A STUDY TRENDS OF RAINFALL PATTERN OF NASHIK DIVISION BASED ON STATISTICAL TOOLS

ANNUAL PROJECT

2022-2023

BY

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Certificate

This is to certify that Shirsale Harshada Jagdish, Patil Kalyani Purushottam, Shinde Pravin Kaduba, Baviskar Jayesh Pravin and Sonar Atharv Rahul. Are student of B.Sc. STATISTICS at M. J. College, Jalgaon have successfully completed their project entitled **"A STUDY TRENDS OF RAINFALL PATTERN OF NASHIK DIVISION BASED ON STATISTICAL TOOLS" (1981-2021)** under my guidance and supervision during the academic year 2022-2023.

Place: Jalgaon

Date:

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Acknowledgement

We would like to express our sincere thanks to **Prof. K. G. khadse sir, Head of Department of Statistics, M. J. College, Jalgaon**. For seeking us the desire permission for this project.

We take this opportunity to express our sense of gratitude to our project guide **Dr. K. G. Khadse** for his valuable guidance, immense support, motivation and encouragement to which we could complete our project work successfully.

- **Shirsale Harshada Jagdish**
- **Patil Kalyani Purushottam**
- **Shinde Pravin Kaduba**
- **Baviskar Jayesh Pravin**
- **Sonar Atharv Rahul**

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INTRODUCTION

Rainfall can simply refer to the falling of water droplets from sky or, most often when used in meteorology the total amount of rain that falls in a given period of time. Rain is liquid precipitation. Rain is water droplets that have condensed from atmospheric water vapor and then fall under gravity. Rain is a major component of the water cycle and is responsible for depositing most of the fresh water on the Earth. It provides water for hydroelectric power plants, crop irrigation, and suitable conditions for many types of ecosystems. Rain is measured in units of length per unit time, typically in millimeters (mm) per hour.

Precipitation, especially rain, has a dramatic effect on agriculture. All plants need at least some water to survive, therefore rain (being the most effective means of watering) is important to Agriculture. A good monsoon brings economic prosperity for the whole country and boosts the India economy as agriculture contributes around 16% of it's total Gross domestic product (GDP).

ABSTRACT

Rainfall is one of the climatological data which is widely analyzed for a long time. The present study is focused on the analysis of rainfall data in Jalgaon, Maharashtra, India for year 1981-2021. With respect to that we also focused on rainfall data of Nashik Division.

Under the Nashik Division we may collected data for the following District:

1. Nashik
2. Dhule
3. Ahmednagar
4. Nandurbar

In addition to the classical procedure for the analysis of rainfall data, Kolmogorov- Smirnov test is used to study normality of data. Correlation is used to study the relation between Precipitation, temperature, wind speed, humidity, surface pressure and regression line is Fitted for given data.

WHY RAINFALL DATA ANALYSIS SO IMPORTANT?

1) **Water Resources Management:**

Water Resource Management (WRM) is the process of planning, developing, and managing water resources, in terms of both water quantity and quality, across all water uses.

2) Disaster Management:

The organization, planning and application of measures preparing for, responding to the recovering from disasters.

3) Planning of Agricultural activities:

An important aspect to be understood regarding the relationship between rainfall and agriculture is that rainfall is the major factor in the growth and production of food crops both at the germination and fruit development stage.

STUDY AREA

District under Nashik Division

- Jalgaon
- Nashik
- Nandurbar
- Dhule
- Ahmednagar

VARIABLES

- Rainfall/ Precipitation (mm): The total amount of Rain that falls in a particular place during a month, Year, etc.
- Temperature (C): Temperature is the degrees of hotness or coldness of a particular place.
- Wind speed (m/s): In meteorology, wind speed, or wind flow speed, is a fundamental atmospheric quantity caused by air moving from high to low pressure, usually due to changes in temperature
- Surface pressure (atm): Atmospheric pressure, also known as barometric pressure, is the pressure within the atmosphere of Earth.
- Humidity (g m^3): Humidity is the amount of water vapor in the air. If there is a lot of water vapor in the air, the humidity will be high.

OBJECTIVES

- To compare Actual rainfall with normal rainfall.
- To identify patterns of rainfall.
- Rainfall is not uniformly distributed.
- Rainfall of different districts is same or not?

- This includes an understanding of the area's rainfall and temperature trend and variability. Understanding the uncertainties associated with rainfall and temperature patterns will provide a knowledge base for better management of agriculture, irrigation
  And other water-related activities in the selected area.
- To study the variation in rainfall due to temperature, humidity, wind speed, surface pressure.
- To study trend in rainfall in 41 years (1981-2022)

CLIMATE AND AVERAGE WEATHER IN JALGAON

(Standard values for Rainfall)

Particular	Minimum	Maximum
Normal Range of annual rainfall	604.48 mm	906.72 mm
Drought	528.9 mm	604.48 mm
Severe Drought	Below 528.9 mm	
Heavy Rain	906.72 mm	982.3 mm
Extremely Heavy rainfall (Flood)	Above 982.3 mm	

Table No.1

IMPORTANT CHARACTERISTICS OF RAINFALL IN MAHARASHTRA

In India, there is great variation in temperature and rainfall, not only from place to place, but also from season to season.

- Rainfall in India mainly occurs in the months of July, August and September.
- The India rains are chiefly orographic in nature. As a result, the regions situated on the windward side receive greater rainfall than the regions located on the leeward side.
- Only a scant amount of rainfall is received from cyclones and convection rainfall.
- Monsoon in India is irregular, not well Distributed and Unpredictable. While there are floods in some region, the other region face drought.
- Central and northern parts of India get occasional rainfall during winter.
- Monsoon type of climate is found in India.
- Monsoon has a tendency and phenomenon to have breaks in rainfall.
- The monsoon has dry and wet spells.
- Rainfall interval intersperse the Monsoon.
- The alternation of wet and dry spells varies in duration, frequency, and intensity.

FACTORS INFLUENCING EFFECTIVE RAINFALL

Factors	Relevant characteristics
Rainfall	Amount, intensity, frequency, distribution over area as well as time.
Other meteorological parameters	Temperature, radiation, relative humidity and velocity.
Land	Topography, slope, type of use.
Soil	Depth, texture, structure, bulk density, salt and organic matter content.
Affecting factors	Latitude, Distance from the sea, Mountains, type and direction of winds.

Table No.2

We can only measure some climate factors that affect rainfall are temperature, wind speed, surface pressure, humidity, relative humidity, wind velocity, etc. But for this project we consider only temperature, wind speed, surface pressure and humidity as factor affecting rainfall.

METHODOLOGY

1) Collection of Data

Due to some limitation that we are mentioned below we wants to study rainfall data of Jalgaon district then it is impossible to collect primary data of rainfall and other factors as it required more manpower and time. While secondary data is easily accessible compared to primary data. It saves efforts and expenses. It is time Saving thus we use secondary data for our study

We have taken secondary data from 'Power Access Climate Data' online data portal of NASA. We collect data for point location of Jalgaon district using Latitude=21.0155 and Longitude-75.5501. We collected data of monthly ana annual precipitation, temperature, humidity, wind speed and surface pressure for 41 years from 1 January 1981 to 31 December 2021.

2) Limitations for data collection

We could not use primary data as we needed weather data to study variation in rainfall so we used secondary data but there were some limitations like we did not get data of different factors for same time period. Selecting the right factors with standard units is important.

3) COLLECTED DATA

Year	Precipitation	Temperature	wind speed	surface pressure	Humidity
1981	801.2	26.18	2.77	97.17	11.24
1982	564.26	27.09	2.63	97.17	11.55
1983	622.27	26.44	2.78	97.16	10.60
1984	390.23	27.18	2.82	97.09	9.63
1985	442.97	27.41	2.83	97.08	9.72
1986	395.51	27.53	2.8	97.14	9.75
1987	664.45	27.24	2.49	97.22	10.80
1988	854.3	26.99	2.44	97.12	10.99
1989	653.91	26.79	2.51	97.16	10.07
1990	833.2	26.49	2.71	97.16	11.67
1991	590.62	27.17	2.59	97.17	9.83
1992	574.8	27.01	2.62	97.21	9.84
1993	917.58	26.37	2.59	97.22	10.98
1994	806.84	26.19	2.6	97.17	10.97
1995	590.62	27.07	2.52	97.14	10.54
1996	664.45	26.87	2.55	97.12	10.66
1997	675	26.58	2.51	97.26	11.39
1998	896.48	26.69	2.43	97.16	12.05
1999	685.55	26.51	2.56	97.12	10.80
2000	638.09	26.89	2.52	97.1	9.94

Year	Precipitation	Temperature	Wind speed	Surface pressure	humidity
2001	569.53	26.94	2.48	97.14	10.64
2002	601.17	27.39	2.67	97.19	10.38
2003	738.28	26.92	2.59	97.2	11.30
2004	643.36	26.97	2.52	97.2	11.08
2005	954.49	26.31	2.45	97.18	11.05
2006	1133.79	26.58	2.34	97.19	11.93
2007	775.2	26.76	2.29	97.14	11.39
2008	595.9	26.85	2.46	97.14	10.79
2009	785.74	27.37	2.48	97.16	11.25
2010	907.03	27.05	2.34	97.13	12.40
2011	680.27	26.69	2.37	97.12	11.20
2012	648.63	26.73	2.59	97.14	10.80
2013	928.12	26.21	2.64	97.14	12.00
2014	648.63	26.9	2.5	97.25	11.43
2015	859.57	26.94	2.36	97.3	11.56
2016	722.46	26.94	2.43	97.22	10.84
2017	817.38	26.91	2.36	97.2	10.98
2018	522.07	27.44	2.45	97.2	9.99
2019	1065.23	26.5	2.54	97.24	11.79
2020	943.95	26.28	2.1	97.2	12.77
2021	856.41	26.8	2.34	97.17	12.33

4)DATA COLLECTION (Nashik division precipitation District wise):

Year	Jalgaon	Nashik	Nandurbar	Dhule	Ahmednagar
1981	801.2	1466.02	917.58	738.28	711.91
1982	564.26	1123.24	601.17	516.8	490.43
1983	622.27	1265.62	696.09	638.09	548.44
1984	390.23	854.3	469.34	363.87	464.06
1985	442.97	806.84	442.97	432.42	432.42
1986	395.51	659.18	374.41	353.32	421.88
1987	664.45	864.84	490.43	585.35	606.45
1988	854.3	1476.56	827.93	775.2	711.91
1989	653.91	1107.42	532.62	622.27	669.73
1990	833.2	1402.73	801.56	801.56	759.38
1991	590.62	1160.16	558.98	569.53	616.99
1992	574.8	943.95	458.79	527.34	469.34
1993	917.58	1286.72	812.11	817.38	717.19
1994	806.84	1587.3	980.86	764.65	580.08
1995	590.62	1049.41	717.19	537.89	479.88
1996	664.45	1223.44	775.2	653.91	601.17
1997	675	1228.71	812.11	653.91	537.89
1998	896.48	1434.38	896.48	859.57	806.84
1999	685.55	938.67	590.62	632.81	448.24
2000	638.09	1033.59	522.07	611.72	553.71

Year	Jalgaon	Nashik	Nandurbar	Dhule	Ahmednagar
2001	569.53	1133.79	569.53	543.16	490.43
2002	601.17	959.77	643.36	580.08	421.88
2003	738.28	1429.1	1044.14	764.65	384.96
2004	643.36	1618.95	896.48	659.18	622.27
2005	954.49	2204.3	1144.34	1007.23	922.85
2006	1133.79	2151.56	1170.7	1086.33	907.03
2007	775.2	1729.69	1023.05	827.93	659.18
2008	595.9	1750.78	780.47	622.27	569.53
2009	785.74	1197.07	843.75	722.46	675
2010	907.03	1655.86	1007.23	838.48	785.74
2011	680.27	1270.9	817.38	669.73	601.17
2012	648.63	1001.95	680.27	574.8	400.78
2013	928.12	1566.21	1170.7	907.03	653.91
2014	648.63	1508.2	764.65	669.73	585.35
2015	859.57	1307.81	891.21	764.65	595.9
2016	722.46	1988.09	727.73	622.27	580.08
2017	817.38	1856.25	685.55	611.72	706.64
2018	522.07	1344.73	458.79	358.59	247.85
2019	1065.23	2415.23	1218.16	901.76	585.35
2020	943.95	2098.83	991.41	796.29	991.41
2021	856.41	1875.94	845.45	625.64	752.71

5)VARIABLE CREATION

Precipitation (rainfall) amount of precipitation, in the form of rain (water from clouds), that descends onto the surface of earth, whether it is on land or water. Factors that are responsible(affect) on rainfall are temperature, wind, topography, Ocean current, Elevation altitude, surface pressure, humidity, etc. But we have data of precipitation, temperature, wind speed, surface pressure, humidity. In analysis we take precipitation as a dependent variable which depends on independent variable (temperature, wind speed, surface pressure, humidity.

ANALYTICAL METHODS

1) CORRELATION

We may be interested to find out if there is any relation between the two variables under the study, then we use Pearson's correlation coefficients for finding the correlation between variables under study. If the change in one variable affects a change in other variable, the variables are said to be correlated, if two variables deviate on same direction i.e increasing or decreasing in one variable increase the corresponding variable are also increase or one variable decrease then corresponding variable are also decrease then this type of correlation are called Positive correlation. Alternative if one variable are increase then corresponding variable decrease or one variable decrease then its corresponding variable are increase this type of correlation are called Negative correlation. From correlation coefficient we categorized correlation in three type as weak correlation (-0.3 to 0 or 0 to 0.3), moderate correlation (-0.7 to -0.3 or 0.3 to 0.7) and strong correlation (-1 to 0.7 or 0.7 to 1). Here we find Correlation between precipitation with respect to temperature, wind speed, surface pressure and humidity.

2) KOLMOGOROV-SMIRNOV TEST

In the data analysis we have interested the distribution of the data. For finding the distribution of the data we test goodness of fit of data. Here we discuss a test that considered the goodness of fit between the hypothesized distribution function and an empirical distribution function. Because of the convergence of the empirical distribution function to theoretical distribution function, it makes sense to construct a goodness of fit test based the closeness of the empirical and hypothesized distribution function say Fn(x).and Fo(x). Here we shall use the Kolmogorov-Smirnov statistics defined by

Dn=sup[|Fn(x)-Fo(x)|] that is Dn is maximum value of all pointwise difference |Fn(x)-Fo(x)|

Here we test hypothesis

$$\textbf{Ho: } F_n(x)=F_0(x) \quad \textbf{Against} \quad \textbf{H1: } F_n(x) \neq F_0(x)$$

We compute Kolmogorov-Smirnov statistics Dn. The Ho is rejected if observed value of Dn is greater than Critical value selected from statistical table. Here we test the Kolmogorov-Smirnov test for precipitation of Jalgaon, Nashik, Nandurbar, Dhule and Ahmednagar.

3) REGRESSION

predict the outcome of a response variable. Consider the situation involving respective variables and n regressors or explanatory A statistical technique that uses several explanatory variables to variables denoted by X1,X2,X3,…,Xn. A multiple linear regression model related k regressor to respond variable y can be written as

$$\mathbf{Y=\beta o+\beta 1X1+\beta 2X2+….+\beta nXn}$$

Where βo, β1,…,βn are parameters (constant) and € is random error.

Assumption:

1 There must be a linear relationship between the dependent and the independent variables.

2 Error are independent and normally distributed with mean 0 and variance δ^2.

Coefficient of determination:

Coefficient of determination is measured of evaluating the strength of regression model. It is denoted by R^2.

R^2=SSR/SST

1 R^2 lies between 0 & 1.

2 If value at R^2 is close to 1 it implies that most of the variability in y is explained by the regression model.

3 If the assume regression model is correct R^2 increase (decrease) as the variability in X increases(decreases). Thus, the large value R^2 may be observed due to large variation in X value.

4) ANOVA

ANOVA is used to test the significance of the difference between more than two sample means and to make inferences about whether our samples are drawn from population having same means. The ANOVA is a powerful and common statistical procedure in the social sciences. It can handle a variety of situations.

5) TIME SERIES

Time series analysis by Least square Method

Time series analysis by least square method is a technique used to estimate the trend in a time series by fitting a linear regression model to the data. The least square method is a popular technique used to estimate the parameters of a linear regression model.

In time series analysis, the data is a sequence of observations that are taken over time. The goal of time series analysis is to identify patterns and trends in the data, and to make predictions about future values based on these patterns.

The least square method involves fitting a straight line to the data using the formula:

$$y = a + bx$$

where y is the dependent variable (i.e., the time series data), x is the independent variable (i.e., the time), a is the intercept, and b is the slope of the line.

To use the least square method for time series analysis, the first step is to plot the data and examine it for any patterns or trends. If the data shows a linear trend, then the least square method can be used to estimate the trend.

The next step is to calculate the slope and intercept of the line using the least square method. The slope (b) is calculated using the formula:

$$b = \Sigma((x-\bar{x})(y-\bar{y})) / \Sigma(x-\bar{x})^2$$

where $\bar{x}$ is the mean of the independent variable, $\bar{y}$ is the mean of the dependent variable, and Σ represents the sum of the values.

The intercept (a) is then calculated using the formula:

$$a = \bar{y} - b\bar{x}$$

Once the slope and intercept have been calculated, the fitted line can be plotted on the graph along with the original data. This line represents the estimated trend in the time series.

It is important to note that the least square method assumes that the residuals (the differences between the observed values and the values predicted by the regression line) are normally distributed and have constant variance. If these assumptions are not met, other methods such as time series decomposition or exponential smoothing may be more appropriate for analysing the data.

1) Descriptive Statistics

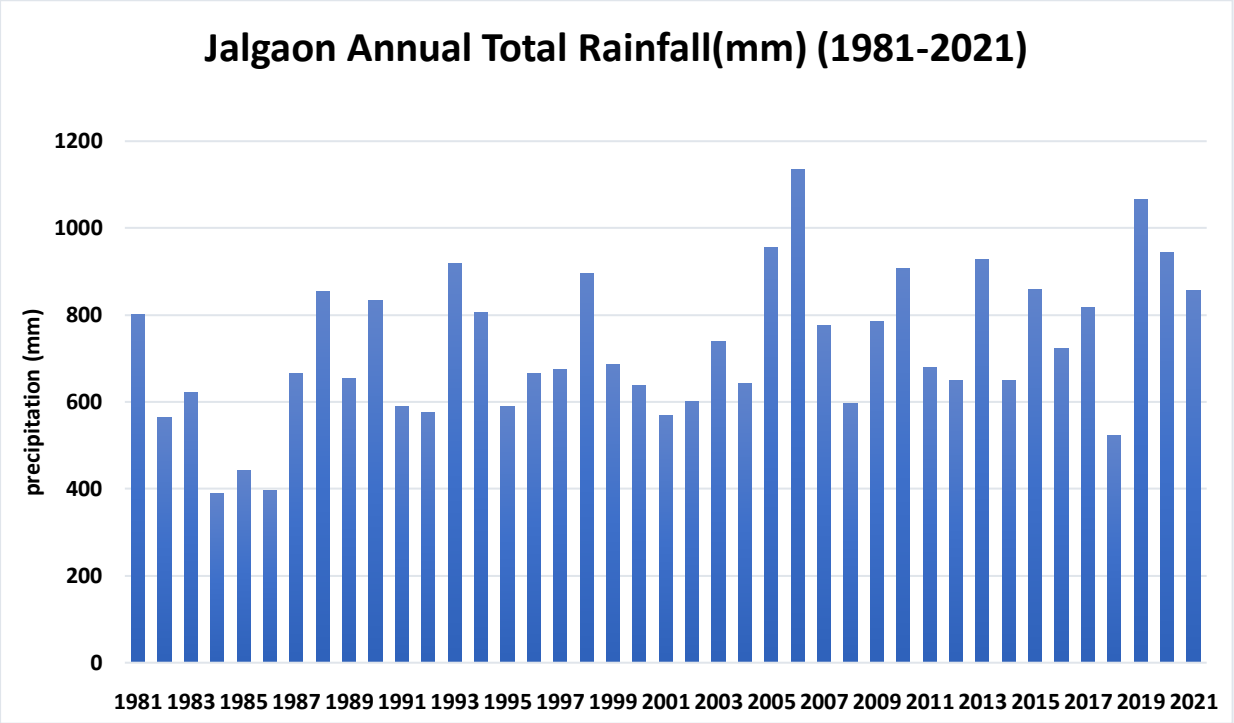


Fig.(A)

	Precipitation	Temperature	Wind speed	Surface pressure	humidity
Mean	723.40341	26.83341	2.52609	97.17048	10.99851
Median	680.27	26.89	2.52	97.17	10.98
Mode	664.45	26.94	2.59	97.14	---
Standard Deviation	169.73554	0.35998	0.15475	0.04706	0.77869
Range	743.56	1.35	0.73	0.22	3.13333
Minimum	390.23	26.18	2.1	97.08	9.63333
Maximum	1133.79	27.53	2.83	97.3	12.76666
Sum	29659.54	1100.17	103.57	3983.99	450
Count	41	41	41	41	41

Table No.3

2) CORRELATION

Since, the r- value between precipitation and temperature (-0.638), precipitation and Wind speed (-0.532) is negative We infer that precipitation and temperature, precipitation and Wind speed is negatively correlated. But r- value between precipitation and surface pressure, humidity are positive (0.337, 0.783 respectively) hence they are positively correlated

		Precipitation	Temperature	Wind speed	Surface pressure	Humidity
Precipitation	**Pearson Correlation**	1	-0.638	-0.532	0.337	0.783
Temperature	**Pearson Correlation**	-0.638	1	-0.130	-0.130	-0.518
Wind speed	**Pearson Correlation**	-0.532	0.145	1	-0.286	-0.577
Surface pressure	**Pearson Correlation**	0.337	-0.130	-0.286	1	0.313
Humidity	**Pearson Correlation**	0.783	-0.518	-0.577	0.313	1

Table No.4

3) KOLMOGOROV-SMIRNOV TEST

Precipitation

District	Jalgaon	Nashik	Dhule	Nandurbar	Ahmednagar
N	41	41	41	41	41
Mean	723.4	1390	673.4	772.0	604.1
Std. deviation	169.7	415.5	163.1	222.0	154.5
KS	0.125	0.090	0.119	0.072	0.087
P-value	<0.105	<0.150	<0.150	<0.150	<0.150
Coefficient of Variation	23.4586	29.8920	24.2203	28.7564	25.5752

Table No.5

Conclusion:

Test interpretation:

H0: The samples follow a Normal Distribution.

H1: The samples Does not follow a Normal Distribution.

As the test statistics (0.105) value is greater than critical value (0.05)

One cannot reject H0.

4) REGRESSION

We know that R is the correlation coefficient measuring the Strength of linear relationship. From output we get R= 94.5404 . R square is the coefficient of determination more usually expressed in percentage. Here R square = 72.08% it us that 72% of variability in the precipitation can be explained by the variability in Humidity, surface pressure, temperature, wind speed. From this values we can fit regression line as y =a+b1*1+b2*2+b3*3+b4*4 where y=independent variable i.e. precipitation x1,x2,x3,x4= dependent variables i.e. temperature, humidity, surface pressure, wind speed respectively a, b1, b2, b3, b4= constants.

Regression Equation

Precipitation = -27747-170.5 **temperature** – 207 **wind speed** + 334 **surface pressure** + 99.8 **humidity**

Analysis of variance

Source	DF	Adj SS	Adj MS	F-Value	p-Value
Regression	4	830643	207661	23.23	0.000
Temperature	1	104838	104838	11.73	0.002
Wind speed	1	25628	25628	2.87	0.099
Surface pressure	1	8761	8761	0.98	0.329
Humidity	1	111414	111414	12.47	0.001
Error	36	321764			
Total	40	1152406			

Table No.6

5) ANOVA

For ANOVA test we take 5 samples of 41 years from the data to test the significance of the difference between five sample means and to make inference. Here we use null hypothesis that all means are equal and alternative hypothesis as at least one sample mean is different. i.e.

Ho: μ1=μ2=μ3=μ4=μ5 against H1: At least one mean is different.

District	Count	Sum	Average	Variance
Jalgaon	41	29659.54	723.4	28810.15
Nashik	41	56978.09	1389.7	172631.5
Nandurbar	41	31652.86	772.0	49274.07
Dhule	41	27609.85	673.4	26597.48
Ahmedabad	41	24767.96	604.1	23855.56

Table No.7

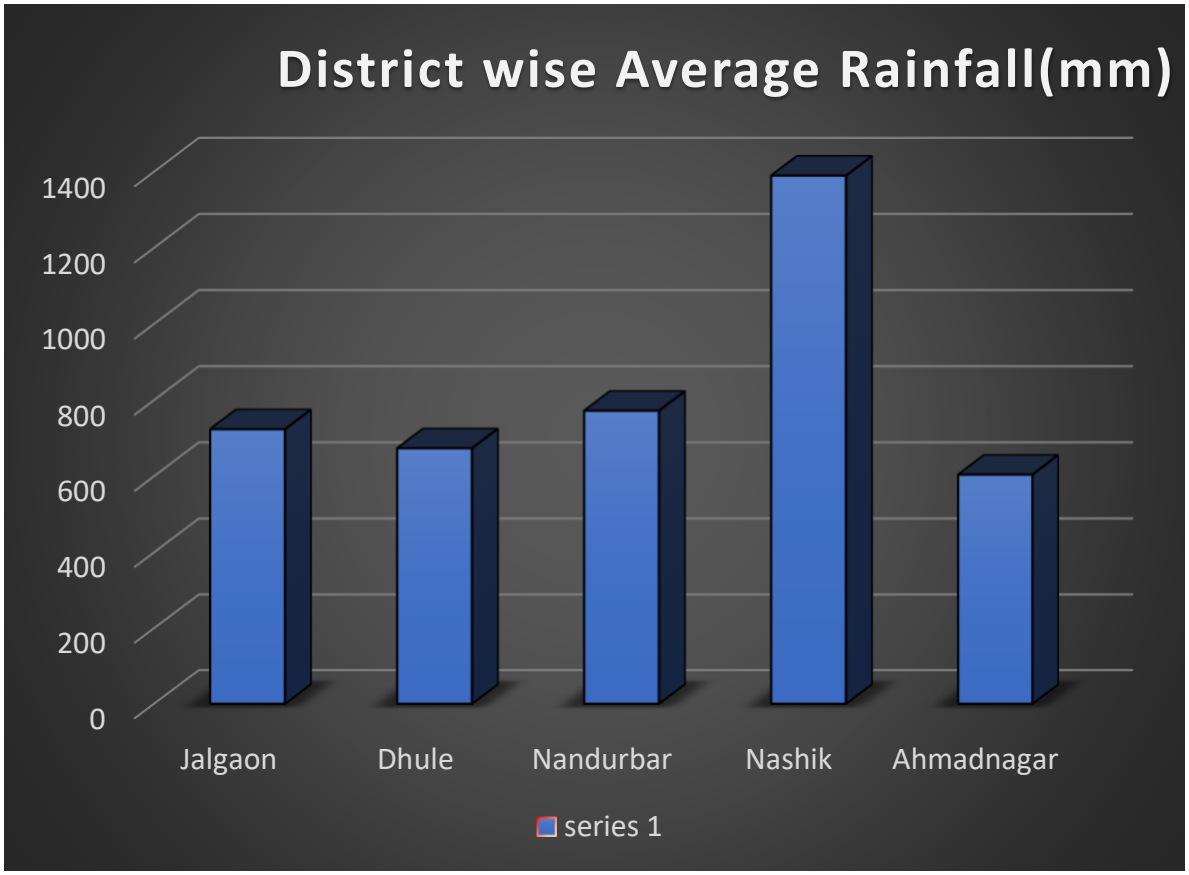
Analysis of Variance (ANOVA)					
Source	DF	Adj SS	Adj MS	F-Value	p-value
Factor	4	16544306	4136076	68.67	0.000
Error	200	12046750	60234		
Total	204	28591056			

Table No.8

Conclusion:

Hence we reject Ho i.e. there is all means are different (averagely precipitation in Nashik division is not uniformly distributed).

From the above result we infer that p-value<0.05.



Above Fig.(B) shows the annual Rainfall of Nashik Division (1981-2021)

Conclusion:

In an Fig.(B) we can see that the annual Rainfall is uniformly Distributed in Nashik Division.

And according to that we can conclude Nashik District has large Rainfall as compare to others District.

6)TIME SERIES

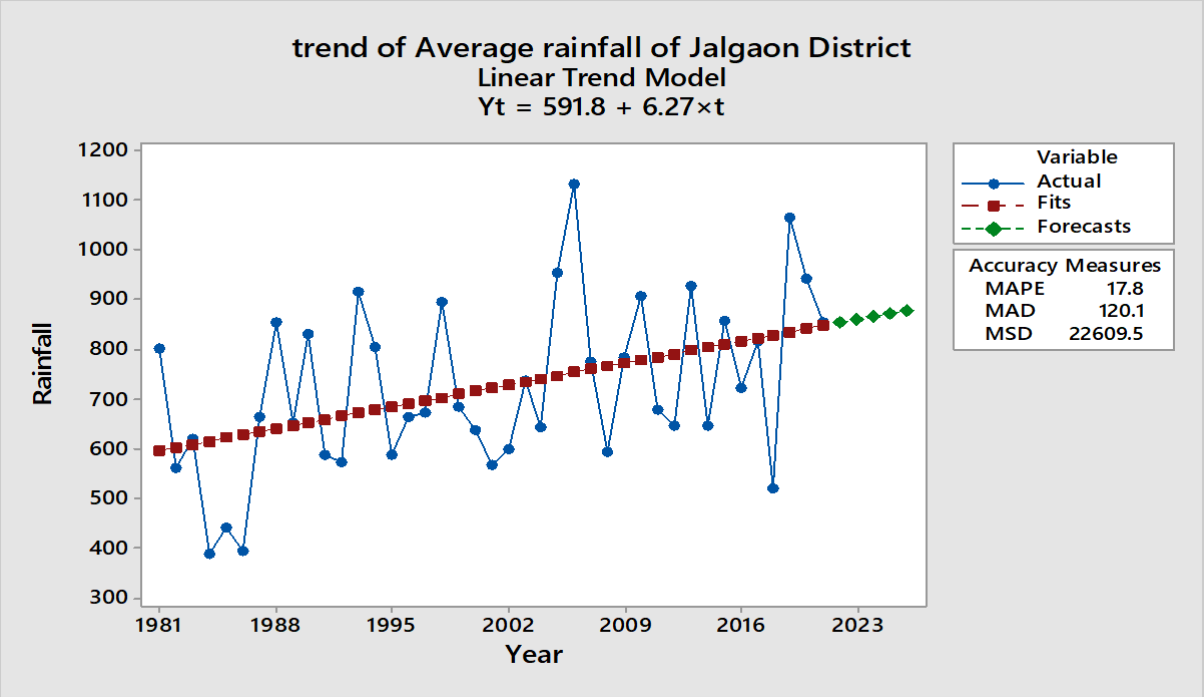


Fig.(C) Time Series

Here trend equation is

Y(t)=591.8+6.27*t

Where Y is trend value to be computed and t=unit of time

Intercept is 591.8 and slope is 6.27.

Assumptions are:

1. the statistical properties of a time series do not change over time.
2. Rate of increase in rainfall is constant.

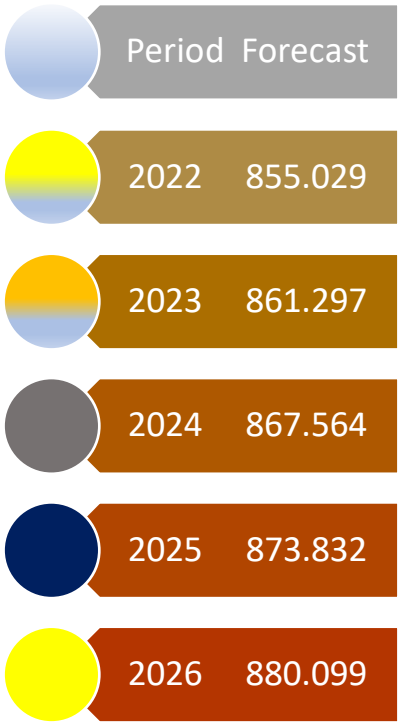


Fig.(D)

Conclusion:

Using Time Series we can conclude over the time period the Rainfall forecast values for Year(2023-2026) and the values are shown in an Fig.(D).

CONCLUSION

We know that main factors that affects rainfalls are distance from equator, distance from sea, height above sea level, ocean current and mountains. The regional distribution of rainfall in Nashik division is mainly explained relief of the land and direction of rain bearings winds. But the scope of these project we consider Jalgaon district, Nashik district, Nandurbar district, Dhule district and Ahmedabad district and check rainfall (precipitation) are uniformly distributed in Nashik division or not and from result we observed averagely precipitation are not uniformly distributed in Nashik division. Next we take the Jalgaon district for analysis in this part we take temperature, surface pressure, wind speed and Humidity as factors causing variation in rainfall (precipitation) in Jalgaon district. And to study these factors and rainfall we used correlation and from results we infer that temperature and wind speed is negatively correlated while surface pressure and humidity are positively correlated. The Kolmogorov- Smirnov test shows that rainfall data is normally distributed in each district. So we used regression analysis on Jalgaon data. The coefficient of determination (R^2) is 72.08% which is show that given model is significant. For trend analysis we have used time series. Apart of these we know that the Higher the Coefficient of Variation (CV), the greater the level of dispersion around the mean and in our result the higher (CV) is found in an Nashik district i.e 29.8920 in an percentage is 29%.and the lower the Coefficient of Variation are considered better because it means there is less variability around the mean, and in our result the lower (CV) is found in an Jalgaon district i.e. 23.4586 in an percentage is 23%.

LIMITATIONS

Our project deals with the following limitations-

1) The main disadvantages are the unequal distribution of observations over the Earth and the presence of “inhomogeneities”.
2) An incomplete understanding of the climate system.
3) An imperfect ability to transform our knowledge into accurate mathematical equations.
4) The results of a single model cannot be gauged for accuracy

REFERANCE

1) Power access climate data (website for data).

   https://power.larc.nasa.gov/data-access-viewer

2) Fundamental of Mathematical Statistics.
3) Online websites.

SOFTWARE

- Minitab
- R Software
- Microsoft Word
- Microsoft Excel
- SPSS