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Identification of Trend in Monthly & Seasonally Rainfall for Rajnandgao District, Chhattisgarh

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Abstract - The climatic change for an area is referred to the long-term dependence on rainfall, temperature, humidity, evaporation, wind speed and other meteorological parameters. Quantification of climate variability is preliminary in order to identify the change that has already occurred and this will be further helpful to make prediction or forecasting of future [1]. This will also lead to a better preparedness for natural disasters. This article presents a trend of monthly and seasonally rainfall data for Rajnandgao district, Chhattisgarh for the period of 94 years that is from 1906 to 2000. The results obtain a significant decrease for the months of November, December, March, thereby inferring for a consequent decrease in annual rainfall, and percentage of rainfall continuously decreases to whole month and seasons of years the months of September, October and Post-monsoon seasons represent an upward trend, whereas the months of January and December show no trend. The months of February March, April, May, June, July, August and November and seasons of Monsoon, winter, Pre-monsoon thereby representing a downward trend.

Keywords: Trend, rainfall, Mann-Kendall, Sen Slope estimator methods.

I. INTRODUCTION

Climate change is long-term dependence. It has raised as a most alarming issue for the whole world. Therefore, quantification of climatic variability has become preliminary. Water resource management is inherently tied to watershed scale and proper management requires understanding how changes in annual rainfall will impact hydrological process Trend detection analysis is a method to determine the spatial and temporal changes for various parameters associated to climate. [2] For a nation like India, this is a crucial issue as our country is having an agro-based economy, which largely depends on rainfall due to monsoon. Thus any change in that phase of a year may ruin the agricultural conditions of the country and thereby the economy. Moreover, it will also cause a threat to the food security of the nation. The climate change is too high for India compared to the global climatic variability. It has further lead to the essence of determining whether the trend is increasing or decreasing. [3] The changes in the most important climatological parameter i.e. rainfall, may be responsible for the natural calamities like drought and flood conditions.

II. STUDY AREA AND DATA USED

A small city in western Chhattisgarh, Rajnandgaon is situated in a small valley and has the population exceeding 165,000 people; it is also the capital city of its district having area of 8,070 square km (3,120 sq mi).Its situated between coordinates of 21° 5' 52.2780" N and 81° 2' 1.3452" E. From the hydro-climatological aspects, the annual average rainfall over Rajnandgao district is about 1274 mm. More than 90% of the total annual rainfall occurs in the month of June-October. The monthly precipitation data for Rajnandgao district for the period of 94 years i.e. 1906-2000 is collected from Indian Meteorological Department (IMD) from the Rajnandgao station.This data is then analyzed for the identification of the trend is monotonic upward or downward.

III. METHODOLOGY

The methodology applied in this paper is Trend analysis using the statistical non-parametric tests i.e. Mann-Kendall test and Sen's Slope Estimator test on the monthly rainfall data for Rajnandgao district for the period of 94 years. Generally, non-parametric tests are preferred over parametric tests because; the problems aroused due to data skew can be evaded by non-parametric ones and this test does not depend on any assumption, distribution-free and robustness [4] Mann-Kendall test is most commonly used test for trend analysis of any hydro-climatic series for identification of spatial variation and temporal deviation.[5] This formula was originated by both Mann and Kendall i.e. Mann (1945) formulated it as a non-parametric test to identify the trend whereas Kendall (1975) gave the test statistic distribution to test non-linear trend and turning point. Sen's Slope Estimator test is also used to determine the magnitude of the trend. This was formulated by Sen (1968), in which slope of data pairs are to be used to identify the trend.[6]

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1.1. Mann-Kendall Test

The Mann-Kendall statistic S is given as

$$S = \sum (n-1, i=1) \sum (n,j=i+1)sgn(Xj-Xi) \quad (1)$$

The application of trend test is done to a time series xi that is ranked from i = 1, 2… n-1 and Xj, which is ranked from j = i+1, 2… n. Each of the data point Xi is taken as a reference point which is compared with the rest of the data point's xj so that,

$$Sgn\ (Xj-Xi) = \{ {}^{+}1,> (Xj-Xi), 0, = (Xj-Xi), 1, = < (Xj-Xi)\} \quad (2)$$

For n > 8, S follows approximately Normal distribution with mean i.e.

$$E(S) = 0, \quad (3)$$

The variance statistic is given by,

$$Var(S) = n(n-1)(2n-5) - \sum(m,i=1)\ ti(i)(i-1)(2i+5)/18 \quad (4)$$

Where ti is considered as the number of ties up to sample i. The test statistics Zmk (Mann-Kendall Co-efficient) is computed as,[7].

$$Zmk = \{S-1/Var(S), S>0, 0, S = 0, S+1/Var(S), S<0\} \quad (5)$$

Zmk here follows a standard normal distribution. A positive and negative value of Zmk indicates an upward trend and downward trend respectively. [8] A significance level α is also utilized for testing either an upward or downward monotone trend (a two-tailed test). If Zmk appears greater than Zα/2 where α depicts the significance level, then the trend is considered as significant Generally, Zmk values are 1.645, 1.960 and 2.576 for a significance level of 10%, 5%, and 1% respectively. But for a greater length of data, Zmk /sqrt (n) is also used as a Mann-Kendall statistic to determine the trend, where n is the number of data values.[9]

1.2. Sen's Slope Estimator Test

This is better than the linear regression test to analyze trend. [10] The slope is to be obtained to check the trend. Therefore, it is the most powerful method for a linear trend. The slope Ti of all data pairs can be computed by,

$$Ti = Xj-Xi/j-k, \quad (6)$$

Where, Xj and Xk are considered as data values at time j and k (j > k) correspondingly. The median of N values of Ti is represented as Sen's estimator of slope is given by,

$$Qi = \{ T_{N+1/2} \quad if\ N\ is\ odd,\ 0.5(T_{N/2} + T_{N+2/2}) \quad if\ N\ is\ even \} \quad (7)$$

After calculating Qi, for testing the significance, Qmedian is computed by a two-sided test and the confidence interval and then a true slope can be obtained by the non-parametric test. Like Mann-Kendall test, the positive and negative value of Qi represents a monotonic upward and downward trend respectively. Values are -2.402,-3.161,-3.335,-2.912,-1.705,--2.227,-1.468,-1.219,-0.323, **0.261**,-4.704,-7.778,-1.817,--2.041,-1.157 and **0.311.** From January to December respectively. The months of January February March, April, May, June, July, August, November, December and seasons of monsoon, winter and pre-monsoon are clearly represented a significant decreasing trend in rainfall whereas the months of September shows no trend for monthly rainfall for 1906-2000**.** The month of October and Post-monsoon season shows an increasing trend of rainfall.

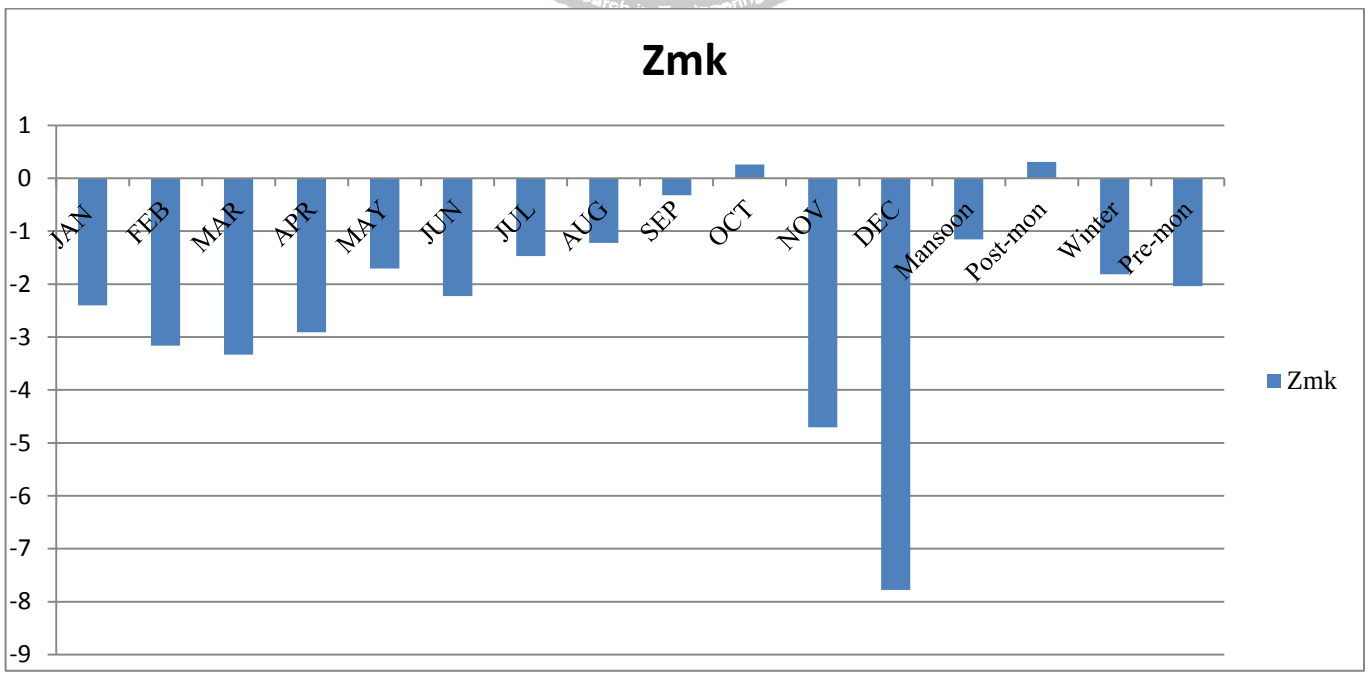

Figure 1: Mann-Kendall Statistic for different months & seasons for 1906-2000

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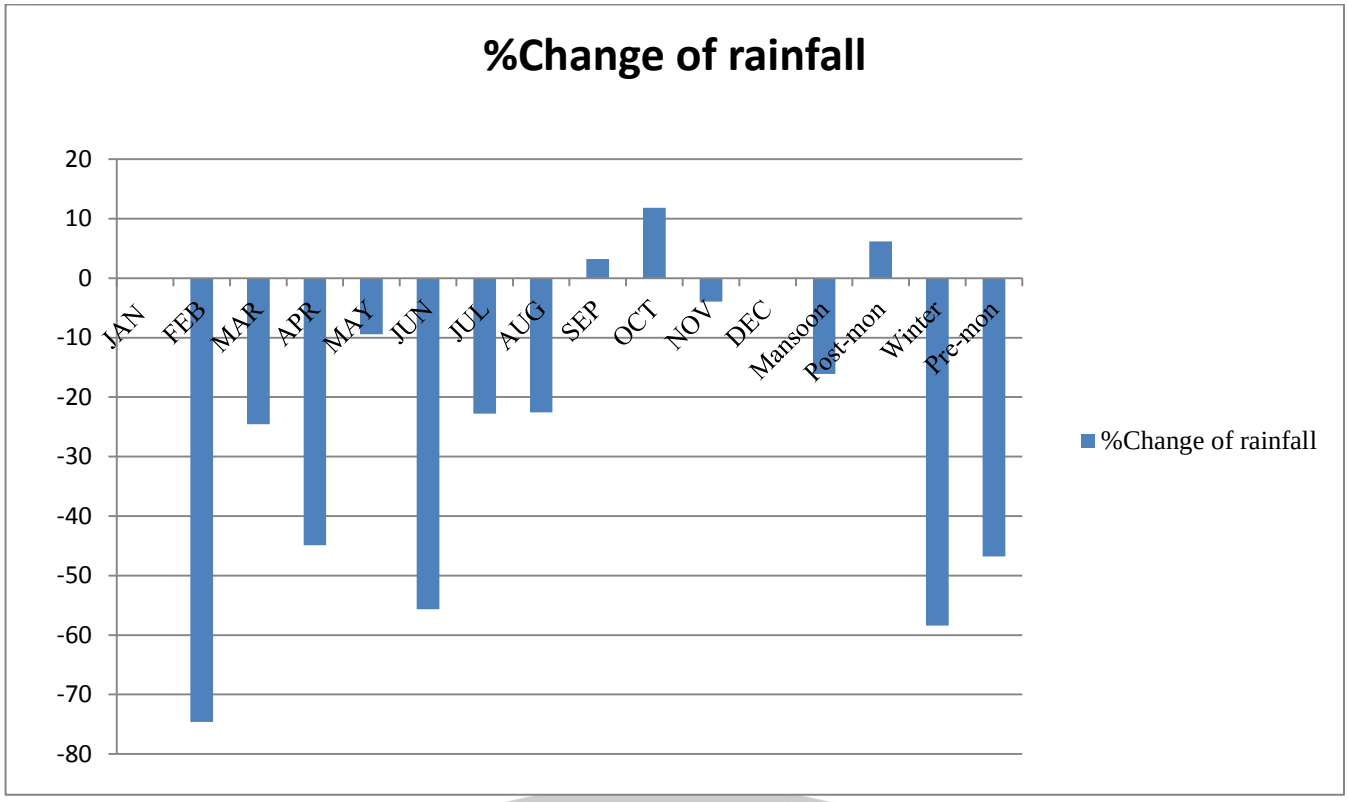

Figure 2: Percentage change of rainfall for different months & seasons for 1906-2000

IV. RESULT AND DISCUSSION

The Mann-Kendall Statistic for different months of a year is represented in figure 1 above. The Zmk and the from figure 2 represent the %change of rainfall over different months and seasons for 1906-2000.February, March, April, May, June, July, August, November, Monsoon and seasons of Winter, Pre-monsoon clearly represents a significant decreasing percentage of rainfall whereas the months of September , October and Post-monsoon season represent the significantly increases the percentage of rainfall whereas the month of January and December clearly represent have no percentage changes of rainfall.

Table 1: Sen Slope values for different months and seasons of a year

Month	Mean	Variance	Standard Deviation	Median	Sen Slope	%Change
January	14.11	17206.31	30.63	0.00	0.000	0.000
February	25.80	27039.00	30.08	14.80	-0.321	-74.604
March	15.05	27039.00	26.51	3.30	-0.062	-24.561
April	17.95	27087.66	31.16	7.10	-0.134	-44.902
May	20.91	27087.66	28.37	9.65	-0.033	-9.455
June	210.78	27104.33	130.53	199.14	-1.955	-55.649
July	345.39	17795.54	143.27	358.78	-1.312	-22.783
August	343.99	21151.76	171.45	330.35	-1.294	-22.568
September	200.38	24441.05	134.75	203.96	**0.107**	**3.192**
October	69.76	33351.74	81.32	41.91	**0.138**	**11.847**
November	13.40	18020.60	29.04	0.00	-0.009	-3.948
December	6.38	42712.80	15.05	0.00	0.000	0.000
Seasonal						
Monsoon	1100.56	13486.69	332.05	1045.28	-2.958	-16.127
Post-monsoon	89.56	34685.96	85.14	66.28	**0.092**	**6.159**
Winter	39.74	14431.06	41.74	26.16	-0.374	-58.388
Pre-monsoon	53.91	27104.33	49.59	40.71	-0.420	-46.789

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The mean, variance, standard deviation, median, Sen's slope and corresponding significance values are presented in table 1. Very similar to the results obtained from Mann-Kendall test, Sen Slope Estimator test values are negative for the months of February March, April, May, June, July, August and November and seasons of Monsoon, Winter, Pre-monsoon thereby representing a downward trend. The months of September, October and Post-monsoon seasons represent an upward trend, whereas the months of January and December show no trend. The month of June and Monsoon season shows a high-level significance in the downward trend. This implies for a decrease in the annual rainfall for the study area. Such deviation in climate is never sustainable. This may lead to drought-like conditions in future.

V. CONCLUSION

Quantification of climate variability is very preliminary to cope up with ever-changing conditions. The trend analysis is made for Rajnandgao district of Chhattisgarh for monthly and seasonally rainfall data for the period of 1906-2000 is performed using non-parametric Mann-Kendall and Sen Slope Estimator test. The results reveal a downward trend for most of the months of a year Since the months of February, March, April, May, June, July, August, November and seasons of Monsoon, Winter, Pre-monsoon shows a significant decreasing trend, it can be inferred for the annual rainfall over Rajnandgao to be decreasing. This study suggests that the knowledge of the change in magnitude of rainfall pattern and its periodicity estimation would be helpful for the hydrologists and effective irrigation planning to utilize water resources in the region and to make an appropriate decision on cropping pattern.

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