Drought Trend Analysis in Kano Using Standardized Precipitation Index

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Abstract— The trend analysis was carried out using non-parametric Mann-Kendall trend test for Kano using a long term 100 years rainfall data. In other to assess the short term, seasonal, annual and long term droughts, the study employed the Standardized Precipitation Index (SPI) to 3, 6, 9, 12 and 24 month time scales using the rainfall time series data. The SPI values computed for all the time scales revealed a non significant increasing trend for the entire study period (1911-2010), while period 1911-1995 revealed a significant decreasing trend especially in August, September and October. For comparison between different time periods, the 100 years series was sub-divided into 30 years overlapping time period. Period 1951-1980 and 1961-1990 revealed the highest number of statistically significant downward trend. The Z values from Mann-Kendall test ranges from 4.05 to -2.86, which shows how erratic the rainfall could be in Kano. All the analyzed months for periods 1911-1940, 1971-2000, 1981-2010 and 1941-1970 (except May in 1941-1970) showed a general increasing trend for all the time scales. However, periods 1971-2000 and 1981-2010 showed a significant increasing trend which implies that rainfall over the station is at the increase. The value of the slope ranges between -0.053 and 0.118 for all the time scales. High slope values were more prevalent in the higher time scales

Keywords—Mann-Kendall, Standardized Precipitation Index, Increasing trend, Time Scales

1 INTRODUCTION

Drought is a treacherous natural hazard characterized by lower than normal precipitation that, when prolonged, is insufficient to meet the demands of human activities and the environment. (WMO, 2006). It is often referred to as a creeping phenomenon that develops slowly and has a prolonged existence, occasionally over a period of years (WMO, 2006). It occurs in both dry and humid regions of the world. It is a normal part of climate, not withstanding that its spatial extent and severity varies on seasonal and annual timescales (WMO 2006).

Drought can be grouped into five categories, depending on the variable that is used to describe the droughts namely meteorological drought; Hydrological drought; Agricultural drought, socioeconomic drought and ground water drought (Mishra and Singh, 2010). Meteorological drought can be said to be the shortage of rainfall in near or above normal conditions. Agnew, 1990 defined meteorological drought as the deviation of precipitation from normal over an extended period of time. Hydrological drought is associated with a deficiency in bulk water supply. It includes water levels in streams, rivers, lakes, reservoirs and aquifers. Hydrological drought is related to negative anomalies in surface and sub-surface water (Van Loon, 2015).

Groundwater drought and stream flow drought are at times defined differently as below-normal groundwater levels and below-normal river discharge, correspondingly (Van Loon 2015). Drought occurrences and reoccurrences have been reported in Nigeria for decades (Aremu, 2011; Ayoade, 1988). As a common natural disaster, its occurrence plays an important role in the way of life and the survival of living and non-living organism at large. It occurs generally as a result of climatic change variable factors such as precipitation deficiency, high temperature, high wind, low relative humidity, greater sunshine, reduced infiltration, run off, deep percolation and ground water recharge, less cloud cover, increase evaporation and transpiration rates which are made worse by human activities such as deforestation, bush burning, overgrazing and poor cropping methods that reduce water retention of the soil (Abubakar and Yamusa, 2013; Adegboyega et al. 2016).The drought that occurred between 1972 and 1973 in Northern Nigeria resulted into death of over 3,000 animals while crop yield dropped by about 60% (Alatise and Ikumawoyi, 2007).

In the few of the drought trend studies that have been undertaken all over the world (Piccarreta et al, 2004; Xu et al, 2011) the Standardized Precipitation Index (SPI) has acquired a widespread application for describing and comparing droughts (Nalbantis and Tsakiris, 2009; Siti et al, 2012). The World Meteorological Organization (WMO) has recommended the use of the SPI for extensive use by all national Meteorological and Hydrological services to ascertain Meteorological drought and complement local drought indices currently being used. SPI was developed by McKee et al. (1993) in order to know the effect of precipitation deficits in both the short period that mainly impacts agriculture, and long period which impacts water resources (Siti et al. 2012).

In Kano, many studies have been undertaken detecting rainfall trends but there are only a few on drought trends. Therefore, this study is aimed at detecting if there is a statistically significant trend in Standardized Precipitation Index (SPI) in Kano by applying Mann-Kendall trend test using a 100 years long term rainfall data.

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2 MATERIAL AND METHODS

2.1 Location and description of study area

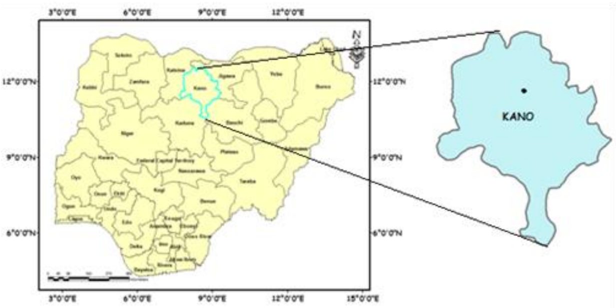

Fig. 1. Map of Nigeria showing the study area (Kano State)

Kano state is located between latitudes 10^0 33'N and 12^0 23'N and longitudes 7^0 45'E and 9^0 29'E as seen in Figure 1. It is bordered to the North East by Jigawa state, to the North West by Kastina, to the South West by Kaduna and to the South East by Bauchi state. The climate of the area is the tropical dry and wet strongly associated with the movement of the Inter-Tropical Discontinuity (ITD). The wet season lasts from May to mid-October with a peak in August while the dry season extends from mid-October of one calendar-year to mid-May of the next (Abaje et al., 2014). The mean annual rainfall is between 800mm to 900mm, and the mean annual temperature is about 26^0C.

2.2 Data used

100 years monthly rainfall data (1911-2010) for Kano station (12.03'N, 08.12'E), obtained from Nigerian Meteorological Agency (NIMET) was used for this study. The station has elevation of about 472.5m.

2.3 Methods of analysis

2.3.1 SPI calculation

Mathematically, SPI can be calculated based on the equation below:

$$SPI = \frac{(x_i - x_n)}{\sigma} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where x_i is the monthly rainfall record for the station; x_n is the average rainfall for the period; and σ is the standard deviation for the period of study. The 100 years monthly rainfall time series was used as an input to the SPI program. The program was downloaded from http://www.drought.unl.edu/monitor/spi/program/spiprogram.htm#program.

The SPI (McKee et. al, 1993) is a powerful, flexible index that is simple to calculate (WMO 2012). Precipitation is the only required input parameter. In addition, it is just as effective in analyzing wet periods/cycles as it is in analyzing dry periods/cycles. Input and output files were created and SPI values for 3, 6, 9 and 12 and 24-month time scales were computed.

2.3.2 Mann-Kendall Test

Mann-Kendall test is a statistical test widely used for the analysis of trend in climatologic (Mavromatis and Stathis, 2011) and in hydrologic time series Yue and Wang, (2004). It has been recommended by the World Meteorological Organisation (WMO) to find out the actuality of statistically significant trends in climate and hydrologic data time series. The advantage of this test is that it does not compulsorily require the data to be normally distributed. According to the test, the null hypothesis of no trend, H_0, is tested against the alternative hypothesis, H_1, where there is either an increasing or decreasing monotonic trend. The Mann-Kendall test statistics S is computed with the equation:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \mathrm{sgn}(x_j - x_k) \quad \ldots\ldots\ldots\ldots 2$$

$$sgn(x_j - x_j) = \begin{cases} 1 & if\ x_j - x_k > 0 \\ 0 & if\ x_j - x_k = 0 \\ -1 & if\ x_j - x_k < 0 \end{cases} \quad \ldots\ldots\ldots\ldots 3$$

Where n is the number of data, x is the data point at times j and k, j > k. The variance of S [VAR(S)] is calculated as follows

$$VAR(S) = \frac{1}{18}\left[n(n-1)(2n+1) - \sum_{q=1}^{p} t_q(t_q - 1)(2t_q + 5)\right] \ldots\ldots 4$$

Where p is the number of tied groups and t_q is the number of data values in the q^{th} group. The test statistic Z is computed as follows using the values of S and VAR(S);

$$Z = \begin{cases} \frac{S-1}{\sqrt{VAR(S)}} & \text{if } S > 0 \\ 0 & \text{if } S = 0 \\ \frac{S+1}{\sqrt{VAR(S)}} & \text{if } S < 0 \end{cases} \quad \ldots\ldots\ldots\ldots 5$$

The Z value is used to evaluate the presence of a statistically significant trend in which a positive value of Z indicates an upward trend and a negative value denotes a downward trend. In other to test for either a downward or an upward monotonic trend, (a two tailed test) at α level of significance, H_0 ought to be rejected if the absolute value of Z is greater than $Z_{(1-\alpha/2)}$, where $Z_{(1-\alpha/2)}$ is obtained from the standard normal cumulative distribution tables. In this study, the tested significance levels α are 0.001, 0.01, 0.05 and 0.1. Significance level of 0.001 shows that there is 0.1% probability that the values x_i are from a random distribution and with such probability we make a mistake to reject H_0 of no trend. Correspondingly, the significance level 0.1 signifies that there is a 10% probability that we make a mistake rejecting H_0.

2.3.3 Sens's slope estimator

The Sen's slope estimator uses a simple non-parametric procedure developed by Sen (1968) to estimate the slope. To obtain an estimate of the slope Q, the slope Q_i of all data pairs are calculated as follows

$$Q_i = \frac{(x_j - x_k)}{j - k}, i = 1,2, \dots .N, \quad j > k \dots\dots\dots\dots\dots\dots 6$$

where x_j and x_k are thought to be data values at times *j* and *k*. The median of these *N* values of *Qi* correspond to Sen's estimator of slope and is computed by

$$Q = Q_{\frac{N+1}{2}}, \text{ if N is odd } \dots\dots\dots\dots\dots\dots\dots 7$$

$$Q = \frac{1}{2}\left(Q_{\frac{N}{2}} + Q_{\frac{N+2}{2}}\right), \text{ if N is even} \dots\dots\dots\dots\dots 8$$

A 100(I-α) % two-sided confidence interval about the slope estimate is obtained by the nonparametric technique based on the normal distribution (Drápela and Drápelová, 2011). Positive value of Q_i denotes an upward or increasing trend and a negative value shows a downward or decreasing trend in the time series.

3 RESULTS AND DISCUSSION

From figure 2, bulk of the rainfall within a year is concentrated between May and September with August having the highest amount (Mohammed et al, 2015). The annual rainfall showed a mono modal pattern as confirmed by Iloeje, (1981). The months from November to February has very insignificant rainfall as a result of the influence of the dry north east trade wind during these months. From figure 3, analysis reveals that the average annual rainfall over Kano was 882mm during the study period. The lowest rainfall was recorded in 1913 (483.8mm), 1944 (484.1mm) and 1973 (416.1mm), while the highest rainfall was recorded in 1998 (1869.3mm), 2001 (1789.4mm) and 2007 (1493.7mm).

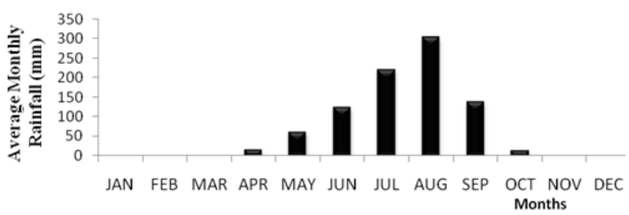

Fig. 2. 100 Years Average Monthly Rainfall over Kano

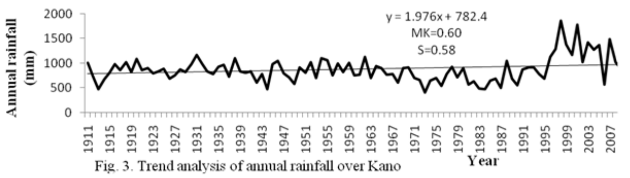

Fig. 3. Trend Analysis of Annual Rainfall over Kano

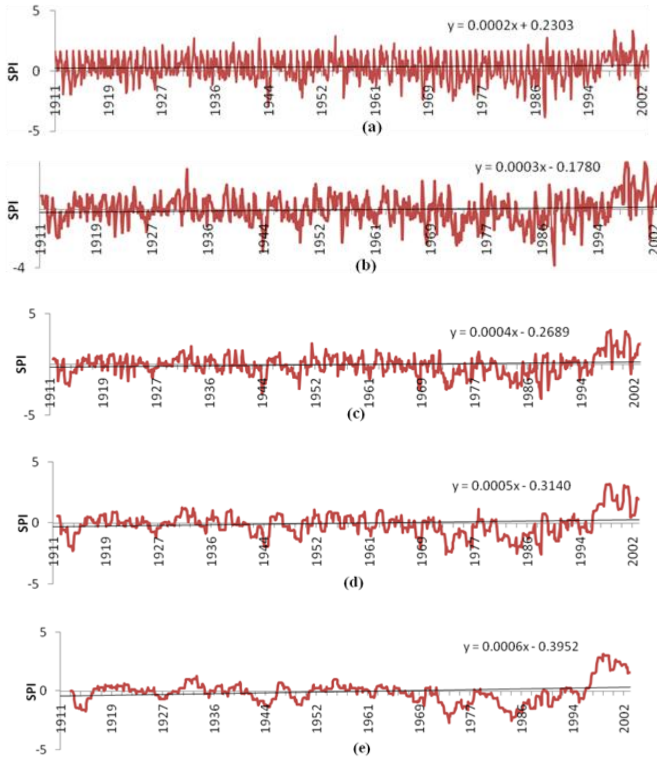

Fig. 4. SPI time series for (a) 3 month; (b) 6 month; (c) 9 month; (d) 12 month; and (e) 24 month

The trend analysis of annual rainfall time series in figure 3 by Mann Kendall test revealed a non significant general increase in the amount of precipitation over the study period. SPI for multiple time scales of 3, 6, 9, 12, and 24 months was applied to the station in order that the severity of the drought can be well estimated both for the short and long term situation.

3 month SPI indicate short and medium term moisture situation, 6-month SPI could be associated with unusual stream-flows and reservoir levels depending on the region and time of year, 9 months SPI bridges a short-term seasonal drought to the longer-term droughts which may become hydrological, or multi-year in nature, while 12 and 24 months SPI is usually tied to stream-flows and reservoir levels (WMO 2012, NIMET 2011). Increasing trend of SPI implies an increasing drought condition and vice versa.

In other to monitor the dry condition, the dry part is divided into near normal situations (-0.99 ≤ SPI < 1.0), moderate drought (-1.49 ≤ SPI < -1.0), severe drought (-1.99 ≤ SPI < -1.50) and extreme drought (SPI ≤ -2.0). A drought event begins when the SPI value gets to -1.0 and terminates when it becomes positive again (McKee et al., 1993). From the calculation of the SPI, the lowest value for 3-month time scale is -3.84 in October 1987, -3.32 for 6-months time scale in December 1987, -3.33 for 9 months time scale in April 1988, -2.53 for 12 months time scale in June 1988. From the graphs, it can be seen that in the shorter time scale, the dry and wet month periods have a high temporal frequency, but however, the frequency decreases with increasing time scale.

Analysis of 3 months SPI time series from 1911 to 2010 from figure 4 revealed that significant or extreme drought having 3 month time scale happened in 1944, 1949, 1956, 1965, 1968, 1973, 1983, 1984, 1987, 1989, 1991 and 2002. The SPI values were less than -2.0 in these years and by implication, it means that Kano was affected by extreme drought for three months in the listed years.

Analysis of 6–months SPI time series shows that extreme drought event having 6 months time scale occurred in 1944, 1950, 1956, 1965, 1968, 1969, 1973, 1974, 1983, 1984, 1985, 1987, 1988, 1989, 1992 and 2002 in different months. Analysis of 9-months SPI time series shows that extreme drought event with 9-months time scale happened in 1914, 1944, 1950, 1969, 1973, 1974, 1983, 1984, 1985, 1988, 1989 and 2008. Analysis of 12-months SPI time series reveals that extreme drought event of 12 months time scale was experienced in 1914, 1969, 1973, 1974, 1984, and 1988 in different months. Analysis of 24–months SPI time series shows that extreme drought event having 24 months time scale occurred in 1974, 1984 and 1985 in different month. However, the analysis showed that the station have experienced a short and medium term fall of moisture condition, unusual stream flows and reservoir level decrease as a result of prolonged fall in rainfall condition. These could be disastrous to the rain fed agricultural production in the area.

From figure 5, the number of occurrences of extreme events (i.e both wet and dry events) and moderate drought increases with increasing time scale from the times series analysis of all the time scale from 1911 to 2010. The number of occurrences of severe drought event increases with increasing time scale except for the 24 month time scale. However, the number of extreme drought occurrences decreases with increasing time sake for 6 months time scale. The trend analysis of each time scale for the study period shows that there is a little decrease in drought events on a general basis. For comparison, the series of 100 years data were subdivided into 30 years overlapping time interval for 3, 6, 9 and 12 month time scale in other to compare one period to the other. The test Z was obtained from Mann-Kendall (MK) trend test, Q values as obtained from Sen's slope estimator

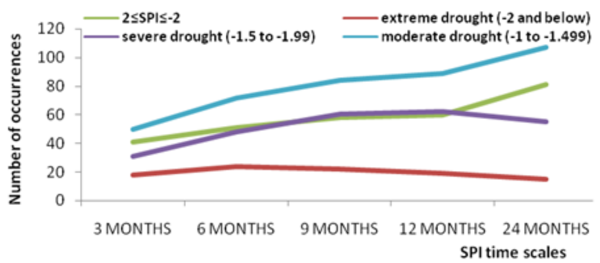

Fig. 5. Number of Occurrence of Extreme Events

Table 1. Mann-Kendal trend test Z, Sen's slope Q and Regression for 3, 6, 9 and 12 Month

	1911-1995			1911-2010		
Months	Test Z	Q	Regression	Test Z	Q	Regression
			3 month			
May	-0.77	-0.003	-0.0028	-0.07	0.000	0.0011
June	-0.07	0.000	-0.0011	1.29	0.004	0.0056
July	-1.84	-0.006	-0.0054	1.14	0.004	0.0075
Aug	-2*	-0.008	-0.0079	1.27	0.005	0.0062
Sept	-3.38***	-0.010	-0.0113	0.08	0.000	0.0033
Oct	-2.84**	-0.011	-0.0118	-0.03	0.000	0.0009
			6 month			
May	-0.58	-0.002	-0.0021	0.09	0.000	0.0016
June	0.34	0.002	0.0005	1.63	0.006	0.0066
July	-0.86	-0.003	-0.0022	1.96	0.007	0.0100
Aug	-2*	-0.007	-0.0067	1.13	0.004	0.0072
Sept	-2.64**	-0.009	-0.0087	0.84	0.003	0.0064
Oct	-2.62**	-0.009	-0.0095	0.85	0.003	0.0057
			9 month			
May	-2.15*	-0.008	-0.0089	0.36	0.001	0.0020
June	0.14	0.001	-0.0003	1.54	0.006	0.0065
July	-1.17	-0.004	-0.0034	1.71	0.006	0.0093
Aug	-2.24*	-0.008	-0.0075	0.95	0.004	0.0068
Sept	-2.99**	-0.010	-0.0096	0.55	0.002	0.0057
Oct	-2.94**	-0.010	-0.0096	0.63	0.002	0.0060
			12 month			
May	-2.24*	-0.008	-0.0093	1.27	0.004	0.0065
June	-2.29*	-0.008	-0.0092	1.1	0.004	0.0066
July	-2.26*	-0.009	-0.0093	1.11	0.004	0.0069
Aug	-2.74**	-0.010	-0.0101	0.68	0.002	0.0062
Sept	-2.74**	-0.009	-0.0092	0.73	0.003	0.0063
Oct	-2.75**	-0.010	-0.0092	0.78	0.003	0.0065

*** trend at $\alpha = 0.001$ level of significance, ** trend at $\alpha = 0.01$ level of significance, * trend at $\alpha = 0.05$ level of significance, + trend at $\alpha = 0.1$ level of significance. (Same applies for other tables)

and regression from regression analysis. The Z statistics from Mann Kendall trend test for SPI values from the four time scales are shown in table 2.

From table 2, period 1911-1995 revealed a statistically significant decreasing trend especially in August, September and October (ASO) except for the 12 months time scale in which all the months showed a significant decreasing trend. Period 1911-2010 showed a non significant increasing trend all through the time scales. Regression and Sen's slope were negative all through in period 1911-1995 and positive in period 1911-2010 for all the time scale.

Table 2. Z values from Mann-Kendall test for 3, 6, 9 and 12 months drought trend analysis

	1911-1940	1921-1950	1931-1960	1941-1970	1951-1980	1961-1990	1971-2000	1981-2010
Months	Test Z	Test Z	Test Z	Test Z	Test Z	Test Z	Test Z	Test Z
				3 Months				
May	0.55	0.70	0.36	-0.62	-1.04	-0.89	0.20	0.55
June	1.07	-0.11	-0.95	0.43	-0.79	-1.45	1.30	2.09*
July	0.96	0.05	-0.27	1.05	-2.03*	-1.30	3.16**	3.57***
Aug	0.68	-0.96	0.11	1.34	-1.16	-1.59	3.37***	3.44***
Sept	0.07	-1.32	0.32	0.46	-2.64**	-1.93+	3.14**	3.14**
Oct	0.29	-1.45	-0.52	0.25	-1.79+	-2.14*	2.86**	2.23*
				6 Months				
May	0.86	0.64	0.30	-0.61	-1.04	-0.77	0.25	0.64
June	1.87+	-0.05	-0.87	0.41	-0.86	-1.53	1.28	2.00*
July	1.68+	-0.29	-0.41	1.30	-1.87+	-1.55	2.94**	3.48***
Aug	1.41	-0.52	-0.23	0.30	-2.21*	-2.34*	3.02**	3.34***
Sept	1.25	-0.91	-0.46	0.68	-2.18*	-2.50*	3.10**	3.68***
Oct	1.68+	-0.96	-0.62	0.57	-2.05+	-2.00*	3.34***	3.60***
				9 Months				
May	0.49	-0.84	-0.41	-0.02	-1.46	-1.37	2.09*	2.85**
June	1.76+	-0.18	-0.95	0.57	-0.80	-1.77+	1.34	1.87+
July	1.28	-0.27	-0.41	1.32	-1.86+	-1.55	2.94**	3.48***
Aug	1.01	-0.52	-0.23	0.30	-2.21*	-2.30*	3.02**	3.34***
Sept	0.55	-0.86	-0.48	0.54	-2.21*	-2.52*	3.12**	3.68***
Oct	0.71	-1.07	-0.73	0.48	-1.93+	-2.12*	3.18**	3.82***
				12 Months				
May	1.20	-1.70+	-0.25	1.32	-2.61**	-2.05*	2.53*	3.59***
June	1.37	-1.62	-0.39	0.86	-2.86**	-2.11*	2.34*	3.57***
July	2.01*	-1.30	0.05	0.91	-2.68**	-1.80+	3.41***	4.05***
Aug	1.78+	-1.02	-0.45	0.57	-2.45*	-2.39*	3.10**	3.69***
Sept	1.24	-0.79	-0.61	0.59	-2.12*	-2.32*	3.30***	3.64***
Oct	1.14	-1.05	-0.75	0.48	-1.96*	-2.12*	3.18**	3.82***

From table 3, period 1951-1980 and 1961-1990 revealed the highest number of statistically significant downward trend. The Z values from Mann-Kendall test ranges from 4.05 to -2.86, which shows how erratic the rainfall could be in Kano. All the analyzed months for periods 1911-1940, 1971-2000, 1981-2010 and 1941-1970 (sake for May in 1941-1970) showed a general increasing trend for all the time scales. However, periods 1971-2000 and 1981-2010 showed a significant increasing trend which imply that rainfall over the station is at the increase as confirmed by Mohamed et al., 2015, Ezenekwe et al, 2013, Aremu 2013 and Buba 2010. Periods 1921-1950, 1931-1960, 1951-1980 and 1961-1990 all showed a decreasing trend for all the analyzed time scale. Periods 1951-1980 and 1961-1990 showed a statistically significant decreasing trend for all the time scale which suggest that the station experienced severe drought situation in these periods. Also, the 12 month time scale gives the highest positive and negative Z value.

From table 4, periods 1911-1940, 1971-2000, 1981-2010 and 1941-1970 (except May in 1941-1970) showed a general increasing trend for all the time scales. The signs of the

Table 3. Sen's slope values for 3, 6, 9 and 12 month drought trend analysis

	1911-1940	1921-1950	1931-1960	1941-1970	1951-1980	1961-1990	1971-2000	1981-2010
Months	Q	Q	Q	Q	Q	Q	Q	Q
				3 Months				
May	0.009	0.016	0.007	-0.016	-0.021	-0.017	0.004	0.017
June	0.023	-0.003	-0.016	0.012	-0.015	-0.039	0.034	0.059
July	0.014	0.000	-0.003	0.019	-0.033	-0.026	0.065	0.100
Aug	0.010	-0.013	0.004	0.020	-0.024	-0.036	0.084	0.103
Sept	0.001	-0.022	0.003	0.004	-0.027	-0.032	0.079	0.095
Oct	0.004	-0.024	-0.011	0.003	-0.025	-0.050	0.080	0.076
				6 Months				
May	0.016	0.016	0.007	-0.016	-0.021	-0.017	0.007	0.020
June	0.030	-0.001	-0.017	0.011	-0.014	-0.039	0.033	0.058
July	0.031	-0.006	-0.003	0.021	-0.033	-0.030	0.064	0.102
Aug	0.025	-0.008	-0.002	0.006	-0.042	-0.046	0.078	0.115
Sept	0.015	-0.010	-0.007	0.010	-0.031	-0.044	0.082	0.116
Oct	0.018	-0.012	-0.009	0.010	-0.033	-0.042	0.087	0.110
				9 Months				
May	0.011	-0.016	-0.007	0.000	-0.033	-0.031	0.063	0.079
June	0.029	-0.004	-0.020	0.014	-0.014	-0.043	0.031	0.050
July	0.021	-0.006	-0.003	0.021	-0.033	-0.030	0.064	0.103
Aug	0.020	-0.007	-0.003	0.006	-0.042	-0.045	0.078	0.115
Sept	0.008	-0.010	-0.007	0.010	-0.031	-0.044	0.083	0.116
Oct	0.011	-0.015	-0.011	0.011	-0.031	-0.042	0.079	0.118
				12 Months				
May	0.018	-0.027	-0.003	0.021	-0.039	-0.046	0.072	0.106
June	0.020	-0.031	-0.006	0.014	-0.038	-0.043	0.072	0.114
July	0.024	-0.020	0.001	0.015	-0.053	-0.039	0.081	0.112
Aug	0.022	-0.012	-0.005	0.008	-0.043	-0.044	0.075	0.118
Sept	0.017	-0.009	-0.009	0.008	-0.029	-0.040	0.082	0.117
Oct	0.016	-0.014	-0.010	0.012	-0.031	-0.042	0.079	0.118

Sen's slope were almost consistent with that of Mann Kendall. The value of the slope ranges between -0.053 and 0.118 for all the time scales. High slope values were more prevalent in the higher time scales.

4 CONCLUSION

The study aimed at revealing potential drought trends in Kano applying the Mann-Kendall trend test. The revelation of these changes provides important information for management of water resources. 100 years data series were subdivided into different time periods for good comparison. This study examined the whole time period 1911-2010, 1911-1995 period and other 30 years overlapping time periods for 3, 6, 9, and 12 month SPI time scales. All the SPI time scales showed a non significant increasing trend for the whole time period. The 1911-1995 period revealed a statistically significant decreasing trend especially in August, September and October (ASO) except for the 12 months time scale in which all the months showed a significant decreasing trend. Also, period 1911-2010 showed a non significant increasing trend all through the time scales which implies that there is an improvement in rainfall of the station in the recent years. Regression and Sen's slope estimator were negative throughout the period 1911-1995 and positive in all through the period 1911-2010 for all the time scale. Though the drought situation in the station is on the better side, but drought as a natural occurrence should not be taken lightly as a reoccurrence can be disastrous without any proactive measures in place to reduce the impact as climate change is no longer illusive but very real. Therefore, the government should put in place the necessary agencies and parastatals that will always be on the alert to attend to issues arising from drought occurrences in other to lessen its impact on the populace.

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