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Impact of Recent Temperature and Rainfall Trends On Farming Activitiesin Selected States in the Niger- Delta Region, Nigeria

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ABSTRACT

This study was carried out to assess the impact of recent temperature and rainfall trends on farming activities in selected States in the Niger- Delta Region, Nigeria. Data on annual rainfall totals and mean temperature were collected from the Nigerian Meteorological Agency (NiMet). The data covered a period of 30 years (1990 to 2019) for Port Harcourt, Calabar and Uyo. MODIS Land Surface Temperature and Emissivity (MOD11) for the year 2019 was made use of. This was used to validate the temperature of other areas within the selected cities. The MODIS 11 was also used because of the anomalies of the landsat imageries and the difference in determining land surface temperature is maximum of ± 2 °C. Some point data were then used to capture the actual temperature value using zonal statistics tool in ArcGIS platform. These values were thereafter used to generate the temperature variability map of each selected city. The Network Detection and Response (NDR) analysis of rainfall and temperature maps using inverse distance weighted (IDW) interpolation technique in ArcGIS 10.2. was also used. Correlation and regression analyses were used in analyzing the meteorological data namely rainfall and temperature. These tools were employed to help in detecting trends in the data through charts. Result of the Correlation and regression using charts and The Network Detection and Response (NDR) analysis of rainfall and temperature maps using inverse distance weighted (IDW) interpolation technique in ArcGIS 10.2 revealed an upward trend of temperature and rainfall across the study statesimplying vulnerability and an increase in the risk level of rainfall and temperature on farming activities. This study suggests the related authorities or institutions take an immediate adaptation intervention to farmers in filling the gaps in infrastructures and technology which is beyond their reach. The development of mobile apps or providing weather information in available media that can be easily handled by the farmers to get access to the weather information, this can help them make appropriate decisions for planting and harvesting time.

Keywords: Temperature, Rainfall, trend pattern, farming, Niger Delta.

I. INTRODUCTION

Weather and climate are mutually exclusive events that affect the environment and activities on the earth surface in a complex way. Weather can be said to be the state of the atmosphere above a given place at a specific time. It is also the day-to-day state of the atmosphere in terms of air temperature and moisture, cloud covering, and relative humidity. Climate on the other hand is described as average weather over a defined time period from 30 to 35 years. Weather has a very limited predictability effect and could be directly perceived by people while climate cannot be perceived by people (Kropp and Scholze, 2009). Climate can vary from place to place, depending on latitude, distance to the sea, vegetation, presence or absence of mountains or other geographic factors. Climate also varies in time, from season to season, year to year, decade to decade or on much longer scales such as the ice ages. From these definitions of climate and because an initial climate ought to be specified before identifying a change (Meyer, 1996), any marked departure from an initial climate due to a sustained trend in any climatic element over a long period of time not less than 30 years can be regarded as a change in climate). Climate change could also be the statistically significant

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variations of the mean state of the Climate or of its variability, typically persisting for decades or longer (Baede, Ahlonsou, Ding & Schimel, 2011). Variability in climate however, refers to the temporal variation about the mean of climatic variables. As a response to these variations in climate, global average surface temperatures have risen by about 0.6 ± 0.2℃ since the late 19th century and about 0.2℃ to 0.3℃ over the past 25 years (considered as the period with the most credible data), and by 0.74℃ in the last 100 years. This increase in global temperature is commonly referred to as global warming. Rainfall on the other hand has trended downward during 1960-2000, and sea level has risen between 1 to 3 mm per year (IPCC, 2007).There is an increasing trend of unusual climatic patterns like unpredictable rainfall, floods, seasonal shifts and increasing temperature in Nigeria which has a significant impact on agricultural productivity (Malla, 2018). Therefore, Nigeria is extremely vulnerable to climate change mainly because of its immense reliance on agriculture as 65.7% of the population is engaged in it (MOAC, 2018). Mainstream farmers from the rural areas are the major victims of it due to lack of awareness and less options to respond to climate change. Therefore, from the perspective of food security as well as socioeconomic reasons, it is very crucial to understand the perceptions, identify the impacts and adaptation practices being taken to enhance the farmer's livelihoods in a better way. Developing the appropriate strategy to cope with the effect of climate change can improve the productivity and financial stability of farmers (Parry, Canziani, Palutikof, Linden, & Hanson, 2007). Therefore, this research broad objective was to determine the impact of recent temperature and rainfall trends on farming activities in selected states in the Niger-Delta Region, Nigeria. Further, this research can provide revised information to the future researchers on the recent trend of climate change, its impacts on local communities and adaptation approaches at micro level.

The Study Area

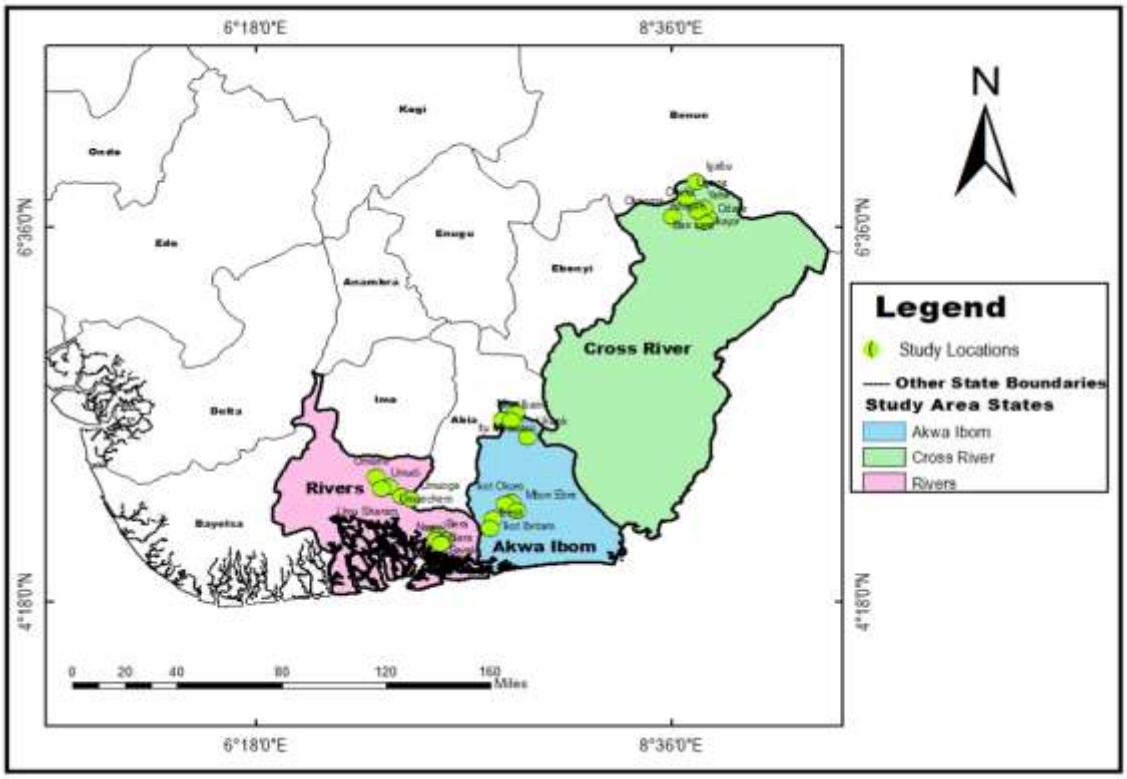

Figure 1: Study Area States and Locations

The area of study is the central Niger Delta States comprising AkwaIbom, Cross River and Rivers States. The Niger Delta Region lies at latitude of 4^0 43' 30.''N and 5^0 53.40'' N while longitude 4^0 46' 20'' E and 8^0 16' 50'' E. The Niger Delta is the largest in Africa and third in the world. It is a geographical area covering about 70,000 km^2. It represents about 12% of Nigeria's

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total surface area. It lies in the southerly part of Nigeria stretching from the Nigeria- Cameroun boundary in the East to Ondo State in the West. The area is bounded in the north by Enugu, Ebonyi, Anambra, Kogi and Ekiti States, while the Atlantic coast forms the southern boundary. The whole area is crisscrossed by dense networks of rivulets, streams, creeks and rivers and consists of several ecological zones, the sandy coastal ridge barrier, brackish and saline mangrove, seasonal and permanent fresh water swamp forest and low land rain forest. The region comprises nine of Nigeria's constituent states; the population as at 2006 was over 28 million.

Niger Delta has a tropical climate. In most months of the year, there is significant rainfall in the area. There is only a short dry season and it is not very effective. The Köppen-Geiger climate classification is Am. The average annual temperature in Abua is 26.5 °C. The area is endowed with abundant sunshine due to its geographical location near the equator. 'The sun is vertically overhead throughout the year. Day light hours are larger because of the long duration of solar radiation.According to the Nigerian Meteorological Agency (NiMet, 2011) the months of February and March records the highest temperature of 33^{o}C, while the months of January and December records the lowest temperature of 21^{o}C. Temperature rises through the months of October, November and December. The monthly rainfall in Niger Delta is slightly predictable due to climate change in the world today, temporally rainfall decreases from the months of October to February which is the dry season (Okhakhu, 2013). The rainfall in Niger Delta is greatly influenced by the Inter Tropical Discontinuity (ITD), due to its location. Rainfall peaks in July and September with a little dry season in August (August break). The area experiences about 2476 mm of precipitation falls annually. The driest month is January with 31 mm. Most precipitation falls in September, with an average of 401 mm. The difference in precipitation between the driest month and the wettest month is 370 mm. The average temperatures vary during the year by 2.4°C (NDDC, 2006). The region vegetation at its inception was dominated by high rainforest, mangrove forest and brackish swamp forest which covers approximately within the range of 5,000km^2 and 8500km^2 of land in the area, however, most parts of the forest are absent lately which may be as a result of climate or anthropogenic activities such as uncontrolled logging, oil exploration and exploitation, agricultural activities and urbanization (Nwilo&Olusegun, 2007; Musa et al., 2014). The vegetation in some parts is dominated by grasses, shrubs and sedges and some tress growing beside each other to form canopies in some area (Uyigue&Agbo, 2007). The Niger Delta region is subdivided into four different ecological zones which are the mangrove swamp zone, coastal inland zone, low land rain forest zone and fresh water zone (NDDC, 2006; Uyigue&Agbo, 2007).The Niger Delta mangrove swamp zone which is about 40 km wide is located in an intertidal land with a large expanse of tidal creek behind the barrier island (NDDC, 2006). The differences in the mangrove swamp in the region are mostly as a result of the interaction between tidal and river water in each estuary and river-system (NDDC, 2006). The predominant trees in the zone are the red mangrove, black mangrove, salt fern and salt grasses, shrubs and small trees (NDDC, 2006). On the floor of the mangrove swamp zone, there is abundance of small animal species such as shrimps, crabs, clams, periwinkles and mudskippers.The coastal inland zone is cushioned by a sandy island in the middle of the Benin and Imo estuaries which is lower than a meter above high tide level (NDDC, 2006). The area is covered mainly by fresh water swamp forest with intermittent small salt marshes. The area is not usually used for farming because they possess sandy soil mainly. Low land rainforest zone is located in the non-riverine region which flanks the delta. Because of agricultural practices, the original rainforest of the area is being replaced by farms, oil palms, and rubber plantations (NDDC, 2006). Animals are scarcely seen in this region because of the shorter fallow periods during cultivation because of the increasing demands of the growing population.Fresh water zone makes up close to 50 percent of the Niger delta region (Umoh, 2008)

II. METHODOLOGY

Data on annual rainfall totals and mean temperature were collected from the Nigerian Meteorological Agency (NiMet). The data covered a period of 30 years (1990 to 2019) for Port Harcourt, Calabar and Uyo. Secondary data such as MODIS Land Surface Temperature and Emissivity (MOD11) for the year 2019 was made use of. This was used to validate the temperature of other areas within the selected cities. The MODIS 11 was also used because of the anomalies of the landsat imageries and the difference in determining land surface temperature is maximum of ± 2 °C (Zhang & He, 2013). Some point data were then used to capture the actual temperature value using zonal statistics tool in ArcGIS platform. These values were thereafter used to generate the temperature

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variability map of each selected city. The point grid pattern of meteorological data was obtained for total precipitation. 1-km GSD of point pattern the climate data were primarily produced by NOAA and IPCC and were obtained from Community Climate System Model which is available from https://gisclimatechange.ucar.edu/gis-data. The data were used because previous studies showed that CLM4.0 simulation is capable of capturing characteristics of the spatial and temporal variations of the climate parameters (Xin Lai, Jun Wen, Sixian Cen, Xi Huang, HuiTian, and Xiaokang Shi, 2016). Climate simulations from the CCSM4 are generated on a Gaussian grid, where each grid point can be uniquely accessed by one-dimensional latitude and longitude arrays (i.e., the coordinates are orthogonal). The point data of each of the climate parameters were clipped to the shapefile of Nigeria Boundary and thereafter interpolation using Inverse Distance Weight (IDW) was done to generate values of rainfall data for the unsampled places. The shapefile of each of the selected cities was used to delineate the raster format of each of the rainfall data. Zonal statistics were used to extract the mean values of total precipitation using some point data to capture the actual rainfall value. These values were used to generate the rainfall variability map of each selected city.The procedures used in getting the temperature and rainfall variability maps were also extended to getting the temperature and rainfall variability maps for the entire Niger Delta but the ground temperature and rainfall values from NIMET were also used.

III. RESULTS

Trends of Temperature and Rainfall over Study Area

Rainfall Trends

The analysis of rainfall over the study area reveals that the area is experiencing an upward trend in rainfall. Port Harcourt rainfall increased at the rate of 3.33mm per annum (Figure 1) during the period studied, that is, 1990 to 2019. In the city of Calabar, rainfall increased by 12.40mm per annum (Figure2), Uyo experienced a 30.67mm per annum increase in rainfall (Figure 3). There is also an upward trend of 15.47mm per annum in rainfall for Niger Delta region as a whole (see Figure 4). This implies that the region is getting wetter. Based on the foregoing, Uyo has the highest increase in rainfall per annum while Port Harcourt has the lowest during the period under study.

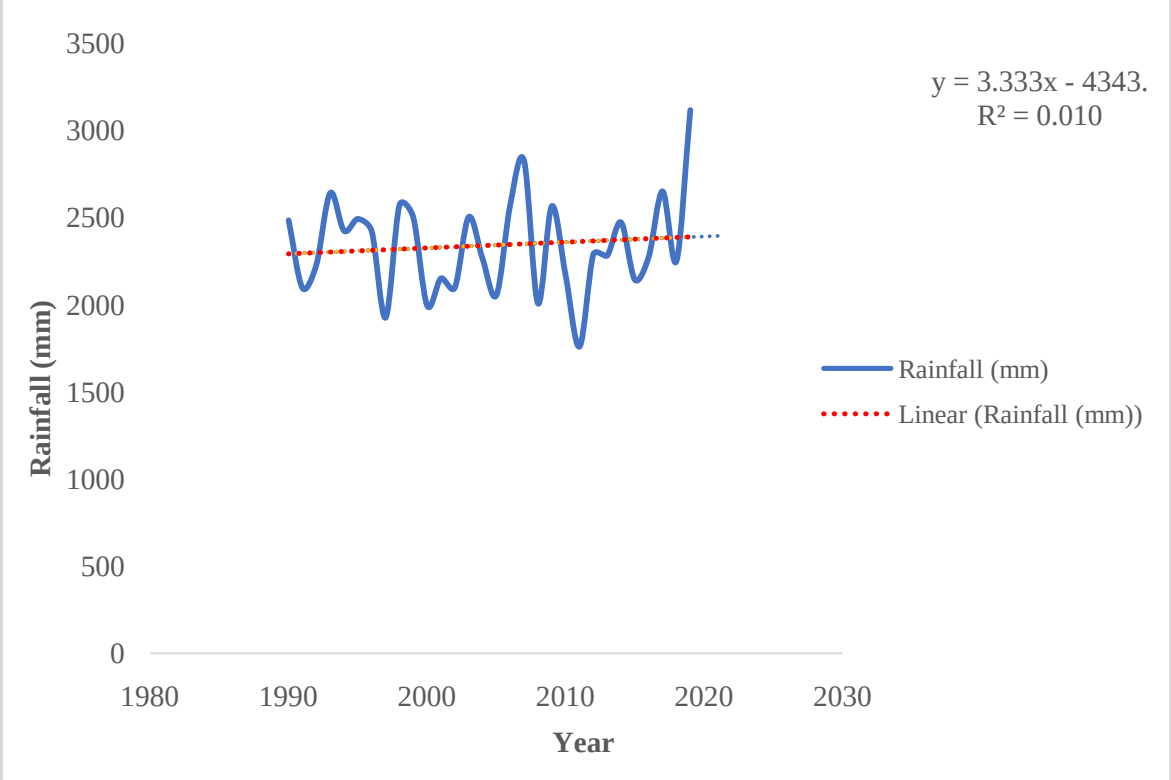

Figure 1: Rainfall Trend over Port Harcourt

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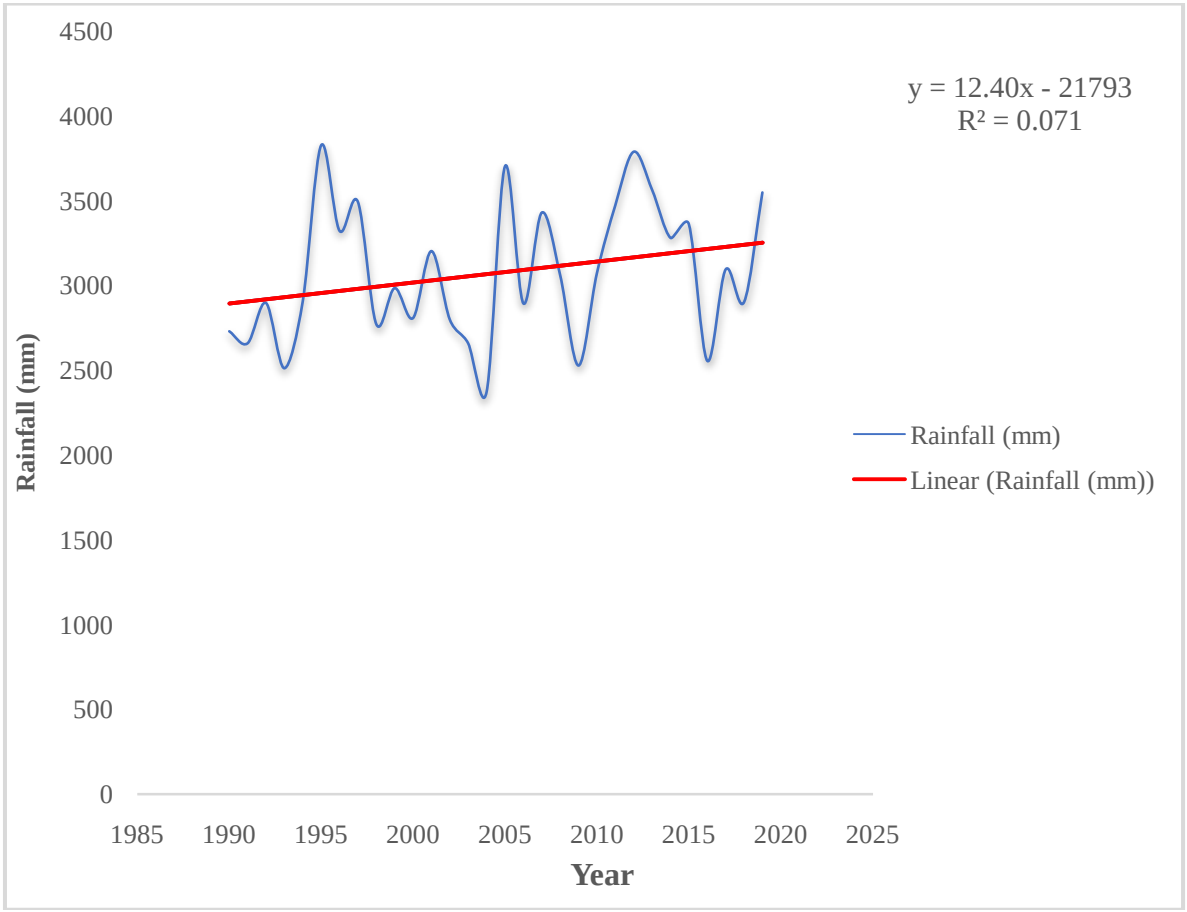

Figure 2: Rainfall Trend over Calabar

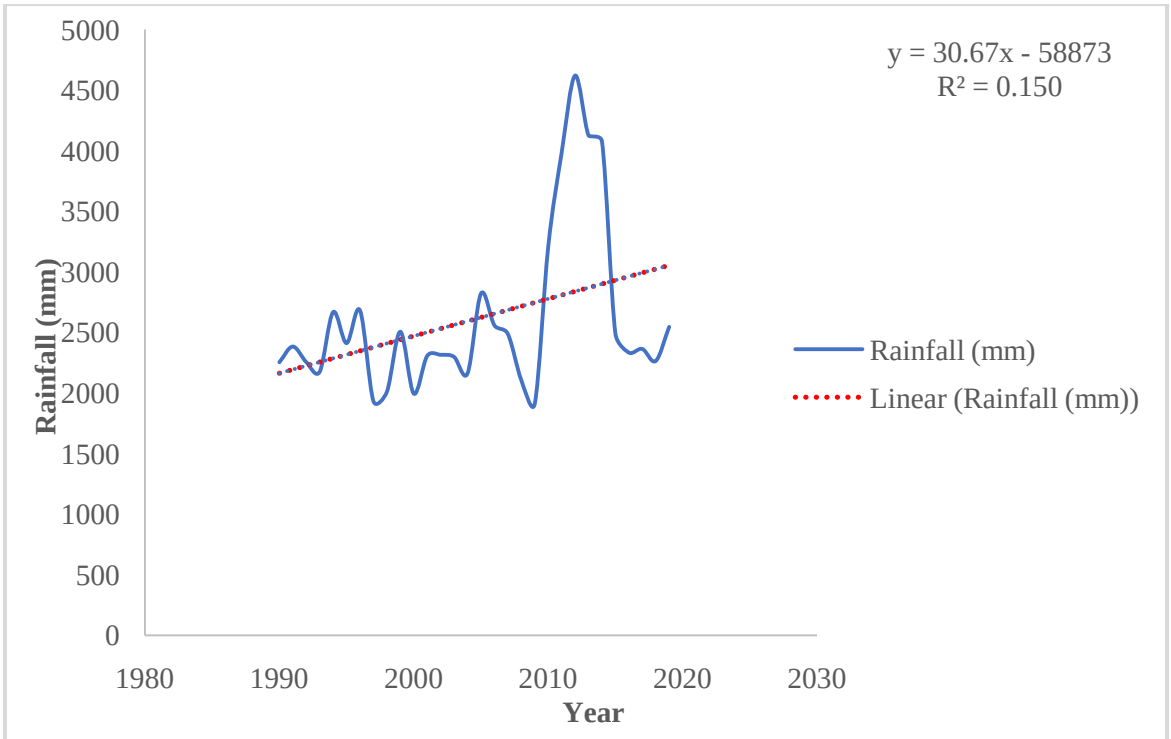

Figure 3: Rainfall Trend over Uyo

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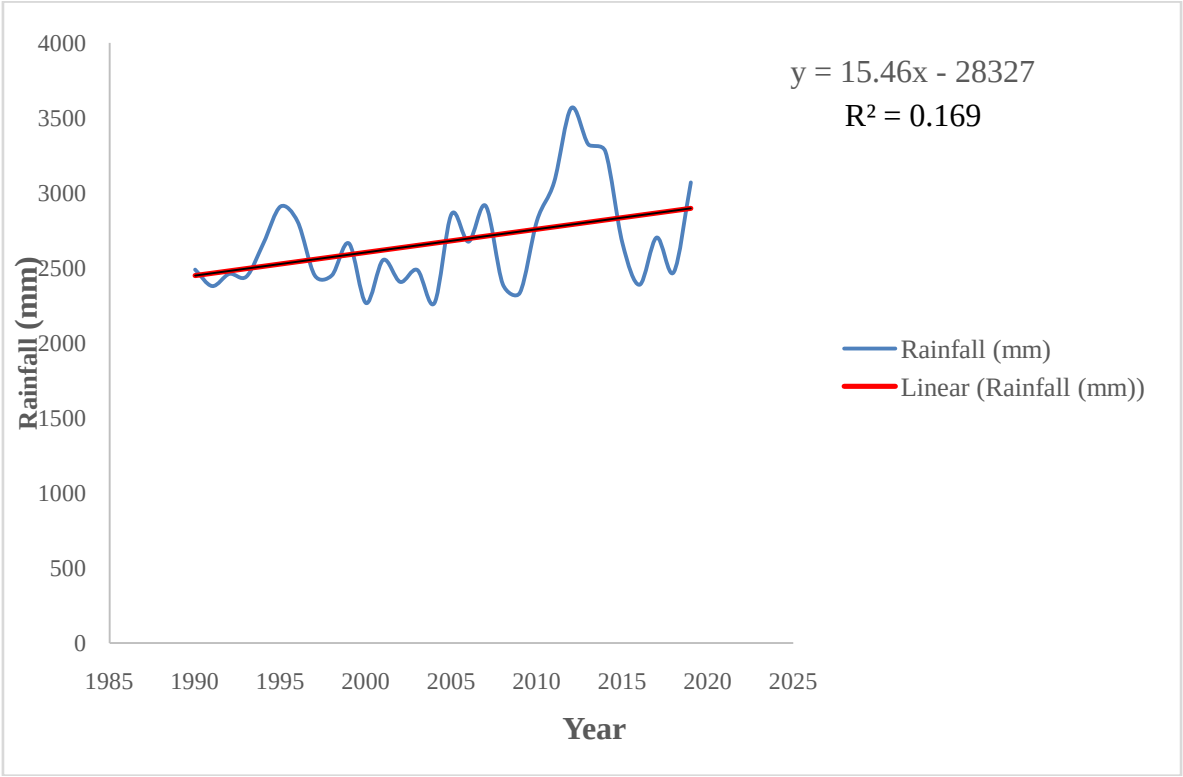

Figure 4: Rainfall Trend over Niger-Delta

Temperature Trends

The trend analysis of temperature across the cities under study shows that temperature was increasing in Port Harcourt at the rate of 0.020°C per annum (Figure 5). In Calabar, temperature increased slightly by 0.014°C per annum (Figure 6), Uyo, temperature increased by 0.016°C per annum as shown in (Figure 7). There is also an upward trend of 0.017mm per annum in mean temperature for Niger Delta region as a whole (see Figure 8). And by implication, the region is getting warmer.

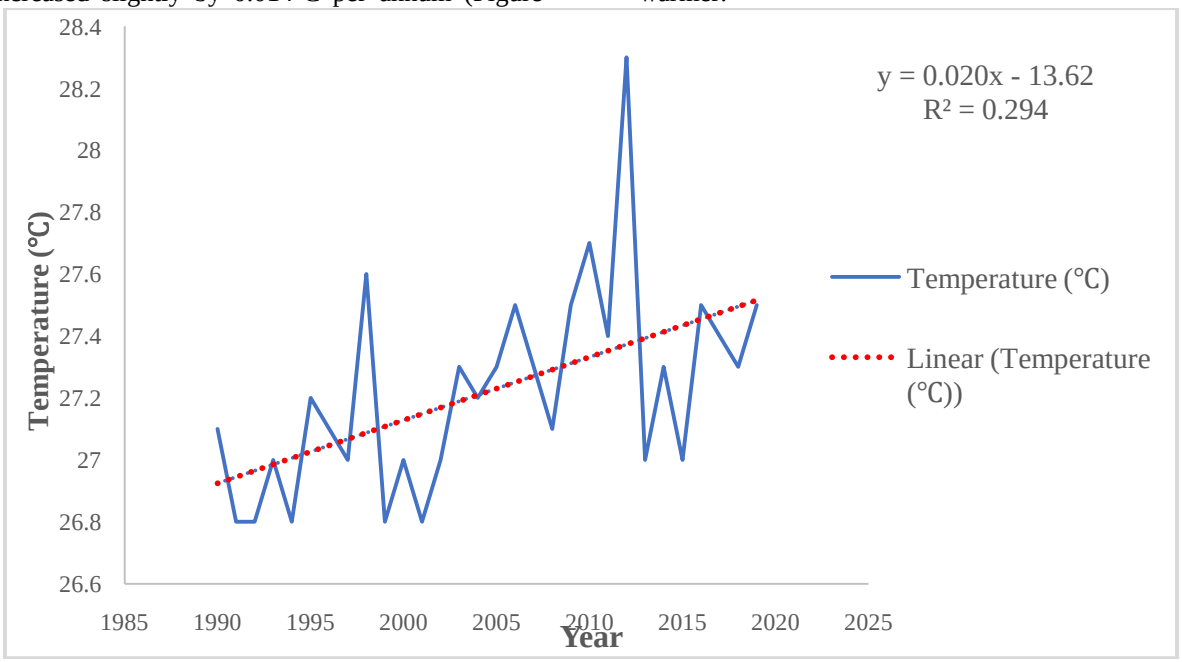

Figure 5: Temperature Trend over Port Harcourt

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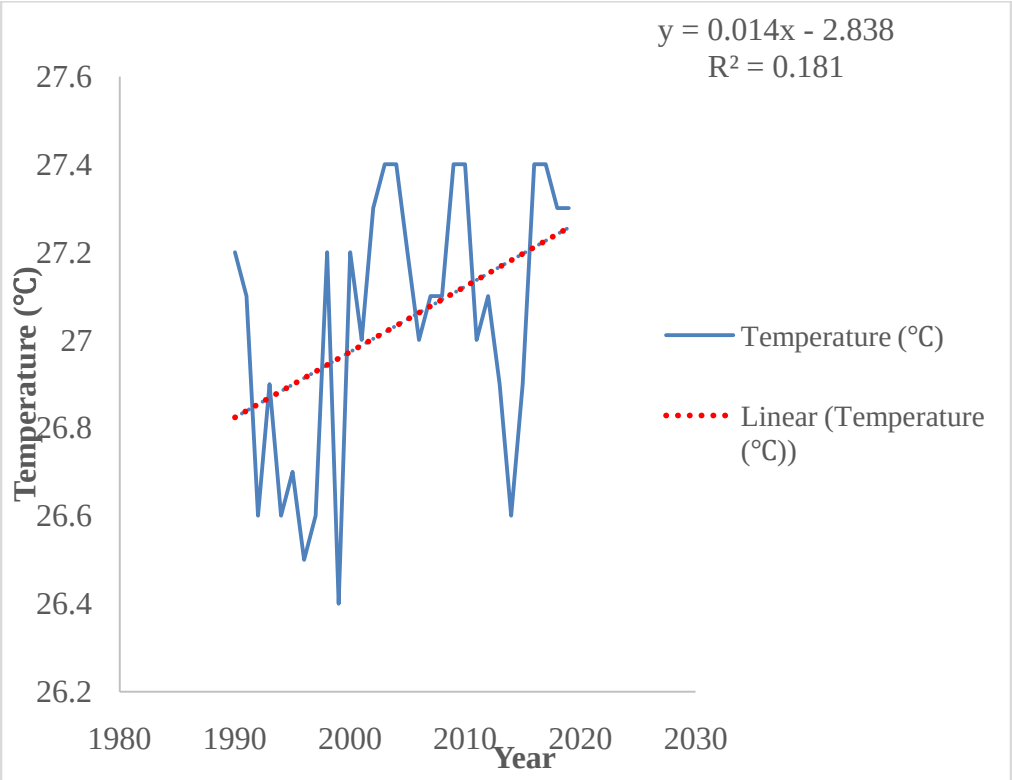

Figure 6: Temperature Trend over Calabar

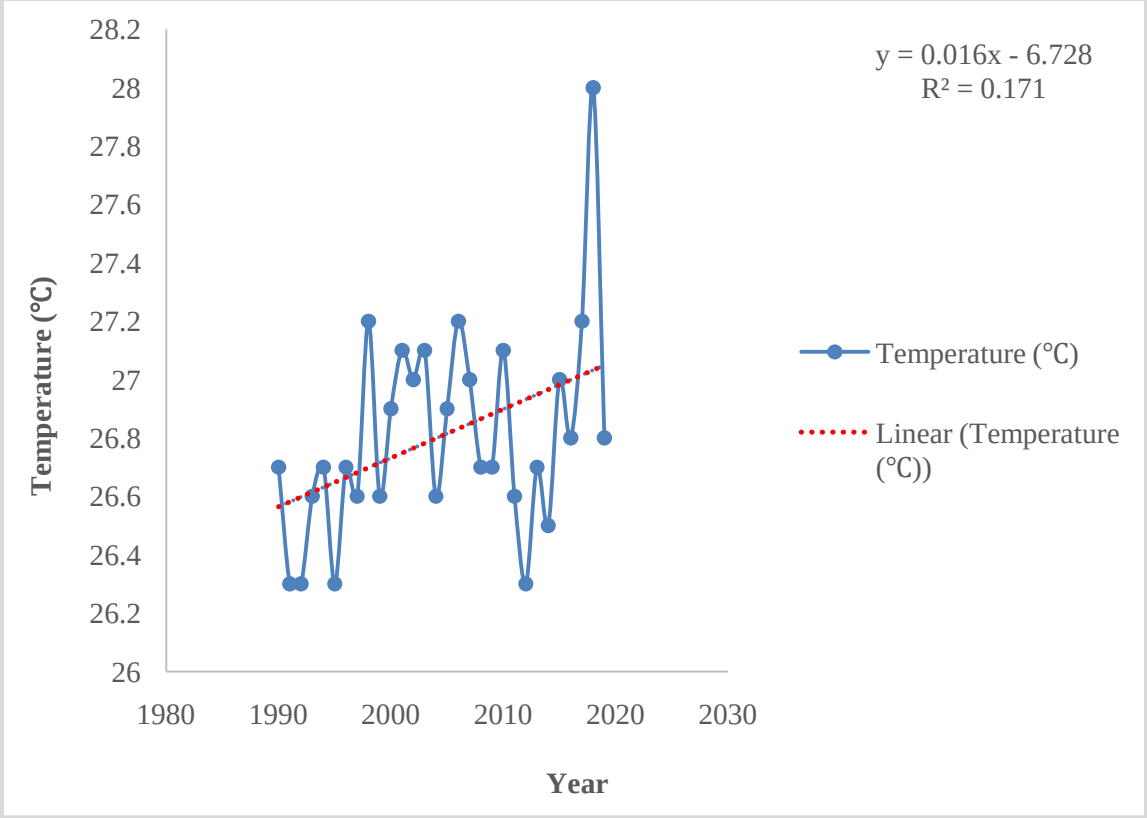

Figure 7: Temperature Trend over Uyo

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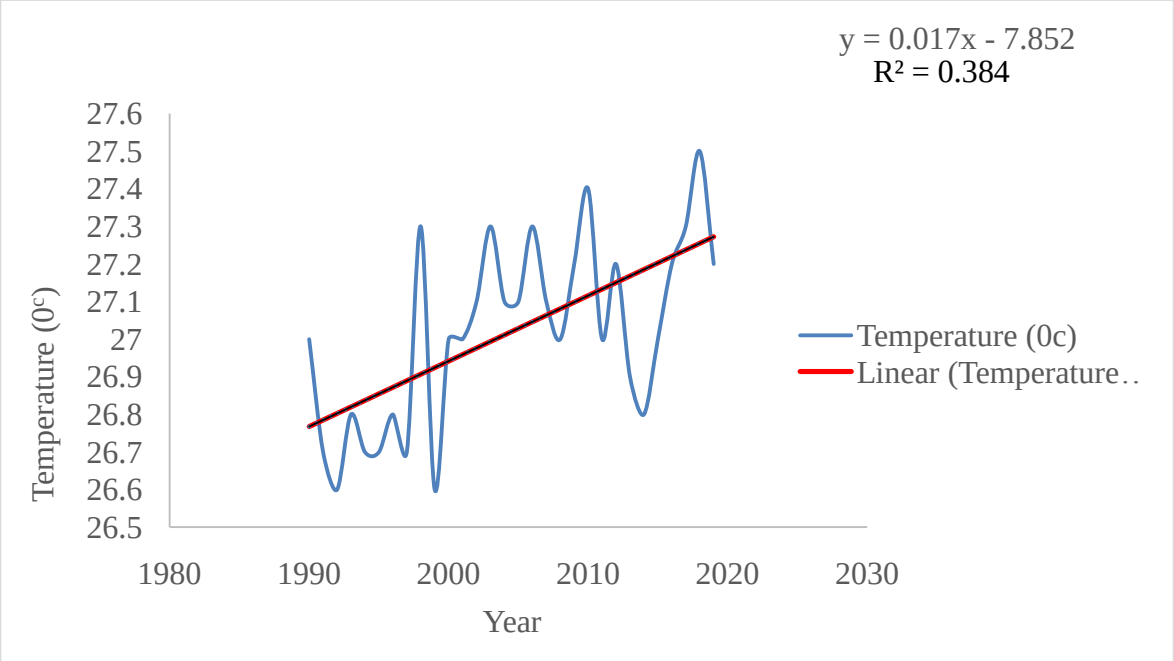

Figure 8: Temperature Trend over Niger Delta

Spatial Variation of Rainfall and Temperature over Study Area

Spatial variation of rainfall

The point grid pattern of meteorological data obtained for total rainfall were used to produce Figures 9,10, 11 and12 representing spatial distribution of rainfall over Port Harcourt, Uyo, Calabar and Niger Delta Region as a whole respectively. This covers the study period, 1990-2019. Areas bordering or closer to the coast (Atlantic Ocean) recorded the highest amounts of rainfall while lowest values were recorded in areas farthest from the coast during the period studied.

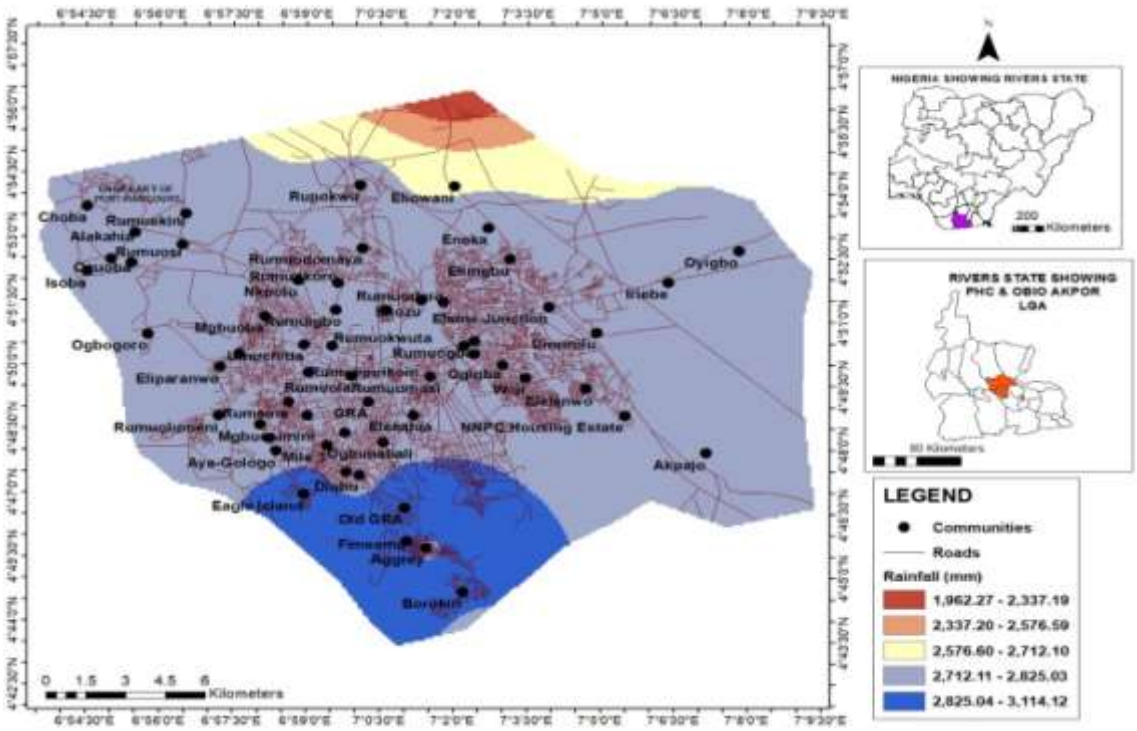

Figure 9: Rainfall distribution over Niger Delta between 1990-2019

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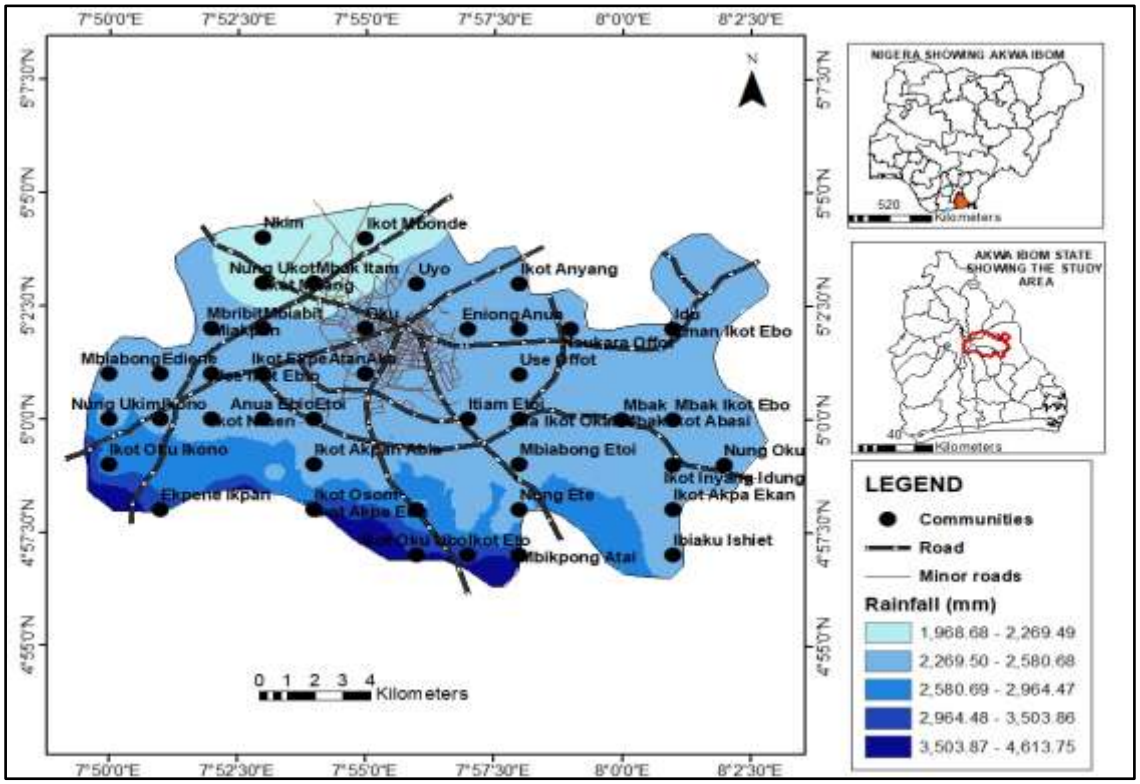

Figure 10: Mean Temperature distribution over Niger Delta between 1990-2019

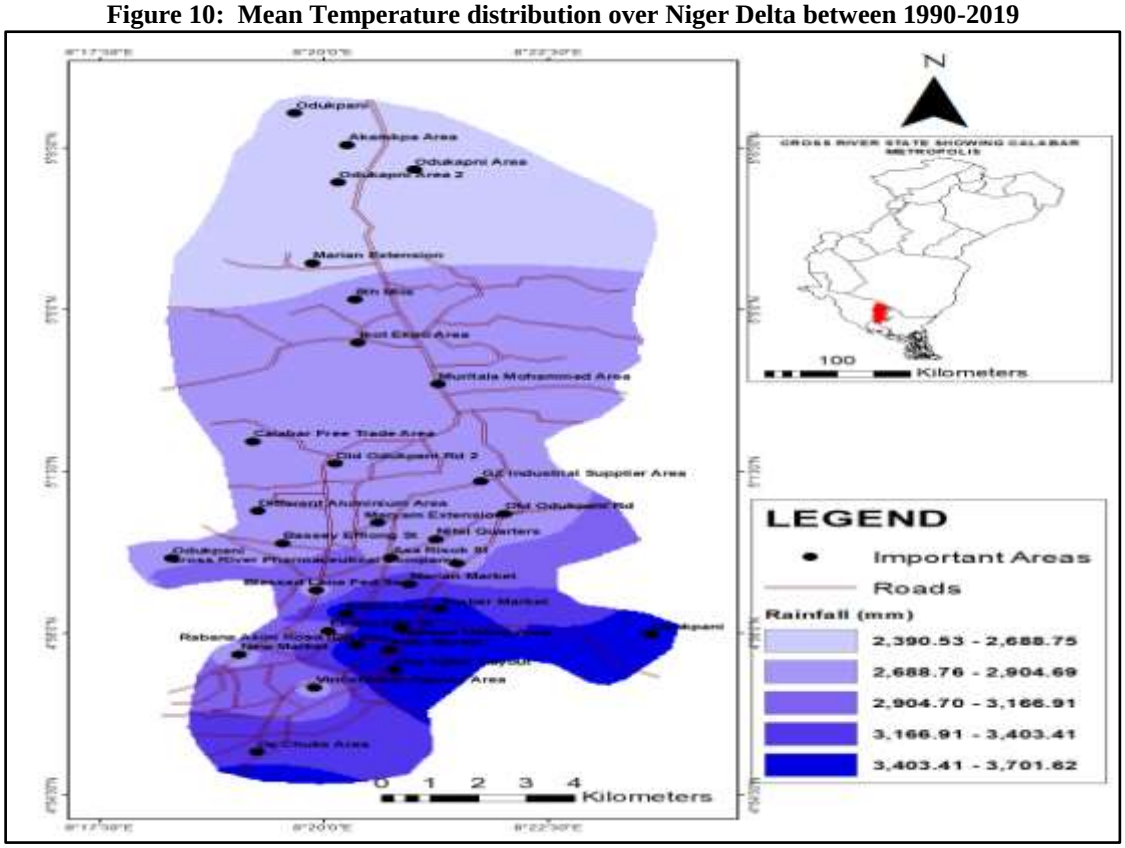

Figure 11 Calabar Rainfall analysis between 1990-2019

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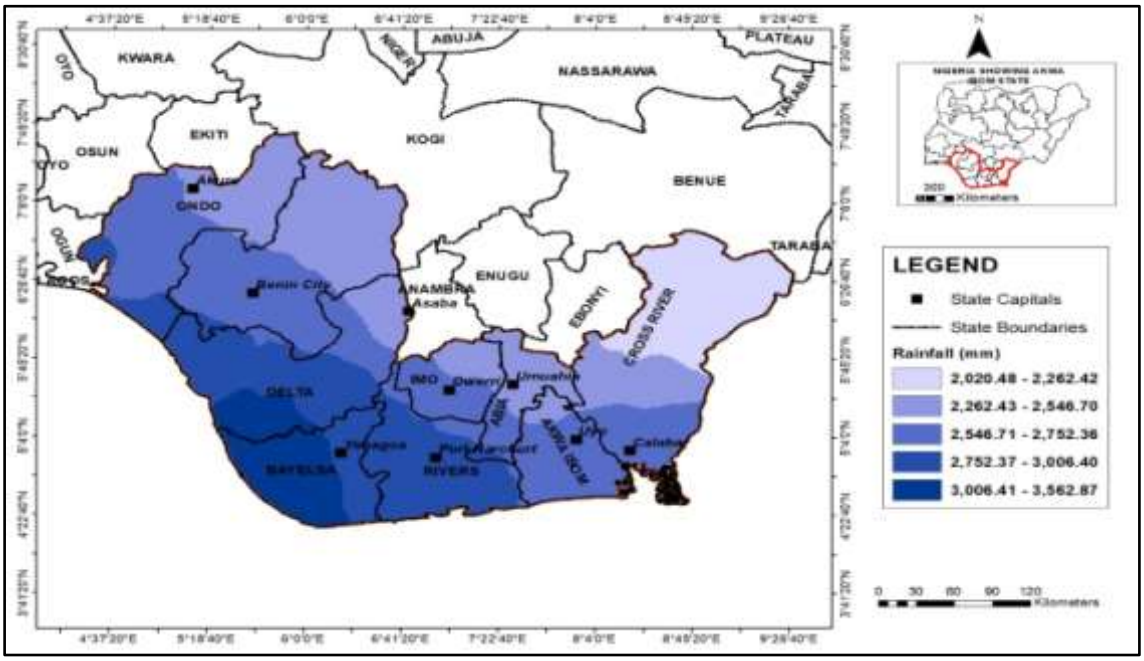

Figure 12: Rainfall distribution over Niger Delta between 1990-2019

Spatial variation of temperature

Secondary data such on MODIS Land Surface Temperature and Emissivity (MOD11) were used to produce Figures13,14,15 and 16 representing spatial distribution of temperature over Port Harcourt, Uyo, Calabar and Niger Delta Region as a whole respectively. This covers the study period, 1990-2019. These figures (the distribution/spatial analysis of mean temperature over the areas studied between 1990-2019 followed no particular pattern unlike that of rainfall. This can be attributed to other geographical factors such as topography, urbanization, industrialization etc.

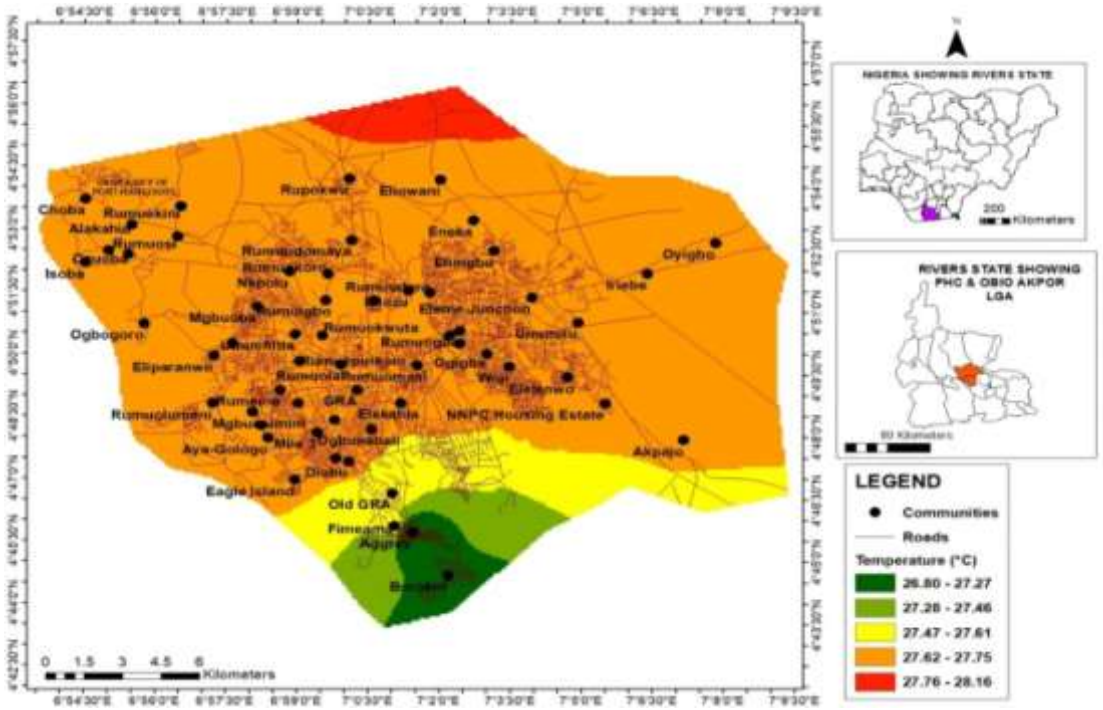

Figure 13 Port Harcourt and Obio-Akpor Temperature analysis between 1990-2019

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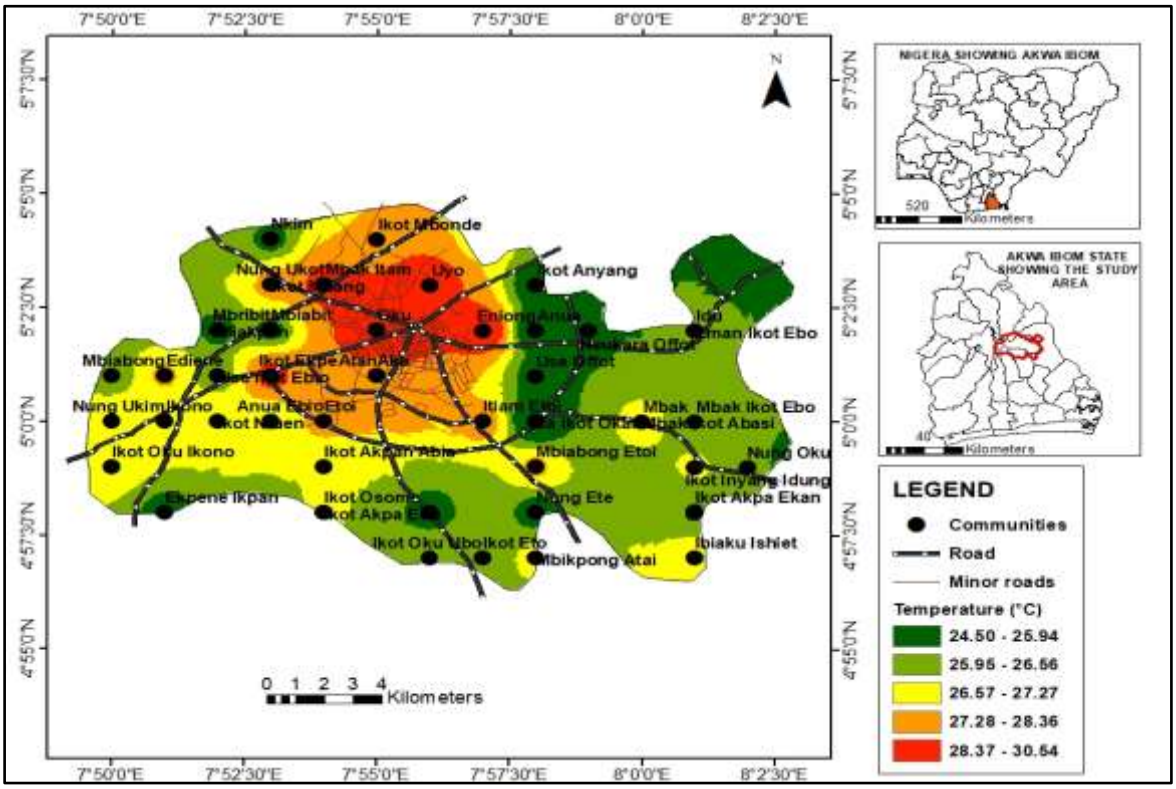

Figure 14 Uyo Temperature analysis between 1990-2019

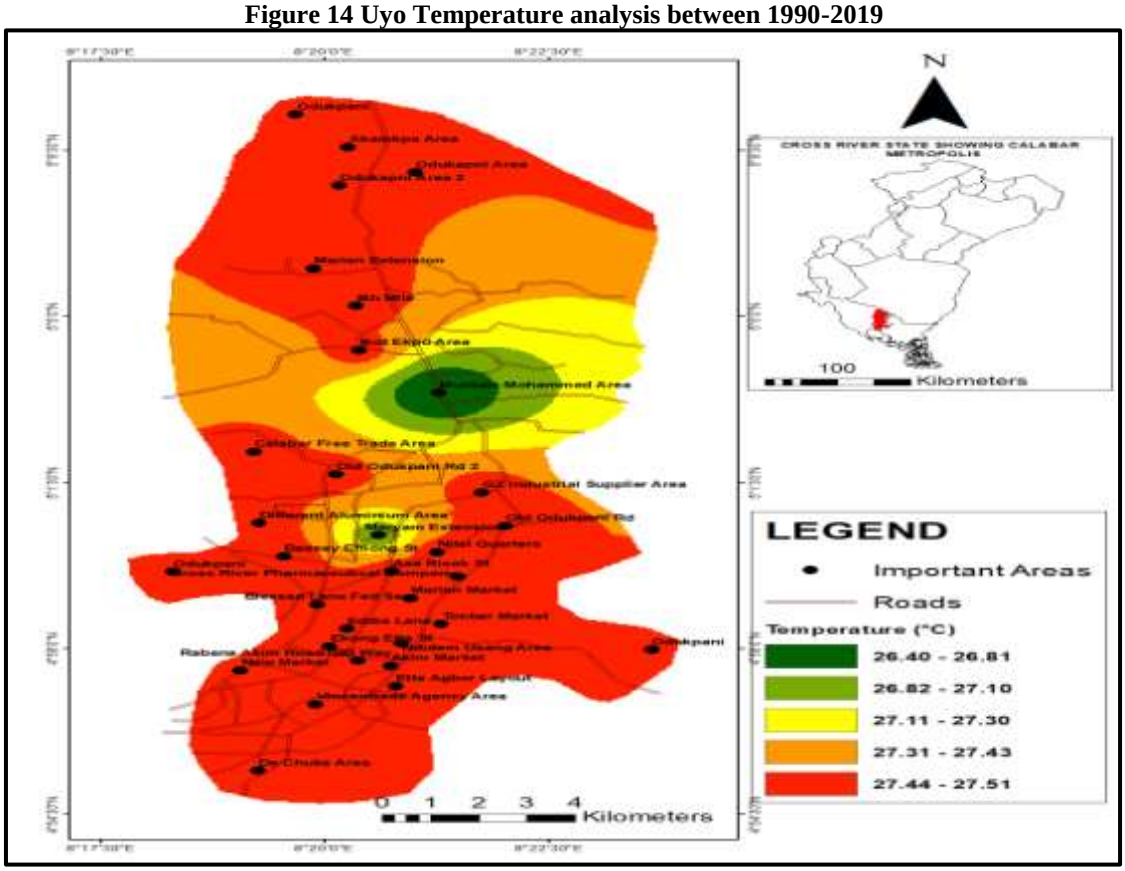

Figure 15 Calabar Temperature analysis between 1990-2019

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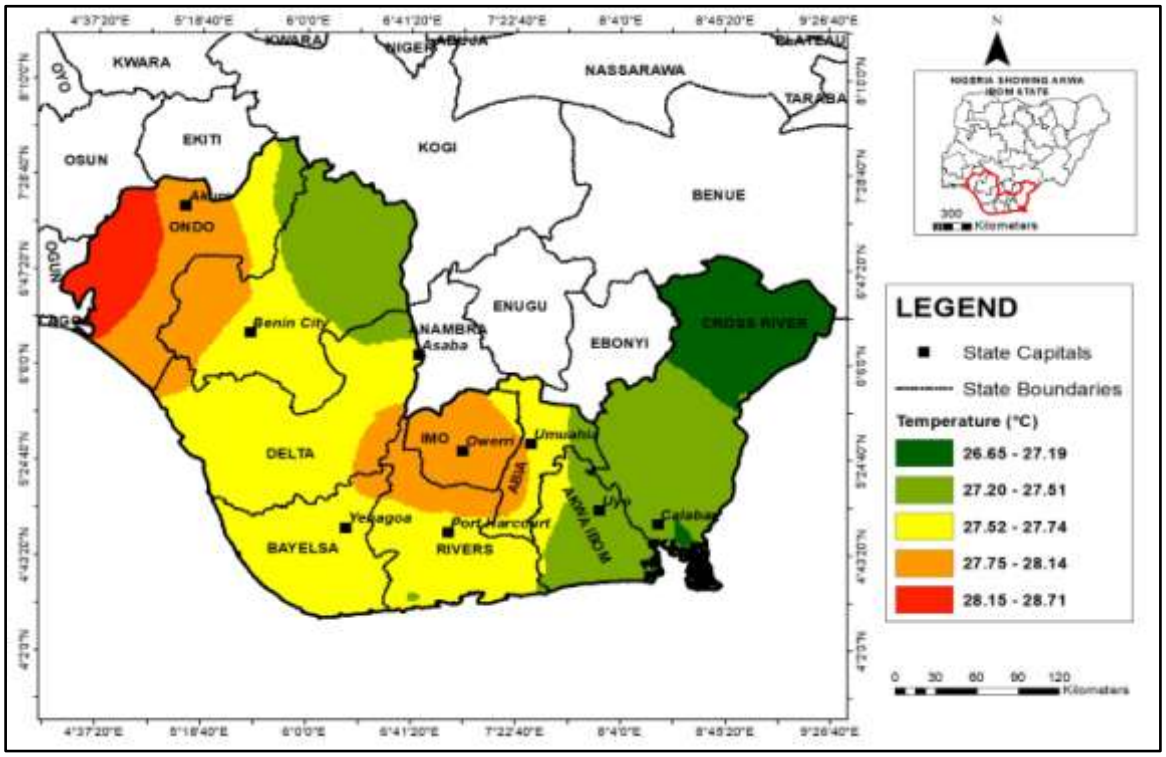

Figure 16: Mean Temperature distribution over Niger Delta between 1990-2019

IV. DISCUSSION OF FINDINGS

The finding of this research analysis revealed an increase in temperature and rainfall in all the cities studied. The analysis of rainfall over the study area reveals that the area is experiencing an upward trend in rainfall with Port Harcourt rainfall increased at the rate of 3.33mm per annum during the period studied, that is, 1990 to 2019. In the city of Calabar, rainfall increased by 12.40mm per annum, Uyo experienced a 30.67mm per annum increase in rainfall. There is also an upward trend of 15.47mm per annum in rainfall for Niger Delta region as a whole. This implies that the region is getting wetter. Based on the foregoing, Uyo has the highest increase in rainfall per annum while Port Harcourt has the lowest during the period under study. On the other hands, the trend analysis of temperature across the cities under study shows that temperature was increasing in Port Harcourt at the rate of 0.020^{o}C per annum, in Calabar, temperature increased slightly by 0.014^{o}C per annum, Uyo, temperature increased by 0.016^{o}C per annum while there is also an upward trend of 0.017mm per annum in mean temperature for Niger Delta region as a whole. And by implication, the region is getting warmer. The finding of this research agrees with the previous research of Balarabe (2018) whose study revealed increasing rainfall and temperature trends over a 30-year period. Also, the finding equally agrees with Sayne(2011) who revealed that many crops are sensitive to even tiny shifts in rainfall and temperature.

V. CONCLUSION AND RECOMMENDATIONS

The study Analysed the temperature and rainfall trend patternsin selected States in the Niger- Delta region**,** Nigeria.

Scientific data and farmers' experience point to changing patterns of temperature and rainfall in the region. Therefore, adaptation measures need to focus more on these climate elements to reduce the impact on farmers by boosting access to the livelihood assets. Support to farmers should strengthen their capacity and ability to cultivate improved crop varieties, adopt portfolio diversification, practice water and soil conservation, and use irrigation.

Based on the findings of the study, the given recommendations are proposed to mitigate or adapt to the climate change in Niger Delta region.

1. The data of the local meteorological hydrological station is accessible to only those who make a proposal with a reason with certain cash payment from the ministry of environment. For better understanding of the change in the climatic conditions, local farmers should be accessible to that information recorded in local weather stations.

There are needs for proper communication between the weather station and farmers about the recorded data through available media or any possible medium. This can help farmers to device a proper strategy for better adaptation or resilience options.

2. Government should play an active role in developing long term policies about the impact and consequences of climate change on farming. Providing awareness on this regard, increasing the number of technical or administrative officials to the community, allocating budgets on big projects to mitigate or improve adaptive capacity, provide incentives like free interest loans for the farmers and so on. Furthermore, the government should act as a bridge to connect these farmers to different farming communities so that they can exchange ideas and information on the issue of climate change and learn from each other. Collaboration of the government with the private sectors can add more benefits to the livelihoods of farmers. For example, implementing the insurance policy and research and development can benefit both the farmers and private sectors whose credit goes to the government.

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