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Rainfall variability analysis of Rewa district in Madhya Pradesh

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ABSTRACT
Time series analysis and statistical significance of trends in rainfall data was carried out using standard Mann- Kendall test statistics. The non- parametric Mann-Kendall statistical rank test, which is widely used in climate research, was employed in this study to find out the fluctuations and presence of trend in time series data of rainfall at a single station as well as regional averages. Analysis of rainfall data (1986-2017) of Madhya Pradesh reveals significant increasing trend in total quantum of annual rainfall.The average annual rainfall of Rewa District in Madhya Pradesh for 32 years from 1986-2017 was 968.8 mm and 30.1 and 100 was the CV and their corresponding percentage contribution respectively. Monthly average rainfall showed, were maximum 292.6 mm in the month of July and minimum 3.71 mm in the month of April. In case of seasonal rainfall, their values for monsoon, pre-monsoon and winter were 726.43, 130.45 and 54.55 mm respectively. The CV and percentage contribution value for seasonal rainfall were 39.39, 68.12 and 74.10 while percentage contribution was 74.97, 13.46 and 5.63 respectively for monsoon pre-monsoon and winter. The study of decadal variability in the annual rainfall showed that an alternate decreasing and increasing trend in all the three decades viz 1986-2017, 1986-2001 and 2002 -2017.
Keywords: *Rainfall, Trend analysis, Decadal rainfall, Annual rainfall and rainfall contribution*

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INTRODUCTION

Climate change is a long-term process. It has raised as most alarming issue for the whole world. Therefore, quantification of climatic change has become necessary. Trend analysis is a method to determine the spatial variation and temporal changes for different parameters associated to climate.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 the phase of a year may change the agricultural condition of the country and their by 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 climate variability. It has further lead to the essence of determining whether the trend is increasing or decreasing.The changes in the most important climatological parameter *i.e.* rainfall, may be responsible for natural calamities like drought and flood conditions. Rainfall is an important factor that needs serious attention as Indian agriculture is drastically affected climate change in rainfed agriculture. Rainfall is a single most important factor for success of crops in the farming areas. It is also one of the most composite and difficult elements of the hydrological cycle to understand due to the great range of variation over a wide range of scales both in space and time. Changes in rainfall trend, variability, amount and its spatial and seasonal distribution critically modify the river runoff pattern and regimes[1], Soil moisture [3] ground water Reservoirs, frequency of rainfall extremes including flood and droughts,cropping pattern and agricultural productivity vegetations activity.The Trends of extreme rainfall events have changed after 1950s in major parts of India.Major changes have occurred after 1975, which are correlated with indiscriminate exploitation of natural resources and rapid urbanization. The distribution of rainfall depends upon various factors.Rainfall climatology brings out the general pattern and characteristics of rainfall of a particular region. The local hydrological, agricultural and economic activities heavily depend

on micro-level rainfall. Analysis of rainfall trends in important for water resources planning and management.

The Rewa district lies in the central part of the state of Madhya Pradesh covering an area of 6287.45 sq. km. It lies between north latitude 24^0 16'30"and 25^0 11' 15" and east longitude $81^0$3'15" and $82^0$18' 45". It is located in the North Eastern corner of the state and bounded by Satna district in the West- Sidhi district in the south and state of Uttar Pradesh in north and East Rewa town is the district headquarter for administrative purposes. The normal annual rainfall of Rewa District is 1141.50 mm.It received maximum rainfall during South- West monsoon period *i.e*. June to September.About 89.20 percent annual rainfall received during monsoon season and only 10.8% of the annual rainfall takes place between October to May period. Thus surplus water for groundwater recharge is available only during the South-West monsoon period (Ministry of Water Resources Central Ground Water Board North Central Region Bhopal 2013).

MATERIAL AND METHODS

Total monthly rainfall of 32 years (1986-2017) of Rewa district of Madhya Pradesh was collected from Indian metrological department (IMD), Pune.The collect data was further divided in three segments; (1) Pre 2001 period (1986-2001), (2) Post 2001 period (1997-2012) and (3) Period 1986-2017. Variability analysis of rainfall was done accordingly. These data were analysing on annual, seasonal basis for the entire series under the study period.

Non- Parametric trend test

(i) Mann- Kendall test
(ii) Sen's Slope
(iii) Spearman's rho test

Mann Kendall analysis

Mann-Kendall's test is a non-parametric method which is less sensitive to outliers and test for a trend in time series without specifying whether the trend is linear or nonlinear. (Partal and Kahya, 2006). The Mann Kendall test statistics is given as:

$$S = \sum_{i=1}^{n-1}\sum_{j=1}^{n} sgn(X_j - X_i),$$ Where S is Mann- Kendall analysis

Sen's Slope

The magnitude of slope of trend is estimated using the approach described by Sen (1968). The Sen's slope estimator is non-parametric, linear slope estimator that works most effectively on monotonic data. The Sen's slope technique is used to determine the magnitude of the trend line. This testcomputes both the slope (*i.e* Linear rate of change) and intercept according to Sen's method. First a set of linear slopes is calculated as follows:

$$d = \frac{X_j - X_i}{j-1} \; For\; (1 \le i \le j \le n)$$, Where, d is slope.

Spearman's rho (SR) test

After Hirsch *et al.* (1982), the MK Test has been popularly used to assess the significance of trends in hydro-metrological trend analysis. $D = 1 - \frac{6\sum_{i=1}^{n}\{R(X_i)-i\}^2}{n(n^2-1)}$, Where, $R(X_i)$ is the rank of i^{th} observation X_i in the sample of size n.

Under the null hypothesis, the distribution of D is asymptotically normal with the mean and variance as follows ([4]; [7].

$$E(D) = 0$$

$$V(D) = \frac{1}{n-1}$$

RESULT AND DISCUSSION

The results emanated from the data considered under purview of this investigation are presented in the table 1.The average annual rainfall of Rewa district in Madhya Pradesh for 32 years from 1986-2017 was 968.80 mm and 30.10 and 100 was the CV and their corresponding percentage contribution respectively. Monthly average rainfall showed maximum 292.6 mm in the month of July and minimum 3.71 mm in the month of April.In case of seasonal rainfall their values for monsoon, pre-monsoon and winter were found respectively 726.43, 130. 45 and 54.55 mm. The CV and percentage contribution value for seasonal rainfall was 39.39, 68.12 and 74.10 while percentage contribution was 74.97, 13.46 and 5.63 respectively for monsoon, pre-monsoon and winter. The monsoon season contributes maximum to annual rainfall in the districts. More rainfall occurs in South- West monsoon (June, July, August and September)while other month also contributes to average annual rainfall but their contribution was least with respect to amount

of rainfall.Data of monthly rainfall since 1986-2017 (last 32 years) have been analyzed and results reflected a significant increasing trend in total quantum of annual rainfall in the (fig. 1), For 1986- 2001 have been analysed also results reflected a significant increasing trend in total quantum of annual rainfall (fig. 2) and for 2000-2017 have been analyzed and again results reflected a significant increasing trend in total quantum of annual rainfall (fig. 3).

It is interesting to observe that when the analysis is made separately then in the month of September for the period 1986-2017 the value of negative, for the period 1986-2001 the value is positive and for the period 2002-2017 again value is negative. It means they shows downward trend for the period 1986-2017. Upward trend is for the period 1986-2017 and again show downward trend. In the above table we can observe easily that in the month of July and October all values are positive it means that the show upward trend.

Table 1 Trend analysis of monthly rainfall in Rewa District

Month	1986-2017				1986-2001				2002- 2017			
	MK	SR	Reg.	S.Slope	MK	SR	Reg.	S. Slope	MK	SR	Reg.	S. Slope
Jan	-0.04	-1.10	-0.01	-0.04	0.09	-0.06	0.02	0.40	0.15	0.10	0.02	0.32
Feb	-0.14	-0.09	-0.01	-0.13	0.02	-0.26	-0.03	0.08	-0.15	-0.27	-0.03	-0.36
Mar	-0.13	-0.14	0.02	-0.13	-0.27	-0.20	-0.04	-1.12	0.17	0.25	-0.01	0.36
Apr	-0.14	-0.15	-0.06	-0.04	0.09	0.21	0.30	0.06	-0.14	-0.14	-0.08	0.00
May	-0.21	-0.39	-0.31	-0.16	0.14	0.02	-0.06	0.38	0.09	0.03	-0.08	0.00
Jun	-0.06	-0.05	-0.01	-0.81	-0.01	0.91	0.00	-0.22	-0.05	0.03	0.00	-2.23
July	0.20	0.34	0.02	5.51	0.09	0.21	0.01	4.03	0.09	0.28	0.01	6.65
Aug	-0.04	-0.11	0.00	-0.32	0.12	-0.02	0.00	2.02	0.09	0.10	0.00	4.72
Sep	-0.23	-0.37	-0.01	-2.68	0.37	0.44	0.04	7.78	-0.18	-0.26	-0.01	-5.38
Oct	0.05	0.10	0.05	0.08	0.09	0.24	0.04	0.30	0.15	0.10	0.02	0.60
Nov	-0.19	-0.28	-0.02	0.00	-0.07	-0.06	0.06	0.00	-0.24	-0.42	-0.07	0.00
Dec	-0.34	-0.51	0.15	0.00	-0.37	0.55	-0.15	-0.65	-0.06	-0.21	-0.11	0.00

Fig. 1- Annual rainfall of Rewa district 1986- 2016

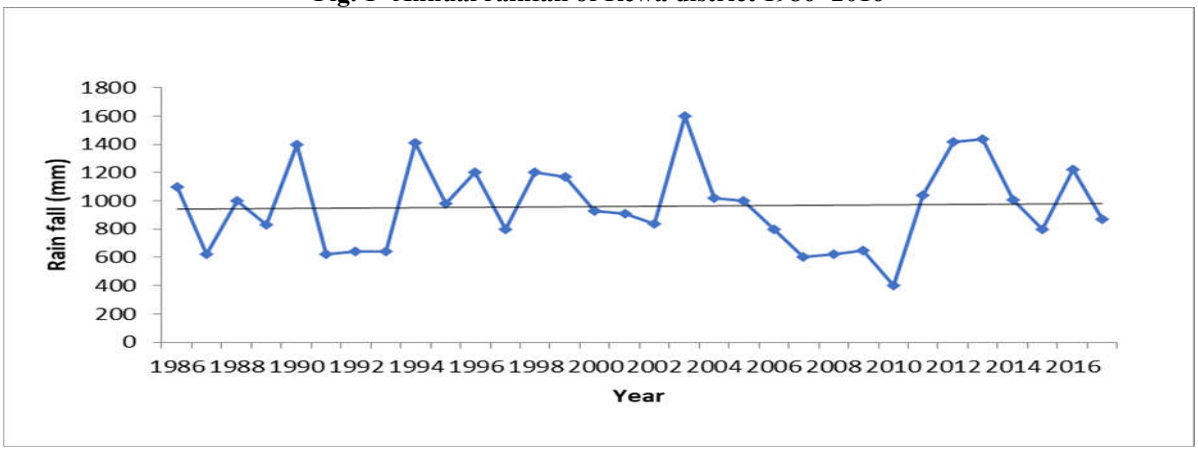


Fig. 2Annual rainfall of Rewa district 1986- 2001

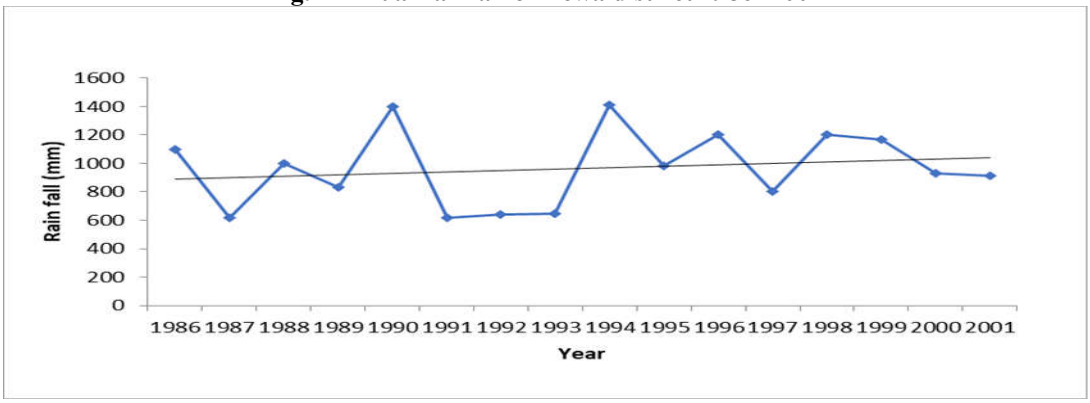
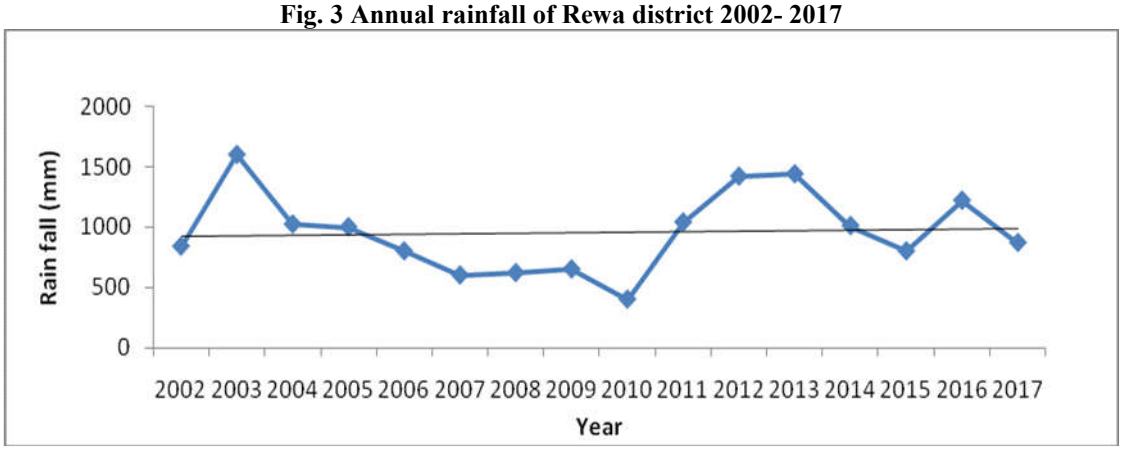


Fig. 3 Annual rainfall of Rewa district 2002- 2017



CONCLUSION

On the basis of long term data analysis (1986-2017) of Rewa district of Madhya Pradesh, it was observed that after 2001 the rate of decrease of total quantum of annual rainfall was more in Rewa as compared to before 2001. The annual rainfall variability was in an increasing trend. In the recent decade (2002- 2017), the rainfall trend was depicted to have increasing trend in Rewa. The seasonal rainfall was also observed in decreasing trend in the order of monsoon rainfall >pre monsoon> winter rainfall in Rewa district of Madhya Pradesh.

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