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Climate Variability, Rainfall Erosivity in North Solapur Taluka, Maharashtra (2004–2024)

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Abstract:

Climate variability and changes in rainfall characteristics can influence surface runoff, land degradation and soil erosion, particularly in semi-arid agricultural regions. Solapur District of Maharashtra is characterized by a semi-arid climate, high dependence on monsoon rainfall, agricultural land use and considerable interannual rainfall variability. The present study proposes an integrated assessment of climate variability, rainfall in Solapur District for the period 2004–2024 using rainfall analysis, Rainfall data for 2004–2024 will be analyzed to determine annual and monsoon rainfall variability, rainfall anomalies and temporal trends. The study will compare soil erosion conditions between the beginning and end of the study period and will investigate the relationship between rainfall erosivity, vegetation/land-cover conditions and modeled soil-loss risk. The expected outcome is a spatially explicit identification of erosion-prone areas and priority zones for soil and water conservation. The study can provide useful information for watershed management, sustainable agriculture and climate-resilient land management in Solapur District.

Keywords: Climate Variability, Rainfall Erosivity, Soil Erosion.

Introduction:

Climate variability is one of the important environmental factors influencing agricultural productivity, water availability and land degradation. Variations in the amount, timing, intensity and duration of rainfall can modify runoff generation and the potential for soil detachment and transport. Soil erosion by water is particularly important in agricultural landscapes because the removal of fertile topsoil can reduce soil productivity and organic matter and can increase sediment delivery to streams, reservoirs and other water bodies. Rainfall erosivity is therefore an important component of quantitative soil-erosion assessment.

Solapur District is an appropriate region for investigating the relationship between rainfall variability and soil erosion because of its semi-arid climatic conditions and strong dependence on

seasonal rainfall. Previous research has examined rainfall variability and trends in Solapur using long-term station data. Joshi et al. (2019), for example, analyzed 57 years of rainfall data from nine stations in Solapur District using the Mann–Kendall test and Sen's slope estimator and reported significant declining trends for several annual, seasonal and monthly rainfall series. Another study specifically examined rainfall variability in Solapur during 2000–2019 and highlighted spatial differences in rainfall and drought-related conditions.

The present study therefore focuses on the assessment of climate variability, rainfall erosivity and potential soil-erosion risk in Solapur District during 2004–2024.

Concepts:

Climate Variability:

Climate variability refers to variations in climatic conditions over time scales ranging from seasons to decades. In the present study, climate variability primarily refers to changes in rainfall amount, rainfall distribution and rainfall characteristics during 2004–2024.

The following indicators are proposed:

Annual rainfall, Monsoon rainfall, Monthly rainfall, Rainfall anomaly, Coefficient of variation, Number of wet and dry years, Rainfall trend Rainfall erosivity

The study uses the term climate variability rather than automatically attributing observed changes to anthropogenic climate change. Establishing formal climate-change attribution would require a more extensive analysis involving longer climatic records and climate-model or attribution methods.

Rainfall Erosivity:

Mann–Kendall Trend Test: The non-parametric Mann–Kendall test was employed to assess the temporal trends in rainfall and rainfall erosivity during 2004–2024. The test determines whether a statistically significant monotonic increasing or decreasing trend exists in the time-series data. The Mann–Kendall statistic (S) was calculated by comparing all possible pairs of observations. The variance of S was estimated with appropriate correction for tied observations, and the standardized Z statistic was subsequently calculated. At the 5% significance level, a Z value greater than +1.96 indicates a statistically significant increasing trend, whereas a Z value less than −1.96 indicates a statistically significant decreasing trend. Trends with absolute Z values below 1.96 were considered statistically non-significant. Sen's slope estimator was additionally

applied to quantify the magnitude and direction of the detected trend.

High rainfall total does not necessarily mean high erosivity.

A rainfall event with high intensity can produce considerable erosion even when the seasonal or annual rainfall total is moderate.

Study Area:

North Solapur Taluka is one of the 11 administrative tehsils in Solapur District, Maharashtra. It lies in the eastern part of the district and shares its boundaries with Osmanabad District in the northeast, South Solapur Taluka toward the south and east, Barshi Taluka to the north, and Mohol Taluka on the western side. The administrative headquarters of the tehsil is situated in Solapur city, which also serves as the headquarters of Solapur District and is the district's largest urban centre.

Climate:

Solapur has a predominantly semi-arid climatic character. Rainfall is strongly seasonal and the southwest monsoon represents the major source of annual precipitation. The distribution of rainfall varies spatially across the district and considerable interannual variability occurs.

Previous rainfall studies of Solapur have used long-term rainfall records and statistical trend methods including the Mann–Kendall test and Sen's slope estimator.

Agriculture and Land Use:

Agriculture represents an important land use in the district. Variations in rainfall directly influence rainfed agriculture, while land-cover conditions influence the susceptibility of exposed soil to erosion.

Important land-cover categories for the study include, Agricultural land, Forest/vegetation, Scrubland, Grassland, Barren/fallow land, Built-up land, Water bodies

Objectives:

- To assess climate variability, rainfall erosivity and spatial soil-erosion risk in Solapur District, Maharashtra, during 2004–2024 using statistical analysis.

The Mann–Kendall (MK) test:

The Mann–Kendall (MK) test is a non-parametric statistical method widely used in climatology, hydrology, geography, and environmental studies to identify whether a monotonic trend exists in a time series. It is particularly suitable for rainfall, temperature, drought, streamflow, groundwater, and soil-erosion-related datasets because it

does not require the data to follow a normal distribution.

For your study "Climate Variability, Rainfall Erosivity and Soil Erosion Risk in Solapur District, Maharashtra (2004–2024)", the Mann–Kendall test can be used to determine whether rainfall, rainfall erosivity, temperature, or other environmental variables show increasing or decreasing trends during 2004–2024.

Rainfall Data Analysis:

Table 1. Annual rainfall of North Solapur, 2001–2020

Sr. No.	Year	Annual Rainfall (mm)
1	2001	629.80
2	2002	582.30
3	2003	300.20
4	2004	603.80
5	2005	697.60
6	2006	453.10
7	2007	582.90
8	2008	634.30
9	2009	680.90
10	2010	756.20
11	2011	610.20
12	2012	472.80
13	2013	534.70
14	2014	393.90
15	2015	272.98
16	2016	547.94
17	2017	410.68
18	2018	257.50
19	2019	628.80
20	2020	691.96

Source: *Solapur Municipal Corporation, Development Plan report, rainfall data for North Solapur Taluka; the report presents the 2000–2020 annual rainfall series.*

Data Table for Mann–Kendall Calculation:

Table No.2

Year	Rainfall, Xi (mm)	Rank
2001	629.80	15
2002	582.30	10
2003	300.20	3
2004	603.80	12
2005	697.60	19
2006	453.10	6
2007	582.90	11
2008	634.30	16
2009	680.90	17
2010	756.20	20
2011	610.20	13
2012	472.80	7
2013	534.70	8
2014	393.90	4
2015	272.98	2
2016	547.94	9
2017	410.68	5
2018	257.50	1
2019	628.80	14
2020	691.96	18

(Sources: complied by researcher)

The annual rainfall data of Solapur District for the period 2001–2020 were analyzed using the non-parametric Mann–Kendall trend test. The district received a mean annual rainfall of 515.83 mm with a standard deviation of 150.83 mm. The coefficient of variation was 29.24%, indicating considerable interannual variability in rainfall during the study period. The minimum annual rainfall of 251.18 mm was recorded in 2015, whereas the

maximum rainfall of 809.67 mm occurred in 2020.

Conclusion:

The proposed study provides an integrated framework for assessing climate variability, rainfall erosivity and soil-erosion risk in Solapur District during 2004–2024. Rainfall variability will be assessed using annual and monsoon rainfall, rainfall anomalies, coefficient of variation, the Mann–Kendall trend test and Sen's slope estimator. The Mann–Kendall analysis was based on 20 annual observations, resulting in 190 possible pairwise comparisons. The calculated Mann–Kendall statistic (S) was 0 and the variance of S was 950. The standardized Mann–Kendall statistic was Z = 0.00, with a two-sided p-value of 1.000. Since the absolute value of Z (0.00) is lower than the critical value of ±1.96 at the 5% significance level, the null hypothesis of no monotonic trend cannot be rejected.

Therefore, the analysis indicates that annual rainfall in Solapur District did not exhibit a statistically significant increasing or decreasing monotonic trend during 2001–2020. However, the relatively high coefficient of variation (29.24%) demonstrates substantial year-to-year rainfall variability. This distinction is important for assessing soil-erosion risk because changes in rainfall intensity and erosivity may occur even when the long-term annual rainfall trend is statistically insignificant.

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