JOURNAL OF METEOROLOGY AND CLIMATE SCIENCE
J. Met & Clim. Sci. 21(1): 184-194 (June, 2022)

Temperature and Rainfall Trend in Agbani, Enugu State Southeastern Nigeria

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Abstract

Complementing climate forecasts with historical data is one way to develop usable climate information for agricultural producers. Farmers are the major end-users of climate information therefore, this study analyzed the trend of rainfall and temperature in Agbani Enugu State. The daily meteorological parameters were acquired using the Automatic Weather Station (AWS) at Enugu State University of Science and Technology (ESUT) from January 2012 to December 2019. The daily data were analyzed using the Excel package to obtain average monthly data. The Trend Regression analysis was used to predict a trend in rainfall and temperature from 2020 up to 2050. The result showed that 2018 recorded the highest rainfall followed by 2015, and 2012 recorded the lowest rainfall. The mean monthly rainfall indicated that January has the lowest rainfall of 53.5 mm, while July recorded the highest rainfall of 2,624.3 mm. The month of March has the highest mean temperature July and August recorded the lowest temperature over the eight years. The trend model forecast indicated Yt = 152.53+0.155t for rainfall and Yt = 27.747+0.02398t for temperature from 2020 to 2050. The result shows an incremental trend of 0.155 mm and 0.2398°C in rainfall and temperature, respectively, associated with every unit increase in period(t). It is recommended that farmers should expect a wetter and hotter climate from 2020 to 2050.

Keywords Climate, Forecast, Rainfall, Temperature, Farmers

1. Introduction

Agriculture is the backbone of the economy employing two-thirds of the population and contributing to 23.92% of the Gross Domestic Product (GDP) in 2020 (National Bureau of Statistics 2021). Agricultural production in Nigeria and several parts of the world is predominantly rainfed. Olayide *et al.* (2016) explained that rainfed agriculture is vulnerable to climate change. Therefore, an increase in temperature and changes in rainfall distribution (erratic and interseasonal fluctuation of rainfall pattern) has become a critical food production risk to farmers. Studies have show an increase in rainfall duration and intensities in

Nigeria, causing runoffs and flooding (Enete 2014). The precipitation in the Southern part of Nigeria is increasing, and in the Northern, droughts have been constant and are expected to continue due to low rainfall and increased temperature. A study by Abaje and Oladipo (2019) shows that the temperature has increased over the past two decades. Shiru *et al.* (2020) added that climate projection reveals an increase in rainfall and temperature in some parts of Nigeria. Considering the climate situation in Nigeria, the temperature and rainfall trend give a better understating of the past and current climate at local and regional scales. This information about the temperature and rainfall trend is essential in agriculture because farmers are the end-user of weather/climate information. The World Meteorological Organization (WMO) posited that climate information is efficient only when it meets the prerequisite of the users as time available, usable, authentic, dependable, credible, and flexible (WMO 2015). Climate information is efficient if provided ahead of the agricultural season. However, most users do not receive forecast information early and the possibility of realizing the value of the forecast and measuring outcomes (Carr *et al.,* 2015). The scale of information concerning the prediction and models must be local so that the users can understand it well and make their decisions on crop cultivation, land conservation, fertilizer application, and planting dates that relate specifically to their livelihoods and their farms (Takle *et al.,* 2014; Tall *et al.,* 2014). Climate information such as temperature and rainfall trends play a vital role in forming correct perceptions of farmers' adaptation. The use of climate information depends on the level and quality of interaction between information producers and users (Lemos *et al.,* 2012). In Nigeria, there exist significant challenges in the uptake of climate information. Studies recommended tutoring and outreach, demonstrations of the utility of climate forecasts and historical information, and participatory interpretation of information to farmers (Haigh *et al.,* 2015; Dorward *et al.,* 2015; Lobo *et al.,* 2017). In Enugu State, Okoro *et al.* (2016) identify poor extension services and infrastructure as the main constraints in communicating climate information to farmers. Complementing climate forecasts with historical data may be one way to develop usable climate information for farmers (Haigh *et al.,* 2015; Dorward *et al.,* 2015). This study examines the temperature and rainfall pattern from 2012 to 2019 and predicts the trend of temperature and rainfall from 2020 up to 2050.

2. Materials and Methods

2.1 Study Area

The study was carried out at Enugu State University of Science and Technology (ESUT) Agbani. Agbani is in Nkanu West Local Government Area of Enugu State, Nigeria. The headquarters of the Nkanu West Local government and its located at latitude 06°21′ to 06°30′N and longitude 07°25′ to 07°45′E. The relief of Agbani is dominated by plains under 230 m above sea level. The East of Agbani is more elevated plains, and the Northern part is a lower relief system. According to Koppen's climate classification, Agbani is tropical savanna. The warm Tropical Maritime air mass originates from the South Atlantic Ocean, and the dry dusty Tropical Continental air masses associated with the dry rainy season. The rainy season starts in late March and

ends in October. The area usually experiences rainfall with maximum peaks in June/July and September/October. The dry season starts in November to early March. The Nigerian Meteorological Agency (2015) opined that the mean rainfall is about 140 mm, the monthly temperature ranges from 25°C to 34°C, and the mean annual temperature is 29°C. Farming is one of the major economic activities of the people. Farmers practices crop rotation, shifting cultivation and mixed cropping on dispersed farmlands. The predominant soil type in Agbani is gravely-silt. The major crops grown in Agbani include cassava, maize, cocoyam, yam, vegetables, sweet potato and economic fruits.

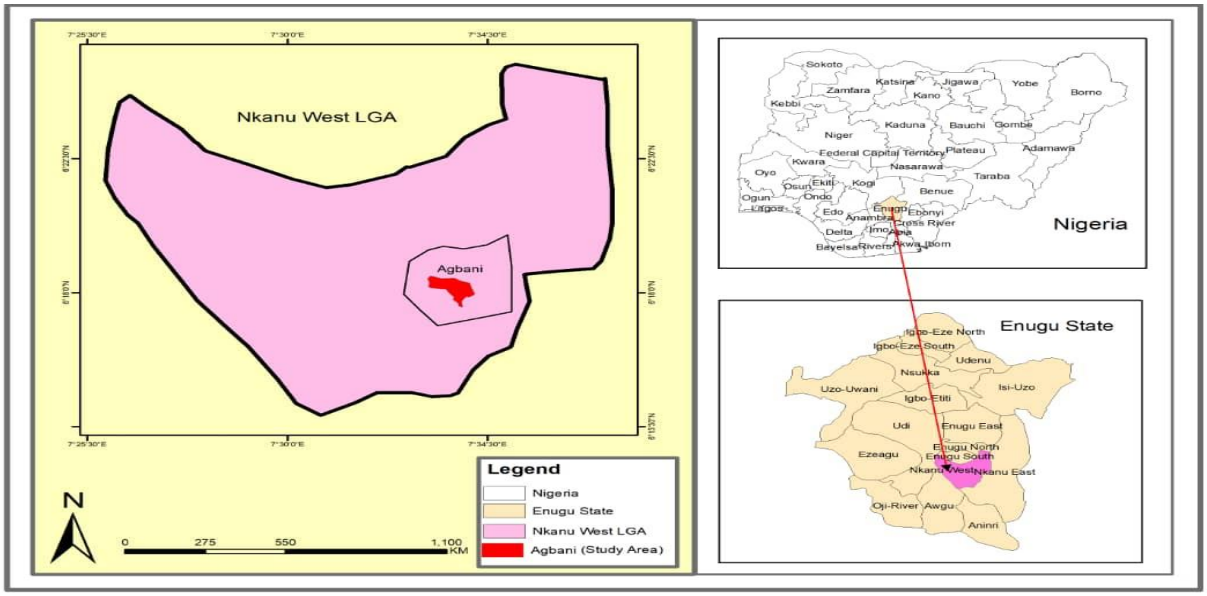

Figure 1: Map of Enugu State showing the Study Area

Source: Okoro *et al.* (2019)

2.2 Methodology

The data used for the study was obtained from ESUT Automatic Weather Station (AWS) installed by the Centre for Atmospheric Research (CAR). The data were in five (5) minutes intervals from January 2012 to December 2019. The data were summed up to obtain a daily temperature and rainfall. The daily temperature and rainfall were summed and divided by the number of days in the month to derive the mean monthly temperature and rainfall using an Excel package:

$$Mean = \frac{S}{C} \qquad (1)$$

Where S = Sum of the total Temperature or Rainfall per month

C = Count per five minutes

The result of the monthly temperature, and rainfall were tabulated.

Time Series Regression Model was used to determine the trend of Temperature and rainfall using the equations

$$Y_t = \beta_0 + \beta_1 t + e_t \qquad (2)$$

Where Y_t is the time series values, β_0 *and* β_1 are the parameters, e_t is the residual, and t the time.

Thus, estimating the linear trend, time series regression was used:

$$Y_t = b_0 + b_1 t \quad (3)$$

Where

Y_t = Linear trend forecast in period t

b_0 = Intercept of the linear trend line

b_1 = Slope of the linear trend line

t = time period.

3. Result

TABLE 1: MONTHLY AND ANNUAL RAINFALL IN AGBANI FROM 2012 - 2019

	MONTHS												
Years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	**Annual Total**
2012	0.0	46.5	10.4	159.1	219.7	296.4	263.3	121.6	270.7	180.5	0.0	0.0	**1,568.2**
2013	23.4	0.0	31.7	140.0	296.7	382.4	326.4	211.9	340.1	113.5	8.7	97.8	**1,972.6**
2014	1.2	2.5	120.3	183.7	241.3	229.6	311.2	308.2	297.8	208.0	56.0	0.0	**1,959.8**
2015	1.7	76.7	96.4	272.8	240.4	238.3	394.2	226.3	382.4	210.8	0.0	0.0	**2,140.0**
2016	0.0	0.0	49.6	93.3	267.7	207.1	334.3	365.1	326.0	278.8	0.0	0.0	**1,923.1**
2017	1.9	0.0	10.8	284.5	168.0	319.3	362.4	137.1	285.2	176.3	56.3	0.0	**1,801.8**
2018	6.3	0.9	63.9	230.4	250.6	320.0	389.7	302.3	343.4	311.5	83.5	0.0	**2,302.4**
2019	19	15.2	70.2	130.4	217.1	252.6	242.8	237.8	292.3	201.9	12.8	8.4	**1,700.2**
Monthly Total	53.5	141.8	453.3	1,494.2	1,901.5	2,245.7	2,624.3	1,910.3	2,537.9	1,681.3	217.3	106.2	15,367.3

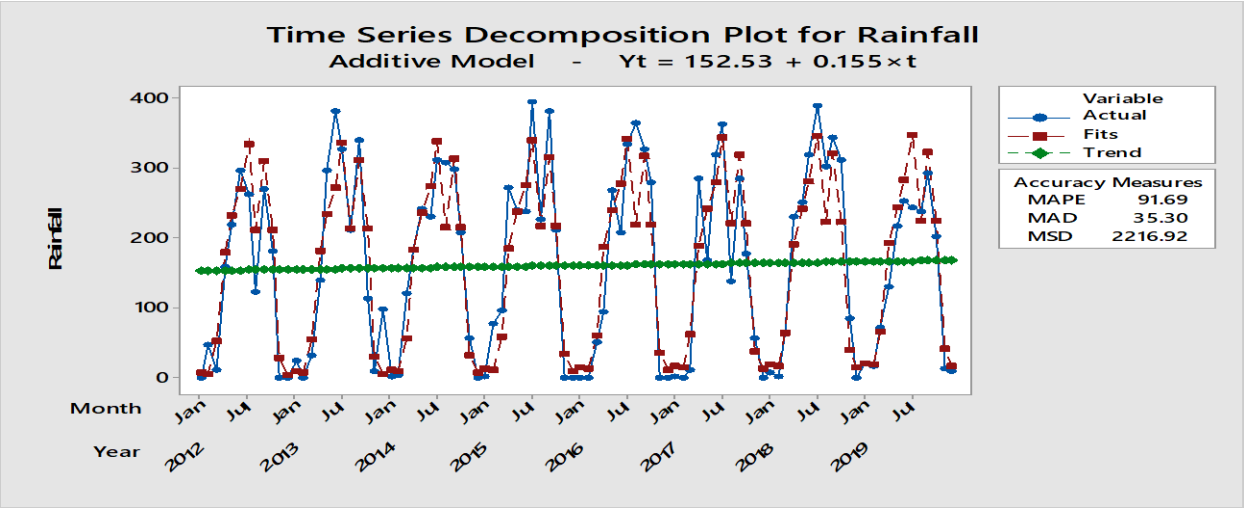

Figure 2: Rainfall Trend for 2012 to 2019

Table 1 shows the monthly mean and the annual rainfall from 2012 to 2019. From the table, January recorded the minimum monthly rainfall of 53.5 mm, while July recorded the maximum amount of rainfall of 2,624.3 mm, 2018 has the highest rainfall, followed by 2015, while 2012 has the lowest rainfall. The total annual rainfall from 2012 to 2019 was 15,367.3 mm.

The chart of the seasonal indices indicates that the rainfall experience fluctuation with a trend model, Yt=152.53+0.155t, averages downward movements from January to March and November and December of the season and upward movements from April to October. The percentage variation by season shows that January has the least while August has the most. The detrended data by season show the months where there is the absolute value of the seasonal effect, from the 1st, 2nd, 3rd, 5th, 9th, 11th, and 12th months tend to have lesser variation. In the 4th, 6th, 7th, 8th, and 10th months, there is no effect of season on the residuals. From the chart there is an increase in rainfall over the eight years.

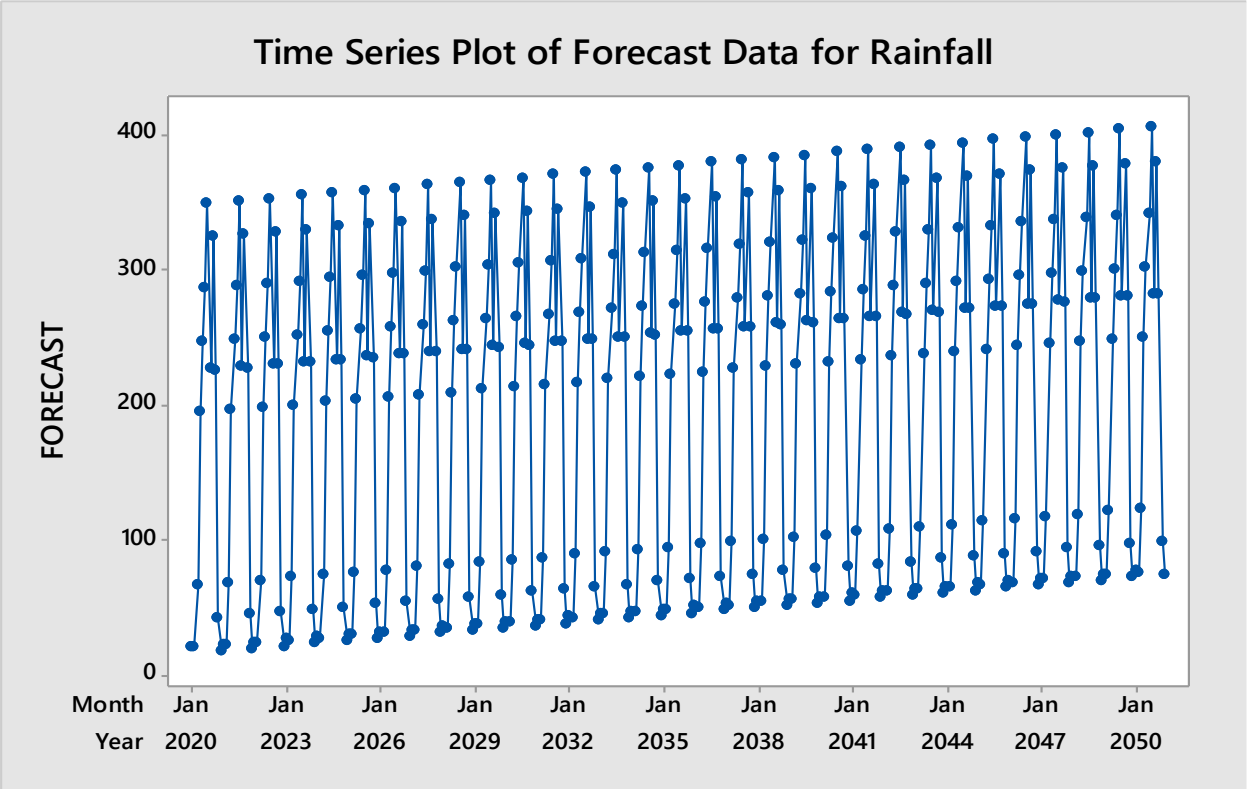

Figure 3: Rainfall forecast for 2020 to 2050

Using the trend model, $\hat{Y}_t = 152.53 + 0.155t$, the forecast for rainfall from 2020 to 2050 shows that the average rainfall will increase since the slope is positive by 0.155 mm per month. It implies as the month increases, rainfall will increase. Hence, we infer that increase in the month is associated with 0.155 mm increase in the expected rainfall from April to October.

Table 2 shows the monthly mean and the annual temperature from 2012 to 2019. From the table, March recorded the maximum monthly temperature of 31.1°C while July and August recorded the minimum temperature of 26.8°C. The year 2017 recorded the highest temperature, followed by 2016, while 2015 has the lowest temperature.

TABLE 2: MONTHLY AND ANNUAL TEMPERATURE IN AGBANI FROM 2012 - 2019

	MONTHS												
Years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	**Annual Mean**
2012	28.4	29.1	32.0	29.5	27.5	26.5	26.0	26.1	26.3	27.8	29.2	28.5	**28.1**
2013	30.1	31.2	31.8	30.7	29.1	27.2	26.3	25.7	26.4	27.6	28.3	27.7	**28.5**
2014	29.9	30.7	29.9	29.4	28.3	28.2	26.6	28.1	29.9	29.3	29.2	29.3	**29.0**
2015	26.5	26.1	27.5	27.3	26.8	25.0	25.0	24.7	24.2	27.5	28.3	26.8	**26.3**
2016	30.4	32.4	31.6	31.0	30.2	28.9	27.9	27.6	27.6	30.9	30.9	30.4	**30.0**
2017	30.8	32.8	33.0	31.2	30.3	29.1	28.0	27.7	28.1	30.2	31.3	30.5	**30.3**
2018	30.3	30.8	30.8	29.8	28.9	28.1	27.5	26.9	27.2	28.5	30.0	31.3	**26.6**
2019	30.9	31.6	31.8	29.5	29.5	27.8	27.1	27.6	29.7	30.0	30.2	30.9	**29.8**
Mean	29.6	30.6	31.1	30.0	28.8	27.6	26.8	26.8	27.4	29.0	29.7	29.4	28.6

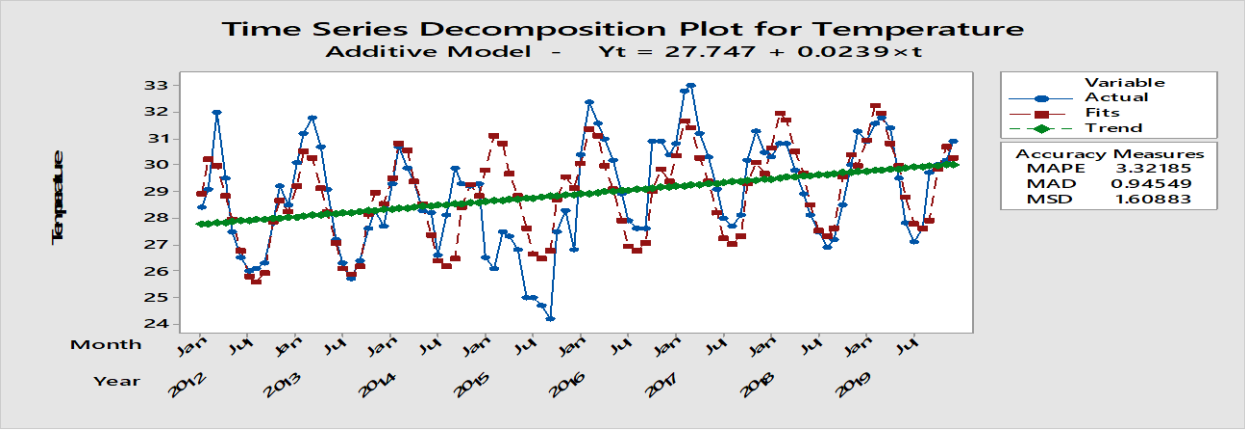

Figure 4: The seasonal indexes of temperature.

The trend model of temperature is Yt=27.747+0.02398t. The temperature in June, July, August, September, and October are below the annual averages, and the temperature in January, February, March, April, May, November, and December are above the annual averages. We expect the temperature in January to be 4.1% (104.1% - 100%) above the annual average. February, March, April, May, November and December are 8.6%, 7.3%, 3.3%, 0.3%, 2.4% and 0.7%, respectively, are above the annual average. However, in June, July, August, September, and October temperatures are 3.7%, 7.3%, 8.0%, 7.2%, and 0.5%, respectively, below the annual average.

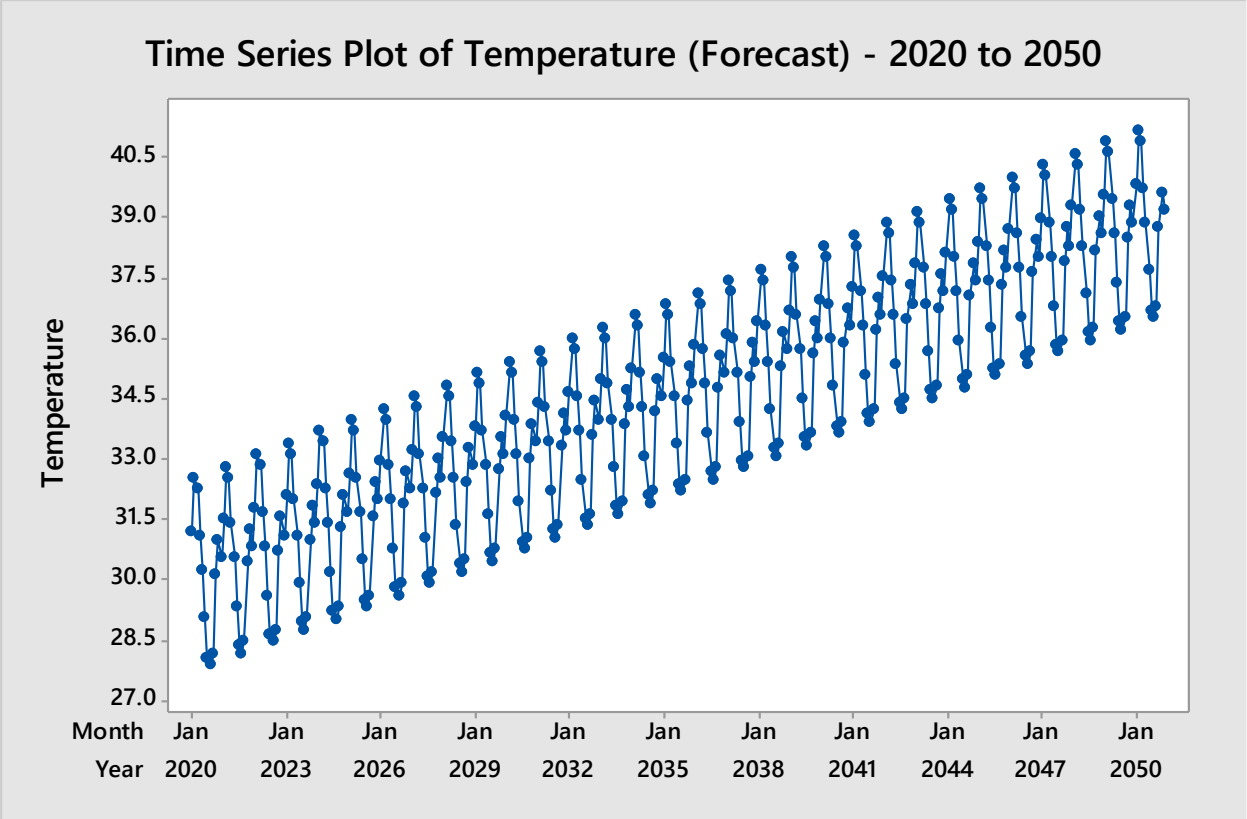

Figure 5: Temperature forecast from 2020 to 2050

Using the trend model, $\hat{Y}_t = 27.747 + 0.02398t$, the forecast for temperature from 2020 to 2050 shows that the mean temperature will increase since the slope is positive by 0.0239 Celsius per period (month). It implies that as the period (month) increases, the temperature also increases. Hence, we can infer that a unit increase in period (t) is associated with 0.0239 Celsius increase in the expected temperature.

4. Discussion of Result

There are numerous studies on trends in temperature and rainfall at spatial and temporal scales over Nigeria. The variations have been reported based on the agro-climatic zone. Different studies have affirmed the occurrence of floods and droughts caused by changes in climate. Nwagbara (2015) opined that the rainfall in the past two decades shows a variance. Another study by Akinsanol and Ogunjobi (2014) observed decreasing and increasing

trends in mean annual precipitation in Nigeria. However, the Nigeria geographical location trend analyses are specific, According to Chinago (2015), the rainfall distribution of Enugu is positively skewed indicating that the total rainfall is reducing slowly. Enete and Ebenebe (2009) showed a general decline in the rainfall trend between 1990 – 2005 in Enugu State, but the rainfall values for the years under study suggested between 265.37 mm and 320.21 mm. Igwenagu (2015) opined that the trend analysis shows fluctuations in the pattern of rainfall pattern in Enugu form (2000 – 2013). Akinbil *et al.*,(2019) further explained an increase in rainfall trend, while temperature has shown an increasing trend in all the cities in the last four decades in Enugu. This findings agrees with this study. Uchechukwu (2018) noted that the annual average rainfall of Enugu state is 1744 mm and peaks bi-modal in July and September. This also agrees with the findings of this study.

According to Ajiere and Nwagbara (2018) rainfall increased by 0.1026 mm per annum in Abia State, and Imo State rainfall decreased by -1.1255 mm per annum. The States within the Southeast recorded positive slopes in mean temperature showing an increase in their trends. The increasing trend in temperatures is consistent with historical trends in the mean. The temperature of Ebonyi State shows a positive trend which acclaims that the temperature of Ebonyi State will increase over time (Diagi *et al.,* 2020). The study of Ifeka and Akinbobola (2015) reported a significant downward trend in the yearly mean rainfall in Anambra State in the last four decades. Also, Nnadi *et al.,* (2019) posit that the trend analysis of rainfall in Anambra has wide variations of the inter-annual rainfall from 1986 – 2017. In Kaduna State, Abaje and Oladipo (2019) revealed an increased temperature trend in the last two decades, and the annual rainfall has increased from 1991 to 2016. At Ogbomoso, Ogunbode and Ifabiyi (2019) discovered that the rainfall trend is positive at a 0.05 significance level. The result implied that more rainfall in the city during the period under consideration. Ukhurebor and Abiodun (2018) reported a downward trend of 94mm/yr between 1978-1987 decade, and an upward trend of 90mm/yr, 30mm/yr, and 118mm/yr during 1988-1997, 1998-2007, and 2008-2017 decades respectively in South-south Nigeria. Similarly, Akinbil *et al.*, (2019) estimated an increasing rainfall trend in Calabar, and Ikeja, and decreasing trends were observed in Ilorin, Kaduna, and Maiduguri while the temperature showed an upward trend in all the cities. The result signifies a positive trend in temperature and rainfall in the cities. The findings suggest that there are variability and uneven distribution of rainfall in Nigeria, and the trend is positive which indicates increased rainfall in Nigeria. The temperature, on the other hand, shows an increasing trend which is also positive. Therefore, the downward and upward trends in the annual rainfall in the period (2012 - 2019) for Agbani, Enugu State agrees with the trends in Ukhurebor and Abiodun (2018) between 1978 – 2017.

5. Conclusion

The study observed a fluctuation of rainfall and temperature in Agbani from 2012 to 2019, while an increasing rainfall and temperature trend was noticed in the forecast from 2020 to 2050. The temperature and rainfall trends showed indications of climate change with notable variation in their trends. The forecast of temperature and rainfall

from 2020 to 2050 predicts an increasing trend in the mean temperature and rainfall with a trend model Yt=27.747+0.02398t and Yt=152.53+0.155t. The positive slope of 0.0239 Celsius per month and 0.155 mm per month indicate an increase in temperature and rainfall. The study recommends climate information in local planning to strengthen the weather-based agro-advisory services for users.

6. Acknowledgements

We want to thank Centre for Atmospheric Research (CAR) for providing the Automatic Weather Station to Enugu State University of Science and Technology and to Prof. U.V. Okwu-Delunzu for her guidance during the research work.

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