“A study of Rainfall Variability and changes in Jalgaon city”

A project submitted in partial fulfilment of requirements for the degree of B.Sc. (Statistics)

Submitted by,

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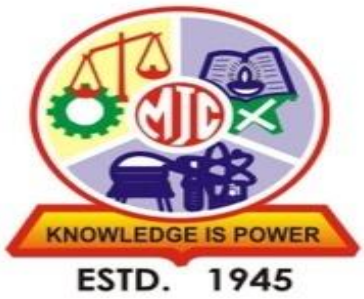

KCE’s Moolji Jaitha College, Jalgaon

Department of Statistics Year: 2021-22

CERTIFICATE

This is to certify that Ms. Deshmukh Manasi Dinesh, Ms. Lohar Gayatri Ravindra, Mr. Tadavi Sahil Musa, Mr.Suryawanshi Prafulla Ravindra of B.Sc. (Statistics) at K.C.E's Moolji Jaitha College , Jalgaon affiliated to K.B.C. North Maharashtra University , Jalgaon have successfully completed the project entitled **"A study of Rainfall Variability and changes in Jalgaon city "** as a part of B.Sc. (Statistics) degree program under my guidance and supervision during the academic year 2021-2022 .

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Introduction:

A good monsoon brings economic prosperity for the whole country and boosts the Indian economy as agriculture contributes around 16% of its total Gross domestic product (GDP). High temperature and heavy rainfall in the summer months are important for different types of Kharif crops. The winter rain supplemented by irrigation is important for rabi crops. Normal rainfall is important for adequate agricultural production in order to maintain food prices. Food prices depend upon the agricultural output. In absence of a good monsoon, the entire nation may be destabilized because of food inflation. Other economic activities like forestry and fishing are also influenced directly by the amount of rainfall. Monsoon rain gives us respite from the high and intolerable summer heat and brings back life to the living earth.

Abstract:

Rainfall is one of the climatological data which is widely analysed for a long time. The present study is focused on the analysis of rainfall data in Jalgaon, Maharashtra, India for year 1981-2020. In addition to the classical procedures 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, humidity, pressure and regression line is fitted for given data.

Keywords:

1. Precipitation - The bias corrected sum of total precipitation at the surface of the earth.
2. Temperature – The average minimum and maximum daily air temperature average range above the surface of earth.
3. Relative humidity- The ratio of actual partial pressure of water vapour to the partial pressure at saturation, expressed in percent.
4. Surface pressure- The average of surface pressure at the surface of the earth.

Motivation:

Analysis of rainfall data is important as it facilitates policy decisions regarding the cropping pattern, sowing date, construction of roads and providing drinking water to urban and rural areas. Considering these important aspects of rainfall analysis, we have chosen this topic for our project work.

Objectives:

To study the variation in rainfall due to temperature, relative humidity and pressure. To study trend in rainfall in 40 years (1981-2020).

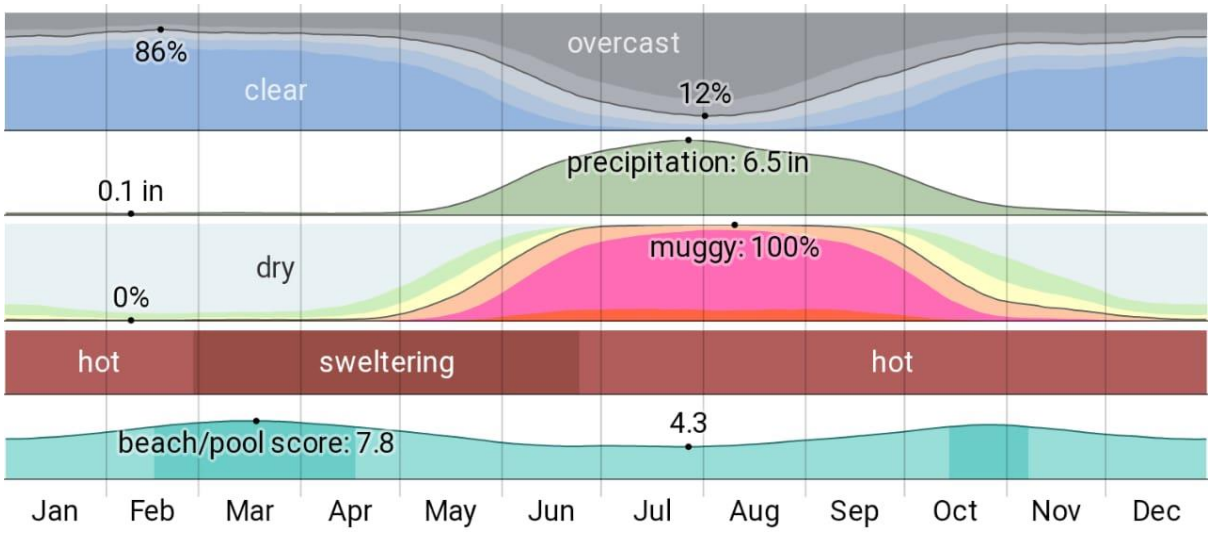
Important Characteristics of Rainfall in India:

In India, there is a great variation in temperature and rainfall, not only from place to place, but also from season to season. The distribution and the occurrence of rainfall in India have the following characteristics:

i. The extremes of humidity and rainfall are experienced almost everywhere.
ii. About 75% of the total annual rainfall is from the south west monsoon winds during the period from June to September.
iii. The rainfall from the monsoon winds is highly variable and quit unreliable.
iv. The total amount of rainfall is either more than normal or much less than the normal.
v. The Rainfall occurs for a few months in the year, i.e. from June to September.
vi. The Rainfall is basically torrential in nature. Even in the rainy season of about for months, the actual rainy days are 40 to 45 Days only.

Climate and average weather in Jalgaon:

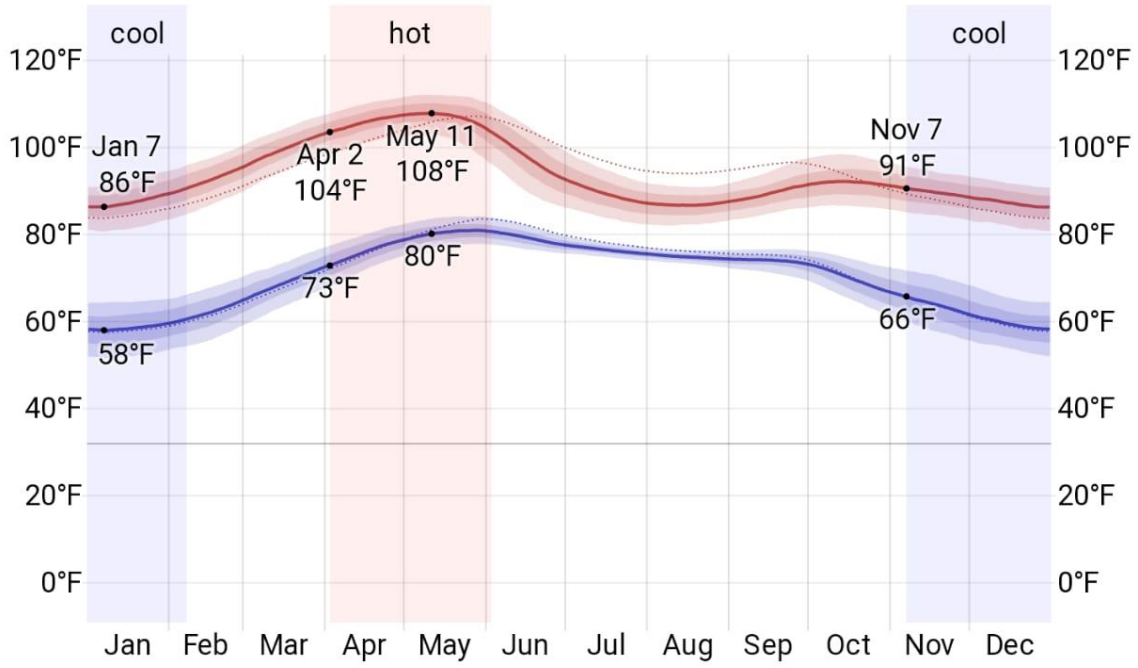
In Jalgaon, the wet season is oppressive and mostly cloudy, the dry season is mostly clear, and it is hot year round. Over the course of the year, the temperature typically varies from 58 F to 108 F and is rarely below 52 F or above 112 F.



Jalgaon weather by month.

1. Average temperature in Jalgaon:

The hot season lasts for 2 months, from April To June, with an average daily high temperature above 104 F. The hottest month of the year in Jalgaon is May, with an average high temperature of 107F and low of 80 F. The cool season lasts for 3 months, from November to February, with an average daily high temperature below 91 F. The coolest month of the year in Jalgaon is January, with an average low of 59 F and high of 87 F.

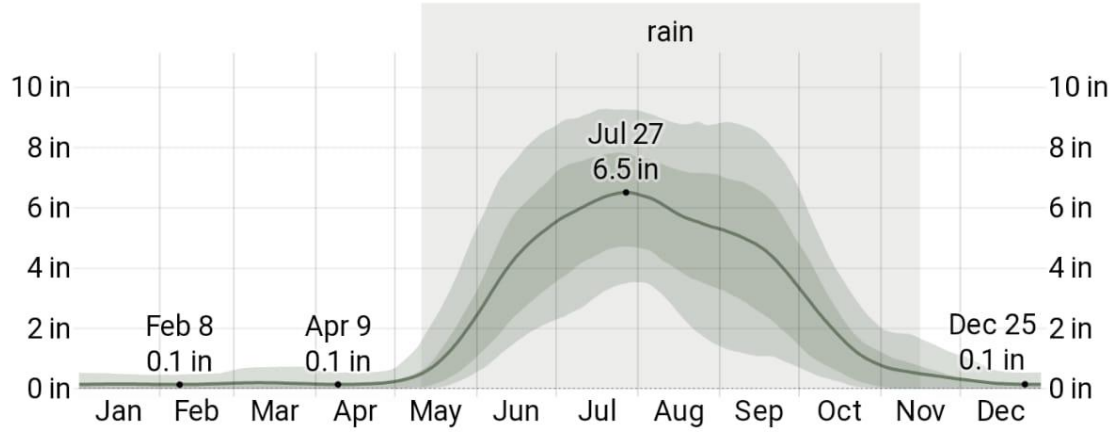


Average High and Low temperature in Jalgaon.

2. Rainfall:

To show variation within the months and not just the monthly totals, we show the rainfall accumulated over a sliding 31 days period centered around each day of the year. Jalgaon experiences extreme Seasonal variation in the monthly rainfall.

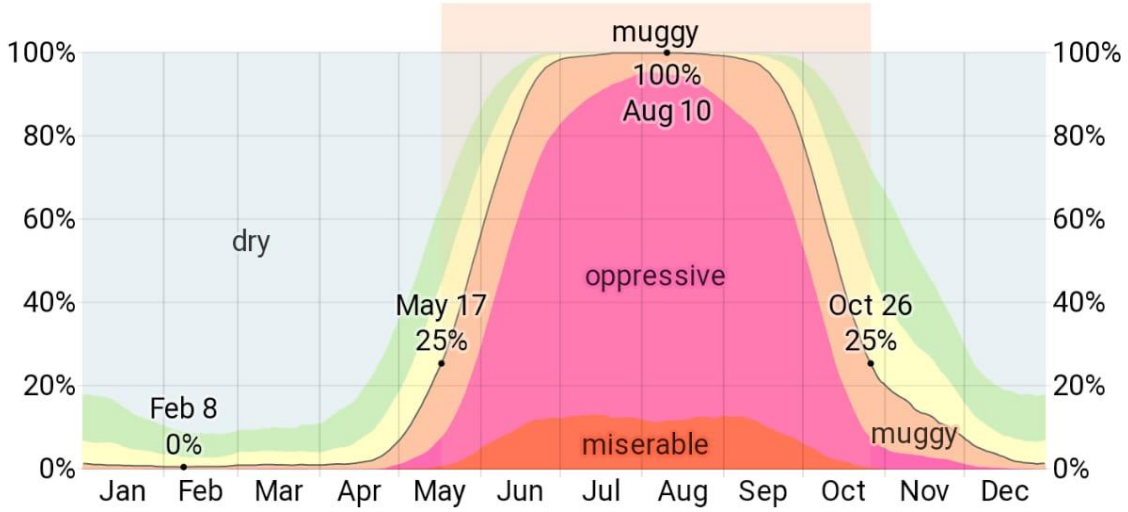
The rainy period of the year lasts for 6.1 months, from May 11 to November 15, with sliding 31 days rain fall of at least 0.5 inches. The month with the most rain in Jalgaon is July, with an average rainfall of 6.3 inches. The average annual rainfall in Jalgaon is 740.7mm.



Average Monthly rainfall in Jalgaon.

3. Humidity:

Jalgaon experiences extreme seasonal variation in the perceived humidity. The muggier period of the year lasts for 5.3 months, from May 17 to October 26, during which time the comfort level is muggy, oppressive, or miserable at least 25% of the time. The month with the most muggy days in Jalgaon is August, with 30.9 days that are muggy.



Humidity comfort level in Jalgaon.

Factors affecting rainfall:

Factors	Relevant Characteristics
Other meteorological parameters	Temperature, radiation, relative humidity, wind velocity.
Land	Topography, slope.
Soil	Depth, texture, structure, bulk density, salt and organic matter content.

The most dominating factor of the Indian climate is the 'monsoon winds' as a result of which it is often called the monsoon climate. The complete reversal of the monsoon winds brings about a sudden change in the season- the harsh summer season suddenly giving way to eagerly awaited monsoon or rainy season.

The south-west summer monsoon from the Arabian Sea and the Bay of Bengal bring rainfall to the entire country. The north-eastern winter monsoon travel from land to sea and do not cause much rainfall except along the Caromandel cost after getting moisture from the Bay of Bengal.

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

Temperature-

As evaporation and transpiration increases with temperature. So, rainfall is higher in area where temperature is higher.

Relative Humidity-

It affects evaporation which is more or less inversely proportional to humidity.

Pressure-

Low pressure is caused by upward moving air. As the air is forced upward, it cools to its dew point forming condensation and rain.

Methodology

1. Collection of data

We wants want 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 and annual precipitation, temperature, humidity and surface pressure for 40 years from 1 January 1981 to 31 December 2020.

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	Relative Humidity	Pressure
1981	801.56	26.18	54.5	97.17
1982	564.26	27.09	53.06	97.17
1983	622.27	26.44	49.62	97.16
1984	390.23	27.18	43.31	97.09
1985	442.97	27.41	43.88	97.08
1986	395.51	27.53	43	97.14
1987	664.45	27.24	48.62	97.22
1988	854.3	26.99	50.38	97.12
1989	653.91	26.79	46.19	97.16
1990	833.2	26.49	54.94	97.16
1991	590.62	27.17	44.56	97.17
1992	574.8	27.01	45	97.21
1993	917.58	26.37	52.56	97.22
1994	806.84	26.19	53.06	97.17
1995	590.62	27.07	48.06	97.14
1996	664.45	26.87	49.62	97.12
1997	675	26.58	53.5	97.26
1998	896.48	26.69	56.56	97.16
1999	685.55	26.51	51.31	97.12
2000	638.09	26.89	44.12	97.1

Year	Precipitation	Temperature	Relative Humidity	Pressure
2001	569.53	26.94	48.38	97.14
2002	601.17	27.39	46.25	97.19
2003	738.28	26.92	52.69	97.2
2004	643.36	26.97	51	97.2
2005	954.49	26.31	52.88	97.18
2006	1133.79	26.58	56.38	97.19
2007	775.2	26.76	53.06	97.14
2008	595.9	26.85	49.25	97.14
2009	785.74	27.37	51.62	97.16
2010	907.03	27.05	57.62	97.13
2011	680.27	26.69	52	97.12
2012	648.63	26.73	49.5	97.14
2013	928.12	26.21	57.69	97.14
2014	648.63	26.9	52.69	97.25
2015	859.57	26.94	52.88	97.3
2016	722.46	26.94	49.69	97.22
2017	817.38	26.91	50.38	97.2
2018	522.07	27.44	44.38	97.2
2019	1065.23	26.5	56.12	97.24
2020	943.95	26.28	60.88	97.2

4. Variable Creation:

Rainfall (precipitation) is amount of water condensing on the earth's surface. Factors that affect rainfall are wind, topography, vegetation, temperature, humidity, altitude, etc. But we have data of precipitation, temperature and humidity. So far analysis we take precipitation as dependent variable which depends on independent variables temperature and humidity, pressure.

Analytical Methods:

1. Correlation-

In a bivariate distribution we may be interested to find out if there is any correlation between the two variables under study. If the change in one variable affects a change in the other variable, the variable is said to be correlated. If the two variables deviate in same direction, i.e., if the increase (or decrease) in one variable results in a corresponding increase (or decrease) in the other, correlation is said to be direct or positive. But if they constantly deviate in the opposite directions, i.e., if the increase (or decrease) in one variable results in a corresponding decrease (or increase) in the other, correlation is said to be diverse or negative. For example, the correlation between the income and expenditure is positive and correlation between price and demand of commodity is negative.

2. Kolmogorov-Smirnov test-

Here we discus a test that considers the goodness of fit between a hypothesized distribution function and an empirical distribution function. Because of the convergence of the empirical distribution function to the 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 $F_o(x)$. Here we shall use the Kolmogorov-Smirnov statistic defined by

Dn = Supx[|Fn(x)-$F_o(x)$|], that is Dn is maximum value of all pointwise differences |Fn(x)-F0(x)|

To test H_o: F(x)=$F_o(x)$ against H1: F(x)≠$F_o(x)$,

We compute Kolmogorov-Smirnov statistic Dn. The H_o is rejected if observed value of Dn is greater than critical value selected from statistical table.

3. Regression-

Consider a situation involving respective variables and p regressors or explanatory variable denoted by X1, X2, X3,….,Xp. A multiple linear regression model related p regressor to respond variable y can be written as

$$Y= \beta0+\beta1X1+\beta2X2+ ….. +\beta pXp + \varepsilon$$

where β0,β1,….βp are constant and ε is random error.

Assumptions for multiple linear regression model:

1. Error are independent and normally distributed with mean 0 and variance δ^2.
2. Measurement on regressors are without error or negligible error.

Coefficient of determination:

Coefficient of determination is measure 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 increases (decreases) 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.

Results:

1. Descriptive Statistics-

	Precipitation	Temperature	Relative Humidity	Pressure
Mean	720.08725	26.83425	50.77975	97.1705
Standard Error	26.96545346	0.057637114	0.69555203	0.00753581
Median	677.635	26.895	51.155	97.165
Mode	664.45	26.94	53.06	97.14
Standard Deviation	170.5445021	0.364529113	4.399057293	0.04766066
Sample Variance	29085.42721	0.132881474	19.35170506	0.00227154
Range	743.56	1.35	17.88	0.22
Minimum	390.23	26.18	43	97.08
Maximum	1133.79	27.53	60.88	97.3
Sum	28803.49	1073.37	2031.19	3886.82
Count	40	40	40	40

2. Correlation-

Since, the r- value between precipitation and temperature is negative (- 0.642) we infer that precipitation and temperature is negatively correlated. But r- value between precipitation and relative humidity, pressure are positive (0.826 , 0.340 respectively) hence they are positively correlated

Correlations

		Precipitation	Temperature	Relative Humidity	Surface Pressure
Precipitation	Pearson Correlation	1	-.642**	.826**	.340*
	Sig. (2-tailed)		.000	.000	.032
	N	40	40	40	40
Temperature	Pearson Correlation	-.642**	1	-.679**	-.130
	Sig. (2-tailed)	.000		.000	.422
	N	40	40	40	40
Relative Humidity	Pearson Correlation	.826**	-.679**	1	.305
	Sig. (2-tailed)	.000	.000		.056
	N	40	40	40	40
Surface Pressure	Pearson Correlation	.340*	-.130	.305	1
	Sig. (2-tailed)	.032	.422	.056	
	N	40	40	40	40
**. Correlation is significant at the 0.01 level (2-tailed).					
*. Correlation is significant at the 0.05 level (2-tailed).					

3. Kolmogorov-Smirnov Test-

One-Sample Kolmogorov-Smirnov Test		
		Precipitation
N		40
Normal Parameters[a,b]	Mean	720.0873
	Std. Deviation	170.54450
Most Extreme Differences	Absolute	.130
	Positive	.130
	Negative	-.080
Test Statistic		.130
Asymp. Sig. (2-tailed)		.085[c]
a. Test distribution is Normal.		
b. Calculated from data.		
c. Lilliefors Significance Correction.		

Test interpretation:
H_o: The samples follow a Normal Distribution.
H1: The samples does not follow a Normal Distribution.
As the test statistic (0.130) value is greater than critical value (0.05), one cannot reject H_o.

4. Regression-

We know that R is the correlation coefficient measuring the strength of linear relationship. From output we get **R=0.8403065**. R square is the coefficient of determination more usually expressed in percentage. Here **R square=0.706115** it tell us that **70% of the variability** in the precipitation can be explained by the variability in relative humidity and pressure. The coefficient are **a=-37040.84, b1=-77.3072, b2= 26.3837, b3= 396.1659** from this values we can fit regression line as y= a+b1x1+b2x2+b3x3 where y = independent variable i.e. precipitation x1, x2, x3 = dependent variables i.e. temperature,

relative humidity, pressure respectively. a, b1, b2, b3 = constants.

Regression Statistics	
Multiple R	0.8403065
R Square	**0.706115**
Adjusted R Square	0.6816246
Standard Error	96.229333
Observations	40

	Coefficients	Standard Error	t Stat	P-value
Intercept	-37040.837	32983.64118	-1.12300629	0.268868561
Temperature	-77.307286	57.92586386	-1.334590126	0.19039061
Relative Humidity	26.383778	4.996736608	5.280201935	6.36638E-06
Pressure	396.16597	341.5051174	1.160058656	0.253660799

5. ANOVA-

For ANOVA test we take 4 samples of 10 years from the data to check the trend in precipitation for 40 years. Here we use null hypothesis that all sample means are equal and alternative as at least one sample is different. i.e. H_o: μ1=μ2=μ3=μ4 vs H1: At least one mean is different.

Groups	Count	Sum	Average	Variance
1981-1990	10	6222.66	622.266	30447.87
1991-2000	10	7040.03	704.003	15859.27
2001-2010	10	7704.49	770.449	33497.35
2011-2020	10	7836.31	783.631	28008.12

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	164018.1	3	54672.71	2.028435	0.127228	2.866266
Within Groups	970313.5	36	26953.15			
Total	1134332	39				

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

Hence accept H0 i.e. there is no trend in the precipitation of Jalgaon district for 40 years (1981-2020).

Conclusions:

We know that the main factors that affects rainfall are distance from equator, distance from sea, height above sea level, ocean current and mountains. The regional distribution of rainfall in Jalgaon is mainly explained by the relief of the land and the direction of rain bearing winds. But for the scope of this project we only considered temperature, pressure and humidity as factors causing variation in rainfall (precipitation). To study relation between this factors and rainfall we used correlation and from results we infer that temperature is negatively correlated while pressure and humidity are positively correlated. The KS test shows that rainfall data is normally distributed. So we used regression analysis on same data. The coefficient of determination (R^2) is 0.706 which shows that given regression model is significant. For trend analysis we have used ANOVA which shows rainfall in Jalgaon is consistent over 40 years (1981-2020).

Limitations:

Our project deals with climatic data which has limitations as follows-

1. An incomplete understanding of the climate system.
2. An imperfect ability to transform our knowledge into accurate mathematical equations.
3. Inaccurate representation of the complex natural interconnections.

References:

1. Power access climate data (website for data). https://power.larc.nasa.gov/data-access-viewer
2. Fundamental of mathematical statistics.
3. Online websites.