The Pharma Innovation

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Trend analysis of rainfall and rainy days of Shajapur District in Madhya Pradesh

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Abstract
An understanding of the spatial distribution and changing patterns in rainfall is a basic and important requirement for the planning and management of crop production. The present study examined trends in the monthly, seasonal and annual rainfall and its variability in Shajapur district. A large data set of daily rainfall was used for the study. The monthly, seasonal, annual and decadal trends show a large variability. A significant no trend was found in Shajapur district at 5% level of significance. While in case of seasonal rainfall, Southwest monsoon showed a decreasing trend at 5% level of significance. In case of monthly rainfall trend, only July month showed a significant trend at 5 % level of significance.

Introduction
The climate of a location/region essentially informs us about the types of flora, fauna, and human living circumstances that are possible. On a long-term basis, it is largely regulated by precipitation (rainfall), temperature, humidity, the availability of brilliant sunlight, and wind speed and direction. Furthermore, rainfall and temperature are important criteria for human and crops (Chaudhary and Tomar, 1999 and Sheoran *et al.* (2008) [5, 29], Burlando (1989) [4], Mirza *et al*. (1998) [17]. The present study will aid us in developing a future strategy to deal with any potential rapid changes that may damage humans and crops. Climate change may be linked to general global/universal phenomena or manmade developments.

The more accurate Information about meteorological parameters and their trends are also needed for the formulation of weather model, which will help to improve sustainability of water resource management planning. Agricultural production is not insulated from the vagaries of weather, despite many years of advance and improved micro level planning in the country. The future rainfall trend will have its impact globally and will be felt severely in developing countries with agrarian economies, such as India. So the trend analysis of rainfall will be useful to construct the future scenario of water availability. The trend analysis (Chaudhary and Shashtri (1999) [5], Serrano *et al*. (1999) [27] of the weekly, monthly and annual rainfall data of the region is an attempt to study the rainfall variations (Chaudhary and Shashtri (1999) [5], Osborn *et al.* (2000) [19], Hundal and Kaur (2002) [9] of the selected stations (Soman *et al.* (1988) [33], Krishnamurthy and Shukla (2000) [14], Sinha and Srivastava (2000) [31] which will be useful for forecasting the future temporal and spatial availability of water.

Changes in rainfall trend, variability, amount and its spatial and Seasonal distribution critically modify the river runoff pattern (Singh *et al.* (2008) [30] and regimes soil moisture, (Jain and Kumar, 2012), ground water Reservoirs, frequency of rainfall extremes, including floods and droughts, Cropping pattern and agricultural productivity (Petrow and Merz (2008) [22], Saha and Rao (2008) [24] vegetation 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 (Abbaspour *et al.* (2009)) [1]. The local hydrological, agricultural and economic activities heavilydepend on micro-level rainfallAnalysis of rainfall trends is important for water Resources planning and management.

A time of need or trouble, as in we knew a rainy day would come sooner or later. This idiom is often used in the context of save for a rainy day, which means to put something aside for a future time of need. According to India Meteorological Department (IMD), a rainy day has

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been defined as a day with rainfall of 2.5 mm or more rainfall. IMD further defines that rainfall for a station is called heavy if it is greater than 650 mm and very heavy if it is greater than 1300 mm.

Historical evidences testify that drought and flood had been occurring throughout the globe at certain time period depending upon its magnitude. Higher the magnitude longer is its probability of Occurrence and lower the magnitude, shorter is its probability of repeating. Of late the anthropogenic Activities have been considered to be causing significant change in various climatological parameters. These Changes now termed as "Climate Change" have been assessed to be adversely affecting the human being.One region of the world where the effects of climate change are being felt particularly hard is Africa. Because of the lack of economic, development and institutional capacity, African countries are Likely among the most vulnerable to the impacts of climate change (IPCC 2001) [10].

Shajapur district has a tropical climate. There are four rain gauge stations in Shajapur district Namely Kalapipal, shujalpur, momanbadodiya, and Shajapur itself. The normal rainfall of Shajapur district Is 990 mm. thehighest rainfall i.e. 1896.26 mm received at Shajapur and minimum at Shajapur i.e.602.43mm. july is the wettest month of the year and about 36% of the annual rainfall takes place during this month only. About 92.4% of the annual rainfall takes place during the southwest monsoon period i.e. between june to september. About 6.2% and 1.4% rainfall received during winter and summer season respectively. Hence, only 7.6% of the annual rainfall takes place from october to may months. (ministry of water resources central ground water board north central region Bhopal 2013). When performing long-term trend analysis on hydrological factors, the trends obtained signify the Overall characteristics of the hydrological factors. However, world climate change has created dissimilar Hydrology trends at different time periods. The intersection where two dissimilar trends meet is called a change point. To determine whether change points exist in the long-term data in this study, Pettit test (Arya et al. (2014) [2] commonly used. With these background of information, the present investigation is proposed with to study the trends in the meteorological data (rainfall and rainy days) of the study area, to test the trends in the meteorological data, to study the change point analysis to know the year from which significant change has been occurred for forecasting.

Fig 1: Map of Shajapur district in Madhya Pradesh and India map

Fig 2: Map of Shajapur District

Methodology
Both parametric (regression analysis) and non-parametric statisticalmethods have been used to test the trends in the meteorological data (suchas rainfall and rainy days) of the study area. Non-parametric tests are more suitable for non-normally distributed data in comparison to parametric statistical tests [Lanzante (1996), Jana *et al.* (2015)] [15]. Change point analysis (Salarijazi *et al.* (2012) [25] was also done to know the year from which significant change has beenoccurred.

The most frequently used non-parametric statistical tool (Gajbhiye *et al.*, 2016) [7] for identifyingtrends in hydro-meteorological time series variables such as water quality,stream-flow, temperature and precipitation is the Mann-Kendall (MK) test (Arya *et al.*, 2014) [2]

The statistical significance trend detected using a non-parametricmodel such as Mann-Kendall (MK) test can be complemented with Sen'sslope estimation to determine the magnitude of the trend. The Spearman'srho (SR) test is another rank-based non-parametric statistical test that canalso be used to detect monotonic trend in a time series [Lehmann (1975) and Sneyers (1990)] [16, 32] and Wilcoxon Mann - Whitney step trend analysis.

A trend is a significant change over time exhibited by a random variable. In general, the magnitude of trend in a time series is determined either using regression analysis (parametric test) and Mann - Kendall's test (non-parametric method). Both these methods assume a linear trend in the time series. In this particular study, both the linear regression and Mann- Kendall's test was employed. For study purpose we have to work out trend analysis on annual basis as well as seasonal basis. In meteorological term year is classified into four seasons i.e. southwest monsoon season (June- Sep), Post monsoon season (Oct-Dec), Winter season (Jan-Feb) and summer season (Mar-May).

Linear regression was the first type of regression analysis to be studiedrigorously, and to be used extensively in practical applications. In linearregression, the relationships are modeled using linear predictor functionswhose unknown model parameters are estimated from the data.

Mean rainfall
The amount of rainfall collected by a given rain gauge in 24 hours is known as daily rainfall (mm or cm) and the amount collected in one year in known as annual rainfall. The mean of the annual rainfall over of 31 years (in India) is known as mean annual rainfall (average annual rainfall or normal annual rainfall).

$$\text{Mean annual rainfall} = \frac{\text{Total rainfall}}{\text{Number of years}}$$

Standard Deviation
It is defined as the square root of the mean of the squares of deviations of the rainfall value from the arithmetic mean of all such rainfall. It is a measure of variability or the scatter or the dispersion about the mean value. It is given by the following formula.

$$SD = \sqrt{\frac{\sum_{i=1}^{n}(X_i - \overline{X})^2}{n-1}}$$

Where,
X_i= rainfall frequency
$\overline{X}$= mean rainfall

n= numbers of year

Variability analysis (Coefficient of variation)
Assessment of rainfall variability through Coefficient of variation (CV %) appears to be simple. CV is defined as the Standard deviation divided by the mean value of rainfall. It shows the variability of rainfall in percentage.

$$CV = \frac{\sigma}{\overline{X}} \times 100 \%$$

The greater the CV, the lesser the dependability of receiving rainfall. Considering the annual CV, the IMD is using the following criteria for assessing the rainfall in a particular area.
Normal = - 19 to 19 % of annual normal rainfall.
Deficit = - 20 to - 59 % of annual normal rainfall.
Scarce = - 60 % and above of annual normal rainfall

A trend is a significant change over time exhibited by a randomvariable. In general, the magnitude of trend in a time series is determinedusing regression analysis (parametric test) and Mann – Kendall's test(non-parametric method). Both these methods assume a linear trend in thetime series. In this particular study, only non – parametric test will be used.
Non – Parametric test are given below.

Non- parametric trend test
1. Mann- Kendall test
2. Sen's Slope test
3. Spearman's rho test

Mann-Kendall Analysis
The Mann-Kendall test is a non-parametric test for identifying trendsin time series data. The test compares the relative magnitudes of sampledata rather than the data values themselves (Gilbert, 1987) [8]. One benefit ofthis test is that the data need not conform to any particular distribution.
This hypothesis test is a non-parametric, rank - based method forevaluating the presence of trends in time-series data. The initial value of theMann-Kendall statistic, S is assumed to be 0 (e.g., no trend). If a data valuefrom a later time period is higher than a data value from an earlier timeperiod, S is incremented by 1. On the other hand, if the data value from alater time period is lower than a data value sampled earlier, S isdecremented by 1. The net result of all such increments and decrementsyields the final value of S. Then the Mann-Kendall statistic (S) is given as:

$$S = \sum_{i=1}^{n-1} \sum_{j=1}^{n} \text{sgn}(x_j - x_i)$$

Where S is the Mann-Kendall's test statistics;

x_i and x_j are the sequential data values of the time series in the years i and j (j>i) and 'n' is the length of the time series.
A positive (S) value indicates an increasing trend and a negative value indicates a decreasing trend in the data series.
The sign function is given as:

$$\text{Sgn}(x_j - x_i) = \begin{cases} +1 \text{ if } (x_j - x_i) > 0 \\ 0 \text{ if } (x_j - x_i) = 0 \\ -1 \text{ if } (x_j - x_i) < 0 \end{cases}$$

The variance of S, for the situation where there may be lies (that is equal values) in the x values, is given by:

$$V(s) = \frac{n(n-1)(2n+5) - \sum_{p=1}^{g} t_p(t_p - 1)(2t_p + 5)}{18}$$

Where,
g = Number of tied groups,
t_p = Number of data values in the pth group.
n = Number of years data.
For (n) larger than 10, approximates the standard normal distribution and computed as follows:

$$Z_{mk} = \begin{cases} \dfrac{S-1}{\sqrt{\text{var}(s)}}; \text{if } S > 0 \\ 0 \ ; \text{if } S = 0 \\ \dfrac{S+1}{\sqrt{\text{var}(s)}} \ ; \text{if } S < 0 \end{cases}$$

The presence of a statistically significant trend is evaluated using the Z_{MK} value. Z_{MK} follows the standard normal distribution [Kendall (1975)]. A positive/negative value of Z indicates an upward/downward trend. In a two-sided test for trend, the null hypothesis H_o should be accepted if $Z_{mk} < Z_{(1-\alpha)/2}$ at a given level of significance. $Z_{(1-\alpha)/2}$ is the critical value of Z_{mk} from the standard normal table. The hypothesis of no trend is rejected if $|Z| > Z_{(1-\alpha)/2}$, Where Z is taken from the standard normal distribution table and α is level of significance [Barnard(1947)] [3].

Sen's slope
The magnitude of slope of trend is estimated using the approach described by Sen (1968). The Sen's slope estimator is a 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 test computes 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:

$$\text{Median } (d_k) = \frac{(x_j - x_i)}{(j - i)}, \text{for}(1 \leq i < j \leq n),$$

Where,
d = is the slope,
X = denotes the variable,
n = is the number of data, and
i, j = are indices

Sen's slope is then calculated as the median from all slopes:
b=median (d_k).

Where,
b= is estimate of the slope of trend and
X_i= is the jth observation.

A positive value of b indicates an upward trend. Whereas a negative value represents a downward trend.
The intercepts are computed for each timestep "t" as given by:

$a_t = X_t - b \times t$

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-meteorological time series, the SR test is seldom used in hydro-meteorological trend analysis. SR test is another non-parametric rank-order test. Given a sample data set {xi, i =1, 2,…, n}, the null hypothesis H0 of the SR test against trend tests is that all the xi are independent and identically distributed; the alternative hypothesis is that xi increases or decreases with i, that is, trend exists. The test statistic is given by (Sneyers, 1990) [32]

$$D = 1 - \frac{6 \sum_{i=1}^{n} [R(x_i) - i]^2}{n(n^2 - 1)}$$

Where, $R(x_i)$ is the rank of ith 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:

E(D)=0

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

Pettitt'stest
The approach of Pettitt (1979) [23] is commonly applied to detect a single change – point in hydrological series or climate series with continous data. It test the H0 : The T variables follow one or More distributions that have the same location parameter (no change), against the alternative; a change point exists.
The Pettitt't test is a non-parametric test, meaning that its application requires no assumption about the distribution of data. This test provides assessment of the null hypothesis (H_0) implying that the data are homogeneous throughout the period of observation, i.e. that the data have been obtained from a single or several distribution with the same local parameters (average values). The alternative hypothesis (H_1) implies presence of a non-accidental component among data causing a shift of the location parameter at a particular moment.
This method detects a significant change in the mean of a time series, when the exact time of the change is unknown.
The non-parametric statistics is defined as :

$K_t = \max |U_t, T|$

$$U_t, T = \sum_{i=1}^{t} \sum_{j=t+1}^{T} \text{sgn} (x_j - x_i)$$

For t= 1,2,……….,T

$$\text{Sgn}(X_j - X_i) = \begin{cases} +1 \text{ if } (X_j - X_i) > 0 \\ 0 \text{ if } (X_j - X_i) = 0 \\ -1 \text{ if } (X_j - X_i) < 0 \end{cases}$$

The test statistics counts the number of times a member of the first sample exceeds a member of second sample. The null hypothesis of the Pettitt's test is the absence of change point. The test statistics K_T and associated probability (P) used in the test are given as:

$$P \cong 2exp\left\{\frac{-6K^2}{T^3 + T^2}\right\}$$

years of rainfall and rainy days data. The results obtained are discussed in the light of relevant literature under the following heads.

Results
This chapter deals with the result obtained from analysis of 31

Table 1: Monthly rainfall and rainy days statistics for the period (1990-2020) of Shajapur district of Madhya Pradesh

Month/Period	Mean monthly rainfall (mm) (1990-2020)			Mean monthly rainy days (1990-2020)		
	Mean(mm)	CV (%)	Contribution (%)	Mean (mm)	CV (%)	Contribution (%)
JAN	6.40	195.79	0.65	1	177.12	1.03
FEB	5.02	192.00	0.51	0	198.74	0.81
MAR	6.09	240.73	0.61	1	212.21	0.97
APR	2.37	156.39	0.24	0	212.75	0.59
MAY	5.98	192.21	0.60	1	215.71	1.41
JUN	117.82	63.97	11.90	10	45.16	16.50
JUL	331.66	40.82	33.50	17	25.18	28.12
AUG	320.97	51.28	32.42	16	28.38	27.53
SEP	157.48	80.84	15.90	10	62.59	17.52
OCT	20.96	133.79	2.12	2	120.09	3.19
NOV	8.38	222.95	0.85	1	258.96	1.35
DEC	6.88	325.82	0.70	1	265.97	0.97
ANNUAL	990.03	63.02	100	60	53.03	100
MONSOON	831.08	54.79	83.94	45	38.89	76.37
PRE-MONSOON	132.26	79.56	13.36	12	70.95	19.47
WINTER	26.69	237.16	2.70	3	228.67	4.16

The standard deviation (SD) and coefficient of variation (CV) of the monthly rainfall and rainy days indicate high degree of variability associated in the monthly rainfall and rainy days in all the months.

Table showed the mean, CV % contribution (%) of rainfall and rainy days. The average annual rainfall of Shajapur district in Madhya Pradesh for 31 years from 1990-2020 was 990.03mm, and 63.02was CV and contribution 100% and their corresponding % contribution respectively. Monthly average rainfall was, were maximum (331.66mm) in the month of July and minimum (2.37mm) in the month of April. In case of seasonal rainfall, their values for monsoon, pre-monsoon and winter were 831.08, 132.26and 26.69mm respectively. The CV and % contribution value for seasonal rainfall were 54.79, 79.56 and 237.16 while % contribution 83.94, 13.36 and 2.70respectively for monsoon, pre-monsoon and winter.

The monsoon season contributes maximum to annual rainfall in the districts. More rainfall occurs in the south-west monsoon(June, July, August and September) while other months also contributes to average annual rainfall but their contributions was least with respect to amount of rainfall.

Table also showed the mean, CV, % contribution value of rainy days. The average annual rainy days of Shajapur district in Madhya Pradesh for 31 years from 1990-2020 was 60 days and 53.03 was CV and their corresponding contribution (100%) respectively. Monthly average rainy days were maximum (17 days) in the month of July and minimum in the month of February and April. In case of seasonal rainy days, their values for monsoon, pre-monsoon and winter were 45, 12 and 3 days respectively. The CV and % contribution value for seasonal rainfall were 38.89, 70.95 and 228.67while % contribution value was 76.37, 19.47and 4.16 respectively for monsoon, pre-monsoon and winter. The monsoon season contributes maximum to annual rainy days in the districts. More rainy days occurs in the south-west monsoon (June, July, August and September) while other months also contributes to average annual rainy days but their contributions was least with respect to amount of rainfall.

Trend analysis of monthly rainfall
The rainfall and rainy days data set of Shajapur district for the period from 1990-2020 have been divided in three time series to know the trend of rainfall and rainy days of two different time series and also compare the trend so; (i) for the period of 1990-2020; (ii) for the period of 1990-2005; (iii) for the period of 2006-2020 and have been analyzed separately.

Table 2: Trend analysis of monthly rainfall

Month/Period	1990-2020				1990-2005				2006-2020			
	MK	SR	Reg.	SS	MK	SR	Reg.	SS	MK	SR	Reg.	SS
JAN	0.06	0.03	0.18	0.00	0.19	0.31	0.52	0.02	0.10	0.16	0.52	0.00
FEB	0.05	0.04	0.02	0.00	0.05	0.09	0.41	0.00	0.13	0.18	0.03	0.00
MAR	0.07	0.11	0.21	0.00	-0.09	-0.10	0.02	-0.00	-0.10	-0.10	-1.35	-0.06
APR	0.10	0.21	0.04	0.01	0.05	0.08	0.18	0.00	-0.15	-0.17	0.09	-0.05
MAY	0.03	0.06	-0.23	0.00	0.04	0.05	-0.11	0.00	-0.41*	-0.54*	-1.28*	-0.26*
JUN	0.11	0.27	1.90	1.86	0.02	0.01	-0.40	0.93	0.18	0.35	6.11	7.38
JUL	0.17	0.16	3.11	2.75	-0.05	-0.07	-2.26	-2.31	0.12	0.15	2.64	5.55
AUG	0.05	0.19	2.08	1.20	-0.32	-0.40	-12.09	-15.25	0.24	0.27	9.44	16.43
SEP	0.01	0.06	1.41	0.25	-0.05	-0.11	-3.64	-2.83	0.01	0.04	7.30	0.25
OCT	-0.05*	-0.03*	-0.12*	-0.02*	-0.03	-0.04	-0.01	-0.03	0.02	0.03	-0.03	0.00
NOV	-0.16	-0.14	0.01	-0.00	-0.35	-0.55*	-0.33	-0.17	-0.28	-0.44	-1.92	-0.06

| DEC | 0.11 | 0.18 | -0.33 | 0.00 | 0.02 | -0.04 | -0.50 | 0.00 | 0.09 | 0.11 | -0.08 | 0.00 |

Here:
MK= Mann-Kendall test,
SR= Spearman's rho test,
SS= Sen's slope
Reg.= Regression Analysis

It is interesting to observe that when the analysis is made separately then in the month of September for the period 1990-2020 the value is negative, for the period 1990-2005 the value is positive and for the period 2006-2020again value is positive but they show downward trend for the period 1990-

2020, upward trend for the period 1990-2005 and again show upward trend.
In the above table we can observe easily that in month of July all values are negative it means that they show downward trend.
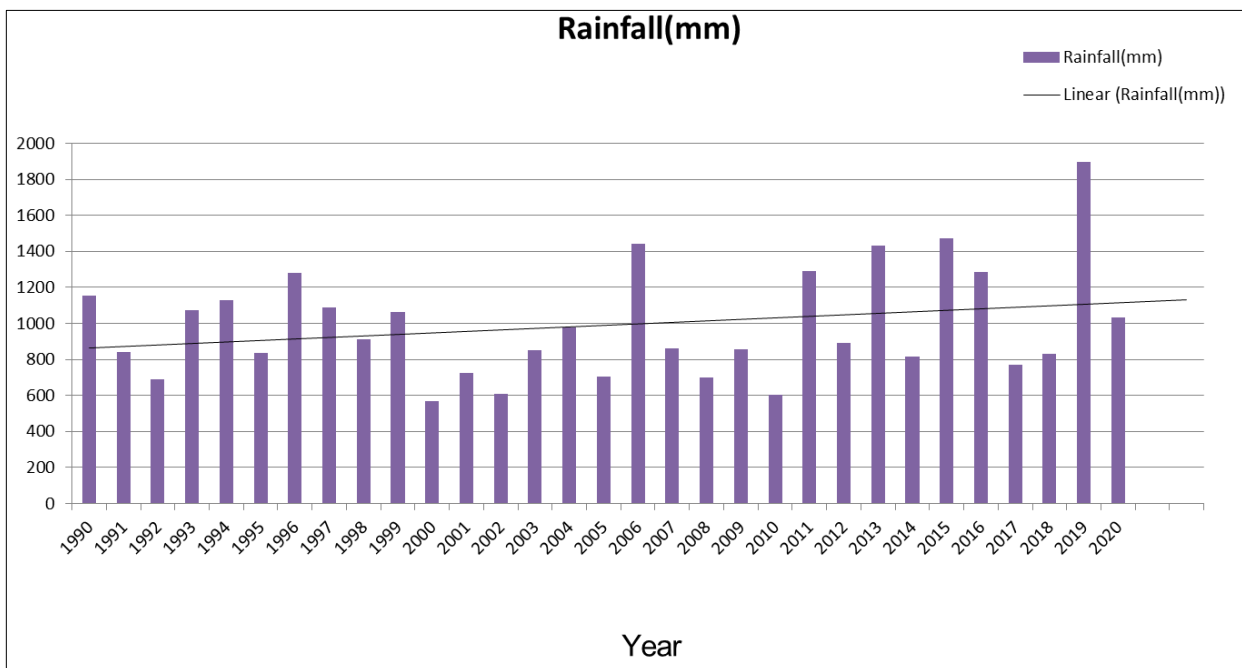

Fig 3: Annual rainfall trend of Shajapur (Madhya Pradesh)

Table 3: Trend analysis of monthly rainy days

Month/Period	1990-2020				1990-2005				2006-2020			
	MK	SR	Reg.	SS	MK	SR	Reg.	SS	MK	SR	Reg.	SS
JAN	0.10	0.15	0.02	0.00	0.20	0.29	0.09	0.00	0.21	0.28	0.05	0.00
FEB	-0.06	-0.08	0.00	0.00	0.07	0.08	0.04	0.00	-0.03	-0.06	0.00	0.00
MAR	0.12	0.15	0.02	0.00	0.10	0.14	0.03	0.00	-0.11	-0.14	-0.07	0.00
APR	0.08	0.11	0.01	0.00	0.11	0.16	0.04	0.00	0.04	0.05	0.01	0.00
MAY	-0.17	-0.22	-0.04	0.00	0.06	0.09	-0.03	0.00	-0.33	-0.43	-0.20	0.00
JUN	0.11	0.18	0.09	0.08	-0.03	-0.06	0.01	0.00	0.21	0.35	0.41	0.39
JUL	0.14	0.18	0.05	0.08	0.06	0.08	-0.05	0.00	-0.05	-0.11	-0.23	0.00
AUG	0.09	0.13	0.05	0.07	-0.40	-0.53*	-0.57	-0.56	0.19	0.31	0.23	0.21
SEP	0.04	0.06	0.02	0.04	0.00	-0.02	-0.05	0.00	0.07	0.08	0.25	0.10
OCT	-0.05	-0.09	-0.03	0.00	0.09	0.07	0.07	0.00	0.10	0.13	0.09	0.00
NOV	0.07	0.08	-0.01	0.00	-0.21	-0.28	-0.04	0.00	-0.14	-0.22	-0.11	0.00
DEC	0.01	0.02	-0.02	0.00	-0.25	-0.33	-0.05	0.00	0.07	0.08	0.00	0.00

Here:
MK= Mann-Kendall test,
SR= Spearman's rho test,
SS= Sen's slope
Reg.= Regression Analysis

Trend analysis was done for three different time period and it is observed that in the month of September, for the period 1990-2020, it was upward trend but in the 1990-2005,trend are first upward than downward and 2006-2020 trends are first downward than upward. In the month of June from 1990-2020 values are negative and October for 1990-2020all statistics test value are positive. It means significantly upward

trends are found. In the month of August all statistics test values are positive they show upward trend.
Annual rainy days trend was shown in figure. This indicate that the district showed increasing trend but it is not significant at 5% level of significance so it is considered as stable Rainy days in Shajapur (Madhya Pradesh).
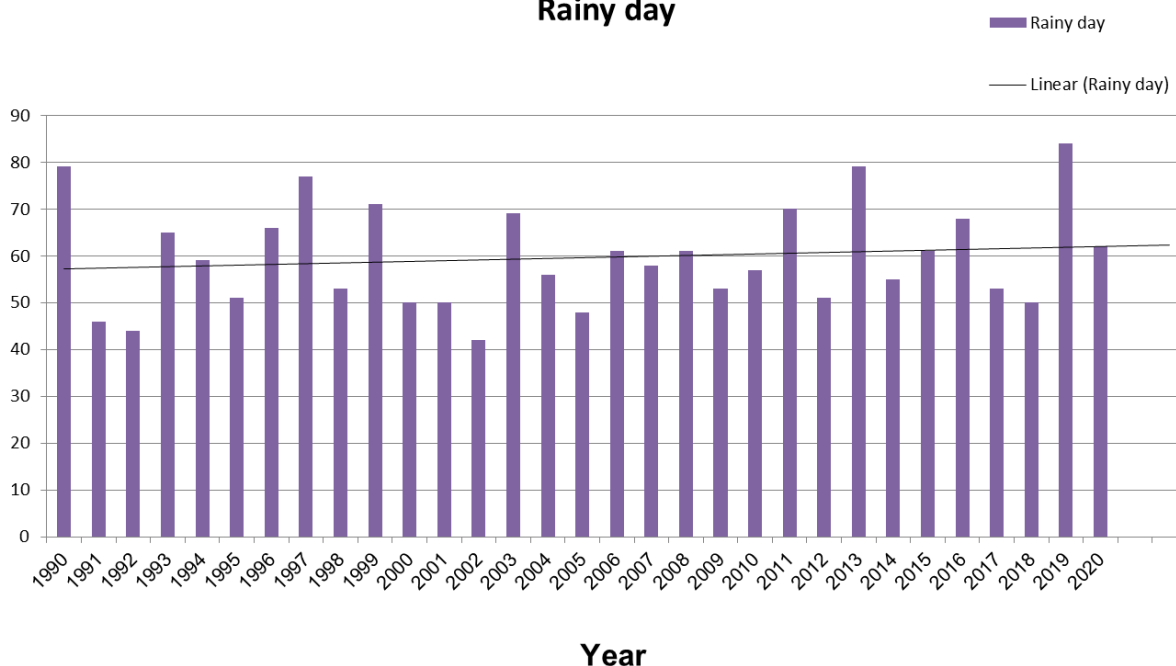
Rainy day

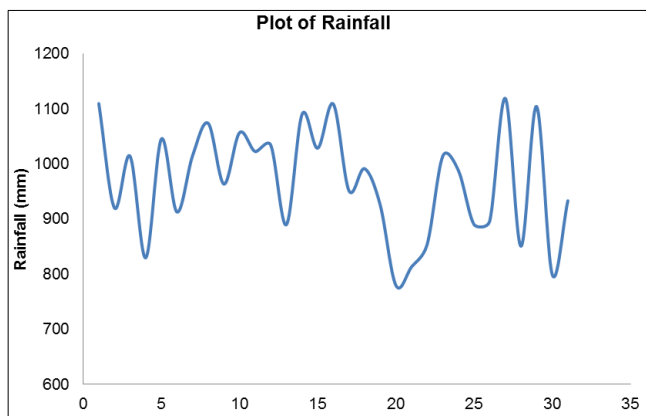**Fig 4:** Annual rainy days trend of Shajapur (Madhya Pradesh)

Fig 5: Pettitt't test for detecting a change in the annual rainfall during the period 1990-2020
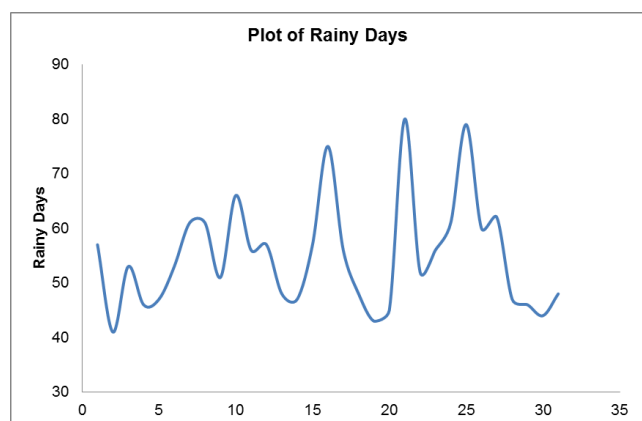

Fig 6: Pettitt't test for detecting a change in the annual rainy days during the period 1990-2020

Change Point Analysis

The Pettitt's test was used to detect changes in annual rainfall and annual rainy days for the period 1990 - 2020. For annual rainfall the calculated value of K is 54 with p=0.413 and for annual rainy days, the calculated value of K is 60 with p=0.718. In the annual rainfall, no change point was detected

for the 31 years and for the annual rainy days, no change point was detected for the 31 years which is observed in fig. 5 and 6 respectively. As the computed p-value is greater than the significance level ∝= 0.05 it means there is a date at which there is a no change in the data.

Table 4: Pettitt's test

	Rainfall	Rainy days
K	54	60
T	2002	2012
p-value	0.413	0.718
∝	0.05	0.05

Discussion

The study of rainfall pattern is very important for the agricultural planning of any region. The detailed rainfall analysis is essential for optimal management of rainwater at various level /uses, like land and crop management and crop planning for any region. The analysis showed the mean, CV, % contribution value of rainfall. The average annual rainfall data of Shajapur district in Madhya Pradeshfor 31 years from 1990– 2020showed990.03 mm, 63.02 and 100 mean annual rainfall, CV and their corresponding % contribution, respectively. Monthly average rainfall, were maximum (331.66mm) in the month of July and minimum (2.37 mm) in the month of April. In case of seasonal rainfall, their values for monsoon, pre- monsoon, and winter were 831.08, 132.26 and 26.69 mm, respectively. The CV value for seasonal rainfall were 54.79, 79.56 and 237.16 while % contribution was 83.94, 13.36 and 2.70, respectively for monsoon, pre-monsoon, and winter. The monsoon season contributes maximum to annual rainfall in the district. More rainfall occurs in the southwest monsoon (June, July, August, and September) while other months also contribute to average annual rainfall but their contribution was least with respect to amount of rainfall. The result of this study also followed same statistical value as reported by Jajoria *et al.* (2015) [12] where they analyzed the daily rainfall data for 39 years (1973- 2011) and found its variability and probability in Udaipur district of

Rajasthan, India. The mean annual rainfall of the area was 630.20 mm and highest (1,145 mm) was recorded in the year 1973 followed by 978 mm in 1983. The contribution from winter, summer/pre-monsoon, monsoon and post-monsoon periods was 1.08, 3.17, 89.89 and 5.86 %, respectively. Rains during June, July, August and September were more helpful to indicate the suitability of crop growing period for profitable crop production. Each standard meteorology week from 26th to 38th receive, a rainfall of above 20 mm, indicating the crop growing period from June 4th week to September 3rd week. The study indicated that the mean annual rainfall was 630.20 mm and monthly mean rainfall was observed to be 14.20, 74.29, 178.52, 212.59, 100.98, 20.51 mm for May, June, July, August, September and October, respectively.

It is interesting to observe that when analysis is made separately then in the month of October for the period 1990-2020 the value is negative, for the period 1990-2005 the value is negative and for the period 2006-2020 again value is positive. It means they show downward trend for the period 1990 – 2020, downward trend for the period 1990-2005 and again show upward trend for the period 2006-2020. The finding of this study is similar as reported by Pandit (2016) [21] where he studied the trend in seasonal rainfall of four rainy months i.e. June, July, August and September of Rahuri, Ahmednagar India. To determine the trend of rainfall, non-parametric Mann-Kendall test and non-parametric Sen's Slope estimator for determination of magnitude of trend were used. From all statistical analysis it was found that there was some change in the trend of rainfall in the rainy months. It is also similar result was reported by Mondal *et al.* (2016) [18] where they analyzed with the changing trend of rainfall of river basin in Orissa near the coastal region. Daily rainfall data of 40 years from 1971 to 2010 has been processed in the study to find out the monthly variability of rainfall using Mann-Kendall (MK) Test, Modified Mann-Kendall Test and Sen's Slope estimator for the determination of trend and slope magnitude. Monthly precipitation trend has been identified. The result showed that there were rising rates of precipitation in some months and decreasing trend in some other months suggesting that these was an overall significant change in the area.

Conclusion
From the above study it is concluded that In case of monthly rainfall the coefficient of variation is less in the months of June, July, August and September (CV < 76%). In case of rainy days June to September have less variability (CV < 75%). Monsoon rainfall has minimum coefficient of variation that is54.79 than pre-monsoon (79.56 %) Winter rainfall has highest coefficient of variation (237.16 %). In case of rainy days, Monsoon rainy days has minimum coefficient of variation 38.89 % than pre-monsoon 70.95%. Winter rainy days has highest coefficient of variation of 228.67%. The Pettitt't test revealed that there is no change point detected for annual rainfall and annual rainy days.Quantification of climate change is very necessary to scope up with ever changing conditions. The trend analysis is done for Shajapur district of Madhya Pradesh for monthly rainfall data for the period of 1990-2020 using non-parametric Mann-Kendall and Sen's Slope Estimator test. The significant decreasing trend is observed in annual, monsoon and September rainfall whereas May rainfall has increased significantly at 5% level of significance though there is no significant trend in rainy days.

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Appendices

Appendix 1: Rainfall (in mm) distribution of Shajapur district of Madhya Pradesh from 1990-2020

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
1990	0.73	9.9	1.24	0.04	30.11	201.05	202.1	440.03	248.79	7.76	2.29	7.64
1991	0	0.07	0.17	3.06	0.07	80.61	375.98	373.72	7.03	0	2.59	0
1992	0	0	0	0	5.27	30.19	191.06	315.7	99.52	45.77	2.29	0
1993	0	0.29	3.4	0.16	0.03	147.18	343.5	293.25	277.6	2.57	4.71	0.16
1994	28.12	5.02	0	9.38	0.45	163.91	267.74	511.62	134.62	0.82	9.34	0
1995	7.84	0	14.88	0.13	0	36.95	304.35	194.86	222.87	33.15	0.41	20.28
1996	4.64	0.23	6.25	0.02	0.04	45.34	537.61	474.85	162.91	48.69	0.7	0
1997	5.46	0	0	6.71	0.42	69.01	341.33	380.92	60.62	38.06	61.81	122.46
1998	0	0	3.48	1	0	108.14	326.25	163.02	281.64	27.15	2.94	0
1999	1.87	37.23	0.16	0	1.51	102.61	411.9	138.49	292.51	79.2	0	0
2000	0	0	0.02	0	48.02	68.74	345.43	80.61	24.01	0	0	0
2001	0.07	0.02	0.04	0.33	10.22	235.49	217.64	219.73	8.8	33.58	0	0.01
2002	0	13.97	0.98	0.63	4.9	126.46	41.16	306.03	114.74	0.75	0.4	0.05
2003	2.16	19.64	0	0.69	0.02	113.33	288.92	202.2	225	0.01	0.04	0.13
2004	35.36	0	0	0	0.34	62.18	310.14	493.66	38.36	33.44	2.53	0
2005	8.7	0.88	9.76	14.9	4.92	92.1	302.4	119.37	146.7	3.19	0	0.02
2006	0	0	73.01	3.67	27.46	68.83	266.34	699.78	293.03	7.9	3.46	0.7
2007	2.39	2.5	5.28	1.97	29.28	81.76	417.23	174.17	125.52	0	20.29	0
2008	0	0	2.27	2.93	3.1	162.64	198.71	170.11	148.43	4.1	8.26	0
2009	8.87	0	0	1.96	2.56	50.76	361.73	156.22	54.61	113.5	77.83	27.6
2010	0.91	8.03	0.6	0.13	0.38	17.64	225.74	206.81	79.41	17.74	44.38	0.65
2011	0	0.02	0.02	0.02	0.39	270.73	414.6	366.65	240.09	0	0	0
2012	0.5	0	0	0.16	2.88	28.94	364.72	337.66	154.55	0	0	0
2013	0	26.09	12.03	3.8	1.53	292.32	492.24	487.76	70.43	37.84	0	8.76
2014	23.89	26.73	0.88	1.29	1.44	18.98	310.72	238.38	173.74	4.74	0.17	12.89
2015	55.01	1.53	39.27	9.34	0.51	224.24	755.87	354.52	29.05	2.97	0	0
2016	4.03	0.01	0.67	0	6.15	148.17	500.42	522.94	81.37	23.27	0	0
2017	0.95	0.28	1.1	0	1.32	132.06	319.76	160.1	150.64	3.91	0	0.39
2018	0	2.87	0.64	1.03	0.09	166.42	340.99	177.27	141.16	2.05	0	0
2019	0	0.3	0	9.15	0.89	90.28	425.76	618.75	662.4	74.59	12.55	1.59
2020	7	0	12.59	0.9	1.19	215.39	79.31	571.01	131.75	3.08	2.77	10.18

Appendix 2: Rainy days distribution of Shajapur district of Madhya Pradeshfrom 1990-2020

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
1990	0	1	0	0	5	15	12	24	20	1	0	1
1991	0	0	0	0	0	10	19	17	0	0	0	0
1992	0	0	0	0	1	2	12	19	7	3	0	0
1993	0	0	0	0	0	13	16	14	21	0	1	0
1994	2	1	0	2	0	12	16	17	8	0	1	0
1995	1	0	2	0	0	5	19	15	5	2	0	2
1996	0	0	1	0	0	6	20	20	14	5	0	0

1997	1	0	0	1	0	7	18	19	8	5	10	8
1998	0	0	0	0	0	8	15	13	13	4	0	0
1999	0	2	0	0	0	11	18	11	21	8	0	0
2000	0	0	0	0	7	10	20	9	4	0	0	0
2001	0	0	0	0	1	14	16	14	0	5	0	0
2002	0	1	0	0	1	11	4	18	7	0	0	0
2003	0	3	0	0	0	10	20	14	22	0	0	0
2004	4	0	0	0	0	9	17	17	4	5	0	0
2005	2	0	2	3	1	8	13	5	14	0	0	0
2006	0	0	5	1	4	6	16	18	10	1	0	0
2007	0	0	1	0	5	10	19	10	12	0	1	0
2008	0	0	0	0	0	13	13	17	17	0	1	0
2009	1	0	0	0	0	6	19	11	5	3	6	2
2010	0	1	0	0	0	1	20	22	8	2	3	0
2011	0	0	0	0	0	16	21	23	10	0	0	0
2012	0	0	0	0	0	5	18	19	9	0	0	0
2013	0	3	1	1	0	19	25	21	4	3	0	2
2014	3	3	0	0	0	2	20	14	11	0	0	2
2015	3	0	4	2	0	15	14	19	3	1	0	0
2016	1	0	0	0	1	11	22	20	8	5	0	0
2017	0	0	0	0	0	13	14	12	13	1	0	0
2018	0	0	0	0	0	9	20	12	9	0	0	0
2019	0	0	0	1	0	11	16	24	26	5	1	0
2020	1	0	2	0	0	17	8	21	11	0	1	1