



## Analysis of Spatial and Temporal Rainfall Variability of Pratapgarh, India

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### ABSTRACT

The weekly rainfall data from 1967 to 2016 for 5 stations of Pratapgarh district was used to analyse rainfall trend. Spatial distribution and temporal variation of rainfall were observed in weekly and annual rainfall data series. Mann Kendall test and Sen's slope estimator were used for the trend analysis. IDW interpolation technique was used for analysing spatial variability of rainfall of the district. The statistical indices such as mean, standard deviation, skewness and kurtosis of rainfall were calculated. The results showed that, peak average weekly rainfall (89.50 mm) of the district was observed in meteorological week MW-31, whereas the minimum rainfall (3.36 mm) was seen in MW-42. Mann Kendall test and Sen's slope estimator confirmed that, the annual rainfall data series of all the stations in the district has no trend. The trend was detected in weekly rainfall data series of MW-30 only. The hypothesis of no trend was accepted for all other weekly rainfall data series.

**Keywords:** Rainfall trend, Mann-Kendall test, IDW interpolation etc.

### INTRODUCTION

Rainfall is an integral component of the hydrological cycle and the global energy balance (Wu et al., 2013). It is a complex combination of dynamic, thermodynamic and cloud microphysical processes operating over a large extent of space and time (Kundu et al., 1901-2011). Rainfall is also an important climatic variable, which affects severity of drought causing wilting of crops or incidence of diseases and pests due to excess rainfall depending upon the particular region (Radhika et al., 2011). The incident of extended dry period or heavy rain at the critical stages of the crop growth and development may lead to

noteworthy reduction in the crop yield and hence significantly affect the economy of the country (Oza & Kishtawal, 2014). Rainfall uncertainty often leads to conservative strategies that sacrifice some productivity to reduce the risk of losses in poor years (Nair et al., 2014). The variable rainfall pattern associated with the climate change needs systematic attention as it affects the food production and the availability of fresh water (Dore, 2005).

The knowledge about rainfall patterns for agriculture is primarily needed for crop planning in rainfed agriculture.

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Rainfed agriculture is highly vulnerable due to rainfall variability, which is often devastating to agriculture (Radhika et al., 2011). Rainfall information is vital for any rational crop planning, irrigation scheduling decision on cropping patterns, ground water recharging and soil water conservation techniques (Radhika et al., 2011). The studies of extreme rainfall events have great relevance and importance for water resources management. Rainfall in the many parts of India is unevenly distributed and erratic (Manoj & Kumar, 2013). If rainfall information is available three to six months ahead of time, it may be possible to modify decisions to minimize unwanted impacts and to take advantage of expected favorable conditions. In the present study, Pratapgarh district, which is an important physiographic unit of Rajasthan state, is

considered. The main objective of this study is to analyse spatial and temporal variation of weekly and annual rainfall from 1967 to 2016. It will help the planners to understand the recent scenario of climate change in this area.

#### Study area

Pratapgarh is an important district of Rajasthan state located at 24.03°N 74.78°E with average elevation of 580 metres above mean sea level. It is situated at the junction of Aravali mountain ranges and the Malwa Plateau. The geographical area of Prtapgarh is 4117 square kilometre. The average annual rainfall is 856 mm. Pratapgarh district comprises 5 subdivisions, viz. Arnod, Chhotisadri, Dhariawad, Pipal Khunt and Pratapgarh. The study area comes under IV B agroclimatic zone (Hussain, 2015).

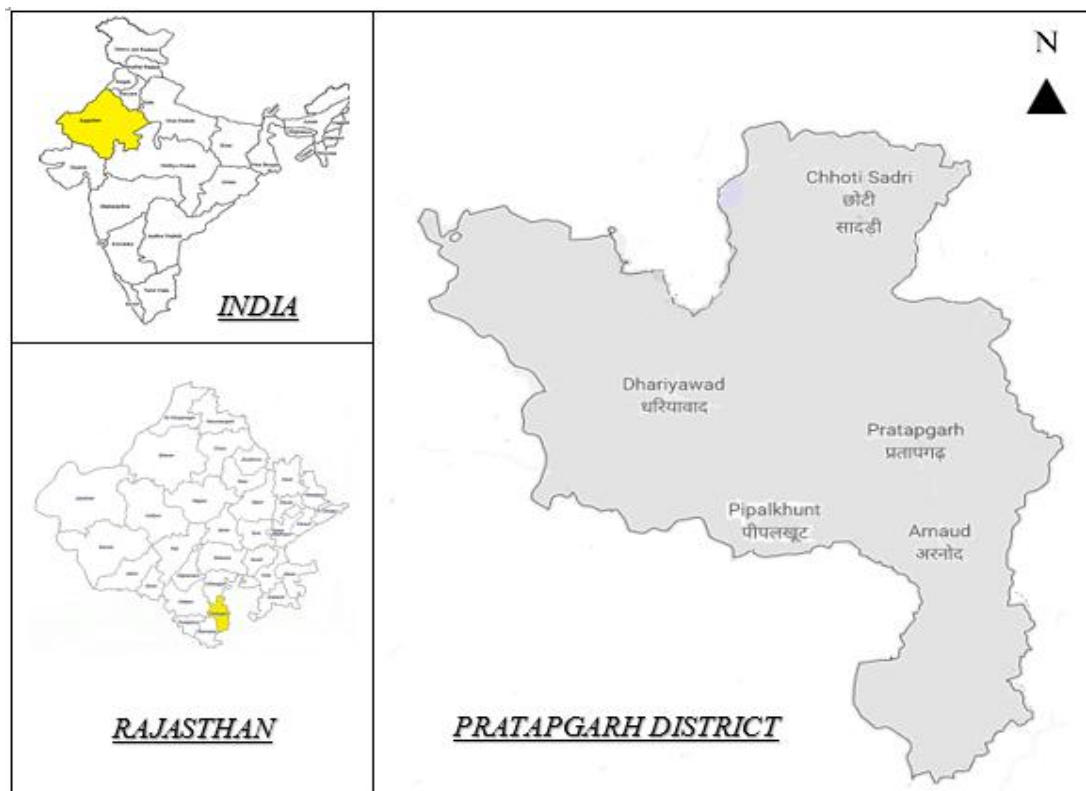


Fig. 1: Location map of the study area

#### Data

The daily rainfall data of 50 years (1967-2016) from Water Resources Department Rajasthan was used for analysis of rainfall trend variability of 5 stations in the study area. The daily rainfall data was converted to weekly data for further use.

#### Methods

The selection of stations in the study area for rainfall analysis was based on adequacy of raingauge stations, availability of consistent data for that particular station, already existed number of stations and amount of missing rainfall data for particular station. The rainfall

data of 50 years was analysed as weekly and annual rainfall for selected stations in Pratapgarh district. The behavioural pattern of rainfall with reference to the amount and variation of rainfall for each meteorological week was evaluated using statistical indices such as mean, standard deviation, skewness and kurtosis from historic weekly rainfall records. These indices help to check stationarity of time series data.

Many researchers employed parametric and non-parametric approaches earlier for detection of trend in time series data. The non-parametric methods, which are distribution free are generally employed for this purpose rather than parametric methods which are very sensitive to extreme values. Mann Kendall nonparametric test performs well even with missing values or outliers and widely used in trend analysis of rainfall data (Brath et al., 2002). Mann (Mann, 1945) formulated this test for trend detection and the test statistic distribution was given by Kendall, (1975) for testing non-linear trend and turning point. The World Meteorological Organization (WMO) has also suggested using the Mann-Kendall method for assessing trends in meteorological data (WMO, 1988). In the present study, Mann-Kendall test was used for detecting and analysing variation in the rainfall time series. For analysing the trend magnitude, Sen's slope estimator was used.

The knowledge of spatial distribution of rainfall is often required for water resource management, irrigation scheduling and

hydrological modelling. With the advent of GIS technology, a large amount of spatial data was able to handle and sophisticated spatial statistical techniques were included in GIS software (Yuan et al., 2016). A number of methods have been proposed for the interpolation of rainfall measurements. The IDW (Inverse Distance Weighted) interpolation technique is an effective method of spatial analysis of rainfall and having the assumption that the variables at a point to be predicted are similar to the values in the nearby observation stations (Sahu & Khare, 2015). Many GIS users are using IDW as a default method to generate a surface when attribute values are available only at sampled locations. In the present study, IDW interpolation technique with ArcGIS platform was used for spatial analysis of rainfall along with preparation of spatial variation maps for different selected stations in the study area.

## RESULTS AND DISCUSSION

Evaluation of statistical properties of rainfall  
The significant rainfall occurred from meteorological week 22 (MW-22) to meteorological week 42 (MW-42) in Pratapgarh district. Therefore, the behavioural pattern of weekly rainfall (MW-22 to MW-42) was evaluated using statistical indices such as mean, standard deviation, skewness and kurtosis. Table 1 shows minimum and maximum rainfall and corresponding minimum and maximum standard deviation for different stations in the study area.

**Table 1: Rainfall distribution of different stations in Pratapgarh district**

Sr. No.	Station	Minimum rainfall (mm) and corresponding week	Maximum/Peak rainfall (mm) and corresponding week	Minimum standard deviation and corresponding week	Maximum standard deviation and corresponding week
1.	Arnod	7.51 (MW-42)	106.41 (MW-31)	20.76 (MW-39)	111.79 (MW-31)
2.	Chhotisadri	2.68 (MW-42)	85.17 (MW-31)	12.06 (MW-42)	101.25 (MW-30)
3.	Dhariawad	3.51 (MW-42)	85.76 (MW-30)	15.81 (MW-42)	98.63 (MW-36)
4.	Pipal Khunt	0.61 (MW-42)	91.07 (MW-30)	3.81 (MW-42)	104.89 (MW-30)
5.	Pratapgarh	2.48 (MW-42)	91.21 (MW-30)	8.98 (MW-42)	108.07 (MW-30)

It is observed that, the minimum average weekly rainfall was observed in MW-42 for all

the five selected stations in Pratapgarh district. The minimum standard deviation value of

weekly rainfall was also observed in MW-42 except for Arnod station, for which it was observed in MW-39. Similarly, the maximum value of average weekly rainfall was observed between MW-30 to MW-31 and the maximum standard deviation of weekly rainfall was observed between MW-30 to MW-31 except Dhariawad station it was noted in MW-36.

The average weekly rainfall distribution of Pratapgarh district is shown in

Fig. 2. The peak average weekly rainfall (89.50 mm) of the district was observed in MW-31, whereas the minimum rainfall (3.36 mm) was seen in MW-42. The weekly rainfall of selected five stations in Pratapgarh district was averaged to estimate average weekly rainfall of district. It was also seen from Fig.3 that for most of the weeks standard deviation is more than the mean, indicating the large variability in weekly rainfall.

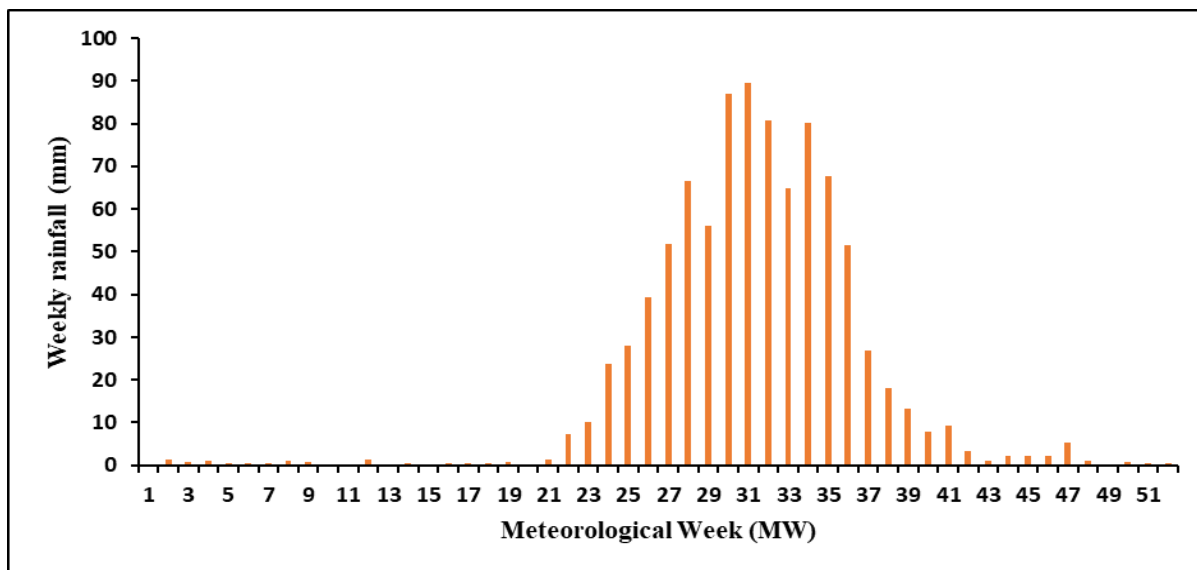


Fig. 2: Average weekly rainfall distribution of Pratapgarh district

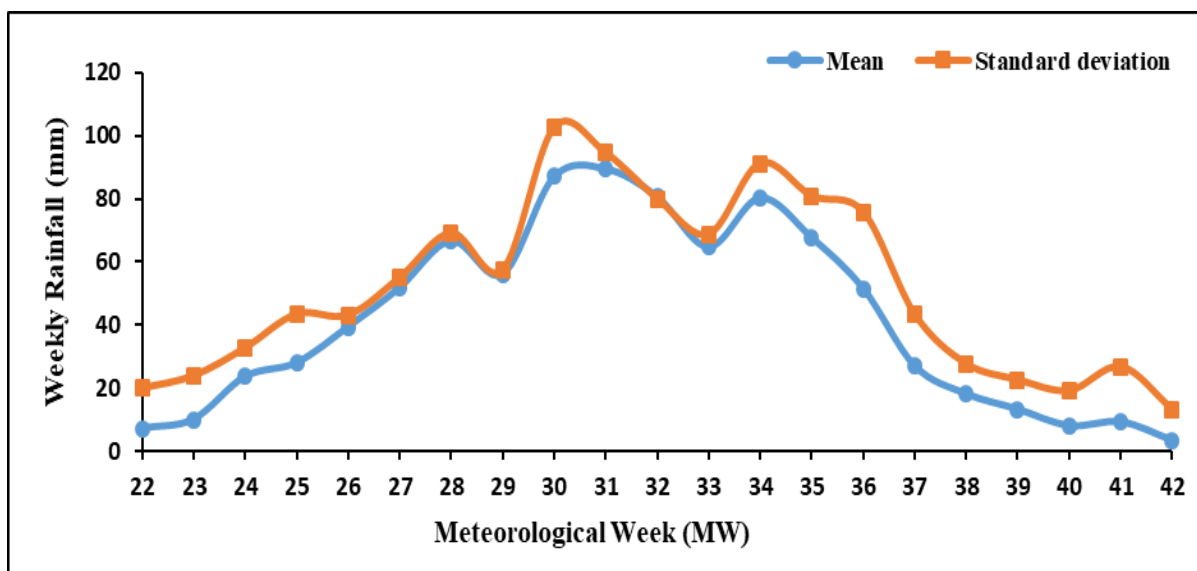


Fig. 3: Comparison between mean and standard deviation of weekly rainfall over monsoon period for Pratapgarh district

**Spatial variation map of rainfall**

The spatial variability of rainfall was studied for the selected stations in the study area and spatial interpolation map of annual rainfall was

derived using IDW interpolation technique with GIS platform. Such map permit a better comprehension of the process with geographical imprint as well as the application

of methodology to large spatial areas. The spatial interpolation map helps planners to understand component variability more

comprehensively. The spatial variation map of annual rainfall for Pratapgarh district is shown in Fig. 4.

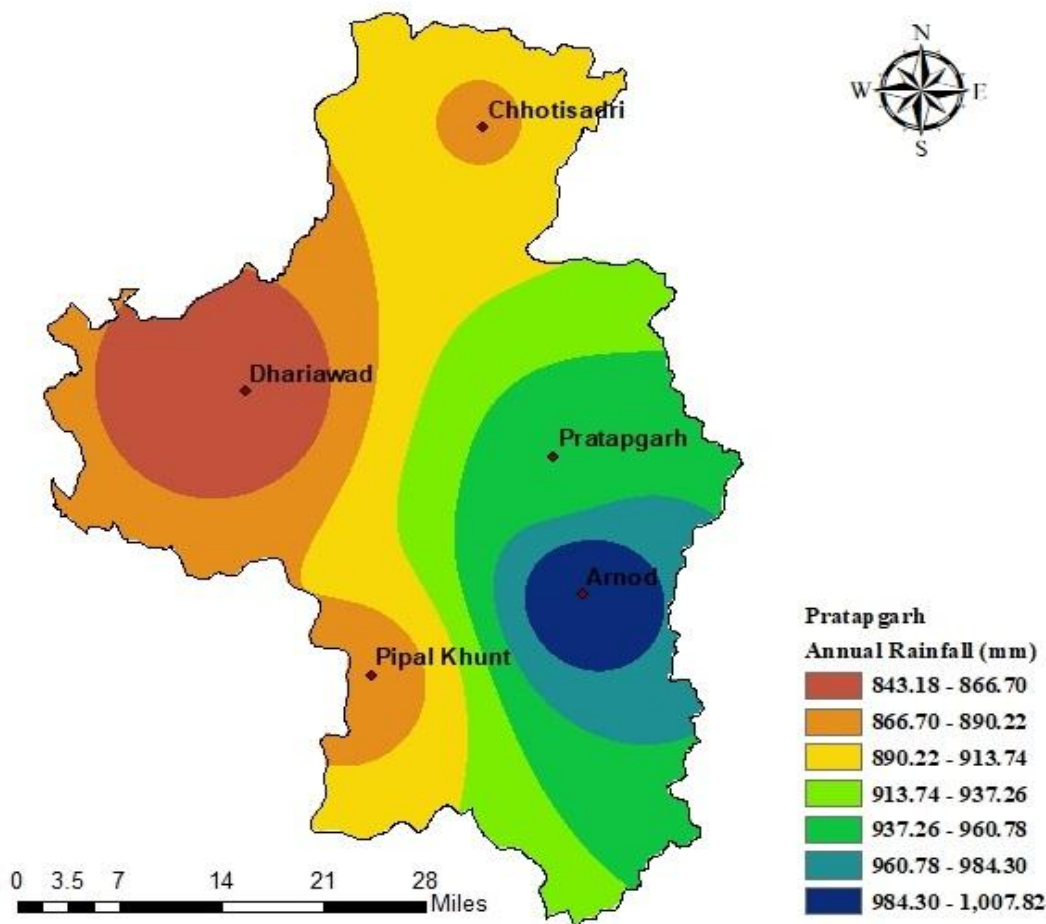


Fig. 4: Spatial variation map of annual rainfall

**Temporal variation of rainfall**

The distribution free non-parametric tests were employed to detect the presence of trend in rainfall data series and evaluation of temporal

variation of rainfall. Mann-Kendall test and Sen’s slope estimator was used to determine trend and magnitude of trend in the annual and weekly rainfall data sets.

Table 2: Trend analysis of annual rainfall for different stations in Pratapgarh district

Sr. No.	Station	Mann Kendall test			Sen’s slope		
		τ value	P value	Trend	Value	Lower bound	Upper bound
1.	Arnod	0.147	0.134	No	4.972	-1.532	11.712
2.	Chhotisadri	-0.027	0.789	No	-0.677	-5.500	4.478
3.	Dhariawad	0.026	0.795	No	0.544	-4.046	5.463
4.	PipalKhunt	-0.109	0.270	No	-3.314	-8.571	2.300
5.	Pratapgarh	0.146	0.136	No	3.667	-1.390	9.387

It is observed that, the computed P value was greater than the significance level alpha ( $\alpha=0.05$ ) for all stations in Pratapgarh district. Thus, the annual rainfall data series of all the stations in the district has no trend. The

hypothesis of no trend was accepted. The Sen’s slope estimator also confirmed same results. The values of Sen’ slope were also within limits (bounds) and hence hypothesis of no trend was accepted.

**Table 3: Trend analysis of weekly rainfall (MW-30) for stations in Pratapgarh district**

Sr. No.	Station	Mann Kendall test		Sen's slope		
		$\tau$ value	P value	Value	Lower bound	Upper bound
1.	Arnod	0.275	0.005	1.632	0.327	3.500
2.	Chhotisadri	0.221	0.025	1.093	0.029	2.167
3.	Dhariawad	0.293	0.003	1.940	0.569	3.232
4.	Pipal Khunt	0.219	0.026	1.313	0.077	2.863
5.	Pratapgarh	0.310	0.002	1.786	0.667	3.372

It is seen that, the trend was present in only MW-30 data series for all the stations in the study area. No trend was found in other weekly rainfall data series. Thus, the results of trend tests for MW-30 are presented in Table 3.

### CONCLUSION

The pattern of weekly rainfall (MW-22 to MW-42) was evaluated using statistical parameters such as mean, standard deviation, skewness and kurtosis for 5 stations in Pratapgarh district. The minimum average weekly rainfall was observed in MW-42 for all the five selected stations.

The maximum value of average weekly rainfall was observed in MW-31 for Dariawad, Pipal Khunt and Pratapgrh whereas for Arnod and Chhotisadri it was observed in MW-31. Considering average weekly rainfall of whole district, peak average weekly rainfall (89.50 mm) was observed in MW-31, whereas the minimum rainfall (3.36 mm) was seen in MW-42. It is noted that, for most of the meteorological weeks standard deviation was more than the mean, which indicated large variability in weekly rainfall. The rainfall of Pratapgarh district was spatially varied between 843.18 mm for Dhariawad station to 1007.84 mm for Arnod station. From the trend analysis using Mann Kendall test and Sen's slope estimator it is concluded that, no trend present in annual rainfall data series of all stations in the study area. In addition, weekly rainfall data series MW-30 showed presence of trend and in other weekly rainfall data series trend was absent.

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