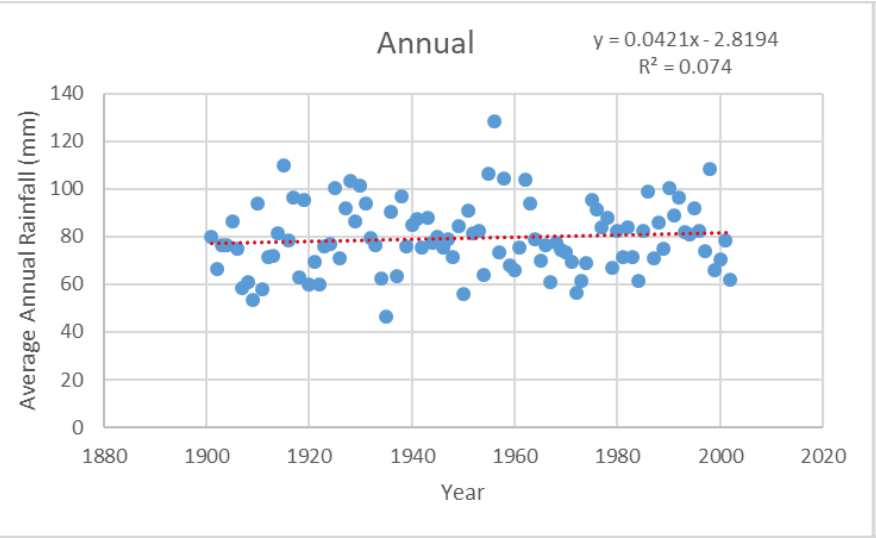
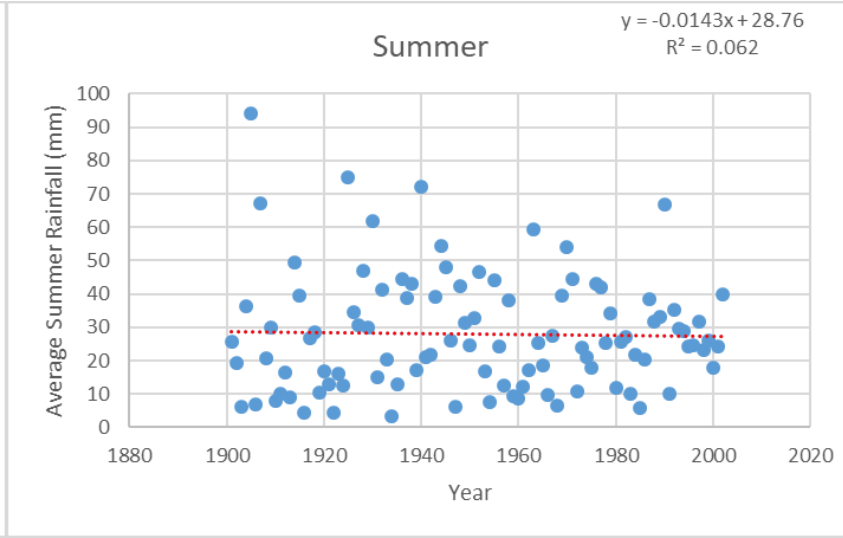
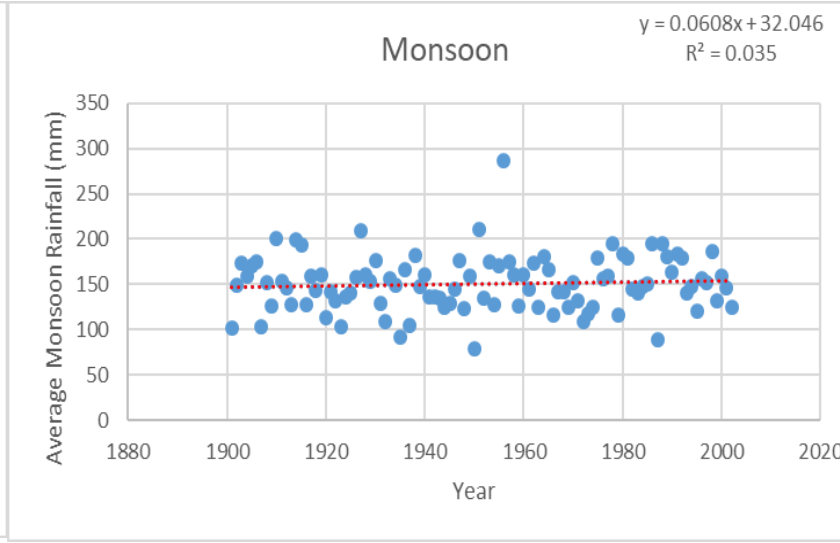
Linear regression analysis

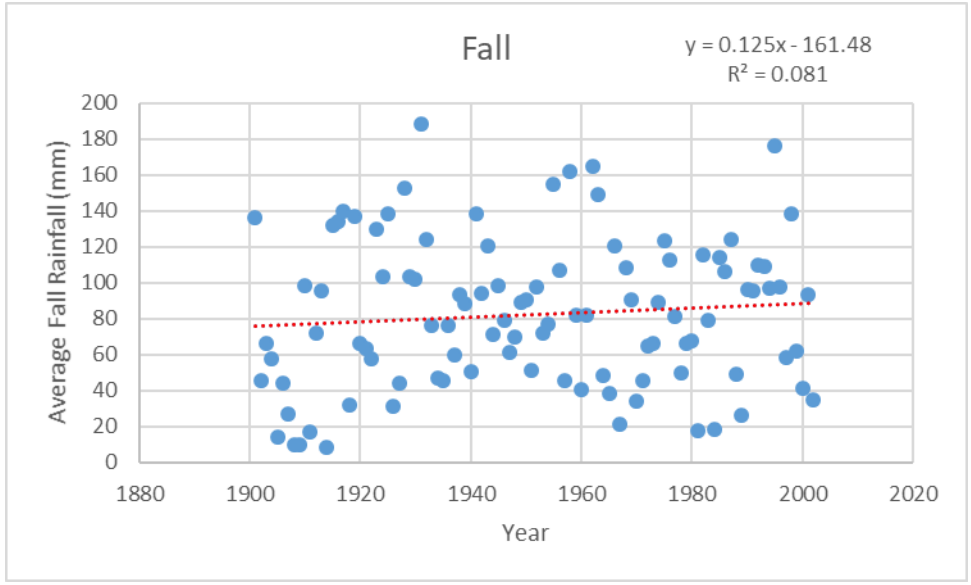
- The linear trend lines of the annual and monsoon rainfall showed a downward trend for Srikakulam, Andhra Pradesh.
- The R-square statistic showed a poor relationship between the rainfall and respective year.
- The result analysis shows a decreasing trend in the Monsoon and fall season for Srikakulam district but in rest of the season there is no trend.
- Linear Regression Analysis showing mean absolute error is 10%.
- The Regression Model Score is 93.34%.

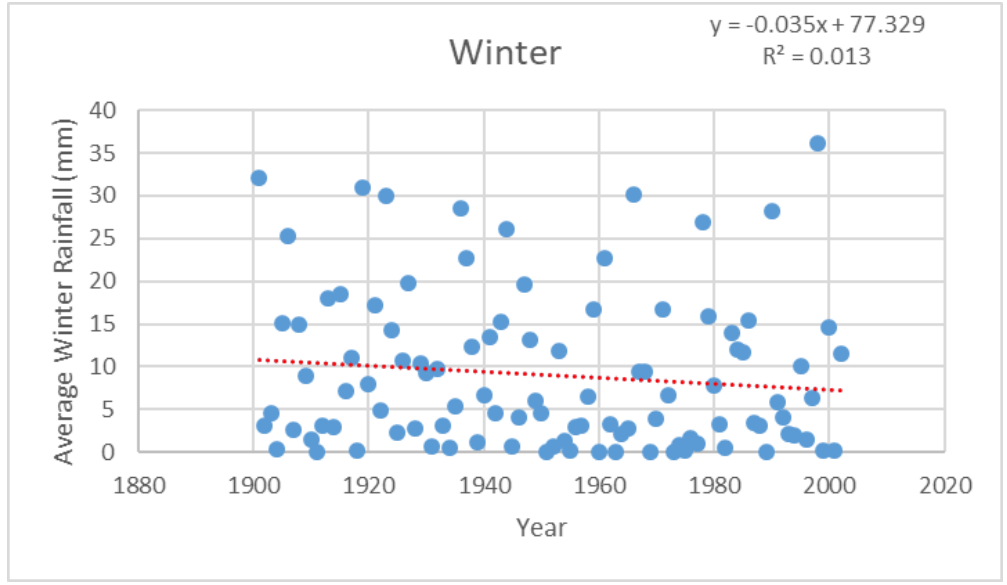
Standardized rainfall (mm) and lowness trend during 1901 and 2002 of Srikakulam, Andhra Pradesh











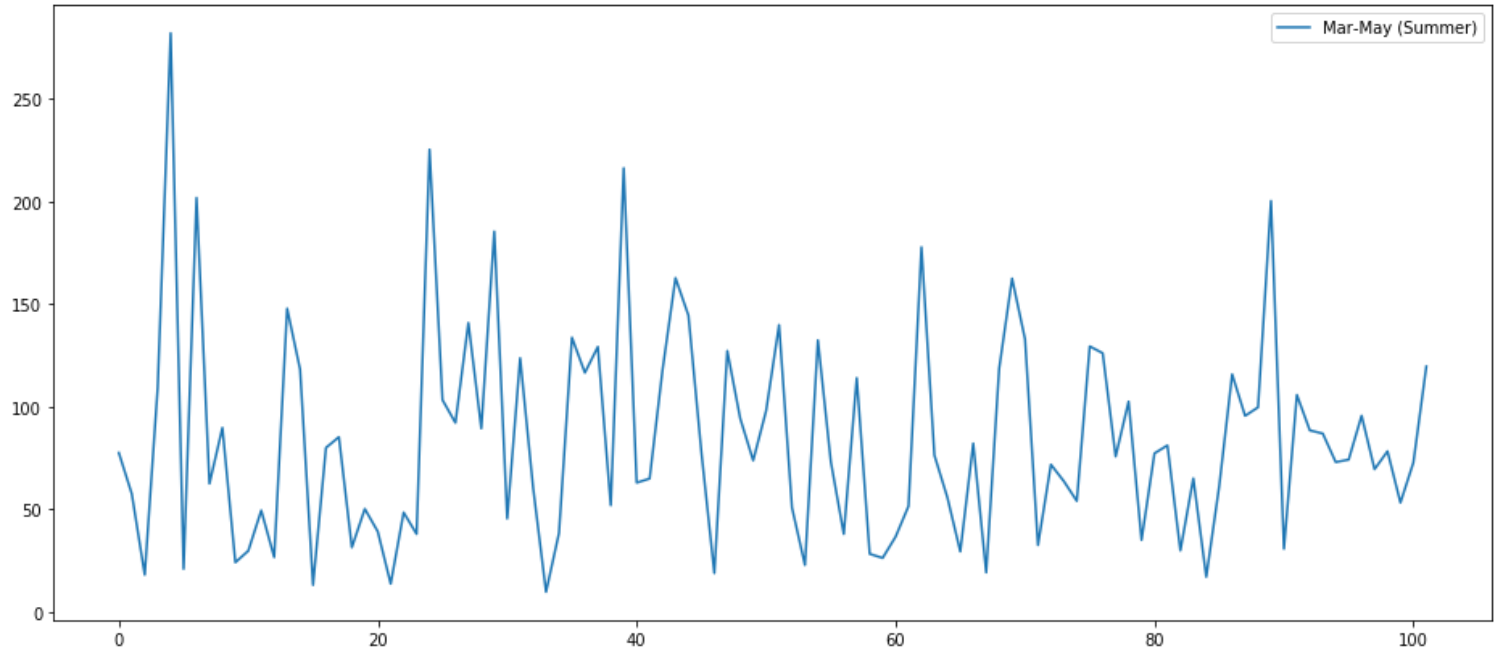
Mann–Kendall and Sen’s slope Estimator Test

- A Mann-Kendall Trend Test is used to determine whether or not a trend exists in time series data. It is a non-parametric test, meaning there is no underlying assumption made about the normality of the data.
- The hypotheses for the test are as follows:

i. H0 (null hypothesis): There is no trend present in the data.

ii. HA (alternative hypothesis): A trend is present in the data. (This could be a positive or negative trend)

- If the p-value of the test is lower than some significance level (common choices are 0.10, 0.05, and 0.01), then there is statistically significant evidence that a trend is present in the time series data.
- The usual method for estimating the slope of a regression line that fits a set of (x, y) data elements is based on a least squares estimate. This approach is not valid when the data elements don’t fit a straight line; it is also sensitive to outliers.



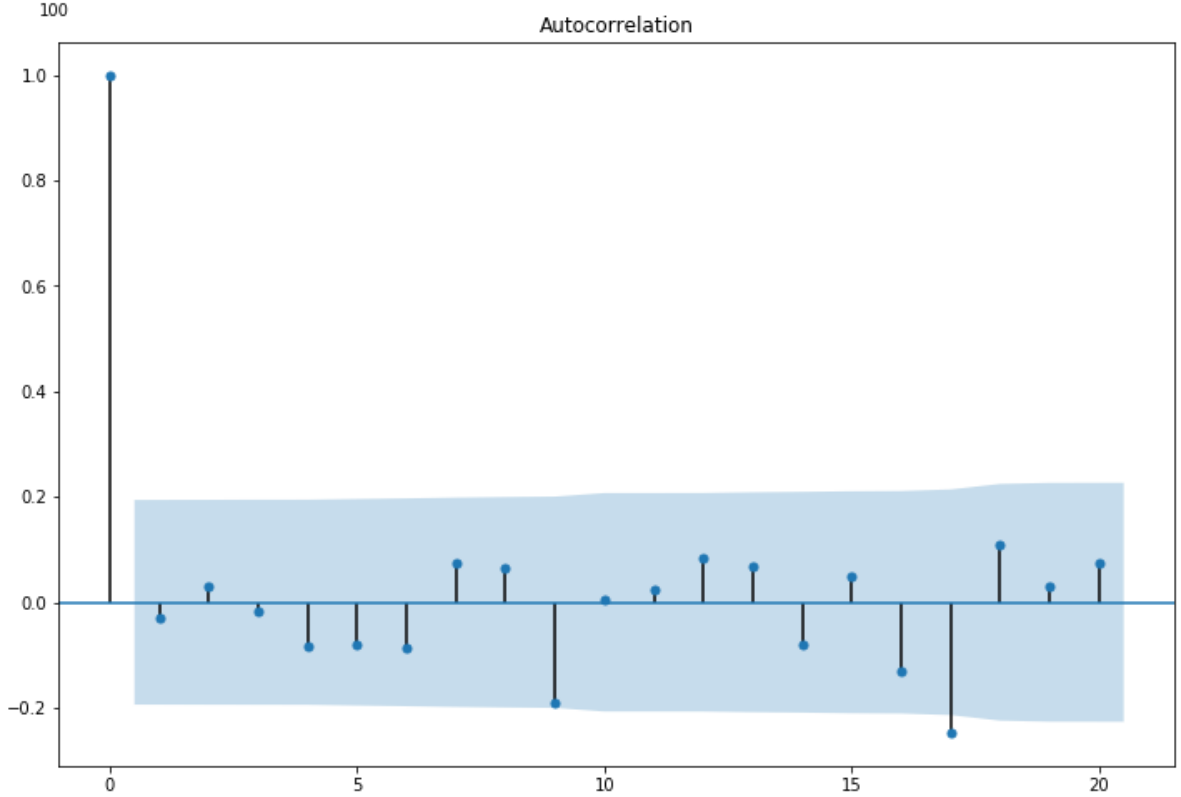
Mann–Kendall Test (Summer)

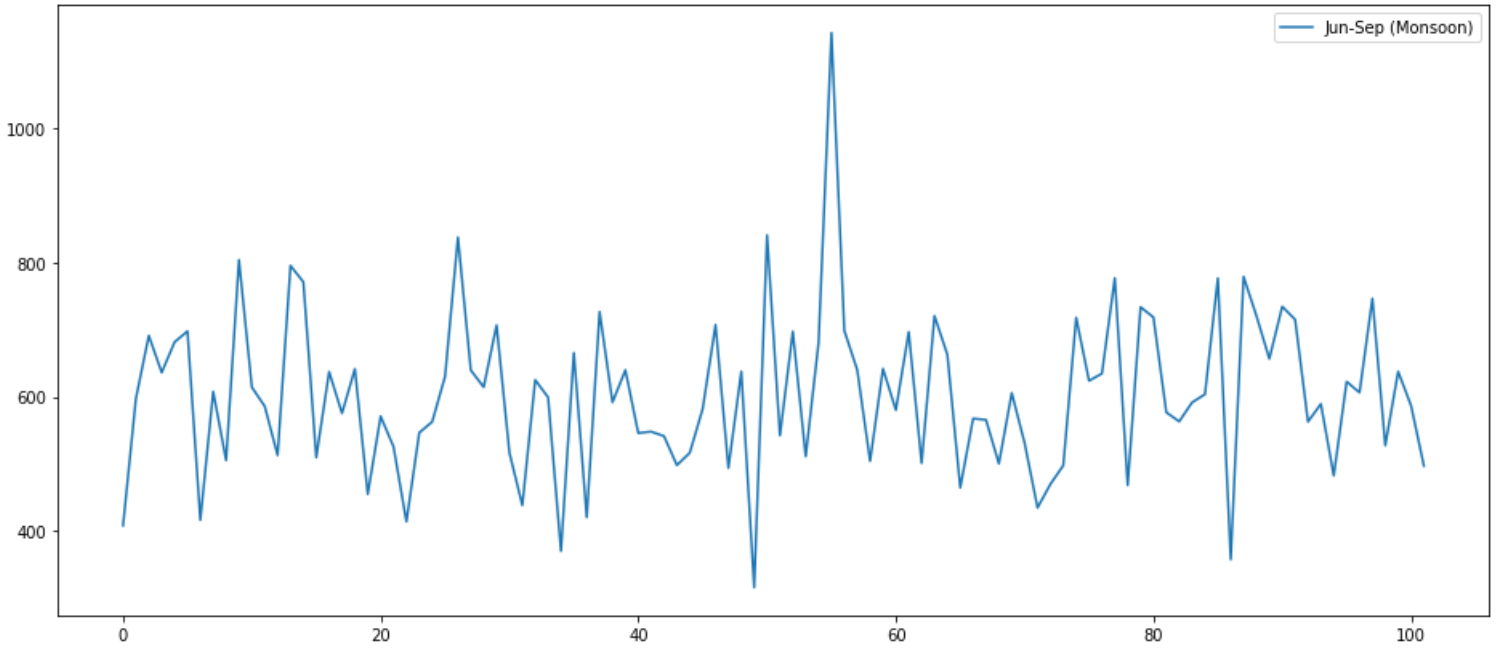
Trend = No trend
H = False
P = 0.9740356
Z = 0.032547
Tau = 0.005208333
S=2.0
var_s = 944
Slope = 0.181458
Intercept = 75.33786

Sen's slope Estimator Test

Slope = 0.09325
Intercept = 71.3921274

The P value is 0.97403 which is not less than 0.05. Thus there is no significant trend in the time series data.





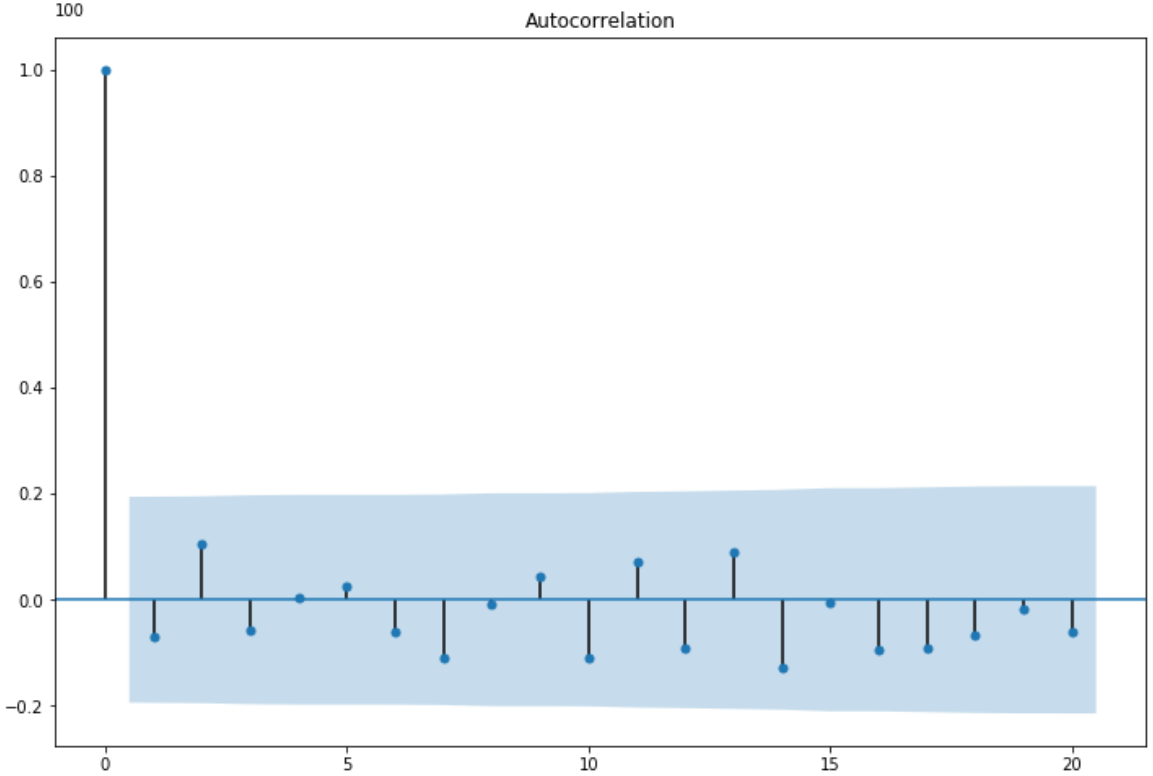
Mann–Kendall Test (Monsoon)

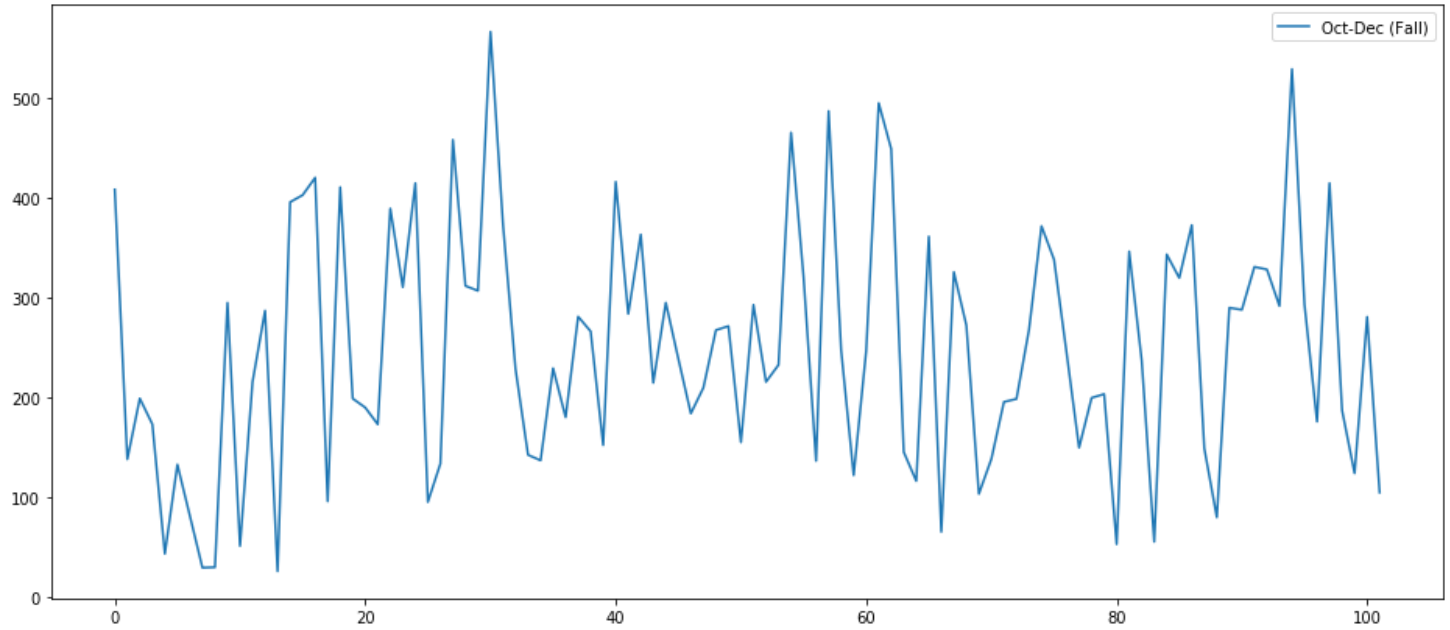
Trend = No trend
H = False
P = 0.31299187
Z = 1.0089640
Tau = 0.083333
S =32.0
var_s =944
Slope = 5.1517
Intercept=576.667

Sen's slope Estimator Test

Slope = 0.22228813
Intercept = 587.122449

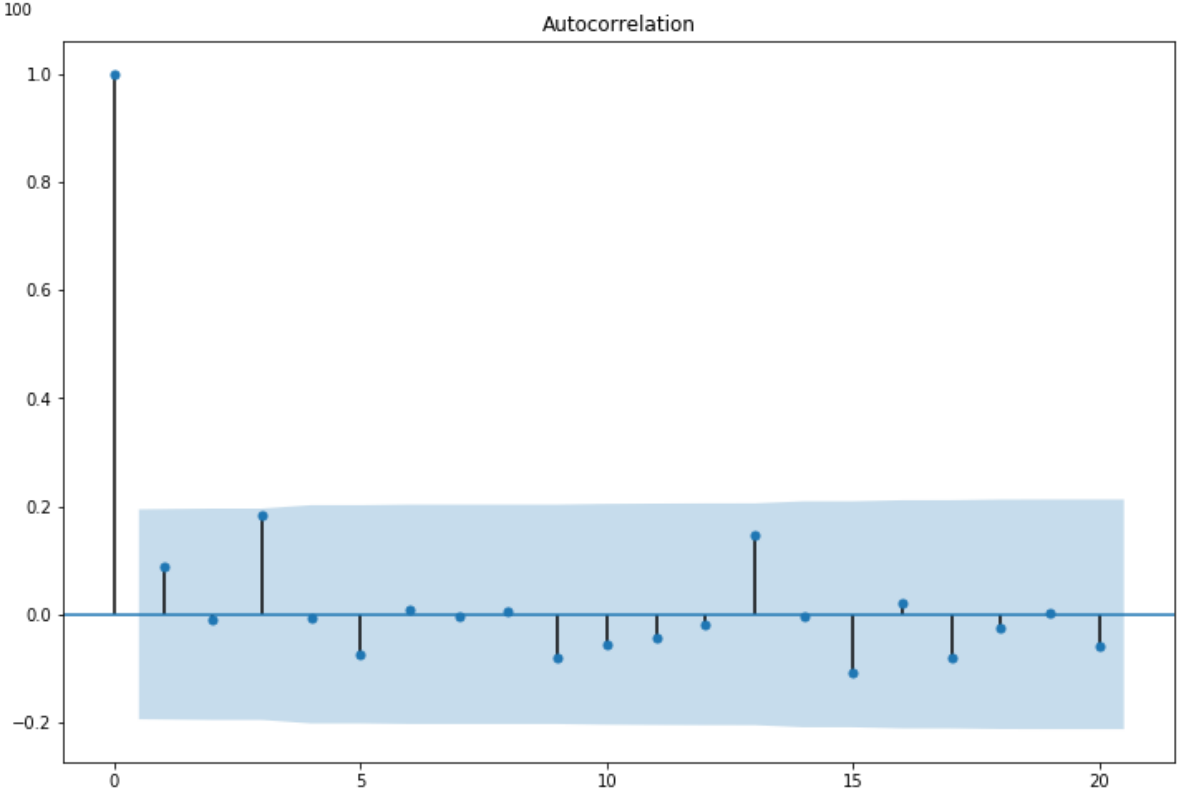
The P value is 0.312991 which is not less than 0.05. Thus there is no significant trend in the time series data.





Mann–Kendall Test (Fall)

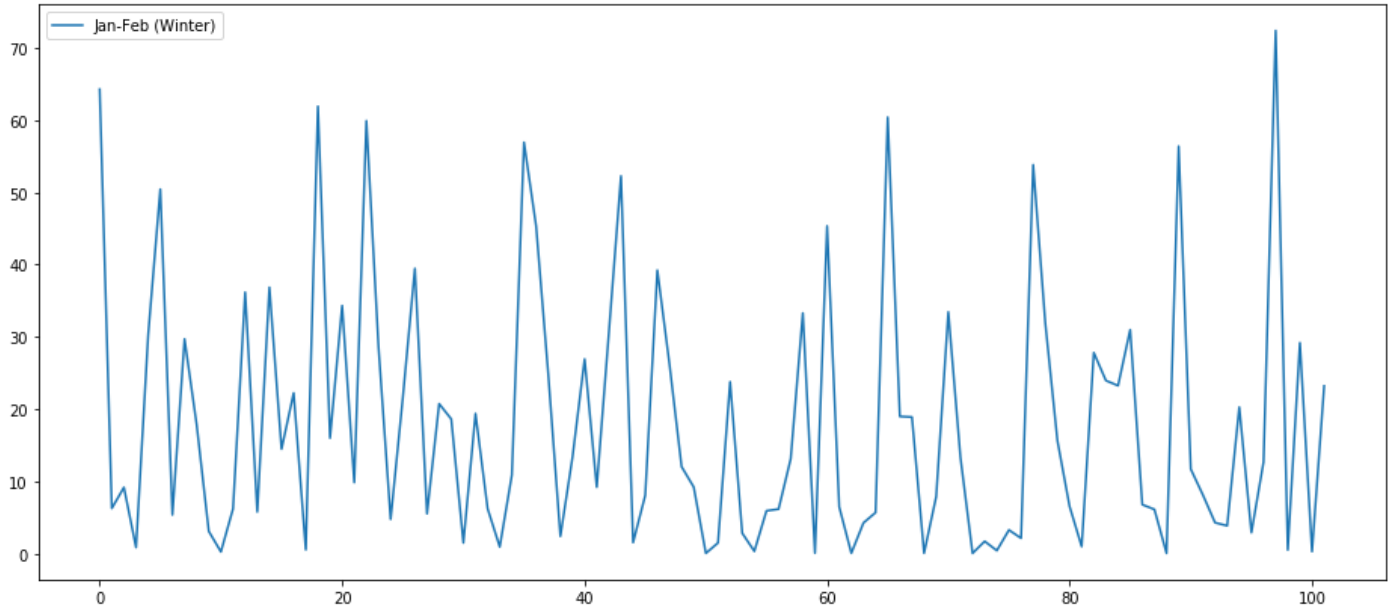
Trend = No trend
H = False
P = 0.769579
Z = 0.29292
Tau = 0.0260416
S = 10.0
var_s = 944
Slope = 1.686125
Intercept = 234.133223



Sen's slope Estimator Test

Slope = 0.4359999
Intercept = 219.210999

The P value is 0.769579 which is not less than 0.05. Thus there is no significant trend in the time series data.



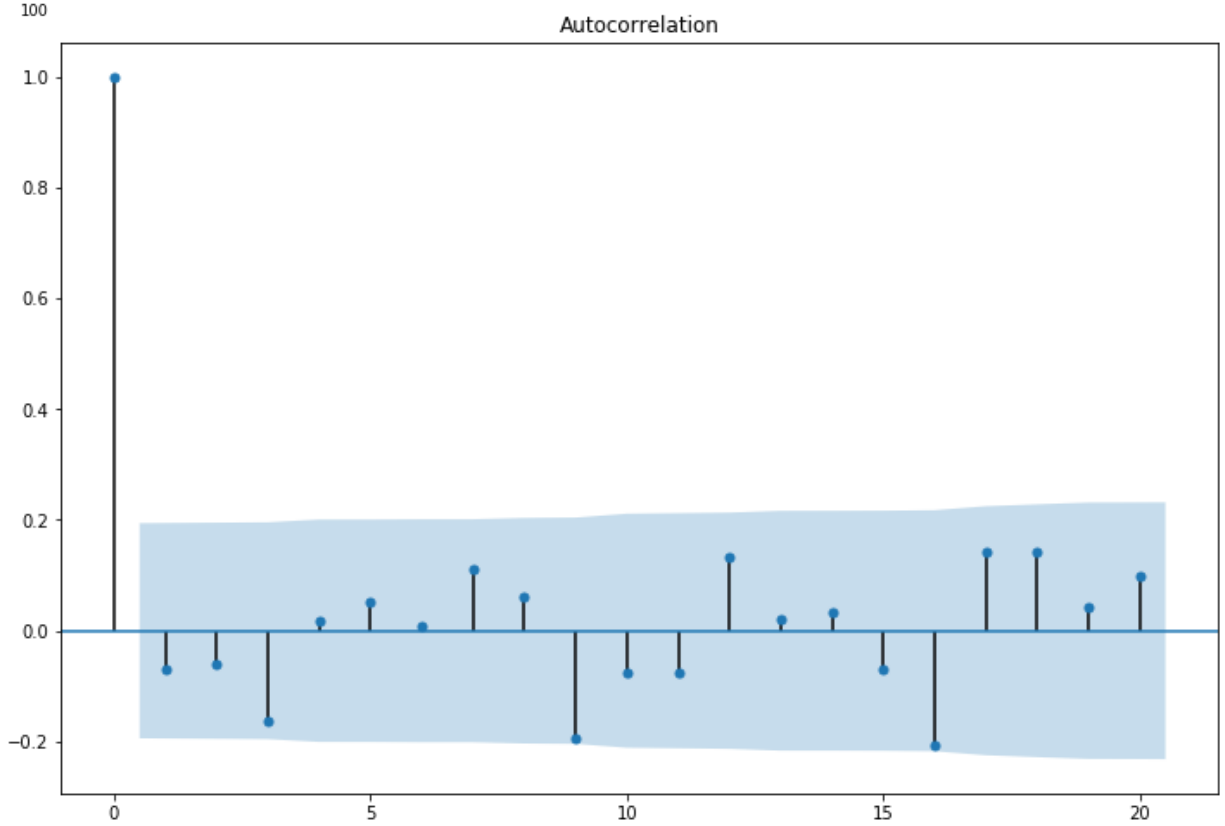
Mann–Kendall Test (Winter)

Trend = No Trend
H = False
P = 0.09632
Z = -1.65990
Tau=-0.13541
S = -52.0,
var_s = 944
Slope = -0.99091
Intercept = 16.0231

Sen's slope Estimator Test

Slope = -0.0565
Intercept = 14.70625

The P value is 0.09632 which is not less than 0.05. Thus there is no significant trend in the time series data.



Q2.

- The following research paper has used 5 different models for the time series analysis of rainfall.
- The models are as follows:

a) Auto-correlation

b) Homogeneity test

c) Linear regression test

d) Mann–Kendall (MK) test

e) Sen’s slope estimator test

- **Linear Regression Analysis**

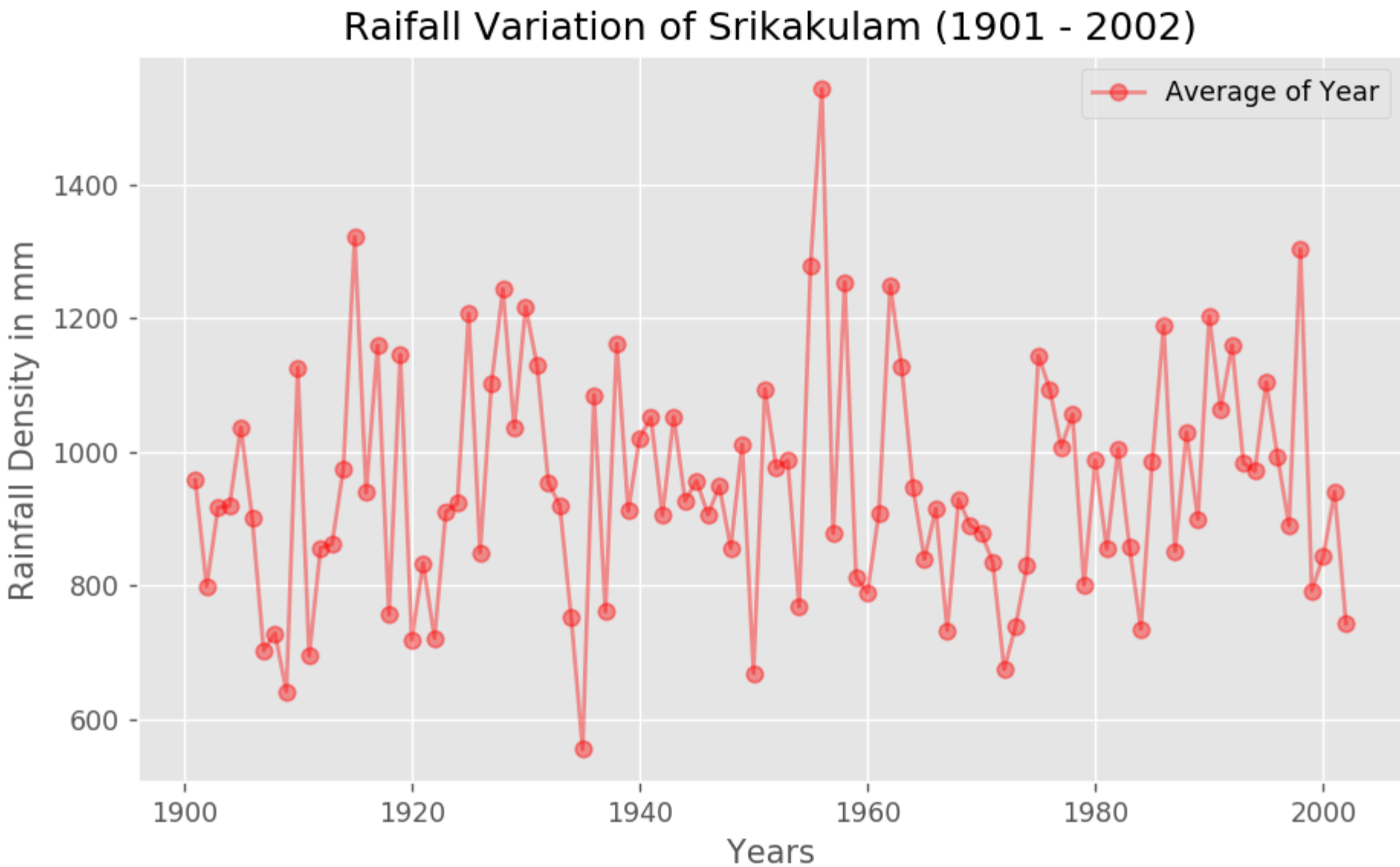
➢ The linear trend lines of the annual and monsoon rainfall showed a downward trend for all study stations.

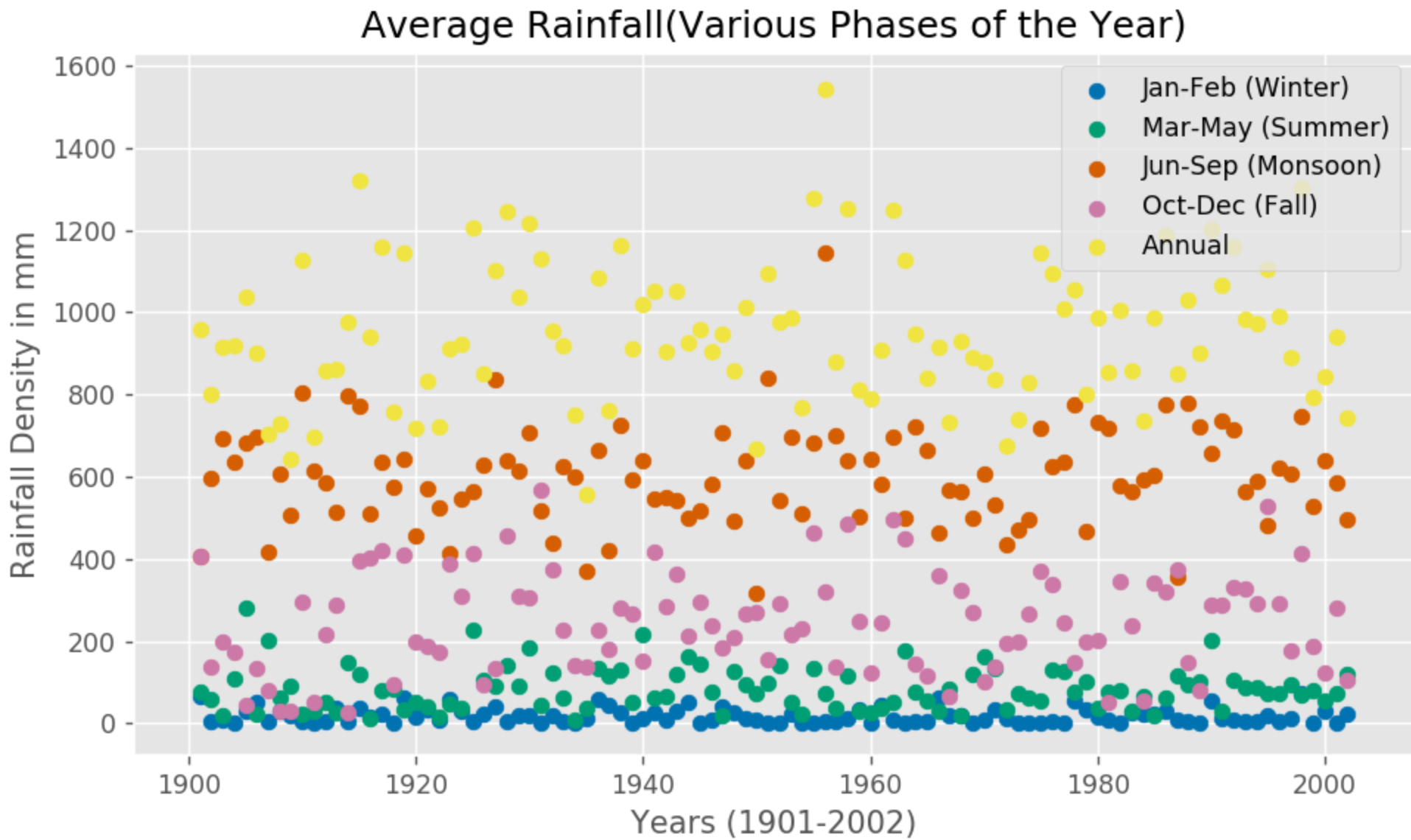
➢ The result shows a downward trend in the post-monsoon rainfall for the stations of Damoh, Jabalpur, Katni, and Narsinghpur, and the rest of the stations recorded upward trend in the rainfall data.

➢ In the pre-monsoon season, five stations showed a downward trend and the rest of the stations showed an upward trend, whereas in winter season, only three stations (Narsinghpur, Raisen, and Sagar) showed upward trend and remaining stations showed a downward trend.

- **Mann–Kendall test**

- The Mann-Kendall Trend Test is used to analyze time series data for consistently increasing or decreasing trends.
- It is a non-parametric test, which means it works for all distributions (i.e. data doesn't have to meet the assumption of normality), but data should have no serial correlation. If the data has a serial correlation, it could affect in significant level (p-value).
- This test shows the values of the Z-statistics of annual and pre-monsoon, monsoon and post monsoon time scale rainfall derived from the MK test.
- The annual, monsoon, and winter seasons showing a negative trend at all study stations. However, the pre-monsoon and post-monsoon seasons in eight and seven stations, respectively, out of the 12 stations, have a non-significant increasing trend.
- In the annual time scale, it was found that three out of 12 stations had a decreasing trend at the 10% significance level, and only one station (i.e., Mahoba, U.P.) had a negative trend at the 5% level.
- In a monsoon case, a total of seven out of 12 stations showed a declining trend at the 10% significance level, and only one station (i.e., Mahoba, in U.P.) showed a statistically decreasing trend at the 5% significance level.


Raifall Variation of Srikakulam (1901 - 2002)
Average of Year
Rainfall Density in mm
1400
1200
1000
800
600
1900
1920
1940
1960
1980
2000
Years


Average Rainfall(Various Phases of the Year)
Jan-Feb (Winter)
Mar-May (Summer)
Jun-Sep (Monsoon)
Oct-Dec (Fall)
Annual
Rainfall Density in mm
0
200
400
600
800
1000
1200
1400
1600
1900
1920
1940
1960
1980
2000
Years (1901-2002)

Statistics of Srikakulam District

Annual			
Mean	Standard Deviation	Skewness	Kurtosis
79.32	14.376	0.485	0.416
Summer			
84.07	52.02	1.083	1.525
Monsoon			
60.26	78.37	0.735	2.821
Fall			
24.71	47.13	0.267	-0.496
Winter			
18.04	17.98	1.138	0.502

Q4.

- For the climate change analysis, we could show a relationship between temperature and rainfall data for the time series analysis.
- This approaches can have useful implications for the water resource planning and local policy making in respect to sustainable water utilization in the current and future changing climate.
- Rainfall trend and forecasting estimation.
- Runoff estimation.