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Analysing the Long-Term Patterns of Seasonal Rainfall for Zari Station: Unveiling the Trends

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Abstract: The most pressing issue in India right now is the shift in the climate and the pattern of rainfall. Scientists are working to reduce the effects of the change and to create plans to lessen its effects. Rainfall is a crucial issue that requires considerable consideration because changes in rainfall patterns have a significant impact on Indian agriculture. The management of water resources, agricultural productivity, and the nation's overall economy are all significantly impacted by changes in the climate across the Indian region, particularly the South-West monsoon. In the Zari region of the Parbhani district, Marathwada, Maharashtra State, the study concentrated on rainfall variance and the identification of seasonal rainfall trends. The statistical parametric test was used to analyze rainfall variation, while Mann-Kendall and Sen's slope test was used to analyze trends. Regarding the seasonal point rainfall in Zari, a negative trend was seen for June and August, but a positive trend was seen for July, September, and October. Sen's slope values for the four rainy season months likewise showed an escalating tendency for the months of July, September, and October, and an escalating trend for the months of June and August.

Keywords:- *Seasonal Rainfall, Trend, Mann-Kendall, Sen's Slope.*

I. INTRODUCTION

The two most crucial climatic factors that influence the growth, development, and production of the crops are temperature and rainfall. Even the sowing of crops for the winter season is influenced by the soil moisture retained from the later phases of the monsoon. Crop growth and yields are dependent on monsoon rain. A significant climate issue today is the change in rainfall patterns, the availability of soil moisture, and its effects on agriculture and water resources. For the best use of water resources, there should be effective planning and management in place to get around these limitations. Understanding rainfall trends is a crucial tool for agriculture's future. The most pressing issue in India right now is the shift in the climate and the pattern of rainfall. By using a variety of strategies, scientists are researching and working to lessen the effects of this ecosystem shift. Rainfall is a crucial issue that requires considerable consideration because changes in rainfall patterns have a significant impact on Indian agriculture. A trend analysis is used to assess whether event series values are generally increasing or decreasing. Using trend analysis, one can ascertain a trend's importance, estimate its size, and plan appropriately for the trend's best usage.

II. METHODOLOGY

➢ *Study Area*

The research site is located at a latitude of 19.40 N and a longitude of 76.77 E, with an elevation of 414 meters above the mean sea level. It falls within the Marathwada region's administrative division. This area is classified as having reliable rainfall, receiving an average annual precipitation of 947.5 milli meters. The soil composition prevalent in the region is characterized as medium-depth black clay, as described by Tarate et al. in 2017.

➢ *Data collection*

Daily rainfall data of 30 years from (1989 - 2019) were collected from MERI (Maharashtra Engineering Research Institute) Nashik, station Zari, Parbhani Maharashtra, and some missing rainfall data were collected from website www.maharain.maharashtra.in

➢ *Software/Programme*

Microsoft office sub-module MS-Excel was used for data analysis. MAKESENS excel template was used for trend detection and estimation of magnitude of trend. (Finnish Metrological Institute 2002).

➢ *Seasonal rainfall Analysis*

- *Mean*

The mean, a measure of central tendency, was calculated by summing up all the values in the variable series and then dividing by the total number of variables. This method follows the explanation by Panse and Sukhatme in 1985.

$$x = \frac{\sum_{i=1}^{n} x_i}{N}$$

Where,
X = Mean,
Xi=Variable
N = Total number of variables.

To assess the fluctuations in rainfall throughout a specific year, it's necessary to estimate the mean rainfall for the given time frame.

- *Standard deviation*

The degree of variability, dispersion, or spread around the mean value was calculated using the subsequent formula, as outlined by Robert et al. in 1971.

$$\sigma = \frac{\sqrt{\sum_{i=0}^{n}(x_i - x)^2}}{N}$$

Where,
Xi = Variable
X = Mean
σ = Standard deviation
N = Total number of variables.

- *Coefficient of Variation*

The coefficient of variation, a statistical indicator of data dispersion around the mean in a dataset, was calculated by dividing the standard deviation by the mean rainfall value, following the methodology described by Robert et al. in 1971.

$$cv(\%) = \frac{\sigma}{x} \times 100$$

Where,
CV = Coefficient of variation
σ = Standard deviation and X = Mean.
CV indicates the variability of rainfall in percentage.

- *Rainfall trend analysis*

Analyzing the trend in a time series involves evaluating both the trend's strength and its statistical importance. To determine the statistical significance of the trend, the Mann-Kendall Test (Mann, 1945; Kendall, 1975) was employed. The magnitude of the trend was assessed using the non-parametric Sen's slope estimator method, as outlined by Choudhury et al. in 2012.

- *Mann- Kendall method*

The Mann-Kendall method is commonly applied to examine the null hypothesis of the absence of a trend versus the alternative hypothesis of a monotonic increasing or decreasing trend. When dealing with time series comprising fewer than 10 data points, the S-Test can be employed. For datasets containing over 10 data points, the normal approximation (Z-Test) is utilized, following the insights from Gilbert in 1987.The Mann-Kendall Statistic (S) is given by following equation.

$$S = \sum_{k=1}^{n-1}\sum_{j=k=1}^{n} \text{Sign}(Xj - Xk)$$

Where,
Xj and Xk = Annual values in years j and k, j > k respectively
n = Number of observed data series
Sign (Xj – Xk) was calculated using equation,
Sign (Xj – Xk) was calculated using equation,

$$\text{Sign(Xj-Xk)} = \begin{cases} 1\ if\ (Xj - Xk) > 0 \\ 0\ if\ (Xj - Xk) = 0 \\ -1\ if\ (Xj - Xk) < 0 \end{cases}$$

$$\text{VAR(S)} = \frac{1}{18}[n(n-1)\ (2n+5) - \sum_{p+1}^{q} tp\ (tp-1)\ (2tp+5)]$$

Where,
n = Number of years
p = Number of tied group (a tied group is a set of sample data having the same value)
tp= Number of data points in the tied group.

The standard normal distribution (Z- statistic) was computed by using equation,

$$Z = \begin{cases} \frac{S-1}{\sqrt{VAR(S)}} \text{ if } S > 0 \\ 0 \text{ if } S > 0 \\ \frac{S+1}{\sqrt{VAR(S)}} \text{ if } S > 0 \end{cases}$$

Positive or negative trends were established at confidence levels of 99%, 95%, and 90%. For the 99% confidence level, the null hypothesis of no trend was refuted when the absolute value of Z exceeded 2.575. At the 95% confidence level, rejection of the null hypothesis occurred if the absolute value of Z surpassed 1.96. Similarly, at the 90% confidence level, rejection of the null hypothesis was based on the absolute value of Z surpassing 1.645.

- *Sen's slope method*

Sen's estimator has found widespread application in quantifying the extent of trend within hydro-meteorological time series data. This method is suitable for situations where the trend can be approximated as linear, as suggested by Joshi et al. in 2019. When a linear trend is identifiable in a time series, Sen's slope method, introduced by Sen in 1968, offers a straightforward non-parametric technique for estimating the actual slope of the trend. The linear model can be described as:

$$Qt = \frac{Xi - Xk}{j-k} \text{ for } 1,2,3\ldots\ldots\ldots\ldots n$$

Where,
Xj and Xk = data values at time j and k, j > k.

$$Qt = \begin{cases} \frac{QN+1}{2}\ if\ N\ is\ odd \\ \frac{1}{2}(QN + \frac{QN+1}{2})if\ N\ is\ even \end{cases}$$

The median of all calculated slope values yields a quantity labelled as Q, representing the magnitude of the trend. A positive value indicates a rising trend in rainfall, while a negative value signifies a declining trend.

III. RESULTS AND DISCUSSION

➤ *Statistical Analysis of Seasonal Rainfall*

The average rainfall for Zari location was determined as 896.05mm. The minimum seasonal rainfall was observed as 482.80 mm in 2014, whereas the maximum rainfall was 1766 mm in 2005, CV denoting the variability in rainfall was observed as 31.85%, whereas Skewness measuring the symmetry in the data, was observed as 1.04, Kurtosis representing distribution of data was observed as 1.37, indicating heavy tailed data. (table.1)

Parameters of statistical analysis of seasonal rainfall of Zari location are presented in table.1

Table 1. Statistical seasonal point rainfall analysis (1989-2019)

Sr. No.	Parameters	Rainfall
1.	Average	896.05 mm
2.	Min.	482.80 mm
3.	Max.	1766.00 mm
4.	Standard Deviation	285.42 mm
5.	Coefficient of variation	31.85 %
6.	Skewness	1.04
7.	Kurtosis	1.37

Month wise variation of rainfall for period of 1989 to 2019 is presented in fig.1

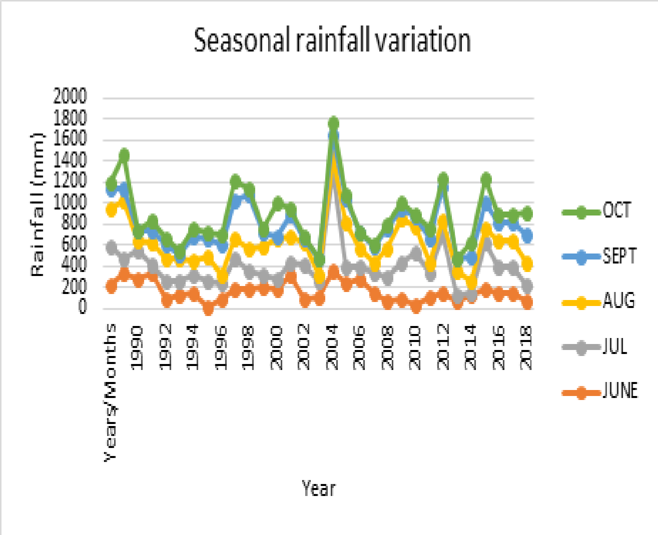

Fig. 1 Seasonal rainfall variation from June to October for Zari location

The scenario of seasonal rainfall fluctuation for the months of June, July, August, September, and October was depicted in Figure 1. The month of June saw the lowest seasonal rainfall for the Zari region compared to the other months of the year. In comparison to the other months, July, August, and September were found to receive the most rainfall.

➤ *Trend Analysis:*

The seasonal rainfall data from June to October at the Zari site were subjected to trend analysis. The trend and trend magnitude were determined using the Mann-Kendall and Sen's Slope Estimator. Table 2 and Fig 2 present the findings of the analysis.

Table. 2 Values of Mann-Kendall test (Z) and Sen's Slope estimator for seasonal rainfall of Zari location

	June	July	August	September	October
Mann-Kendall trend test (Z)	-1.95	0.75	-0.07	1.29	0.37
Sen's slope	-3.39	2.58	-3.35	2.05	6.33

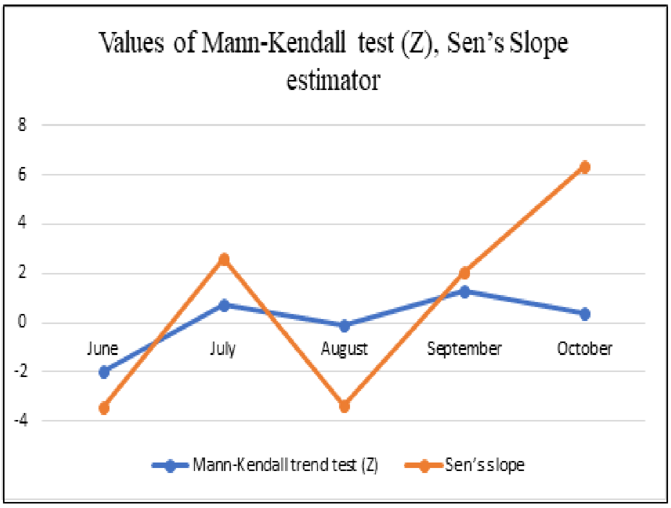

Fig. 2 Values of Mann-Kendall test (Z), Sen's Slope estimator

Table 2 data showed a negative (declining) trend for the months of June and August, with Z values of -1.95 and -0.07, respectively. Positive (rising) trend was seen for the monthly seasonal rainfall in the months of July, September, and October. Z values for July, September, and October were, respectively, 0.75, 1.29, and 0.37. Sen's estimate determined that the seasonal rainfall amounts for the months of June, July, August, September, and October were, respectively, -3.39, 2.58, -3.35, and 6.33.

IV. CONCLUSION

Among the five rainy months, negative trend was observed for June and August, but for July, September and October positive trend was observed. Sen's slope values for the four rainy months also indicated increasing magnitude of trend for July, September and October and decreasing magnitude of trend during June and August corresponding with the Mann-Kendall test values. Decreasing trend in seasonal rain fall for Zari region, during June and August,

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indicates limited availability of soil moisture period of these two months coincides with the sowing and mid-stage of short duration crops. Therefore, it is advisable to undertake sowing operations after outset of affective monsoon only. To mitigate the effect of less moisture availability during mid-stage, at most care must be taken severe as providing protective irrigation or to adopt intensive moisture stress management practices.

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