Statistical analysis of seasonal rainfall data in Chandigarh: A case study

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Abstract: The following research focuses on Chandigarh’s annual rainfall of past 50 years i.e. from 1968 to 2017. Parameters like Kurtosis, Variance, Goodness of Fit, Mann-Kendall’s Test were performed along with total annual forecast as well as seasonal forecast was predicted. Seasonal rend was also studied so as to study in detail about the past, present, and future of rainfall in Chandigarh. This study was performed with the help of MS-Excel and ExcelStat. A rising trend was found in Chandigarh for total as well as seasonal rainfall with a maximum rainfall of 1510.9 mm in the year of 1996 and a minimum of 371.1 mm in year 1987, other than this Sen.’s slope was 6.431 whereas skewness was found to be 0.6018.

Keywords : Rainfall, analysis, Forecast, parameters

1. INTRODUCTION
Chandigarh is a Union Territory as well as the capital of Haryana and Punjab. It is 250 km N from the capital city of New Delhi. It lays 365 m above mean sea level and between latitude 30°40’N and 30°46’N, longitude 76°42’E and 76°51’E. It covers an area of 114 km2 in which 78 km2 comes under the Urban and 2.1 km2 areas comes under forest cover. The southwest (SW) monsoon is principle rainfall, brings about 80% of total precipitation, which is critical for the availability of freshwater for drinking and irrigation. The heavy precipitation (rainfall) in monsoon months results in flash floods in low line areas[1].

Rainfall starts increasing from June with the beginning of pre-monsoonal activities. July and August are the rainiest days in Chandigarh. Monsoon in Chandigarh withdraws in the last week of September. After the retreat of monsoon rainfall starts decreasing from October leading towards the driest month of November[2].

In view of the above, numerous studies have attempted to investigate the trend of climate variables for the country. These studies have looked at the trends on the country scale, regional scale, and at the individual stations. The earliest of all studies was by Walker (1910) which indicated no significant
trend in rainfall in the monsoon season during the second half of the 19th century [3,4]. Later studies have been confined to trends and periodicities over specific regions of India using different periods of data depending on the data availability[5]. It was that there is a statistically significant (except dry sub-humid) decreasing trend in annual mean rainfall data of Punjab by M. Sharma[6]. Rainfall was decreasing with a rate of 0.571 mm per year in hills and 0.107 mm per year in plains but increasing with a rate of 0.686 mm per year in north-west India found by M. Singh et.al. [7]. The annual and effective growing seasonal rainfall showed an increasing trend in the eastern part, a decreasing trend in the western part. The annual and effective growing seasonal rainfall showed an increasing trend in the eastern part, a decreasing trend in the western part, and almost no change in the central part of the study area and almost no change in the central part of the study area found by M. Singh [8]. He also concluded that during the effective growing season rainfall was increasing with the rate of 3.38 mm/ years, 2.77 mm/ years, and 4.56 mm per year in hills, plain and north-west India, respectively[8].

2. METHODOLOGY
The monthly rainfall data for the period 1968-2017 (50 years) were collected from Meteorological Centre, Chandigarh, India Meteorological Department. Statistical analysis of any data can be described on certain parameters. Parameters like mean, standard deviation, variance, skewness, and kurtosis. All these have been used in the present study followed by the monthly forecast [9–11].

3. RESULTS
Each graph consists of shifted variation from mean/ average along with shifting average as well as trend line and its equations i.e. linear equation and coefficient of determination, see figure 1.

![Figure 1 Total Rainfall](image)

Results can be further subcategorized in three parts i.e. seasonal variation, test results, and monthly forecast.

3.1 Seasonal variation
Figure 2 Winter Variation

WINTER

\[ y = 0.8286x - 21.152 \]

\[ R^2 = 0.0706 \]

Figure 3 Pre-Monsoon

PRE - MONSOON

\[ y = 1.1918x - 29.772 \]

\[ R^2 = 0.1641 \]

Figure 4 Monsoon

MONSOON

\[ y = 3.8768x - 105.02 \]

\[ R^2 = 0.048 \]
From figure 2 to figure 5, it can be noted that the linear trend of Chandigarh is positive. This change is greatest in winter and minimum in monsoon season. It can also be seen that the highest rainfall deviation both positive and negative are in monsoon i.e. 552.5 in 1996 and -443.6 in 1987 respectively.

### 3.2 Test Results

![Figure 5: Post-Monsoon](image)

#### Table 1: Test Results

| Parameter         | Value          | Chi-square test | Mann-Kendall trend test |
|-------------------|----------------|-----------------|-------------------------|
| **Average**       | 867.412        |                 |                         |
| **TOTAL**         | 43370.6        | Observed value  | Kendall’s tau           |
| Maximum           | 1510.9         | Critical value  | S                        |
| Kurtosis          | -0.04758       | DF              | Var(S)                  |
| Skewness          | 0.601816       | p-value         | p-value                  |
| Variance          | 77672.58       | alpha           | alpha                    |
| Trend             | 707.8621       | Goodness of fit statistics | Anderson-Darling test |
| Standard Deviation| 278.698        | R²              | A²                       |
| Confidence        | 26.85414       | SSE             | p-value                  |
| Kolmogorov-Smirnov test | MSE         | 60776.366   | alpha                    |
| D                 | 0.098          | RMSE            |                          |
| p-value (Two-tailed) | 0.691       |                 |                          |
| alpha             | 0.05           |                 |                          |

The above table showcase the values of total rainfall, average rainfall, maximum rainfall, kurtosis, skewness, variance, trend, standard deviation, and confidence. In addition to these values, it also gives the results of the Kolmogorov – Smirnov test, Chai-Square test, Mann – Kendall test, and Goodness of Fit, see Table 1.

### 3.3 Seasonal Forecast
Figure 6 Total Forecast

Table 2 Statistic for Total Rainfall Forecast

| Value | Total Forecast |
|-------|----------------|
| Alpha | 0.251          |
| Beta  | 0.001          |
| Gamma | 0.25           |
| MASE  | 1.080523       |
| SMAPE | 0.295658       |
| MAE   | 286.8715       |
| RMSE  | 352.6159       |

Figure 7 Winter Forecast
Table 3 Statistic for Winter Forecast

| Statistic | Value  |
|-----------|--------|
| Alpha     | 0.002  |
| Beta      | 0.001  |
| Gamma     | 0.125  |
| MASE      | 1.05928|
| SMAPE     | 0.592554|
| MAE       | 37.79803|
| RMSE      | 49.3514|

Figure 8 Pre-Monsoon Forecast

Table 4 Statistic for Pre-Monsoon Forecast

| Statistic | Value  |
|-----------|--------|
| Alpha     | 0.126  |
| Beta      | 0.001  |
| Gamma     | 0.001  |
| MASE      | 1.056831|
| SMAPE     | 0.419368|
| MAE       | 32.53581|
| RMSE      | 45.11004|
Table 5 Statistic for Monsoon Forecast

| Statistic | Value  |
|-----------|--------|
| Alpha     | 0.251  |
| Beta      | 0.001  |
| Gamma     | 0.25   |
| MASE      | 0.738368 |
| SMAPE     | 0.251458 |
| MAE       | 191.9679 |
| RMSE      | 254.0415 |

Figure 9 Monsoon Forecast

Figure 10 Post-Monsoon Forecast
Table 6 Statistics for Post-Monsoon Rainfall

| Statistic | Value post |
|-----------|------------|
| Alpha     | 0.251      |
| Beta      | 0.001      |
| Gamma     | 0.25       |
| MASE      | 1.099861   |
| SMAPE     | 0.778503   |
| MAE       | 27.12485   |
| RMSE      | 36.9152    |

Figure 6 to figure 10 represent the forecast for total annual rainfall till 2065 and table 2 to table 6 gives the statistical information respectively.

4. CONCLUSIONS

After a thorough study of rainfall data from 1968 to 2017 of Chandigarh the following conclusions can be drawn:

- The total rainfall during the period was 43370.6 mm with a maximum of 1510.9 mm in 1996 and a minimum of 371.1 in 1987.
- Seasonal minimum rainfall was 2 mm in winter 2016, 18.7 mm in pre-monsoon 2013, 257.4 mm in monsoon 1987, and 0 mm in post-monsoon 2000.
- Seasonal maximum rainfall was 173.8 mm in 1995, 191.8 mm in 2014, 1253.5 mm in 1996 and 261.2 mm in 1997 as of winter, pre-monsoon, monsoon and post-monsoon respectively.
- Sen.’s slope for Chandigarh was 6.431.
- Chandigarh rainfall showed a positive trend.

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