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# Analysis of Temperature and Rainfall Variability over two Coastal States in the Niger Delta, Nigeria

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## ABSTRACT

*Temperature and rainfall has been of primary importance in most climate science studies. With their variability exerting significant impact on the Society. This study analysed temperature and rainfall variability over two coastal states in the Niger Delta region of Nigeria. Annual temperature and rainfall time series data from 1986 to 2016 for Uyo (AkwaIbom State) and Port Harcourt (Rivers State) respectively were the archive of the Nigeria Meteorological Agency (NIMET). The descriptive qualitative and quantitative method of time series analysis was employed, charts such as time graph to aid in the empirical analysis. Correlational analysis between temperature and rainfall was test to carry out on the variables. The result shows that temperature and rainfall in the study area are inversely related. This means that as the temperature increases, rainfall decreases in the study area. Though, the result is statistically insignificant ($p > 0.05$). Conclusively the data shows that effect of climate change is mainly affecting temperature in the area*

**Keywords:** *Temperature, Rainfall, Variability, Trend, Correlation, Niger Delta*

## INTRODUCTION

Intergovernmental Panel on Climate Change (IPCC) esteem climate as the statistical explanation in terms of the mean and variability of the relevant atmospheric quantities, such as temperature and rainfall over a long period of time, which could range from months to thousands or millions of years (IPCC, 2014).IPCC contemporary report on climate change and global warming IPCC (2013 and 2018 ) has evaluated the average trend of global temperature over the period of years 1880-2012, it being equal to 0.85°C, with a degree of uncertainty ranging of 0.65°C - 1.06 °C. The rise occurred during the years 2003-2012 is +0.78°C - for a minimum of 0.72°C and a maximum of 0.85 °C (IPCC, 2018). National Climatic Data Centre (NCDC) considers 2014 as the warmest year ever recorded, with an anomaly of + 0.69 °C, calculated for the period of the years 1880-2014 (NOAA, 2015).

The World Meteorological Organization (WMO), in 2016, considers the period 2011-2015 as being hottest on record, and 2015, as the hottest year since modern observations was began in the late 1800's. If, on a global scale, increase in temperatures is unquestionable, evolution of world pluviometry is much more contrasting, being a subject of a strong spatiotemporal variability. Fascinating into thought of this reality, also considering rise in temperature, an increase in rainfall is to occur in certain regions of the world favorable to such a climate evolution. Certainly, hydrological cycle acceleration under the influence of extreme temperatures could lead to more rainfall and evaporation processes (WMO – 2012, 2013, 2016, 2017; Nouaceur *et al.*, 2017; FAO *et al.*, 2017; IPCC, 2018). Climate variability refers to variations in the mean state of the climate on all temporal and spatial scales beyond that of individual events. The time scale could be in months to years (McDonnell *et al.*, 2000; Shaibu and Weli, 2017).

Rainfall tends to decrease with distance from the equator. The variability of rainfall from annual average is greater in a region that gets little precipitation (Thornton, 2014; Abdullahi*et al.*, 2020). A climatological cycle of the total annual rainfall and temperature across Nigeria is believed to be regular in terms of wet and dry seasons in the 60s, 70s and parts of 80s from South to the

North and to some extent from East to the West (Owolabi, 2016). The Niger Delta region of Nigeria is highly vulnerable to adverse environment changes caused by climate change and chiefly a change(s) in the temperature and rainfall. Niger Delta is located in the coastal region of the world are already experiencing flooding due to rise in sea level due to melting of polar ice a consequence of increase in temperature. Indisputably, it is notable that oil exploration and exploitation had adversely affected temperature change in the Niger Delta (Chinedu *et al*., 2001; Efenji *et al*., 2014).

Obasi&Ikubuwaje (2012) conducted an analytical study of rainfall and temperature trends in some catchment States of Nigeria using the Benin-Owena River Basin as case study. The study covers Climatic data for rainfall and temperature for 35years. Akinsanola *et al*., ( 2014) analyzed for the occurrences of abrupt changes in temperature and rainfall values over Nigeria using data from 25 synoptic stations from 1971- 2000 (30years).Their result shows that there have been statistically significant increases in precipitation and air temperature in vast majority of the country, with sequence of alternately decreasing and increasing trends in mean annual precipitation and air temperature in the study area. In another note, Nwafor *et al.*, (2018) using vector auto regressive techniques modelled meteorological data in selected states in Southern Nigeria with emphasis on monthly rainfall and temperature a period of 1972 – 2011. The predicted value from the modeled data suggests continues increase in amount of monthly rainfall and temperature at different confidence interval.

Shaibu and Weli, (2017) examined the relationship between certain meteorological elements and $PM_{2.5}$ concentration in selected cities of the Niger delta region of Nigeria. Meteorological data were obtained from the Nigerian Meteorological Agency. $PM_{2.5}$ data that was used for this study was Aerosol Optical Depth (AOD), it was acquired from remotely sensed satellite data from National Aeronautics and Space Administration (NASA's) earth observing system data and information system, $PM_{2.5}$ concentration data and meteorological monthly data were obtained from 2001 to 2015 and multiple regression analysis was employed to test the relationship between $PM_{2.5}$ concentration and the meteorological elements (Temperature, Rainfall, Relative Humidity and Wind Speed). The correlation analysis result showed that temperature and wind speed had a positive correlation, while rainfall had a negative Relationship with $PM_{2.5.}$ This has an effect on $PM_{2.5}$ concentration because as temperature increases and rainfall decreases with low wind speed, $PM_{2.5}$ concentration increases and this can lead to adverse health effects on human beings in the study area.

Furthermore, Abdullahi *et al.*, (2019) noted that proximity to the Atlantic Ocean and topography contributed greatly to variation in rainfall characteristics in Nigeria. Despite the spatial differences in rainfall trends, rainfall received across the study period in Nigeria is consistent. Akwaibom and Rivers state are two states in the Niger Delta that has very close proximity to the Atlantic Ocean. However there seem to be noticeable variation in the characteristic of temperature and rainfall characteristics especially at the annual scale. This variation despite having similar geographical characteristics calls for probing in order to identify where changes is more pronounced. To solve this dilemma, this study seeks to analyse temperature and rainfall variability over the two coastal states in the Niger delta region of Nigeria.

## MATERIALS AND METHOD

This study utilized annual temperature and rainfall time series data for 1986 to 2016 period, sourced from the archives of the Nigeria Meteorological Agency (NIMET) Uyo (AkwaIbom State) and Port Harcourt (Rivers State) respectively. Descriptive statistical techniques were employed to summarize the characteristics of temperature and rainfall in the study area. Ordinary least square regression method was used to estimate trend in the time series data. Person product moment correlation technique was used to establish the relationship between temperature and rainfall.

## STUDY AREA, LOCATION / EXTENT

Niger Delta region is located on the Atlantic coast of Southern Nigeria, the Niger Delta lies within the lower reaches of the Niger river, extending between latitudes 05°19′34″N 06°28′15″E and 5.32611°N 6.47083°E (WGS, 1984). The average monthly temperature of the region is 27°C, and an annual rainfall ranging from 3000 to 4500 mm. There are two distinct seasons with the wet season occurring from July to September and the dry season from December to February (World Bank, 1995). The study area consists of alluvial deposits and an extensive, low-lying, typical deltaic plain with essentially flat topography which, in conjunction with the high annual rainfall, is responsible for the extremely poor drainage conditions and the widespread development of marshes and back swamps (Nwankwoala & Jibril,

2019). This area is usually submerged during the wet season where flood waters range from 0.5 to 4 m deep (Akpokodje 1986). There are a number of perennial streams, oxbow lakes and rivers in the area e.g. Stubbs creek, Sobriebo creek, New Calabar river Bonny River , Qua Ibom Estuary, Taylor Creek, Imo River Estuary, Itu River, Kolo Creek, Epie Creek, Yenagoa and Nun river, etc. They all form a network which empties to the Atlantic Ocean. These rivers are mostly turbid during the wet season possibly due to discharge of clay and silt (Amadi *et al.*, 1987).

The geology of the Niger Delta has been described in details by various authors. The formation of the Delta started during Early Paleocene and resulted mainly from the buildup of fine grained sediments eroded and transported by the River Niger and its tributaries. The Tertiary Niger Delta is a sedimentary structure formed as a complex regressive offlap sequence of clastic sediments ranging in thickness from 9,000 - I2, 000 m (Abam, 1999). Starting as separate depocenters, the Niger Delta has coalesced to form a single united system since Miocene. The Niger Delta is a large and ecologically sensitive region, in which various water species including surface and sub-surface water bodies exist in a state of dynamic equilibrium (Abam, I999).The natural vegetation of the study area is that of the rain forest but this has been destroyed by the activities of man such as bush burning, farming, construction and illegal crude oil refining activities. The vegetation consists of various kinds of evergreen trees, including palms trees and a variety of shrubs. More than 70 % of the inhabitants of the study area are engaged in subsistent farming and fishing. The Niger Delta is made up of nine states namely (See Fig 1), Abia, AkwaIbom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo and Rivers with a home of over 30 million people, approximately 22% of the country's population (NPC, 2006).

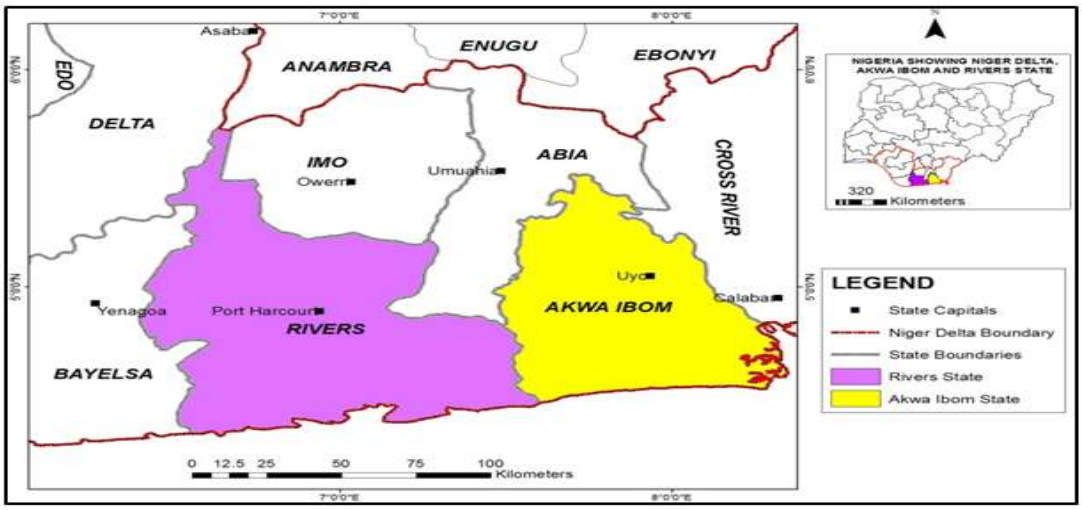


**Figure1.** *Niger Delta Showing the two Coastal States (Source: Department of Geography and Environmental Management Cartography Laboratory, University of Port Harcourt, 2020)*

## RESULTS AND DISCUSSIONS

### Descriptive Characteristics of Temperature and Rainfall in the Study Area

Temperature and rainfall are the two basic components of weather and climate. Any abnormal changes on these two, may subject the environment to the effect of climate change. The characteristics of temperature and rainfall in the study area are presented in Table 1.

**Table1.** *Descriptive Statistics of Annual Temperature and Rainfall in the two Coastal States of Niger Delta, Nigeria (1986-2016)*

| | AkwaIbom State (Uyo) | | Rivers State (Port Harcourt) | |
|---|---|---|---|---|
| | *Temperature ($^0$C)* | *Rainfall (mm)* | *Temperature ($^0$C)* | *Rainfall (mm)* |
| Mean | 23.2 | 249.0 | 27.1 | 187.7 |
| Median | 23.3 | 242.1 | 27.0 | 188.4 |
| Minimum | 22.20486 | 196.341667 | 26.25816 | 145.7667 |
| Maximum | 23.8 | 337.1 | 27.7 | 232.6 |
| Standard Deviation | 0.454927 | 33.700021 | 0.30899 | 20.65031 |
| Coef. of Variation | 0.019651 | 0.13532479 | 0.011412 | 0.110037 |
| Range | 1.5 | 140.7 | 1.5 | 86.8 |

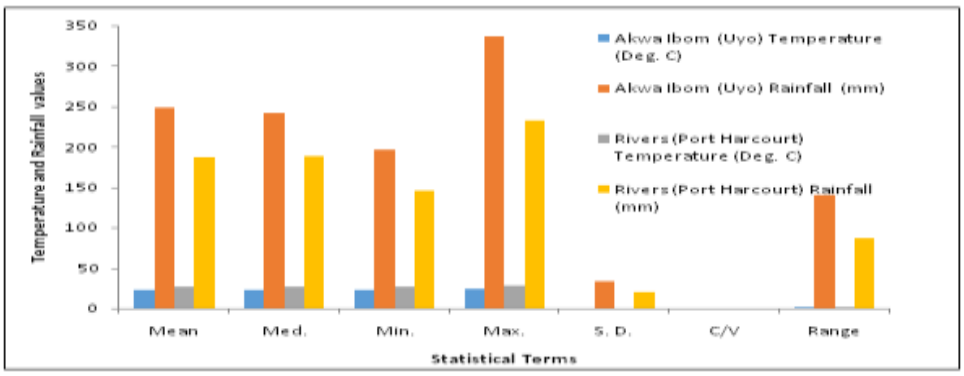


**Figure2.** *Graphical presentation of Descriptive Statistics for the study area*

The study area (AkwaIbom and Rivers States) have demonstrated similarities in terms of temperature and rainfall over the study period. The measure of central tendency used (mean, median, min., max., standard dev., coefficient of variation and range) explained that there is consistency on the temperature and rainfall among the two states. This is so because the two states were situated in a region with uniform climatic and ecological characteristics. This shows that as one variable increases in one state, the other state will also experiences increase (Table 1 and Figure 2). Looking at the two states as a single entity, the area has average annual rainfall between 150mm and 250mm, with average temperature between $23^0$C and $27^0$C. The area has Coefficient of Variations in temperature of $0.01^0$C and rainfall of 0.1mm. This shows that rainfall in the area experiences annual changes compared to temperature.

## Fluctuations and Trend in Annual Temperature and Rainfall in the Study Area

Fluctuation and trend in the inter-annual fluctuation of temperature in the study area is shown in Figure 3, AkwaIbom State experiences lowest temperature in 1999 and highest is 2003with positive trend ($r^2$ = 0.103). In the other hand, Rivers State experiences lowest temperature in 2006 and highest in 2016 with positive trend ($r^2$ = 0.091). It is generally observed that temperature is gradually increasing. Figure 4 show that rainfall experiences little fluctuations among the two locations. This shows that variations in annual rainfall among the years are minimum compared to observed temperature. It also shows that AkwaIbom experiences increase in rainfall ($r^2$ = 0.127), while Rivers experiences consistency in rainfall ($r^2$ = 0). This shows that effect of climate change is mainly affecting temperature in the area.

Figure 5 is a result of correlation analysis between temperature and rainfall, where temperature stands as predictor on *x*-axis while rainfall stands as the target on *y*-axis. The result shows that temperature and rainfall in the study area are inversely related. This means that as the temperature increases, rainfall decreases in the study area. Though, the result is statistically insignificant ($p > 0.05$).

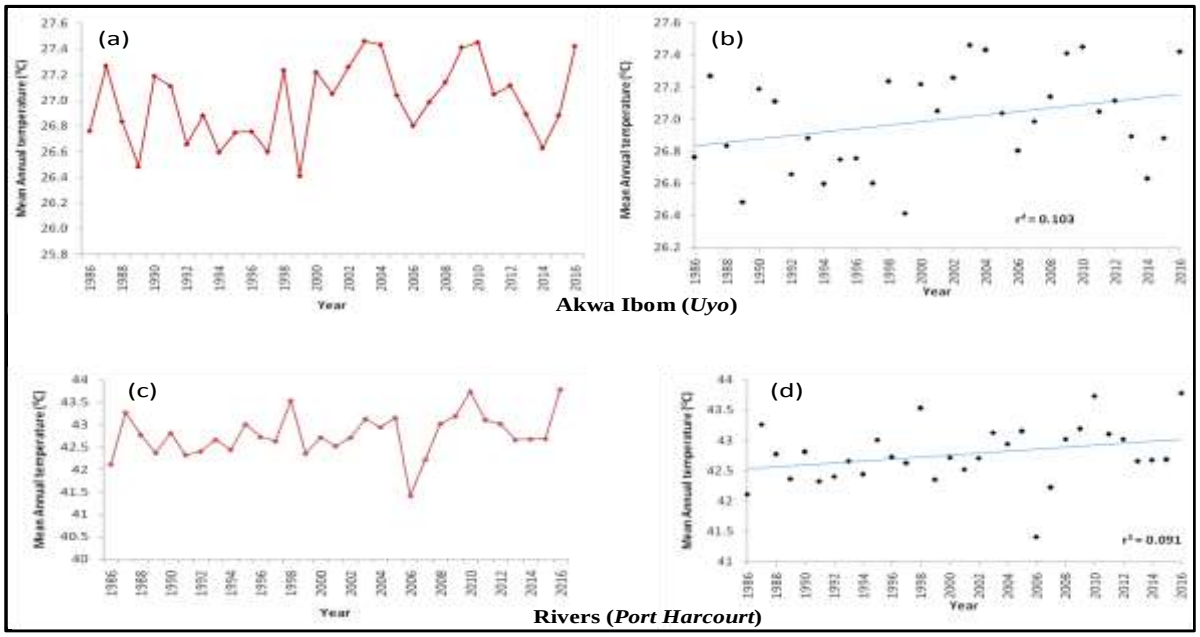


**Figure3.** *Temperature Characteristics*

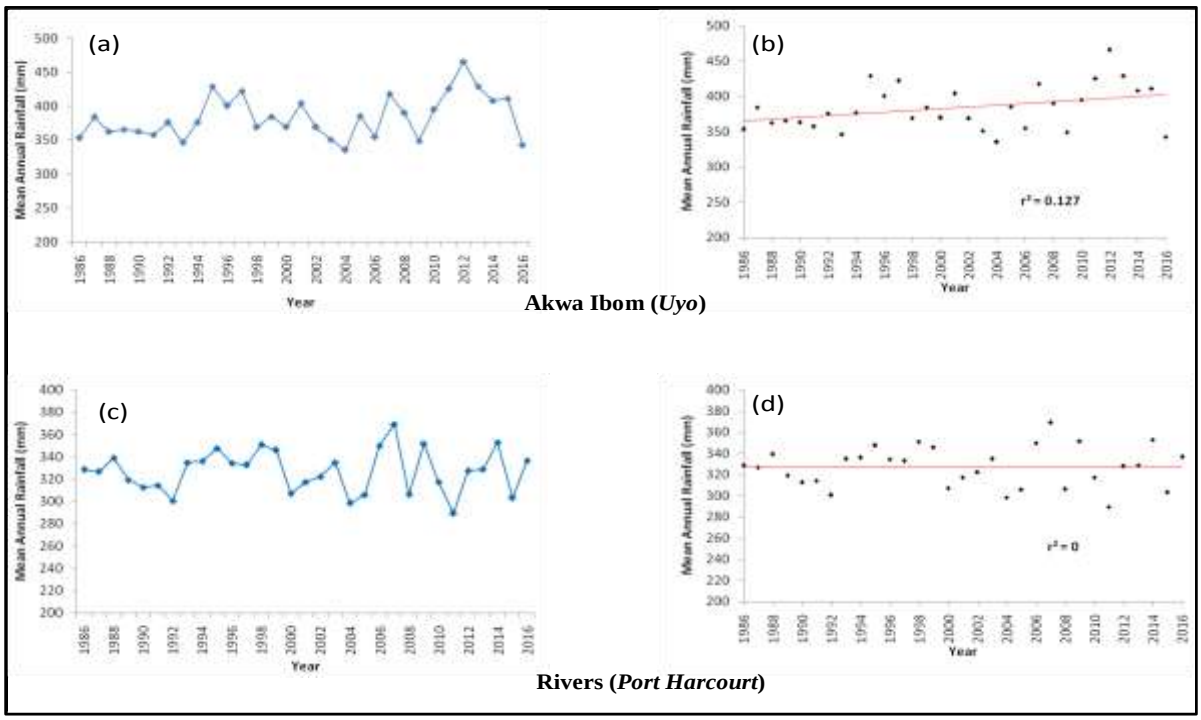


**Figure4.** *Rainfall Characteristics*

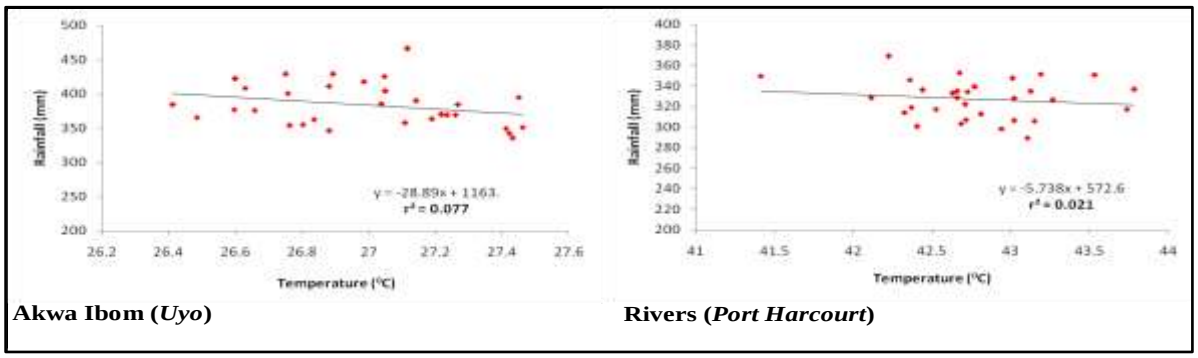


**Figure5.** *Temperature-rainfall relationship*

## CONCLUSION

The analysis shows that there is uneven temporal distribution of rainfall in the study area which is attributed to effect of climate change. Conclusively, the analyses show that climate change causes temperature to increase with decrease in rainfall amount. This phenomenon may subject the region to drought which may subsequently affect agricultural activities in the area. Farmers in the area should adjust their farming technique to suit the prevailing conditions. The point is that concerning temperature and rainfall, the extrapolative skill is really in the right direction. But, Policy pathway resulting upon the empirical results is to alert the economic and agricultural policy decision makers to prudently utilize the factors which affect some of these key parameters in the study area.

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