



ISSN Print: 2618-060X
 ISSN Online: 2618-0618
 NAAS Rating (2026): 5.20
 IJRA 2026; SP-9(9): 498-505
www.agronomyjournals.com
 Received: 09-07-2026
 Accepted: 29-08-2026
 Published: 26-09-2026

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Rainfall trends and their relationship with agricultural production in Latur district of Maharashtra

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i9Sf.6672>

ABSTRACT

Rainfall is an important climatic factor influencing agricultural production. The present study was undertaken to examine the rainfall trend and its relationship with agricultural crop production in Latur district of Maharashtra. Secondary data on rainfall for the period 2015–2025 were obtained from the Maharashtra Rainfall Information System, while data on crop area, production and productivity were obtained from the Department of Agriculture, Government of Maharashtra. Descriptive statistical measures including mean, standard deviation, coefficient of variation, minimum, maximum, skewness and kurtosis were used to examine rainfall variability. Time-series trend analysis was carried out using linear, quadratic, cubic and logarithmic trend models. Pearson's correlation coefficient was employed to examine the relationship between southwest monsoon rainfall and production of major crops. The results showed that the district received an average annual rainfall of 877.31 mm, of which 736.14 mm, or 83.91 per cent, was received during the southwest monsoon season. Rainfall exhibited considerable year-to-year variability, with annual rainfall ranging from 456.60 mm in 2015 to 1446.60 mm in 2023. Six years were identified as relatively dry and five as relatively wet based on deviations from mean annual rainfall. Annual rainfall deviations further indicated alternating surplus and deficit conditions across the study period, demonstrating the unstable nature of rainfall distribution. Trend analysis indicated a positive linear tendency in annual rainfall, with a slope of 25.20 mm per year, but the low R^2 value of 0.08 indicated limited explanatory power. Among the models, the cubic model recorded the highest R^2 value of 0.21, indicating substantial fluctuations around the fitted trend. Correlation analysis revealed varying relationships between monsoon rainfall and crop production. Jowar showed the highest positive correlation ($r = 0.34$), whereas green gram recorded the highest negative correlation ($r = -0.37$). Soybean ($r = -0.05$) and wheat ($r = -0.02$) showed very weak negative relationships. The findings indicate considerable rainfall variability and crop-specific responses, highlighting the importance of improved rainfall monitoring, water management and climate-responsive agricultural planning within the district.

Keywords: Rainfall, Rainfall variability, Rainfall trend, Southwest monsoon, Agricultural production, Correlation, Latur district

Introduction

Agriculture plays an important role in the economy and livelihood of rural households, particularly in regions where farming is largely dependent on rainfall. In Latur district of Maharashtra, agricultural activities are closely associated with the availability and distribution of rainfall. The district receives most of its annual rainfall during the southwest monsoon season, which coincides with the major sowing and crop-growing period. Therefore, variations in the amount, timing and distribution of rainfall can influence crop planning, moisture availability and agricultural production. The climatic conditions of Latur are characterised by a distinct monsoon season followed by a relatively dry winter and hot summer. The district is predominantly cultivated under black soils, which have good moisture-retention capacity and support the cultivation of crops such as soybean, jowar, tur, wheat, gram and other pulses.

Rainfall variability is important from an agricultural perspective because the total quantity of rainfall alone does not adequately describe its usefulness to crops. The timing and distribution of rainfall across different months and seasons can also determine the availability of soil moisture during critical stages of crop growth. In Latur district, rainfall is mainly concentrated during the southwest monsoon, while comparatively smaller quantities are received during the pre-monsoon, northeast monsoon and winter periods. During 2015–2025, the southwest monsoon accounted for the major share of rainfall, with an average of 736.15 mm. However, the coefficient of variation of rainfall differed across seasons, indicating that rainfall distribution was not uniform throughout the year.

The occurrence of both deficient and excess rainfall years creates uncertainty for agricultural production. The rainfall records for Latur district during 2015–2025 show considerable year-to-year fluctuations. Annual rainfall varied from only 456.60 mm in 2015 to 1446.60 mm in 2023. Several years received rainfall below

the study-period mean, whereas others recorded substantially higher rainfall. Such fluctuations may create different agricultural conditions, ranging from moisture stress during deficient rainfall years to problems associated with excessive rainfall during wet years. The analysis of rainfall behaviour is therefore useful for understanding the changing moisture environment under which agricultural activities are undertaken.

Rainfall trends provide an indication of the direction and nature of changes in rainfall over time. However, rainfall does not necessarily follow a uniform pattern from one year to another. Previous studies reviewed for the present study have also reported that rainfall behaviour can differ across locations, seasons and time periods. Studies conducted in Maharashtra and other regions have used statistical and trend-analysis techniques to examine such variability, highlighting the importance of location-specific assessment of rainfall behaviour.

The relationship between rainfall and agricultural production may also differ among crops because crops vary in their water requirements, growing periods, management practices and access to irrigation. In Latur district, the analysis of southwest monsoon rainfall and production of major crops showed both positive and negative relationships. Jowar recorded a positive correlation of 0.34, while green gram recorded a negative correlation of -0.37. Maize and cotton also showed negative correlations, whereas rice, gram, tur and sugarcane showed positive relationships. Soybean and wheat recorded very weak negative correlations. These differences indicate that the association between rainfall and crop production is crop-specific and cannot be explained by rainfall alone.

In addition to correlation analysis, examining the influence of climatic variables on agricultural production provides a broader understanding of production variability. For cereal crops in Latur district, the regression analysis showed that the selected rainfall, temperature and cultivated-area variables together explained a substantial proportion of the variation in average production, with an R^2 of 0.80 and adjusted R^2 of 0.71. The estimated coefficient for annual rainfall was positive, while mean temperature showed a negative relationship with cereal production.

Considering the dependence of agriculture on monsoon rainfall and the considerable fluctuations observed in the district, systematic analysis of rainfall behaviour is necessary for agricultural planning. Understanding the trend, variability and relationship between rainfall and crop production can provide useful information for farmers, researchers and planners in developing appropriate crop and water-management strategies. Therefore, the present study was undertaken to analyse rainfall trends and their relationship with agricultural production in Latur district of Maharashtra during the study period. The study particularly focuses on the variability and distribution of rainfall, changes in rainfall over time, and the relationship between southwest monsoon rainfall and the production of major crops in the district.

Objectives

1. To study the trends of rainfall in Latur district.

Materials and Methods

The present study was based on secondary data collected and compiled from various reliable sources. The rainfall data for Latur district were obtained from the Maharashtra Rainfall Information System (MahaRain), while data on crop area, production and productivity were collected from the Department of Agriculture, Government of Maharashtra. The study covered the period 2015–2025. Descriptive statistical measures, namely mean, standard deviation (SD), coefficient of variation (CV), minimum, maximum, skewness and kurtosis, were used to examine rainfall variability. Trend analysis and Pearson's correlation coefficient were also employed to study rainfall trends and its relationship with crop production.

Trend analysis

To determine the trend of rainfall in Latur district of Maharashtra State, Time series analysis was used. The trend of the selected variables was estimated using a linear trend equation based on linear regression analysis.

- a) Linear equation model - $Y = a + bt$
- b) Quadratic equation model - $Y = a + bt + ct^2$
- c) Logarithmic Model - $Y = ab^t$
- d) Cubic equation model - $Y = a + bt + ct^2 + dt^3$

Where,

Y = Rainfall

a = Intercept

b, c, d = Partial regression coefficients

t = Time

Pearson correlation coefficient

The Pearson correlation coefficient (r) was employed to measure the degree of linear relationship between rainfall and crop production. In the present study, the correlation between monsoon rainfall and crop production was examined by considering rainfall as the independent variable and crop production as the dependent variable. The significance of the calculated correlation coefficient was determined using the Student's t -test.

Where,

r = Pearson correlation coefficient

n = pairs of observations

x = crop production

y = monsoon rainfall

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

Result and Discussion

Trends of rainfall in Latur district and changes in rainfall pattern over the years (2015–2025)

Rainfall is a major climatic factor affecting agricultural activities and the productivity of various crops. To assess the variation and changes in the rainfall pattern of Latur district, monthly and annual time-series rainfall data for the period 2015–2025 were analysed. Annual rainfall (mm) and its deviation from the mean rainfall were calculated and are presented in Table 1.

Selected descriptive statistical measures, namely mean, standard deviation (SD), coefficient of variation (CV), minimum, maximum, skewness and kurtosis, were used to examine the behaviour of monthly, seasonal and annual rainfall in Latur district during 2015–2025. The mean annual rainfall of Latur district was 877.30 mm, with a coefficient of variation of 33.06 per cent, indicating considerable variation in annual rainfall during the study period. The monthly rainfall also showed noticeable variability, as reflected by differences in the coefficient of variation across months. The highest mean monthly rainfall was recorded in August (209.29 mm), followed by September (182.35 mm) and July (174.76 mm), whereas the lowest mean rainfall was observed in February (1.61 mm), followed by January (1.77 mm). The highest mean monthly rainfall was recorded in August (209.29 mm), followed by September (182.35 mm) and July (174.76 mm), whereas the lowest mean rainfall was observed in February (1.61 mm), followed by January (1.77 mm). August rainfall varied from 101.40 to 442.70 mm, while September rainfall ranged from 91.10 to 285.20 mm.

The results indicate that rainfall in Latur district was largely concentrated during the southwest monsoon period, particularly from June to September. Based on the coefficient of variation, the highest rainfall variability was observed in February (120.10%), followed by January (115.53%) and December (112.61%), indicating irregular rainfall occurrence during these months. In contrast, September recorded the

lowest CV (31.93%), followed by October (41.73%) and July (44.32%), suggesting comparatively stable rainfall during these months. Skewness values showed differences in the distribution of rainfall across months. The highest positive skewness was recorded in

August (1.49), while October showed the highest negative skewness (-1.28). Kurtosis values also varied among the months, with the highest value recorded in October (2.45), indicating differences in the shape and distribution of monthly rainfall during the study period.

Table 1. Descriptive statistics of annual rainfall (mm) of Latur district from (2015-2025)

Month	Mean	SD	CV	Maximum	Minimum	Skewness	Kurtosis
January	1.77	2.05	115.53	6.40	0.00	1.14	1.19
February	1.61	1.93	120.10	4.70	0.00	0.48	-1.81
March	4.49	4.11	91.48	12.70	0.20	0.67	-0.26
April	9.03	8.56	94.88	23.40	0.00	0.46	-1.08
May	20.13	15.12	75.13	53.10	0.30	0.63	1.29
June	169.74	82.38	48.53	328.40	59.20	0.52	-0.23
July	174.76	77.46	44.32	295.10	58.10	0.38	-0.85
August	209.29	106.48	50.87	442.70	101.40	1.49	1.44
September	182.35	58.23	31.93	285.20	91.10	0.00	-0.51
October	87.51	36.52	41.73	140.60	2.40	-1.28	2.45
November	14.22	10.74	75.54	29.40	0.00	-0.12	-1.15
December	2.42	2.72	112.61	7.20	0.00	0.98	-0.52
Seasonal							
Southwest Monsoon	736.15	258.75	35.15	1209.40	359.10	0.37	-0.64
Northeast Monsoon	104.15	42.02	40.34	158.30	6.90	-1.19	2.02
Winter	26.57	18.22	68.58	63.10	5.40	1.03	0.14
Annual	877.30	290.03	33.06	1446.60	456.60	0.59	1.05

Table 2 presents the mean rainfall in millimetres along with the coefficient of variation (CV) for the monsoon months, southwest monsoon season and annual rainfall of Latur district during 2015–2025. The findings reveal that the southwest monsoon is the major contributor to the district's annual rainfall, accounting for 83.91 per cent of the total annual rainfall received during June to September. Among the monsoon months, August receives the largest share of annual rainfall,

accounting for 23.86 per cent, followed by September (20.79 per cent), July (19.92 per cent) and June (19.35 per cent). The corresponding mean rainfall during these months is 169.73 mm in June, 174.76 mm in July, 209.29 mm in August and 182.35 mm in September. Thus, the major portion of the annual rainfall in Latur district is concentrated during the southwest monsoon season.

Table 2. Mean rainfall (mm) and coefficient of variation of the district for the monsoon months, southwest monsoon and annual rainfall from 2015–2025

Latur	June	July	August	September	Monsoon	Annual
Mean	169.73	174.76	209.29	182.35	736.14	877.31
(mm)	(19.35)	(19.92)	(23.86)	(20.79)	(83.91)	(100)
CV (Percent)	48.53	44.32	50.87	31.93	35.14	33.05

Table 2 presents the mean rainfall in millimetres along with the coefficient of variation (CV) for the monsoon months, southwest monsoon season and annual rainfall of Latur district during 2015–2025. The findings reveal that the southwest monsoon is the major contributor to the district's annual rainfall, accounting for 83.91 per cent of the total annual rainfall received during June to September. Among the monsoon months, August receives the largest share of annual rainfall, accounting for 23.86 per cent, followed by September (20.79 per cent), July (19.92 per cent) and June (19.35 per cent). The corresponding mean rainfall during these months is 169.73 mm in June, 174.76 mm in July, 209.29 mm in August and 182.35 mm in September. Thus, the major portion of the annual rainfall in Latur district is concentrated during the southwest monsoon season. The coefficient of variation shows differences in the extent of rainfall variability across the monsoon months. August records the highest CV of 50.87 per cent, followed by June (48.53 per cent) and July (44.32 per cent), while September records the lowest CV of 31.93 per cent. The CV of southwest monsoon rainfall is 35.14 per cent, compared with

33.05 per cent for annual rainfall, indicating noticeable variability in rainfall during the study period.

Changes in rainfall pattern in Latur district (2015–2025)

The annual rainfall in Latur district showed considerable year-to-year variation during 2015–2025, with both positive and negative deviations from the mean rainfall (877.30 mm). In 2015, annual rainfall was 456.60 mm, showing a negative deviation of 47.96 per cent from the mean. It increased to 969.40 mm in 2016 and 1133.10 mm in 2017, with positive deviations of 10.50 and 29.15 per cent, respectively. In 2018, rainfall was 891.90 mm, with a slight positive deviation of 1.66 per cent. During 2019, rainfall declined to 823.40 mm, recording a negative deviation of 6.15 per cent. A further decline was observed in 2020 and 2021, when rainfall was 689.30 and 646.40 mm, with negative deviations of 21.43 and 26.32 per cent, respectively. In 2022, rainfall increased to 803.40 mm but remained below the mean, with a deviation of -8.43 per cent. The highest annual rainfall was recorded in 2023 at 1446.60 mm, showing a positive de

viation of 64.89 per cent. Rainfall again decreased to 605.10 mm in 2024, with a negative deviation of 31.03 per cent, while 2025 recorded 1185.30 mm with a positive deviation of 35.10 per cent. Thus, the annual rainfall pattern indicated substantial fluctuations, with the highest rainfall in 2023 and the lowest in 2015. The results indicate that rainfall was not uniform across the study period. Similar findings were reported by Patil and Gopale (2018).

Deviation of annual rainfall over the normal rainfall (2015 to 2025)

The variation in climatic conditions, particularly rainfall, has an important influence on agricultural activities and the cropping pattern of a region. The results presented in Table 4 clearly indicate that there

was considerable instability in the annual rainfall pattern of Latur district during 2015–2025. The mean annual rainfall during the study period was 877.30 mm. In 2015, the district received 456.60 mm of rainfall, showing a negative deviation of 47.96 per cent from the mean and -61.48 per cent from the previous year, indicating a substantial decline in rainfall. During 2016, rainfall increased to 969.40 mm, with a positive deviation of 10.50 per cent from the mean and 112.31 per cent over the previous period. In 2017, rainfall further increased to 1133.10 mm, resulting in positive deviations of 29.15 per cent from the mean and 16.89 per cent from the previous year.

Table 3. Year wise annual rainfall (mm) and deviation from the mean in Latur district (2015-2025)

Year	Annual Rainfall (mm)	Deviation from mean percentage
2015	456.6	-47.96
2016	969.4	10.5
2017	1133.1	29.15
2018	891.9	1.66
2019	823.4	-6.15
2020	689.3	-21.43
2021	646.4	-26.32
2022	803.4	-8.43
2023	1446.6	64.89
2024	605.1	-31.03
2025	1185.3	35.1
mean	877.3	
Cv	33.10	
(Per cent)		

In 2018, annual rainfall declined to 891.90 mm, but it remained slightly above the mean, recording a positive deviation of 1.66 per cent. The deviation from the previous period was -21.29 per cent, indicating a decline compared with 2017. During 2019, rainfall decreased further to 823.40 mm, with a negative deviation of 6.15 per cent from the mean and -7.68 per cent from the preceding year. The declining rainfall pattern continued in 2020 and 2021, when annual rainfall was 689.30 mm and 646.40 mm, respectively. The deviations from the mean were -21.43 per cent and -26.32 per cent, while the deviations from the previous year were -16.29 per cent and -6.22 per cent, respectively, indicating a continuous reduction in rainfall during these years.

In 2022, annual rainfall increased to 803.40 mm and showed a negative deviation of 8.43 per cent from the mean, whereas the deviation from the previous period was positive at 24.29 per cent. During 2023,

the district recorded the highest annual rainfall of 1446.60 mm, which was 64.89 per cent above the mean and 80.06 per cent higher than the previous year. In 2024, rainfall declined sharply to 605.10 mm, recording negative deviations of 31.03 per cent from the mean and 58.17 per cent from the previous period. In 2025, rainfall again increased substantially to 1185.30 mm, with positive deviations of 35.10 per cent from the mean and 95.88 per cent from the previous year.

Overall, the annual rainfall pattern in Latur district showed substantial year-to-year fluctuations during 2015–2025, with both positive and negative deviations from the mean and previous year. The maximum positive deviation from the mean was observed in 2023 (64.89%), while the maximum negative deviation was recorded in 2015 (-47.96%). The results therefore indicate that rainfall was highly variable and lacked stability during the study period.

Table 4. Deviation of annual rainfall over the normal rainfall (2015 to 2025)

Year	Annual rainfall (mm)	Deviation for mean (Per cent)	Deviation over the Previous Period (Per cent)
2015	456.6	-47.96	-61.48
2016	969.4	10.5	112.31
2017	1133.1	29.15	16.89
2018	891.9	1.66	-21.29
2019	823.4	-6.15	-7.68
2020	689.3	-21.43	-16.29
2021	646.4	-26.32	-6.22
2022	803.4	-8.43	24.29
2023	1446.6	64.89	80.06

(continued on next page)

Year	Annual rainfall (mm)	Deviation for mean (Per cent)	Deviation over the Previous Period (Per cent)
2024	605.1	-31.03	-58.17
2025	1185.3	35.1	95.88
Normal rainfall	877.30 mm		

Percentage deviation from normal rainfall in Latur district (2015–2025)

The deviation of annual rainfall from normal rainfall in Latur district during 2015–2025 was estimated and is presented in Table 5. The deviations were classified according to their sign into positive and negative categories. Further, the deviations were grouped into six ranges, namely less than 10 per cent, 10–20 per cent, 20–30 per cent, 30–40 per cent, 40–50 per cent and more than 50 per cent. The results reveal that annual rainfall exhibited both positive and negative deviations from the mean during the study period. The classification of deviations indicates the years of surplus and deficit rainfall and the extent of variation from the normal rainfall in Latur district.

Among the positive deviations, 2023 recorded a deviation of more than 50 per cent, with annual rainfall showing a positive deviation of 64.89 per cent. The 30–40 per cent category observed 2025, with a positive deviation of 35.10 per cent, while 2017 recorded a positive

deviation of 29.15 per cent and falls under the 20–30 per cent category. The 10–20 per cent category observed 2016, with a positive deviation of 10.50 per cent. The year 2018 was observed in the category of less than 10 per cent, with a positive deviation of 1.66 per cent.

With regard to negative deviations, 2019 and 2022 recorded deviations of less than 10 per cent, with values of -6.15 per cent and -8.43 per cent, respectively. The 20–30 per cent category included 2020 and 2021, with negative deviations of -21.43 per cent and -26.32 per cent, respectively. The year 2024 fell under the 30–40 per cent category, with a negative deviation of -31.03 per cent. The highest negative deviation was recorded in 2015 at -47.96 per cent, placing it in the 40–50 per cent category. Overall, the annual rainfall in Latur district showed considerable variation during 2015–2025, with both surplus and deficit rainfall years. The classification of deviations clearly indicates fluctuations in annual rainfall from the normal level throughout the study period.

Table 5. Per cent deviation from normal rainfall of rainfall in Latur district (2015-2025)

Percent deviation of rainfall from normal rainfall	Annual Rainfall (Per cent)
Positive deviations	
> 50 Per cent	2023
40-50 Per cent	2025
30-40 Per cent	2017
20-30 Per cent	--
10-20 Per cent	2016
< 10 Per cent	2018, 2019
Negative deviations	
< 10 Per cent	2022
10- Per cent	2020
20-30 Per cent	2021, 2024

Dry and wet years during the period (2015–2025) in Latur district

The dry and wet years were identified based on the deviation of annual rainfall from the mean rainfall, and the results are presented in Table 6. Years showing a negative deviation from the mean annual rainfall was considered dry years, while those with a positive deviation were classified as wet years. During the study period, the years 2015, 2019, 2020, 2021, 2022 and 2024 were identified as dry years, as the rainfall received during these years was below the mean. The

lowest annual rainfall was recorded in 2015 at 456.60 mm, followed by 2021 at 646.40 mm and 2020 at 689.30 mm. All these years recorded negative deviations from the mean rainfall.

The years 2016, 2017, 2018, 2023 and 2025 were classified as relatively wet years, as their annual rainfall exceeded the mean of 877.30 mm. The highest annual rainfall was observed in 2023 at 1446.60 mm, followed by 2025 at 1185.30 mm and 2017 at 1133.10 mm. Overall, the results indicate substantial year-to-year fluctuations in rainfall in Latur district, with both dry and wet years occurring during the period 2015–2025.

Table 6. Dry and Wet years during period (2015 – 2025) in Latur district

Sr. no	Dry Years	Rainfall (mm)	Wet Years	Rainfall (mm)
1	2015	456.6	2016	969.4
2	2019	823.4	2017	1133.1
3	2020	689.3	2018	891.9
4	2021	646.4	2023	1446.6
5	2022	803.4	2025	1185.3
6	2024	605.1		

(continued on next page)

Rainfall trend and pattern of changes over the years

Table 7 presents the trends in rainfall during the period 2015–2025 using four different trend functions, namely linear, quadratic, cubic, and logarithmic models. The models were evaluated based on their intercept, regression coefficient (b), and coefficient of determination (R^2).

The results indicate that the linear trend model had an intercept of 726.07 and a positive slope ($b = 25.20$), with an R^2 value of 0.08. The

positive value of b indicates an overall increasing tendency in rainfall during the study period, although the relatively low R^2 value suggests that the linear model explains only a small proportion of the variation in rainfall. The quadratic model showed an intercept of 762.52 and a positive coefficient ($b = 8.38$), with an R^2 value of 0.08. Similar to the linear model, the low R^2 indicates a weak fit and limited explanatory power for the observed rainfall variability.

Table 7. Trends of Rainfall (2015-2025)

Sr. no	Functions	Intercept	b	R2
1	Linear	726.07	25.20	0.08
2	Quadratic	762.52	8.38	0.08
3	Cubic	303	387.96	0.21
4	Logarithmic	676.25	126.24	0.10

Among the four models, the cubic model showed the highest R^2 (0.21), with an intercept of 303.00 and coefficient of 387.96, indicating that it explained about 21 per cent of the variation in rainfall. The logarithmic model recorded an R^2 of 0.10, with an intercept of 676.25 and a positive coefficient of 126.24, indicating an increasing rainfall trend. Overall, the cubic model provided the comparatively better fit.

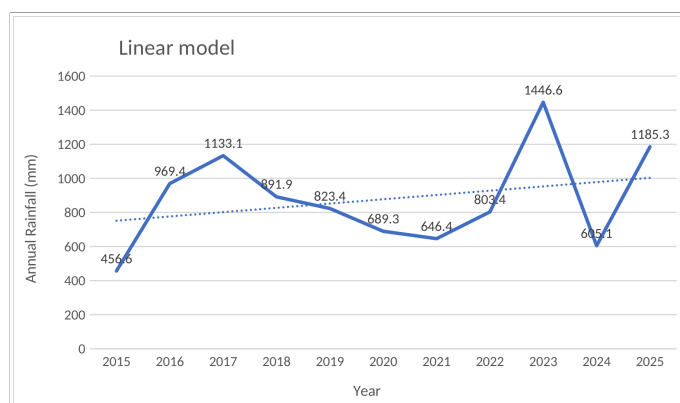


Figure 1. Linear Equation model for annual rainfall

Figure 1, 2, 3 and 4 represent the annual rainfall of Latur district. The linear regression analysis was carried out for annual rainfall. It indicated that linear trend line falling on the time series for annual rainfall from 2015–2025. The graph depicts the increasing and decreasing rainfall trend pattern of the Latur district for the period 2015–2025. On the annual basis the value of the coefficient of determination (R^2) for linear equation is at lower magnitude which indicates that linear regression method is not better fit for the data under consideration. Similar linear regression analysis for the rainfall variability during the period 1980–2019 in Jagtial district of Telangana state was found in earlier studies. Navnath *et al.* (2021) [1].

The results of linear regression trend it was interpreted that there were both increasing and decreasing trend patterns present in the rainfall data. The computed time series trend analysis of rainfall through linear regression shows an increasing trend with a positive regression slope value of 25.21 indicates an increasing trend through an increase of each time period of 2015–2025.

The quadratic trend analysis was also attempted in fig 2 however, the results from quadratic trend analysis shows no significant improvement in the results. As shown in fig 3, the cubic trend analysis results the trend of rainfall is showing both increasing and decreasing patterns during the study period.

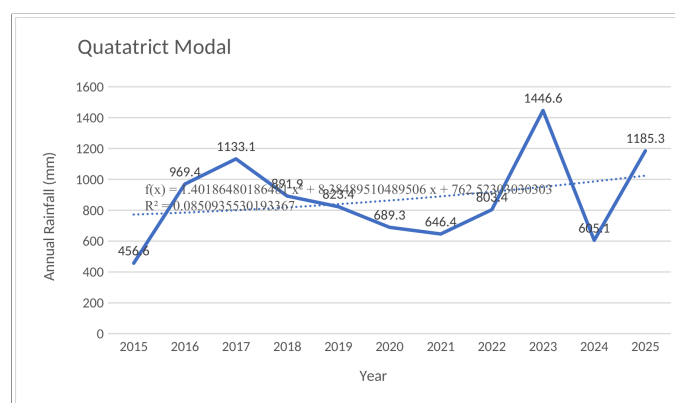


Figure 2. Quadratic Equation model for annual rainfall

Among the four selected models, the trend analysis showed that the cubic model was best fitted for rainfall trend analysis. On the annual basis the value of the coefficient of determination (R^2) for cubic equation is at moderate magnitude which indicates that cubic equation model is better fit for the data under consideration.

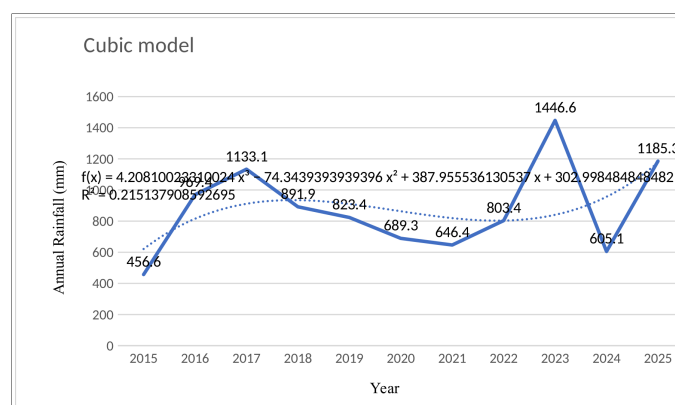


Figure 3. Cubic Equation model for annual rainfall

From the results of cubic trend analysis, it was interpreted that there are both increasing and decreasing trend patterns present in the rainfall data.

As shown in fig. 4, the logarithmic trend analysis results the trend of rainfall is increasing as the slope is positive, no significant improvements in the results is shown by the logarithmic trend analysis though the coefficient of determination value is also at lower magnitude. Based on the R^2 value along with significance of coefficient. Among the four selected models, the trend analysis showed that the cubic model was best fitted for rainfall trend analysis. On the annual basis the value of the coefficient of determination (R^2) for cubic equation is at moderate magnitude which indicates that cubic equation model is

better fit for the data under consideration. From the results of cubic trend analysis, it was interpreted that there are both increasing and decreasing trend patterns present in the rainfall data. The computed time series trend analysis of rainfall through linear regression shows a increasing trend with a positive regression slope value of 25.21 indicates a increase in trend through an increase of each time period of 2015–2025.

Correlation between agricultural crop production and rainfall

In order to find the relationship between crop production and monsoon rainfall, the coefficient of correlation method was used for Table 8. The analysis shows both positive and negative correlation between monsoon rainfall and the production of major crops during the study period. The monsoon seasonal rainfall covers the period from June to September, which is an important sowing and growing period for the region. Monsoon rainfall influences crop production differently among various crops. The highest positive correlation is observed for Jowar ($r = 0.34$), indicating a moderate positive relationship with total monsoon rainfall. This is followed by Rice ($r = 0.15$), Gram ($r =$

0.10), Tur ($r = 0.09$) and Sugarcane ($r = 0.01$), which show weak positive correlation with monsoon rainfall.

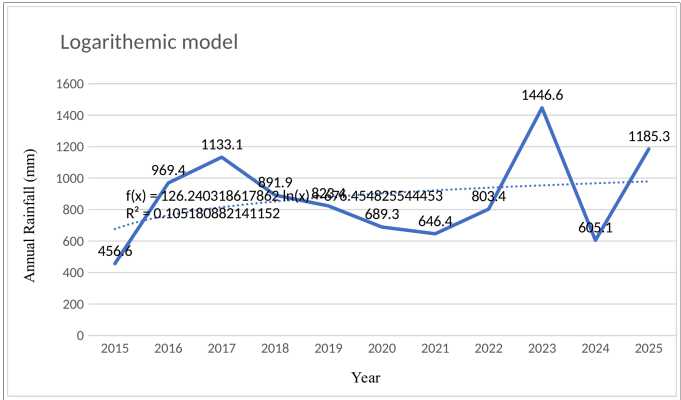


Figure 4. Logarithmic model for annual rainfall

Major Crops for 2015-16 to 2024-25 Periods in Latur district

Table 8. Correlation Coefficient for Southwest Monsoon and Production of

Agriculture Crop	Monsoon Rainfall
Jowar	0.34
Wheat	-0.02
Maize	-0.29
Rice	0.15
Green Gram	-0.37
Gram	0.10
Tur	0.09
Soybean	-0.05
Cotton	-0.14
Sugarcane	0.01

On the other hand, Green Gram shows the highest negative correlation ($r = -0.37$) with total monsoon rainfall, followed by Maize ($r = -0.29$) and Cotton ($r = -0.14$). Soybean ($r = -0.05$) and Wheat ($r = -0.02$) show very weak negative correlation with monsoon rainfall. Thus, the correlation analysis indicates that Jowar has the strongest positive relationship with monsoon rainfall, whereas Green Gram has the strongest negative relationship.

Conclusion

The analysis of rainfall pattern and trend in Latur district during 2015–2025 revealed considerable variation in rainfall across different months, seasons and years. The mean annual rainfall during the study period was 877.30 mm, while substantial deviations from the mean were observed in several years. The highest annual rainfall was recorded in 2023 (1446.60 mm), showing a positive deviation of 64.89 per cent from the mean. In contrast, the lowest rainfall was observed in 2015 (456.60 mm), with a negative deviation of 47.96 per cent. This wide difference indicates that rainfall distribution was not uniform during the study period. The annual rainfall pattern showed both positive and negative deviations from the mean. Rainfall remained above the mean during 2016, 2017, 2018, 2023 and 2025, whereas below-normal rainfall was recorded during 2015, 2019, 2020, 2021, 2022 and 2024. The sharp increase in rainfall during 2023, followed by a substantial decline in 2024, demonstrates the irregular nature of rainfall in the district. In 2025, rainfall again increased to 1185.30 mm, recording a positive deviation of 35.10 per cent from the mean. The trend analysis also confirmed variability in annual rainfall. The linear regression model showed an overall increasing tendency with a positive slope of 25.21 mm per year. However, the rainfall series exhibited fluctuations rather than a continuous increase. Among the four

selected trend models, the cubic model recorded the highest R^2 value of 0.21, indicating that it provided the comparatively better representation of the observed rainfall trend. The logarithmic model also indicated an increasing tendency, with a positive coefficient of 126.24 and an R^2 value of 0.10, but its explanatory power was comparatively lower. Overall, the findings indicate that rainfall in Latur district was highly variable and lacked a consistent pattern during 2015–2025. The occurrence of both deficit and excess rainfall years may create challenges for crop planning, sowing decisions, irrigation management and overall agricultural production. Therefore, greater emphasis on rainfall forecasting, water conservation, suitable crop varieties and climate-resilient agricultural practices would help farmers manage fluctuations in rainfall. Crops and varieties with suitable maturity duration and better tolerance to moisture stress or excess rainfall may be considered according to prevailing seasonal conditions. Further analysis linking rainfall variability with crop area, production and productivity would provide a better understanding of its effects on agriculture in the district. Future scope The rainfall pattern in Latur district showed considerable fluctuations, with both excess rainfall and below-normal rainfall years creating uncertainty for agricultural planning. Future efforts should therefore focus on strengthening adaptation and risk-management measures to reduce the effects of rainfall variability. Improved rainwater harvesting, farm-level water storage, efficient irrigation facilities and better soil-moisture conservation practices could help farmers manage periods of inadequate rainfall. Adoption of suitable crop varieties and climate-resilient farming practices may further reduce production risks associated with irregular rainfall. Strengthening rainfall monitoring, fore

casting and timely dissemination of weather information can support farmers in making appropriate decisions regarding sowing, crop selection and water use. Greater emphasis on integrated water-resource management and location-specific agricultural planning would also contribute to maintaining stable and sustainable agricultural production in the district.

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How to cite this article: Bansode H, Perke D, Kamble S, Shelke R, Totawar V. Rainfall trends and their relationship with agricultural production in Latur district of Maharashtra. *International Journal of Research in Agronomy*. 2026;SP-9(9):498-505. doi: <https://www.doi.org/10.33545/2618060X.2026.v9.i9Sf.6672>