

Rainfall trend analysis for crop planning under rainfed conditions in district Agra of Uttar Pradesh

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सार – इस शोध पत्र में पैरामीट्रिक और नॉन पैरामीट्रिक मॉडलों का उपयोग करते हुए आगरा जिले में वर्षा के ऐतिहासिक आँकड़ों के ट्रेंड का विश्लेषण किया गया है। यह विश्लेषण उत्तर प्रदेश के शहर आगरा के भारतीय मृदा और जल संरक्षण अनुसंधान केंद्र संस्थान में स्थित मौसम वेधशाला के वर्षा मापी स्टेशनों के 51 वर्षों (1965-2015) के आँकड़ों का उपयोग करते हुए किया गया है। सरल सांख्यिकी प्राचलों का परिकलन किया गया और इससे यह पता चला कि यहाँ 671.58 मिमी. वार्षिक औसत वर्षा हुई। इसी प्रकार औसत 38 से वार्षिक वर्षा के दिन 15 से 55 के बीच थे। मासिक मौसमी और वार्षिक आधार पर वर्षा और वर्षा वाले दिनों के आंकड़ों के ट्रेंड का विश्लेषण रेखिकीय समाश्रयण पद्धतियों का उपयोग करके किया गया। यह पता चला है कि कुछ महीने ट्रेंड में बढ़ोतरी दिखाते हैं जबकि कुछ वर्षा के ट्रेंड में कमी को दर्शाते हैं। इसी प्रकार के परिणामों से पता चलता है जब वार्षिक और मौसमी वर्षा तथा वर्षा वाले दिनों के क्रम की जाँच उनके ट्रेंड के लिए की जाती है। मई और अगस्त के महीनों की मासिक वर्षा को छोड़ कर और मानसून ऋतु की वर्षा और वर्षा वाले दिनों को छोड़ कर अधिकांश मामलों में 5% के विशेष स्तर पर कोई विशेष बात नहीं है।

ABSTRACT. Trend analysis of historical data of rainfall of Agra district has been conducted in the present study using parametric and non-parametric models. The analysis was carried out using 51 years data (1965-2015) of rain gauge station located at meteorological observatory of ICAR-Indian Institute of Soil and Water Conservation, Research centre, Agra, Uttar Pradesh. Simple statistical parameters were calculated and it was found that rainfall ranged from 241.4 mm to 1235.1 mm with average annual rainfall 671.58mm. Similarly, annual rainy days ranged from 15 to 55 with average 38. Mann-Kendall, Sen's slope and linear regression methods were used for the trend analysis of rainfall and rainy days data on monthly, seasonal and annual basis. It was found that some of the months are showing rising trend whereas others showing falling trend of rainfall. Similar types of results were found when annual and seasonal rainfall and rainy days series were tested for their trend. In most cases trends were found no significant at 5% significance level except monthly rainfall of May and August months and also for monsoon season rainfall and rainy days.

Key words – Rainfall, Rainy days, Monsoon, Climate, Rainfed, Regression, Mann-Kendall, Sen's slope.

1. Introduction

In India nearly 65% of cultivable area is under rainfed agriculture. The rainfall is one of the important factors deciding success of rainfed agriculture of the particular agro- ecological region where the major part of the precipitation is rainfall. The productivity of the rainfed area is very low and uncertain due to total dependency on monsoon as compared to irrigated area. Crop growth and yield is affected by the amount of rainfall received during the period and its distribution. Detailed knowledge of the rainfall pattern helps in planning crop calendar and designing of different soil and water conservation structures including water harvesting structures to meet out irrigation requirement during drought periods. The livelihood and socio- economic activities of people in the

Agra region of U. P. is heavily dependent on the rainfall pattern because of mainly rainfed agriculture. Region is facing severe water scarcity problem because of multiple reasons like erratic rainfall, undulating topography, limiting soil depth, etc. In recent year, climatic change has also posed a new threat to this region. Inter-governmental Panel on Climatic Change (IPCC, 2007) has reported that in near future climatic change is likely to affect agriculture, increase of risk of hunger and water scarcity and may also lead to rapid melting of glaciers. Kumar and Jain (2010) reported that a higher or lower or changes in rainfall distribution would influence the spatial and temporal distribution of runoff, soil moisture, ground water storage and would alter the frequency of droughts and floods. While the observed monsoon rainfall at the national level does not show any

significant trend, regional monsoon variations have been recorded. An increasing trend of monsoon season rainfall has been found along the west coast, northern Andhra Pradesh, and north western India (+10% to +12% of the normal over the last 100 years) while a decreasing trend of monsoon seasonal rainfall has been observed over eastern Madhya Pradesh, North-eastern India and some parts of Gujarat and Kerala (6 to 8% of the normal over the last 100 years) (Kumar and Singh, 2011; Singh and Kumar, 2016).

Rainfall trends in response to climate change and probability analysis have been studied by various researchers (Jayawardene *et al.*, 2005; Parta and Kahya, 2006; Kumar and Singh, 2011; Obot *et al.*, 2010; Kumar and Jain, 2010; Manikandan and Tamilmani, 2012; Manivannan *et al.*, 2016; Mohanty *et al.*, 2000) and they have emphasized that the knowledge of location specific rainfall variations is essential for proper water harvesting and water management practices.

A comprehensive knowledge of the trend and persistence in rainfall of the area is great importance because of economic implications of rain sensitive operations (Sharma *et al.*, 2015; Sharma and Dubey, 2013; Jakhar *et al.* (2011). Keeping above in view, the present study has been conducted to analyze rainfall trend of long-term historical data of Agra district of Uttar Pradesh using parametric and non-parametric approaches.

2. Materials and method

This study was conducted at ICAR - Indian Institute of Soil and Water Conservation (ICAR-IISWC), Research Centre, Agra located between 27° 10" north latitude and 78°02" east longitude at 168 m above mean sea level. Climate of the region is characterized as semi-arid with average annual rainfall around 650 mm. Temperature ranges from 48.3 °C in the month of May - June to -0.4 °C during December - January.

2.1. Rainfall data

Daily rainfall data of 51 years for the period 1965 to 2015 were collected from the meteorological observatory at research farm of ICAR-IISWC, research centre, Chhalesar, Agra, Uttar Pradesh. Monthly, seasonal, viz., kharif (June - September), *rabi* (October - February) and summer (March - May) and annual rainfall data were computed from daily rainfall data. The trend of annual, seasonal and monthly rainfall data were also worked out. Statistical parameters such as mean, median, standard deviation, range, coefficient of variation, skewness and kurtosis of these rainfalls were also calculated.

2.2. Trend analysis

2.2.1. Mann - Kendall test

The trend analysis and estimation of Sen's slope are done using Kendall (1975) and Sen's (1968) method, respectively for the given data sets. Mann - Kendall test is a non-parametric test for finding trends in time series. This test compares the relative magnitudes of data rather than data values themselves (Gilbert, 1987). The benefit of this test is that data need not to conform any particular distribution. In this test, each data value in the time series is compared with all subsequent values. Initially the Mann - Kendall statistics (S) is assumed to be zero, and if a data value in subsequent time period is higher than a data value in previous time period, S is incremented by 1 and *vice versa*. The net result of all such increments and decrements gives the final value of S . The Mann - Kendall statistics (S) is given as:

$$S = \sum_{j=1}^{n-1} \sum_{i=j+1}^n \text{Sign}(X_j - X_i)$$

where,

$$\text{sign}(x_j - x_k) = 1,$$

$$\text{if } (x_j - x_k) > 0; 0,$$

$$\text{if } (x_j - x_k) = 0; -1,$$

$$\text{if } (x_j - x_k) < 0.$$

Positive value of S indicates an increasing trend, and a negative value indicates a decreasing trend. However, it is necessary to perform the statistical analysis for the significance of the trend. The test procedure using the normal - approximation test is described by Kendall (1975). This test assumes that there are not many tied values within the data set. The variance (S) is calculated by the following equation:

$$\text{Var}(S) = \frac{1}{18} [n(n-1)(2n+5) - \sum_{p=1}^g t_p(t-1)(2t+5)]$$

where, n is the number of data points, g is the number of tied groups and t_p is the number of data points in the p^{th} group.

The normal Z - statistics is computed as:

$$Z = (S-1)/\sqrt{\text{Var}(S)}, \text{ if } S > 0$$

$$Z = 0, \text{ if } S = 0$$

TABLE 1
Statistical properties of monthly rainfall at gauging station, Agra (1965-2015)

Rainfall/Rainy days series	Mean (mm)	Median (mm)	Minimum (mm)	Maximum (mm)	SD	CV	Skewness	Kurtosis
Jan	10.28	4.80	0.00	61.40	12.80	1.24	1.67	3.76
Feb	12.67	5.40	0.00	64.40	16.26	1.28	1.51	1.70
Mar	9.59	1.60	0.00	85.20	16.90	1.76	2.73	8.49
Apr	7.55	0.50	0.00	56.70	14.09	1.87	2.40	5.18
May	16.17	8.40	0.00	89.10	21.04	1.30	1.69	2.45
Jun	65.68	36.90	1.40	372.60	73.63	1.12	2.32	6.78
Jul	199.05	178.10	29.60	542.30	115.96	0.58	0.83	0.45
Aug	210.40	213.50	0.00	456.30	118.26	0.56	0.27	0.79
Sep	101.26	81.60	0.00	308.50	77.41	0.76	0.81	0.00
Oct	28.38	7.80	0.00	163.20	42.19	1.49	1.76	2.52
Nov	4.83	0.00	0.00	60.00	13.10	2.71	3.04	9.00
Dec	5.70	0.00	0.00	57.30	11.53	2.02	3.00	9.93

TABLE 2
Statistical properties of annual and seasonal rainfall and rainy days at Agra (1965-2015)

Rainfall/Rainy days series	Mean (mm)	Median (mm)	Min (mm)	Max (mm)	SD	CV	Skewness	Kurtosis
Annual R*	671.58	658.5	241.4	1235.1	213.41	0.32	0.43	0.13
Kharif R	576.39	592.7	192.4	1103.7	205.27	1.24	0.27	0.22
Rabi R	61.76	57.3	0	204.5	44.61	1.36	1.31	2.18
Summer R	35.59	26.6	0	144.7	33.25	1.33	1.58	2.87
Annual RD**	37.80	36.00	15	55	9.28	24.54	0.19	-0.67
Kharif RD	28.98	28.00	10	46	8.43	29.10	0.16	-0.64
Rabi RD	4.16	4.00	0	9	2.27	54.51	0.19	-0.38
Summer RD	2.78	2.00	0	9	2.11	75.79	0.79	0.42

*R- Rainfall, **RD-Rainy days

$$Z = (S+1)/\sqrt{\text{Var}(S)}, \text{ if } S < 0$$

The trend said to be decreasing if Z is negative and the computed Z - statistics is greater than the z - value corresponding of the 5% level of significance. The trend is said to be increasing if the Z is positive and the computed Z - statistics is greater than the z - value corresponding to the 5% level of significance. If the computed Z - statistics is less than the z - corresponding of the 5% level significance, there is no trend.

2.2.2. Sen's slope estimator

Simple liner regression is one of the most widely used model to detect the linear trend. However, this

method require the assumption of normality of residuals (McBean and Motiee, 2008). Viessman *et al.* (1989) reported that many hydrological variable exhibit a marked right skewness partly due to influence of natural phenomena and do not follow a normal distribution, the Sen (1986) slope estimator is found to be a powerful tool to develop the linear relationships. Sen's slope has the advantage over the regression slope in the sense that it is not much affected by gross data errors and outliers. The Sen's slope is estimated as the median of all pair - wise slopes between each pair of points in the dataset (Sen, 1968). Each individual slope (m_{ij}) is estimated using the following equation:

$$m_{ij} = (Y_j - Y_i) / (j - i)$$

TABLE 3

Regression analysis of monthly rainfall at Agra (1965-2015)

Months	Slope of regression	R ²
Jan	-0.191	0.047
Feb	0.146	0.017
Mar	0.361	0.073
Apr	0.072	0.005
May	0.171	0.014
Jun	0.017	0.000
Jul	-0.225	0.000
Aug	-2.93	0.136
Sep	-0.541	0.010
Oct	0.129	0.002
Nov	-0.124	0.025
Dec	0.164	0.036

TABLE 4

Regression analysis of seasonal and annual rainfall and rainy days at Agra (1965-2015)

Annual/Seasonal	Slope of regression	R ²
Annual R	-3.165	0.048
KharifR	-3.688	0.071
RabiR	0.124	0.001
SummerR	0.605	0.073
Annual RD	-0.116	0.033
KharifRD	-0.161	0.081
RabiRD	-0.011	0.006
SummerRD	0.019	0.018

where,

$I = 1$ to $n-1$, $j = 2$ to n , Y_j and Y_i are data values at time j and I ($j > i$), respectively. If there are n values of Y_j in the time series, there will be $N = n(n-1)/2$ slope estimates. The Sen's slope is the median slope of these N values of slopes. The Sen's slope is:

$$m = m_{\{N+1/2\}}, \text{ if } n \text{ is odd.}$$

$$m = 1/2 (m_{\{N/2\}} + m_{\{N+2/2\}}), \text{ if } n \text{ is even.}$$

Positive Sen's slope indicates rising trend while negative Sen's indicating falling trend.

TABLE 5

Mann-Kendall trend analysis of monthly rainfall at Agra (1965-2015)

Rainfall/rainy days series	z-Statistics _{comp}	Trend	Trend at 5% significance level
Jan	1.00	Rising	No
Feb	0.42	Rising	No
Mar	0.05	Rising	No
Apr	0.60	Rising	No
May	1.44	Rising	Yes
Jun	0.42	Rising	No
Jul	-0.32	Falling	NO
Aug	-2.60	Falling	Yes
Sep	-0.78	Falling	No
Oct	-0.38	Falling	No
Nov	0.00	No Trend	No
Dec	0.00	No Trend	No

2.2.3. Linear regression analysis

Linear regression analysis is a parametric model and one of the most commonly used methods to detect a trend in a data series. This model develops a relationship between two variables (dependent and independent) by fitting a linear equation to the observed data. The data is first checked whether or not there is relationship between the variables of interest. This can be done by using the scatter plot. If there appears no association between the two variables, linear regression model will not prove a useful model. A numerical measure of this association between the variables is the correlation coefficient, which range between -1 to +1. A correlation coefficient value of ± 1 indicates a perfect fit. A value near zero means that there is a random, nonlinear relationship between the two variables. The linear regression model is generally described by the following equation:

$$Y = mX + C$$

where, Y is the dependent variable, X is the independent variable, m is the slope of the line and C is the intercept constant. The coefficient (m and C) of the model are determined using the least - squares method, which is the most commonly used method. The t -test is used to determine whether the linear trends are significantly different from zero at the 5% significance level.

TABLE 6

Sen's slope estimator of monthly at Agra (1965-2015)

Rainfall series	Sen's slope	Trend	Confidence limits for slope at 5% significance level	Regression slope
Jan	0.000	No Trend	Lower limit = 0.000; Upper limit = 0.205	-0.191
Feb	0.000	No Trend	Lower limit = -0.114; Upper limit = 0.190	0.146
Mar	0.000	No Trend	Lower limit = -0.034; Upper limit = 0.070	0.361
Apr	0.000	No Trend	Lower limit = 0.000; Upper limit = 0.015	0.072
May	0.085	Rising	Lower limit = 0.000; Upper limit = 0.344	0.171
Jun	0.153	Rising	Lower limit = -0.638; Upper limit = 0.953	0.017
Jul	-0.265	Falling	Lower limit = -2.640; Upper limit = 1.812	-0.225
Aug	-3.162	Falling	Lower limit = -5.594; Upper limit = -0.881	-2.938
Sep	-0.661	Falling	Lower limit = -2.119; Upper limit = 0.634	-0.541
Oct	0.000	No Trend	Lower limit = -0.182; Upper limit = 0.052	0.129
Nov	0.000	No Trend	Lower limit = -0.000; Upper limit = 0.000	-0.124
Dec	0.000	No Trend	Lower limit = 0.000; Upper limit = 0.000	0.164

3. Results and discussion

3.1. Rainfall and rainy days analysis

The average annual rainfall (51 years) of the region was 671.58 mm which ranged from 241.40 to 1235.1 mm. It was estimated that about 86.6% of annual rainfall received during monsoon season (June to September). The average seasonal rainfall during *kharif*, *rabi* and summer were worked out to be 576.39 mm (85.55%), 61.76 mm (9.16%) and 35.59 mm (5.29%) respectively. Mean, median, range, standard deviation (SD), coefficient of variation, skewness and kurtosis for monthly, seasonal and annual were computed and given in (Tables 1&2). It is clear from the table that CV of rainfall is lower during *kharif* (33.41%) followed by the *rabi* (67.86%) and summer (77.84%) season rainfall. It showed that more uniform rainfall received during *kharif* season results in assured crop growth without any supplemental irrigation. However, during *rabi* and summer, farming needs assured irrigation. The skewness data for monthly rainfall varied from 0.27 to 3.04. The monthly rainfall data showed positive skewness and shows that the data are right skewed. The Kurtosis of monthly rainfall varied from 0.00 to 9.93. Positive kurtosis shows a peaked distribution that means monthly rainfall data had peaked distribution during monsoon period (Table 1). Similarly, skewness and kurtosis data of annual and seasonal time series showed positive data.

The average annual rainy days was found to be 37.8 and ranged between 15 to 55 days. Out of these, 28.98

rainy days occurred during monsoon season and 4.16 and 2.78 were respectively in *rabi* and summer season. The mean, median, range, SD, coefficient of variation, skewness, kurtosis of rainy days presented in Table 2 that showed high variability in *rabi* and summer season than the *kharif* season. The skewness data of rainy days varied from 0.16 to 0.79 and are right skewed. The Kurtosis data varied from -0.38 to 0.42 and showed peaked (positive kurtosis value) and flat distribution (negative kurtosis value).

The monthly, seasonal and annual variation of rainfall during the years is presented in Table 3. It is revealed that rainfall of June month is showing increasing trend whereas month of July, August and September showing decreasing trend of monthly rainfall. The regression slope of August month rainfall was found very high which showed significant reduction in rainfall. From monthly rainfall of *rabi* season it is clear that months of October, December and February has showed increasing trend whereas November and January decreasing trend of monthly rainfall. Similarly summer month's rainfall showed that in all months from March, April and May the rainfall was increasing trend. This is something interesting to note for planning soil and water conservation measure including water harvesting and also for planning irrigation to summer crops. The time series data of seasonal and annual rainfall are presented in Table 4 and it showed that annual and *kharif* (monsoon) rainfall is decreasing over the year whereas *rabi* and summer season rainfall showed increasing trend. The regression slope of annual and monsoon rainfall are almost close and have same pattern.

TABLE 7

Mann-Kendall trend analysis of annual and seasonal rainfall and rainy days at Agra (1965-2015)

Rainfall/rainy days series	z-Statistics _{comp}	Trend	Trend at 5% significance level
Annual R	-1.41	Falling	No
Kharif R	-1.66	Falling	Yes
Rabi R	-0.26	Falling	No
Summer R	1.26	Rising	No
Annual RD	-1.06	Falling	No
Kharif RD	-1.69	Falling	Yes
Rabi RD	-0.52	Falling	No
Summer RD	0.83	Rising	No

TABLE 8

Sen's slope estimator of annual and seasonal rainfall and rainy days at Agra (1965-2015)

Rainfall series	Sen's slope	Trend	Confidence limits for slope at 5% significance level	Regression slope
Annual R	-3.092	Falling	Lower limit = -7.191; Upper limit = 1.0009	-3.165
Kharif R	-3.756	Falling	Lower limit = -7.551; Upper limit = 0.517	-3.688
Rabi R	-0.092	Falling	Lower limit = -0.827; Upper limit = 0.687	0.124
Summer R	0.313	Rising	Lower limit = -0.152; Upper limit = 0.854	0.605
Annual RD	-0.098	Rising	Lower limit = -0.286; Upper limit = 0.091	-0.116
Kharif RD	-0.167	Rising	Lower limit = -0.333; Upper limit = 0.020	-0.161
Rabi RD	0.000	No Trend	Lower limit = -0.057; Upper limit = 0.023	-0.011
Summer RD	0.000	No trend	Lower limit = 0.000; Upper limit = 0.056	0.019

Similarly time series data of annual and seasonal rainy days (Table 4) showed that there was decreasing trend in annual, monsoon and *rabi* season rainy days whereas increasing trend was found in summer rainy days.

3.2. Trend analysis

The results of Mann-Kendall analysis of monthly rainfall series are presented in Table 5. The positive Z value indicates rising trend and vice versa. It can be seen from the table that in some cases there was rising trend and in some cases rainfall is falling. The computed z-statistics is less than the z value (1.36) in most cases that means that there was no significant rising or falling trend in those monthly rainfall during the period of study. The trend of monthly rainfall in May and August is showing significant rising and falling trend respectively. The magnitude of trend of monthly rainfall was calculated using Sen's slope estimator and presented in Table 6. A positive slope mean rising trend whereas negative gives

falling trend. The zero slope means no trend in the rainfall series. It can be seen from the table that out of twelve month, in seven monthly no trend was detected in monthly rainfall. Interestingly May and June months i.e summer rain is showing rising trend whereas July, August and September, i.e., monsoon rainfall showing falling trend. Out of that month of August which is crucial monsoon month for this region for *kharif* crop point of view is showing falling trend with high magnitude. It means there need to be a planning of harvesting of July month rainfall for recycling as life saving irrigation to *kharif* crops during dry spell expected during the month of August. Linear regression analysis was also carried out for monthly rainfall series and data of regression slopes are presented in Table 4. Linear regression also gave similar trend as given by Mann-Kendall except for the month of January, October, November and December.

The results of Mann-Kendall analysis of annual and seasonal rainfall and rainy days are presented in Table 7.

The positive Z value indicates rising trend and vice versa. It can be seen from the table that in some cases there was rising trend and in some cases rainfall and rainy days both are falling. The computed z -statistics is less than the z value (1.56) in most cases that means that there was no significant rising or falling trend during the period of study. The trend of annual rainfall at Agra is having falling trend but not significant at 5% significance level. Among seasonal rainfall, monsoon and *rabi* season rainfall is showing falling trend whereas summer season rainfall giving rising trend. The falling trend of monsoon (*kharif* season) rainfall is found to be significant at 5% significance level. Similarly, the trend of annual rainy days at Agra is having falling trend but not significant at 5% significance level. Among seasonal rainy days, monsoon and *rabi* season rainy days is showing falling trend whereas summer season rainy days giving rising trend. The falling trend of monsoon (*kharif* season) rainy days are found to be significant at 5% significance level.

The magnitude of trend of annual and seasonal rainfall and rainy days was calculated using Sen's slope estimator and presented in Table 8. A positive slope mean rising trend whereas negative gives falling trend. The zero slopes mean no trend in the rainfall and rainy days series. It can be seen from the table that only summer rainfall is having rising trend and other series are showing falling trend. No trend was detected in the *rabi* season and summer season rainy days. Linear regression analysis was also carried out for these time series and data of regression slopes are presented in Table 6. Linear regression also gave similar trend as given by Mann-Kendall except *rabi* season rainfall.

3.3. Crop planning for rainfed condition

Test of significance (t -test) at 5% significance level was carried out on the regression slopes for the cases studied. The falling trend of August month rainfall and rising trend of March and May month rainfall was found to be significant when analyzed the trend of monthly rainfall in Agra region. Moreover, annual and monsoon season rainfall and rainy days were also found to be decreasing at 5% significant level when data were analyzed on seasonal basis. In all other cases, no significant rising or falling trend was detected. Study revealed that month of August is very critical for *Kharif* crop point of view in this region and rainfall of this particular month is decreasing significantly, hence there is need to harvest more rainfall of July month through construction of different *in situ* and *ex situ* water conservation and storage structures. This stored water can be useful for providing life saving irrigations during long dry spells because the numbers of rainy days were also found to be reduced significantly during monsoon season.

Moreover, farmers need to make some changes in their cropping pattern to cope with changing rainfall pattern like switching over to less water demanding crops, such as pulse, millets etc. Another interesting finding of the study is that the rainfall of month of May has increased significantly, which means that farmers can take more vegetables, fodder crops and summer moong crop during summer season utilizing this very effective May month rainfall. Even, rain water can also be harvested during this period for recycling.

4. Conclusions

The Mann - Kendall's analysis indicated that the trend of annual rainfall at Agra is having falling trend but not significant at 5% significance level. Among seasonal rainfall, monsoon and *rabi* season rainfall is showing falling trend whereas summer season rainfall giving rising trend. The falling trend of monsoon (*kharif* season) rainfall is found to be significant at 5% significance level. Similarly, the trend of annual rainy days at Agra is having falling trend but not significant at 5% significance level. Among seasonal rainy days, monsoon and *rabi* season rainy days is showing falling trend whereas summer season rainy days giving rising trend. The falling trend of monsoon (*kharif* season) rainy days are found to be significant at 5% significance level. The regression analysis, however, indicates significant rising trend in rainfall during summer season only, while monsoon rainfall indicates decreasing trend.

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