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CHANGE IN RAINFALL AND TEMPERATURE PATTERNS AS EVIDENCE OF CLIMATE CHANGE IN BENIN-CITY, EDO, NIGERIA

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Abstract

This paper examined change in rainfall and temperature patterns as evidence of climate change in Benin-City, Edo State Nigeria. To achieve the above goal, the paper examined the major causes of change in rainfall and temperature patterns, the major evidence of change in rainfall and temperature patterns as evidence of climate change, the pattern of rainfall and temperature as evidence of climate change in Benin City, Edo State, Nigeria from 2003-2017. To accomplish the above goal, the paper gave a detailed explanation of the selected climatic elements, collected and examined them. The data required for this study were climatic data. These data were painstakingly collected from the Meteorological Station of Rubber Research Institute of Nigeria (RRIN), Benin-City, Edo State. Oral interview schedule was used to collect first-hand information from the staff of Rubber Research Institute of Nigeria (RRIN), Benin-City, Edo State, Nigeria to further validate them where applicable. The paper examined the causes of monthly and yearly meteorological data of rainfall (mm), mean monthly and annual Temperature (^oC) in Benin-City, Edo State of Nigeria from 2003-2017 (15 years), The paper shows that rainfall, and temperature in the study area vary from month to month and from year to year. The paper further reveals that the highest monthly rainfall amounts were recorded in July, 2012 (654.4mm), August, 2017 (608.5mm), May, 2013 (516.0mm) June, 2012 (512.0mm), and August, 2010 (456mm). Also, the high rainfall amounts in August have altered the long-standing pattern of August Break in Benin City. This observed rise in rainfall amount and the alteration in August Break is crystal-clear evidence of change in the rainfall pattern in Benin City, Edo state, Nigeria. Maximum temperature of 35.2^0C recorded in September, 2017 (the highest within the period). This is not only revealing a rise in temperature but also a threat to the earth, its atmosphere and humankind. The findings also reveal that rainfall amounts and temperatures are higher in the latter years These findings, unarguably are crystal clear evidences of change in rainfall and temperature pattern as evidence climate change in Benin City, Edo state, Nigeria. Owing to the above, this paper concludes that human activities that are capable of affecting climate markedly and negatively should be discouraged, and where possible avoided completely. Finally, the following actionable policy recommendations are made: the creation of awareness, sensitization and orientation in every nook and cranny on the causes of climate change, the proofs, and the damaging effects of climate change particularly enhanced global warming. In addition, there is the urgent need to bring to bear ways of returning to or creating a pristine environment on earth lest man will soon face terrible risks or challenges of climate change. So, authorities at the family, ward, local, state, national, regional, inter-regional and global levels should be involved in non-political sensitization on the problems of climate change and how to avoid them.

Keywords: *Temperature, Climate Change, Rainfall, Pattern and Benin City*.

Introduction

Climate change refers to any significant change in the measures of climate lasting for any extended period of time. In other words, climate change includes major changes in temperature, precipitation (in all its forms), or wind patterns among other effects that occur over several

decades or longer. It can also be seen as the physical modification of the general circulation of the earth's atmosphere on which climate ultimately depends (Ayoade, 2004). Furthermore, Okhakhu (2019) and IPCC (2021; Oxford Advance Learner's Dictionaries (2025)), opined that climate change is the statistical distribution of weather patterns, when that change lasts for an extended period of time, that is, decades to millions of years. Climate change may be conceived of as the change in average weather conditions or in time variation of weather around longer-term average conditions, that is, more or fewer extreme weather events. Rim-Rukeh (2009) refers to climate change as the changes in the statistical properties (mainly its mean and spread) in the climate system when considered over long periods of time. In a similar vein, Okhakhu (2019) observed that climate change is the realistic increase in the average temperatures of the global environment (atmosphere, lithosphere, hydrosphere, biosphere, cryosphere) and other constituent elements which constitute the planet Earth as a result of the unguided human activities.

From the foregoing, climate change can be referred to as the technical terminology used to describe the significant and long-lasting change in statistical distribution of weather patterns over periods ranging from decades to millions of years. It is also worthy of note to point out at this juncture that accordingly, fluctuations over periods shorter than a few decades do not represent climate changes. Moreso, climate change is sometimes used to specifically refer to climate change caused by human activities as opposed to changes in climate that may have resulted as part of natural processes of the earth.

Ayoade (2004), Emielu (2011), and Okhakhu (2019) posited that in the tropics, the term rainfall is interchangeable with precipitation since snow is generally absent except on some high mountains like the Kilimajaro in Tanzania, East Africa. So, in this paper, rainfall and precipitation are used interchangeably because the study area falls within the tropics (humid tropics). Therefore, in this paper, rainfall comprises rainfall itself, mist, fog, dew and hail. Ayoade (2004), Emielu (2011), and Okhakhu (2019) maintained that rainfall is the release of excess condensed water vapour from the lower atmosphere (troposphere) to the surface of the earth. They added that it is any aqueous deposit in liquid form derived from the lower atmosphere (troposphere). Rainfall is measured by means of rain gauge–the recording or autographic and the non-recording (Ayoade, 2004; Emielu, 2011). Rainfall is expressed in millimeters (mm) or centimeters (cm). However, in some countries (and in the past), it is measured in inches (inch).

Temperature as used in this paper is conceived of in terms of movement of molecules such that the more rapid the movement the higher the temperature. Temperature is usually defined in relative terms, that is, on the basis of the degree of heat a body has (Ayoade, 2004; Emielu, 2011; Okhakhu, 2019; Oxford Advance Learner's Dictionaries (2025)). It is the condition that determines the flow of heat from one substance to another. More frequently, heat moves from body with high temperature to a body with a lower temperature. The temperature a body has is determined by the balance between incoming and outgoing radiation and its transformation into latent heat and others (Petterssen, 1969; Nelkon and Parker, 1970; Ayoade, 2004; Emielu, 2011; Okhakhu, 2019). Temperature is measured by means of an instrument called thermometer (maximum and minimum) and it is expressed in degree Fahrenheit (^{o}F) or degree Celsius (^{o}C)

Climate change is one of the most pressing environmental challenges facing the globe today, with significant implications for ecosystems, agriculture, and human livelihoods. The humid tropics, characterized by high rainfall and temperature, are particularly vulnerable to climate variability and change due to their ecological sensitivity and socioeconomic dependence on natural resources (IPCC, 2020). Observations over recent decades have revealed notable shifts in temperature and rainfall patterns across tropical regions, suggesting a changing climate regime (Gonzalez et al., 2018; World Bank, 2023).

Temperature increases in the humid tropics have been documented globally, with mean surface temperatures rising steadily, leading to altered phenology, biodiversity loss, and increased frequency of extreme heat events (Taylor et al., 2017). This warming trend is consistent with global climate models that project amplified warming in tropical regions, despite historically smaller temperature increases compared to higher latitudes (Malhi et al., 2004). Additionally, changes in rainfall patterns, including shifts in the onset, intensity, and duration of rainy seasons, have been reported, often leading to more erratic precipitation regimes (Li et al., 2019). Such alterations affect water availability, soil moisture, and agricultural productivity, which are critical to the livelihoods of populations in the humid tropics (Xie et al., 2015; Dasgupta et al., 2021).

The humid tropics are influenced by complex climatic systems, including the Intertropical Convergence Zone (ITCZ), which governs rainfall distribution. Changes in the position and intensity of the ITCZ due to global warming have resulted in spatial and temporal variations in rainfall, causing some areas to experience prolonged droughts while others face intense flooding events (Xie et al., 2015). Understanding these changes is essential for developing effective adaptation strategies to mitigate the adverse impacts of climate variability on vulnerable communities.

Over the years, it has been observed that rainfall and temperature patterns across the globe in general and Benin-City in particular have changed. Owing to this, studies have been carried out in this area to ascertain the cause of the observed change. For instance, New, Todd, Hulme and Jones (2001), Rim-Rukeh (2009) and Okhakhu (2019) observed that climate change is responsible for change in rainfall patterns. Rainfall pattern has changed drastically because of increased evaporation of the runoff due to increased temperature. Also, rainfall pattern has changed because of decreased precipitation.

Furthermore, Edokpa (2020) observed that a significant increase in annual mean temperatures in southern Nigeria, with annual maximum, minimum, and mean temperatures rising at rates of 1.1°C, 1.4°C, and 1.2°C per 61 years, respectively. Notably, the highest increases were observed in February and March, suggesting a warming trend that could impact local climates, including Benin-City The study by Amaechi, Obeto, & Okoduwa, (2025) analyzed rainfall trends in Edo State from 1983 to 2023. The findings revealed that while the mean annual rainfall increased from 1,425 mm in 1983 to 1,892 mm in 2023, with a peak of 2,242 mm in 1995, no statistically significant trend was detected over the 41-year period. This suggests variability in rainfall patterns, which could have implications for water resources and agriculture in Benin-City.

Salami, Balogun & Ogunjobi, (2015)), in their study observed that Nigeria is experiencing adverse climatic conditions with negative impacts on the welfare of millions of people. Persistent droughts and flooding, off season rains and dry spells have sent growing seasons out of orbit, in a country dependent on a rain fed agriculture. Alarm bells are ringing with lakes drying up and a reduction in river flow in the arid and semi-arid regions. The result is fewer water supplies for use in agriculture, hydro power generation and other uses. The main suspect for all this havoc is climate change.

From the several yet detailed studies carried out by the above scholars (some of which would be used in the literature review), it is obvious that studies on change in rainfall and temperature patterns as evidence of climate change in Benin City, Edo State, Nigeria are non-existent. This non-existent nature of the above subject matter creates the research gap which this current paper intends to fill, that is, change in rainfall and temperature patterns as evidence of climate change in Benin City, Edo State, Nigeria.

Objectives of the Study

The overall aim of this paper is to examine change in rainfall and temperature patterns as evidence of climate change in Benin-City, Edo State, Nigeria. The specific objectives are to:

- **i.** examines the major causes of change in rainfall and temperature patterns in Benin-City. Edo State, Nigeria;
- **ii.** examine the major evidence of change in rainfall and temperature patterns as evidence of climate change in Benin-City. Edo State, Nigeria;
- **iii.** examine the pattern of rainfall and temperature as evidence of climate change in Benin City, Edo State, Nigeria from 2003-2017.

The Study Area

The study area is Benin-City and it is the administrative headquarters of Edo State. Benin-City lies roughly within latitudes$6^0$20'N and $6^0$58' N of the Equator and longitude $5^0$35'E and $5^0$41'E of the Prime Meridian (Okhakhu, 2010; Eseigbe, 2011, Ilenre, 2019). Benin-City comprises three local government areas and they are Oredo, Egor and Ikpoba-Okha. Benin-City occupies approximately an area of 607.48sqkm with an average elevation of 77.8m above mean sea level (Ministry of Lands and Surveys, Benin-City, 2008; Okhakhu, 2010; Ministry of Lands and Surveys, Benin-City, 2008). Furthermore, the meteorological station used in this paper is located within the study area but specifically lies within latitudes $6^0$26'N and $6^0$28' N of the Equator and longitude $5^0$37'E and $5^0$38'E of the Prime Meridian. Going by the latitudinal and longitudinal location of the study area, it falls within the Sub Equatorial Humid Region.

As noted earlier, the study area is located within the Sub Equatorial Humid Region and as a result, it experiences the Humid Tropical Climate. Humid Tropical Climate is usually characterized by two seasons: dry and wet. The dry and wet seasons in the study area are usually determined by rainfall (the amount, intensity, duration and distribution throughout the study area are brought about by the wind systems, clouds cover, temperature, atmospheric pressure and the deflection of the maritime air masses). Rainfall rather than temperature (albeit temperature plays significant impact) is the most influential element of climate in the study area (Udo, 1978; Okhakhu, 2010; Eseigbe, 2011; Balogun & Onokerhoraye. (2022).

The wet season is experienced from early February to mid-December every year. However, in most parts of the study area, scanty rainfall is experienced in December and January annually (Udo, 1978; Agboola and Hodder, 1979; Ilenre, 2019). Rainfall is mostly the convectional type and it falls heavily with torrential down pour. The dry season normally occurs between December and January with scanty rainfall. As a result of its latitudinal location, the study area has a daily temperature of between 27 and 36^{o}C and a rainfall amount of about 2000-2200mm yearly (Eseigbe, 2011). The heavy rainfall experienced virtually throughout the year and high temperatures all year round encourage the growth of rain forest vegetation. The rainfall and temperature conditions described above also encourage the growth and development of food crops (such as yam cocoyam, cassava, corn, groundnut and banana) and cash crops (such as natural rubber, cocoa, oil palm, oranges and pawpaw).

The study area experiences the bimodal rainfall cycle with the highest rainfall amounts recorded in the months of July and September yearly. The hilly landscape, insolation of the sun, presence of rivers and streams, presence of thick ever green rainforest vegetation and the availability of warm ocean currents have encouraged this heavy rainfall (Okhakhu, 2010; Ilenre, 2019). The second air mass which is technically termed tropical continental air mass is most dominant and felt as from mid-December and persists till January. The tropical continental air mass originates from the Sahara Desert and blows in North-East direction. This air mass is associated with the

harmattan wind which is cold, dry, dusty, harsh and hazy in nature. It brings about dry season in the study area (Udo, 1978; Okhakhu, 2010; Eseigbe, 2011).

In the study area, the first peak of rainfall is experienced in July, whereas the second peak is experienced in September. The wet season begins in February and attains its first peak in July while the second occurs in September. Both peaks are separated by a brief spell of dry weather technically referred to as" August Break". The wet and dry seasons as well as the double rainfall cycles are controlled by the position of the Inter-Tropical Discontinuity (ITD) whose movement is reflected in the corresponding shift within the rain belt (Okhakhu, 2010; Eseigbe, 2011; Ilenre, 2019).

High relative humidity of between 75-85% occurs regularly in the study area. This relative humidity is steady in the mornings, unstable in the afternoons and enhances during the evening and night times because of the difference in environmental factors of evaporation, transpiration, pressure decrease and the dominance of tropical maritime air mass for a greater part of the year (Okhakhu, 2010; Eseigbe, 2011; Ilenre, 2019; Dimuna, Ekhaese, and Ndimako, 2024).

In the study area, the prevalent winds are the North East Trade Wind (Tropical Continental Air Mass) and the South West Trade Wind (Tropical Maritime Air Mass). The North East Trade Wind (Tropical Continental Air Mass) is dominant from late November to early February yearly while the South West Trade Wind (Tropical Maritime Air Mass) prevails from late February to late November/early December yearly. The wind system in the study area has an average speed of 70-80km/h yearly (Okhakhu, 2010; Ilenre, 2019).

Literature Review

Climate change is unarguably altering global weather patterns, with significant implications for various ecosystems and human societies. The humid tropics, characterized by high temperatures and abundant rainfall, are particularly vulnerable to these shifts. This literature review examines the changes in rainfall and temperature patterns as evidence of climate change, focusing on the humid tropics in general and Benin-City in particular. Recent studies have highlighted significant changes in rainfall and temperature patterns in southern Nigeria, reflecting broader climatic shifts. For instance, Edokpa (2020) observed a significant increase in annual mean temperatures in southern Nigeria, with annual maximum, minimum, and mean temperatures rising at rates of 1.1°C, 1.4°C, and 1.2°C per 61 years, respectively. Notably, the highest increases were observed in February and March, suggesting a warming trend that could impact local climates. In terms of rainfall, Amaechi *et al*. (2025) analyzed rainfall trends in Edo State from 1983 to 2023. The findings revealed that while the mean annual rainfall increased from 1,425 mm in 1983 to 1,892 mm in 2023, with a peak of 2,242 mm in 1995, no statistically significant trend was detected over the 41-year period. This suggests variability in rainfall patterns, which could have implications for water resources and agriculture in Ekpoma. Studies in the Amazon basin (Malhi et al., 2004) and Southeast Asia (Cruz et al., 2007) have documented consistent increases in mean annual temperatures, along with a rise in the frequency and intensity of heat-waves. These increases have implications for heat stress on ecosystems and human populations. Researches in various parts of the humid tropics have shown an increase in rainfall variability. For instance, in West Africa, some studies indicate a general decrease in total annual rainfall in certain sub-regions since the 1970s, while others point to an increase in the frequency of extreme rainfall events and prolonged dry periods (Sylla et al., 2016). Similar trends of increased heavy rainfall events and drier dry seasons have been observed in parts of the Congo Basin (Zhou et al., 2014) and the Indo-Pacific Warm Pool (Cai et al., 2015; Dimuna, Ekhaese, and Ndimako, 2024).

The literature review showed that the diseases of natural rubber induced by the climatic elements of rainfall and temperature have been carried out in the humid tropics of the world. However, the specific case of the diseases of natural rubber induced by the climatic elements of rainfall, and

temperature in Ikpoba-Okha Local Government Area of Edo State, Nigeria has not been examined in any study. This recent vacuum is what this current paper intends to fill scientifically.

Materials and Methods

The data required for this paper are mainly meteorological and first-hand data (which require questionnaire administration). The meteorological data were sourced from the Meteorological Station of Rubber Research Institute of Nigeria (RRIN), Benin-City. The meteorological data were obtained through field investigations. Four hundred structured questionnaires were prepared and administered randomly to the respondents in the study area. All the structured questionnaires administered were retrieved. The data (meteorological and the ones obtained from the questionnaires) were analyzed using descriptive and cartographic methods such as tables and figures.

Results and Discussions

The Major Causes of Change in Rainfall and Temperature Patterns in Benin-City. Edo State, Nigeria

Table 6.1 shows the major causes of change in rainfall and temperature patterns as evidence of climate change in Benin-city. It reveals that burning of fossil fuels with 136 (34.00%) responses ranks first among all the causes and it is followed by deforestation which has 88 (22%) responses of the sample population. Table 6.1 also clearly reveals that the Use of fluorinated gases recorded 64 (16%) responses while, industrial actives had 37 (9.25%) responses of the sample population. The others are: emissions from dump sites which had 20 (5.00%) responses, agricultural activities and Heat from concrete floors recorded 15 (3.75%) responses each, heat from roof tops which is the second to the last in the ranking recorded 13 (3.25) % responses of the sample population while bush burning which ranked lowest in the study area had 12 (3.00%) responses of the sample population in the study area.

Table 1: The Major causes of Change in Rainfall and Temperature Patterns in Benin-City. Edo State, Nigeria

The Major causes of Change in Rainfall and Temperature Patterns in Benin-city	Frequency	Percentage
Burning of fossil fuels	136	34.00
Deforestation	88	22.00
Industrial activities	37	9.25
Agricultural activities	15	3.75
Use of fluorinated gases	64	16.00
Bush burning	12	3.00
Emissions from dump sites	20	5.00
Heat from roof tops	13	3.25
Heat from concrete floors	15	3.75
Total	**400**	**100**

Source: Field Survey, 2024

The Major Evidence of Change in Rainfall and Temperature Patterns in Benin-City. Edo State, Nigeria

Table 2 shows the major evidence of change in rainfall and temperature patterns in Benin-City, Edo State, Nigeria. The table clearly reveals that early arrival of dry season ranks first with 112 (28%) responses of the sample population and it is followed by irregular rainfall with 92 (23%)

responses of the sample population. Figure 6.2 further reveals that excessive temperature had 78 (19.50%) responses of the sample population while destructive thunderstorms had 74 (18.50%) responses of the sample population in the study area. Others are delayed rainy season with 26 (6.50%) responses of the sample population, disappearance of August Break recorded 11 (2.75%) responses of the sample population and cloudless skies which is the least of the evidences, recorded 7 (1.75%) responses of the sample population in the study area.

Table 2: The Major Proofs of Change in Rainfall and Temperature Patterns in Benin-City. Edo State, Nigeria

The major proofs of change in rainfall and temperature patterns as evidence of climate change in Benin-City	Frequency	Percentage
Delayed rainy season	26	6.50
Early arrival of dry season	112	28.00
irregular rainfall	92	23.50
Excessive temperature	78	19.50
Destructive thunderstorms	74	18.50
Disappearance of August Break	11	2.75
Cloudless skies	7	1.75
Total	**400**	**100**

Source: Field Survey, 2024

Change in Rainfall and Temperature Patterns as Evidence of Climate Change in Benin-City, Edo State, Nigeria from 2003-2017

From Table 3, it is very obvious that there is a change in the known rainfall pattern in Benin-City within the years under examination. For instance, January and December which are regarded as dry months, that is, with little or no rainfall recorded as high as 49.31mm, 26.0mm, 25.0mm, 23.5mm and 22.5mm in January 2003, 2017, 2004, 2012, and 2006 respectively. Also, December recorded as high as 49.3mm, 43.0mm, 32.2mm, and 21.6mm of rainfall 2012, 2016, 2014, and 2017 respectively. In addition, rainfall amount is on the increase in the study area within the period under consideration. For instance, the highest monthly rainfall amounts were recorded in July, 2012 (654.4mm), August, 2017 (608.5mm), May, 2013 (516.0mm) June, 2012 (512.0mm), and August, 2010 (456mm) respectively. The other months recorded less than 456mm of rainfall. Also, the data reveals that rainfall amounts are higher in the latter years. Within the period, the total rainfall amount is 30229.5, the monthly rainfall range is 654.1mm (654.1mm-0.0mm) while the annual rainfall range is 1494.8mm (2824.4mm-1527.6mm = 1494.8mm). The mean annual rainfall is 2015.3mm (30229.5mm/15 = 2015.3mm). These are very clear evidences of change in the rainfall pattern in Benin City, Edo state, Nigeria.

Furthermore, August which is known for break in the rains (August Break) in Benin City recorded the highest amount of rainfall in the years 2017 (608.5mm), 2010 (456.3mm), 2014 (391.4mm) and 2006 (335.9mm). These months were also among the highest in the study area within the period under review. This may have prompted Iboaya (2013) and Ilenre (2019) to maintain that there is a change in the pattern of rainfall in Benin City, Edo state, Nigeria and that it is reflected in the unpredictable nature of rainfall in Benin City. These high rainfall amounts in August have altered the long-standing pattern of August Break in Benin City. This observed alteration in August Break is crystal-clear evidence of change in the rainfall pattern in Benin City, Edo state, Nigeria. Figure 1 further elucidates the change in rainfall and temperature patterns as evidence of climate change in Benin-City Edo state, Nigeria.

Table 3: Meteorological Data of Mean Monthly and Annual Rainfall (mm) in Benin-City, Edo State of Nigeria from 2003-2017 (15 Years)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
2003	49.31	26.90	68.30	250.8	181.2	162.9	155.0	170.1	131.5	293.7	31.3	0.0	**1703.0**
2004	25.2	13.5	55.3	106.4	323.4	355.7	214.3	298.6	251.1	247.0	28.3	0.0	**1595.0**
2005	0.0	15,7	167.2	114.1	138.9	292.7	406.8	80.9	177.3	167.2	33.9	0.0	**1595.0**
2006	22.5	10.5	61.5	158.0	246.8	172.5	289.0	335.9	347.4	304.5	24.7	0.0	**1972.9**
2007	0.0	104.2	56.2	197.7	246.2	380.9	284.7	171.4	256.0	270.0	32.4	17.1	**2036.5**
2008	1.2	4.2	72.4	182.7	208.6	360.9	297.5	186.4	266.6	270.0	32.4	4.0	**1819.7**
2009	1.6	134.2	78.3	226.6	248.6	207.7	148.7	254.0	278.1	192.8	109.4	1.3	**1882.0**
2010	0.0	57.5	38.7	219.9	125.4	174.6	257.8	456.8	282.1	373.8	109.3	0.0	**2094.4**
2011	0.0	116.2	84.9	118.3	264.0	275.2	430.3	277.8	250.9	240.8	68.8	0.0	**2127.2**
2012	23.5	84.0	56.2	209.7	308.6	512.0	654.4	96.8	332.3	240.9	256.4	49.6	**2824.4**
2013	7.5	10.6	122.3	254.3	516.0	315.0	402.2	235.7	585.0	260.4	86.9	10.8	**2606.7**
2014	13.6	10.6	122.3	254.3	232.3	252.7	336.8	391.6	255.3	422.2	109.0	32.2	**2433.6**
2015	0.0	4.0	15.1	23.0	168.2	324.0	182.3	156.1	348.1	74.5	22.2	0.0	**1327.6**
2016	0.0	2.9	53.8	98.0	126.1	204.7	272,2	242.9	258.9	106.4	15.4	43.0	**1559.3**
2017	26.0	26.0	53.8	107.0	96.1	315.0	402.2	608.5	250.8	103.0	41.5	21.6	**2652.2**

Source: Rubber Research Institute of Nigeria (RRIN), Benin-City, Edo State, Nigeria, 2018

Table 4 Meteorological Data of Mean Monthly and Annual Temperatures (ºC) in Benin-City, Edo State of Nigeria from 2003 -2017 (15 Years)

Table 4 shows the distribution pattern of temperature in Benin City, Nigeria from 2003-2017. From the Table, it is crystal clear that temperature is steadily on the increase. For instance, the total annual temperature was 343.7^{0}C in 2009, 341.5^{0}C in 2014, 337.5^{0}C in 2012, 335.0^{0}C in 2013, 333.4^{0}C in 2008, 329.1^{0}C in 2004, 326.7^{0}C in 2010, 326.5^{0}C in 2003 and 320.5^{0}C in 2015. Also very interesting is the maximum temperature of 35.2^{0}C recorded in September, 2017 (the highest within the period). This is not only revealing a rise in temperature but also a threat to the earth, its atmosphere and humankind. This further supports the findings of World Health Organization (WHO) (2021), the high temperature in Benin-City is a threat to human life. February, 2003 recorded 30,4^{0}C while March, 2009 and 2010 recorded 30.1^{0}C each. The other months recorded less than 30.1^{0}C of temperature in the study area within the period under consideration. Also, the data reveal that temperatures are higher in the latter years. Within the period, the total temperature is 4887.2^{0}C, the annual temperature range is 39.0^{0}C (347.7^{0}C - 308.7^{0}C = 39.0^{0}C) while the monthly temperature range is 11.5^{0}C (35.2^{0}C -23.7^{0}C = 11.5^{0}C). The mean annual temperature is 325.8^{0}C (4887.2^{0}C //15 = 325.8^{0}C). These are very clear evidences of change in temperature pattern occasioned by climate change in Benin City, Edo state, Nigeria.

The above observation agrees with the findings of Rim-Rukeh (2009) and Iboaya (2013) that there is a dangerous increase in the temperature of the earth and apparently Benin-City included. Tables 6.2 and Figure1further revealed that there is a significant relationship between the amount of rainfall and temperature in the humid tropics. It is very obvious from the rainfall and temperature data in Tables6.1 and 6.2 that rainfall amount is high in Benin-City because of the correspondingly high temperature. This characteristic is typical of the humid tropics and Benin-City falls within this region.

Table 6.4: Mean Monthly Temperature (°C) in Benin-City, Edo State of Nigeria from 2003-2017 (15 Years)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
2003	25.9	30.4	29.3	28.0	28.2	25.6	25.4	26.4	25.4	26.9	27.5	27.5	**326.5**
2004	27.6	29.1	27.5	28.1	27.3	26.8	26.3	25.8	26.0	26.7	27.6	28.3	**329.1**
2005	26.5	29.6	27.9	28.3	26.4	26.2	23,7	24.3	26.0	26.3	26.5	27.0	**318.7**
2006	28.2	29.2	28.5	28.8	26.4	25.7	26.4	24.7	24.0	25.4	26.2	26.3	**319.8**
2007	26.3	28.2	28.3	27.6	26.8	23.0	25.5	25.5	24.5	24.5	24.5	26.2	**310.4**
2008	26.3	28.9	28.2	28.3	27.3	28.0	26.1	26.1	27.0	28.3	29.7	29.2	**333.4**
2009	28.7	29.4	30.1	29.8	29.5	28.4	27.8	27.4	27.3	26.7	27.8	29.5	**343.7**
2010	29.4	29.8	30.1	24.7	28.5	27.0	25,4	24.8	25.9	26.6	27.3	27.2	**326.7**
2011	26.1	27.8	28.6	27.5	27.2	26.4	24.8	24.7	25.3	26.4	27.4	26.6	**318.8**
2012	28.1	28.1	29.2	28.8	28.3	27.9	26.8	27.8	26.5	27.8	27.5	27.6	**335.0**
2013	28.4	29.1	29.3	29.0	29.5	28.1	27.0	26.1	26.8	27.8	28.7	27.7	**337.5**
2014	28.9	29.1	29.2	29.5	28.7	28.3	25.9	26.5	27.0	25.6	25.5	27.3	**341.5**
2015	24.1	26.8	26.7	27.0	26.8	25.6	24.9	26.7	25.5	26.3	26.4	23.7	**320.5**
2016	25.0	25.4	26.7	27.4	26.2	24.6	24.4	24.9	25.4	26.0	26.5	26.2	**308.7**
2017	24.1	26.2	26.5	27.6	26.2	28.1	27.0	26.5	35.2	26.2	26.7	26.5	**316.9**

Source: Rubber Research Institute of Nigeria (RRIN), Benin-City, Edo State, Nigeria, 2018

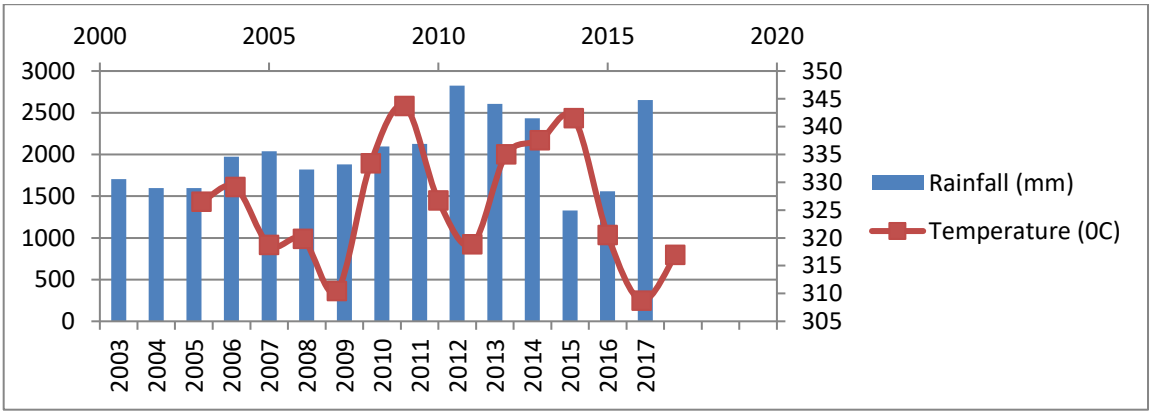

Figure 1: Yearly Meteorological Data of Rainfall (Mm) and Temperature (^{O}C) IN Benin-City, Edo State of Nigeria from 2003 -2017 (15 Years)

Conclusion and Recommendations

The consciousness of the modern man not to be at the mercy of the weather is also responsible for the risk of weather-related problems that he has. Man's effort to control weather at one time leads to a far-reaching negative effect in the nearest or later future. The study looked at change in rainfall and temperature patterns as evidence of climate change in Benin-City Edo state, Nigeria in details because they are aftermath of man's attempts to have control over weather. In view of the above, the study looked causes of climate change in Benin-City, the evidence of climate change in Benin-City and an examination of the changes in the patterns of rainfall and temperature attributed to climate change in Benin-City. The paper revealed that there is a change in rainfall and temperature patterns due to climate change in Benin-city, Edo State, Nigeria. This paper passionately recommends the creation of awareness, sensitization and orientation in every nook and cranny on the causes of climate change, the proofs, and the damaging effects of climate change particularly enhanced global warming. In addition, there is the urgent need to bring to bear ways of returning to or creating a pristine environment on earth (the home of man) with Benin-City included lest man will soon face terrible risks or challenges of climate change. So, authorities at the family, ward, local, state, national, regional, inter-regional and global levels should be involved in non-political sensitization on the problems of climate change and how to avoid them.

References

Amaechi, C., Obeto, M., &Okoduwa, A. K. (2025). Trend and spatial distribution of rainfall: A case study of Edo State, Southern Nigeria from 1983–2023. *NIPES Journal of Science and Technology Research, 6*(4). https://doi.org/10.5281/zenodo.14649294.

Atkinson, B. N. (1972). The atmosphere. In D. Q. Bowen (Ed.), *A concise physical geography*. Hulton Educational Publication.

Ayoade, J. O. (2004). *Introduction to climatology for the tropics*. Spectrum Books Ltd.

Balogun, T. F., &Onokerhoraye, A. G. (2022). Assessment of the urban climate of Benin City, Nigeria. *Journal of Environment and Earth Science, 12*(4).

Cai, W., Borlace, S., Lengaigne, M., van Rensch, P., Yang, D., Santoso, M., ... &McPhaden, M. J. (2015). Increasing frequency of extreme El Niño events due to greenhouse warming. *Nature Climate Change, 5*(2), 143–147.

Christner, B. C., Morris, C. E., Foreman, C. M., Cai, R., & Sands, D. C. (2008). Ubiquity of biological ice nucleators in snowfall. *Science, 319*(5867), 1214.

Dasgupta, S., Laplante, B., Meisner, C., Wheeler, D., & Yan, J. (2021). The impact of climate change on water resources in the humid tropics: A review. *Environmental Science & Policy, 112*, 52–63.

Dimuna, K. O., Ekhaese, E. N., &Ndimako, O. O. (2024). Climate change impact on the architecture and built environment dwellers' well-being in Niger Delta Region: A systematic review. *Frontiers in Climate.*https://www.frontiersin.org/articles/10.3389/fclim.2024.1498938/full

Edokpa, D. A. (2020). Variability in the long-term trends of rainfall and temperature over Southern Nigeria. *Journal of Geography, Meteorology and Environment, 3*(1). https://journals.unizik.edu.ng/jgme/article/view/377

Emielu, S. A. (2011). *Senior secondary geography*. Geographical Bureau Nigeria.

Eseigbe, J. O. (2011). *The impact of soil erosion on the physical landscape in the Benin Metropolis, Edo State, Nigeria* (Unpublished PhD thesis). Department of Geography and Regional Planning, Ambrose Alli University.

Gonzalez, P., Tucker, C., & Sy, H. (2018). Climate change and the tropical forest: Evidence from rainfall and temperature trends. *Global Change Biology, 24*(5), 2203–2212.

Iboaya, B. A. (2013). *A comprehensive certificate geography for schools and colleges* (Revised ed.). Benking Intellectual Publishers.

Ilenre, A. E. (2019). *The impact of some climatic elements on the yield of natural rubber (Hevea brasiliensis) in Ikpoba Okha Local Government Area of Edo State, Nigeria* (Unpublished PhD thesis). Department of Geography and Environmental Management, Ambrose Alli University, Ekpoma, Nigeria.

Iloeje, N. P. (1982). *A new geography of Nigeria*. Longman Nigeria Ltd. *(Note: Originally listed as 1882, corrected to 1982 as appropriate.)*

Intergovernmental Panel on Climate Change (IPCC). (2021). *Climate change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Li, X., Zhang, W., & Chen, D. (2019). Changes in rainfall seasonality in the humid tropics under global warming. *Journal of Climate, 32*(14), 4521–4537.

Malhi, Y., & Wright, J. (2004). Spatial patterns and recent trends in the climate of tropical rainforests. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 359*(1443), 311–329.

Nelkon, M., & Parker, P. (1970). *Advanced level physical geography* (3rd ed.). Heinemann.

New, M., Todd, M., Hulme, M., & Jones, P. (2001). Review: Precipitation measurements and trends in the twentieth century. *International Journal of Climatology, 21*(15), 1889–1922.

Okhakhu, P. A. (2010). *The significance of climatic elements in planning urban environment of Benin City, Nigeria* (Unpublished PhD thesis). Department of Geography and Regional Planning, Ambrose Alli University, Ekpoma, Edo State, Nigeria.

Okhakhu, P. A. (2019). *Research methods in climatology*. Ambrose Alli University Publishing House.

Oxford Advanced Learner's Dictionaries. (2025). https://www.oxfordlearnersdictionaries.com

Petterson, S. (1969). *Introduction to meteorology* (3rd ed.). McGraw-Hill.

Rim-Rukeh, A. (2009). *Environmental science: An introduction*. Kraft Books Limited.

Salami, A. O., Balogun, A. A., & Ogunjobi, K. O. (2015). Trend analysis of rainfall and temperature in Akure, Ondo State, Nigeria. *Journal of Scientific Research & Reports, 7*(3), 227–236.

Sylla, M. B., Giorgi, F., & Mariotti, L. (2016). Rainfall change in West Africa in the recent past and future projections in CMIP5 models. *International Journal of Climatology, 36*(2), 692–702.

Taylor, L., Mapfumo, P., &Rukuni, M. (2017). Temperature changes and their impact on tropical agriculture. *Agricultural Systems, 156*, 165–173.

Udo, R. K. (1982). *The human geography of tropical Africa*. Heinemann Educational Books (Nig.) Ltd.

World Bank. (2023). *Benin country climate and development report*. https://www.worldbank.org/en/country/benin/publication/benin-country-climate-and-development-report

World Health Organization (WHO). (2021). *Health climate change survey report: Tracking global progress*. https://www.who.int/news-room/fact-sheets/detail/climate-c