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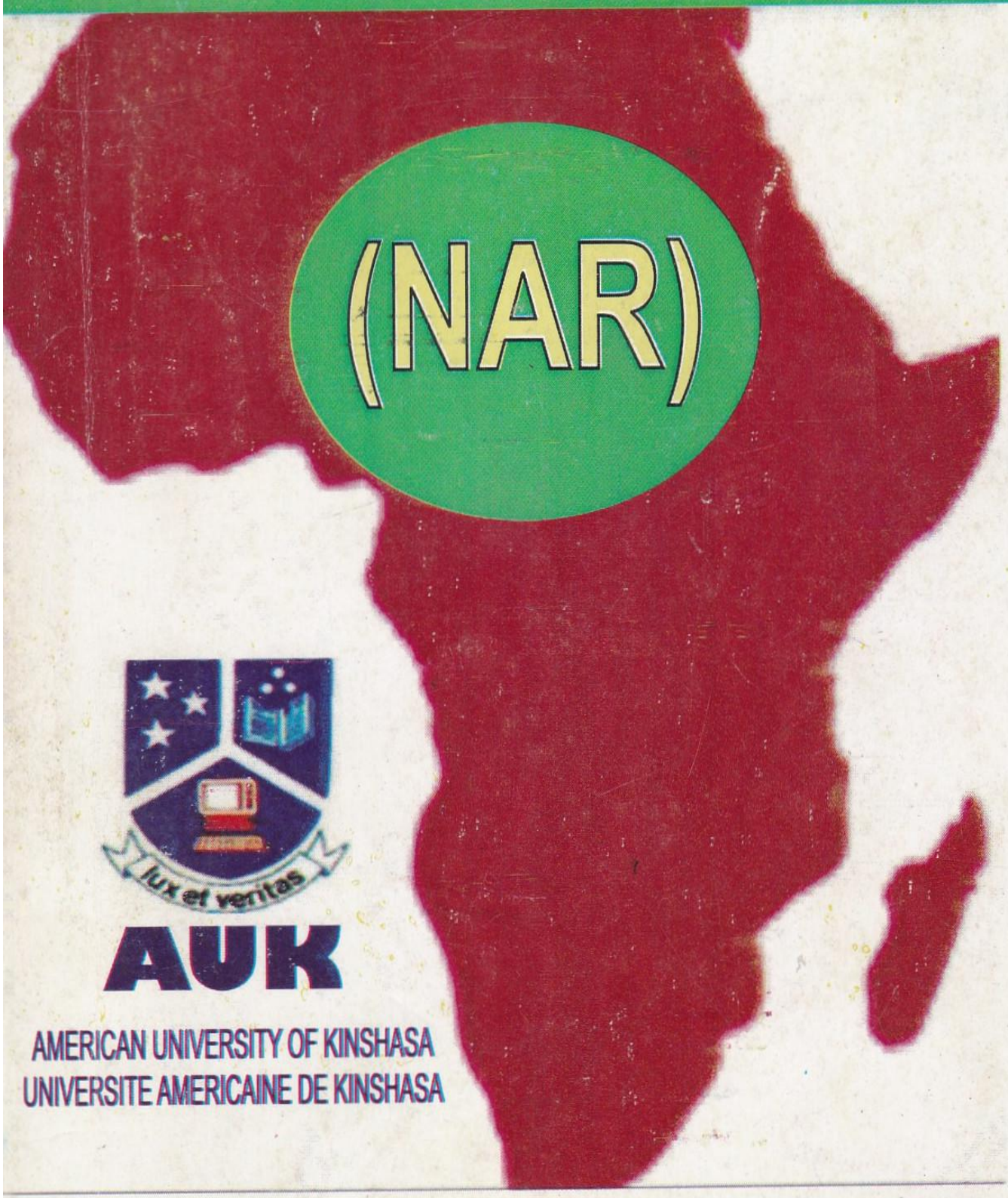

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An Analysis of the Trend in Annual Rainfall Dynamics for the Humid Tropics, a Case Study of Calabar, Cross River State - Nigeria

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Abstract

Fifty three years (1951-2004) annual rainfall averages for Calabar, Nigeria with the synoptic type A meteorological observatory provided the climatological data for the baseline studies. The analysis of the means, fluctuations and periodicities revealed expectedly a most variable and fluctuating regime. Without defined periodicities, the 53-year series trend is positive but insignificant. Projections upto year 2010 are slightly negative. The ecological problems of flooding and erosion are most frequent demanding planned adaptive response actions.

KEYWORDS: Annual Rainfall, Climate, Adaptive Response, sustainability, fluctuations, periodicity.

INTRODUCTION

Water is life; therefore the problem of water is the problem of life in the short or long term. All of the earth's waters (surface and underground) come from the atmosphere, (rainfall), whose primary phase are known atmospheric subsystem of the hydrologic cycle that have been interfered with and unbalanced by man through development in science and technology, population growth, fossil fuel consumption, urbanization, etc. Also, natural interferences and distortions through volcanicity, the El-Nino phenomenon as well as fluctuations on the intensity and locations of dynamic meteorological controls decades in and out within the sub-region have led to global warming and climate change with disastrous consequences for sub-saharan Africa. According to Trendberth et. al. (2003); IPCC (2001) initial increases in the annual averages and sea level rise are expected globally particularly in the temperate world. However significant declines that can lead to multiple problems in the amount, intensity, frequency and duration of annual rainfall are manifesting in tropical and sub-Saharan Africa, Asia and South America. Furthermore, the alarming incidence of hunger and starvation in sub-saharan Africa and elsewhere from droughts and desertification as well as erosion and flooding in the coastal and humid regions are linked to the global climate change problem. From the health sector, the prevalence of heat-related health problems of man such as meningitis, heat-stress and exhaustion etc from excessively hot and dry season (November-March) are considered clear impacts of the global warming. Put differently, while the human population and water needs of man are seen to be

growing exponentially, the supply of water from the primary input source (rainfall) is in apparent surplus in some places while some other locations may be experiencing shortages. Either way however there is the urgent need for scientific studies to establish the trend and variably of weather and climatic varieties for possible re-strategizing regarding weather – dependent human initiatives for sustainability.

Besides its academic relevance through the updating of an earlier knowledge base, rainfall climatological studies also provide baseline information for present and future planning and development purposes. For now however, awareness creation for planned mitigations and adaptations strategies against vulnerable areas and socio-economic sectors may be initiated.

The study objective is to analyse the trend in the annual rainfall regime for Calabar between 1951 to 2004, its implication for climate change. Specifically, it sought to:

- Examine the trend in rainfall dynamics over time in the prescribed area from 1951-2004;
- Find out the relationship between time and annual rainfall dynamics from 1951 to 2004;
- Proffer policy implications for climate change.

Theoretical Issues

The reigning explanatory paradigm regarding the change and variability in the global weather an climate is the anthropogenic climate change concept. In general, the concept posits that climate has changed and is currently changing because of a wide range of natural factors which operate over a wide variety of time scales IPCC (1992). However, with the increasing human population and the concomitant rising levels of technology. Industrialization , urbanization and agricultural practices, it is now most likely believed within the last century or so that man has become a significant factor in the change

(WWO, 1979; IPCC, 1992; UNFCCC, 1996; UWEP, 1990). Continued exponential growth and development of man is adding an unprecedented amount of carbondioxoide and methane, the major causative agents to the atmosphere. Outgoing long wave radiation is thus intercepted thereby heating up the lower atmosphere with grievous consequences on terrestrial temperature, rainfall and aridity for the tropical worlds and elsewhere in general. (Mintzer, 1987; Keeling and Hoffman, 1987; Allen and Ingram, 2002). Coastal segments such as Calabar, the study area, are expected to experience sea level rises together with increase down pouring of rainfall and flooding.

Methodology

Data types and sources

Data for this study are sourced from the Nigeria Meteorological Services (NIMET), Calabar International Airport, Calabar Cross River State, Nigeria. The data covered the periods 1951 to 2004. As a full synoptic station with standard equipments and trained personnel, the data gathered from the station is highly reliable and high- grade. The meteorological office rain-guage mk 2 is used for routine observation involving measurements of amounts of precipitation for periods from one to 24 hours. Rainfall is collected in a bottle placed in a removable copper bucket. The bottle facilitates handling and pouring and reduces loss by evaporation and melting. The bucket ensures retention, for measurement of exceptionally heavy rainfall which may overflow from the bottle into the bucket. Both bottle and bucket are housed within the base of the guage which is sunk firmly into the ground. Rainfall is measured in millimeters with eight observations for a 24 hour period.

Estimation Procedure

Several descriptive statistics (means, standard deviation, ranges etc) are used in estimation. Trend analyses are examined out using 5-yearly running averages technique and the least square regression technique for quantitative trend analysis, modeling and projection.

Time – series estimation is a form of statistical analysis which enables us to determine the behavior of past data (Okoko, 2000). The most common ones are the moving averages and the Least – Squares regression techniques. The 5-yearly moving averages that is used is a mathematical concept that 'flushes' out random occurrences of five yearly occurrence from the original sets of data. It simply involves the determination of the rainfall averages for five years (1951-1996) and recording the result against the medium year 1953. The next five-year averages, 1952 to 1956, is determined and recorded against 1954. The process is repeated upto year 2004. The method is easy to compute and gives a clear picture over time of the rainfall regime.

Though time-series data are not bivariate data, a linear trend line can be obtained by using the simple regression analysis technique (Udofia, 2004). In this study, time in years is our independent variable (x) while the annual rainfall figures from 1951 to 2004 consisted the dependent variable (y). The least square regression line equation is mathematically presented as:

$$y = a + bx + e$$

Where y = dependent variable (annual rainfall in mm)
x = independent variable (time in years);
a = a constant (y-intercept)
b = regression coefficient for x;
e = error term (random, irregular occurrences)

Time in years is the only explanatory variable as the anthropogenic factor of change is time dependent. The single most important advantage of the least square trend analysis is its inferential capability in hypothesis testing and projection.

Hypothesis Test

Hi: Annual rainfall averages for the period 1951 – 2004 has significantly changed.

Ho: It has not significantly changed over time.

The rejection level is *a priori* at 5% probability and 52 degrees of freedom

RESULTS AND DISCUSSION

The main descriptive climatological indices for the annual rainfall regimes are shown below:

Table 1: Descriptive Statistical Data for Annual Rainfall Averages in Calabar – Nigeria

*	Mean	-	2896.235mm
*	Median	-	2825.400mm
*	Maximum	-	3392.500mm
*	Minimum	-	2109.500mm
*	Skewness	-	0.756565
*	Kurtosis	-	4.213576
*	Probability	-	0.016978

Source: Field Data An analysis, 2007.

The baseline analysis presented above establishes the series mean and standard deviation as 2896.235mm and 343.719mm respectively. Both indices however indicate the 50% annual rainfall probability value as well as the degree of fluctuation in the annual value. The range of the distribution is equally high

at 1283.0mm with the highest and lowest annual averages recorded in 1998 and 1973 respectively. Simple filtering with the divergent line graph (fig, 1c) reveals that for 26 years the annual average was below the 54 years annual average figure of 2896.235mm. While the remaining 28 years experienced values higher than the annual average values. Trend analysis with the 5-yearly running averages technique that flushes out five-yearly errors or random occurrences in the rainfall series for clarity reveals little (Fig 1b) except the unexplained rising trend from 1990-1994 with annual totals of 3000 mm and above. The trend prior to 1990 can be regarded as normal climatic fluctuations without definite periodicities. The overall series is however not significant at 95% confidence ($t_c < t_t = -0.2640 < 2.009$). Projections with the series equation up to year 2010 reveal a declining trend in the annual rainfall averages for the study area.

Statistical analysis of the 54 years annual rainfall averages for the city of Calabar Nigeria, a coastal location in the Humid Tropics among other things reveals expectedly an area with the Equatorial weather and climatic type with high annual averages, extremities, deviations and range. There is no discernable trend and / or pattern in the 54 years series. Besides the seeming positive or rising trend is not statistically significant. The theoretical annual average estimates for Calabar up to the year 2010 is not expected to be significantly higher either. (Table II).

Global warming with its associated climate change issues have thus been partially analyzed and understood for Calabar, Nigeria, from the results of the study. The trend analyses (qualitative and quantitative) showed no clear nor significant direction of change for the period under review. Both the theoretical projections and hypothesis testing are negative. However the

Table 2: Projected Annual Rainfall Averages for Calabar (2005-2010).

Year	Projection
2005	2872.24mm
2006	2871.46mm
2007	2870.67mm
2008	2869.89mm
2009	2869.10mm
2010	2868.32mm

Intense human interference with the environment through agricultural activities, growth in human population density and rising energy consumption through urbanization and industrialization among others, the tests may be significant. In more recent times however, the apparent extremely in the mean weather and climate of Calabar town is strange and worrisome. Either the rainy season is extremely wet and lengthy and the dry season exceedingly hot with floodings, meningitis and heat stress health problems prevalent.

Conclusion

The foregoing discussions and conclusions are not in anyway tragic in the short to medium term scenarios, as the study location and surrounding environments can be assured 'its over seven months of active convective activities'. In the long run however, the picture is not all the same clear and assured for expectations can be surpassed within a while. The established annual averages and the projected figures can be influenced positively with intense global warming, the melting of polar ice and sea level rises resulting in higher annual precipitation values than predicted. Besides climate change problems Are time depend (IPCC 2001) apparently becoming

extensive, intensive and complex through time. Planned mitigative and adaptive response strategies for sensitive natural and human systems are urgently needed for human sustainability.

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