SSRG International Journal of Recent Engineering Science
ISSN: 2349–7157 / https://doi.org/10.14445/23497157/IJRES-V11I3P117

Volume 11 Issue 3, 138-142, May-Jun 2024

Original Article

Patterns and Variability of Rainfall and Temperature in Port Harcourt Metropolis, Rivers State, Nigeria

Vivian N. Otugo[1], Arobo R. C Amakiri[1*]

[1]*Department of Physics, Rivers State University Port Harcourt, Nigeria.*

**Corresponding Author : amakiri.arobo@ust.edu.ng*

Received: 10 May 2024 Revised: 17 June 2024 Accepted: 30 June 2024 Published: 12 July 2024

Abstract *- The study of the weather and weather parameters of a region is very significant for sustainable development of agriculture, urban planning and economic growth. Therefore, this research is focused on the investigation of the observable variations and trends in some meteorological parameters (Rainfall and Temperature) in Port Harcourt Metropolis for a period of 11 years (2008-2018). The results from the statistical analysis depict the highest Correlation of Variation (CV) for rainfall in January (219.67%), and the lowest CV for rainfall was recorded in June (7.32%). Conversely, the maximum temperature has its maximum CV in May (14.77%) and its lowest CV in July (1.1%). This finding depicts that temperature is a more stable parameter than rainfall. The monthly mean of rainfall for the 11 years has its peak in June and its lowest in December. Furthermore, the result reveals a strong anti-correlation in CV between maximum temperature and rainfall. There were also indications of a strong correlation between temperature and rainfall over the years studied. A similar trend was observed in the cross plot of annual rainfall against maximum temperature. Finally, the ANOVA analysis reveals that F-cal is 0.14, which is slightly higher than F.tab at α = 0.05, which implies a significant difference in rainfall amounts between the months, indicating a non-random pattern in rainfall. However, no significant difference was observed in temperature trends over the period. The result from this study is relevant for effective monitoring of weather conditions in Port Harcourt city and can be useful for future prediction and timely responses to extreme events.*

Keywords **-** *Correlation of variation, Meteorological parameters, Temperature, Rainfall, Weather.*

1. Introduction

The weather of any location is dependent on the dynamics of the meteorological elements, which include temperature, pressure, relative humidity, wind speed, etc. The variations in these weather parameters result in a corresponding fluctuation in weather both spatially and temporally. Weather condition is also affected by direct or indirect energy released into the atmosphere by natural events or through anthropogenic activities. The knowledge of the weather condition of any locality is rather indispensable; since this affects human activities, directly or indirectly. All facets of life, extending from agriculture, aviation, health, education, and sports to the economy are all dependent on the weather conditions. Therefore, a good understanding of the changes in weather conditions is imperative for national planning and sustainable development schemes.

The two most significant factors that determine the weather condition of a place are temperature and rainfall. Rainfall is a form of precipitation commonly experienced in tropical regions of the world [1]. Rainfall size ranges from 1–5mm in diameter [2]. The southern regions of Nigeria experience strong rainfall events during the rainy season from March to October, with annual rainfall usually amounting to above 2,000mm, and can get to 4,000mm and even more in the Niger Delta [3].

Numerous studies have investigated the trends and variability of weather parameters in Nigeria, but few studies have been carried out on Port Harcourt Metropolis. According to Nigerian Meteorological Agency (NiMet), the weather in Nigeria is warm and humid and has two separate seasons: the rainy season (April- October) and the dry season (November to March) [4]. There are some discrepancies in the results of several authors when it comes to the trend of rainfall. Author [5] found a decreasing trend in rainfall in his studies of the Niger Delta region, while another author [6] observed an increasing trend in the rainfall in the same Niger Delta region. Similarly, temperature trends have been investigated, with most studies suggesting an increasing trend in temperature in Nigeria as a whole [6,7]. Author [8] investigated the variations and trends of some meteorological parameters over Ibadan, a tropical–humid area in Nigeria, using the daily mean data of some meteorological parameters and found an annual decreasing trend for temperature and an increasing trend for rainfall and relative humidity. Also, in [9], their study of rainfall trends reveals that rainfall in Ilorin township has an increasing trend with a positive slope of 5.30.

A few studies have examined weather trends in Port Harcourt city. Author [10] analyzed rainfall and temperature

using data from 1971 to 2005, and they found a decreasing trend in rainfall and an increasing trend in temperature. A study [11] examined temperature trends from 1998 to 2010 and found a significant warming trend, and work by [12] shows that Temperatures are moderately constant with an average of about 25 to 28°C. However, these studies did not investigate recent trends and variabilities of weather in Port Harcourt.

Notable Studies have highlighted the importance of understanding the weather trends and variability in urban areas like Port Harcourt city. For example, a study by [13] discovered that urbanization in Lagos City has led to increased temperatures and probably affected the pattern of rainfall. This was affirmed by another study done by [14] stated that weather variability in Ibadan city has significant impacts on urban agriculture.

Previous research shows that Port Harcourt experiences the heaviest rainfall typically in September, with an approximate value of 367mm and the least rainfall in December, with an average value of 20mm [2, 15], while the average temperature over the city is between 25°C and 28°C with little or no variation. Further studies revealed that, in Port Harcourt, about 2293.6 mm (90.3 in) of rainfall occurs per year, or 191.1 mm (7.5 in) per month [16]

Port Harcourt City is a major oil and gas-producing state of Nigeria in the Niger Delta region [3]. An increase has been observed in the amount of annual rainfall in Port Harcourt in the range of 2 to 4mm [17]. Not much research has been done recently to validate this result from NiMet.

Significantly, the population and economy of this city have grown rapidly over the years; hence, understanding the trends and variability of weather parameters in this locality is pertinent. Therefore, this study examines the trends and variations in rainfall and temperature in Port Harcourt city over 11 years (2008-2018). The research aims to identify patterns, variations and irregularities in rainfall and temperature data, which will provide significant information to the general public and policymakers for future planning.

2. Materials and Methods

2.1. Study Area

The city lies in a low latitude of within 4.40°N-4.55°N and the longitude of within 6.98°E -7.60°E respectively. It is situated in the tropical zone of southern Nigeria. Port Harcourt city is characterized by a lengthy and heavy rainy season and a very short dry season. The city features a tropical monsoon climate. The moist southwest wind transports its moisture to the city along the coastline [18]. Previous studies show that rainfall is observed throughout the year in this city and is mainly drained by the Bonny River, with an average elevation of about 18 m above sea level [19, 20]. The weather pattern in Port Harcourt city is mainly influenced due to its location in the tropical region; leading to relatively high temperature and humidity throughout the year.

2.2. Data Analysis

The monthly mean data values of temperature and Rainfall were obtained from the Nigeria Meteorological Agency (NiMet) for a period of 11 years (2008-2018). The Statistical Analyses were done using descriptive statistics (Analysis of Variance (ANOVA)) and correlation) and data collected were analyzed electronically using Ms-Excel.

Mann-Kendall(τ) or Spearman rho Statistics were applied in testing for non-randomness against the trend in order to examine the possible decreasing or increasing trend. In applying the Mann-Kendall test to trend, the Null and its Alternative hypothesis were implemented. In this method, Null hypothesis H_0 shows that there is no trend; while alternative hypothesis H_1 shows that there exists a trend in time series.

The coefficient of variation of temperature and rainfall was calculated using this relation:

$$CV = \left(\frac{\partial}{MP}\right) x100\% \quad (1)$$

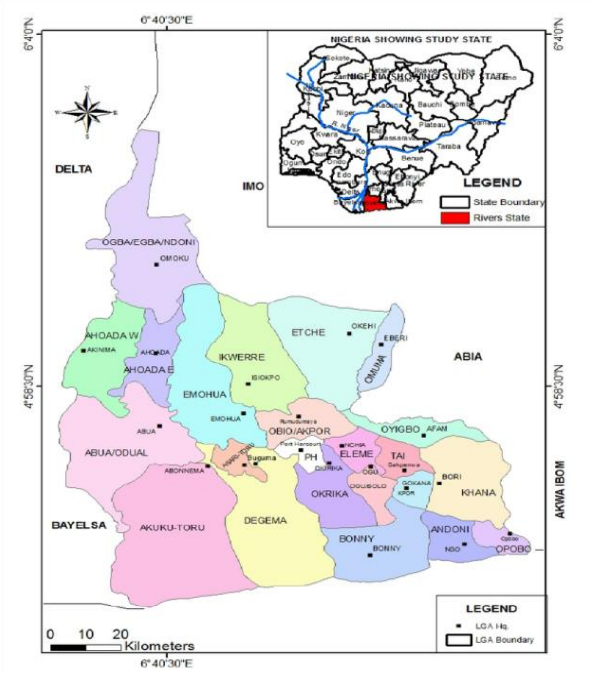

Fig. 1 Map of rivers state showing Port Harcourt city (inset: map of Nigeria)

3. Results and Discussion

3.1. Rainfall

Values and trend of the Distribution of Mean, Standard deviation and Coefficient of variation of monthly rainfall over Port Harcourt are presented in Table 1. Table 1 shows that the monthly mean rainfall over the city of Port Harcourt has its minimum value in December with a value of 16.32mm and its maximum value in June with a value of 367.05mm; the standard deviation ranges from 23.54(January) to 111.79 (August).

Figure 2 shows the monthly variation of rainfall for the eleven years spanning from 2008 to 2018. The estimated monthly mean values of rainfall for November, December, January and February are all 100mm, depicting low rainfall amounts during the period.

Table 1. Distribution of monthly mean, standard deviation and coefficient of variation of precipitation over Port Harcourt (2008-2018)

Month	TOTAL	MEAN	STD	CV
Jan	9563.91	21.39	23.54	100.05
Feb	88436.35	74.51	60.48	81.17
Mar	244109.22	135.86	81.33	59.86
Apr	316427.42	167.09	64.32	38.49
May	596129.41	237.39	60.17	25.35
Jun	1353753.79	367.05	26.87	7.32
Jul	1073338.27	316.17	90.49	28.62
Aug	831084.57	268.07	111.79	41.7
Sept	1118957.42	320.58	100.69	31.41
Oct	704293.87	255.53	75.53	29.56
Nov	89346.31	89.89	30.8	34.26
Dec	14232.1	16.32	35.85	219.67

This finding is consistent with the results of previous authors [3, 21].

The trend indicates that rainfall increased linearly from January to June and got to a peak in June, a sharp decrease in August, increased slightly in September, and then decreased linearly from October to December. The abrupt decrease in August is commonly referred to as "August Break". From the plot, it can also be evidently seen that the rainfall trend is double peaked; one in June and the other in September.

Figure 3 depicts a decrease in the coefficient of variation for rainfall from January to June and then a gradual increase from June to November. There was, however, an irregular spike noticed in December. This is an absolute deviation from normal and indicates little or no rain. The coefficient of variation of the maxima and the minima has values of 219.67mm and 7.32 mm, respectively.

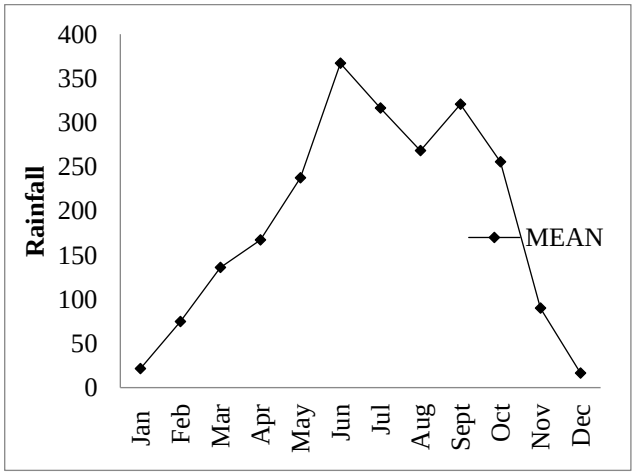

Fig. 2 Monthly variation of Rainfall from 2008-2018

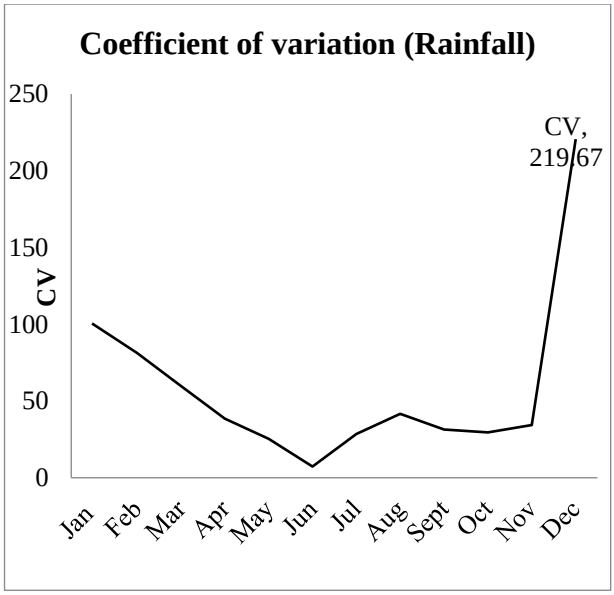

Fig. 3 Coefficient of variation of the rainfall

Table 2 presents the ANOVA analysis. The Degree of Freedom (DF), Sum of Squares (SS) and Mean of Squares (MS), F-Statistics(F-cal.) and the F-table(F-tab) were all evaluated. The F-Statistics determines the significance of the variance between groups. A large F-cal indicates significant differences between groups, while a small one indicates no significant differences between groups. In this case, the result reveals that F-cal is 0.14, which is slightly higher than F.tab at $\alpha = 0.05$; we, therefore, accept H_1: there is a significant difference in the mean. This implies a significant difference in rainfall amounts between the months, indicating a non-random pattern in rainfall.

Table 2. ANOVA result for rainfall

Source	DF	SS	MS	F-cal	F-tab
Total	119	4293515.85			
Treatment	11	98174.22	8924.93	0.14	0
Block	9	-4172684.91	-463631.65	-7.27	0
Error	99	6310487.23	63742.3		

Table 3. Maximum, mean, standard deviation, and coefficient of variation of temperature data over Port Harcourt (2008-2018)

Month	TOTAL	MEAN	STD	CV
Jan	11328.47	33.65	0.76	2.26
Feb	11559.86	33.98	1.22	3.59
Mar	11034.09	33.21	0.75	2.26
Apr	10525.24	32.42	3.83	11.82
May	10062.29	31.71	4.68	14.77
Jun	9350.34	30.56	1.12	3.6
Jul	8422.54	29.02	0.32	1.11
Aug	8405.73	28.99	0.41	1.42
Sept	9061.94	30.1	0.45	1.5
Oct	9631.21	31.03	0.54	1.73
Nov	10352.13	31.17	0.58	1.81
Dec	11186.8	33.44	0.7	2.11

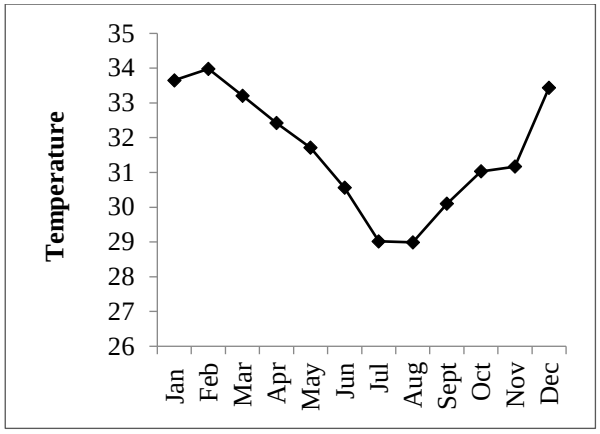

Fig. 4 Monthly variation of temperature from 2008-2018

The variation of the monthly mean of temperature in Port Harcourt, computed over the period of 11 years (2008-2018), was analyzed by determining the Mean, Standard Deviation, and Coefficient of Variation of the temperature data and presented in Table 3 and Figure 4. Table 3 shows the results obtained from the descriptive statistical analysis. The estimated deviation in the mean monthly value of temperature is somehow small. For the dry season, the mean monthly value of 32.58 ºC was obtained, while for the wet season, the mean monthly value of 31.21 ºC was obtained; the coefficient of variation between the maximum temperature and the minimum temperature is 3.59ºC and 1.42 ºC respectively.

Figure 5 presents the Coefficient of variation of maximum. The obtained results (Figure 4) indicate that the peak temperature value was observed in January and December, which are months in the dry season, then a gradual decrease to the minimum in July and August. This could be related to the continual rainfall that is typically observed in July.

Temperature with months: Figure 4**,** the maximum temperature, was observed to have spiked in May; this could be possibly related to weather conditions too. There were no meaningful variations observed during the dry season from Figure 5.

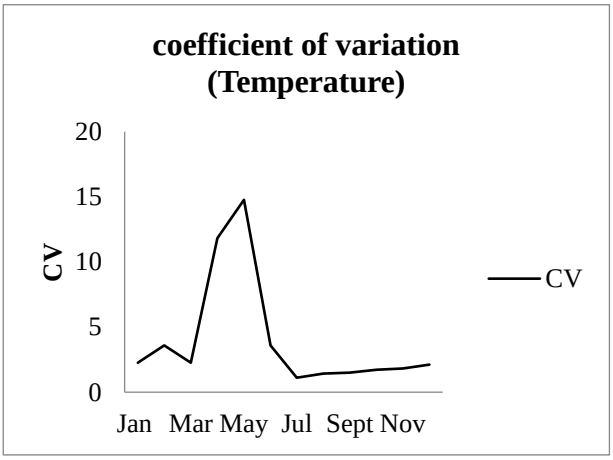

Fig. 5 Coefficient of variation of the max. temperature

3.1. Comparative Analysis of the Variation of Temperature and Rainfall

An investigation of how rainfall varies in relation to temperature was also carried out in order to ascertain the correlation between both meteorological parameters.

The results of the monthly variation between both parameters are presented in Figure 6; the correlation analysis gives a correlation coefficient of r =-0.884, which shows a strong anti-correlation between temperature and rainfall; implying that as one parameter increases, the other decreases,

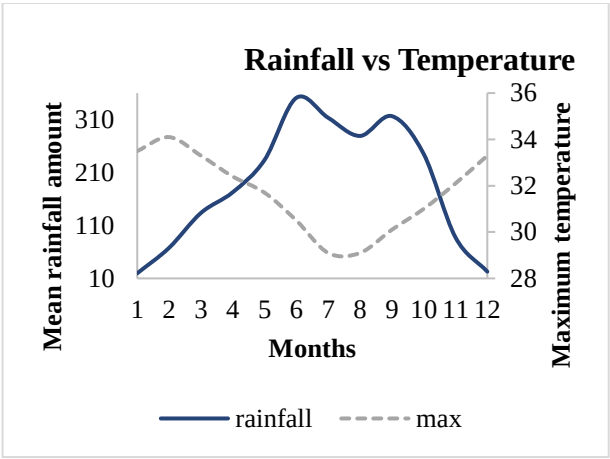

Fig. 6 Comparative plot of the monthly variation of rainfall and maximum temperature

4. Conclusion

The unpredictability of weather conditions and changes in weather parameters have a direct influence on the environment and, of course, on human existence and livelihood. A negative change in the weather always has its corresponding adverse effects on the ecosystem, locally as well as globally, on a long-term scale. Adverse weather contributes significantly to flooding, poor agricultural yield, famine and even death. Therefore, this research investigated the variations in meteorological parameters as well as their trend in the Port Harcourt metropolis from 2008 to 2018. It was observed that the Correlation of Variation (CV) for rainfall in January was 219.67.05%, and the least CV for rainfall was recorded in June (7.32%) over the period studied; high CV for rainfall was observed in January and December. On the other hand, CV for maximum temperature has its maximum recorded in May (14.77%). Therefore, we surmise that temperature is a less variable parameter and, hence, a more stable parameter than rainfall. Furthermore, there existed a strong anti-correlation (r= -0.884) between Temperature and rainfall over the years studied. Finally, the ANOVA analysis reveals that F-cal is 0.14, which is slightly higher than F.tab at $\alpha = 0.05$, which implies a significant difference in rainfall amounts between the months, indicating a non-random pattern in rainfall. However, no significant increase or decrease was detected in the temperature trend over the period.

Authors' Contribution Statement

VNO conceived and designed the research; ARCA articulated the structure of the research. All authors read and approved the manuscript.

Acknowledgment

The authors acknowledge the Nigerian Meteorological Agency (NIMET) for granting us access to the data used in this study. We also acknowledge and appreciate the critical proofreading of the work by two anonymous scholars.

Funding of the Research

The authors sponsored the Research.

References

[1] Susan Mayhew, *Dictionary of Geography*, University of Oxford Press, 5th ed., pp.1-546, 2004. [Google Scholar] [Publisher Link]

[2] Alexander Budnuka Chinago, "Analysis of Rainfall Trend, Fluctuation and Pattern Over Port Harcourt, Niger Delta Coastal Environment of Nigeria," *Biodiversity International Journal*, vol. 4, no. 1, pp. 1-8, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[3] World Bank Group, 2024. [Online]. Available: https://www.worldbank.org/en/home

[4] E.O. Olusola, "Rainy an Dry Seasons in Nigeria: A Review of Patterns, Causes and Effects," *Journal Of Geography and Regional Planning*, vol. 13, no. 2, pp.1-12, 2020.

[5] Peter A.O. Odjugo, "Regional Evidence of Climate Change in Nigeria," *Journal of Geography and Regional Planning*, vol. 3, no. 6, pp. 142-150, 2010. [Google Scholar] [Publisher Link]

[6] O. Akpomuvie, and Ukoro, "Rainfall Trend and Variability in the Niger Delta Region of Nigeria," *Journal of Hydrology and Environment Research*, vol. 9, no. 2, pp. 123-135.

[7] Samuel Adebayo Adejuwon, "Impacts of Climate Variability and Climate Change on Crop Yield in Nigeria," *Paper presented at the Stakeholder's Workshop on Assessment of Impacts and Adaptation to Climate Change, Conference Centre, Obafemi Awolowo University*, Ile-Ife, 2004. [Google Scholar]

[8] E.O. Ogolo, and B. Adeyemi, "Variations and Trends of Some Meteorological Parameters at Ibadan, Nigeria," *The Pacific Journal of Science and Technology*, vol. 10, no. 2, pp. 980-987, 2009. [Google Scholar] [Publisher Link]

[9] Oluwadare Akinyemi et al., "Trend and Variability Analysis of Rainfall and Temperature Trends in Ilorin Metropolis, Kwara State, Nigeria," *Journal of Human Ecology*, vol. 74, no. 1-3, pp. 1-7, 2021. [CrossRef] [Publisher Link]

[10] L.A Nwankwo, and G.S. Umoh, "Rainfall Trend and Agricultural Productivity in South Eastern Nigeria," *Journal of Agricultural Science and Environment*, vol. 12, no. 2, pp. 145-158.

[11] Eucharia Okoro, and Francisca Okeke, "Effects of Zonal Wind on Stratospheric Ozone Variations over Nigeria" *International Journal of Remote Sensing*, vol. 38, no. 6, pp. 1665-1681, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[12] M.E. Agbor, S.O. Udo, and S.O. Amadi, "Characteristic Temporal Variability and Trend of Annual Rainfall Series in Port Harcourt Nigeria, A Tropical Coastal Location," *Global Journal of Earth and Environmental Science*, vol. 4, no. 2, pp. 23-31, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[13] A.O. Adewale, A.A. Adeniyi, and L.F., "Adekunle Analysis of Rainfall trend and Variability in Port Harcourt, Nigeria," *Journal of Water and Climate Change*, vol. 11, no. 3, pp. 533-544, 2020.

[14] S.O. Oyedepo et al., "Generation of Typical Meteorological Year Data for a City in South-Western Nigeria," *IOP Conference Series: Materials Science and Engineering*, vol. 1107, no. 1, pp. 1-17, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[15] S.O. Amadi, and T.O. Chigbu, "Trends and Variations of Some Meteorological Parameters in Uyo, Nigeria" *International Journal of Pure and Applied Sciences and Technology*, vol. 25, no. 2, pp. 36-35, 2014. [Google Scholar]

[16] Climate Top website, 2024. [Online]. Available: https://www.climate.top/nigeria/port-harcourt/precipitation

[17] NiMet, 2008, *Nigerian Climate Review Bulletin 2007*, The Nigerian Meteorological Agency, February 2008, NiMet No: 001.

[18] E.D. Uko, and I. Tamunobereton-Ari, "Variability of Climatic Parameters in Port Harcourt, Nigeria," *Journal of Emerging Trends in Engineering and Applied Sciences*, vol. 4, no. 5, pp. 727-730, 2013. [Google Scholar] [Publisher Link]

[19] H.O. Nwankwoala, "An Integrated Approach to Sustainable Groundwater Development and Management in Nigeria," *Journal of Geology and Mining Research*, vol. 3, no. 5, pp. 123-130, 2011. [Google Scholar] [Publisher Link]

[20] Vincent Ezikornwor Weli, Moses Okemini Nwagbara, and Famous Ozabor, "The Minimum and Maximum Temperature Forecast Using Statistical Downscaling Techniques for Port-Harcourt Metropolis, Nigeria," *Atmospheric and Climate Sciences*, vol. 7, no. 4, pp. 424-435, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[21] M.T. Daramola, E.O. Eresanya, and S.C. Erhabor, "Analysis of Rainfall and Temperature over Climatic Zones in Nigeria," *Journal of Geography, Environment and Earth Science International*, vol. 11, no. 2, pp. 1-14, 2017. [CrossRef] [Google Scholar] [Publisher Link]