

## Seasonal Trend Analysis in Rainfall and Temperature for Udaipur District of Rajasthan

VAIBHAV DEOLI\* and SAROJ RANA

Department of Soil and Water Conservation Engineering, G B Pant University of  
Agriculture and Technology, Pantnagar – 263145, Uttarakhand, India.

### Abstract

The present study is mainly focused on to detection of changing trend in rainfall and temperature for Udaipur district situated in Rajasthan state of India. The district situated in the western part of India which obtained less rainfall as compared with the average rainfall of India. In the present article, the approach has been tried to analysis to detect rainfall trend, maximum temperature trend and minimum temperature trend for the area. For this daily rainfall data of 39 years (1975 to 2013) add seasonally and temperature has been calculated by averaging of daily temperature for a period of 39 years. For determining the trend the year has been shared out into four season as winter season, pre-monsoon season, monsoon season and post-monsoon season. To obtained magnitude of trend San's slope estimator test has been used and for significance in trend Mann-Kendall statistics test has been applied. The results obtained for the study show significantly decreasing rainfall trend for the season winter and season post-monsoon whereas pre-monsoon and monsoon show increasing rainfall trend. The maximum temperature of pre-monsoon and monsoon months shows a significantly increasing trend whereas in minimum temperature, winter season and pre-monsoon season shows an increasing trend which is significant at 10% level of significance and post-monsoon shows a decreasing trend which is also significant at 10% level of significance.



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Temperature,  
Trend.

### Introduction

Quantitative estimation of the temporal distribution of rainfall and temperature for an area is important to different purposes such as hydrological modelling,

hydraulic structures modelling, flood forecasting, surface water modelling, groundwater modelling, agriculture modelling, crop scheduling, evaporation modelling etc. High temperature can cause worsen

**CONTACT** Vaibhav Deoli ✉ deolivaibhavdeoli@gmail.com 📍 Department of Soil and Water Conservation Engineering, G B Pant University of Agriculture and Technology, Pantnagar – 263145, Uttarakhand, India.



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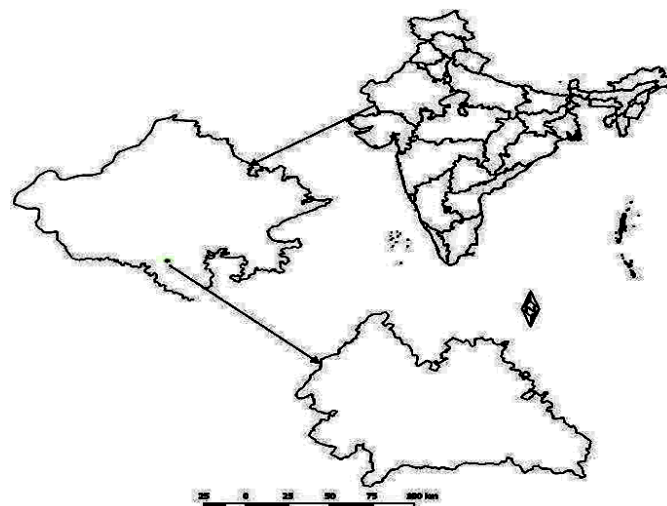
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drought in an area and also a reason for forest fires. High temperatures are also responsible for reducing yields in the field and crop-damaging. Low temperatures able to cause heavy snowfalls and rime. Heavy rainfall is a cause of flood in plane areas and landslides in hilly areas. A standout amongst all factor which is responsible for climate change, greenhouse gases would be the main factor for the uncertainty of the rainfall and temperature variation and India have been also affected by this factor. Change in the pattern of rainfall and temperature increases have occurred all over the world. In India, most of the agricultural areas depending upon the climate mainly rainfall hence in India rainfall have a major role for deciding the total economy of the country. Hence, the study of trend and pattern by metrological data for an area is important to detect long term climate change and its impact (Jain *et. al.*, 2012). According to many researches, climate change and evidences are not same for whole world. In certain areas an increase of rainfall or decrease of temperature is expected, while other areas at the same time may suffer from decreased rainfall or increased temperature. If the temperature is higher it cause a condition of formation of clouds. As temperature is high the atmosphere may contain more vapour of water which is responsible for heavy rainfall such as summer thunderstorms.

All over the world, to know the impact of climate changes many researchers have been working on the trend of rainfall and temperature to predict long term changes in climate. Cheung

*et. al.*, (2007) studied trend in annual rainfall for Ethiopia to know variability, quantity and changes in rainfall for 13 watershed. By this study they determined significance level and value of change in rainfall for studied area. Haris *et. al.*, (2010) used Mann-Kendal test to know the significant trends in rainfall and temperature at three representative agro-ecological zones of Bihar. Jain *et. al.*, (2012) analyzed rainfall and temperature trends for the north-east states in India by Mann-Kendal & San-Slope estimator test. Yadav *et. al.*, (2014) worked on seasonal trend analysis in rainfall and temperature for Uttarakhand state to know the overall insignificant changes in the area. Meshram *et. al.*, (2016) used long term precipitation data to analysis seasonal trend in precipitation for Chhattisgarh state of India by linear regression, Mann-Kendal and San slope's estimator test. Longueville *et. al.*, (2015) studied long-term trend of rainfall and temperature for Burkina Faso. The trend was determined in rainfall, temperature and rainy days. They observed the tren of this area did not show significant trend in rainfall and temperature.

Udaipur is in one of that area in India where average rainfall is less than average rainfall of India and it also suffer from high temperatures. So it is important to determine the rainfall and temperature trend in different seasons for the purpose of agricultural activities, crop water balance model as well as to know about drought condition and productivity of that area.



**Fig. 1: Study map of Udaipur**

### Study Area and Data Used

This study carried out to Udaipur district of Rajasthan. The longitude and latitude of the study area are 73°42' and 24°45' respectively with 582.17 meters above mean sea level (Figure 1). Udaipur receives maximum rainfall due to the south-west monsoon in monsoon season and in all other seasons rainfall is very low for this area. Hence there is always a wide variation in daily annual rainfall as well as seasonal rainfall.

In this study, daily data of 37 years were obtained from the website of the Department of Water Resource, Govt. of Rajasthan. Daily data has been used to determine the rainfall trend, maximum temperature trend and trend in minimum temperature in the basis of different season. Seasonal rainfall data obtained by adding daily rainfall data of particular season of that year and maximum and minimum temperature data has been obtained by the average of the maximum and minimum daily temperature for that particular season of a year.

For seasonal analysis each year has been divided into four climatic season, namely winter season which included 2 months (January & February), pre-monsoon included 4 months (March to May), monsoon included 5 months (June to October), and in last, post-monsoon included 2 months (November

& December) (Rao 1981; Jain *et. al.*, 2012). After that, data has been analysed season wise.

### Methodology

In the present study, to determine the rainfall trend, maximum temperature trend and minimum temperature trend non-parametric test has been used. Non-parametric tests are less affected by outliers and represent a measure of linear dependence (Yadav *et.al.*, 2014; Lanzante 1996; Rosssi *et.al.*, 1992). In non-parametric test, for detection of significance trend Mann-Kendall statistic has been used and to determine trend magnitude San slope estimator's used.

### Mann-Kendall Statistic

Mann-Kendall statistic is used to as certain a significant trend in climatically data. To trend analysis Mann-Kendall statistic is one of the best method to detect trend and has been using continuously (Jain *et. al.*, 2012; Kumar *et. al.*, 2018). In this study, Mann-Kendall statistic has been used to determine a significant rainfall trend as well as maximum temperature trend and minimum temperature trend. In this statistic, the null hypothesis sets as data shows no trend and alternative hypothesis sets as there is a trend in data which may be either increasing trend or decreasing trend. This method is less affected by outliers hence more suitable

**Table 1: Statistical Parameter of Seasonal Rainfall**

Season	Mean (mm)	SD (mm)	CV (%)
Winter	5.32	9.33	174.13
Pre-monsoon	42.27	42.73	101.06
Monsoon	558.72	203.85	36.48
Post-monsoon	17.46	36.17	207.15

**Table 2: Statistical Parameter of Maximum Temperature**

Season	Mean (°C)	SD (°C)	CV (%)
Winter	27.92	3.67	13.14
Pre-monsoon	35.80	2.16	6.03
Monsoon	31.13	1.49	4.78
Post-monsoon	26.45	2.29	8.65

for data which are non – normally distributed. (Kumar *et. al.*, 2018).

Let  $y_1, y_2, y_3, \dots, y_m$  are  $m$  data, then the Mann-Kendall statistic can be given by

$$S = \sum_{p=1}^{m-1} \sum_{q=p+1}^m \text{sgn}(y_q - y_p)$$

Where  $S$  denotes Mann-Kendall statistic,  $m$  is the total number of observations taken and  $y_q$  is  $q^{\text{th}}$  observation and  $y_p$  is  $p^{\text{th}}$  observation in total.

Let  $(y_q - y_p) = \alpha$

$$\text{sgn } \alpha = \begin{cases} +1 & \text{if } \alpha > 0 \\ 0 & \text{if } \alpha = 0 \\ -1 & \text{if } \alpha < 0 \end{cases}$$

The variance of  $S$  is calculated as

$$\text{variance}(S) = \frac{m(m-1)(2m-5)}{18} \sum_{i=1}^n t_i(t_i-1)(2t_i-5)$$

Where,  $n$  is the total tied groups present and  $t(p)$  is the total number of data points in the  $p^{\text{th}}$  tied group.

**San’s Slope Estimator Test**

San’s slope estimator is used to determine the magnitude of the trend in data. This method consider temporal series data follow linear trend. If  $x_p$  &  $x_q$  are considered as values of time series data at  $m$  and  $n$  time as  $p > q$ .

The slope ( $Q_i$ ) of data pairs is computed as

$$Q_i = (x_p - x_q) / (p - q)$$

The median of  $q$  values of  $Q_i$  is Sen’s slope estimator of slope, which may be computed as:

$$\beta = \begin{cases} \frac{T_{q+1}}{2} & \text{for } n \text{ is odd} \\ \frac{1}{2} \left( \frac{T_q}{2} + \frac{T_{q+1}}{2} \right) & \text{for } n \text{ is even} \end{cases}$$

**Table 3: Statistical Parameter of Minimum Temperature**

Season	Mean (°C)	SD (°C)	CV (%)
Winter	7.67	1.87	24.38
Pre-monsoon	20.48	2.05	10.00
Monsoon	20.64	1.33	6.44
Post-monsoon	7.41	2.01	27.125

**Table 4: Detection of Trend by Mann-Kendall Test for Seasonal Rainfall**

Climatic characteristics	Z – value for different seasons			
	Winter	Pre-monsoon	Monsoon	Post monsoon
Rainfall	-1.896*	0.503	0.064	-1.741*
Max Temperature	0.064	4.347**	2.077**	0.284
Min Temperature	2.180**	2.322**	-0.206	-1.419*

\* Significant negative trend and \*\*significant positive trend at 10% level of significance

**Results and Discussions**

**Statistical Parameter of Rainfall and Temperature**

The maximum rainfall obtained in Udaipur district in the monsoonal season with an average of 558.72 mm with 203.85 mm standard deviation during the study period. The minimum average rainfall of 5.32 mm has been obtained in winter season with 9.33 mm standard deviation. (Table 1). Minimum variation in rainfall has been obtained in monsoon season and maximum variation in rainfall has been obtained in the season of post-monsoon.

The maximum mean average temperature for 39 years obtained in pre-monsoon followed by monsoon season. Minimum variation in maximum temperature has been obtained in the monsoon season and maximum variation has been obtained in the winter season (Table 2). The average minimum temperature has been incurred in the post-monsoon season with a maximum variation of 27.12% just followed by winter season which has 24.38% variation (Table 3).

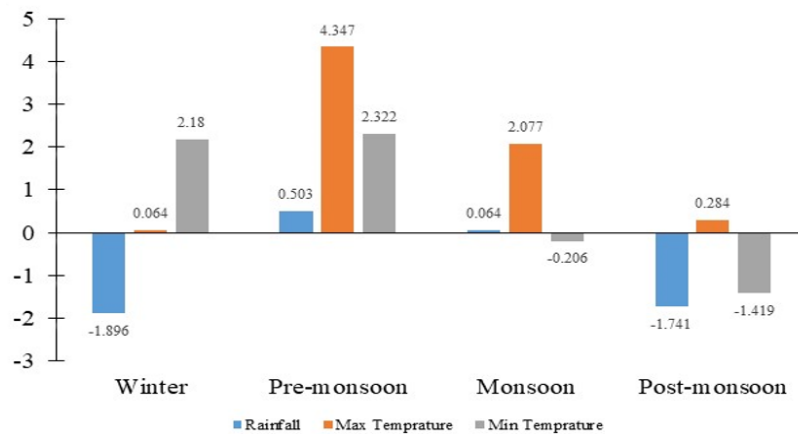
**Significance of Trend**

To detection of weather trend is Mann-Kendall significant or not in rainfall, maximum temperature and minimum temperature for Udaipur district Mann-Kendall statistic has been used. Results obtained by Mann-Kendall test is listed in Table 4.

Based on Mann-Kendall test, in the rainfall winter season & post-monsoon season show significant negative trend where in pre-monsoon & monsoon there was positive trend but not significant at 10% level of significance. In maximum temperature significant positive trend for season of pre-monsoon and monsoon whereas maximum temperature in season of winter & post-monsoon also increased but not significantly. In last, minimum temperature shows increasing significant trend in winter and pre-monsoon whereas in post-monsoon minimum temperature trend decreased significantly. Monsoon-season shows negative trend in case of minimum temperature but not significantly at the 10% level.

**Table 5: San's Estimator of Slope**

San's slope estimator values for different seasons				
Climatic characteristics	Winter	Pre-monsoon	Monsoon	Post monsoon
Rainfall	-0.033	0.269	0.057	0.000
Max Temperature	0.004	0.789	0.043	0.002
Min Temperature	0.583	0.085	-0.011	-0.040



**Fig. 2: Mann-Kendal's Statistics for Different Seasons**

**Magnitude of Trend**

Magnitude of rainfall trend, maximum temperature and minimum temperature was also calculated by San's slope estimator test and obtained results are in Table 5.

Based on San's slope estimator, rainfall in winter season decrease by -0.033 mm wherein pre-monsoon and monsoon season increased by 0.269 mm and 0.057 mm. Post monsoon season didn't show any result because rainfall in post monsoon was not linear for Udaipur district. The maximum temperature of Udaipur district has been observed increases in all season by 0.004°C in winter, 0.789°C in pre-monsoon, 0.043°C in monsoon and 0.002°C in post-monsoon season respectively. Minimum temperature shows an increase of 0.583°C in winter and 0.085°C in pre-monsoon season whereas the decrease of -0.011°C and -0.040°C in monsoon and post-monsoon season.

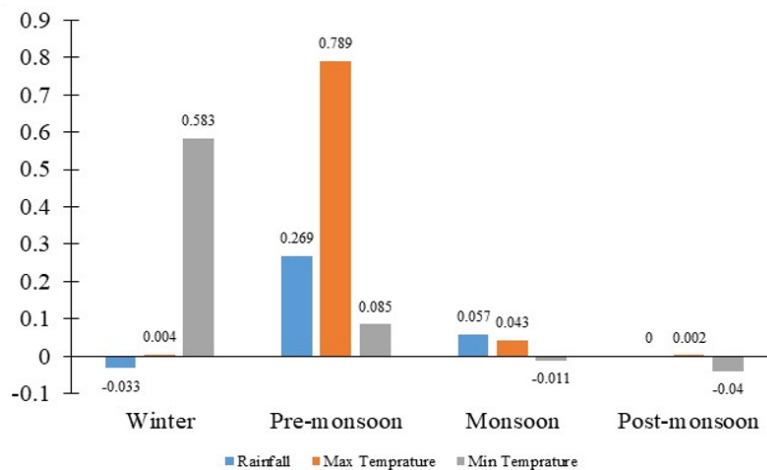
**Percentage Change**

In the study, after calculating magnitude of trend, based on that trend magnitude percentage changes in rainfall, maximum temperature and minimum temperature also determined. The total percentage changes for 39 years from 1975 to 2013 has been shown in Table 6.

From Table 6, maximum changes in rainfall 240.16%, observed in winter followed by 24.82% in pre-monsoon season for studied period. As san's slope magnitude zero in post-monsoon season, hence post monsoon season does not shows any changes in rainfall. Changes in maximum temperature for all season shows positive percentage changes. Maximum increase in temperature is observed in pre-monsoon season by 85.94% and minimum increase in temperature 0.29% is observed in post-monsoon season. Change in minimum temperature

**Table 6: Percentage changes in studied climate characteristics from 1975 to 2013**

Climatic characteristics	Percentage changes			
	Winter (%)	Pre-monsoon (%)	Monsoon (%)	Post monsoon (%)
Rainfall	240.16	24.82	0.40	0.00
Max Temperature	0.55	85.94	5.39	0.29
Min Temperature	296.44	16.17	-2.08	-21.05



**Fig. 3: San's slope values for different seasons**

is observed maximum in winter season by 296.44% followed by pre-monsoon season with increase of 16.17%. Post-monsoon season shows decrease of 21.05% in minimum temperature and monsoon season also shows decrease of 2.08% in minimum temperature.

### Conclusion

Change in climate affect all facets of life. Decreasing rainfall will result in a decrease in water availability. A country like India, where agriculture totally based on climate, it is important to detect a trend in all meteorological data. In rainfall and minimum-maximum temperature (39 years) variability analysis and detection of trends in winter, pre-monsoon, monsoon, post-monsoon study carried out for Udaipur district. As the decrease in winter rainfall will affect the Rabi crop of that area. There is a slight

increasing trend in pre-monsoon and monsoon rainfall which may be an indication of early rainfall in monsoon season for that particular district. In winter the temperature of the region shows an increasing trend which may be due to decreasing rainfall trend.

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