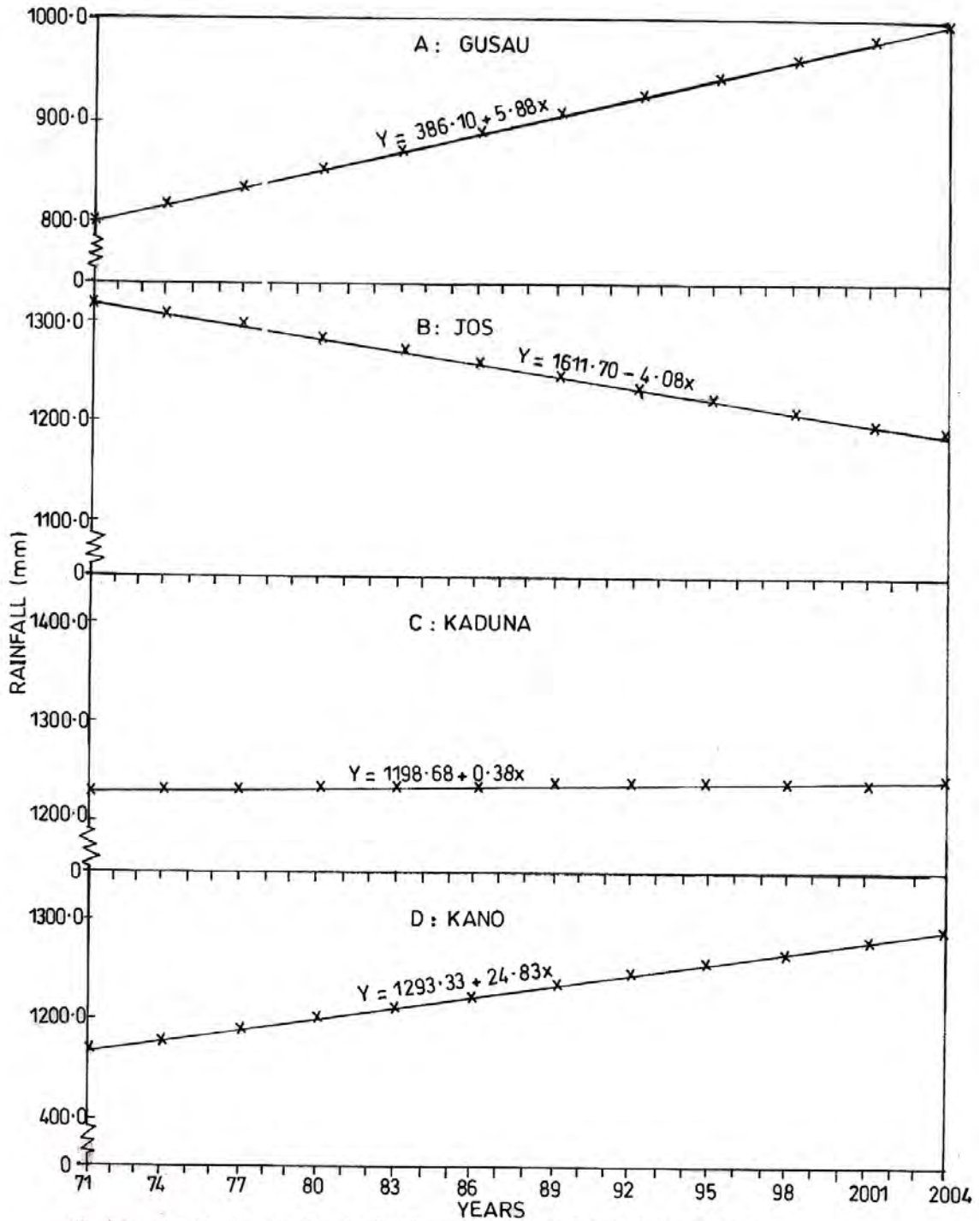


Fig.3 : A - D: Linear Trends for Annual Rainfall Totals (1971-2004)

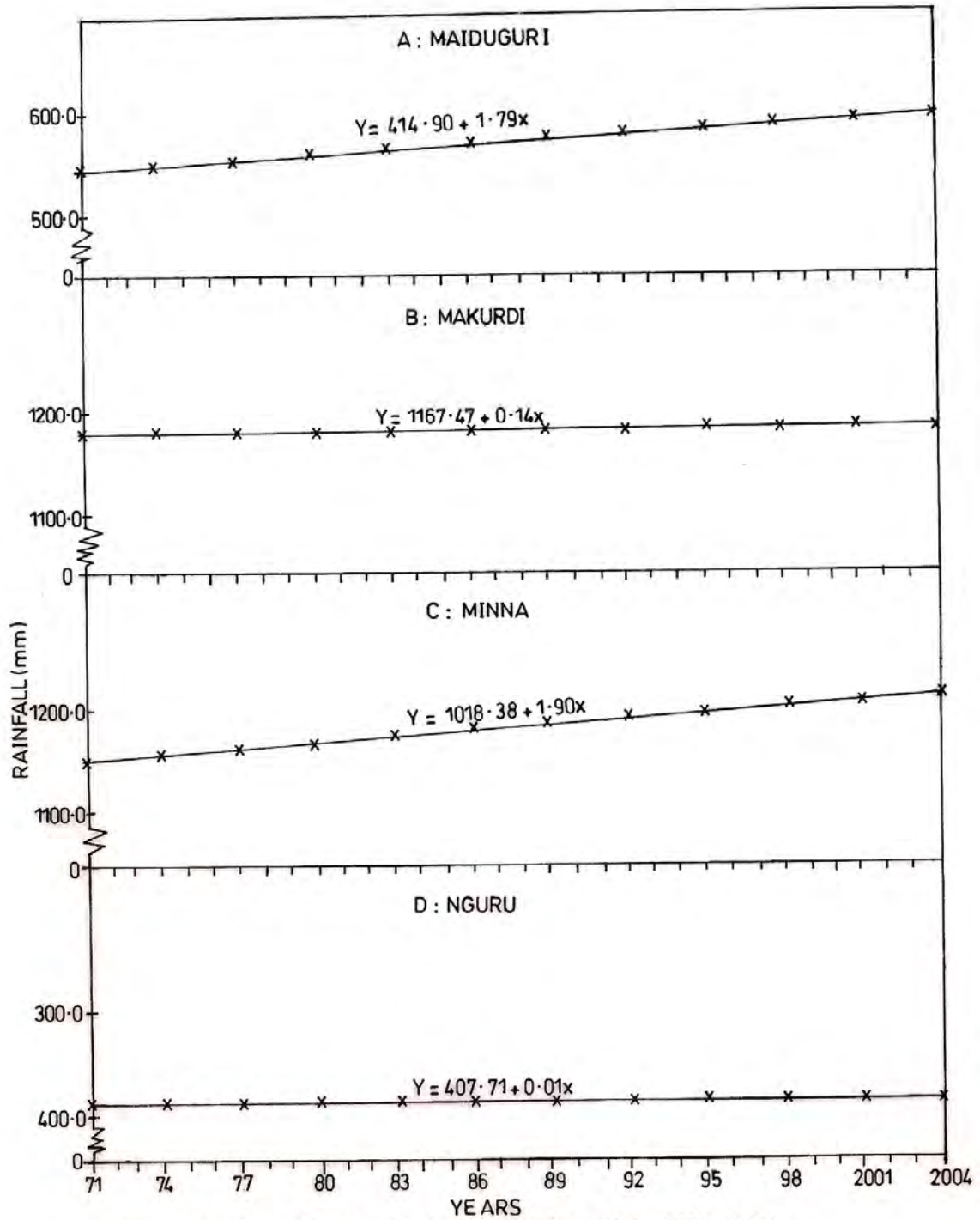


Fig. 4 : A-D : Linear Trends for Annual Rainfall Totals (1971-2004)

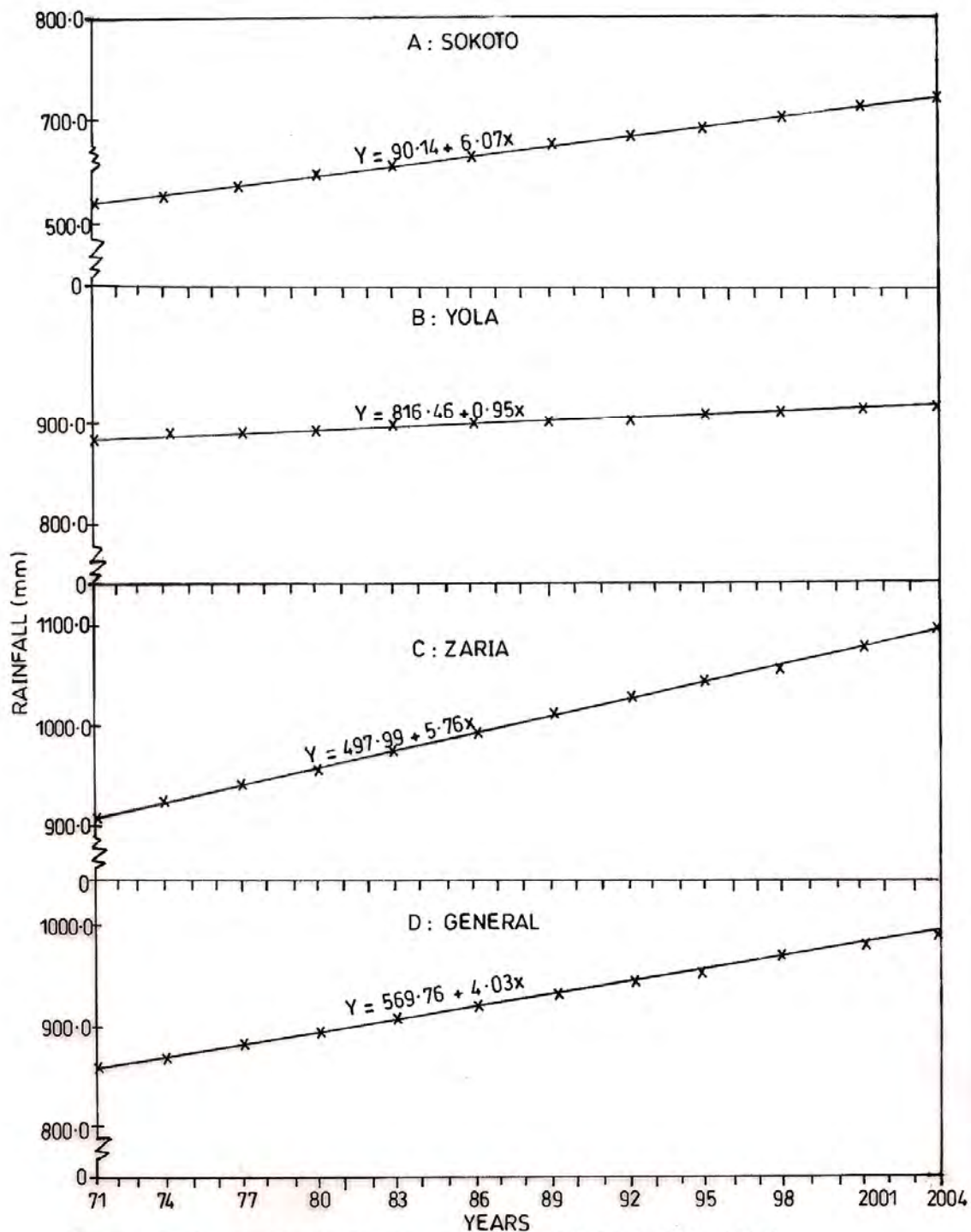


Fig.5 : A-D: Linear Trends for Annual Rainfall Totals (1971-2004)

stations have upward trends in their annual rainfall totals except Jos. Put differently, the stations are becoming wetter over the study period with Kano having the steepest slope of 24.83 and Nguru possessing the gentlest of only 0.01. The

steepness of the slope is visualized in Figs. 3A – D, 4A – D and 5A – D.

The relationship between rainfall trends and some dam/irrigation projects in Northern Nigeria is presented in Table 2.

Table 2: Relationship between Rainfall Trends and Some Dam/Irrigation Projects in Northern Nigeria

S/N of Hydro-logical Area	Dam/Irrigation Projects	Dam/Project Area (ha)	Total Dam/Project Area (ha)	Meteoro-logical Station in Hydrological Area	Approximate Project Distance to Station (km)	Trend Slope (mm)
1.	i. Kafin Zaki ii. Challawa Gorge iii. Tiga	50,000 50,000 62,000	162,000	Kano	13 7 5	24.83
2.	i. Bakolori ii. Goronyo iii. Zobe	33,000 45,000 5,000	83,000	Sokoto	5 20 17	6.07
3.	Environs of Lake Chad	67,000	67,000	Maiduguri	21	1.79

Data Source: NEST, 1991 and Authors' Field Survey, 2007.

An examination of Table 2, reveals that Kano has the highest trend slope (i.e. 24.83mm), and incidentally has the highest number of earth-filled dams in operation with Tiga dam as the largest (NEST, 1991) among the stations studied. The surface area of the reservoir behind the Tiga Dam has a surface area, at full capacity, of 178 square kilometres (NEST, 1991). Incidentally too, Maiduguri area with comparatively fewer number of Dam/irrigation projects has a rainfall trend slope of only 1.79mm.

5. DISCUSSION

Massive dam and irrigation projects are becoming common in Northern Nigeria. In general, all the major rivers in Nigeria have been dammed or about to be dammed for one purpose or the other or a combination of them e.g. irrigation, flood control and power generation. Though dam and irrigation projects are usually a source of water molecules in the earth's atmosphere, the increase in global temperature, and sizes and number of these projects in Northern Nigeria seem to have accelerated the rate of evapo-transpiration. Ordinarily, evapo-transpiration increases with increasing

atmospheric temperature. The 24.83mm average rate of increase in the annual rainfall total of Kano is indicative of the influence of these projects on rainfall. This is because massive dams as found around Kano in the face of global warming are bringing about increased evaporation since larger evaporation surface is created by the dams. Similarly, the irrigation projects in the face of increased world temperatures are causing an increase in evapo-transpiration in the sense that such projects increase the leave-area as plants increase in number, and the wet surface available. With this, the tendency for condensation to take place and cloud formed under this circumstance is very high. Areas of fewer and smaller dam/irrigation projects or none at all have a relatively far lower average rates of increase in their annual rainfall totals e.g. Maiduguri with 1.79mm and in the same climate region with Kano i.e. Tropical Continental North.

6. CONCLUSION

The first goal of the Millennium Development Goals (MDGs) is to eradicate extreme poverty and hunger by 2015. The

increasing rainfall totals in Northern Nigeria which is attributable to increasing world temperatures and number and sizes of dams in the area (Chima and Nwagbara, 2007; and Nwagbara, 2008) is a positive climatic event which if tapped will bring about higher agricultural productivity. Through this, poverty will be substantially reduced in the area. This is because the population is still predominantly agrarian and dominated largely by small-holder subsistence farmers (Nnaji, 2001) who depend largely on rainfall for the survival of their crops and animals. With this positive role of massive dam/irrigation projects in encouraging rainfall, more of such projects should be developed by governments at the federal, state and local government levels. In doing this, mitigation measures against flooding of adjoining settlements and farmlands must be taken into consideration. The very large population of Nigeria and its "big-brother" role in Africa make it expedient to encourage irrigation farming especially as Africa as a whole has been identified as having very little irrigation, less than 5 percent compared to more than 30 percent of the land in Asia (Hassan, 2008). When more food is produced through the enhancement of more water from rainfall and dams/irrigation projects, food security will be guaranteed not only for the region but for Nigeria as a whole and even Africa, thus eradicating hunger in these areas.

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