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A statistical discourse of the climate of the Niger Delta Region of Nigeria

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Abstract
The study aimed at investigating the climate of the Niger Delta Region (NDR) of Nigeria. This is to ascertain the variations in rainfall and temperature in the Niger Delta Region. The study utilized the ex-post facto research design. The study utilized the annual rainfall and temperature time series data from 1925 – 2018 periods. That was generated from the archive of the Climate Research Unit (CRU) Ts 4.03 using Google earth. The grided points of 5^{o}x5^{o} high resolution of thirty-two (32) CRU Ts 4.03 stations were utilized for the study. In order to analyse the data on rainfall and temperature the descriptive statistical techniques were employed. While testing the formulated hypotheses, the one-way analysis of variance (ANOVA) was utilized to decide the significant difference in stations, additionally the Turkey Test was utilized to decide were the difference in the mean lies, while the Mann-Kendell Trend Test was used to determine the upward and downward trends in rainfall and temperature. Thus, the study revealed that the mean distribution of rainfall and temperature in the Niger Delta region for the past ninety-four (94) years showed a downward and upward trend with a mean of 2238.3mm and 26.7^{o}C in rainfall and temperature respectively. While, the highest and lowest rainfall (2600.7mm and 1854mm), was recorded in 1955 and 1984 which indicates an increase of 746.7mm. The highest and lowest temperature (27.4^{o}C and 25.9^{o}C) was recorded in 2017, 1976 and 1977 respectively which indicate a rise of 1.5^{o}C. Furthermore, the study revealed that there is a statistically significant variation in rainfall in the Niger Delta Region and also that there is a statistically significant variation in temperature in the Niger Delta Region.

Keywords: Climate, rainfall, temperature, variation

Introduction
Climate is extensively characterized as the drawn-out measurements or qualities of climate that are resolved over a long period (Charron, 2016). These can be any attributes, going from the normal anticipated that weather patterns should the proportion of the changeability and probability of extraordinary occasions, while the National Geographic Science (NGS, 2020) characterized climate as long period example of climate in a specific region. There can be alteration in weather from hour-to-hour, consistently, month-to-month or from year-to-year. An area's climate designs, generally followed for at any rate 30 years, are viewed as its climate (NGS, 2020).

To comprehend the climate of an area, a drawn-out measurement is performed on meteorological information to comprehend the average scope of conduct we expect, notwithstanding the typical conditions around which that atmospheric fluctuation happens (Charron, 2016). Creating a hearty measurable depiction of the climate system for the most part needs at any rate a very long while of information. The traditional timeframe is 30 years, as characterized by the World Meteorological Organization (WMO), yet a proper time-frame over which to test the scope of inner

changeability will rely upon the measurement of interest. Thusly, changes in climate are regularly characterized by changes in these drawn-out insights over numerous a very long times to hundreds of years (Charron, 2016).

Along these lines, the intergovernmental Panel on Climate Change (IPCC) have shown that climate can be clarified utilizing the significant atmospheric quantities and means, like temperature and precipitation throughout an extensive stretch of time that can shift from months to years (IPCC, 2014). IPCC (2018) has researched the pattern of worldwide temperature normal over the time of years 1880-2012, and the examination exhibited that is equivalent to 0.85℃, going from 0.65℃ - 1.06℃ level of vulnerability. The research identifies an increase of +0.78℃ with lowest of 0.72℃ and a limit of 0.85℃ which occurred during the year 2003-2012. In pondering the hottest year on earth, the National Oceanic and Atmospheric Administration (NOAA, 2015) uncovered that 2014 as year with the hottest record ever, with + 0.69℃ anomaly, this was carried out utilizing climate information from 1880 - 2014. Albeit, in 2016, The World Meteorological Organization (WMO), affirmed that year 2011-2015 as being hottest at any point in time, with year 2015 as the hottest since the creation of present-day equipment for weather observations started in the last part of the 1800's. Likewise thinking about increase in temperature, an increase in precipitation is to happen in specific areas of the world ideal for such climate development. Unquestionably, hydrologi-cal cycle quickening affected by extraordinary temperatures could prompt more precipitation and evaporation processes (WMO, 2012, 2013, 2016, 2017; Food & Agriculture Organization et al., 2017; Nouaceur et al., 2017; IPCC, 2018).

Human activities sway on the physical environment contrarily in various degrees: deforestation, contamination, overpopulation and consuming of petroleum products, a little change in the physical environment in these structures create soil disintegration, undrinkable water, poor air quality and climate change (NGS, 2020). While, Sahney et al. (2010), Cook (2016), United States Environmental Protection Agency (2016), Climate Science Special Report (2017) consider human negative influence on the environment as changes in the biological system biophysical conditions, biodiversity and natural resources caused by direct or indirect by human exercises including degradation of the natural environment (like sea acidification), mass elimination, a worldwide temperature alteration and biodiversity destruction, environmental disaster, and natural breakdown (Ceballos et al., 2017; Ceballos et al., 2015; Pimm et al., 2014). The alteration in the characteristic of the climate by man's activities to suit its necessities affect the climate, as human overpopulation proceeds with the difficulty more regrettable (Stockton, 2015; Ripple et al., 2019). Perkins (2017); Nordström et al. (2020) recorded a portion of the human exercises that affected contrarily on the climate either in a roundabout way or directly on a worldwide scale to incorporate overconsumption, population growth, overexploitation, contamination, and deforestation and so forth. A portion of the issues, including a global warming and biodiversity disaster represent an existential danger to humanity (Scripps Institution of Oceanography, 2017; Phil, 2016) and human overpopulation is firmly related with those issues (Center for Biological Diversity, 2017).

Researchers had showed that precipitation generally diminishes with distance from the equator. The fluctuation of precipitation from yearly normal is more prominent in an area that gets little precipitation (Thornton, 2014; Abdullahiet

al., 2020). A climatological pattern of the all-out yearly precipitation and temperature across Nigeria is accepted to be regular in terms of wet and dry seasons during the 60s, 70s and parts of 80s from South toward the North and somewhat from East toward the West (Owolabi, 2016). The Niger Delta region is exceptionally vulnerable against unfriendly environmental changes brought about by climate change and essentially a change in the temperature and precipitation. Most climate studies that have been carried out in the Niger Delta Region are qualitative in nature but this study is bridging the gaps by carrying out a statistical discourse of the climate of the Niger Delta. The changes in the climate of the Niger Delta region have been affirmed by different researches across disciplines, for example, Wali et al. (2020) analyses temperature and precipitation fluctuation in the Niger Delta district of Nigeria. The outcome shows that temperature and precipitation in the investigation zone are conversely related. This implies that as the temperature expands, precipitation diminishes in the investigation zone. However, the outcome is measurably insignificant ($p > 0.05$). Definitively the information shows that impact of environmental change is mostly influencing temperature in the region.

Ozabor and Obisesan (2015) looked at gas flaring and its impacts on temperature, agriculture and Ebedei people in Delta State, Nigeria. The discoveries showed that there is variety in temperature as far as distance from the flare site inside Ebedei zone is huge. While, Emaziye (2015) analysed the impact of temperature and precipitation on the yields of maize, sweet potato and cassava among provincial family units in Delta state, Nigeria. The result of the research showed that there was an expanding pattern in the yearly mean temperature and a diminishing pattern in yearly mean precipitation while their projected future qualities are expanding in the state. On the other hand, Akinsanola et al., (2014) investigated the events of unexpected changes in temperature and precipitation esteems over Nigeria utilizing information from 25 stations from 1971-2000 (30 years). Their outcome shows that there have been measurably huge expansions in precipitation and air temperature in dominant part of the country, with grouping on the other hand diminishing and expanding patterns in mean yearly precipitation and air temperature in the area of study. Based on the above-mentioned research problem and gap in knowledge, the researcher therefore investigates the climate of the Niger Delta Region (NDR) of Nigeria.

Conceptual framework

The investigation depends on the idea of greenhouse gas (GHG), GHG are those vaporous constituents of the atmosphere that retain and discharge radiation in the warm infrared reach (IPCC, 2014). Traces of GHG, both anthropogenic and natural are available in the lower atmosphere (See Fig 1). The most bountiful GHG in expanding of significance are: water vapour, carbon dioxide (CO_2), methane (CH_4), nitrous oxides (N_xO) and ozone (O_3) (Kiehl&Trenberth, 1997). GHG rates differ every day, occasionally, and yearly (Cassia et al, 2018).

Fig. 1: Schematic of Greenhouse gas effect
Source: Buzzle.com (2021)

Study area

This current investigation depends on Niger Delta region (Niger Delta Region), the Niger Delta Region is pinpointed in the Atlantic shore of Southern Nigeria, the area including between scopes 05°19′34″N 06°28′15″E and 5.32611 ℕ 6.47083 ℰ (WGS, 1984). The region envelops a zone of 20,000 km^2 and is the biggest delta in Africa and the world's third biggest (Dupont et al., 2000; Uluocha&Okeke, 2004; Ajonina et al., 2008; Umoh, 2008). The Niger Delta area is an occupant to around 42, 657,086 million individuals, as per the 2018 estimated population figure for Nigeria, with Abia 3,727,347; AkwaIbom 5,487,177; Bayelsa 2,277,961; Cross River 3,866,269; Delta 5,663,362; Edo 4,235,595; Imo 5,408,756; Rivers 7,303,924; Ondo 4,671,695. The Niger Delta region is privileged with the biggest wetland in Africa and third position on the planet (Spalding et al., 1997; Azaiki, 2003).

The normal month to month temperature of the area is 27 ℃, and a yearly precipitation going from 3000mm to 4500 mm. The Niger Delta is among the 10 greatest on earth, with a coastline of around 450km which closes at Imo waterway entrance. Throughout the long term, sediment stores, water discharged and different loads carried across rivers in the Southern Nigeria and deposited in the Atlantic Ocean has brought about the development of a multifaceted and delicate Delta, bountiful in biodiversity (Abam, 2001; Ogbe, 2005). Around 2,370 km^2 of the Niger Delta territory comprises of streams, rivers, estuaries and stagnant swamplands. Around half of the Delta is covered with water representing 55% of all freshwater swamps in Nigeria (Ikelegbe, 2006; Umoh, 2008).

The current situation of the Niger Delta region by and large directed the socio-economic presence of people nearby. The individuals who live around the riverside are generally into fishing and trading, while those in the hinterland are into cassava, sweet potato, yam and vegetables farming and also into cash crops like palm and rubber plantation. The abundant of oil and gas and its exploration and exploitation and its effects on the temperature and rainfall of the Niger Delta region is enormous, for example it has caused temperature increases, rainfall decreases and acid rain in the study area this is often notice on the roofing sheets of buildings and body of vehicles and cloths spread outside mostly area closed to the Warri Refinery in Ejeba area.

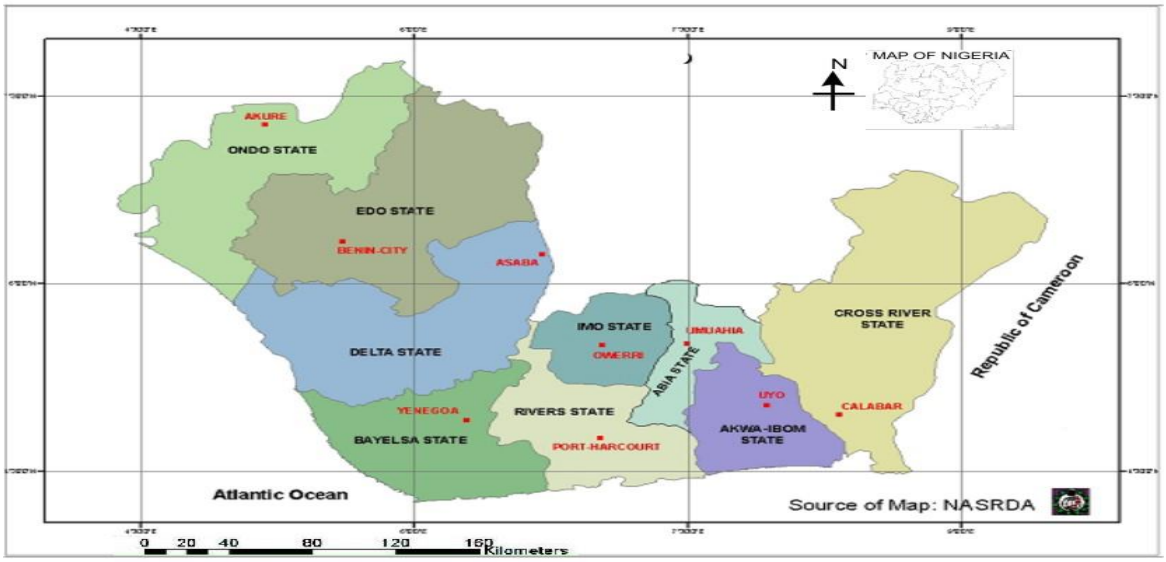

Fig. 2: The Niger Delta Region of Nigeria
Source: National space research and development Agency (2021)

Materials and methods

The study utilized the ex-post facto research design, in obtaining temperature and rainfall data that were used to examine the climate of the Niger Delta Region. This study utilized annual temperature and rainfall time series data from 1925 to 2018 period that was collected from the archive of the Climate Research Unit (CRU) University of East Anglia. The following existing grided points of 5^o x 5^o gridded high-resolution thirty-two (32) CRU Ts 4.03 stations of temperature and rainfall were utilized for this study: AkwaIbom – 3; Delta – 6; Bayelsa – 3; Cross River – 6; Edo – 5; Imo – 3; Ondo – 3; Abia – 1; and Rivers – 3. In order to analyse the data on climate characteristics, the descriptive statistical techniques were employed. The one-way analysis if variance (ANOVA) was utilized to decide the huge contrast between stations, additionally the Turkey Test was utilized to decide were the differences in the mean lies, while, the Mann-Kendell Trend test was used to determine the upward and downward trends.

Results and discussion

The mean distribution of rainfall and temperature in the Niger Delta region for the past ninety-four (94) years showed a downward and upward trend with a mean of 2238.3mm and 26.7^{o}C in rainfall and temperature respectively. While, the highest and lowest rainfall (2600.7mm and 1854mm), was recorded in 1955 and 1984 which indicates an increase of 746.7mm. The highest and lowest temperature (27.4^{o}C and 25.9^{o}C) was recorded in 2017, 1976 and 1977 respectively which indicates a rise of 1.5^{o}C (See Fig. 3)

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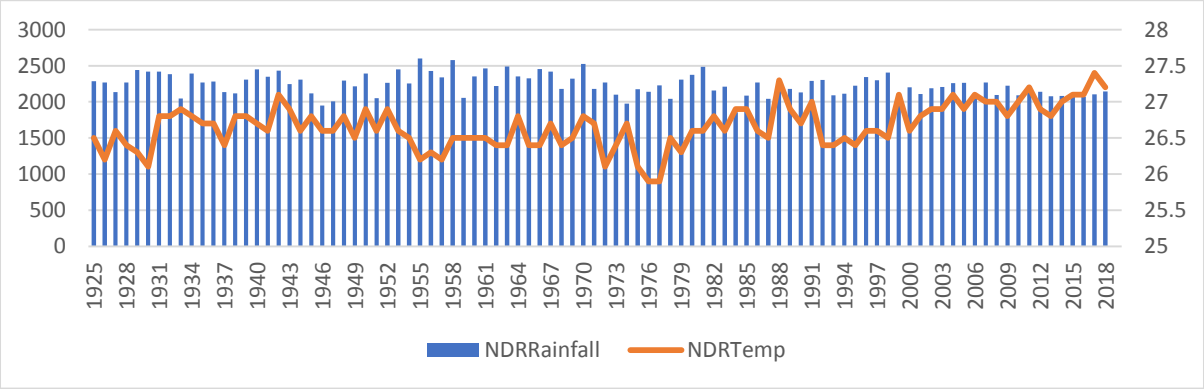

Fig. 3: Mean Distribution of Rainfall and Temperature in the Niger Delta Region (1925 – 2018)

Table 1: Rainfall distribution within three (3) climatic periods in the Niger Delta Region (mm)

Normals		Total Count	Mean	StDev	CoefVar	Minimum	Maximum	Range	Change (mm)
Mean	1925-1954	30	2263.9	140.4	6.20	1948.7	2449.3	500.6	-

1955-1984	30	2286.0	182.0	7.96	1854.0	2600.7	746.7	22.1
1985-2018	34	2173.6	92.9	4.27	2042.3	2403.5	361.2	-112.4

Based on the Minitab output in Table 1, it revealed that rainfall distribution ranged from 1948.7mm – 2449.3mm; 1854.0mm – 2600.7mm, and 2042.3mm – 2403.5mm during the three (3) normals (1925 -1954; 1955 – 1984; and 1985 – 2018 respectively). These periods also showed 6.20, 7.96 and 4.27 Coefficient of Variation (CV) which indicate a high level of rainfall variability over the years. This corroborated Dewar and Wallis (1999) on similar study. Thus, the change has an increase of 22.1mm in rainfall between 1955 – 1984 and 1985 – 2018 a decrease of -112.4mm was observed.

The high value of the standard deviation can be handily associated with the high precipitation range. The precipitation range means the contrast between the greatest and least yearly precipitation. The standard deviation and the range demonstrate the changeability of yearly precipitation and thus indicate how dependable the precipitation regarding its persistence as steady and stable renewing source. High value of the standard deviation additionally proposes that year-to-year vacillations are high while a low standard deviation shows that variances are lower. At the end of the day, precipitation with an exclusive expectation deviation is viewed as more unstable than precipitation with a low figure.

Table 2: Temperature distribution within three (3) climatic period in the Niger Delta Region (^oC)

Normals		Total Count	Mean	StDev	CoefVar	Minimum	Maximum	Range	Change (^oC)
Mean	1925-1954	30	26.650	0.224	0.84	26.100	27.100	1.000	-
	1955-1984	30	26.453	0.254	0.96	25.900	26.900	1.000	-0.2
	1985-2018	34	26.859	0.272	1.01	26.400	27.400	1.000	0.4

From Table 2, it can be inferred that the three (3) climatic normal have equal mean temperature of 27^{o}C, 1955 – 1984 and 1985 – 2018 having equal coefficient of variation**,** range value (1.0^{o}C, and 1.0^{o}C) respectively with 1955 – 1984 and 1985 – 2018 having a corresponding equal standard deviation (0.3^{o}C), and 1925 – 1954 having low standard deviation and coefficient of variation (0.2^{o}C and 0.8^{o}C) while 1955 – 1984 having the minimum and maximum temperature of 25.9^{o}C and 26.9^{o}C respectively. From the foregoing, the temperature distribution in the Niger Delta Region, showed a change of -0.2^{o}C and 0.4^{o}C between 1955 – 1984 and 1985 – 2018 respectively.

Table 3: Mean annual rainfall in the Niger Delta Region

Variable	Total Count	Mean	StDev	CoefVar	Minimum	Maximum	Range
Akure	94	1572.7	172.3	10.96	1148.4	2091.6	943.2
Benin	94	1978.7	189.7	9.59	1495.2	2433.6	938.4
Warri	94	2561.2	245.6	9.59	2066.4	3180.0	1113.6
Yenagoa	94	2612.6	255.9	9.79	2066.4	3180.0	1113.6
Owerri	94	2156.7	174.8	8.11	1596.0	2565.6	969.6
Calabar	94	2140.5	164.7	7.69	1648.8	2637.6	988.8
Port Harcourt	94	2424.7	203.1	8.38	1920.0	2936.4	1016.4
Umuahia	94	2214.2	172.5	7.79	1670.4	2650.8	980.4
Uyo	94	2483.1	235.7	9.49	1902.0	3057.6	1155.6

As can be observed from Table 3, the highest and lowest mean annual rainfall for the period under review occurred in Yenagoa (2612.6 mm) and Akure (1572.7mm) respectively with corresponding StDev (255.9mm) and (172.3mm). However, the highest coefficient of variation was recorded in Akure indicating the town with the highest rainfall variability. While, Warri and Yenagoa having the highest minimum and maximum rainfall values (2066.4mm and 3180.0mm) respectively with the highest range of 1155.6mm being recorded in Uyo.

Table 4: Mean annual temperature in the Niger Delta Region

Variable	Total Count	Mean	StDev	CoefVar	Minimum	Maximum	Range
Akure	94	26.240	0.417	1.59	25.200	27.200	2.000
Benin	94	26.920	0.356	1.32	26.100	27.700	1.600
Warri	94	26.826	0.326	1.21	26.100	27.600	1.500
Yenagoa	94	26.646	0.304	1.14	25.900	27.400	1.500
Owerri	94	26.854	0.317	1.18	26.100	27.600	1.500
Calabar	94	26.499	0.260	0.98	25.800	27.100	1.300
Port Harcourt	94	26.716	0.276	1.03	26.000	27.300	1.300
Umuahia	94	26.645	0.281	1.06	25.900	27.300	1.400

Uyo	94	26.618	0.258	0.97	25.900	27.200	1.300

Table 4, indicated the highest mean annual temperature for the period under review occurred in eight stations (27^{o}C) except Akure, however, the highest StDev (0.417) occurring in Akure, with corresponding coefficient variation (1.59^{o}C). While, Akure had a minimum temperature of (25.2^{o}C) and Benin, Warri and Owerri had a maximum temperature of (28^{o}C) respectively. However, with Akure having high range of 2.0^{o}C and Calabar, Port Harcourt and Uyo having the lowest range of (1.3^{o}C) respectively.

Table 5: Monthly distribution of rainfall in the Niger Delta Region

Variable	Mean	StDev	CoefVar	Minimum	Maximum	Range
Jan	28.63	13.57	47.41	9.50	43.90	34.40
Feb	55.19	19.13	34.66	35.10	98.30	63.20
Mar	122.91	23.94	19.48	87.60	157.60	70.00
Apr	182.73	23.93	13.09	140.90	221.60	80.70
May	239.6	30.4	12.67	179.9	272.9	93.0
Jun	287.6	30.0	10.45	222.2	322.6	100.4
Jul	311.6	34.0	10.90	234.3	346.2	111.9
Aug	287.6	60.9	21.18	170.7	363.1	192.4
Sept	333.5	44.6	13.37	257.2	384.2	127.0
Oct	246.5	63.1	25.59	113.1	306.8	193.7
Nov	86.5	37.4	43.25	37.3	131.6	94.3
Dec	27.16	12.47	45.91	10.20	40.90	30.70

It is evident from Table 5, that the coefficient of variation for the months of April through July is lower which indicates lower variability from the mean and similar comparable perception is made for the long stretches of September. Gomez and Gomez (1984) expressed that the coefficient of variation means that the level of accuracy to which the treatments are thought about and is a good index of the unwavering quality of the test. They further demonstrated that the higher the coefficient of variation esteem, the lower the unwavering quality of the trial. The standard deviation is one way of summarizing the spread of a probability distribution; it relates directly to the degree of uncertainty associated with predicting the value of a random variable. Table 5, clearly revealed that October had the highest standard deviation. The highest amount of average monthly rainfall was recorded in September (333.5mm), followed by July with 311.6mm and the lowest was in December with 27.2mm of annual total followed by January with 28.6mm and this shows double rainfall maxima in July and September.

Table 6: Monthly distribution of temperature in the Niger Delta Region

Variable	Mean	StDev	CoefVar	Minimum	Maximum	Range
Jan	26.489	0.333	1.26	25.900	26.900	1.000
Feb	27.422	0.774	2.82	26.500	28.500	2.000
Mar	27.789	0.560	2.02	27.000	28.600	1.600
Apr	27.689	0.267	0.96	27.200	28.100	0.900
May	27.389	0.530	1.94	26.600	28.200	1.600
Jun	26.411	0.465	1.76	25.700	27.200	1.500
Jul	26.022	0.692	2.66	24.500	26.800	2.300
Aug	26.111	0.724	2.77	24.500	26.900	2.400
Sept	26.367	0.680	2.58	25.000	27.200	2.200
Oct	26.789	0.523	1.95	25.800	27.500	1.700
Nov	27.333	0.391	1.43	26.800	28.000	1.200
Dec	27.222	0.526	1.93	26.500	28.100	1.600

The monthly variation in temperature listed in Table 6, showed that temperature ranged from 26.1ºC in August to 27.8ºC in March respectively with 1.7ºC. It also clearly revealed that February, March, May-October and December had the highest standard deviation above 0.5 whereas the months of January, April and November showed less than 0.5 standard deviation. The highest amount of average monthly temperature was recorded in February – May and October – December above 27ºC. This is because of the progress in change in the climate of the region due to anthropogenic activities and natural causes.

Mann-Kendall trend test: the test is sometimes called the M-K test, is used to analyse data collected over time for consistently increasing or decreasing trends (monotonic).

Table 7: Mann-Kendall trend test for rainfall in the Niger Delta Region

Stations	Calculated Z	Upward p-value	Remark	Downward p-value	Remark
Akure	0.620638	0.267419	No trend	0.732581	No trend
Benin	0.695749	0.243293	No trend	0.756707	No trend
Warri	-3.97524	0.999965	No trend	0.0000352	Trend
Yenagoa	-3.02138	0.998742	No trend	0.0012581	Trend
Owerri	-1.75735	0.960571	No trend	0.0394288	Trend
Calabar	-3.92961	0.999957	No trend	0.0000425	Trend
Port Harcourt	-3.1`6513	0.9999229	No trend	0.0007751	Trend
Umuahia	-3.55727	0.999813	No trend	0.0001874	Trend
Uyo	-3.48524	0.999754	No trend	0.0002458	Trend

Rainfall Mann-Kendall test results are shown in table 7, it revealed that there is no upward trend in all the stations in the region. However, on the downward trends Akure and Benin have no downward trends but, seven towns (Warri, Yenagoa,

Owerri, Calabar, Port Harcourt, Umuahia and Uyo) have downwards trends.

Table 8: Mann-Kendall trend test for temperature in the Niger Delta Region

Stations	Calculated Z	Upward p-value	Remark	Downward p-value	Remark
Akure	2.99760	0.0013606	Trend	0.998639	No trend
Benin	3.65872	0.0001267	Trend	0.999873	No trend
Warri	4.30130	0.0000085	Trend	0.99999	No trend
Yenagoa	4.70085	0.0000013	Trend	1.00000	No trend
Owerri	3.87847	0.0000526	Trend	0.99947	No trend
Calabar	2.28823	0.00110620	Trend	0.988938	No trend
Port Harcourt	4.05482	0.0000251	Trend	0.999975	No trend
Umuahia	3.47972	0.0002510	Trend	0.999749	No trend
Uyo	3.77898	0.0000787	Trend	0.999921	No trend

Table 8, showed the Mann-Kendall test results of temperature, it revealed that there are upward trend in temperature in all the stations in the region. This indicates a general rise in temperature in all the communities of the Niger Delta region. However, there is no downward trend in all stations in the region.

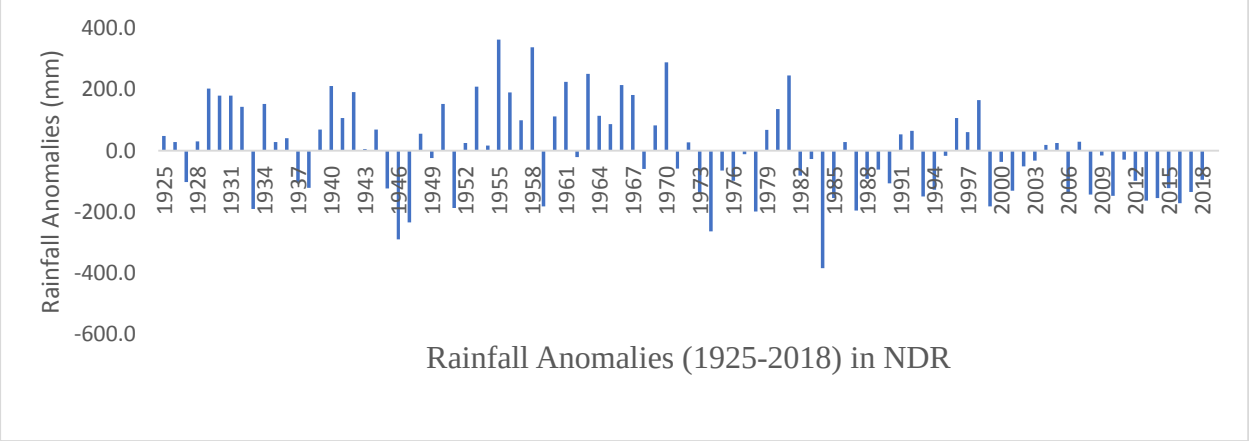

Fig. 4: Rainfall Anomalies in the Niger Delta Region 1925 - 2018

From Fig 4, the highest negative anomalies were recorded in 1946, 1974 and 1984 with -289.6mm, -263.9mm and -384.3mm respectively, indication that in these years the average rainfall received was far below the reference normal (Zhao et al., 2005). While, 1955, 1958 and 1970 on the other hand, received the highest rainfall above the reference normal of 362.4mm, 338.0mm and 288.3mm individually as represented in Figure 4.

Spatial variation in rainfall and temperature in the Niger Delta Region

Table 9: Summary of ANOVA result for rainfall in the Niger Delta Region

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Stations	8	81422724	10177840	243.76	0.000
Error	837	34947144	41753		
Total	845	116369867			

Table 9, present the analysis of variance output concerning rainfall characteristics in the Niger Delta Region. In Table 9, the model indicates (243.76, 8, 837, p-value <0.05). The output shows that there is a statistically significant variation in rainfall in the Niger Delta Region.

Table 10: Model summary

S	R-sq	R-sq(adj)	R-sq(pred)
204.335	69.97%	69.68%	69.32%

In these results, the factor explains 69.97% of the variation in the response. S shows that the standard deviation between the information focuses and the fitted values is around 204.3 units. Researches had shown that models that have bigger predicted R^2 values have better prognostic capacity.

Table 11: Turkey pairwise comparisons

Stations	N	Mean	Grouping				
Yenagoa	94	2612.6	A				
Warri	94	2561.2	A	B			
Uyo	94	2483.1		B	C		
Port Harcourt	94	2424.7			C		
Umuahia	94	2214.2				D	
Owerri	94	2156.7				D	
Calabar	94	2140.5				D	
Benin	94	1978.7					E
Akure	94	1572.7					F

Means that do not share a letter are significantly different.

In these results, Table 11, shows that Yenagoa, Port Harcourt, Umuahia, Owerri, Calabar, Benin and Akure do not share a letter, which indicates that Yenagoa has a significantly higher mean than other six stations that do not share a letter. Thus, the

variation lies in Yenagoa, Port Harcourt, Umuahia, Owerri, Calabar, Benin and Akure.

Table 12: Summary of ANOVA result for temperature in the Niger Delta Region

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Stations	8	31.97	3.99610	40.45	0.000
Error	837	82.69	0.09879		
Total	845	114.66			

Table 12, present the analysis of variance output concerning temperature characteristics in the Niger Delta Region. In the above table the model indicates (40.45, 8, 837, p-value <0.05). The output shows that there is a statistically significant variation in temperature in the Niger Delta Region.

Table 13: Model summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.314316	27.88%	27.19%	26.32%

In these results, the factor explains 27.88% of the variation in the response. S shows that the standard deviation between the information focuses and the fitted values is around 0.31 units.

Table 14: Tukey pairwise comparisons

Stations	N	Mean	Grouping			
Benin	94	26.9202	A			
Owerri	94	26.8543	A	B		
Warri	94	26.8255	A	B		
Port Harcourt	94	26.7160		B	C	
Yenagoa	94	26.6457			C	
Umuahia	94	26.6447			C	
Uyo	94	26.6181			C	D
Calabar	94	26.4989				D
Akure	94	26.2404				E

Means that do not share a letter are significantly different.

In these results, Table14, shows that Benin, Yenagoa, Umuahia, Calabar and Akure do not share a letter, which indicates that Benin has a significantly higher mean than other four stations that do not share a letter. The variation lies in the temperature of Benin, Yenagoa, Umuahia, Calabar and Akure.

Table 15: Summary of ANOVA result for mean monthly rainfall in the Niger Delta Region

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Seasons	11	1310990	119181	89.91	0.000
Error	96	127256	1326		
Total	107	1438245			

Table 15 present the analysis of variance output concerning mean monthly rainfall characteristics in the Niger Delta Region. In the above table the model indicates (89.91, 11, 96, p-value <0.05). The output shows that there is a statistically significant variation in mean monthly rainfall in the Niger Delta Region.

Table 16: Model summary

S	R-sq	R-sq(adj)	R-sq(pred)
36.4085	91.15%	90.14%	88.80%

In these results, the factor explains 91.15% of the variation in the response. S shows that the standard deviation between the information focuses and the fitted values is around 36.41units.Researches had shown that models that have larger predicted R^2 values have better predictive ability.

Table 17: Tukey pairwise comparisons

Seasons	N	Mean	Grouping				
Sept	9	333.5	A				
Jul	9	311.6	A				
Aug	9	287.6	A	B			
Jun	9	287.6	A	B			
Oct	9	246.5		B			
May	9	239.6		B	C		
Apr	9	182.73			C		
Mar	9	122.91				D	
Nov	9	86.5				D	E
Feb	9	55.19					E F
Jan	9	28.63					F
Dec	9	27.16					F

Means that do not share a letter are significantly different.

In these results, table 17, shows that September, July, October, April, March, January and December do not share a letter, which indicates that September has a significantly higher mean than other six stations that do not share a letter. This change in the rainfall season could be attributed to the so-called climate change. Thus, the rainfall variation lies in September, July, October, April, March, January and December.

Table 18: Summary of ANOVA result for mean monthly temperature in the Niger Delta Region

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Seasons	11	38.78	3.5255	11.25	0.000
Error	96	30.09	0.3134		
Total	107	68.87			

Table 18, present the analysis of variance output concerning mean monthly temperature characteristics in the Niger Delta Region. In the above table, the model indicates (11.25, 11, 96, p-value <0.05). The output shows that there is a statistically significant variation in mean monthly temperature in the Niger Delta Region.

Table 19: Model summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.559845	56.31%	51.30%	44.70%

In these results, the factor explains 56.31% of the variation in the response. S shows that the standard deviation between the information focuses and the fitted values is around 0.56 units.

Table 20: Tukey pairwise comparisons

Seasons	N	Mean	Grouping				
Mar	9	27.789	A				
Apr	9	27.6889	A				
Feb	9	27.422	A	B			
May	9	27.389	A	B			
Nov	9	27.333	A	B	C		
Dec	9	27.222	A	B	C	D	
Oct	9	26.789		B	C	D	E
Jan	9	26.489			C	D	E
Jun	9	26.411				D	E
Sept	9	26.367				D	E
Aug	9	26.111					E
Jul	9	26.022					E

Means that do not share a letter are significantly different.

In these results the table shows, that March, April, July and August do not share a letter, which indicates that March has a significantly higher mean than other three stations that do not share a letter. The temperature variation lies in March, April, May, July and August.

Climate implication of the Niger Delta Region on socio-economic development of the region

Universally, and Niger Delta in particular, climate characterises of the Niger Delta Region has precipitated either ecological or environmental disasters in the region like flooding, sea level rise (SLR), soil erosion, acid rain in the region etc. with the attendance socio-economic implication. Efe (2010, 2012); Efe and Wali (2015); and Wali and Efe (2015) has listed these implications to include food insecurity (hunger), the prevalence of diseases that lead to health issues, loss of properties and lives, building collapse, road failure and collapse.

While, Garg (2010) listed these climate characterizes implications on the socio-economic development of the region to include loss of cattle and livestock, destruction of personal property, loss of earnings and services, lossof growing and pre-harvest crops in agricultural fields, reduction in property values, collapsing of bridges, buildings, roads, communication, infrastructures, destruction of schools, hospitals, loss incurred in flood-fighting measures, relief, evacuation and rehabilitation of flood victims and other social amenities in the area affected that were destroyed. In the same vein, a study carried out by Johnson (2001) averred that in the serene city of Calabar, properties worth millions of naira were destroyed by flooding in the month of June 2000.

Eli and Bariweni (2020)identified these implications to be loss of farm produce, collapse of buildings, bridges and no access road. He further stressed that school system was disrupted as communication and personal mobility proved difficult. Etuonovbe (2011) revealed that 4000 people in Awka-Ibom and 560 houses were destroyed and 820 people affected in Edo State due to flooding activities. While in Bayelsa State, houses, schoolsand farmlandsweresubmerged during1999and2001flooding.

Increased temperature has exacerbated the problems of food insecurity in the region where crops met for planting are dried up on or before the planting season due to the excessive high temperature in the region. Also, once they germinate they are destroyed by high temperature. Thereby leading to stunted growth and yield of crops.

Sea level Rise has affected the region heavily, places that being inhabited before are inundated due to excessive rainfall in the region for instance in Yenagoa, Patani and Burutu, Mbiama, Port Harcourt are heavy inundated in September – November yearly.

Acid rain has been found to be responsible for the loss of nutrients essentially for crop growth in most agricultural villages of the Niger Delta region. World Health Organization occupational studies (1987) also identified rainwater containing various metals (as Cd, Pb, Hg) as a major cause of serious health problems in the lower Niger Delta Area. Some of these health problems include anaemia, renal dysfunction, lung cancer and other neo-behavioural effects. Other negative effects of acid rain are corrosion and tarnishing of metals (including building roofs) erosion and soiling of buildings as well as discolouration and peeling of paints (Harter, 1986).

Conclusion

The study posted that there is a general rise in temperature and excessive rain fall

in the region. The mean distribution of rainfall and temperature in the Niger Delta region for the past ninety-four (94) years showed a downward and upward trend with a mean of 2238.3mm and 26.7^{o}C in rainfall and temperature respectively. While, the highest and lowest rainfall (2600.7mm and 1854mm), was recorded in 1955 and 1984 which indicates an increase of 746.7mm. The highest and lowest temperature (27.4^{o}C and 25.9^{o}C) was recorded in 2017, 1976 and 1977 respectively which indicate a rise of 1.5^{o}C.

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