TREND ANALYSIS OF METEOROLOGICAL PARAMETERS FOR OSOGBO, NIGERIA

[1*]Mohammed A. A., [2]Salami A. W., [2]Sule, B. F. and *[3]Adikwu, J. P.*

[1]National Centre for Hydropower Research and Development, University of Ilorin, Ilorin, Nigeria

[2] Department of Water Resources and Environmental Engineering, University of Ilorin, Ilorin, Nigeria

[3]Land and Water Engineering Department, National Center for Agricultural Mechanization, Idofian, Kwara State, Nigeria

**Corresponding Author email: rasaq.muhammed@yahoo.com*

ABSTRACT

The aim of this study is to analyse the trend exhibited by meteorological parameters such as evaporation, precipitation and temperature for Osogbo, Nigeria. The data used for the analysis was for a duration of fifty-one years (1960 to 2010). The data were subjected to statistical analysis like measures of dispersion and central tendency. Non-parametric Man Kendall test was used to detect presence or absence of monotonic trends, standardised anomaly indices (SAIs) was used to depict trends associated with the parameters and simple linear regression model was used to develop linear relationship for the variables with time. It was observed from the results of the analyses that trends occur in all the meteorological parameters. The results of SAIs and Mann Kendall analyses reveal that precipitation, evaporation and temperature have positive trend. Also the maximum temperature demonstrates a significantly increasing trend but trend exhibited by other parameters are not significant. Hence, it can be concluded that the maximum temperature has tendency to increase in the study area in future.

***Keywords**: Man Kendall, Trend, Osogbo and Standardised anomaly index*

1.0 INTRODUCTION

Globally, the study of climatic elements of a region is vital for sustainable development of agriculture and water resources planning. Particularly, rainfall and temperature temporal analyses for trends, fluctuations and periodicities are deemed necessary as such can indirectly furnish the "health" status of an environment. A declining and/or rising trend in meteorological parameters may be quite instructive for different segments of the human and natural systems. Extreme weather events can lead to drought, prolonged heat and flooding which can be assessed through statistical analysis of regional temporal rainfall regime (Afangideh *et al.* 2010). Abaje *et al.* (2012) studied the trends and fluctuations of annual rainfall in the sudano-sahelian ecological zone of Nigeria using rainfall data from 1949 to 2008 for eight meteorological stations. Cramer's (tk) test was used to compare the means of sub-periods with the mean of the whole record period. The results revealed that there was a change towards wetter conditions in the last 30-year period.

McBean and Motiee (2008) used seventy years of historical data to examine trends in precipitation, temperature and streamflow in the Great Lakes of North America. Regression analyses and Mann-Kendall statistics were used to assess the trends and level of statistical significance in the variables. The result obtained demonstrated statistically significant increases in precipitation and streamflow over the period of 1930-2000. Makanjuola *et al.* (2010) used hydro-meteorological variables such as precipitation, maximum and minimum temperature and streamflow to evaluate the impact of climate change on surface water resources of Ilorin. The variables were subjected to statistical, trend, and reduction pattern analyses using Mann-Kendall and Reduction pattern methods. The results revealed that there was tendency for an increase in rainfall while there was tendency for decrease in evaporation. It was also discovered that there was no significant change in minimum and maximum temperature for Oyun and Asa streamflow.

Olofintoye and Adeyemo (2011) assessed the impact of global warming in the Kainji reservoir using statistical analysis of hydro-meteorological data at Kainji dam. The non-parametric Man-Kendall test was used to detect monotonic trends. The Sen's slope estimator and regression analysis were used to develop models for the variables. A Man-Kendall statistic revealed that there was evidence of global warming in the areas around the dam. The temperature trend was significant at the 95 and 99% level of significance thus indicating a significant rise in temperature. Olofintoye and Sule (2010) used non-parametric Man-

Kendall test to detect monotonic trends and Sen's slope estimator to develop models for the rainfall and maximum and minimum temperature variables for some selected cities in the Niger Delta of Nigeria. The stations considered for this study were Owerri, Port-Harcourt and Calabar. The study showed that there was evidence of global warming in Owerri and rainfall had significantly increased in Calabar over the years. Though the trends in rainfall at Owerri and Port-Harcourt were not significant, the slope estimates showed a positive trend in the rainfall of the stations.

Salami *et al.* (2010) used statistical analysis such as measure of dispersion, skewness, regression and Mann-Kendall to assess the impact of climate change on the water resources of Jebba hydropower reservoir using hydro-meteorological variables obtained from Jebba hydropower station. The results showed that the reservoir inflows, outflows and temperature showed significant positive trends which means the parameter has tendency to increase. Precipitation, evaporation and relative humidity were observed to exhibit insignificant negative trends. Ikhile (2003) assessed the effects of climate change on irrigation activities in the Benin-Owena River Basin (BORB) in the south-western Nigeria using rainfall and temperature data from 1961 to 2000. The rainfall variation between 1980-2000 was less pronounced and rainfall was much lower. The period 1982-1986 exhibited the greatest downward trend in rainfall. The decadal range of temperature showed a gradual warming of the environment.

Gebrehiwot and Vanderveen (2013) assessed the evidence of climate variability in the northern part of Ethiopia. Rainfall, minimum and maximum temperature from 1954 to 2008 was used in this study. Standardized rainfall anomaly was used to examine the temporal characteristics of climate variability and determine the prevalence of droughts. The results revealed that the average annual minimum temperature over the region had increased by about 0.72ºC every ten years while average annual maximum temperature had increased by about 0.36ºC per decade. This showed that the northern part of Ethiopia is warming faster than the national average of 0.25ºC per decade. *Karabulut et al. (2008) analysed the precipitation and temperature trend in Samsun, Turkey sing parametric and non-parametric trend tests. Results showed that there is no negative or positive statistically significant trend in the study area, despite slight precipitation decrease in winter. Mondal et al. (2012) studied precipitation trend of north-eastern part of Cuttack District, Orissa, India using Mann-Kendall (MK) test and Sen's Slope estimator. Results revealed that there is statistically insignificant change in the precipitation.*

2.0 METHODOLOGY

The meteorological data used in this study are monthly precipitation, evaporation, minimum and maximum temperature spanning a period of fifty years (1960-2010) for Osogbo, South-western Nigeria. Osogbo is located on the latitude 7.7667°N and longitude 4.5667°E. The study area is shown in the map in Fig. 1. The data were sourced from the archive of Nigerian Meteorological Agency (NIMET), Oshodi, Lagos. In order to establish trends and fluctuations exhibited by the meteorological parameters, the meteorological data were subjected to standardized anomalies index (SAI), Mann Kendall and regression analyses.

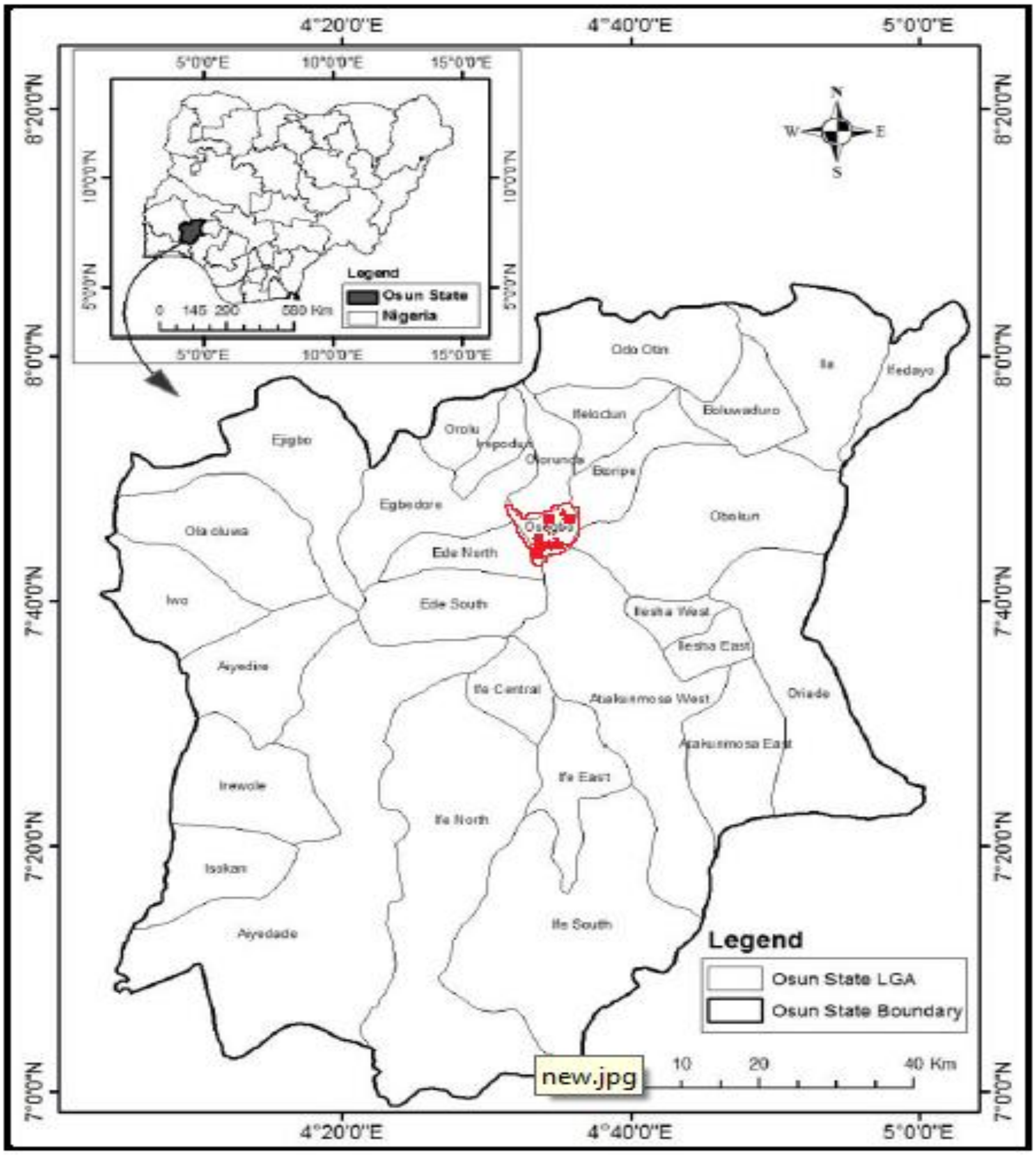

Figure 1: Map of Osun State (with the study area inscribed in red): adapted from Osun State Government (2014)

2.1 Mann-Kendall Trend Analysis

The Mann-Kendall test is a non-parametric test for identifying trends in time series data. It compares the relative magnitudes of sample data rather than the data values. The major benefit of this test is that the data need not conform to any particular distribution. Moreover data reported as non-detects can be included by assigning them a common value that is smaller than the smallest measured value in the data set. The procedure for the trend analysis assumes that there exists only one data value per time period. When multiple data points exist for a single time period the median value is used. The data values are evaluated as an ordered time series and each data value is compared to all subsequent data values. The initial value of the Mann-Kendall statistic (S) is assumed to be 0 if there is no trend. If a data value from a later period is higher than a data value from an earlier time period, S is incremented by 1. Conversely if the data value from a later period is lower than a data value sampled earlier S is decremented by 1. The net result of all the increments and decrements yield the final value of S. The expressions for the Mann-Kendall trend analysis are given in the Equations 1 to 4. Let X_1, $X_2 \ldots X_n$ represents n data points where X_j represents the data point at time *j*. The

Mann-Kendall statistic (S) and its sign can be computed using Equations 1 and 2.

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} Sgn(X_j - X_i) \quad (1)$$

$$Sgn(X_j - X_i) = \begin{cases} +1, & X_j > X_i \\ 0, & X_j = X_i \\ -1 & X_j < X_i \end{cases} \quad (2)$$

A very high positive value of S is an indication of an increasing trend while a very low negative value indicates a decreasing trend. However it is important to compute the probability associated with S and the sample size n in order to statistically quantify the significance of the trend (Prashanth, 2005). Equation 3 was used to estimate the variance (σ^2) of S.

$$\sigma^2 = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{g}(t_p - 1)(2t + 5)\right] \quad (3)$$

Where n is the number of data points, g is the number of tied groups (a tied group is a set of sample data having the same value) and t_p is the number of data points in the p^{th} group. Computation of a normalized test statistic Z_s is shown in Equation 4.

$$Z_s = \begin{cases} S - 1/\sigma & for \quad S > 0 \\ 0 & for \quad S = 0 \\ S + 1/\sigma & for \quad S < 0 \end{cases} \quad (4)$$

The test statistic Z_s is used as a measure of trend significance. In fact this analysis is used to test the null hypothesis, H_0: There is no monotonic trend in the data if $|Z_s|$ is greater than $Z_{\propto/2}$ where $\propto$ represents the chosen significance level (usually 5% with $Z_{0.025} = 1.96$) then the null hypothesis is invalid meaning that the trend is significant. Being significant implies that the trend has a causative factor and did not occur by chance.

2.2 Standardized Anomaly Index

Standardized anomaly index (SAI) is a statistical tool used to depict the fluctuation exhibited by the hydro-meteorological parameters. SAI was used by Kraus (1997) to provide a synthesis of the average area behaviour of precipitation at a specified time. The index was found to be effective for rainfall variability in the Niger basin area (Babatolu, 1998). SAI was used to test for the fluctuation of hydro-meteorological parameters in the study of climate change impact on water resources and adaptation strategies in the Sudano-Sahelian Ecological Zone (SSEZ) of Nigeria (Ojoye, 2012). It was used to investigate the annual precipitation trends in homogeneous precipitation of sub-divisions of western Iran so as to assess the variability during the last thirty-five years (Raziel, 2008). The SAI is used to assess fluctuation in hydro-meteorological parameter; the name of the index is adopted to suit the parameter under consideration (Ojoye, 2012). The climate data used for this study were subjected to SAI in order to depict the fluctuation and trend exhibited by each of the hydro-meteorological parameters as explained in (Ojoye, 2012). It was used in the study to examine the fluctuation of the meteorological variables at the study area for the period of fifty-one years (1960 to 2010). Equation 5 was used to assess the trends exhibited by the meteorological parameters using the SAIs.

$$X_{ab} = \frac{1}{N_b}\sum_{j=1}^{N_b}(T_{ab} - T_a)\sigma \quad (5)$$

where:

X_{ab} = departure for the b^{th} year
T_{ab} = the year total
T_a = the mean for the base period
σ = standard deviation for the base period
N_b = number of year when the data are available

2.3 Regression Models

Regression models are statistical tools used to model the relationship between two or more variables. It usually contains one independent variable and one or more dependent variable(s). Regression models provide scientist with a powerful tool which allow predictions about past, present or future events to be made with the available information. There are basically two major regression models namely: linear and multiple regression models, in this study, linear regression model was adopted.

2.3.1 Linear regression model

A linear regression model is a statistical tool that is used to model relationship between one independent and one dependent variable. Equation 6 is a simple linear regression equation that can be used to predict property of one variable based on another. There are some assumptions which must hold when building a linear regression model. The sign of the slope defines the direction of the trend of the variable: increasing if the sign is positive and decreasing if the sign is negative (Olofintoye and Adeyemo, 2011). Several descriptive statistics comprising the mean, standard deviation and range have been used for descriptions and comparisons. Linear regression model was employed in this study to show relationship between meteorological parameter and time. In this study, time in years was used as independent variable (*X*) while annual meteorological parameter was considered as the dependent variable (*Y*). The value of constants a and b were obtained using Equations 7 and 8.

$$Y = a + bX + e \quad (6)$$

where:

Y = dependent variable (annual meteorological parameters)

X = independent variable (time in year)

a = constant on Y- intercept

b = regression coefficient

e = error random term

$$a = \frac{n\sum(XY) - \sum X \sum Y}{n\sum(X^2) - (\sum X)^2} \quad (7)$$

$$b = \frac{\sum Y - a\sum X}{n} \quad (8)$$

where:

n = total observation

∑ = summation

2.3.2 Correlation coefficient

The Pearson product moment correlation coefficient (r) measures the strength of linear relationship between two variables. It always takes a value between -1 and +1, with +1 or -1 indicating a perfect correlation (all points would lie along a straight line, having a residual of zero). A correlation coefficient close to or equal to zero indicates no relationship between the variables. A positive correlation coefficient indicates a positive (upward) relationship and a negative correlation coefficient indicates a negative (downward) relationship between the variables (Olofintoye and Adeyemo, 2011). The correlation coefficient was used to test the relationship between the meteorological parameters and time at the study area using Pearson product moment correlation coefficient in Microsoft Excel.

3.0 RESULTS

Tables 1 to 4 show the monthly statistical summaries of meteorological parameters. Tables 5 and 6 presents the summaries of the Mann-Kendall and simple linear regression analyses of the meteorological parameters for Osogbo. The outcome of simple regression analyses presents the analysis of variance (ANOVA) for all the meteorological parameters considered in the study are shown in Tables 7 to 10. The results of SAIs are presented in Figures 2 to 5.

Table 1: Monthly Statistical Summary for Minimum Temperature

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	18.95	21.30	22.50	22.62	22.05	21.60	21.27	21.00	21.10	21.20	20.80	19.20
Median	19.10	21.70	22.70	22.60	22.10	21.60	21.40	21.10	21.10	21.20	21.00	19.50
STD	2.37	1.77	0.71	0.74	0.59	0.48	0.48	0.54	0.47	0.46	1.24	1.74
Min	13.50	15.90	20.60	20.60	20.30	20.20	19.50	19.50	19.90	19.70	17.90	14.90
Max	23.70	24.30	23.80	24.00	23.50	22.50	22.10	22.00	22.00	22.20	23.00	22.10
Skew	-0.44	-0.90	-0.63	-0.36	-0.51	-0.50	-1.11	-0.80	-0.20	-0.45	-0.30	-0.30
Kurtosis	-0.03	0.88	0.52	-0.22	1.43	0.87	2.99	0.81	-0.10	1.15	-0.70	-0.60

Table 2: Monthly Statistical Summary for Maximum Temperature

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	33.00	34.80	34.20	32.60	31.10	29.70	28.10	27.70	28.90	30.20	32.00	32.50
Median	33.10	34.90	34.30	32.50	31.20	29.80	28.00	27.70	28.90	30.10	31.80	32.50
STD	0.83	0.92	1.19	0.87	0.81	0.72	0.68	0.69	0.57	0.54	0.98	0.96
Min	31.20	33.00	31.70	30.70	29.30	27.10	26.50	26.60	27.60	28.80	30.00	30.70
Max	35.30	36.60	37.20	34.80	32.90	30.50	29.90	29.10	30.00	31.00	34.10	34.30
Skew	0.13	-0.10	0.27	0.51	-0.70	-2.01	0.14	0.30	-0.03	-0.48	0.19	-0.06
Kurtosis	0.47	-0.90	0.25	0.47	0.52	5.04	0.31	-0.71	-0.61	-0.10	-0.80	-0.77

Table 3: Monthly Statistical Summary for Evaporation

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	5.23	6.23	5.06	3.62	2.51	2.25	1.7	1.59	1.69	1.87	3.07	4.15
Median	5.30	6.10	4.70	3.50	2.40	2.00	1.60	1.50	1.70	1.90	3.00	3.25
STD	1.42	1.55	1.31	1.08	0.42	0.95	0.50	0.28	0.20	0.30	0.62	0.79
Min	1.30	3.50	3.20	2.50	1.50	1.50	1.30	1.20	1.20	0.60	1.70	2.80
Max	8.60	9.60	9.10	9.80	3.50	6.10	4.90	2.50	2.20	2.60	4.70	6.60
Skew	0.08	0.44	1.23	3.92	0.45	3.38	5.00	0.99	-0.04	-1.20	0.31	0.60
Kurtosis	0.57	-0.5	1.67	21.5	0.19	11	31	1.16	0.31	5.61	0.11	0.25

Table 4: Monthly Statistical Summary for Precipitation

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	16.58	22.79	85.13	121	158.4	181.9	163.7	134.10	211.03	193.50	38.79	8.32
Median	3.10	15.30	82.70	124	154.7	178.2	156.8	122.70	212.70	191.90	25.60	2.70
STD	26.75	25.06	44.77	46.30	51.42	55.21	83.19	93.12	67.59	61.90	38.60	20.64
Min	0	0	5.50	24.70	46.70	69.20	40.60	27.90	73.80	73.70	0	-88.10
Max	118.10	92.90	212.30	248	313.20	307.10	361.70	449.60	378.70	393.10	135.20	52.10
Skew	2.17	1.11	0.59	0.34	0.63	0.05	0.62	1.21	0.40	0.74	1.11	-2.21
Kurtosis	4.90	0.39	0.67	0.24	0.72	-0.64	-0.23	1.454	0.52	1.37	0.16	12.10

Table 5: Mann-Kendall of Meteorological Parameters

Variable	Autocorrelation factor	Lag	Kendall's S	Z_s	Trend nature	Trend significance
Min Temp	0.371	1	185	1.4861	Positive	No
Max Temp	0.070	1	381	3.0945	Positive	Yes
Evaporation	0.072	1	11	0.0813	Positive	No
Precipitation	0.068	1	111	0.937	Positive	No

Table 6: Regression Analysis of Meteorological Parameters

Variable	Regression Equation	Determination Coefficient, R^2 (%)	Correlation Coefficient (r)
Min Temp	$Y = 0.0051X + 21.023$	1.5	0.89
Max Temp	$Y = 0.0099X + 30.980$	1.2	0.35
Evaporation	$Y = 0.00048X + 3.261$	0.033	0.85
Precipitation	$Y = 0.2109X + 110.68$	2.0	0.87

Table 7: Analysis of Variance for Minimum Temperature

Sample	DF	SS	MS	F	$F_{significant}$
Regression	1	0.22519	0.22519	0.76612	0.38569
Residual	49	14.4029	0.29394		
Total	50	14.6281			

Table 8: Analysis of Variance for Maximum Temperature

Sample	DF	SS	MS	F	$F_{significant}$
Regression	1	1.08575	1.08575	6.73927	0.01241
Residual	49	7.8943	0.16111		
Total	50	8.98005			

Table 9: Analysis of Variance for Evaporation

Sample	DF	SS	MS	F	$F_{significant}$
Regression	1	0.00259	0.00259	0.01626	0.89907
Residual	49	7.80767	0.15934		
Total	50	7.81026			

Table 10: Analysis of Variance for Precipitation

Sample	DF	SS	MS	F	$F_{significant}$
Regression	1	491.554	491.554	0.99029	0.32456
Residual	49	24322.4	496.375		
Total	50	24813.9			

where:

DF = Degree of freedom

SS = Sum of square

MS = Mean of square

F = F- test statistic

$F_{siginificant}$ = p-value, it was used to test if time has affected the meteorological variables at 95% significant level in study area.

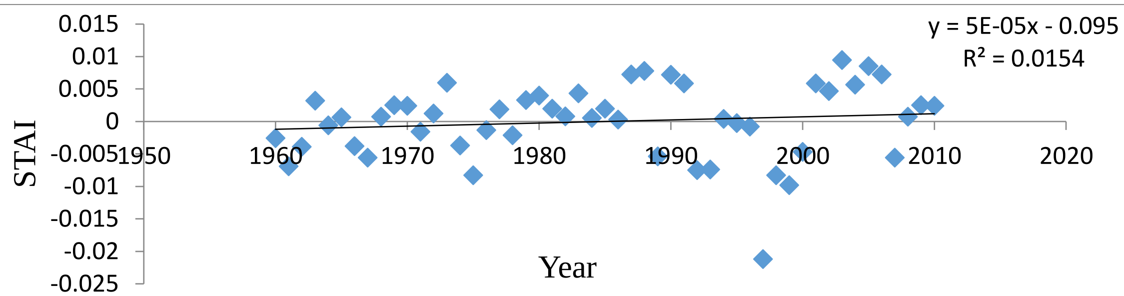

Figure 2: Minimum Temperature Trend

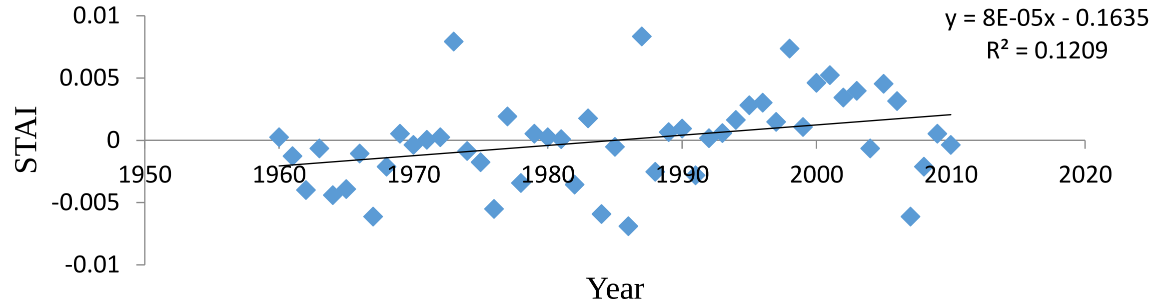

Figure 3: Maximum Temperature Trend

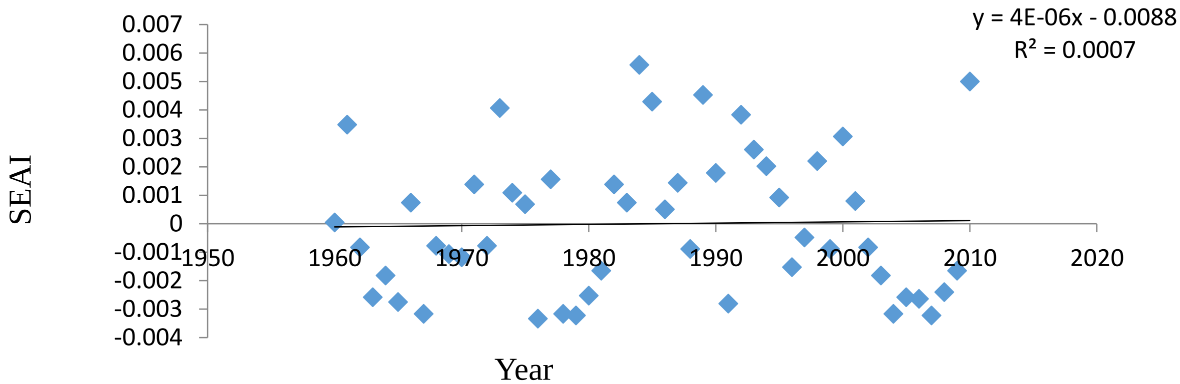

Figure 4: Evaporation Trend

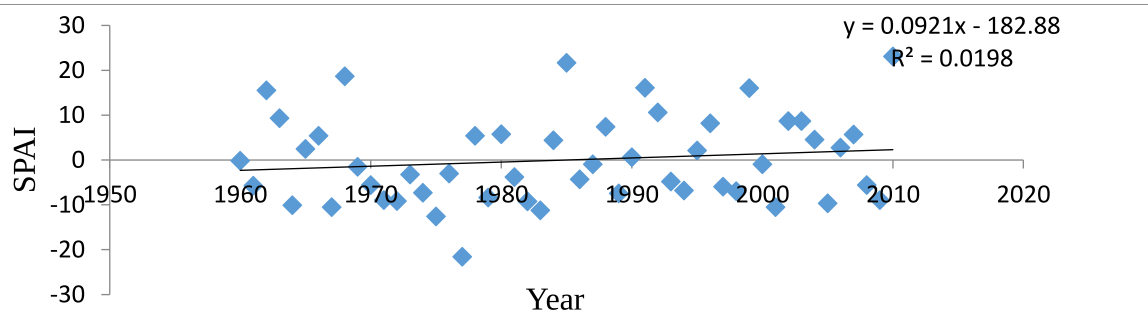

Figure 5: PrecipitationTrend

4.0 DISCUSSION OF RESULTS

The mean minimum temperature varied between 18.95 °C to 22.62 °C while the standard deviation ranged 0.462 °C to 2.37 °C. The mean maximum temperature range between 27.7 °C to 34.84 °C while standard deviation ranged from 0.534 °C to 1.19 °C. The average evaporation varied between 1.58 mm to 6.23 mm while its standard deviation varied between 0.20 mm to 1.55mm. Precipitation on average varied between 8.32 mm to 211.03 mm. The variation in monthly meteorological parameters was shown in the results of the statistical analyses (Tables 1 to 4). The precipitation, evaporation, minimum and maximum temperature have positive Kendall's (S) values which indicates that all the parameters have positive trend and can increase over time. Minimum temperature, evaporation and precipitation have test statistic (Z_s) values of 1.4861 0.0813 and 0.937 respectively which are less than 1.96 (test statistic for a significant level of 5% i.e. $Z_{0.025}$) this implies that a statistically significant trend is not demonstrated for minimum temperature, evaporation and precipitation. The maximum temperature has Z_s values of 3.0945 which is greater than 1.96 this implies that a statistically significant positive trend is demonstrated for maximum temperature as shown in Table 5. Hence, only maximum temperature has the tendency to increase with time.

The results of the regression analysis revealed that the linear models of the precipitation, minimum and maximum temperature and evaporation have tendency to increase with time considering their slopes (Table 6). Also the correlation coefficient (r) for all the parameters are very high, this indicates a strong positive correlation between the meteorological parameters and time except maximum temperature.

The results of linear models reveal that mean value of precipitation, evaporation, minimum and maximum temperature are: 110.68 mm, 3.2610 mm, 21.023 °C and 30.980 °C respectively (Table 6). These values are similar to what was obtained using the measure of central tendency. The analysis variance (ANOVA) test shows an $F_{siginificant}$/p-value of 0.385691, 0.899067 and 0.324561 for minimum temperature, evaporation and precipitation respectively. These values are all less than 0.05 at 95% significant level, it can be deduced that time affects the meteorological variables. Also, maximum temperature has $F_{siginificant}$/p-value of 0.012413 which is less than 0.05 at 95% significant level, the result reveals that maximum temperature varies with time. STAI for both minimum and maximum temperature with SPAI and SEAI have positive trend (Figures 2 to 5) this corroborate the results obtained for Mann-Kendall trend analysis.

5.0 CONCLUSION

It can be concluded from the results that trends occur in all the meteorological variables considered in the study area. The results of SAIs and Mann Kendall analyses revealed that precipitation, evaporation, minimum and maximum temperature have positive trend. Also the maximum temperature demonstrates a significantly increasing trend but trend exhibited by other parameters are not significant. Hence it can be concluded that the maximum temperature has tendency to increase in the study area in future. The linear regression models also reveal that there is highly positive trend in precipitation, minimum and maximum temperature but evaporation has low positive trend.

REFERENCES

Abaje, I. B., Ati, O. F. and Iguisi, E. O. (2012) Recent Trends and Fluctuations of Annual Rainfall in the Sudano-Sahelian Ecological Zone of Nigeria: Risks and Opportunities. Journal of Sustainable Society, 1 (2): 44-51.

Afangideh, A. I., Okpiliya, F. E. and Eja, E. I. (2010) A Preliminary Investigation into the Annual Rainfall Trend and Patterns for Selected Towns in Parts of South-Eastern Nigeria. Journal of Sustainable Development, 3(3): 275-282.

Babatolu, J. S. (1998) Climate Change and its Implications for Water Supply in the Niger River Basin Development Authority Area of Nigeria. A P.hD Thesis, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria.

Gebrehiwot, T. and Vanderveen, A. (2013) Assessing the Evidence of Climate Variability in the Northern Part of Ethiopia. Journal of Development and Agricultural Economics, 5(3): 104-119.

Ikhile, C. I. (2003) Effects of Climate Change on Irrigation Activities: A Case Study of the Benin-Owena River Basin Irrigation Projects. IAHS Publication, 281: 287-293.

Karabulut, M. Gürbüz, M. and Korkmaz, H. (2008) Precipitation and Temperature Trend Analyses in Samsun. J. Int. Environmental Application & Science, 3(5): 399-408.

Kraus, E. B. (1997) Subtropical Droughts and Cross-equatorial Energy Transports Mon. Wea. Rev. 105: 1009-1018.

Makanjuola, O. R., Salami, A. W., Ayanshola, A. M., Aremu, S. A., and Yusuf, K. O. (2010) Impact of Climate Change on Surface Water Resources of Ilorin. 2nd Annual Civil Engineering Conference, University of Ilorin, Ilorin, Nigeria. pp. 284-297.

McBean, E. and Motiee, H. (2008) Assessment of Impact of Climate Change on Water Resources: A Long Term Analysis of the Great Lakes of North America. Hydrology Earth Syst.Science. 12, 239–255.

Mondal, A. Kundu, S. and Mukhopadhyay, A. (2012) Rainfall Trend Analysis by Mann-Kendall Test: A Case Study of North-Eastern Part of Cuttack District, Orissa. International Journal of Geology, Earth and Environmental Sciences, 2 (1): 70-78.

Ojoye, S. (2012) Climate Change Impact on Water Resources and Adaptation Strategies in the Sudano-Sahelian Ecological Zone of Nigeria. A Ph.D Thesis, Department of Geography and Environmental Management, University of Ilorin, Ilorin, Nigeria.

Olofintoye, O. O. and Adeyemo, J. (2011) The Role of Global Warming in the Reservoir Storage Drop at Kainji Dam in Nigeria, International Journal of the Physical Sciences, 6(19): 4614-4620.

Olofintoye, O. O. and Sule, B. F. (2010) Impact of Global Warming on the Rainfall and Temperature in the Niger Delta of Nigeria) USEP: Journal of Research Information in Civil Engineering, 7(2): 33-48.

Osun State Government, (2014) Official Diary of Osun State of 2013, Osogbo: Osun State Ministry of Information and Strategy.

Prashanth, K. (2005) Mann-Kendall Analysis for the Fort Ord Site. 1155. HydroGeoLogic, Inc. Annual Groundwater Monitoring Report, California. U.S. Army Corps of Engineers. pp. 1-7.

Raziel, T. (2008) Investigation of Annual Precipitation Trends in Homogeneous Precipitation Sub-Divisions of Western Iran. BALWOIS Ohrid, Macedonia Republic pp. 1-7.

Salami, A.W., Raji, M. O., Sule, B. F., Abdulkareem, Y. A. and Bilewu, S. O. (2010) Impacts of Change Climate on the Water Resources of Jebba Hydropower Reservoir. 2nd Annual Civil Engineering Conference University of Ilorin Nigeria, pp. 298-312.