

## Statistical Analyses on the Seasonal Rainfall Trend and Annual Rainfall Variability in Baramati Tehsil of Pune District, Maharashtra

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**Abstract:** Rainfall is an extremely important environmental factor as changes in rainfall patterns have a major impact on agriculture. Understanding rainfall trends is an important tool for the development and future of agriculture. The variable attributes of climate are the annual climate temperature and precipitation, which have received a great deal of attention worldwide. The degree of variability or fluctuation of this factor varies from place to place and time to time. Therefore, it is necessary to design and examine climate science software systems in various formats to assess climate induced change and suggest adaptive strategies in countries with rain-fed agriculture attributing to a changing climate. In the present study we have studied the pattern and changes of rainfall and its distribution in Baramati Tehsil. For this research, the average rainfall period and rainfall from 2007 to 2023 have been studied. Also these correlations have been studied through statistical systems.

**Keywords:** Rainfall, Trend, Spatial distribution, Statistical Analysis, Variability.

### 1. Introduction

Rainfall is one of the vital climatic elements that affect not only agricultural activity, but also entire ecology in any region. Hence the rainfall distribution and its trends in the district may help to understand water availability and to take decisions for the agricultural activities of that place. Rainfall in any geographical area is a decisive factor affecting agriculture, plant biodiversity, water resources, management, industry and tourism as well as socio-economic activities of that region. Changes in rainfall patterns lead to severe floods in some areas and frequent droughts in others. However, we can see that modern technology has greatly affected the management of agriculture<sup>(1,6)</sup>. Analytical studies of rainfall characteristics are important due to the impact of climate change on rainfall patterns. Also, they have been the focus of many scientists around the world in recent years. For this, you can see the study using various technologies like Remote Sensing and GIS to study the pattern and distribution of rainfall, forecasting rainfall. Rainfall is a natural resource on which the development of the whole world depends. Water is one of the most important natural resources. Humans use water for various purposes,

so the economic, social, political and cultural development of that region depends on water <sup>(2,3)</sup> . Development of agriculture or development of any sector depends on water. Precipitation is very important for the survival of plants and animals. Precipitation is considered very important for the availability of fresh water on Earth's surface. If there is less rainfall, there is scarcity of water and therefore drought conditions arise <sup>(7,9)</sup> . In case of heavy rainfall, flood conditions arise and this affects the lives of people. Proper use of water and water planning for it helps to reduce drought conditions. It is necessary to create awareness among the people regarding water. Along with water, it is necessary to create awareness among people about water pollution caused by agriculture and various businesses. Because if there is water, there is life, otherwise this water will not be available for drinking for the next generation. The main reason for this is the growing population and the growing factories, urbanization and domestic water consumption due to this population. It is necessary to plan water using modern technology in agriculture because if there is water then there is life. The three major characteristics of rainfall are mainly its amount, frequency and intensity. The value of rainfall varies greatly from day to day, place to place, month and year to year<sup>(7)</sup> As India is an agricultural country, Indian agricultural is totally dependent on monsoon rainfall. But Indian monsoon rainfall in India is uneven and unregularly due to this there is a large amount of drought in India. Some parts of India receive about 400 cm of rainfall annually. However, it is less than 60 cm in Rajasthan and adjoining parts of Gujarat, Haryana, and Punjab. The rest of the country receives moderate rainfall. Owing to this nature of monsoons, the annual rainfall is highly variable from year to year. Pune district falls in the rain fed region as the entire winds are blocked in the Sahyadri range and rest of the dry winds move to the rest other area. A study looks at the trends, patterns and distribution of rainfall in Baramati Tehsil. By which this study will help in planning water in terms of agriculture in this tehsil.

## 2. Study Area:

Baramati tehsil is located from 18°4' to 18°32' North latitudes and 74°26' to 74°69' East longitudes. It is located at an altitude of 550 mts. above means sea level. Baramati town is located at 18°15' and 74°58' E it has a versant elevation of 538 mts. (1765 feet). It is surrounded by Phaltan tehsil from South, Daund tehsil from North, Malshiras tehsil from East, Indapur tehsil from East and Purandar tehsil to West side (Fig. 1). It is characterized by a hot summer and dry during the south-west monsoon season and average rainfall is 502 mm per year.

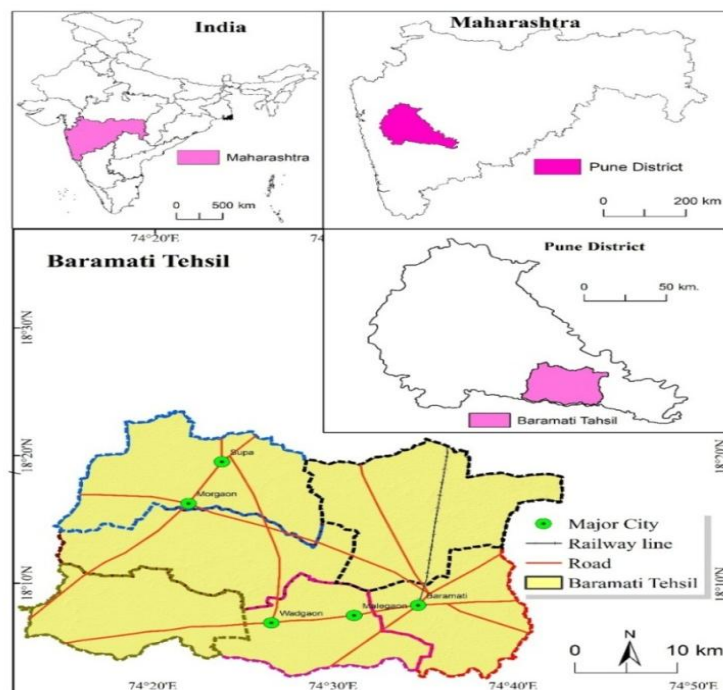


Fig. no 01: Location of study area

### 3. Aims and Objectives:

The main objective is to study the environmental rainfall of Baramati Tehsil. To complete the said research the following objectives have been studied.

1. To study the annual rainfall trend and pattern of Baramati Tehsil.
2. To study the spatial distribution of rainfall in Baramati Tehsil.

### 4. Methodology:

The study methodology of the said research paper mainly relies on secondary data. In order to fulfil the objective of the study, the following study method has been adopted. Firstly, the Rainfall data of the study area has been taken from Rain fall- India Meteorological Department (IMD) Pune website, on top of which a qualitative map has been prepared. A rainfall map has been prepared from the average rainfall in the study area. The present research article has secondary data use for Ahmednagar statistical department. The data analyzed and presented in the form of table and maps with analysis is done with the help of SPSS software and for mapping purposes used ILWIS 3.8 version GIS software. In this research she has drawn maps according to the Average rainfall 2007 to 2023 and the index value are namely divided into 07 groups high rainfall area above 500 mm and very low rainfall less than 450 mm . Also line graph of average rainfall for the period rainfall 2007 to 2022 has been drawn. The research methodology is given in the following chart. 3-year and 5-year moving averages are valuable tools for analyzing rainfall patterns, reducing variability, and identifying trends

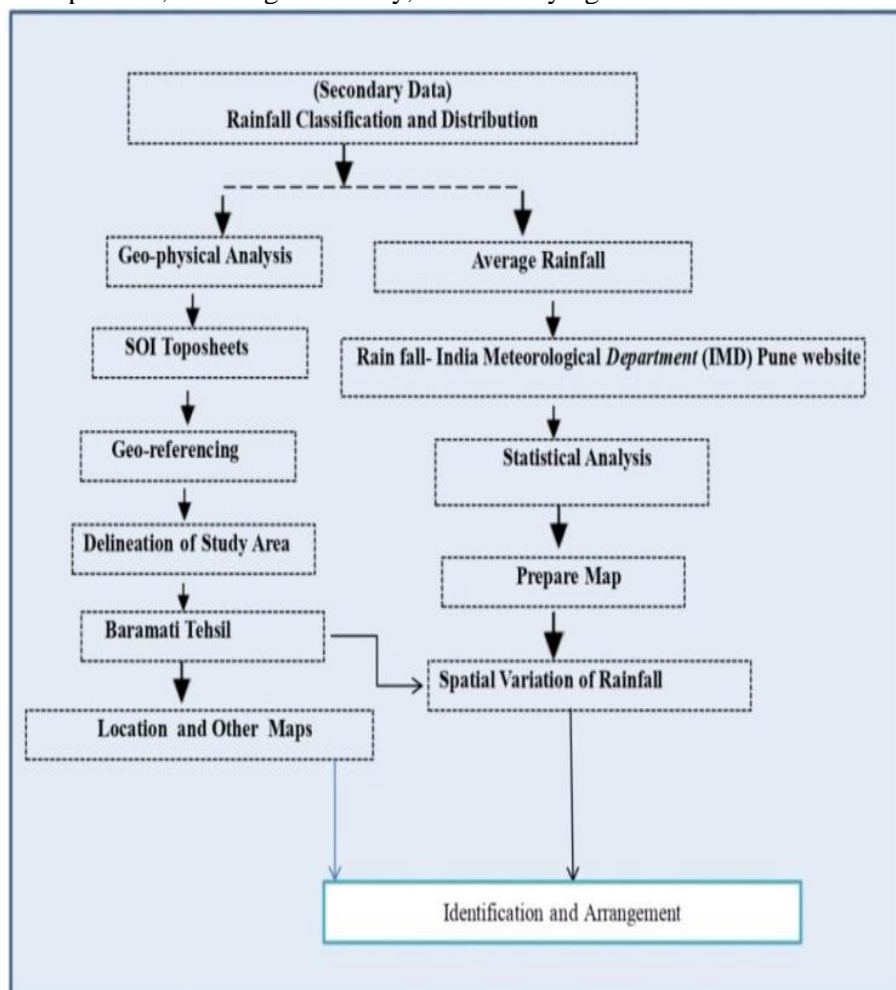
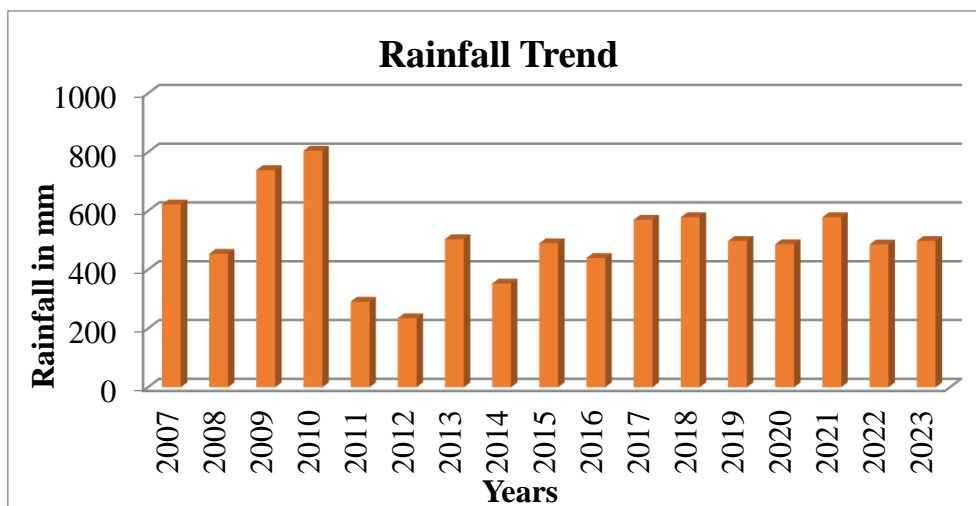


Chart no 1: Research Methodology

**5. Result:**

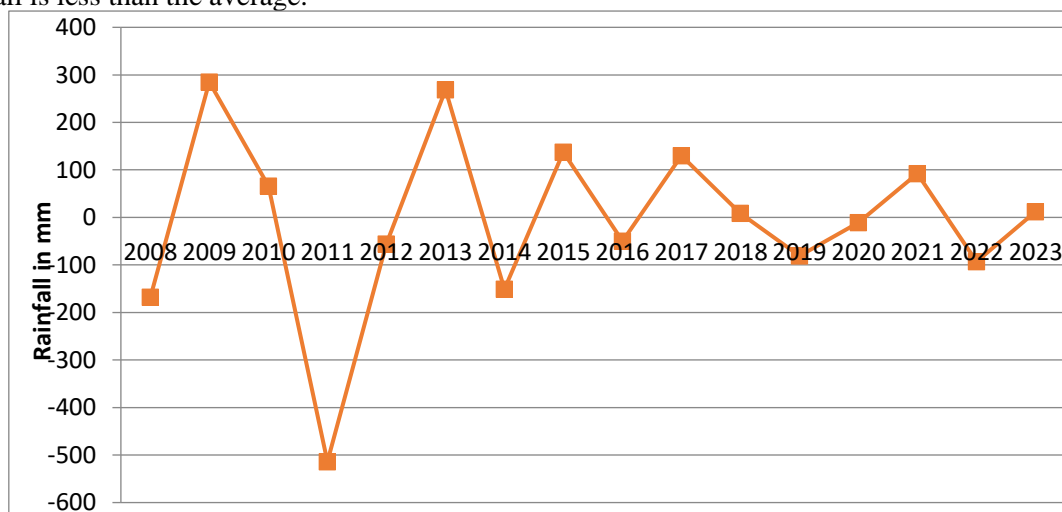
**1. Rainfall Trend and Pattern :**

To study the rainfall trend of Baramati Tehsil, average rainfall for the years 2007 to 2023 has been studied. This Trend is shown Graph number 01, the annual average rainfall of Baramati Tehsil. Baramati tehsil has an average annual rainfall of 508 km from 2007 to 2023. In Baramati tehsil, the average rainfall during the study period is 508 millimetres. The years with less than 508 mm of rainfall are mainly 2008, 2011 to 2016, 2019 to 2020, 2022 and 2023 years. In 2007 the average rain fall was 622 mm in 2008 year it was 454 mm. The lowest rainfall was 235 mm in the year 2012 year. The next rainfall was 291 mm in 2011 year. On the contrary, the highest rainfall is seen in the year 2010 and also in the year 2009, 739 mm of rainfall. The said rainfall is more than the average rainfall during the entire study period.

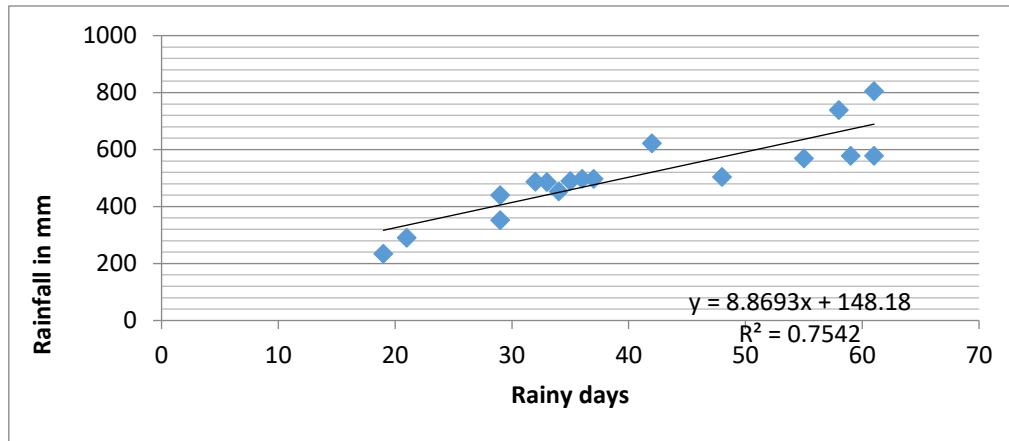


Graph no 01: Rainfall Trend in Baramati Tehsil (Annual Average)

Graph No. 02 shows the variation of rainfall in the study area from this it is clear that the year 2011 shows the highest difference in rainfall. After that, even in the year 2008, there is a difference in rainfall. In short 2022, 2020, 2019 Rainfall in the years 2016 and 2014 is observed to be less than the previous year or is negative. Otter wise, 2009 year, 2010 year, 2013 year, 2015 year, 2017 year, 2018 year, 2019 and 2023 years show an increase in rainfall. The year 2009 year is the year with the highest rainfall (285mm) and the year 2013 is also the year with the highest rainfall (269mm) rainfall increasing in back year. Rainfall in Baramati Tehsil is currently observed to be more or less in 2008 year with negative rainfall in 2010, 2014, 2019 and 2022 year than the previous year. Also 2009, 2013, 2015, 2017, 2021 and 2023 shows a positive increase in rainfall. However, in 2010, 2015, 2017, 2018, 2021, 2023, the rainfall is less than the average.



Graph no 02: Variation in annual rainfall



Graph no 03: Linear Regression of Rainfall Days and Rainfall

In graph number 03 are shown the linear regressions/ correlation between rainfall days and annual average rainfall in the Baramati Tehsil.

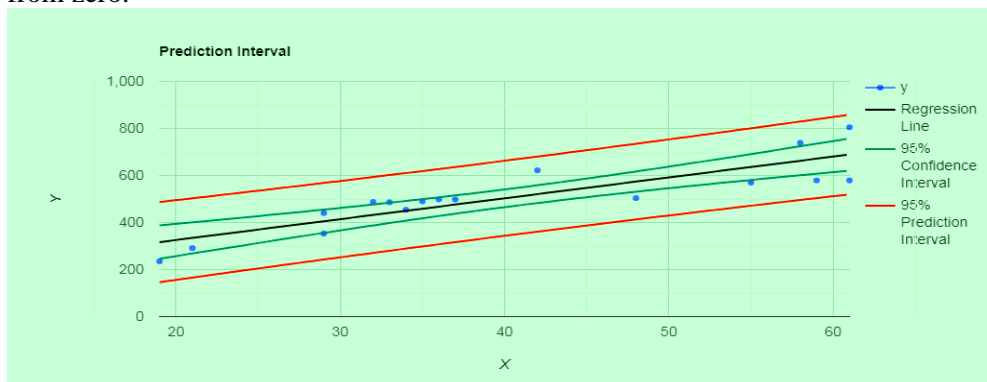
A) Y and X relationship

1. R-Squared ( $R^2$ ) equals 0.7542. This means that 75.4% of the variability of Y is explained by X.
2. Correlation (R) equals 0.8685. This means that there is a very strong direct relationship between X and Y.
3. The Standard deviation of the residuals ( $S_{res}$ ) equals 72.763.
4. The slope:  $b_1=8.8693$  CI[6.083, 11.6556] means that when you increase X by 1, the value of Y increases by 8.8693.
5. The y-intercept:  $b_0=148.1796$  CI[29.1524, 267.2067] means that when X equals 0, the prediction of Y's value is 148.1796.
6. The x-intercept equals -16.707.

This shows that there is a correlation between the amount of rainfall in those particular years and the number of days in which the rainfall occurred. From the above figure it can be seen that their correlation through linear regression is positive Correlation (R) equals 0.8685.

B) Goodness of fit:

1. Overall regression: right-tailed,  $F(1,15) = 46.0333$ , p-value = 0.00000615. Since p-value  $< \alpha$  (0.05), we reject  $H_0$ .
2. The linear regression model,  $Y = b_0 + b_1X + \epsilon$ , provides a better fit than the model without the independent variable resulting in  $Y = b_0 + \epsilon$ .
3. The slope ( $b_1$ ): two-tailed,  $T(15)=6.7848$ , p-value = 0.00000615. For one predictor it is the same as the p-value for the overall model.
4. The y-intercept ( $b_0$ ): two-tailed,  $T(15) = 2.6535$ , p-value = 0.01806. Hence,  $b_0$  is significantly different from zero.

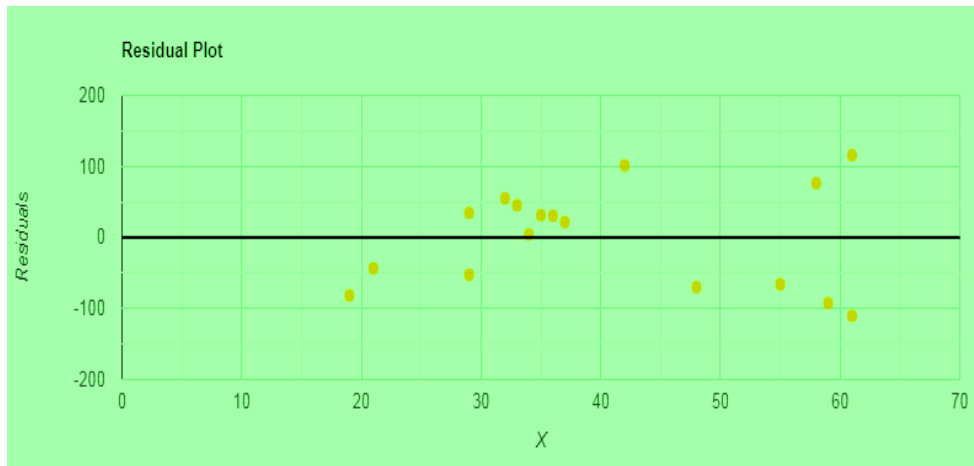


Graph no 04: Prediction Interval of Rainfall Days and Rainfall

X = Axis on Rain days, Y= Axis on Rain fall in mm

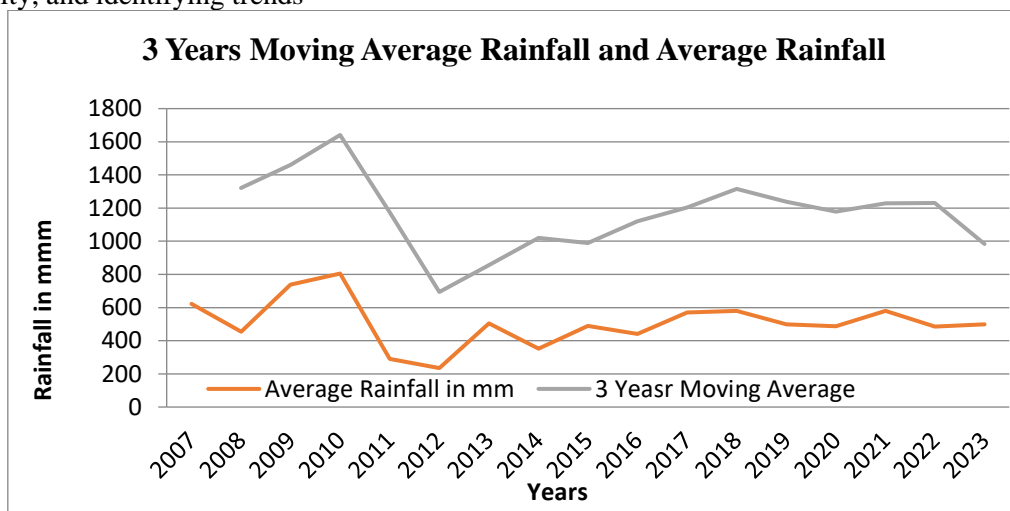
C) Residual normality:

1. The linear regression model assumes normality for residual errors. The Shapiro-Wilk p-value equals 0.3537. It is assumed that the data is normally distributed,

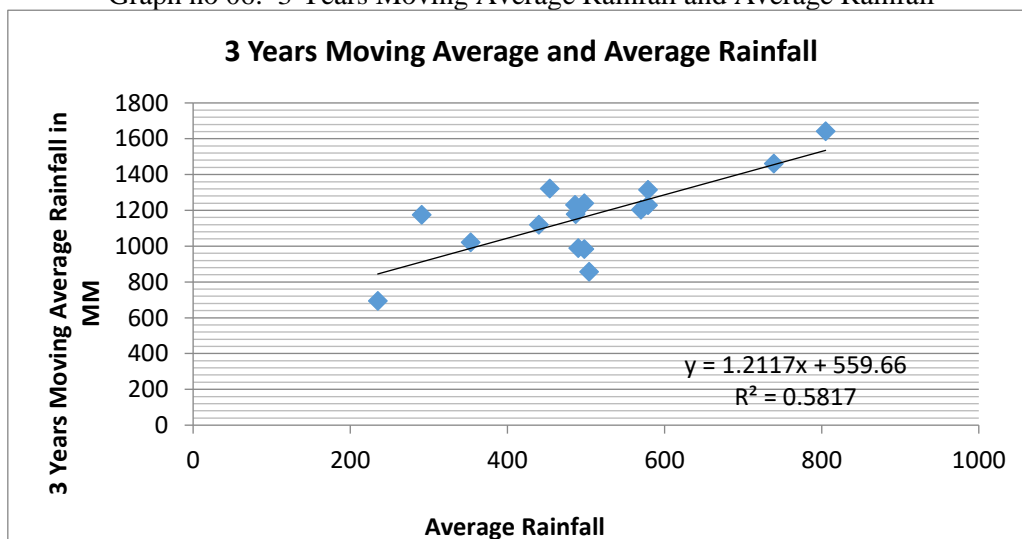


Graph no 05: Residual Plot of Rainfall Days and Rainfall

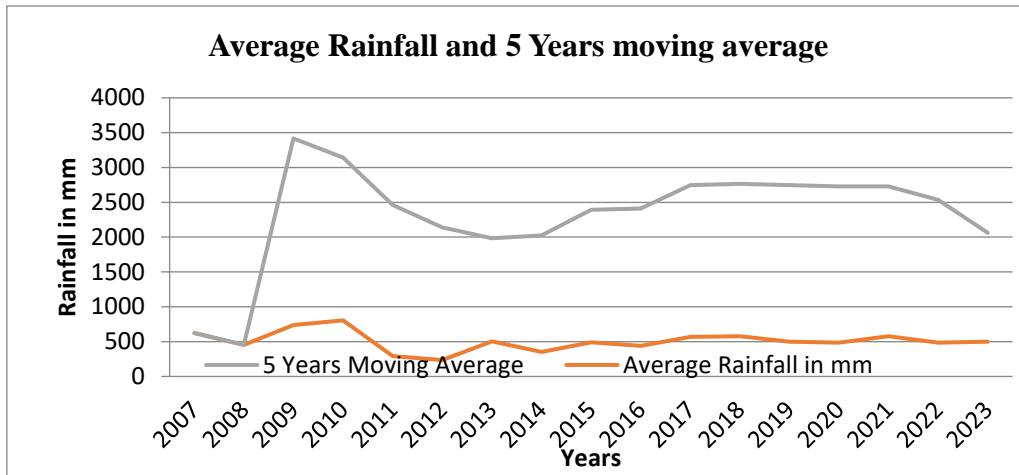
3-year and 5-year moving averages are valuable tools for analyzing rainfall patterns, reducing variability, and identifying trends



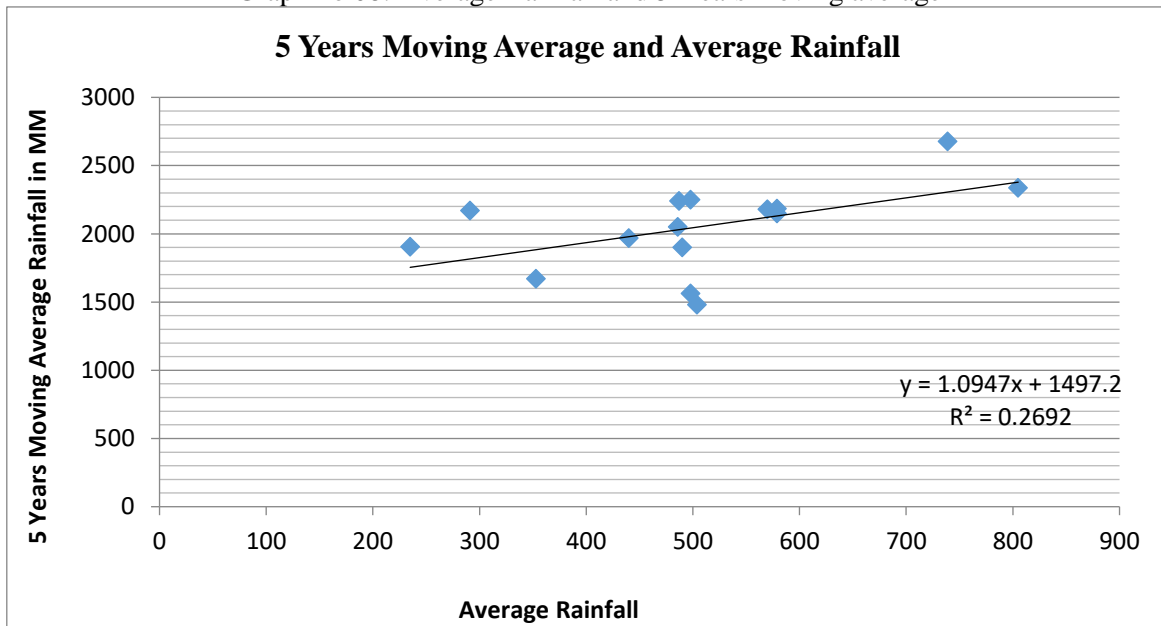
Graph no 06: 3 Years Moving Average Rainfall and Average Rainfall



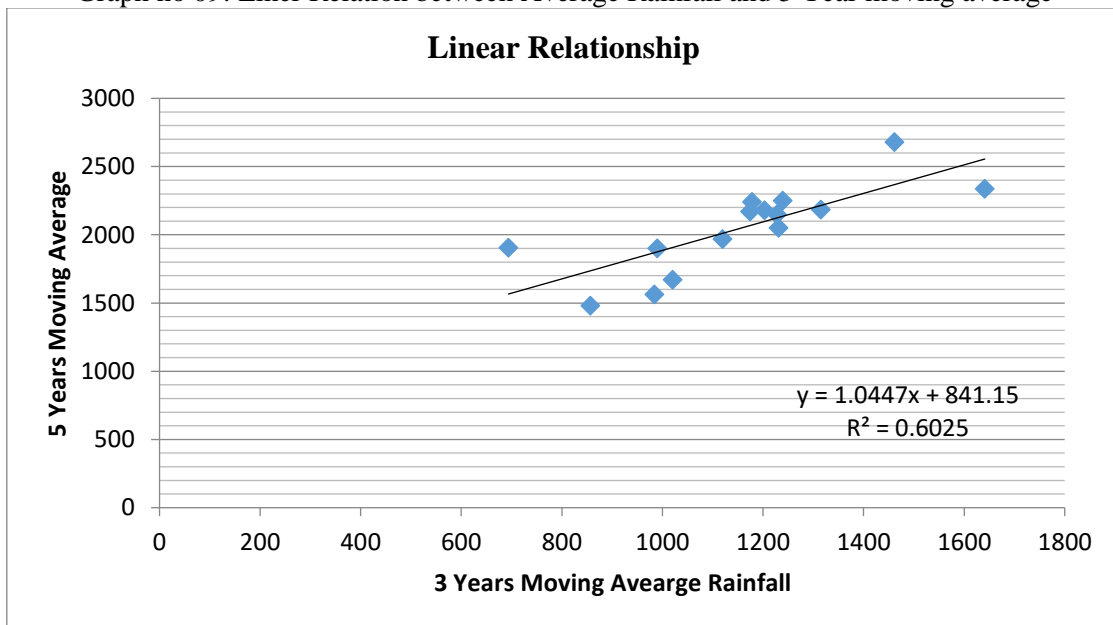
Graph no 07: Liner Relation between Average Rainfall and 3 Year moving average



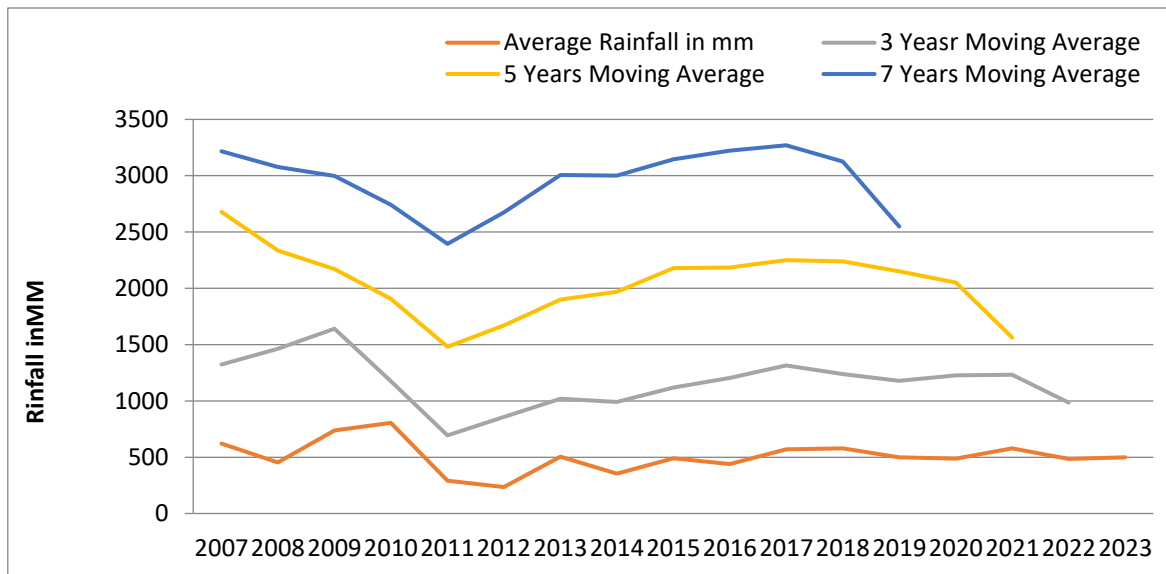
Graph no 08: Average Rainfall and 5 Years moving average



Graph no 09: Liner Relation between Average Rainfall and 5 Year moving average



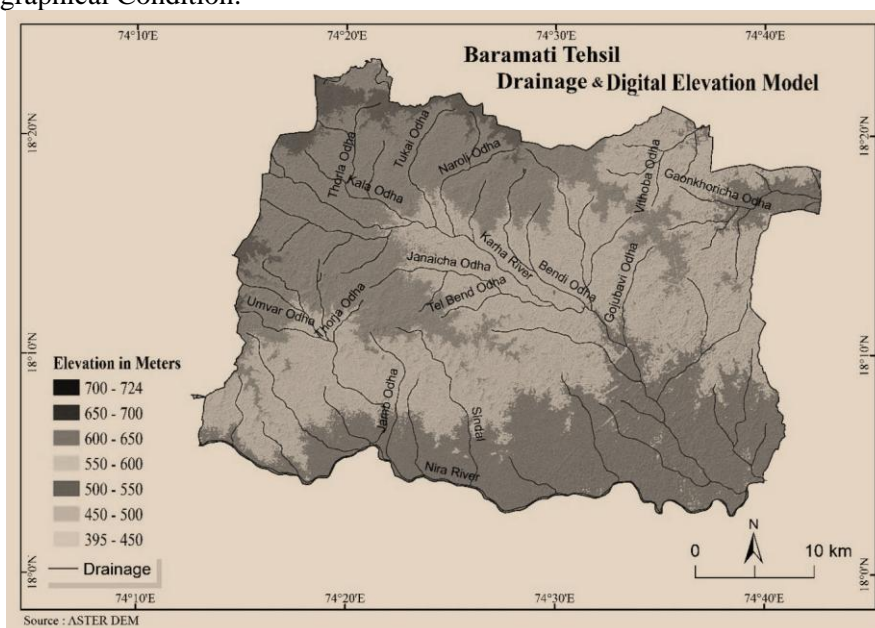
Graph no 10: Linear Relationship between 3 and 5 Year moving average



Graph no 11: Annual and Average Rainfall and 3,5,7 Moving Years Average  
Table 01 Moving 3, 5 and 7 years average, annual and average rainfall (mm)

Years	3 Years Moving Average	5 Years Moving Average	7 Years Moving Average
2007	1322	2678	3218
2008	1461	2336	3078
2009	1641	2171	2997
2010	1174	1906	2741
2011	694	1481	2394
2012	857	1670	2675
2013	1020	1901	3007
2014	990	1969	3000
2015	1120	2179	3147
2016	1203	2184	3222
2017	1315	2250	3270
2018	1239	2240	3127
2019	1178	2150	2548
2020	1228	2050	
2021	1231	1563	
2022	984		
2023			

2. Topographical Condition:

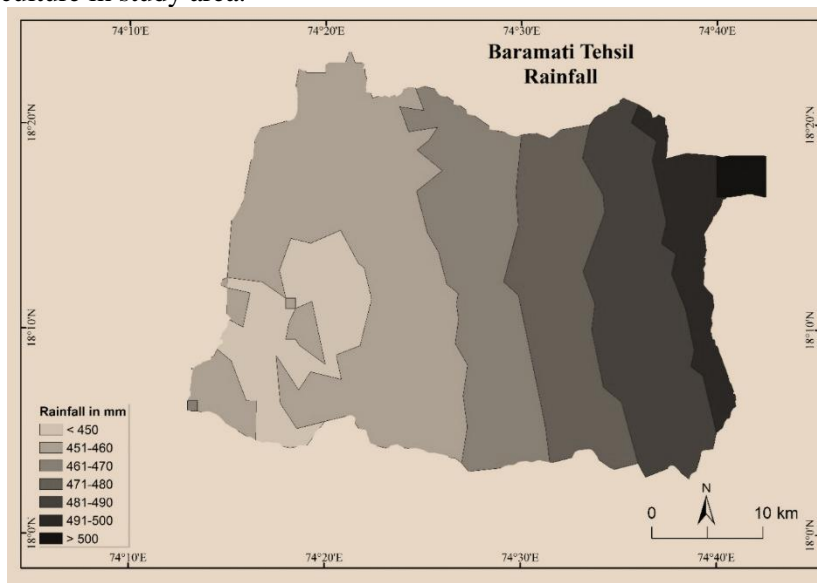


Map no 02: Topographical Condition and River Pattern

The rainfall in the study area between 2007 and 2023 is shown. The rainfall during these years is increasing and decreasing, but the 03 year moving average is to be more than the average rainfall and there is a positive relationship between the average rainfall and the three-year moving average, which means that both the rainfalls are seen to be changing in the same direction. Also, from the average rainfall and 5 year moving average rainfall, it is seen that the 5 year moving average rainfall is more than the average and there is a positive relationship between three years and 5 year moving average rainfall. This makes it clear that 03 years and 5 year moving average rainfall are changing in the same direction or both the factors have the same trend. Also, we see a positive relationship. Also, we see a positive relationship between three years and 07 years moving average rainfall. From this, it can be inferred that the topography of this study area has an effect on the distribution of this rainfall. The areas where the height above sea level is high have more rainfall and the rainfall decreases towards the lowlands.

### 3. Rainfall Distribution:

The three major characteristics of rainfall are mainly its amount, frequency and intensity. The value of rainfall varies greatly from day to day, place to place, month and year to year. Monsoon rainfall in India is irregular and its distribution is uneven. Average rainfall in India is 110cm to 1250cm annually. India falls under the monsoon climate zone and rainfall is said to be the backbone of Indian agriculture and economy. So rainfall is very important for India. Rainy season in India mainly starts from July to August and it becomes more aggressive in the later period. Windward of the Western Ghats receives heavy rainfall and decreases or falls opposite to it. 250 cm of rain falls on the windward side and less against it. Pune district receives an average rainfall of less than 70 cm. Map 02 shows the distribution of rainfall in Baramati Tehsil. Rainfall in Baramati increases from east to west, more than 500 mm of rainfall is found in the western part and less than 450 mm of rainfall is found in the eastern part. This means that we can see the effect of this rainfall on the soil distribution. The reason behind uneven distribution of rainfall in Baramati tehsil is mainly due to environmental conditions of rainfall Map 02 shows that the rainfall is less in the eastern part and as we move towards the western part the rainfall increases. More than 500 mm of rainfall falls in the western part and less than 450 mm of rain falls in the eastern part. Nimbodi, Jainakwadi, Sawal, Katewadi and dhekalwadi villages are in the tribal areas and the rainfall is high due to the high mountain area and vegetation in the western part of Baramati tehsil. Also the villages between 400 and 500 mm include Parwadi, Katphal, Vanjarwadi, Rui, Zargadwai and Songaon. The effect of all these on the crops here and the soil types and distribution can be seen above. In the western part you get to see a large amount of cash crops while in the eastern part you get to see pulses and pulses. This means that the effect of environmental factors is seen on the agricultural production and type of agriculture in study area.



Map no 03 : Spatial Distribution of Rainfall in the Baramati Tehsil.

The moving average (MA) is a widely used technical indicator in finance and trading. Moving averages help identify the direction and strength of a trend. A rising MA indicates an uptrend, while a falling MA indicates a downtrend.

1. Reduces variability: Moving averages reduce the impact of extreme rainfall events, providing a clearer picture of the overall trend.
  2. Identifies patterns: By smoothing out yearly fluctuations, moving averages help identify patterns, such as increasing or decreasing rainfall trends.
  3. Improves forecasting: Moving averages can be used as a predictive tool to forecast future rainfall patterns, helping with water resource management and planning.
  4. Enhances comparison: Moving averages enable comparison of rainfall patterns across different regions or time periods, facilitating a better understanding of rainfall variability.
  5. Supports decision-making: By providing a more accurate representation of rainfall trends, moving averages support informed decision-making in areas like agriculture, water management, and urban planning.
- 3-year and 5-year moving averages are valuable tools for analyzing rainfall patterns, reducing variability, and identifying trends

## **6. Conclusion:**

Rainfall is one of the vital climatic elements that affect not only agricultural activity, but also entire ecology in any region. Hence the rainfall distribution and its trends in the district may help to understand water availability and to take decisions for the agricultural activities of that place. Water is one of the most important natural resources. Humans use water for various purposes, so the economic, social, political and cultural development of that region depends on water. Development of agriculture or development of any sector depends on water. Mainly the vegetation and the topography of the region are two factors that mainly affect it. For example, west of the Sahyadri mountain range in Maharashtra receives heavy rainfall and decreases from this range towards the east. Briefly, in the study area, the rainfall is high due to the higher amount of vegetation and mountainous areas towards the west and as the plains are coming towards the east, the rainfall decreases.

Applications of Research Paper:

1. Climate change research: Help analyze long-term rainfall trends, supporting climate change research.
2. Water resource management: Inform water resource management decisions, such as reservoir management and irrigation planning.
3. Agricultural planning: Support agricultural planning by providing insights into rainfall patterns, helping farmers make informed decisions

Conflict of Interest:

There is no conflict of interest.

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