



## ASSESSING RAINFALL DATA QUALITY AND TRENDS IN THE SOUTHWESTERN LITTORAL BASIN OF NIGERIA

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### Abstract

Understanding of rainfall data quality and trends is crucial for watershed modeling in the Southwestern littoral basin of Nigeria. This research aims to assess the reliability of rainfall dataset to identify potential trends for informed decision-making on sustainable water resource management. The research employed rigorous homogeneity tests to evaluate the consistency and reliability of rainfall data collected from various gauge stations within the Southwestern littoral basin (SWLB). Trend tests such as Mann-Kendall and Sen's slope were used to detect any systematic changes or long-term trends. Homogeneity tests revealed instances of data inconsistencies across the thirteen stations, potentially caused by factors such as instrumentation and land use/land cover modifications. Trend analysis identified significant alterations in hydrological variables over time, including shifts in rainfall patterns. Based on the results of Standard Normal Homogeneity Test (SNHT), the annual rainfall time series were homogeneous at all stations. The SNHT detected insignificant breaks near the start of the data series at the 1983 year while the Pettit test detected breakpoints at the middle of the series at mostly year 1997 and 2006. The trend analysis showed a non-significant increasing trend at five stations and decreasing trend at eight stations at the annual timescale for both Mann-Kendall (MK) test and the Sen's slope. On the monthly timescale, April, May, June, July and August were dominated by a negative trend in the study area while the months of November and January showed increasing trends most of the stations at the 5% significance levels.

**Keywords:** Rainfall, homogeneity, trend analysis, Mann-Kendall test, standard normal homogeneity test, Pettit test, Sen's slope

### Introduction

A climate time series is said to be homogenous if the fluctuations are only due to changes in the climate (Aguilar et al. 2003, Costa and Soares, 2009). The results of climatic and hydrological research may be skewed by non-climatic influences that obscure the real climatic signals and trends. Relocations of monitoring stations, modifications to instrumentation, alterations to the environment, instrumental errors, and modifications to observational and computation protocols are common causes. Regretfully, there aren't many long-term climate time series that are error-free (Auer et al. 2005, Costa and Soares, 2009).

Hydrological models are essential tools for understanding and predicting the behavior of water systems, ranging from small watersheds to large river basins. These models play a critical role in water resources management, flood forecasting, and environmental impact assessment. However,

the accuracy and reliability of these models heavily depend on the quality of the input data. Rainfall is an important input data watershed modeling. Adeyeri et al. (2022) suggested that when observations are used in climate and hydrological studies, robust homogenization of climate series should be carried out to reduce inhomogeneity errors and enhance the quality of the information. Data from observational ground stations can be impacted by trends, change points, and inhomogeneities. Trend analysis of rainfall data provides insights into the long-term changes in precipitation patterns and helps in understanding the impact of climate change. Yang et al. (2019) proposed a high-dimensional integrative analysis approach that combines homogeneity and sparsity recovery to detect trends in data. These time series' statistical characteristics are a source of uncertainty because it is frequently challenging to pinpoint their origin, which might affect the conclusions of

hydrological models. To ensure the models produce reliable results, rigorous testing and validation of hydrological data are necessary. Akinsanola and Ogunjobi (2017) applied modified Mann-Kendall, Pettitt's and Standard Normal Homogeneity Tests on 23 stations in Nigeria during a 40-year period spanning from 1974 to 2013 to investigate the long-term spatio-temporal trends of rainfall on annual and seasonal scales. Their findings indicate that most of the stations exhibit homogeneous trends in annual and seasonal rainfall over the country.

In order to make reliable estimation and future projections of water resources in SWLB, reliable rainfall data is needed hence homogeneity test on thirteen rain gauged stations data in the basin. This study accessed the years of break point and trend of recent 33 years datasets from ground observed stations.

**Materials and Method**

**Description of the Study Area**

The Southwestern littoral basin lies between latitudes 5°22'N, 8°37'N and longitudes 3°0'E, 6°40'E in the Southwestern region of Nigeria as shown in Figure 1. The basin is about 114,936 km<sup>2</sup> with a uniformly appearing plateau at elevation ranging from 0 m to 1110 m. Two major sub-basins (Benin-Owena and Ogun-Osun) were combined to form the SWLB. The main rivers in the basin comprise the Osse, Ossiomo, Owena, Adofi, Ethiopie, Yewa, Ogun, Owena, Ado odo and Osun Rivers. As at the time of this study, the SWLB has thirteen active meteorological stations which were used for the point evaluation and they include the Abeokuta, Akure, Benin, Ibadan, Ijebuode, Ikeja, Iseyin, Lagos Marine, Lokoja, Ondo, Oshodi,

Oshogbo, Shaki, and Warri stations.

**Characteristics of the Station-observed Rainfall Data**

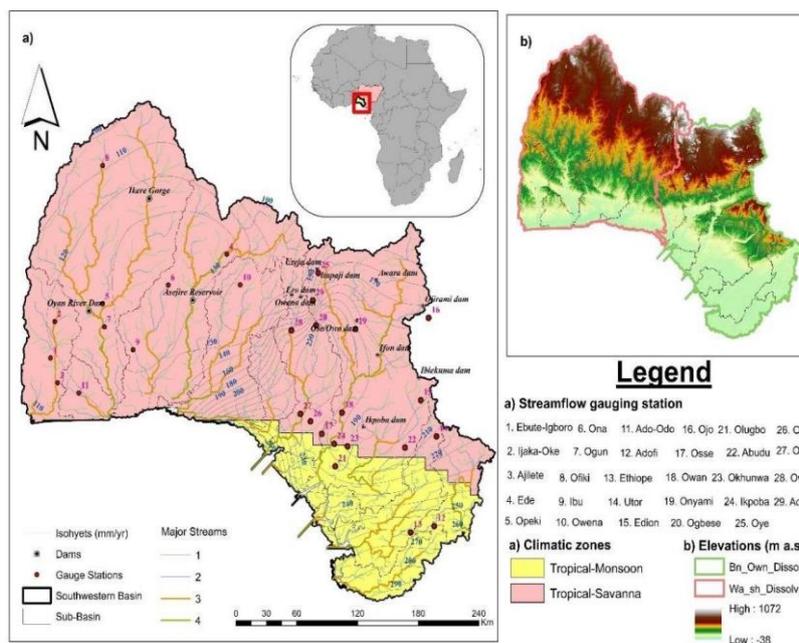
Thirteen weather stations are unequally distributed across the Southwestern Littoral Basin (SWLB) of Nigeria with the Ogun-Osun sub-basin accounting for nine of those stations. Daily total rainfall and other hydro-meteorological observations were obtained from these weather stations. For the period (1983–2015), daily observations have been collected from each of the thirteen weather stations from the Benin-Owena and Ogun-Osun Basin Authorities. Figure 2 and Table 1 provide a statistical summary of the stations.

**Homogeneity Tests**

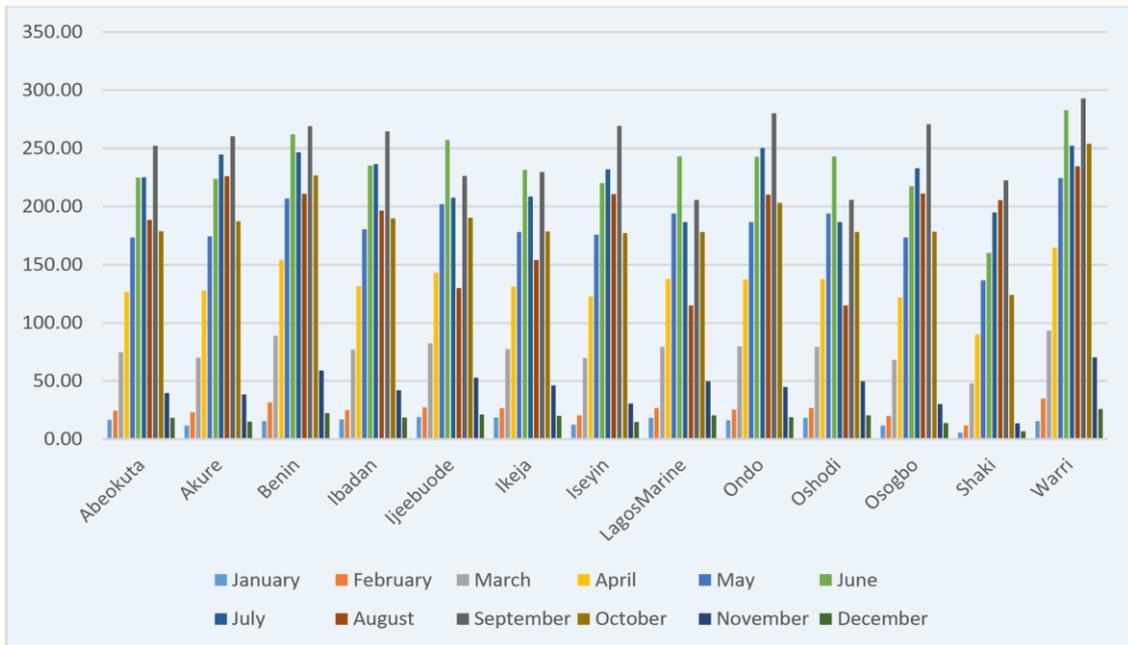
Two homogeneity tests are selected to detect breaks (inhomogeneities) in rainfall time series data: the Pettitt test (Pettitt 1979) and the SNHT for a single break (Alexandersson 1986). These are regarded as absolute homogeneity tests and are capable to specify the homogeneity of a given time series data (Schönwiese and Rapp 1997; Wijngaard et al. 2003). The Pettitt, the SNHT identify jump in the time series and find the break point and is more susceptible to break points in the middle of the time series, whereas the SNHT is more sensitive to breaks near the beginning and end of the time series (Hawkins 1977; Wijngaard et al., 2003; Costa and Soares, 2009).

**Pettitt Test**

Pettitt's test is a rank-based statistical method designed to identify significant changes in the mean of time series data when the actual timing of



**Figure 1:** Map of the SWLB Showing the Sub-basins, Active Gauge Stations, Elevations and Climatic Zone



**Figure 2:** Mean Monthly Precipitation for the Thirteen Meteorological Stations in the SWLB

**Table 1: Overview of the Thirteen Weather stations in the SWLB**

Station Name	Region	Latitude (deg.)	Longitude (deg.)	Altitude above sea level (m)
Abeokuta	Ogun-Osun	7.01701	3.03301	46
Akure	Benin-Owena	7.28301	5.30001	349
Benin	Benin-Owena	6.32001	5.10001	41
Ibadan	Ogun-Osun	7.43001	3.90001	218
Ijebu-Ode	Ogun-Osun	6.08301	3.93001	0
Ikeja	Ogun-Osun	6.58001	3.33001	40
Iseyin	Ogun-Osun	7.97001	3.60001	323
Lagos-Marine	Ogun-Osun	6.43001	3.42001	6
Ondo	Benin-Owena	7.10001	4.08301	107
Oshodi	Ogun-Osun	6.05001	3.38001	0
Osogbo	Ogun-Osun	7.78301	4.48301	307
Shaki	Ogun-Osun	8.67001	3.38001	478
Warri	Benin-Owena	5.51601	5.73001	15

the change is not known (Pettitt, 1979). This approach is particularly useful for detecting abrupt change points in hydrological and climatic records (Mavromatis and Stathis, 2011). It is known for its sensitivity to changes occurring at the beginning and end of the time series, and is robust to variations in the distribution of the data. The test utilizes a modified version of the Mann–Whitney

statistics  $U_{t,N}$ , which assesses whether two subsets of data,  $x_1, \dots, x_i$  and  $x_{i+n}, \dots, x_n$ , originate from the same population (see Equations 1 and 2). The test statistic  $U_t, N$  is defined as follows (Mann and Whitney, 1947):

$$U_{t,\tau} = \sum_{i=1}^n \sum_{j+1}^{i-1} \text{sgn}(X_i - X_j) \quad (1)$$

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

The non-appearance of changing points is the null hypothesis of Pettitt's test. Equations 3 and 4 show the statistic  $K_t$  and the associated probabilities used in significance testing and are given as (Pettitt 1979):

$$K_t = \text{Max}|U_{t,T}|, 1 \leq t < T \quad (3)$$

$$POA = 2 \exp \{-6(K+)^2 / (T^3 + T^2)\} \text{ for } T \rightarrow \infty \quad (4)$$

If  $P < 0.5$ , a significant change point exists, the time series is divided into two parts at the location of the change point.

### The Standard Normal Homogeneity Test (SNHT)

Standard Normal Homogeneity Test (NSHT) is a widely used homogeneity test for change detection. Alexandersson and Moberg (1997) proposed a statistic  $T(k)$  as shown in Equations 5-8 to compare the mean of the first  $k$  years of the record with that of the last  $(n - k)$  years:

$$T_{(k)} = \max_{1 \leq a < n} T_{(a)} = \max_{1 \leq a < n} (a\bar{Z}_1^2 + (n - a)\bar{Z}_2^2) \text{ with } a = 1, 2, \dots, n \quad (5)$$

$$\bar{Z}_1 = \frac{1}{a} \sum_{i=1}^a \frac{(Y_i - \bar{Y})}{s} \quad (6)$$

$$\bar{Z}_2 = \frac{1}{n-a} \sum_{i=a+1}^n \frac{(Y_i - \bar{Y})}{s} \quad (7)$$

$n$  is the data set length,  $Y_i$  is the  $i_{th}$  element of the data set, and  $\bar{Y}$  is the mean value of the data set. The mean of the first  $k$  years and the last  $n - k$  years of the record are compared. If a break is located at the year  $K$ , then  $T_{(k)}$  reaches a maximum near the year  $k = K$ . The test statistic  $T_0$  is defined as

$$T_0 = \max_{1 \leq a < n} T_{(a)} \quad (8)$$

### Trend analysis

Two trend tests are selected to detect the trend in the data series: Mann-Kendall test and Sen's slope estimator.

### Mann Kendall trend test

The Mann-Kendall (MK) test was developed by Mann (1945) and Kendall (1975). This is a nonparametric test to identify monotonic trend in a time series. The MK test is based on the statistic  $S$  (see Equations 9 and 10), which can be expressed by

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^n sgn(x_j - x_k) \quad (9)$$

$$sgn(x_j - x_k) = \begin{cases} 1 & \text{if } x_j - x_k > 0 \\ 0 & \text{if } x_j - x_k = 0 \\ -1 & \text{if } x_j - x_k < 0 \end{cases} \quad (10)$$

where  $x_j$  and  $x_k$  are sequential data values for the time series data of length  $n$ .  $S$  is the number of positive differences minus the number of negative differences. If  $S$  is a positive number, observations obtained later in time tend to be larger than observations made earlier. If  $S$  is a negative number, then observations made later in time tend to be smaller than observations made earlier.

Mann (1945) and Kendall (1975) noted that the statistic  $S$  is roughly normally distributed, under the null hypothesis, when  $n \geq 8$  (data length of 33 years in this study), with Equation 11 indicating the variance and mean of statistics  $S$  as follows:

$$\text{VAR}(S) = \frac{1}{18} [n(n-1)(2n+5) - \sum_{p=1}^g t_p(t_p - 1)(2t_p + 5)] \quad (11)$$

where  $g$  is the number of tied groups and  $t_p$  is the number of observations in the  $p$ th group.

Equation 12 shows the standard normal variate value of  $Z$  calculated as:

$$Z = \begin{cases} \frac{S-1}{[\text{VAR}(S)]^{1/2}}, & \text{if } S > 0 \\ 0, & \text{if } S = 0 \\ \frac{S+1}{[\text{VAR}(S)]^{1/2}}, & \text{if } S < 0 \end{cases} \quad (12)$$

Positive values of  $Z$  indicate a rising trend and negative values show a descending trend.

### Sen's slope estimator

Sen's slope is an alternative, more robust, nonparametric estimate of the slope, for the set of pairs  $(i, x_i)$  where  $x_i$  is a time series (see Equation 13). Sen's slope is defined as

$$\text{Sen's slope} = \text{Median} \left\{ \frac{x_j - x_i}{j - i} : i < j \right\} \quad (13)$$

A  $1-\alpha$  confidence interval for Sen's slope was calculated as (lower, upper) where

$$N = C(n, 2) \quad k = se \cdot Z_{crit} \\ \text{lower} = m_{(N-k)/2} \quad \text{upper} = m_{(N+k)/2+1}$$

Here,  $N$  = the number of pairs of time series elements  $(x_i, x_j)$  where  $i < j$  and  $se$  = the standard error for the Mann-Kendall Test. Also  $m_h$  = the  $h^{th}$  smallest in the set  $\{(x_j - x_i)/(j - i) : i < j\}$  and  $z_{crit}$  = the  $1-\alpha/2$  critical value for the normal distribution.

**Table 2: Statistical Summary of Annual Rainfall at the Considered Stations for 1983–2015**

STATION	Product	Max Daily Rainfall	No. of Rainy Days	No. of Non-Rainy Days	Daily Mean Rainfall	Daily Rainfall STD	Max Monthly Rainfall	Min Monthly Rainfall	Monthly Rainfall Mean	Monthly Rainfall STD	Max Yearly Rainfall	Min Yearly Rainfall	Yearly Rainfall Mean
Abeokuta	Gauge	139.37	10405	2014	4.23	6.13	466.91	0	128.65	104.83	2092.1	1048	1543.8
Akure	Gauge	103.39	10548	1871	4.39	6.03	480.37	0	133.6	113.91	2185.09	895.15	1603.17
Benin	Gauge	94.73	10652	1767	4.91	6.95	654.83	0	149.52	126.39	2523.5	1014.5	1794.3
Ibadan	Gauge	160.97	10117	2302	4.42	6.52	483.5	0	134.53	110.95	2179.3	1082.4	1614.4
Ijebu Ode	Gauge	101.32	10068	2351	4.27	6.6	531.61	0	129.95	108.77	2239.8	977.14	1559.4
Ikeja	Gauge	108.53	10444	1975	4.11	6.18	477.82	0	125.05	102.19	2148.8	962.98	1500.6
Iseyin	Gauge	162.51	10024	2395	4.26	6.13	495.83	0	129.64	107.88	2082	1026.8	1555.7
Lagos Marina	Gauge	103.92	10399	2020	3.98	6.12	490.47	0	121.28	100.58	2114.2	929.48	1455.3
Lokoja	Gauge	91.46	10084	2335	3.52	5.38	479.35	0	107.17	103.53	1906.3	433.47	1286
Ondo	Gauge	142.63	9837	2216	4.51	6.53	487.67	0	137.19	113.51	2234.7	1122	1646.3
Oshodi	Gauge	103.92	10399	2020	3.98	6.12	490.47	0	121.28	100.58	2114.2	929.48	1455.3
Osogbo	Gauge	141.87	10030	2389	4.24	6.01	498.36	0	129.13	107.79	2088.6	1032.6	1549.5
Shaki	Gauge	100.01	9731	2688	3.34	4.84	437.27	0	101.65	90.58	1649.7	819.17	1219.8
Warri	Gauge	131.34	10605	1814	5.33	8.26	963.68	0	162.14	148.87	3513.7	1083.1	1945.7

STATION	Yearly Rainfall STD	Maximum Wet-Season Rainfall	Minimum Wet-Season Rainfall	Wet-Season Rainfall Mean	Wet-Season Rainfall STD	Maximum Dry-Season Rainfall	Minimum Dry-Season Rainfall	Dry-Season Rainfall Mean	Dry-Season Rainfall STD
Abeokuta	259.99	1889.7	925.81	1369.9	233.86	348.4	66.85	173.95	70.54
Akure	331.58	2006.3	810.95	1444.5	317.36	362.73	46.13	158.64	67
Benin	407.65	2359.5	871.41	1576.6	383.74	522.33	59.45	217.7	95.79
Ibadan	274.39	1974.9	975.11	1434.9	245.33	351.86	68.03	179.42	75.11
Ijebu Ode	315.63	1881.6	861.21	1356.6	265.79	409.54	73.91	202.87	94.54
Ikeja	283.27	1813	855.16	1311.4	246.92	351.87	70.41	189.19	81.69
Iseyin	239.57	1907.8	926.23	1407.6	225.22	297.46	57.7	148.07	57.27
Lagos Marina	291.74	1770.1	815.16	1260.3	249.24	376.96	70.45	194.93	87.32
Lokoja	339.6	1848.1	409.88	1204.4	325.4	214.38	10.94	81.64	42.81
Ondo	282.38	2030.7	978.79	1467.2	252.74	328.89	71.7	179.1	74.88
Oshodi	291.74	1770.1	815.16	1260.4	249.24	376.96	70.45	194.93	87.32
Osogbo	238.39	1923.2	910.75	1405.8	224.45	267.92	57.96	143.69	54.26
Shaki	195.98	1560.9	729.76	1134.3	193.63	151.82	24.28	85.44	32.23
Warri	598.53	3250.1	908.94	1705.8	559.91	631.62	44.7	239.97	119.55

**Table 3: Results of the Pettitt test and SNHT on annual rainfall (1983-2015)**

Station	Pettitt Test			SNHT		
	P-value	C.P (year)	Significance	P-value	C.P (year)	Significance
Abeokuta	1	1997	NS	0.7636	1983	NS
Akure	0.8635	1997	NS	0.8483	1983	NS
Benin	0.7462	1997	NS	0.752	2006	NS

\*Significant at the 5% level  
NS: Not Significant

**Table 4: Results of the Pettitt test and SNHT on annual rainfall (1983-2015)**

Station	Pettitt Test			SNHT		
	P-value	C.P (year)	Significance	P-value	C.P (year)	Significance
Ibadan	0.6375	1997	NS	0.7863	1983	NS
Ijebu-ode	1.0000	2006	NS	0.8962	1986	NS
Ikeja	0.9040	2006	NS	0.0865	1983	NS
Iseyin	0.4777	1997	NS	0.5812	1983	NS
Lagos-Marine	1.0000	2006	NS	0.8456	1983	NS
Lokoja	1.0000	1997	NS	0.6546	1983	NS
Ondo	0.6727	1997	NS	0.8213	1983	NS
Oshodi	0.9873	2006	NS	0.8346	1983	NS
Osogbo	0.6727	1997	NS	0.7042	1983	NS
Shaki	0.9454	1998	NS	0.5447	1983	NS
Warri	0.6375	1997	NS	0.7141	1997	NS

\*Significant at the 5% level

NS: Not Significant

## Results and Discussion

### Evaluation of the Precipitation Products in the SWLB

The Rainfall dataset were analyzed for each of the thirteen stations in the basin at two different temporal scales: monthly and annual. The statistical summary of all annual rainfall for the thirteen stations are shown in Table 2.

### Homogeneity Test

Homogeneity tests were carried out using the Pettitt test and SNH test for the gauged rainfall. The data series were considered inhomogeneous when the p-values were lower than 5% significance level. The analyses were carried out at the monthly and annual total rainfall time scales.

### Results of Homogeneity Tests on Rainfall Data at the annual timescale

In general, the gauge annual rainfall datasets were homogenous at all stations; the dataset from the 13 stations showed homogenous nature when tested with the Pettitt test and the Standard Normal Homogeneity Test (Tables 3-4). The results indicated that there were no inhomogeneous stations with p-value lower than the significance level of 5%.

Tables 3-4 also showed the change points in the annual rainfall series by the Pettitt's test and SNHT but none of the change points were significant at the significance level of 5%. The p-values of the series were all greater than 5% which gives the conclusion of a non-significant change point.

### Trend Analysis

Trend analyses were carried out using the Mann-Kendall test and Sen's Slope for the gauged rainfall. The preliminary data analyses were carried out to find the statistical parameters (Mann-Kendall's test statistic Z, significance level of 5%, Var-S, P-value and Sen's Slope). The analyses were carried out using the above-mentioned trend tests at the monthly and annual total rainfall time scales of the gauged rainfall data from 1983 to 2015.

### Results of Trend Tests on Rainfall Data at the Annual Timescale

Trend According to Anderson (1942), to exclude the influence of serial correlation, before using MK test statics, serial autocorrelation was tested by Lag-I autocorrelation using different levels of significance (0.01, 0.05 and 0.1%). Depending on the test, the observed data were serially independent, therefore to detect the trend at 5 % levels of significance, the MK trend test was used on the actual data series.

The statistics of the MK test annual rainfall for the Southwestern littoral basin during the period 1983-2015, are presented in Table 5 and 6. Eight out of thirteen stations showed presence of a decreasing trend (Negative values of Z) while in five stations the trend was increasing (Positive values of Z. The details of these seven stations are presented in Table 6, but the trends were not statistically significant at the chosen significance level of 0.05.

**Table 5: Result of MK test and Sen’s slope on annual rainfall (1983-2015)**

Station	MK Test		Sen’s Slope
	Z	P-value	Sens’s Slope Estimate
Abeokuta	0.17044	0.8647	0.8581
Akure	-0.29439	0.7685	-1.0715
Benin	-0.38736	0.6985	-1.8274
Ibadan	-0.0775	0.9382	-0.45
Ijebu-ode	0.44934	0.6532	2.6269
Ikeja	0.38736	0.6985	3.2071
Iseyin	-0.41835	0.6757	-2.2119
Lagos-Marine	0.29439	0.7685	2.5417

\*Significant at the 5% level

Positive values of z indicate increasing trend while negative values indicate decreasing trend

**Table 6: Result of MK test and Sen’s slope on annual rainfall (1983-2015)**

Station	MK Test		Sen’s Slope
	Z	P-value	Sens’s Slope Estimate
Ondo	0.077472	0.9382	0.7614
Oshodi	0.44934	0.6532	1.9087
Osogbo	-0.29439	0.7685	-1.5899
Shaki	-0.29439	0.7685	-1.6253
Warri	-0.41835	0.6757	-2.3625

The Sen’s slope estimator was employed after Mann-Kendal test statistics in order to determine the change and variability of rainfall trend through time series. As presented in Tables 5 and 6, the Sen’s slope estimator indicated an upward trend in five stations and downward trend in eight stations for annual rainfall.

**Results of Trend Tests on Rainfall Data at the Monthly Timescale**

The statistics of the MK test on monthly rainfall in the Southwestern littoral basin, are presented in Table 7.

Table 7 shows the MK and statistics at 5% significance level. A positive z-statistics value indicates an increasing trend whereas a negative value indicates a decreasing trend. MK showed that 48% of the values fall under negative trend(s) respectively. Out of 156 cases (13 Stations × 12 months) at 5% significance level, 75 cases showed a positive trend, 81 cases showed a negative trend, 30 cases showed a positive significant trend and 1 case showed a significant negative trend.

The months of November and January most likely showed a significant positive trend for almost all stations for MK test (12 out of 13 stations, and 11 out of 13 stations for November and January respectively).

A large variation was observed in the magnitude and direction of the rainfall trends for the Southwestern littoral basin. Table 8 shows the Sen’s slope for the rainfall time series on a monthly basis for the period 1983– 2015. The medians of five months’ slopes showed negative values. The lowest point value was observed in the month of July (–3.21 mm/year) and the highest point value was observed in the month of November (2.45 mm/year). A total of 156 values were considered for detecting the trends for the period of 1983–2015 on a monthly basis.

As shown in Table 8. Out of the 156 cases 75 values were negative and 98 values were positive. The month of February had all positive values whereas the month of April had mostly negative values except for one station. The month of May had all negative values.

**Table 7: Z-statistics values for monthly rainfall using MK for the 13 stations in the southwestern littoral basin of Nigeria during 1983-2015**

Station	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Abeokuta	2.5154*	1.7666	0.124	-	0.7438	1.0374	0.9762	-0.1085	-	1.1311	3.8431*	-
Akure	1.3808	1.8438	-0.914	0.1085	-	0.5579	0.5753	0.1395	0.0465	0.0775	0.3874	2.2743*
Benin	1.8453*	1.4566	-	-	0.3564	0.7282	0.2634	-0.9142	0.5425	0.8832	0.0465	2.6186*
Ibadan	2.3479*	1.7199	0.2014	-	0.6663	0.3874	0.9451	-0.2684	0.7282	0.4184	0.7902	3.9980*
Ijebu-ode	2.3949*	2.0608*	0.1704	-	0.6663	0.3254	0.7592	-0.0755	0.5113	0.0155	0.6353	4.4009*
Ikeja	2.5154*	1.8596*	0.2014	-	0.8522	-0.124	0.9142	0.0755	0.6353	0.0155	0.9452	3.8891*
Iseyin	2.4832*	2.1075*	0.1085	-	0.2014	0.6043	-1.348	-1.1001	1.1311	0.4184	1.4257	3.1342*
Lagos Marina	2.4832*	2.0455*	0.1085	-	0.7902	0.1764	0.6043	0.7104	0.5113	0.1395	0.7592	4.1060*
Ondo	2.4420*	1.8128	0.0929	-	0.7128	0.4439	1.1004	0.0775	0.5113	0.5113	0.7592	3.9821*
Oshodi	2.5010*	2.0145	0.1085	-	0.7592	0.2634	0.5733	0.1085	0.5113	0.2014	0.7282	4.1990*
Osogbo	2.4678*	1.8954*	0.4209	-	0.2634	0.7592	-1.377	-0.7902	0.8832	0.5113	1.2241	3.7341*
Sharki	2.4132*	2.2169*	0.4169	-	0.4209	0.5113	1.1621	2.0608*	0.7282	0.124	1.9368*	3.2852*
Warri	1.0851	1.2081	-	-	0.1065	0.8522	0	-0.7592	0.3254	0.946	-0.2015	1.6116

\*Significant at the 5% level

**Table 8: The Sen Slope of monthly rainfall data for the Southwestern littoral basin during 1983–2015**

Station	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Abeokuta	0.39	0.59	0.17	-0.7	-0.33	-1.02	-0.14	-0.94	-0.15	1.55	1.52	-0.02
Akure	0.12	0.51	-0.92	0.09	-0.43	-0.83	-0.21	-0.1	0.13	0.75	0.99	-0.04
Benin	0.16	0.53	-1.04	-0.45	-0.67	-0.55	-1.09	-1.14	1.27	0.08	1.57	-0.08
Ibadan	0.38	0.73	0.22	-0.78	-0.66	-1.65	-0.49	-1.57	-0.66	1.23	1.77	0.00
Ijebu-ode	0.35	0.7	0.1	-0.89	-0.3	-1.72	-0.28	-1	-0.14	1.17	2.45	0.00
Ikeja	0.34	0.64	0.18	-0.92	-0.47	-1.36	0.12	-0.76	-0.08	1.13	1.89	-0.03
Iseyin	0.3	0.64	0.1	-0.21	-0.55	-1.4	-2.17	-1.79	-0.57	2.19	1.35	-0.03
Lagos Marina	0.37	0.74	0.11	-0.97	-0.45	-0.96	0.38	-0.66	-0.21	1.1	2.13	-0.02
Lokoja	0.01	0.11	-0.75	-0.43	-0.88	-0.59	-0.54	0.12	0.23	2.19	0.39	0.00
Ondo	0.4	0.78	0.05	-0.81	-0.65	-2.13	0.3	-1.12	-1.11	1.87	1.92	-0.03
Oshodi	0.35	0.75	0.1	-0.9	-0.39	-1	0.26	-0.52	-0.34	1.21	2.08	-0.03
osogbo	0.28	0.35	0.2	-0.12	-0.75	-1.22	-1.17	-1.36	-0.71	1.88	1.36	-0.03
Sharki	0.07	0.4	0.17	0.35	-0.44	-0.69	-3.21	-1.12	0.15	2.21	0.47	-0.01
Warri	0.1	0.31	-0.07	-0.15	-0.88	-0.03	-1.36	-0.67	1.53	-0.25	0.94	-0.05

## Conclusion

This study examined rainfall patterns and data consistency across the Southwestern Littoral Basin (SWLB) from 1983 to 2015, using SNHT and Pettitt tests to check for homogeneity. Results from both tests showed that the rainfall data were consistent across all stations, though SNHT flagged slight inconsistencies near the start of the series, and Pettitt highlighted breakpoints around 1997 and 2006. Trend analysis using the MK test and Sen's slope revealed mostly decreasing trends across eight stations annually, with five stations showing slight increases. On a monthly scale, most of the region showed negative trends from April through August, while November and January showed positive trends at several stations. The findings of this study reinforce the value of rigorous data testing before conducting climate studies, especially when rainfall is central to the hydrological cycle.

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