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Statistical Analysis of Rainfall Event in Seonath River Basin Chhattisgarh

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Abstract— *To understand the mechanism of potential hydrologic impacts of climate and land use land cover changes. In this study identified to the significant temporal trend was carried out monthly, seasonal timescales. Using the rainfall data of 39 Meteorological stations under entire seonath basin which is subdivided into five weighted stations with the help of by creating Thiessen polygon over Seonath River, Chhattisgarh state of 32 years for a period of 1980-2012. Hydro metrological variables are analysed by using a combined Mann-Kendall/Thiel-Sen slope estimator trend detection approach. The results reveal a significant decreasing trend for the month of January, February, March, and may, September, October and December for all the five gauging stations similarly the month of April, June, July, August and November show the significant increasing trend. For all the five gauging stations excluded month of January in simga gauging station shows having no trend. Whereas the trend in different seasons are follows (1) season of winter and pre-monsoon shows significant decreasing trend for all the five gauging stations and post-monsoon season andhyakore, pathridih and simga gauging stations also represents the decreasing trend and (2) the season of monsoon shows increasing trend for all the five gauging stations and seasons of winter and pre-monsoon of ghatora and simga stations also shows the increasing trend.*

Keywords— Trend Analysis, Rainfall, Mann-Kendall, Sen Slope, Thiessen polygon.

I. INTRODUCTION

Change in climate is a long-term phenomenon and most alarming issues for the entire world, Therefore; quantification of climate changes has become preliminary. Identification of temporal trend of hydro-metrological variables is important to sustainable management and development of water resources in future. Rainfall is one of a most important event of the hydrological cycle.[1] This depends on the changes in the variations of atmospheric concentration of greenhouse gaseous. A number of studies done on rainfall trend analysis in various regions. Most of the paper used non-parametric approaches for detecting trend and few of the paper have used a linear regression test. In this study we have to use non-parametric methods because they are distributed free and mostly used non-parametric method which is recommended for detection of significant monotonic upward and downward trend for different climatologic and hydrologic time scale by World Meteorological Organization (WMO) and Thiel-Sen slope estimator is mostly used for estimating magnitude of linear trend and it has been also most commonly used for detecting the magnitude of linear trend in hydro-meteorological time series.[2]

II. STUDY AREA AND DATA USED

The study area is the seonath river basin of Chhattisgarh state, India.It is a major tributary of Mahanadi river which is situated between 20° 16'N to 22° 41'N Latitude and 80° 25'E to 82° 35'E Longitude it consists a large portion of the upper Mahanadi valley and its traverse length of 380 kilometres.The area of the basin is 30560 square kilometres. The Monthly precipitation data of 39 Meteorological stations for whole seonath river basin for a period of 32 years i.e. 1980-2012 is collected from Department of state data centre Water Resources, Raipur (Chhattisgarh) this data is then analysed for detecting if the trend is monotonic increasing or decreasing. The latitude, longitude and area (Thiessen polygon) for each station is shown in table Moreover, the location of each station in Seonath river basin map is represented in figure

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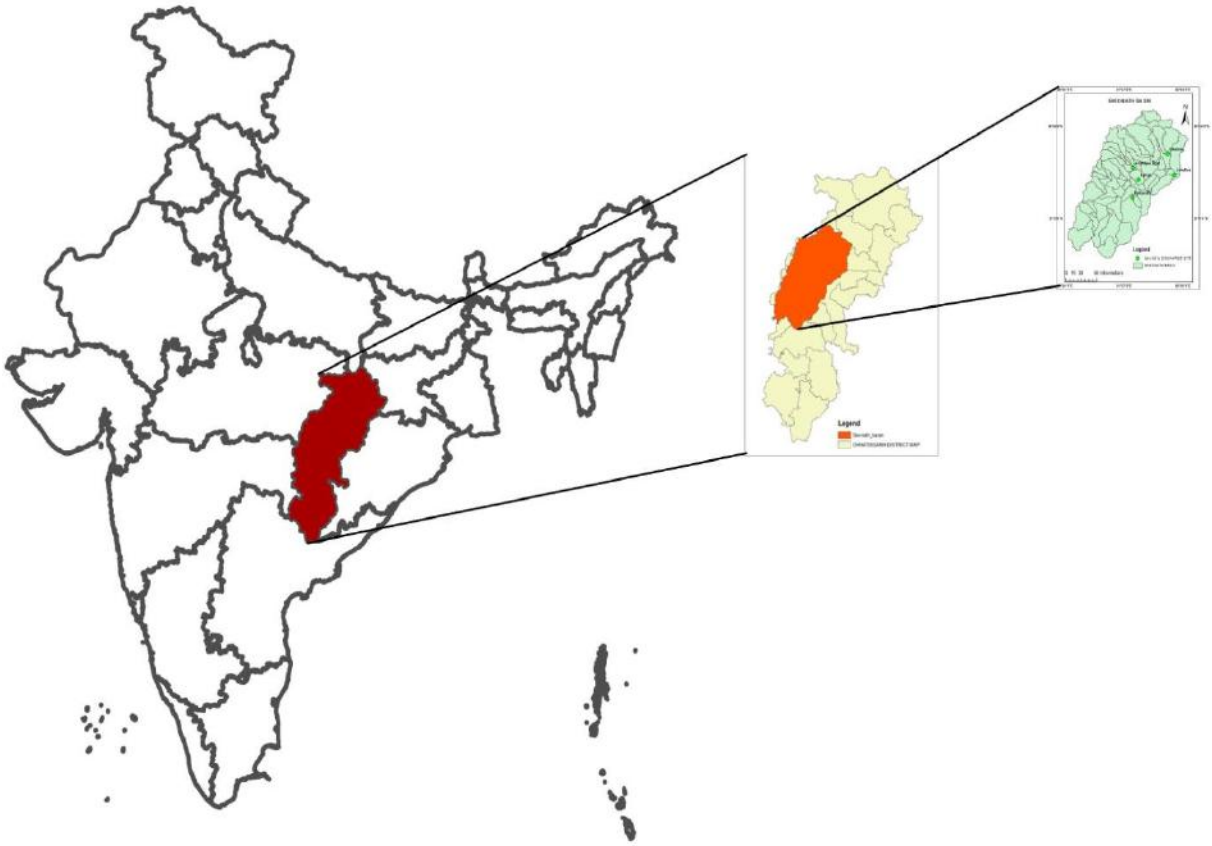

Fig: Seonath River basin with Gauge & Discharge stations.

Table.1: Location and Area (Thiessen Polygon) for Station

STATION NAME	LATITUDE	LONGITUDE	AREA (km^2)
Ambagarh Chowki	20.7778	80.7486	1298.78
Andhyakore CWC	21.78	81.61	364.887
Balod	20.7334	81.23334	934.391
Bemetara	21.7291	81.5486	537.711
Bilaspur	22.08334	82.15	1185.89
Bodla	22.1816	81.223334	114.63
Chilhaki	21.7916	82.30833	1030.25
Chirapani	22.2083	81.1958	547.10
Chuikhadan	21.53334	81.01666	1167.67
Dhamtari	20.8219	81.55222	1158.84
Dongargaon	20.975	80.8625	622.855
Dongargarh	21.1833	80.7666	976.89
Doundi	20.4847	81.0958	789.881
Durg	21.2166	81.28334	1574.88
Gandai	21.667	81.1166	684.03
Ghonga	22.30	81.9667	1562.45
Gondly	20.75	81.1334	641.39
Jondhara CWC	21.72	82.34	490.28
Kawardha	22.0166	81.2334	630.16
Kendiri	21.10	81.7334	563.02
Kharkhara	20.9667	81.0334	924.55
Khuria	22.3875	81.59889	1519.24
Khutaghat	22.30	82.208334	1523.80
Kota	22.2667	82.0334	382.00
Kotni CWC	22.130	81.240	229.80
Madiyan	21.990	83.20	386.26
Mungeli	21.1334	80.61667	1114.24

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STATION NAME	LATITUDE	LONGITUDE	AREA (km^2)
Nawagarh	22.0667	81.68334	689.73
Newara	21.9061	81.60583	1050.78
Pandariya	21.550	81.83334	881.23
Patharidih CWC	22.2166	81.41667	552.49
Pindrawan	21.34	81.60	610.78
Raipur	21.40	81.850	394.21
Semartal	21.25	81.6334	432.25
Shahspur	20.97	81.87	667.41
Simga CWC	21.90	81.11666	291.54
Simga WRD	22.1834	82.16667	590.47
Sond	21.6202	81.705	931.62
Surhi (Palemeta)	21.22	81.69	472.04

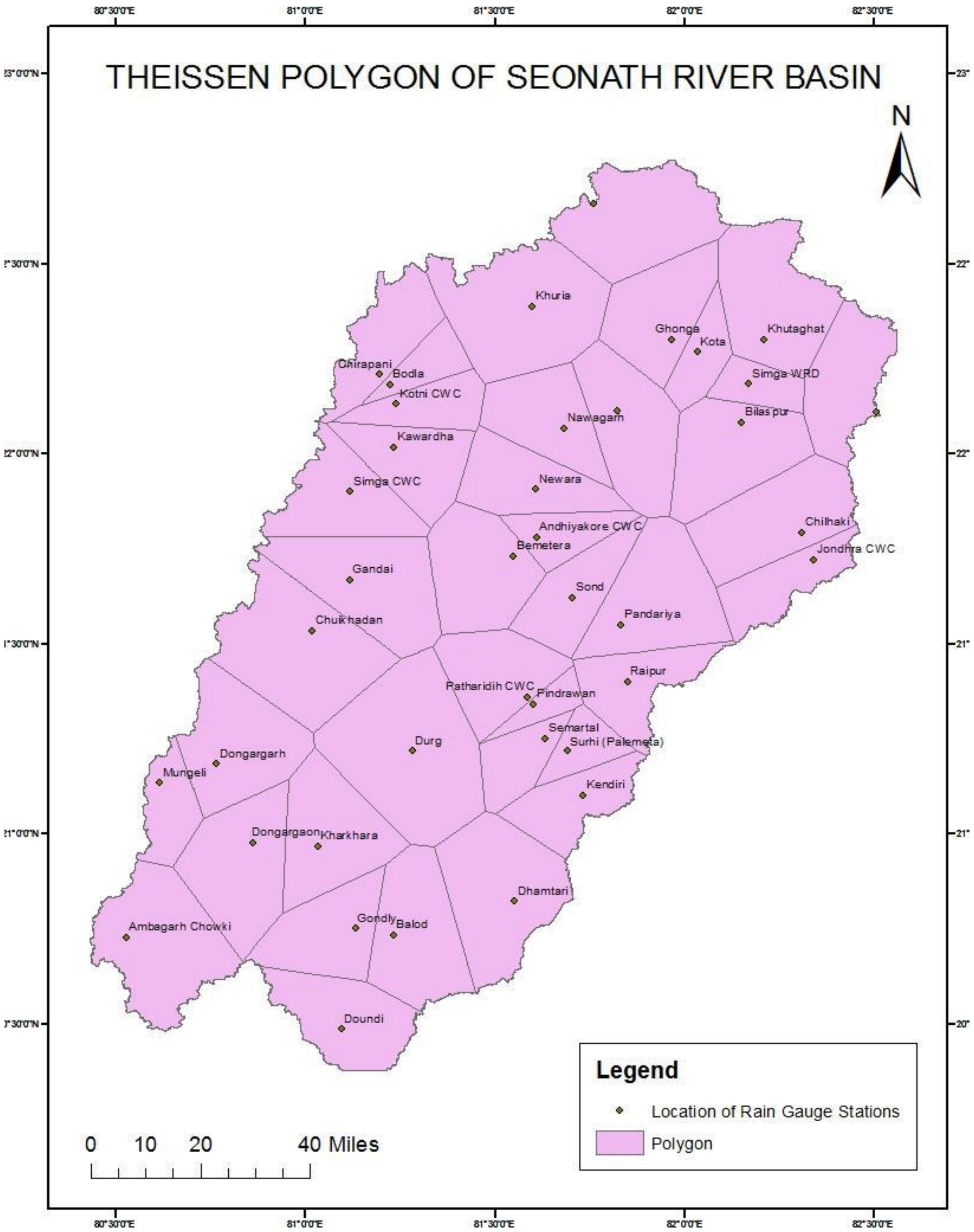

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Fig.1: Location of rainfall station over whole Seonath River basin (Thissen Polygon)

III. METHODOLOGY

3.1 STUDY OF TIME SERIES

A time series is a combination of statistics, usually collected at a regular interval (average monthly rainfall, annual rainfall temperature) and it occurs naturally in many application areas (precipitation, rainfall, temperature).The method of time series analysis pre-date those for general stochastic processes and Markov chains.[3] The objective of time series analysis is to describe and summarise the time series data and assembles to low dimensional model and to predict the future forecast.

3.2 TREND ANALYSIS

It is a statistical method which is most commonly used for studying the temporal trend of hydroclimatic timescales. In the present study, trend detection analysis has been done by using non-parametric (Mann-Kendall test and Thiel Sen Slope estimator test).A non-parametric test approach is taken into account against the parametric one because it is distribution-free, robustness against outliers. [4]

IV. METHODS FOR TREND DETECTION ANALYSIS

4.1 Testing significance of trend by MK test

The purpose of the Mann-Kendall (MK) test is to statistically assess if there is a monotonic upward or downward trend of the variable of interest over time series. A monotonic upward (downward) trend means that the variables consistently increase (decreases) through time, but the trend sometimes may or may not be linear. An assumption not required by the MK test, that is the MK test is a nonparametric (distribution-free) test. In MK test statics we have to use Signum function and correlate the variables if X1<X2 =-1, ifX1=X2, =0 and if X1>X2,=1and by adding all this correlation values to detect whether significant increasing or decreasing trend in the given series In MK test statics the sample size should not be less than 4. It is the most widely used for the analysis of detecting a trend in climatologic and hydrologic time scales.[5]

The test is based on statistic S defined as follows:

$$S = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} sgn(xj - xi)$$

Where N is the number of data point in the given time series, xi and xj are the data values at time scale I and j (j>i) respectively. This test statistics represent a number of positive differences minus negative of differences for considering all the differences. And denoted by,

$$\delta = (xj\text{-}xi)$$

$$\text{sgn}(\delta) = \{1 \quad if\ \delta > 0, 0 \quad if\ \delta = 0, -1 \quad if\ \delta < 0\}$$

For sample (N>4), the distribution of S is assumed to follow the normally distributed with variance and zero mean.

$$\text{Var}(S) = \frac{N(N-1)(2N+5) - \sum_{k=1}^{n} tk(tk-1)(2tk+5)}{18}$$

Where N is the number of tied (the difference between compared values is zero) group and tk is the number of data points in the kth group of tied.

The Z- statistics or standard normal deviate is computed by using the equation:

$$Z = \left\{ \frac{s-1}{\sqrt{var(s)}} \quad if\ S > 0, \ \ 0\ if\ S = 0, \quad \frac{s+1}{\sqrt{var(s)}} \quad if\ S < 0 \right\}$$

Here, if the value of │Z│>Z' then the null hypothesis of no trend is rejected at 0.05% of significance level in a two-tailed test. (Trend is significant), in this study, a positive value of Z represents an upward or increasing trend and negative value of Z represents the downward or decreasing trend.[5]

4.2 THIEL SEN'S SLOPE ESTIMATOR TEST

Thiel-Sen's slope estimator is useful for estimating the changes in the amount of trend and it has been most commonly used for detecting the magnitude of a linear trend in hydro-meteorological time series. Here, the Slope (Ti) of the entire data group is computed as follows.[6]

$$\mathbf{Ti} = \frac{xj - xk}{j - k} \qquad \text{for } i = 1, 2, 3................N$$

Where, xj and xk are taken as values of data at time j and k (j>k) respectively.

The median of the sen's slope estimator is represented as,

$$\text{Qi} = \left\{ \frac{TN+1}{2}, N\ is\ odd, \quad \frac{1}{2}\left(\frac{TN}{2} + \frac{TN+2}{2}\right), \ N\ is\ even \right\}$$

A positive value of Qi represents the upward trend and a negative value represents a downward trend in the given time series.

V. RESULT AND DISCUSSION

The Mann-Kendall Statistic (Zmk) for different months and seasons of a year is represented in figure 2. The Zmk values for five gauge & discharge stations are (1) Andhyakore, the (Zmk) values are -1.10,-0.50,-0.60,-0.40,-1.40, 0.20, 1.40, 0.50,-0.40,-1.0,1.90 and -0.50 respectively from January to December the month of January, February, March April, may, September, October and December clearly mention significant decreasing trend in streamflow whereas the month of June, July, August and November shows increasing trend for monthly streamflow for 1980-2012. And Zmk values for seasonal variations for andhyakore stations are -1.10,-1.0, 0.30 and -0.30 respectively for winter, pre-monsoon, monsoon and post-monsoon. The season of winter, pre-monsoon and post-monsoon represent a decreasing trend and monsoon season shows the increasing trend.(2)

Ghatora, the (Zmk) values are -0.90,-1.10,0.90,0.40,1.0,0.40,1.40,2.10,0.40,0.10,0.80and -1.0 respectively from January to December the month of January, February, and December clearly mention significant decreasing trend in streamflow whereas the month of March April, may, June,July, August, September, October and November shows increasing trend for monthly streamflow for 1980-2012. And Zmk values for seasonal variations for ghatora stations are -1.20, 1.60, 1.70 and 0.30 respectively for winter, pre-monsoon, monsoon and post-monsoon. The season of winter represents decreasing trend and pre-monsoon, monsoon and post-monsoon season show the increasing trend. (3) Jondhara, the (Zmk) values are -1.20,-1.0,-0.50,0.80,-0.80,-0.20,1.70,-0.20,0.10,-0.80,1.10 and -0.50 respectively from January to December the month of January, February, March, may, June, August, October and December clearly mention significant decreasing trend in streamflow whereas the month of April, July, September and November shows increasing trend for monthly streamflow for 1980-2012. And Zmk values for seasonal variations for jondhara stations are -0.80, -0.10, 0.30 and 0.10 respectively for winter, pre-monsoon, monsoon and post-monsoon. The season of winter and pre-monsoon represents decreasing trend and monsoon and post-monsoon season shows the increasing trend. (4) Pathridih, the (Zmk) values are -0.70,-0.30,-0.80,1.20,-1.0,-0.60,1.10,-0.70,0.13,-1.0,0.20 and -0.70 respectively from January to December the month of January, February, March, may, June, August, October and December clearly mention significant decreasing trend in streamflow whereas the month of April, July, September and November shows increasing trend for monthly streamflow for 1980-2012. And Zmk values for seasonal variations for pathridih stations are -0.50, -0.30, 0.30 and -0.70 respectively for winter, pre-monsoon, monsoon and post-monsoon. The season of winter and pre-monsoon and post-monsoon represents decreasing trend and monsoon season shows the increasing trend. (5) Simga, the (Zmk) values are 0.00,0.00,-1.20,0.30,-1.30,-0.50,0.90,-1.10,0.20,-0.60,1.10 and -0.30 respectively from January to December the month of March, may, June, August, October and December clearly mention significant decreasing trend in streamflow whereas the month of April, July, September and November shows increasing trend for monthly streamflow for 1980-2012. And the month of January and February shows having no trend similarly the Zmk values for seasonal variations for simga stations are 0.50, -0.50, -0.60 and -0.10 respectively for winter, pre-monsoon, monsoon and post-monsoon. The season pre-monsoon, monsoon and post-monsoon represent decreasing trend and winter season shows the increasing trend.

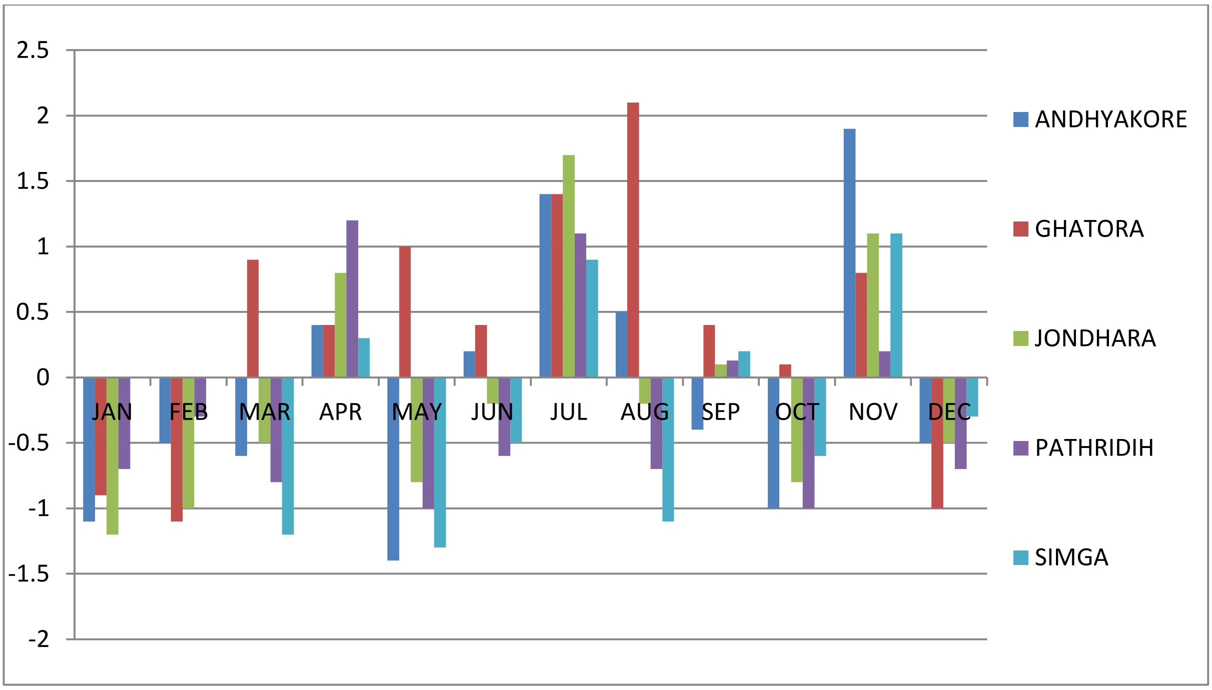

Fig.2: Mann-Kendall test statistics for five gauging stations for different months of the year from 1980-2012.

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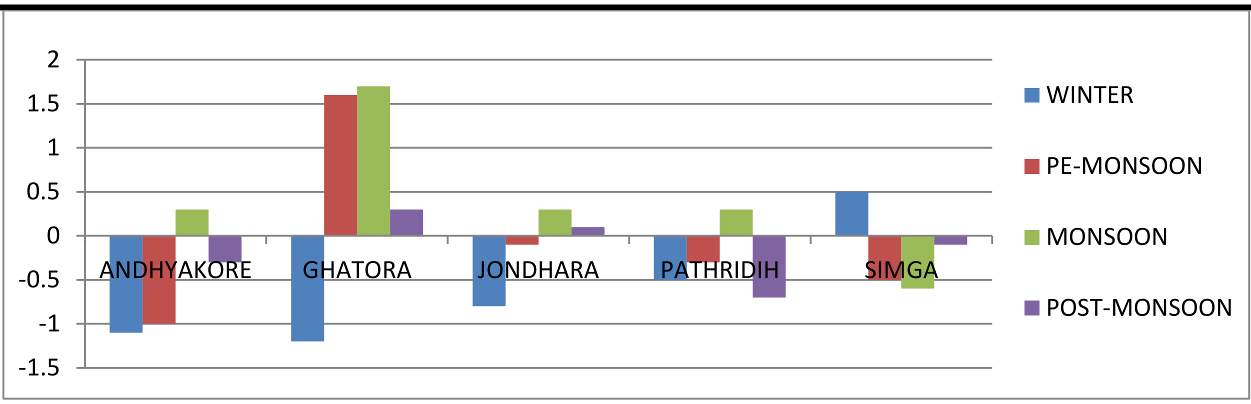

Fig.3: Mann-Kendall test statistics for five gauging stations for different Seasons of the year from 1980-2012.

Table.1: Sen Slope (Qi) values for different months and seasons of year from 1980-2012

Effective Rainfall Stations	Andhyakore	Ghatora	Jondhara	Patharidih	Simga
JANUARY	-0.200	-0.0012	-0.0123	-0.430	0.00
FEBUARY	-0.300	-0.0013	-0.0241	-0.320	0.00
MARCH	-0.0005	0.0014	-0.0092	-0.0014	-0.0025
APRIL	0.0006	0.30	0.0112	0.0028	0.0009
MAY	-0.0051	0.0019	-0.0151	-0.0032	-0.0095
JUNE	0.007	0.0226	-0.048	-0.0313	-0.0345
JULY	0.0643	0.1048	0.3987	0.0808	0.0529
AUGEST	0.0254	0.0929	-0.0019	-0.0529	-0.0947
SEPTEMBER	-0.014	0.0274	0.0068	0.0031	0.0204
OCTOBER	-0.0151	0.001	-0.0595	-0.0187	-0.007
NOVEMBER	0.0002	0.70	0.0062	0.10	0.90
DECEMBER	-0.600	-0.50	-0.40	-0.520	-0.120
WINTER	-0.0119	-0.0158	-0.1734	-0.0048	0.0062
PRE-MONSOON	-0.0138	0.0166	-0.0108	-0.0036	-0.0079
MONSOON	0.0281	0.2298	0.196	0.0309	-0.0877
POST-MONSOON	-0.0052	0.0041	0.0112	-0.017	-0.0024

Where the Positive value of Qi represents the increasing or upward trend and a negative value represents a decreasing or downward trend in the given time series.

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 also negative for the months January, February, March, and may, September, October and December for all the five gauging stations similarly the month of April, June, July, August and November shows the significant increasing trend. For all the five gauging stations excluded month of January in simga gauging station shows having no trend. Whereas the trend in different seasons are follows (1) season of winter and pre-monsoon shows significant decreasing trend for all the five gauging stations and post-monsoon season andhyakore, pathridih and simga gauging stations also represents the decreasing trend and (2) the season of monsoon shows increasing trend for all the five gauging stations and seasons of winter and pre-monsoon of ghatora and simga stations also shows the increasing trend.

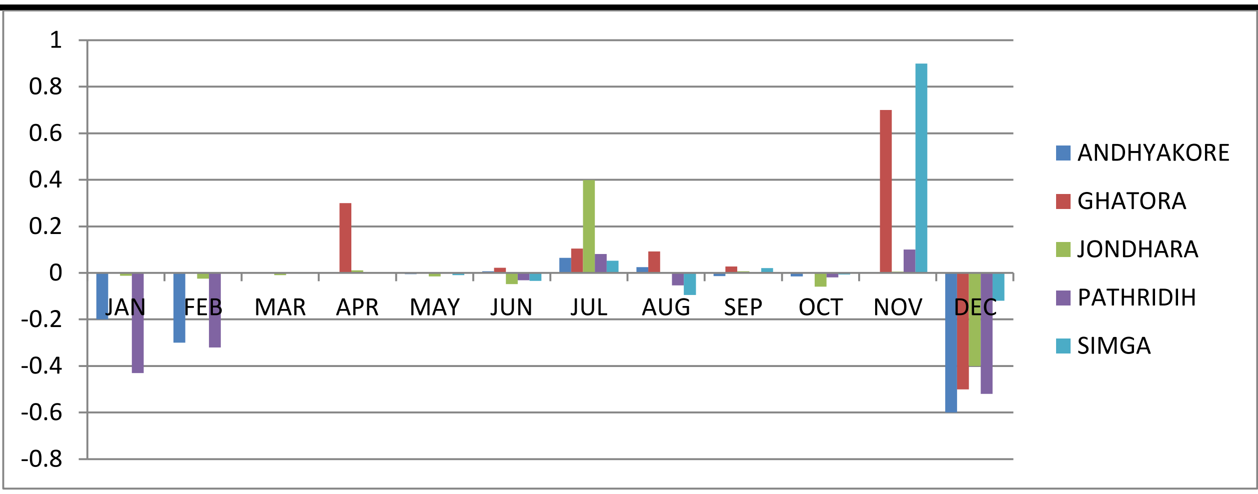

Fig.4: Sen Slope (Qi) values for different months of year from 1980-2012

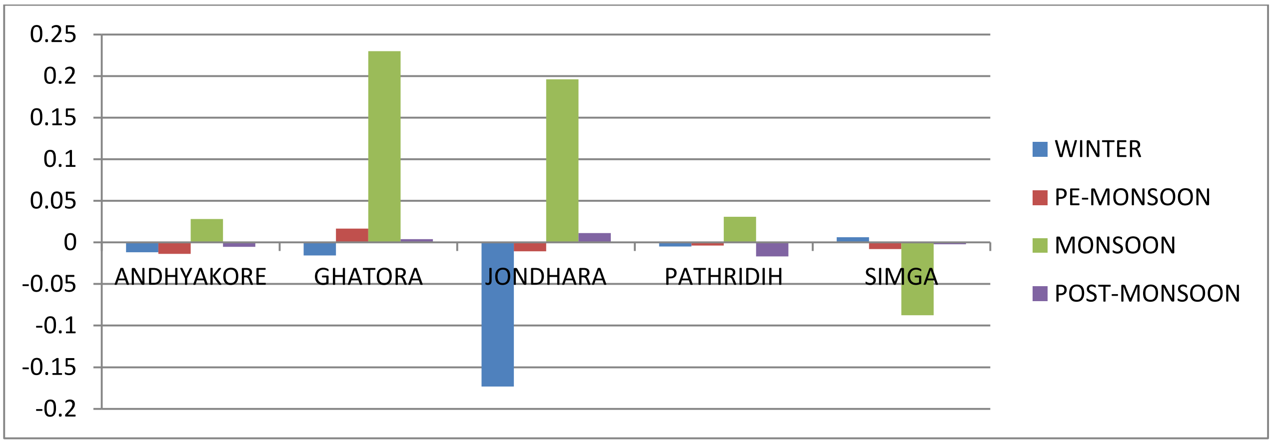

Fig.5: Sen Slope (Qi) values for different seasons of year from 1980-2012

VI. CONCLUSION

Change of climate is very preliminary to cope up with ever-changing conditions. The trend analysis is done for seonath river basin of Chhattisgarh state for monthly rainfall data for the period of 1980-2012 is analysed by using a non-parametric Mann-Kendall and Theil-Sen Slope Estimator test. The results reveal a downward or decreasing trend for most of the months and seasons of a year for the period of 1980-2012 under the analysis. In this study, we noticed that the rainfall events in the whole seonath river basin are continuous decreases. Both from Mann-Kendall's and Sen Slope estimator test. The adverse effect of the observed decreasing trend in rainfall event may be expected for different water-related sectors, primarily rain-fed agriculture and freshwater availability in the region. This study suggests that the knowledge of changes in rainfall pattern and its periodicity estimation could be useful for the hydrologist and management of irrigation planners for more efficient utilisation of water in the region and to make an appropriate decision on cropping pattern.

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