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VARIABILITY OF RAINFALL AND TEMPERATURE DISTRIBUTIONS IN DELTA STATE, NIGERIA

NDAKARA, OFUDJAYE EMMANUEL AND EYEFIA, OGHENERUKEVWE ALEXANDER
[1] https://orcid.org/0000-0001-8622-7342, [2] https://orcid.org/0000-0001-6207-7175
ndascoemma@yahoo.com

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ABSTRACT

The knowledge of variability in climatic attributes is necessary for the evaluation of their distributions within regions. This research investigated the distributions and how rainfall and temperature (R&T) varied across the Delta State region of Nigeria. The research design employed is the ex post facto. The study employed yearly and monthly (R&T) data gotten from the Climate Research Unit (CRU) through Google earth, and Time-Series (TS) monthly climate variation data from January, 1901 to December, 2019. Statistical analysis involved the mean, climographs, Analysis of variance (ANOVA), Fisher Test, Post Hoc test, and Minitab 18 macro tool. The study observed increase of 0.4^{o}C in temperature and 320.3mm in rainfall. Significant variations in both monthly and annual (R&T) were observed. On the trends results, increasing trend in temperature within the 8 stations were observed, while no increasing trend in rainfall within the 8 stations were observed. Decreasing trend in seasonal temperature from January to June, and August to December was observed. Furthermore, decreasing rainfall trend was observed in February, May, June, July and November, with August and September having increasing trends while the January, March, April and December having no trends.

KEYWORDS: Climate change, rainfall variability, seasonality, temperature distribution, weather elements.

INTRODUCTION

The essential aspects of climate attributes remain of immense importance for the sustenance and adaptation of humans within their environment. The extent to which the distribution of these elements vary, determines man's possibilities to adapt and thrive within a given region, on the account that both the environment and man's activities are climate dependent (Ndakara & Atuma, 2021; Efe & Ndakara, 2010).

The elements of climate determine the type of food taken by man, amount of water to drink, the type of clothes to wear at any given time, the time and season to grow crops, the air man breathes, and the types and patterns of house to live in. The distributions and prevailing climatic conditions within a given region have a great influence on how the inhabitants adapt. It is therefore of immense importance to have a good understanding of the level of variability of the

Ndakara, Ofudjaye Emmanuel, Department of Geography and Regional Planning, Delta State University, Nigeria
Eyefia, Oghenerukevwe Alexander, Department of Geography and Regional Planning, Delta State University, Nigeria

climate attributes so as to guide and direct the activities of humans at regional perspective (Ndakara & Eyefia, 2021; Odjugo, 2011).

Climate variability refers to the deviations from the mean of climatic statistics within a given time-frame. Variability in climate is estimated by the observed deviations, which are typically known as anomalies (WMO, 2019). Climate variabilities could either be internal, being those that occur within the climate system naturally; or external, being variability that occur as a result of anthropogenic factors. From the opinion of Ghil (2002), climatic attributes vary with time in a scale which ranges from months, years, decades to centuries. The intricate idea of this variability is a significant impediment to the compacted documentation of worldwide changes achieved in the past and present, or to be achieved in future, by the presence of humans and their activities within the earth's planet (Ike & Emaziye, 2012). The elements of climate within Delta State are highly varied, and manifest in climate extremes such as floods, sea level rise, soil erosion and extreme heat events, all of which have increased in frequency and severity over the past years (Ohwo & Ndakara, 2022; Ndakara & Ohwo, 2023).

The flooding is noticeable in all riverine parts within the state and areas closed to the River Niger due to their low terrain and water-logged environment. These extreme flood events affect the livelihood and economic activities of the people living in Ndokwa East, Oshimili South, Burutu, Ughelli South, Patani, Bomadi and Ughelli North. After a torrential rainfall, flood disaster has been perilous to the people and institutions. According to European Commission Joint Research Centre (2018) the most affected states of Nigeria by a 100-year flood event would be Delta, Bayelsa and Rivers states (between 1.5 and 3 million people affected). Also, the National Emergency Management Agency [NEMA] (2018), reported that 12 States were affected by floods. Extreme heat events reported manifested in the form of heat stress which have contributed to numerous diseases ranging from skin diseases bordering on meningitis, measles, heat rashes, heat syncope, heat cramps, heat edema, heat exhaustion and heat stroke (Ukoji & Ndakara, 2021; Efe & Ndakara, 2010).

Moreover, analysis of time series at different time scales around Africa have revealed that rainfall is either decreasing or increasing, depending on the location (Sam, Nwaogazie & Ikebude, 2022; Ndakara & Eyefia, 2021; Abaye, Ati & Iguisi, 2012; Ekpoh & Nsa, 2011). For example, the study by Sam, Nwaogazie, Ikebude, Irokwe, El Hourani, Inyang, and Worlu, (2023) comparatively analysed the trend in climatic change in four stations within Niger Delta. Findings showed that trends in two of the stations were statistically significant, while mild trends were observed in the other two stations. Chinago (2020) analysed rainfall trends, together with its pattern and fluctuation across Port Harcourt and the entire South – South states of Nigeria. From the study, it was discovered that no significant climatic variability in the pattern of rainfall or change in climatic pattern exist. Mangodo, Akemien, Yusuf, Bakpolor, and Oyewole (2020) carried out a study to analyse the trend of climatic variables within Niger Delta of Nigeria. Findings from the study showed that there was an upward trend of temperature which was significant at 0.01 alpha level; while rainfall trend was insignificant. Efe (2016) compared the amount of rainfall between Port Harcourt and Warri, from which high annual rainfall amounts of 2360mm and 3125mm were observed in Port Harcourt and Warri respectively thus indicating that Warri experiences higher rainfall than Port Harcourt. The study also revealed 33% and 20% urban influence on the precipitation of the built-up areas than the surrounding rural areas of Port Harcourt and Warri, which the researcher ascribed the increased to the socio-economic activities (SEA) and anthropogenic activities of the residents of Warri over that of Port Harcourt (Obi & Ndakara, 2020). He further stated that the increased precipitation in these cities has triggers adverse environmental and socio-economic effects on the residents, this study only focused on Warri to the neglects of other areas in the state. However, all the studies carried out in these regions are rainfall based, studies on temperature were neglected, these studies are centered on the South-South region, while Delta State has not been examined. This study utilized the annual (R&T) data of one hundred and eleven years (1901-2017) for eight Stations in Delta State.

The imperative of this study lies in the fact that it is perhaps, one of the recent studies on (R&T) variability in this part of Nigeria.

CONCEPTUAL FRAMEWORK

This study adopted the framework of climate variability (ClimVar) concept. This concept emphasises that climatic attributes vary across regions due to factors which could either be natural or anthropogenic. However, the anthropogenic factors are promoted by the increase in the populations of humans who inhabit the environment (Ndakara, 2012a). The increase in human population has negative impacts on climate system and these impacts are increasing every day. The environment is altered by human as a result of animals rearing, disforestation, agricultural activities, and road construction. The activities of man have occasioned the discharge of gases and aerosol particles in substantial quantities into the atmosphere that have affected its composition and structure. When the physical and chemical modifications of the environment due to human activities become large enough, significant global changes are expected to appear. Climate system comprises air, water, ice and permafrost, lithosphere, living things, and any changes within climate system's components, cause the climate to vary from place to place on the earth surface. These changes are caused by internal variability and external forces.

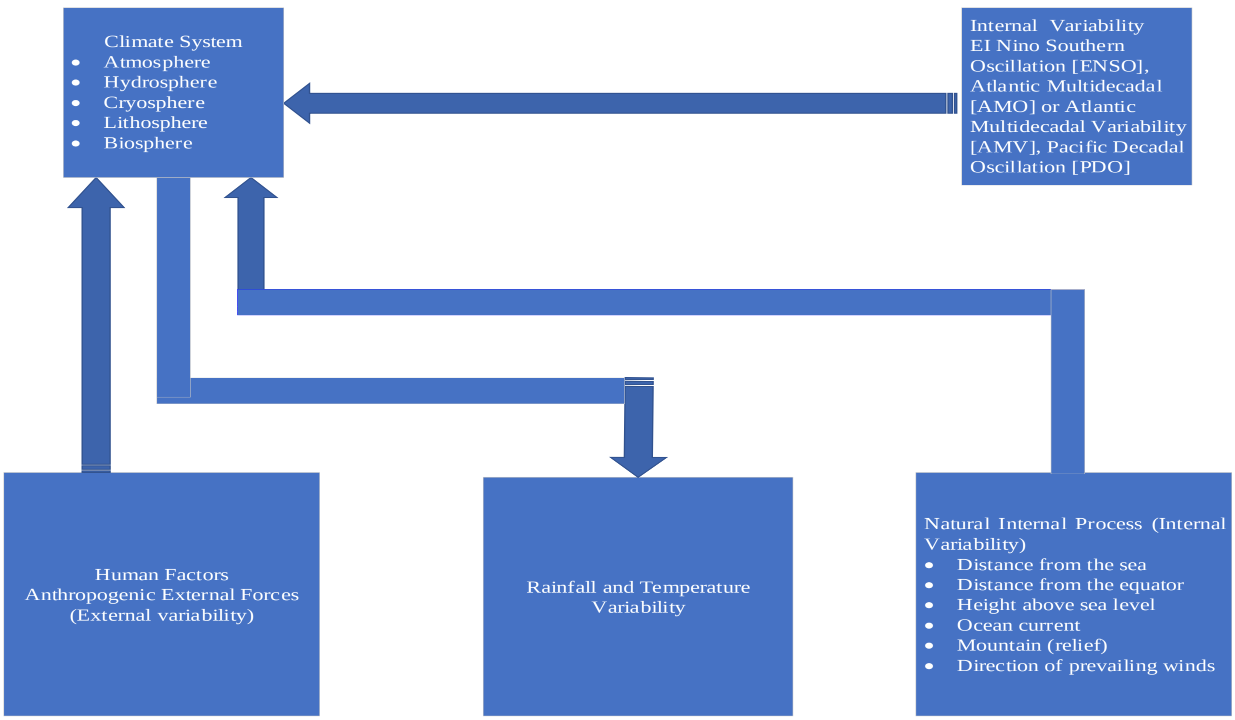


Figure 1: Climate Variability (ClimVar) Conceptual Model for Rainfall and Temperature Variability
Source: Authors Conceptualization (2023)

STUDY AREA

Delta State which covers approximately 18,050 km² of land, lies between latitudes 5°00'N and 6°35'N, and longitudes 4°50'E and 6°50'E (Figure 2). It is bordered to the northern and western parts by Edo State; east by Anambra, Imo, and Rivers States; and south-east by Bayelsa State. Delta State is falls within the lowland regions of Nigeria, which is interspersed with water bodies and undulating plains. Delta State has numerous water bodies that drain the environment, and make up the coastal water bodies to the Atlantic Ocean. According to Ndakara and Eyefia (2021), the climate of this region falls within the Af Koppens climatic classification, with long rainfall period between March and October, and double rainfall maxima in the months of July and Septembers respectively. The tropical humid climate experienced defines two significant air masses which are the tropical continental (cT) and tropical maritime (mT). The dry spell is experienced in the months between November and February. The climate of the region is dominated by mT air mass, while the remaining 2 to 4 months of the year are under the influence of the dry cT air mass (Ndakara, 2016). The mean annual rainfall is about 3470 mm in the coastal areas and decreases inland both in amount and duration to less than 1800 mm in the northern areas. The mean monthly temperature is 27°C, with relative humidity which decreases from the coast inland. It ranges from about 85% in the coastal areas to less than 80% in the northern fringes (Ndakara, Eyefia & Atuma, 2022, Ndakara, 2012b; Ndakara, 2012c).

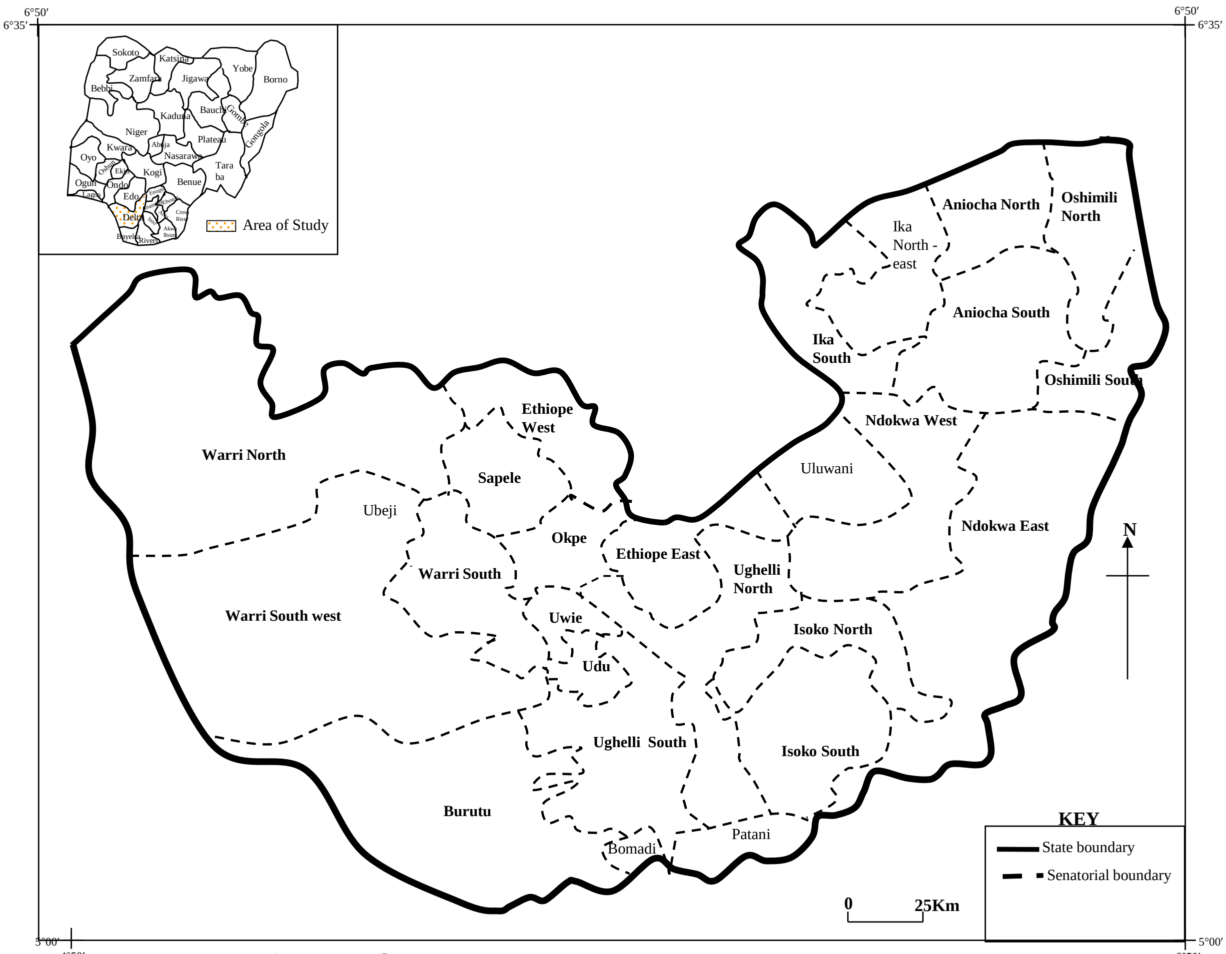


Figure 2: Delta State Map

Source: Ministry of Lands and Survey, Asaba 2021

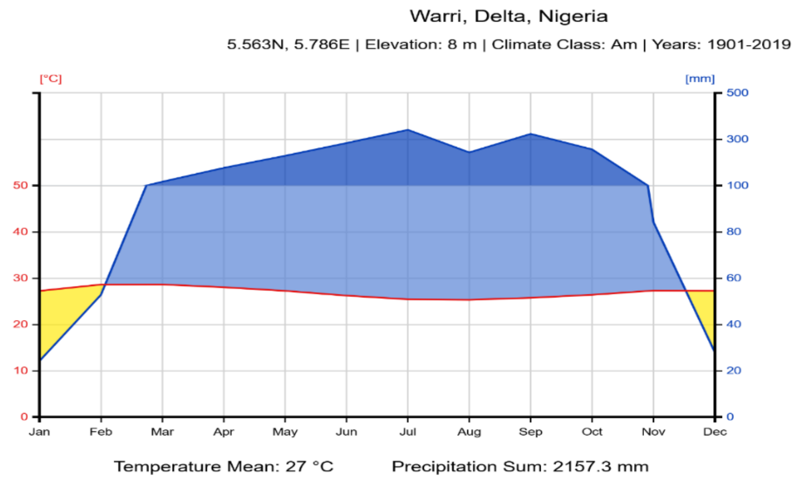
MATERIAL AND METHODS

The ex-post facto design was adopted in this study. Monthly and annual rainfall and temperature data were used in this study. The data were obtained from the CRU through Google earth using ESRI. Version 4.04 of Time Series with high-resolution gridded data raster cells of monthly variations in weather parameters from January, 1901 to December, 2019 were used. Statistical analysis involved the mean, climographs, Analysis of variance (ANOVA), Fisher Test, Post Hoc test, and Minitab 18 macro tool. Mann-Kendall (M-K) Trend Test by Normal Approximation: The trend is said to be decreasing (Downward) if the calculated Z is negative and the computed p-value is lesser than the level of significance. The trend is said to be increasing (Upward) if the calculated Z is positive and the computed p-value is lesser than the level of significance.

RESULTS AND DISCUSSION

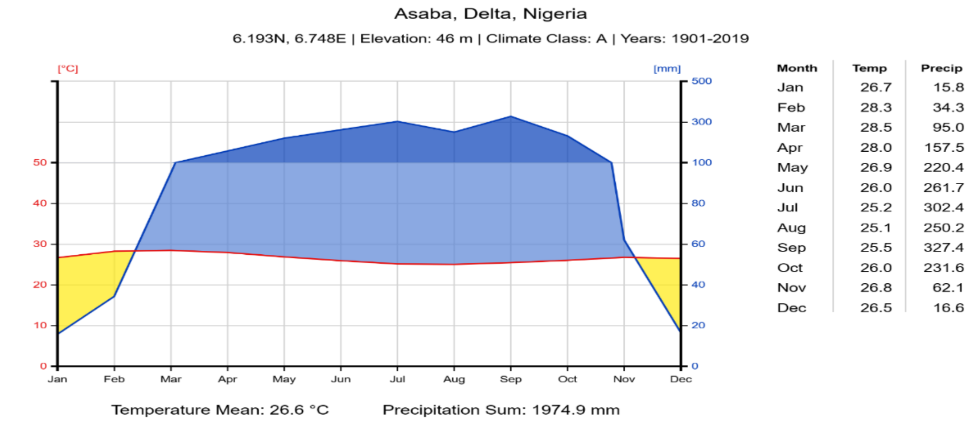
A very popular form of visualizing meteorological data is the so-called Walter-Lieth graph. Such a graph illustrates precipitation and temperature changes throughout the year. It is especially useful to determine dry and wet months throughout the annual cycle. The Walter and Lieth climatic diagram for temperature (red line) and precipitation (blue line) series of Eight Stations in Delta State. On the left axis, values in red represent the absolute temperature along the whole period. On the right axis, values in blue represent the value of mean annual precipitation along the whole period.

A common way to describe the climate characteristic of a location in a graphical form is to use the so-called Walter-Lieth diagram (Walter & Lieth, 1964). In a Walter-Lieth diagram, monthly air temperature and precipitation averages are plotted against the months of the year. Air temperature is plotted on the left y-axis, and precipitation is plotted on the right y-axis. The axes are scaled in such a way that 20mm of monthly precipitation are equal to 10ºC average air temperature. If the precipitation curve falls below the temperature curve, the space between both curves is shown in red, indicating a dry season. In the opposite case, where the precipitation curve lies above the temperature curve, vertical blue lines are used in the space between the curves to indicate a wet season. In the case of a particularly wet period, during which time monthly precipitation exceeds 100mm, the area between the precipitation curve and the 100mm threshold is shown in blue. The 8 stations in Delta State show a typical seasonal tropical climate pattern (Figures 3-10).



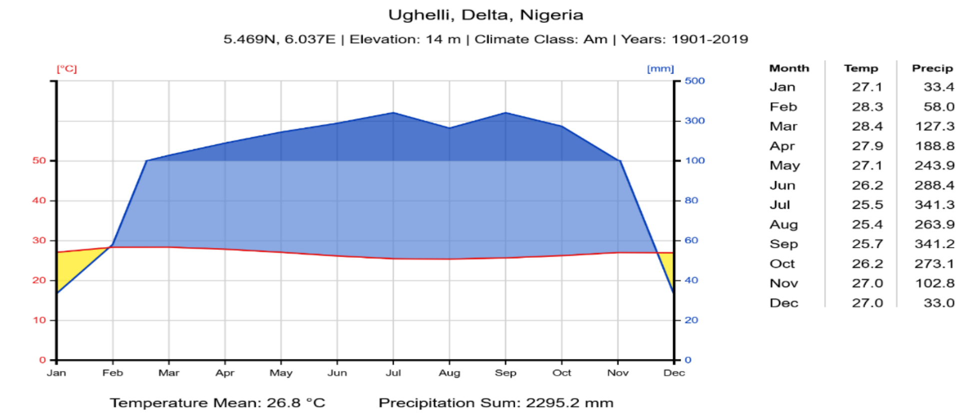
Month	Temp	Precip
Jan	27.3	24.3
Feb	28.6	52.8
Mar	28.6	116.6
Apr	28.0	176.3
May	27.3	228.6
Jun	26.2	283.5
Jul	25.4	340.6
Aug	25.3	243.1
Sep	25.8	323.2
Oct	26.4	256.3
Nov	27.3	84.2
Dec	27.3	28.0

Figure 3: Climograph for Warri, Delta State, Nigeria.



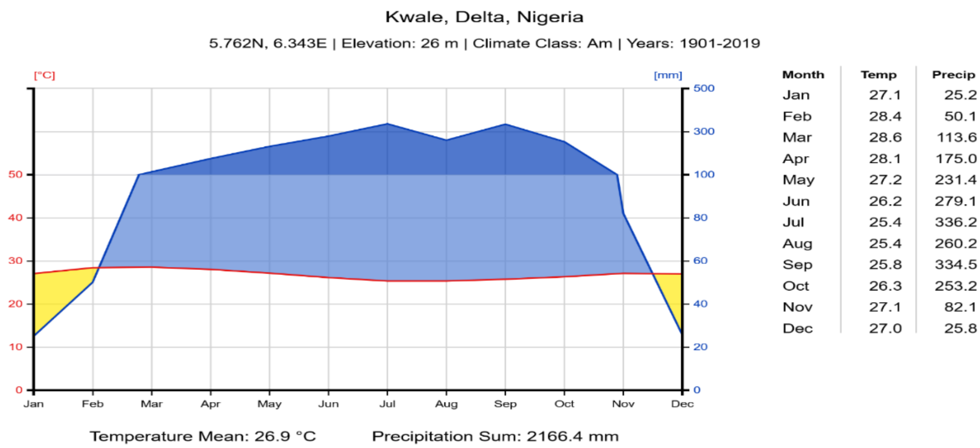
Month	Temp	Precip
Jan	26.7	15.8
Feb	28.3	34.3
Mar	28.5	95.0
Apr	28.0	157.5
May	26.9	220.4
Jun	26.0	261.7
Jul	25.2	302.4
Aug	25.1	250.2
Sep	25.5	327.4
Oct	26.0	231.6
Nov	26.8	62.1
Dec	26.5	16.6

Figure 4: Climograph for Asaba, Delta State, Nigeria.



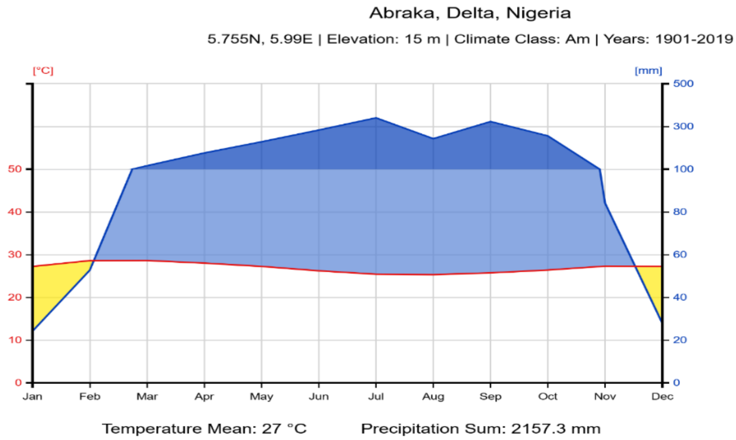
Month	Temp	Precip
Jan	27.1	33.4
Feb	28.3	58.0
Mar	28.4	127.3
Apr	27.9	188.8
May	27.1	243.9
Jun	26.2	288.4
Jul	25.5	341.3
Aug	25.4	263.9
Sep	25.7	341.2
Oct	26.2	273.1
Nov	27.0	102.8
Dec	27.0	33.0

Figure 5: Climograph for Ughelli, Delta State, Nigeria.



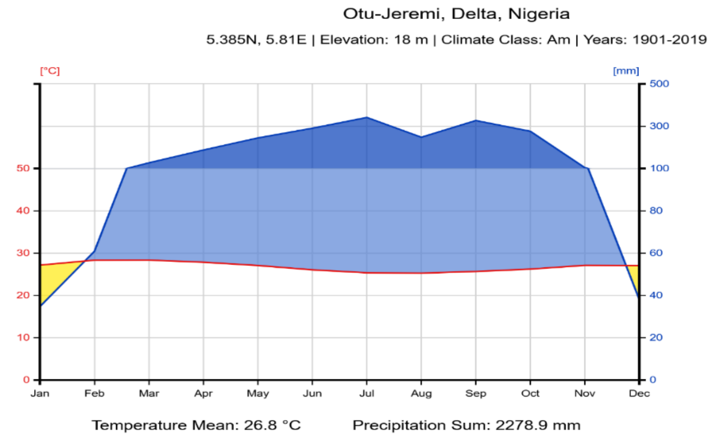
Month	Temp	Precip
Jan	27.1	25.2
Feb	28.4	50.1
Mar	28.6	113.6
Apr	28.1	175.0
May	27.2	231.4
Jun	26.2	279.1
Jul	25.4	336.2
Aug	25.4	260.2
Sep	25.8	334.5
Oct	26.3	253.2
Nov	27.1	82.1
Dec	27.0	25.8

Figure 6: Climograph for Kwale, Delta State, Nigeria.



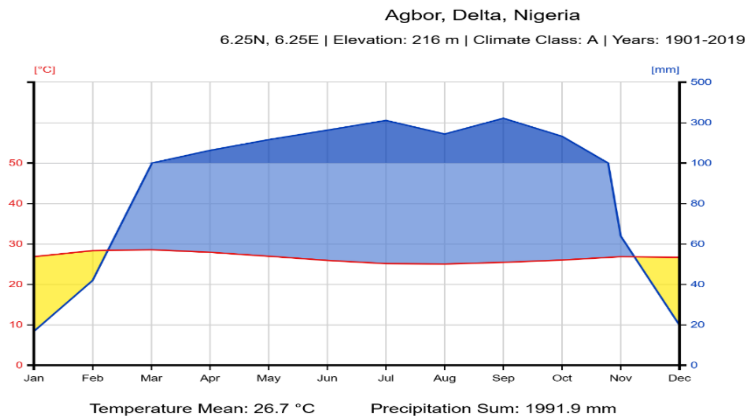
Month	Temp	Precip
Jan	27.3	24.3
Feb	28.6	52.8
Mar	28.6	116.6
Apr	28.0	176.3
May	27.3	228.6
Jun	26.2	283.5
Jul	25.4	340.6
Aug	25.3	243.1
Sep	25.8	323.2
Oct	26.4	256.3
Nov	27.3	84.2
Dec	27.3	28.0

Figure 7: Climograph for Abraka, Delta State, Nigeria.



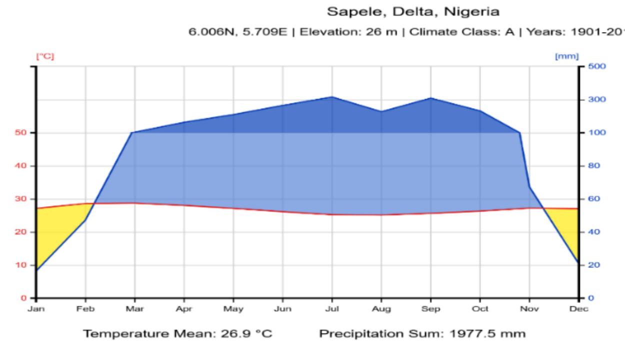
Month	Temp	Precip
Jan	27.2	34.7
Feb	28.3	60.9
Mar	28.4	126.9
Apr	27.8	187.3
May	27.1	244.5
Jun	26.1	290.4
Jul	25.4	341.3
Aug	25.3	247.8
Sep	25.7	326.8
Oct	26.2	276.0
Nov	27.1	104.1
Dec	27.1	38.1

Figure 8: Climograph for Otu-Jeremi, Delta State, Nigeria.



Month	Temp	Precip
Jan	26.9	16.8
Feb	28.4	41.9
Mar	28.6	99.3
Apr	28.0	162.8
May	27.0	215.8
Jun	25.9	262.8
Jul	25.1	310.9
Aug	25.0	243.6
Sep	25.5	321.7
Oct	26.0	232.3
Nov	26.9	63.9
Dec	26.7	19.9

Figure 9: Climograph for Agbor, Delta State, Nigeria.



Month	Temp	Precip
Jan	27.2	16.5
Feb	28.6	47.3
Mar	28.8	103.4
Apr	28.1	163.3
May	27.2	209.8
Jun	26.1	265.1
Jul	25.3	315.9
Aug	25.1	227.2
Sep	25.7	309.0
Oct	26.3	231.9
Nov	27.3	67.3
Dec	27.1	20.9

Figure 10: Climograph for Sapele, Delta State, Nigeria

From Figures 3 to 10 representing all the stations, it can be observed that, the period from February to early December is wet (blue areas); while in the other month's dry season (light yellow areas) predominate. The months from March until late October show high rainfall. Obviously, there is a significant difference between the rainy and dry season due to the fact that in the rainy season, the atmosphere is mostly dominated by high moisture depth of water vapour in the cloud, which eventually increases humidity in the atmosphere compared to the dry season, which is characteristic of most tropical areas. All of the stations show a double peak in terms of rainfall and a pronounced dry period between November and February. This result is in agreement with Chinago (2020), and Adejuwon (2012). The rains typically start in late February and March or early April, during which the rainy season covers everywhere throughout the area. At all stations, precipitation peaks for the first time is in July. The second precipitation peak occurs for all sites in September, as caused by tropical storms. This result is also in agreement with Chinago (2020). All the stations studied experienced a more pronounced precipitation peak towards the middle of the rainy season (Amadi & Udo, 2015). The climographs also showed that air temperature reaches its maximum at the start of the dry season, and then declines during the course of the wet season. This implies that the first rainy season begins around February and last to the end of July with a peak in July. This rainy season is then followed by a depression in precipitation in August known as the August Hiatus, which is a reduction in monthly rainfall (short dry season) lasting for two to three weeks. This break is broken by the short rainy season starting around early September and lasting to October with a peak period at the end of September. The result of this present study is in tandem with the work of Chinago (2020). As it appears from all the graphs, July recorded the highest monthly rainfall in Warri (313.9mm) and Abraka (338mm) respectively and September recorded the highest monthly rainfall in Asaba (328.6mm); Ughelli (354.9mm); kwale (345.6mm); Otu-Jeremi (341.3mm); Agbor (330.5mm) and Sapele (316mm) during the period. From all the graphs, it can be observed that temperature rises during the dry periods (December-March); and gradually cools at the approach of the wet season. This may be due to increase in rainfall which was observed in all the stations in the state. The results are in agreement with Egor, Osang, Uquetan, Emeruwa & Agbor (2015) and Efe (2016). All the graphs also revealed that there was no month in Delta state where there was no rainfall.

The mean annual temperature for Warri is 27°C; the annual total rainfall is 2157.3mm. Asaba 26.6°C; the annual total rainfall is 1974.9mm; Ughelli 26.8°C; the annual total rainfall is 2295.2mm; Kwale 26.9°C; the annual total rainfall is 2166.4mm; Abraka 27°C; the annual total rainfall is 2157.3mm; Otu-Jeremi 26.8°C; 2278.9mm; Agbor 26.7°C; the annual total rainfall is 1991.9mm and Sapele 26.9°C; the annual total is 1977.5mm. Warri and Abraka exhibit high temperature (27°C) with Asaba having the lowest temperature (26.6°C) and Ughelli having the highest rainfall (2295.2mm) with the lowest rainfall in Asaba (1974.9mm), with 0.4°C increase in temperature and 320.3mm in rainfall.

Table 1: Summary of Annual Variations of Temperature in Delta State

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Stations	7	17.54	2.50594	25.88	0.000
Error	944	91.42	0.09684		
Total	951	108.96			

Table 1 shows that the p-value is less than 0.05, the null hypothesis is rejected at 5 percent level of significance, *F* (7, 944) = 25.88, *P* = .000. Hence it is concluded that there is a significant variation in annual temperature in Delta State. With significant differences in the mean of Warri, Ughelli, Otu-Jeremi, Agbor and Asaba (See Table 2).

Table 2: Fisher Pairwise Comparisons

Stations	N	Mean	Grouping				
Warri	119	27.0211	A				
Abraka	119	26.9974	A	B			
Sapele	119	26.9307		B	C		
kwale	119	26.8815			C	D	
Ughelli	119	26.8155				D	
Otu-Jeremi	119	26.8140				D	
Agbor	119	26.6727					E
Asaba	119	26.6148					E

Means that do not share a letter are significantly different.

Table 3: Summary of Annual Variations of Rainfall in Delta State

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Stations	7	17075053	2439293	5.69	0.000
Error	944	404645675	428650		
Total	951	421720728			

Table 3 indicates that p-value is less than 0.05, the null hypothesis is rejected at 5 percent level of significance, *F* (7, 944) = 5.69, *P* = .000. Hence it is concluded that there is a significant variation in annual in rainfall in Delta State. With significant differences in the mean of Ughelli, Otu-Jeremi and Sapele (See Table 4). This result is in agreement with Chinago (2020) and Egor et al. (2015).

Table 4: Fisher Pairwise Comparisons

Stations	N	Mean	Grouping			
Ughelli	119	2352.0	A			
Otu-Jeremi	119	2336.3	A			
Kwale	119	2220.8	A	B		
Abraka	119	2212.3	A	B		
Asaba	119	2145		B	C	
Warri	119	2121.9		B	C	
Agbor	119	2041.7			C	D
Sapele	119	1927.3				D

Means that do not share a letter are significantly different.

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Table 5: Summary of Monthly Temperature Variation in Delta State

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Months	11	13067	1187.87	5324.71	0.000
Error	11412	2546	0.22		
Total	11423	15612			

Table 5 reveals that p-value is less than 0.05, the null hypothesis is rejected at 5 percent level of significance, F (11, 11412) = 5824.71, *P* = .000. Hence it is concluded that there is a significant variation in the monthly temperature in Delta State. With significant differences in the mean of all the months (Table 6).

Table 6: Fisher Pairwise Comparisons

Months	N	Mean	Grouping									
Mar	952	28.5209	A									
Feb	952	28.4508		B								
Apr	952	27.9605			C							
May	952	27.1238				D						
Nov	952	27.1057				D						
Jan	952	27.0954				D						
Dec	952	27.0218					E					
Oct	952	26.2522						F				
Jul	952	25.8382							G			
Sep	952	25.6652								H		
Jun	952	25.6014									I	
Aug	952	25.2462										J

Means that do not share a letter are significantly different.

Table 7: Summary of Monthly Rainfall Variation in Delta State

Source	**DF**	**Adj SS**	**Adj MS**	**F-Value**	**P-Value**
Months	11	123890287	11262753	3502.96	0.000
Error	11412	36692001	3215		
Total	11423	160582288			

Table 7, indicates that p-value is less than 0.05, the null hypothesis is rejected at 5 percent level of significance, *F* (11, 11412) = 3502.96, *P* = .000. Hence it is concluded that there is a significant variation in the monthly rainfall in Delta State. With significant differences in the mean of all the months (See Table 8).

Table 8: Fisher Pairwise Comparisons

Months	N	Mean	Grouping								
Sep	952	313.15	A								
Jul	952	312.44	A								
Jun	952	276.96		B							
Oct	952	252.77			C						
Aug	952	233.39				D					
May	952	229.00				D					
Apr	952	173.26					E				
Mar	952	114.93						F			
Nov	952	86.20							G		
Feb	952	50.87								H	
Dec	952	30.948									I
Jan	952	27.565									I

Means that do not share a letter are significantly different.

Table 9: Mann-Kendall Trend Test by Normal Approximation for Annual Temperature

Stations	Nos. of Years	Calculated Z	Increasing p-value	Decreasing p-value	**Trend (at alpha 0.05 Sig.)**
Warri	116	3.91183	0.0000458	0.999954	Upward
Abraka	116	4.04030	0.0000267	0-999973	Upward
Kwale	116	4.41073	0.0000052	0.99999	Upward
Otu-Jeremi	116	4.27807	0.0000060	0.99999	Upward
Ughelli	116	4.05440	0.0000251	0.999975	Increasing
Agbor	116	3.56287	0.0001834	0.999817	Increasing
Sapele	116	3.57706	0.0001737	0.999826	Increasing
Asaba	116	3.43900	0.0002919	0.999706	Increasing

Source: Authors' Computation (2023)

Table 9 shows the M-K trend test results for temperature. The result indicates that there is an increasing trend in temperature in the 8 stations in Delta State. This result strengthens the findings of this study that temperature is increasing in the study areas

Table 10: Mann-Kendall Trend Test by Normal Approximation for Annual Rainfall

Stations	Nos. of Years	Calculated Z	Increasing p-value	Decreasing p-value	**Trend (At alpha 0.05 Significance)**
Warri North	116	1.00215	0.158134	0.841866	No Trend
Abraka	116	0.837512	0.201152	0.798848	No Trend
Kwale	116	-0.617999	0.731712	0.268288	No Trend
Otu-Jeremi	116	-0.264854	0.604439	0.395561	No Trend
Ughelli	116	1.45312	0.926905	0.0730952	No Trend
Agbor	116	-0.252925	0.599837	0.400163	No Trend
Sapele	116	0.0190887	0.492385	0.507615	No Trend
Asaba	116	-1.08566	0.861186	0.138814	No Trend

Source: Author's Computation (2023)

Rainfall M-K trend test results in Table 10 shows that there is no trend in rainfall in the 8 stations in Delta State.

Table 11: Mann-Kendall Trend Test by Normal Approximation for Monthly Temperature

Stations	Nos. of Years	Calculated Z	Increasing p-value	Decreasing p-value	**Trend (At alpha 0.05 Significance)**
Apr	928	-3.26379	0.999450	0.0005497	Decreasing
Aug	928	-2.07196	0.980865	0.0191346	Decreasing
Dec	928	-9.14149	1	0.0000000	Decreasing
Feb	928	-7.55024	1	0.0000000	Decreasing
Jan	928	-7.35491	1	0.0000000	Decreasing
Jun	928	-2.22979	0.987119	0.0128813	Decreasing
Mar	928	-5.88321	1.00000	0.0000000	Decreasing
May	928	-7.77246	1	0.0000000	Decreasing
Nov	928	-9.51296	1	0.0000000	Decreasing
Oct	928	-7.42541	1	0.0000000	Decreasing
Sep	928	-6-05873	1.00000	0.0000000	Decreasing
Jul	928	-1.54947	0.939366	0.0606338	No Trend

Source: Author's Computation (2023)

Temperature M-K trend test results in Table 11 shows that there is a decreasing trend in the seasonal temperature in January – June and August - December except in the month of July with no trend.

Table 12: Mann-Kendall Trend Test by Normal Approximation for Monthly Rainfall

Stations	Nos. of Years	Calculated Z	Increasing p-value	Decreasing p-value	**Trend (At alpha 0.05 Significance)**
Feb	928	-2.37753	0.991285	0.0087146	Decreasing
Jul	928	-2.09250	0.981803	0.0181971	Decreasing
Jun	928	-360530	0.999814	0.0001559	Decreasing
May	928	0.532721	0.297113	0.702887	Decreasing
Nov	928	-0.110277	0.543905	0.456095	Decreasing
Oct	928	0.425413	0.335268	0.664732	Decreasing
Aug	928	4.31531	0.0000080	0.99999	Increasing
Sep	928	3.21477	0.0006527	0.999347	Increasing
Apr	928	-0.201997	0.580041	0.419959	No Trend
Dec	928	-1.06365	0.856256	0.143744	No Trend
Jan	928	0.354812	0.361365	0.638635	No Trend
Mar	928	-1.08474	0.860982	0.139018	No Trend

Source: Author's Computation (2023)

Rainfall M-K trend test results in Table 12 reveals that there is a decreasing trend in rainfall in the months of February, May, June, July and November, with the months of August and September having an increasing trend, whereas January, March, April and December have no trends. These results are in tandem with work of Žalud, Brotan, Hlavinka and Trnka (2013), Yadav, Tripathi and Dubey (2014), Rahman and Lateh (2017), Dorji, Olesen, Bøcher and Seidenkrantz (2016) which found out that numerous studies conducted on rainfall and temperature time series throughout the globe indicate negative, positive and in some cases no trends.

CONCLUSION

In general, there were agreements in the results obtained from the analysis of variance and the Mann-Kendall test trend line for the 8 stations. The ANOVA result shows that there is variation in annual temperature in the eight stations, with significant difference in Warri, Ughelli, Otu-Jeremi, Agbor and Asaba. The result also shows that there is a variation in annual rainfall in eight stations with significant difference in Ughelli, Otu-Jeremi and

Sapele. On the monthly temperature, there are significant variations in the eight stations, with significant differences from January to December. On rainfall, there are significant variations in the twelve months of the year, from January to December. Furthermore, the Mann-Kendall trend test result for temperature shows that there are increasing trends in the eight stations (Warri, Abraka, Kwale, Otu-Jeremi, Ughelli, Agbor, Sapele and Asaba). Mann-Kendall result for rainfall however, revealed no trends in the eight stations (Warri, Abraka, Kwale, Otu-Jeremi, Ughelli, Agbor, Sapele and Asaba). But on the monthly trends result for temperature for all the stations there is decreasing trends for the months of January to June, August to December in the eight stations, while the month of July displayed no trends in the eight stations. On the other hand, monthly rainfall trends for the eight stations indicates that there is decreasing trend for the months of February, May, June, July, October and November. But, the months of August and September had increasing trends in the eight stations. However, April, January, March and December no trends were recorded in the eight stations.

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