Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 12 ~ Issue 8 (August 2026) pp: 01-09
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

Analysis of the Long-Term Trends in Temperature and Rainfall in Delta State

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Abstract
Aims: *To assess the spatial and temporal distribution of temperature and rainfall and to evaluate changes in direction, magnitude, and significance of long-term temperatures and rainfall using descriptive, inferential, and non-parametric methods.*
Study Design: *This study employed a retrospective observational research design based on analysing long-term climatic time-series data.*
Place and Duration of Study: *Abraka, Agbor, Asaba, Ughelli, and Warri in Delta State, covering the period 1901–2024.*
Methodology: *The study analysed the long-term trends in temperature and rainfall in Delta State, Nigeria. The two variables used for the study (monthly temperature and rainfall) were extracted from the Climate Research Unit (CRU) at 0.5° × 0.5° spatial resolution (CRU TS v4.09) grid cells for the periods 1901–2024. The climatic characteristics of the study area were summarised through descriptive statistics. One-way analysis of variance (ANOVA) was used to assess spatial variation;Tukey's HSD post hoc test was performed to detect where the differences lie, andEta squared (η^2) was used to detect the effect size. Sen's slope estimator and the Mann–Kendall test were used to identify temporal trends in rainfall and temperature.*
Results: *The results showed that temperature exhibited a relatively uniform spatial distribution with very low variability andstatistically significant spatial differences, with a small effect size ($\eta^2 = 0.019$). In contrast, rainfall demonstrated substantial variability, as reflected by its high coefficient of variation, although statistically significant spatial differences were also observed, with a small effect size. Across the fivestudy locations examined, the trend analysis showed a positive and statistically significant increase in temperature.Sen's slope estimations indicated a warming trend of about 0.00375°C-0.0043°C per year and 0.0375°C-0.043 °C per decade, with Kendall's tau values ranging from 0.361-0.404.*
Conclusion: *The study's findings suggest that using evidence-based climate change adaptation measures improves community resilience.*

KEYWORD: *Long-Term, Trends, Temperature, Rainfall, Mann-Kendall, Sen's Slope, Variability*

*Received 01 Aug., 2026; **R**evised 05 Aug., 2026; **A**ccepted 07 Aug., 2026 © The author(s) 2026. **P**ublished with open access at **www.questjournals.org***

I. Introduction

Climate is one of the most significant parts of the Earth's system. It influences various aspects of the environment and human activities, for example, ecosystems, agriculture, water resources, and health. Climate change affects the Earth's systems majorly and the health of the people mainly through the rise in global temperatures, changing patterns of rainfall, and the occurrence of extreme weather.These effects have been documented in several studies (Efe & Eyefia, 2014a; 2014b; Weiskopf et al., 2020; Anjum et al., 2024). In recent decades, global concern regarding climatechange has become increasingly pronounced, as a result of its vastimpact on people'shealth in developing and developed nations (Campbell-Lendrum & Corvalán, 2007; Ludwig et al., 2007; World Health Organisation [WHO], 2023; Alam & Gounder, 2025).

The Niger Delta region, which is highly sensitive toenvironmental change,is getting more vulnerable to theimpacts of climate change becauseits socioeconomic development and livelihoods are heavily dependent on climatic conditions (Odigwe et al., 2020; Ebelegi, 2025; Osah et al., 2025).Delta State is located in the southernmost geographical parts of Nigeriaand experiences a hot, humid tropical climate with rainfall throughout the year (Efe, 2007; Ndakara & Eyefia, 2021). The State has long been characterised by consistent climatic conditions of highrainfall and high temperatures (Adejuwon, 2012; Balogun & Onokerhoraye,2022). These favourable climatic factors make it possible for people to take up different agricultural activities, amongother climate-dependent livelihood activities. However, recent studies on regional climate indicate clear increases in temperature and rainfall patterns (Eyefia,2023). Besides increasing temperature and rainfall variation, there is a growing frequency of floods and droughts, which illustrates clearly one of the effects of climate change and also indicates that the pattern of climate in the region is changing (Okeke & Ebekwem, 2017; Ekwueme & Khan, 2020; Ndakara & Eyefia, 2021; Eteh et al., 2025; Ntor & Ekong, 2025). A climate that comes with extreme temperatures as well as irregular rainfall can lead to environmental destruction, loss of freshwater resources, and hunger.Activities such as deforestation, urbanisation, and oil exploration are harmful to the environment. One of the ways these activities affect the climate is the release of greenhouse gases into the atmosphere (Msimanga & Mukwada, 2022; Wright et al., 2024; Abebaw, 2025). Delta State is particularly vulnerable to environmental impacts because of its flat coastal topography, extensive river systems, and dependence on climate-sensitive livelihoods,whichare allsensitive to theclimate(Efe,2016; Dike et al.,2024; Eyefia,2024).A study by Emaziye et al. (2012) revealed that rainfall in Delta State is decreasing while temperature is rising. Such a scenario may have effects on the level of agricultural production.

Similarly, Olali et al. (2025) reported warming trends and temperature change points in Warri using 31 years of meteorological records. Chinago (2020) observed a downward trend of rainfall in Port Harcourt, whereas Ndakara and Eyefia (2024) reported an increasing temperature trend and mixed rainfall patterns across Delta State. Collectively, these studies highlight the need for localised long-term assessments of climatic variability. However, many previous investigations were based on relatively short observational records and relied primarily on descriptive statistical analyses. Addressing these shortcomings, the present study employed 124 years (1901–2024) of high-resolution CRU TS v4.09 gridded climate data to provide a comprehensive assessment of long-term spatial and temporal changes in temperature and rainfall in Delta State, Nigeria. Specifically, the study assessed the spatial and temporal distribution of temperature and rainfall, whether there are significant spatial differences in temperature and rainfall at the selected locations, and evaluated changes in direction, magnitude, and significance of long-term temperatures and rainfall using descriptive, inferential, and non-parametric methods.

II. Materials and Methods

Study Area

Delta State is a geographical enclave situated between latitudes 5° N and 6.5°N and between longitudes 5° E and 6.75°E. It spans a total landmass of about 16,842 km².Except for the flat topography, which is the dominant feature of the study area, another interesting point is that nearly all the area under study is less than 150 meters above sea level. The coastal belt is largely dominated by mangroves, while the interiors mainly consist of freshwater swamps. The state is drained by major rivers, includingthe Niger, Ethiope, Okumeshi, and Ase, which discharge into the Bight of Benin through the Forcados and Escravos Rivers (Eyefia et al., 2023).Delta State is characterised by a prolonged rainy season, with abundant rainfall during the wet season (Efe, 2006; Efe, 2011; Efe & Eyefia, 2015).

The temperature and the rainfall in the study area are mainly regulated by its geographical position at a very low latitude and by its proximity to the Atlantic Ocean. One of the most important factors that contribute to the wet rainy season is the moist maritime air mass that prevails and the seasonal cycle of the Intertropical Convergence Zone (ITCZ). Other elements that contribute to this phenomenon are the flat and low landscape common in the region, which results in a relatively even distribution of temperatures and the poor drainage and high capacity for moisture that leads to flooding (Efe, 2007).The large number of swamps and networks of rivers further increases local humidity, thereby promoting frequent rainfall events.

Research Design

This study employed a retrospective observational research design based on analysing long-term climatic time-series data. This The design was appropriate since it largely depended on historical weather data to detect spatial and temporal differences in temperature and rainfall in selected locations in Delta State, Nigeria, without any manipulation of the climatic variables.

Data Collection

Temperature and rainfall data spanning the years 1901-2024 were accessed using the Climate Research Unit (CRU) Time-Series dataset, version 4.09 (CRU TS v4.09) (Harris et al., 2025). Its long temporal coverage (1901–2024) and consistent methodology make it suitable for long-term trend analysis, particularly in datasparse regions such as the Niger Delta.For this study, the CRU grid cells corresponding to Delta State were identified and extracted using the geospatial interface in Google Earth. Five representative grid cells were chosen to encompass different parts of the three senatorial districts of Delta State.

For each of the study locations, the study used a single CRU grid cell. In the Delta North region, Asaba and Agbor were selected; Abraka and Ughelli were selected from Delta Central; whereas, in the Delta South region, Warri was selected.Before the data were analysed, the datasets were properly checked for missing data and data inconsistency.To facilitate the temporal trend analysis, monthly data were converted into annual and long-term trends analysis.Since the temperature and rainfall data contained no missing values and no influential outliers, which suggest that the observed variability reflects natural climatic variability rather than data quality issues.

Data Analysis

The dataset was examined using descriptive statistics, including minimum, maximum, mean,and standard deviation, as well as coefficient of variation (CV) as measures of central tendency and dispersion, and inferential statistical techniques such as one-way analysis of variance (ANOVA) to see whether there were statistical geographical differences in temperature and rainfall across the five stations.Following statistically significant ANOVA results, a post hoc analysis using Tukey's Honestly Significant Difference(HSD) test was performed to detect the groups significantly different from each other.Alongside, Eta squared (η^2), an indicator of effect size, was used, showing the proportion of the total variance in the dependent variable due to differences between the groups. Eta squared (η^2) is computedas follows:

$$\eta^2 = SS\_between/SS\_total$$

Before the Analysis of Variance (ANOVA) and trend analysis were conducted on the time series data, the dataset was tested for stationarity, seasonality, and autocorrelation. Serial autocorrelation was assessed through the lag-1 autocorrelation coefficient, and when it was found that autocorrelation was significant in the data, the Trend Free Pre-Whitening (TFPW) procedure was conducted before the Mann–Kendall test was performed. The assumptions for employing one-way ANOVA were tested usingthe Shapiro–Wilk test for normality and Levene's test for homogeneity of variances.

To examine whether temperature trends are statistically significant, the Mann–Kendall test assessed statistical significance, whereas Sen's slope estimated the magnitude of changes over time with the help of Sen's slope estimator. IBM SPSS Statistics Version 21 and Python 3 were used for all the statistical analyses, and the statistical significances were tested at $\alpha = 0.05$. These methods have been extensively used for investigating the climate variation in Delta State and the Niger Delta region (Efe, 2006; Efe & Eyefia, 2015; Eyefia et al., 2023; Eyefia, 2025e). In addition, Eta squared (η^2) was computed to quantify the magnitude of spatial differences beyond statistical significance (Field, 2018; Cohen, 1988).

III. Results and Discussion

This section presents the results of the statistical analyses used to examine the long-term trends and spatial differences in temperature and rainfall across the selected locations in Delta State. Climatic variables were first summarised using descriptive statistics.

Diagnostic Analysis of Time Series

Serial autocorrelation was evaluated using lag-1 autocorrelation coefficients before the Mann–Kendall test. Temperature showed a very strong positive lag-1 autocorrelation (0.657-0.714) while rainfall was characterised by weak to moderate lag-1 autocorrelation (0.15-0.25). Thus, the Trend-Free Pre-Whitening (TFPW) method was applied; in this study,only the TFPW-modified Mann-Kendall results are presented. After removing the effect of serial autocorrelation, the temperature trends remained statistically significant across all locations ($p < 0.001$), with Sen's slope estimates varying between 0.00375–0.00430°C year^{-1} (0.0375–0.0430 °C decade^{-1}), confirming a robust regional warming trend. On the contrary, rainfall trends were not statistically significant following TFPW adjustment ($p > 0.05$), which implies that rainfall variability is dominated by interannual fluctuations rather than persistent long-term trends.

Temperature Characteristics and Spatial Variability

The analysis of the patterns and spatial distribution of temperature observations at the five study locations: Abraka, Agbor, Asaba, Ughelli and Warri in Table 1 reveals that temperature conditions are homogeneous across Delta State, with only negligible practical variation among the study locations despite statistically significant differences.The average temperature changed very little, between 26.60°C at Ughelli and 27.06°C at Warri. It suggests that temperature variability in this area is low. The minimum temperature varied from 24.0 to 24.5°C, and the maximum temperature values ranged from 29.5 to 30.3°C, respectively. The minimum and maximum temperatures reflect the relatively stable tropical climate of the Niger Delta.

The standard deviations varied between 1.07°C and 1.24°C (Table 1),indicating that temperature observations were closely clustered around their mean values. Meanwhile, the coefficient of variation (CV) values ranging between 4.01 and 4.65% suggested a very low level of relative variation. Collectively, results show a relatively consistent distribution of temperature across the different locations in the study area; only slight temperature differences exist in the different locations.

Nevertheless, this small difference may also be attributed to Delta State's location within a narrow equatorial latitudinal belt, its predominantly flat relief, and the relatively uniform climatic conditions experienced across the state. Consequently, temperature differences are statistically significant but negligible in practical terms.These results are in line with earlier studies that also pointed toincreasing temperatures in Warri and across Nigeria (Olali et al., 2025; Eyefia, 2025c). Similarly, Ishaku et al. (2024) reported notable warming trends in many Nigerian cities, which are consistent with the broader regional warming pattern observed in this study.

Table 1: Summary of Temperature Descriptive Statistics

Location	Minimum	Maximum	Mean	Std Dev	CV (%)
Abraka	24.3	29.7	26.77	1.15	4.3
Agbor	24	29.9	26.69	1.24	4.65
Asaba	24.5	30.3	26.92	1.21	4.51
Ughelli	24.3	29.5	26.6	1.07	4.01
Warri	24.3	30.1	27.06	1.22	4.5

Rainfall Characteristics and Spatial Variability

Except for a few slight differences in average monthly rainfall across the locations under study, rainfall demonstrated considerabletemporal variability throughout the whole study period. The mean monthly precipitation was lowest at 161.9 mm for Asaba and highest at 209.2 mm for Ughelli (Table 2), which shows variation in the spatial distribution. Still, the high standard deviations and coefficients of variation indicate that the fluctuation in rainfall was mainly due to temporal (interannual) variation and not differences among the study locations. Nonetheless, coastal locations like Warri and Ughelli experienced a larger amount of rainfall as compared to inland locations like Agbor and Asaba, reflecting the influence of their proximity to the Atlantic Ocean.

Therefore,rainfall is influenced by the advection of moisture-laden maritime air masses resulting from the closeness to the Atlantic Ocean. The standard deviations ranged from 116.7 mm–147.6 mm, indicating substantial temporal variabilityand considerable rainfall variability.

Additionally, the coefficient of variation ranges between 67% and 72%, which means that the variation in rainfall is relatively high (Table 2). These results are similar to those of other studies by Efe (2013) and Ndakara, Eyefia (2024), who have reported that interannual rainfall variability varies spatially and seasonally in the Delta State.

Table 2: Summary of Rainfall Descriptive Statistics

Location	Minimum	Maximum	Mean	Std Dev	CV (%)
Abraka	0.1	573.6	194.57	136.79	70.30
Agbor	0	546.2	171.28	123.54	72.13
Asaba	0.1	449.5	161.93	116.73	72.09
Ughelli	0.1	597.4	209.20	140.26	67.04
Warri	0	691.2	204.59	147.58	72.13

The study results reveal that location significantly influenced temperature, $F(4, 7435) = 36.11$, $p < 0.0005$ (Table 3). This finding implies that temperature differences among the locations were not just due to random changes.However, despite the statistically significant nature of the difference, its magnitude was relatively small. This was evident from the small differences in mean temperatures across the study locations.

Table 3: Summary of ANOVA Results for Temperature

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	200.857	4	50.214	36.113	.000
Within Groups	10338.145	7435	1.390		
Total	10539.002	7439			

As presented in Table 4, Tukey's HSD test showed that Warri had a much higher average temperature than Abraka, Agbor, Asaba, and Ughelli,suggesting that the differences found are not due to chance alone.The study indicates that only Ughelliconsistently records a lower mean temperature.The observed temperature differences may be associated with factors such as urban development and gas flaring around oil-producing communities (Efe, 2003; 2011).

Table 4: Multiple Comparisons Results (Tukey HSD) for Temperature

Dependent Variable:

(I) State			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Tukey HSD	Warri	Abraka	.28887*	0.04323	0.000	0.1709	0.4068
		Ughelli	.45890*	0.04323	0.000	0.3409	0.5768
		Agbor	.37509*	0.04323	0.000	0.2571	0.4930
		Asaba	.14169*	0.04323	0.009	0.0237	0.2596
	Abraka	Warri	-.28887*	0.04323	0.000	-0.4068	-0.1709
		Ughelli	.17003*	0.04323	0.001	0.0521	0.2880
		Agbor	0.08622	0.04323	0.269	-0.0317	0.2042
		Asaba	-.14718*	0.04323	0.006	-0.2651	-0.0292
	Ughelli	Warri	-.45890*	0.04323	0.000	-0.5768	-0.3409
		Abraka	-.17003*	0.04323	0.001	-0.2880	-0.0521
		Agbor	-0.08380	0.04323	0.297	-0.2018	0.0341
		Asaba	-.31720*	0.04323	0.000	-0.4352	-0.1993
	Agbor	Warri	-.37509*	0.04323	0.000	-0.4930	-0.2571
		Abraka	-0.08622	0.04323	0.269	-0.2042	0.0317
		Ughelli	0.08380	0.04323	0.297	-0.0341	0.2018
		Asaba	-.23340*	0.04323	0.000	-0.3514	-0.1154
	Asaba	Warri	-.14169*	0.04323	0.009	-0.2596	-0.0237
		Abraka	.14718*	0.04323	0.006	0.0292	0.2651
		Ughelli	.31720*	0.04323	0.000	0.1993	0.4352
		Agbor	.23340*	0.04323	0.000	0.1154	0.3514

*. The mean difference is significant at the 0.05 level.

One-way ANOVA was conducted to find out whether mean rainfall varied significantly between study locations. Table 5 revealed that location indeed had a statistically significant influence on rainfall distribution, $F(4,7435) = 36.07$, $p < 0.001$, indicating that different rainfall patterns were significantly seen across the Delta State study locations.

Table 5: Summary of ANOVA Results for Rainfall

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2569302.432	4	642325.608	36.065	.000
Within Groups	132418054.703	7435	17810.095		
Total	134987357.134	7439			

Table 6 indicates that pairwise comparison between the locations using Tukey's HSD showed that mean rainfall significantly varied depending on locations such as Warri, Ughelli, Agbor and Asaba. The HSD test also found that the mean rainfall of Warri differed significantly statistically from the rainfall at other study areas. The study indicates that approximately 3.50 mm of rainfall on the average was observed between Warri and Agbor

(Table 6).On the average, Ughelli rainfall wasapproximately 3.88mm higher than that of Agbor but 12.00 mm less than that of Asaba.

The rainfall recorded at Abraka was intermediate between the higher-rainfall locations such as Warri and Ughelli) and the lower-rainfall locations (Agbor and Asaba). The relatively higher rainfall over time in Warri and Ughelli can be attributed to their location's closeness to the Atlantic Ocean, which allows the movement of moisture-laden air masses that enhancerainfall.The result is similar to that of Efe (2006), who observed that the sea was an important factor in the distribution of rainfall in southern Nigeria. A similar result was also given by Efe and Eyefia (2015). Besides, Ndakara and Eyefia (2024) reported great variation in interannual rainfall variability across Delta State.

Table 6: Multiple Comparisons Results (Tukey HSD) for Rainfall

Dependent Variable:

(I) State			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Tukey HSD	Warri	Abraka	10.01956	4.89268	0.243	-3.3298	23.3690
		Ughelli	-4.61478	4.89268	0.880	-17.9642	8.7346
		Agbor	33.30968*	4.89268	0.000	19.9603	46.6591
		Asaba	42.65894*	4.89268	0.000	29.3095	56.0083
	Abraka	Warri	-10.01956	4.89268	0.243	-23.3690	3.3298
		Ughelli	-14.63434*	4.89268	0.023	-27.9837	-1.2849
		Agbor	23.29012*	4.89268	0.000	9.9407	36.6395
		Asaba	32.63938*	4.89268	0.000	19.2900	45.9888
	Ughelli	Warri	4.61478	4.89268	0.880	-8.7346	17.9642
		Abraka	14.63434*	4.89268	0.023	1.2849	27.9837
		Agbor	37.92446*	4.89268	0.000	24.5751	51.2739
		Asaba	47.27372*	4.89268	0.000	33.9243	60.6231
	Agbor	Warri	-33.30968*	4.89268	0.000	-46.6591	-19.9603
		Abraka	-23.29012*	4.89268	0.000	-36.6395	-9.9407
		Ughelli	-37.92446*	4.89268	0.000	-51.2739	-24.5751
		Asaba	9.34926	4.89268	0.311	-4.0001	22.6987
	Asaba	Warri	-42.65894*	4.89268	0.000	-56.0083	-29.3095
		Abraka	-32.63938*	4.89268	0.000	-45.9888	-19.2900
		Ughelli	-47.27372*	4.89268	0.000	-60.6231	-33.9243
		Agbor	-9.34926	4.89268	0.311	-22.6987	4.0001

*. The mean difference is significant at the 0.05 level.

Analysis of the Magnitude of the Temperature Effect

The effect size analysis revealed that temperature and rainfall had small effect sizes (Eta squared, η^2 = SS_between / SS_total = 0.019), indicating that differences in the study location explained only 1.9% of the total variation in each variable. However, ANOVA detected statistically significant spatial differences ($p < 0.05$), suggesting that the practical significance of these differences was limited. The results indicate that temperature and rainfall patterns in Delta State are mainly controlled by regional climatic processes and temporal variability rather than local spatial differences, which agrees with previous studies (Ndakara & Eyefia, 2024; Eyefia, 2025c; Chinago, 2020; Emaziye et al., 2012).

Trend Analysis of Temperature

The Mann–Kendall test was applied as a means of revealing the existence of long-term trends in the temperature data, with Sen's slope estimator being used to estimate the magnitude of temperature change over time. These methods jointly revealed a statistically significant temperature change in addition to the rate of change. Table 7 showed that temperature increased across the five study locations of Abraka, Agbor, Asaba, Ughelli, and Warri. Positive Kendall's tau (τ = 0.361, 0.404) and Sen's slope (0.0038, 0.0043 °C year^{-1}) suggest a statistically significant and consistent warming trend across all the study locations ($p < 0.001$). A reasonably homogeneous increase in temperature across the region indicates that climate change is the primary driver of variations rather than the geographical differences. The noticeable warming (~0.04 °CC per decade) that was observed could negatively impact agriculture, water resources, ecosystems, and human health, thus pointing out the necessity of climate adaptation.

Table 7: Trend Analysis for Temperature

Location	Trend Direction	Kendall's Tau (τ)	p-value	Sen's Slope (°C/year)	Sen's Slope (°C/decade)	Significance
Abraka	Increasing	0.367	<0.001	0.0038	0.0376	Significant
Agbor	Increasing	0.361	<0.001	0.0043	0.0401	Significant
Asaba	Increasing	0.365	<0.001	0.0038	0.0375	Significant
Ughelli	Increasing	0.404	<0.001	0.0043	0.043	Significant
Warri	Increasing	0.375	<0.001	0.0043	0.0427	Significant

Table Note: A trend is considered statistically significant at $p < 0.05$.

The Mann–Kendall test and Sen's slope estimator revealed no statistically significant monotonic trend in rainfall in Abraka, Agbor, Asaba, Ughelli, and Warri. Tau (τ) values ranged between -0.102–0.031, which indicates weak and inconsistent rainfall trends among the study locations (Table 8). Moreover, Sen's slope estimates ranged from -0.063–0.027 mm year^{-1} (or -0.63 to -0.27 mm decade^{-1}), demonstrating only negligible long-term changes in rainfall.

The negative slopes observed in Abraka, Agbor, Asaba, and Ughelli indicated a slight decrease in rainfall amounts during the period of study, while a marginal positive trend was exhibited in Warri. The results indicate that the changes were very insignificant and none of the detected trends was considered statistically significant ($p > 0.05$), a clear indication that the overall rainfall trend was not monotonic across the studied locations (Table 8).The rainfall variations witnessed seem to be largely driven by natural causes rather than persistent long-term directional change.

Such variability may reflect the influence of large-scale atmospheric and oceanic dynamics, for example, seasonal migration of the Intertropical Convergence Zone (ITCZ) and regional ocean--atmosphere interactions, which are strong regulators of rainfall over southern Nigeria.

These findings agree with previous studies reporting high interannual rainfall variability without significant long-term trends in southern Nigeria (Chinago, 2020; Emaziye et al., 2012).

Although no significant long-term rainfall trend was detected, the high interannual variability has important implications for flood risk, agriculture, and water resources, highlighting the need for climate adaptation strategies.

Table 8: Trend Analysis for Rainfall

Location	Trend Direction	Kendall's Tau (τ)	p-value	Sen's Slope (mm/year)	Sen's Slope (mm/decade)	Significance
Abraka	No Significant Trend	-0.061	0.312	-0.036	-0.36	Not Significant
Agbor	No Significant Trend	-0.049	0.402	-0.034	-0.34	Not Significant
Asaba	No Significant Trend	-0.102	0.083	-0.063	-0.63	Not Significant
Ughelli	No Significant Trend	-0.094	0.109	-0.061	-0.61	Not Significant
Warri	No Significant Trend	0.031	0.612	0.027	0.27	Not Significant

Note: Negative Sen's slope values indicate decreasing trends, whereas positive values indicate increasing trends.

IV. Conclusion

This study provides a comprehensive analysis of the long-term changes in temperature and rainfall that have occurred over a long period withinDelta State of Nigeria, providing valuable insights into the prevailing climate of the area. Nonetheless, temperature shows a gradual and statistically significant overall increase over the period of study, which suggests this warming trend aligns with climate change. The study areas exhibited considerable rainfall variability, with no evidence of statistically significant long-term trends. The lack of a consistent directional shift, combined with the strong temporal variability of rainfall, suggests that rainfall in the region is dominated by short-term climatic fluctuations rather than a persistent long-term trend.Climate change effects such as rising temperatures and irregular rainfall in Delta State could have major implications on the ecosystem, agricultural production and water resource management in Delta State. Such results emphasise the importance of implementing forward-looking and climate-conscious adaptation strategies that are tailored to a specific locale so that the state can be able to strengthen its resilience to cope with any future climate change or variability.

V. Recommendations

Based on the findings of this study, several recommendations are given, The government, in cooperation with private-sector stakeholders and local communities, should create and execute location-specific climate adaptation plans to tackle the increasing temperature and highly unreliable rainfall patterns.

Climate-smart agriculture practices should be encouraged, such as growing heat-resistant crop varieties, implementing water-efficient irrigation techniques and climate-responsive planting schedules not only to raise crop yields but also to make farmers more resilient to climate stresses such as heat waves and droughts.

Given the high variability of rainfall, flood management capacity should be strengthened.To reduce the risk of inundation, flood management capacity needs to be bolstered by enhancing the drainage system's performance and putting together effective warning systems.

Investment in meteorological infrastructureshould also be increased to ensure continuous improvement of meteorological observation quality, broader geographical coverage, frequencyof climate observations, and climate data available to researchers and decision-makers.

Public awareness programmesand community outreach programs should be revitalised to raise more people's awareness about the negative effects of climate variability and encourage them to preserve and manage natural resources sustainably.

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