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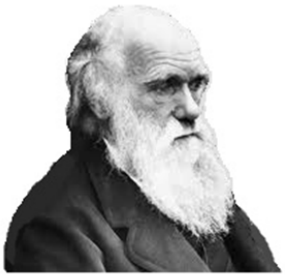

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Spatial Variation of Climate in South-Southern Nigeria

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ABSTRACT

Climate has never been constant; variations have occurred in different time scales worldwide, within a region, and even within a locality. This indicates that no part of the world has the same climate. Although changes or variations may not happen on a time scale that will make them visible to us, historical studies of the earth's climate have shown that climate variation has been a constant occurrence. This study uses archival data to examine the spatial variation of climate in South-Southern Nigeria. The study adopted the ex post facto research method and employed the Analysis of Variance (ANOVA) to analyse the data collected. The result of the analysis showed that there is a significant variation in rainfall, [F (5, 2840.251) = 4.788 $p < .001$], for relative humidity, [F (5, 2707.601) = 3.109 $p = .008$], and for temperature, [F (5, 2721.219) = 23.850, $p < 0.001$] in the South-Southern states. This means that although Akwa Ibom State, Bayelsa State, Cross River State, Delta State, Edo State, and Rivers State are within the same region (South-Southern states), there is spatial variation of the climate characteristics among these states. The study also revealed that temperature is statistically more significant than rainfall and relative humidity between and among the South-Southern States. The study is important to policymakers, farmers, urban and rural planners, the general populace, etc., who need the knowledge of climate variability/change to avert the disruption of the natural environment and ensure a balanced social and economic system. Providing a more sustainable and resilient tomorrow can also be significant for future planning.

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***Keywords*:** Climate, South-Southern, Spatial Variation, Climate Variability, Rainfall, Relative Humidity, Temperature

1. INTRODUCTION

The deviation of climate parameters from the long-term mean leads to climate variation. According to [12], climate variation is said to have occurred when there is a fluctuation around the mean and this variability occurs for short periods, decades or longer. Climate characteristics are constantly changing due to specific natural internal or external causes or anthropogenic effects. The natural causes which include periodic changes in air and water circulation, volcanic eruptions, Climate variability is caused by redistribution and changes in the amount of energy consumed, which results in changes in climatic variables such as rainfall, temperature, etc. The amount of energy distributed results from factors which could be from the external earth's system and internal factors.

The amount of solar radiation emitted that gets to the earth determines the temperature of the earth's atmosphere [5]. The more solar radiation emitted to the earth, the warmer it will be. On the other hand, volcanic activities can help to hinder some amount of solar energy from getting into the earth's atmosphere, reducing the energy released into the atmosphere [8]. These activities can lead to variability. Others include the tilting of the earth that can cause seasonal variations in the northern and the southern hemispheres and alterations in the amount of energy on the sea-surface temperatures.

Man's activities have significantly affected all aspects of the environment, especially climate. His activities in relation to his basic needs have affected the environment by releasing greenhouse gases into the atmosphere [9].

Climate change is due to several human activities. Industrialisation and urbanisation have taken the forefront of most nations that desire development and have led to the release of greenhouse gases into the atmosphere, thereby increasing the amount of energy from solar radiation retained in the earth's atmosphere.

Climate variability/change affects man's health [6], [7]. It is mainly experienced in urban areas, which expose the city population to extreme weather conditions, thereby exposing them to climate-related illnesses [14]. Also, [17] and [9] stated that climate variability has effects on food security, agriculture in general, and lives and properties. In addition, [4] stated that one of the implications of climate variability (global warming) is water scarcity, water pollution, etc.

Several studies have been carried out on climate variability in Nigeria [3], [10], [12], [13] and some in the South [1], [2], [11], but very few have been done on South-Southern Nigeria [17]. [1] did a study on the spatial and temporal variability of rainfall in the Niger Delta from 1990-2020, that is, 31 years.

The study focused on only the climatic variable, rainfall, and the result of the study showed that rainfall distribution in that region is not regular. Another study in South-South Nigeria by [17] on rainfall and temperature variability studies between 1978-2017, a period of 40 years. For the variability studies, the authors used rainfall, maximum temperature, and minimum temperature as their parameters to ascertain if there is variation in rainfall and temperature in the region, the period of study done between 1978-1997 and 1998-2017. The study's outcome is that there is variability in these parameters within the region [18].

Based on these studies, it was discovered that some studies employed only temperature, some only rainfall and some used both rainfall and temperature. Although studies have been carried out on climate variability, some parameters have been neglected in these studies. This study looks at the spatial variation of climate (rainfall, relative humidity, and temperature) in the South-Southern region. Therefore, the main objective of the study is to ascertain the spatial variation of rainfall, temperature, and relative humidity in the South-Southern region of Nigeria.

2. MATERIALS AND METHODS

2. 1. Area

The area under study is the South-Southern region of Nigeria, comprising six states: Akwa Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers states. The area is bounded in the west by Ondo and Ekiti States; east by the Republic of Cameroon; north by Kogi, Benue and the south-eastern States; and south by the Atlantic Ocean. The South-South Geopolitical Zone of Nigeria is located within latitudes 4°2′0″N–7°4′0″N and longitudes 5°–9°2′0″E of the Greenwich meridian [16]. The area has a humid tropical climate with wet and dry seasons. The temperature ranges are almost constant throughout the year. The mean daily maximum temperature is over 27 °C throughout the year while the daily minimum temperature is not usually below 18 °C [2].

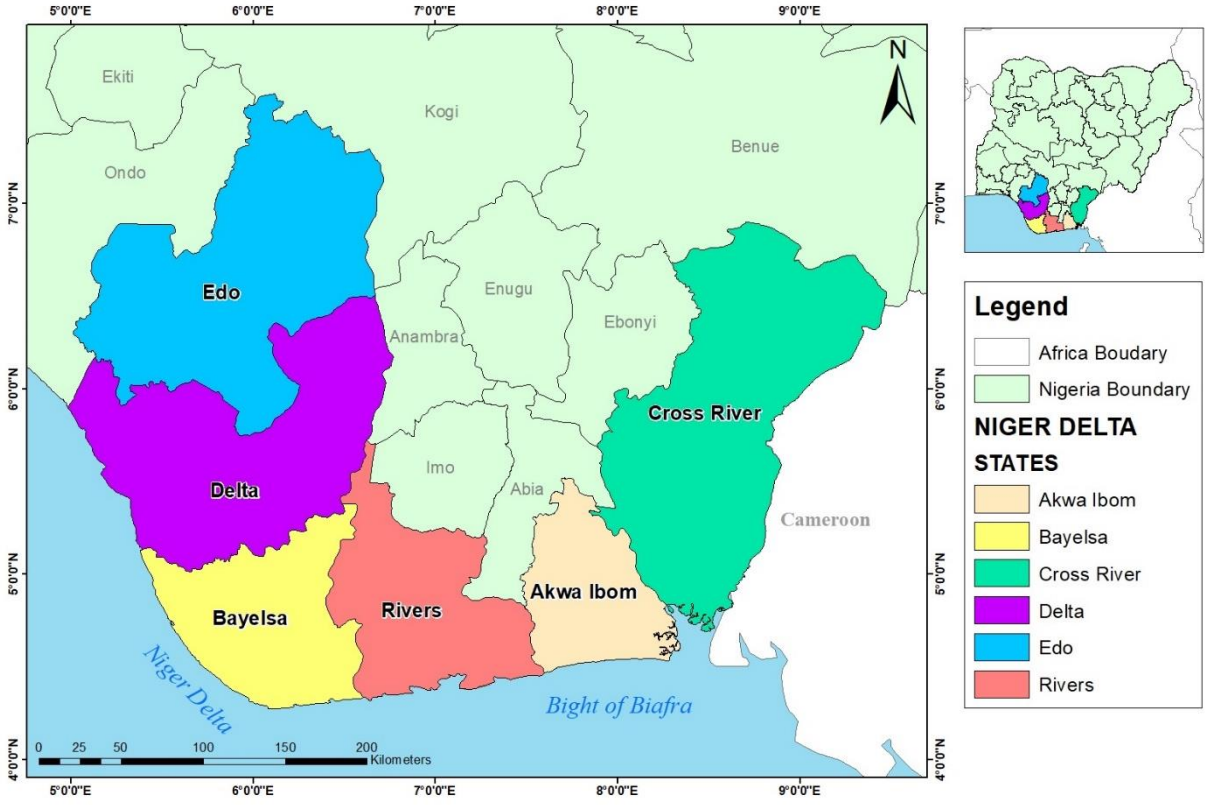

Figure 1. South-South Zone of Nigeria Showing the States

2. 2. Method of Data Collection

This study adopted the ex post facto research method. It employed three (3) climatic parameters - rainfall, relative humidity, and temperature. Monthly archival data for the climate was collected from Climatic Research Unit Gridded time series (CRU TS) version 4 and National Aeronautics and Space Administration (NASA) for 40 years (1981-2020). The reason for the 40 years (10 years above a climatic normal) is to have enough period the for the study of climate variability.

The climate data was collected from the six states in the South-Southern region (Akwa-Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers States) of Nigeria. Each state had 480 data samples collected for each climatic variable. That is, a total of 2880 for rainfall, 2880 for relative humidity and 2880 for temperature data samples were collected from the six states in South-Southern Nigeria.

The Statistical Package for Social Sciences (SPSS) was used to analyse the data. The analysis of variance was used to determine the spatial variation of climate in South-Southern Nigeria. [10] and [15] adopted this technique in their study.

Table 1. Means of Rainfall, Relative Humidity and Temperature

States	Rainfall in mm	R. Humidity in %	Temperature in ℃
Akwa Ibom	2285.5775	86.89245833	26.55625
Bayelsa	2303.19	87.597875	26.7720833
Cross River	2411.0475	86.88645833	26.7452083
Delta	2167.448	87.78720833	27.1997916
Edo	1985.355	86.8239375	27.1127083
Rivers	2302.3625	86.87952083	26.80875

Researcher's computation

Figure 2 is the spatial variation of rainfall in South-Southern Nigeria. It shows that rainfall is highest in Cross River State (2411.0475 mm), followed by Bayelsa State (2303.19 mm), River State (2302.3625), Akwa Ibom State (2285.5775 mm), and then Delta State (2167.448 mm). The lowest occurrence of rainfall is in Edo State (1985.355 mm). This depicts a spatial variation of rainfall in the South-Southern States. It is observed that rainfall is generally high, a typical characteristic of the humid climate.

In Figure 3, the spatial variation of relative humidity has been represented. The figure shows that Delta State has the highest distribution of relative humidity (87.787%), followed by Bayelsa State (87.598%), Akwa Ibom State (86.892%), Cross River State (86.886%), and then Rivers State (86.879%).

The lowest distribution of relative humidity is in Edo State (86.824%). The figure shows that there is spatial variation relative humidity in the region.

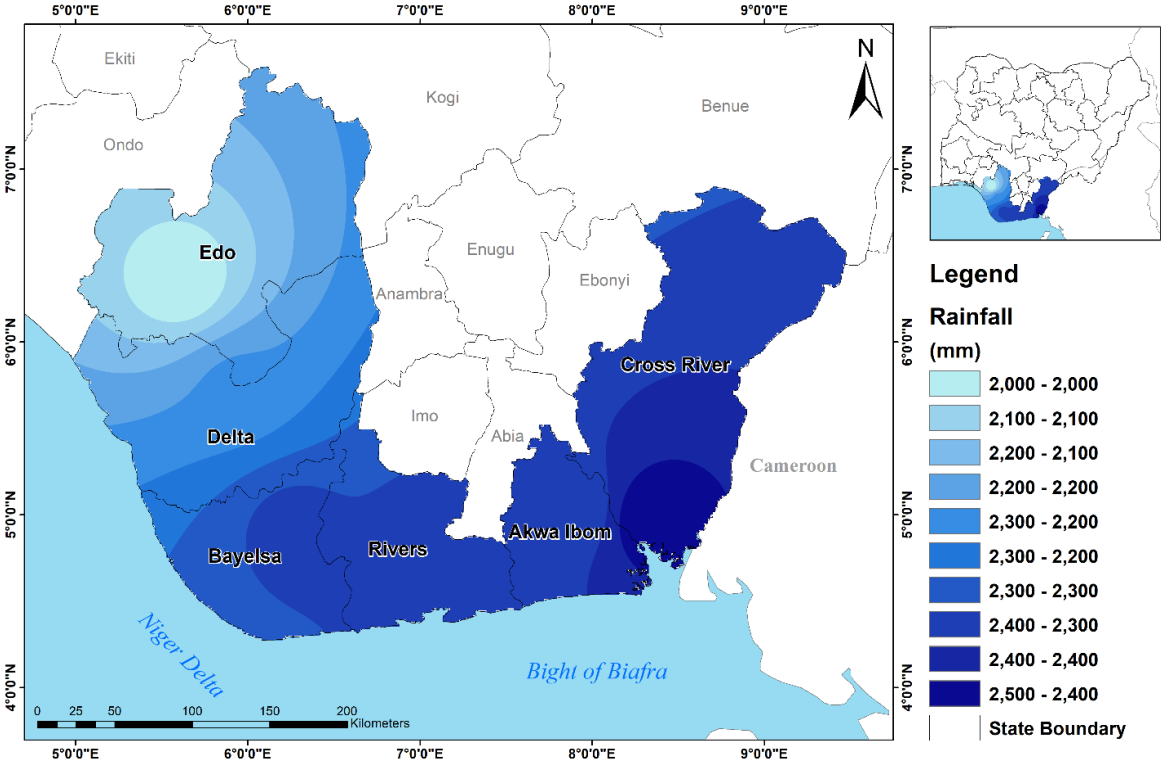

Figure 2. Spatial Variation of Rainfall in South-Southern Nigeria

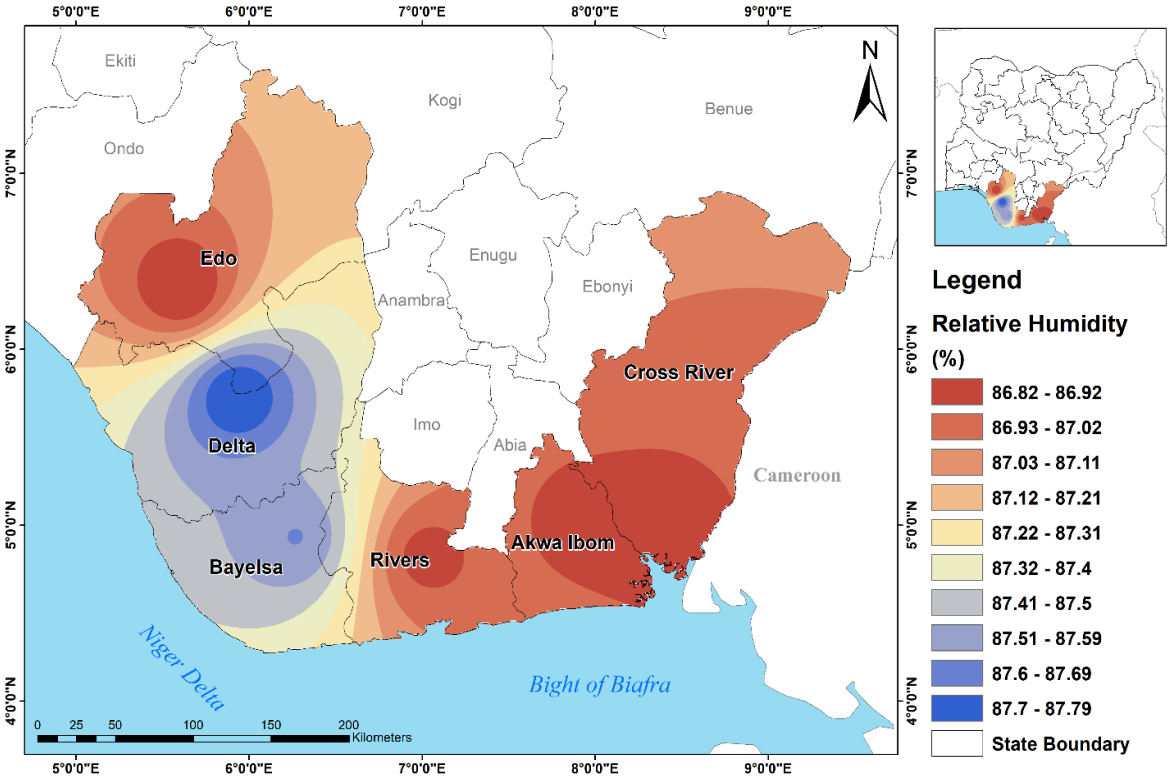

Figure 3. Spatial Variation of Relative Humidity in South-Southern Nigeria

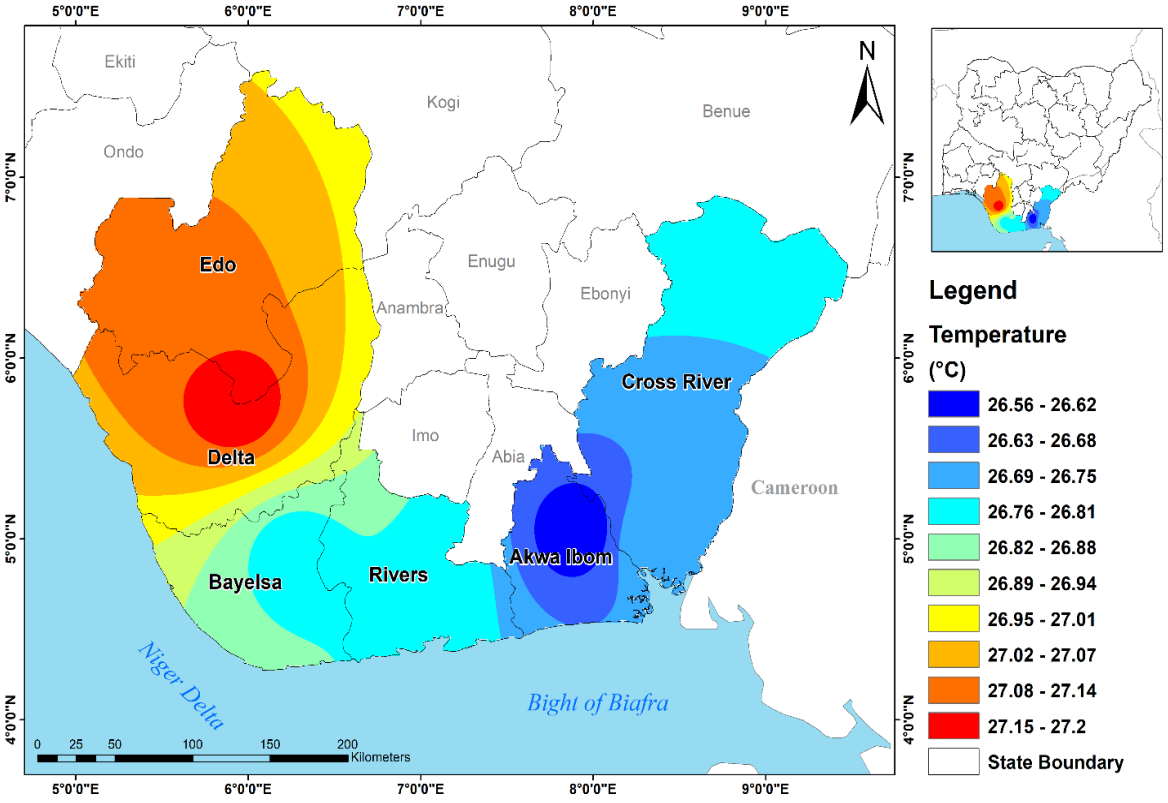

Figure 4. Spatial Variation of Rainfall in South-South Nigeria

Figure 4 is the spatial variation of temperature in the South-Southern region. It shows that Delta State has the highest temperature in the area with a value of 27.2 ℃, followed by Edo State with a temperature as high as 27.1 ℃, then Rivers having a value of 26.8 ℃, Bayelsa State, 26.7 ℃ and Cross River, 26.7 ℃. Akwa Ibom has the lowest temperature in the region, with a value of 26.5 ℃. Spatial variation of temperature occurs in the region, as shown in Figure 4. Temperature is generally high in the area, and this is one attribute of a warm, humid climate.

3. RESULTS AND DISCUSSION

The statistical technique employed in this study is the Analysis of Variance (ANOVA) using the SPSS version 25. Monthly data was collected for the six states in South-Southern Nigeria from 1981 to 2020. Each state had 480 data samples collected for each climatic variable. That is, rainfall had a total of 2880 data samples from the six states, relative humidity had 2880 data samples from the six states in South-Southern Nigeria, and temperature had the same number of data samples.

Table 2 provides descriptive statistics for rainfall. It shows that the average rainfall for Akwa Ibom is 190.4648; for Bayelsa, it is 191.9325; for Cross River, it is 200.9206; for Delta, it is 180.6207; for Edo, it is 165.4463; and for Rivers, it is 191.8635.

Table 2. Descriptive Statistics for Variation in Rainfall

RAINFALL								
States	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Akwa Ibom	480	190.4648	128.93009	5.88483	178.9015	202.0281	.10	537.40
Bayelsa	480	191.9325	115.65945	5.27911	181.b5594	202.3056	.30	469.50
Cross River	480	200.9206	133.89292	6.11135	188.9123	212.9290	.00	629.60
Delta	480	180.6207	124.96925	5.70404	169.4126	191.8287	.00	529.90
Edo	480	165.4463	118.50152	5.40883	154.8183	176.0742	.00	505.50
Rivers	480	191.8635	117.10362	5.34502	181.3609	202.3661	.00	476.80
Total	2880	186.8747	123.76134	2.30616	182.3528	191.3966	.00	629.60

Source: SPSS Output

Table 3. Test for Homogeneity of Variance for Rainfall

		Levene Statistic	df1	df2	Sig.
RAINFALL	Based on Mean	4.877	5	2874	.000
	Based on Median	4.849	5	2874	.000
	Based on Median and with adjusted df	4.849	5	2815.109	.000
	Based on trimmed mean	4.847	5	2874	.000

Source: SPSS Output

The test homogeneity of variance in Table 3 shows that the assumption of homogeneity of variance is violated as the p-value is less than 0.05. Therefore, a robust test of equality of means will be needed.

Table 4 shows that [$F = (5, 2874) = 4.788$, $p < .001$], meaning that there is a significant variation in rainfall among the states, but the result of this table cannot be used since the test for homogeneity variance is violated. Therefore, the robust tests of equality of means will be used to test for the statistical significance.

Table 4. ANOVA for Rainfall

RAINFALL					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	364290.265	5	72858.053	4.788	.000
Within Groups	43732974.851	2874	15216.762		
Total	44097265.116	2879			

Source: SPSS Output

Table 5: Robust Tests of Equality of Means for Rainfall

RAINFALL				
	Statistic[a]	df1	df2	Sig.
Welch	4.850	5	1340.608	.000
Brown-Forsythe	4.788	5	2840.251	.000
a. Asymptotically F distributed.				

Source: SPSS Output

Table 5 shows statistically significant spatial variation ($p < 0.01$) for both the Welch and Brown-Forsythe test. Using the result of the Brown-Forsythe test, [F (5, 2840.251) = 4.788 $p <$ .001]. Therefore, there is a significant spatial variation in rainfall in South-Southern Nigeria.

Table 6. Multiple Comparisons for Rainfall

Dependent Variable: RAINFALL						
LSD						
(I) STATES	(J) STATES	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Akwa Ibom	Bayelsa	-1.46771	7.96261	.854	-17.0807	14.1453
	Cross River	-10.45583	7.96261	.189	-26.0688	5.1572

	Delta	9.84412	7.96261	.216	-5.7689	25.4571
	Edo	25.01854*	7.96261	.002	9.4055	40.6315
	Rivers	-1.39875	7.96261	.861	-17.0118	14.2143
Bayelsa	Akwa Ibom	1.46771	7.96261	.854	-14.1453	17.0807
	Cross River	-8.98813	7.96261	.259	-24.6011	6.6249
	Delta	11.31183	7.96261	.156	-4.3012	26.9248
	Edo	26.48625*	7.96261	.001	10.8732	42.0993
	Rivers	.06896	7.96261	.993	-15.5440	15.6820
Cross River	Akwa Ibom	10.45583	7.96261	.189	-5.1572	26.0688
	Bayelsa	8.98813	7.96261	.259	-6.6249	24.6011
	Delta	20.29996*	7.96261	.011	4.6870	35.9130
	Edo	35.47437*	7.96261	.000	19.8614	51.0874
	Rivers	9.05708	7.96261	.255	-6.5559	24.6701
Delta	Akwa Ibom	-9.84412	7.96261	.216	-25.4571	5.7689
	Bayelsa	-11.31183	7.96261	.156	-26.9248	4.3012
	Cross River	-20.29996*	7.96261	.011	-35.9130	-4.6870
	Edo	15.17442	7.96261	.057	-.4386	30.7874
	Rivers	-11.24288	7.96261	.158	-26.8559	4.3701
Edo	Akwa Ibom	-25.01854*	7.96261	.002	-40.6315	-9.4055
	Bayelsa	-26.48625*	7.96261	.001	-42.0993	-10.8732
	Cross River	-35.47437*	7.96261	.000	-51.0874	-19.8614
	Delta	-15.17442	7.96261	.057	-30.7874	.4386
	Rivers	-26.41729*	7.96261	.001	-42.0303	-10.8043
Rivers	Akwa Ibom	1.39875	7.96261	.861	-14.2143	17.0118
	Bayelsa	-.06896	7.96261	.993	-15.6820	15.5440

	Cross River	-9.05708	7.96261	.255	-24.6701	6.5559
	Delta	11.24288	7.96261	.158	-4.3701	26.8559
	Edo	26.41729*	7.96261	.001	10.8043	42.0303
*. The mean difference is significant at the 0.05 level.						

Source: SPSS Output

An LSD Multiple Comparison test was conducted for rainfall to show how each state is varied from each other. Table 6 shows that there is no significant variation between Akwa Ibom and Bayelsa (p = .854), no significant variation between Akwa Ibom and Cross River (p = .189), no significant variation between Akwa Ibom and Delta (p = .216), no significant variation between Akwa Ibom and Rivers (p = .861) but there is a significant variation between Akwa Ibom and Edo (p = .002). Bayelsa is not significantly varied with Cross River (p = .259), Delta (p = .156), and Rivers (p = .993) but significantly varied with Edo (p = .001). Also, Cross River is not significantly varied with Delta (p = .011) and Rivers (p = .255) but significantly varied with Edo (p < .001). While Delta is not significantly varied with Edo (p = .057) and Rivers (p = .158), but Edo is significantly varied with Rivers (p = .001).

From the Robust Tests of Equality of Means and the LSD test for rainfall, it is shown that that the p value is less than 0.05 [F (5, 2840.251) = 4.788 p < .001] this means that there is a significant spatial variation for rainfall in the south-southern of Nigeria.

Table 7. Descriptive Statistics for Variation in Relative Humidity

RELATIVE HUMIDITY								
States	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Akwa Ibom	480	86.8865	5.21830	.23818	86.4184	87.3545	67.19	92.25
Bayelsa	480	87.5979	4.90206	.22375	87.1582	88.0375	68.40	92.81
Cross River	480	86.8865	5.21830	.23818	86.4184	87.3545	67.19	92.25
Delta	480	87.7872	4.52531	.20655	87.3813	88.1931	70.75	97.62
Edo	480	86.8239	6.56344	.29958	86.2353	87.4126	59.31	93.31
Rivers	480	86.8795	5.41187	.24702	86.3941	87.3649	67.00	92.50
Total	2880	87.1436	5.35358	.09976	86.9480	87.3392	59.31	97.62

Source: SPSS Output

Table 7 provides descriptive statistics for relative humidity. It shows that the mean relative humidity for Akwa Ibom is 86.8865; for Bayelsa, 87.5979; for Cross River, 86.8865; for Delta, 87.7872; for Edo, 86.8239; and for Rivers, 86.8795.

Table 8. Test for Homogeneity of Variance for Relative Humidity

		Levene Statistic	df1	df2	Sig.
RELATIVE HUMIDITY	Based on Mean	12.773	5	2874	.000
	Based on Median	4.952	5	2874	.000
	Based on Median and with adjusted df	4.952	5	2579.890	.000
	Based on trimmed mean	9.911	5	2874	.000

Source: SPSS Output

The test for homogeneity of variance in Table 8 shows the assumption of homogeneity of variance is violated as the p-value is less than 0.05. Therefore, a robust test of equality of means will be conducted for relative humidity.

Table 9. ANOVA for Relative Humidity.

RELATIVE HUMIDITY					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	443.886	5	88.777	3.109	.008
Within Groups	82070.467	2874	28.556		
Total	82514.353	2879			

Source: SPSS Output

Table 9 shows that [$F = (5, 2874) = 3.109$, $p < .001$], meaning that there is a significant variation in relative humidity among the states, but the result of this table cannot be used since the test for homogeneity variance is violated. Therefore, the robust tests of equality of means will be used to test for the statistical significance.

Table 10 shows that there is statistically significant spatial variation ($p < 0.01$) for both the Welch and Brown-Forsythe test. Using the result of Brown-Forsythe test, [F (5, 2707.601) = 3.109 p = .008], there is a significant spatial variation for humidity in South-Southern Nigeria.

Table 10. Robust Tests of Equality of Means for Relative Humidity

RELATIVE HUMIDITY				
	Statistic[a]	df1	df2	Sig.
Welch	3.584	5	1338.840	.003
Brown-Forsythe	3.109	5	2707.601	.008

a. Asymptotically F distributed.

Source: SPSS Output

Table 11. Multiple Comparisons for Relative Humidity

Dependent Variable: RELATIVE HUMIDITY						
LSD						
(I) STATES	(J) STATES	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Akwa Ibom	Bayelsa	-.71142*	.34494	.039	-1.3878	-.0351
	Cross River	.00000	.34494	1.000	-.6764	.6764
	Delta	-.90075*	.34494	.009	-1.5771	-.2244
	Edo	.06252	.34494	.856	-.6138	.7389
	Rivers	.00694	.34494	.984	-.6694	.6833
Bayelsa	Akwa Ibom	.71142*	.34494	.039	.0351	1.3878
	Cross River	.71142*	.34494	.039	.0351	1.3878
	Delta	-.18933	.34494	.583	-.8657	.4870
	Edo	.77394*	.34494	.025	.0976	1.4503
	Rivers	.71835*	.34494	.037	.0420	1.3947
Cross River	Akwa Ibom	.00000	.34494	1.000	-.6764	.6764
	Bayelsa	-.71142*	.34494	.039	-1.3878	-.0351

	Delta	-.90075*	.34494	.009	-1.5771	-.2244
	Edo	.06252	.34494	.856	-.6138	.7389
	Rivers	.00694	.34494	.984	-.6694	.6833
Delta	Akwa Ibom	.90075*	.34494	.009	.2244	1.5771
	Bayelsa	.18933	.34494	.583	-.4870	.8657
	Cross River	.90075*	.34494	.009	.2244	1.5771
	Edo	.96327*	.34494	.005	.2869	1.6396
	Rivers	.90769*	.34494	.009	.2313	1.5840
Edo	Akwa Ibom	-.06252	.34494	.856	-.7389	.6138
	Bayelsa	-.77394*	.34494	.025	-1.4503	-.0976
	Cross River	-.06252	.34494	.856	-.7389	.6138
	Delta	-.96327*	.34494	.005	-1.6396	-.2869
	Rivers	-.05558	.34494	.872	-.7319	.6208
6	Akwa Ibom	-.00694	.34494	.984	-.6833	.6694
	Bayelsa	-.71835*	.34494	.037	-1.3947	-.0420
	Cross River	-.00694	.34494	.984	-.6833	.6694
	Delta	-.90769*	.34494	.009	-1.5840	-.2313
	Edo	.05558	.34494	.872	-.6208	.7319
*. The mean difference is significant at the 0.05 level.						

Source: SPSS Output

An LSD Multiple Comparison test was conducted for the relative humidity to show how each state varied from the others. Table 11 shows that there is a significant variation between Akwa Ibom and Bayelsa (p = .039), Akwa Ibom and Delta (p = .009), but not significant with Cross River (p = 1.000), Edo (p = .856) and Rivers (p = .984). Bayelsa is significant with Cross River (p = .039), Edo (p = .025) and Rivers (p = .037) but not significant with Delta (p = .583). Also, Cross River is significant with Delta (p = .009) and not significant with Edo (p = .856) and Rivers (p = .984), while Delta is significant with Edo (p = .005) and Rivers (p = .009). Edo is not significant with Rivers (p = .872).

From the Robust Tests of Equality of Means, it is shown that the p-value is less than 0.05 [*F* (5, 2707.601) = 3.109 p = .008], and the LSD Multiple Comparison test for humidity shows that there is variation in the South-Southern States of Nigeria. but the Tukey post hoc test could not ascertain where this variation lies among the states. Therefore, from the Robust Tests of Equality of Means and the LSD Multiple Comparison test for humidity, it can be stated that there is a significant spatial variation for relative humidity in south-southern Nigeria.

Table 12. Descriptive Statistics for Variation in Temperature.

TEMPERATURE								
States	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Akwa Ibom	480	26.5563	.99342	.04534	26.4672	26.6453	24.50	29.10
Bayelsa	480	26.7721	1.01727	.04643	26.6808	26.8633	24.70	29.20
Cross River	480	26.7452	.98835	.04511	26.6566	26.8339	24.60	29.20
Delta	480	27.1998	1.21946	.05566	27.0904	27.3092	24.80	30.10
Edo	480	27.1127	1.29103	.05893	26.9969	27.2285	24.60	30.10
Rivers	480	26.8087	.98486	.04495	26.7204	26.8971	24.50	29.10
Total	2880	26.8658	1.11093	.02070	26.8252	26.9064	24.50	30.10

Source: SPSS Output

Table 12 provides descriptive statistics for temperature. It shows that the average temperature for Akwa Ibom is 26.5563, for Bayelsa, it is 26.7721, for Cross River, it is 26.7452, for Delta, it is 27.1998, for Edo, it is 27.1127, and for Rivers, it is 26.8087.

Table 13. Test for Homogeneity of Variance for Temperature

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
TEMPERATURE	Based on Mean	18.288	5	2874	.000
	Based on Median	18.384	5	2874	.000

	Based on Median and with adjusted df	18.384	5	2733.474	.000
	Based on trimmed mean	18.306	5	2874	.000

Source: SPSS Output

The homogeneity of variance in Table 13 shows the assumption of homogeneity of variance is violated as the p-value is less than 0.05. Therefore, a robust test of equality of means will be conducted.

Table 14. ANOVA for Temperature

TEMPERATURE					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	141.559	5	28.312	23.850	.000
Within Groups	3411.602	2874	1.187		
Total	3553.161	2879			

Source: SPSS Output

Table 14 shows that [$F = (5, 2874) = 23.850$, $p < .001$], meaning that there is a significant variation in temperature among the states. but the result of this table cannot be used since the test for homogeneity variance is violated. Therefore, the robust tests of equality of means will be used to test for the statistical significance.

Table 15. Robust Tests of Equality of Means for Temperature

TEMPERATURE				
	Statistic[a]	df1	df2	Sig.
Welch	21.730	5	1339.031	.000
Brown-Forsythe	23.850	5	2721.219	.000
a. Asymptotically F distributed.				

Source: SPSS Output

Table 15 shows that there is statistically significant spatial variation ($p < 0.01$) for both the Welch and Brown-Forsythe test. Therefore, using the result of Brown-Forsythe test, [F (5,

2721.219) = 23.850 $p < .001$] Therefore, there is a significant spatial variation for temperature in South-Southern Nigeria.

Table 16. Multiple Comparisons for Temperature.

Dependent Variable: TEMPERATURE						
LSD						
(I) STATES	(J) STATES	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Akwa Ibom	Bayelsa	-.21583*	.07033	.002	-.3537	-.0779
	Cross River	-.18896*	.07033	.007	-.3269	-.0511
	Delta	-.64354*	.07033	.000	-.7814	-.5056
	Edo	-.55646*	.07033	.000	-.6944	-.4186
	Rivers	-.25250*	.07033	.000	-.3904	-.1146
Bayelsa	Akwa Ibom	.21583*	.07033	.002	.0779	.3537
	Cross River	.02688	.07033	.702	-.1110	.1648
	Delta	-.42771*	.07033	.000	-.5656	-.2898
	Edo	-.34063*	.07033	.000	-.4785	-.2027
	Rivers	-.03667	.07033	.602	-.1746	.1012
Cross River	Akwa Ibom	.18896*	.07033	.007	.0511	.3269
	Bayelsa	-.02688	.07033	.702	-.1648	.1110
	Delta	-.45458*	.07033	.000	-.5925	-.3167
	Edo	-.36750*	.07033	.000	-.5054	-.2296
	Rivers	-.06354	.07033	.366	-.2014	.0744
Delta	Akwa Ibom	.64354*	.07033	.000	.5056	.7814
	Bayelsa	.42771*	.07033	.000	.2898	.5656
	Cross River	.45458*	.07033	.000	.3167	.5925

	Edo	.08708	.07033	.216	-.0508	.2250
	Rivers	.39104*	.07033	.000	.2531	.5289
Edo	Akwa Ibom	.55646*	.07033	.000	.4186	.6944
	Bayelsa	.34063*	.07033	.000	.2027	.4785
	Cross River	.36750*	.07033	.000	.2296	.5054
	Delta	-.08708	.07033	.216	-.2250	.0508
	Rivers	.30396*	.07033	.000	.1661	.4419
Rivers	Akwa Ibom	.25250*	.07033	.000	.1146	.3904
	Bayelsa	.03667	.07033	.602	-.1012	.1746
	Cross River	.06354	.07033	.366	-.0744	.2014
	Delta	-.39104*	.07033	.000	-.5289	-.2531
	Edo	-.30396*	.07033	.000	-.4419	-.1661
*. The mean difference is significant at the 0.05 level.						

Source: SPSS Output

The LSD Multiple Comparison test in Table 16 showed how the temperature of each state significantly varied from the other. Akwa Ibom is significantly varied from Bayelsa ($p = .002$), Cross River ($p = .007$), Delta ($p < .001$), Edo ($p < .001$), and Rivers ($p < .001$). It showed that Bayelsa is significantly varied from Delta ($p < .001$) and Edo ($p < .001$), but not significantly varied from Cross River ($p = .702$) and Rivers ($p = .602$). For Cross River, there is significant variation with Delta ($p < .001$) and Edo ($p < .001$), but there is no significant variation between Cross River and Rivers ($p = .366$). Also, Delta is not significantly varied from Edo ($p = .216$) but significantly varied from Rivers ($p < .001$). For Edo, there is a significant variation with Rivers ($p < .001$).

It was observed from the Robust Tests of Equality of Means and the LSD test for temperature that the p-value is less than 0.05 [$F (5, 2721.219) = 23.850$, $p < 0.001$]. This means a significant spatial variation exists for temperature in the six states of the South-Southern Nigeria. In this study, "spatial variation of climate in South-Southern Nigeria", it was ascertained that there is spatial variation in climate in the South-Southern region of Nigeria. From the analysis done in table 4, the ANOVA showed that there is a significant spatial variation in rainfall [$F (5, 2874) = 4.788$, $p < .001$] as $p < .05$, and the robust test of equality table for rainfall, which is table 5, also showed a significant spatial variation, using the result of Brown-Forsythe test, [$F (5, 2840.251) = 4.788$ $p < .001$].

For relative humidity, the ANOVA table, table 9, the $p < .05$ as shown [$F (5, 2874) = 3.109$, $p < .001$], and the robust test of equality of means for relative humidity showed a

statistically significant spatial variation, using the result of Brown-Forsythe test, [F (5, 2707.601) = 3.109 p = .008]. Here, p = .008, which is equally less than .05. Also, the analysis for temperature showed a statistically significant spatial variation in table 14, the ANOVA table, with a p-value less than .05, as shown [F (5, 2874) = 23.850, p < .001] and robust test of equality of means for temperature, showed a significant spatial variation using the result of Brown-Forsythe test, [F (5, 2721.219) = 23.850 p < .001].

From the above, using the ANOVA tables and the robust test of means for rainfall, relative humidity, and temperature, it is evident that there is statistically significant spatial variation for these climate variables in South-Southern Nigeria. However, using the LSD multiple comparisons (Tables 6, 11 and 16), it is observed that the significant spatial variation between and among the states in the South-Southern States is more substantial with temperature than rainfall and relative humidity.

4. CONCLUSIONS

This study examined the spatial variation of climate in South-Southern Nigeria. It looked at the variation of rainfall, relative humidity, and temperature in the region. Although few studies have been done in this region, none of these studies took cognisance of humidity. In addition, the studies were restricted to a few years of study. The inclusion of humidity in this study will further reveal that there is significant spatial variation in climate.

The study's findings are that there is significant spatial variation in climate characteristics in the region. This shows that even though these states are located within the same region, the climate of each state varies spatially from the other states. In addition, the study shows that the spatial variation of temperature is more significant among the states than that of rainfall and relative humidity within the region. The study of the spatial variation of climate is important in general planning. Climate variation affects human activities, plants and animals, human health, and the entire environment. Hence, it will aid in planning for agriculture, aid health personnel in planning, and aid government parastatals and other stakeholders that need knowledge of climate for planning.

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