Rainfall Trends in Gujarat Cities (2014–2023): An SPSS-Based Analysis

S D Bhagat
Assistant Professor, Mathematics Department,
BVM Engineering College, Vallabh Vidyanagar–
Gujarat – India.

N C Sonara
Assistant Professor, Mathematics Department,
BVM Engineering College, Vallabh Vidyanagar–
Gujarat – India.

Abstract: This research analyzes the rainfall patterns of various cities in Gujarat using several statistical measures such as mean, standard deviation, variance, skewness, and kurtosis. The mean provides insight into the average level of precipitation, while the standard deviation and variance indicate the degree of fluctuation or variability in rainfall. Skewness reflects the imbalance in rainfall distribution, highlighting whether rainfall tends to be more frequent at lower or higher levels. Kurtosis, on the other hand, reveals the frequency of extreme rainfall events. The analysis uncovers notable differences in the distribution and timing of rainfall across the region. These insights are valuable for effective water resource management, agricultural planning, and the development of climate resilience strategies tailored for Gujarat.

Keywords*: Rainfall analysis, Gujarat cities, SPSS, Climate change, Urban planning, Water management.*

1. Introduction

1.1 Background

Gujarat experiences considerable climatic variation due to its location along the western coast of India and its exposure to the southwest monsoon, which typically occurs from June to September. Coastal regions receive significantly more rainfall compared to the drier zones of Kutch and Saurashtra, while central areas, such as Ahmedabad, witness moderate precipitation levels. Rainfall distribution across the state is influenced by geographical features and larger climatic phenomena such as the El Niño Southern Oscillation and La Niña. These factors contribute to the unpredictability of the monsoon, and the impact of global warming has further intensified these variations, resulting in more frequent occurrences of floods and droughts. Understanding these rainfall trends is crucial for efficient water resource management, agricultural planning, and sustainable urban development. This study aims to analyze historical rainfall data across Gujarat's cities, identify patterns and trends, and assess the influence of climate change—ultimately providing valuable insights for policymakers and stakeholders.

1.2 Research objectives

- Analyse rainfall patterns in Gujarat cities from 2014 to 2023.
- Identify annual and seasonal variations in rainfall.
- Use SPSS to uncover statistical trends and correlations

2 Rainfall pattern in India

India's rainfall is largely governed by seasonal monsoon winds, which contribute most of the country's annual precipitation. There are two primary monsoon phases: the southwest monsoon and the northeast monsoon.

Southwest Monsoon

- Onset: Arrives on the Kerala coast by late May or early June.
- Peak: July and August are the peak months, with heavy rainfall across most parts of the country.
- Withdrawal: Begins to withdraw from the northern regions by early September and from the southern regions by late October.

Northeast Monsoon

- Onset: Affects the southeastern coast, particularly Tamil Nadu and Andhra Pradesh.
- Peak: November and December are the peak months.
- Withdrawal: Typically withdraws by the end of December.

Regional Variations

- Western Ghats: Receives heavy rainfall during the southwest monsoon, with some areas recording over 2,000 mm annually.
- Thar Desert: Receives very little rainfall, often less than 100 mm annually.
- Central India: States like Madhya Pradesh and Chhattisgarh experience moderate rainfall, crucial for agriculture.
- Northeast India: States like Assam and Meghalaya receive heavy rainfall, with Cherrapunji and Mawsynram being among the wettest places on Earth.

3 Rainfall variability

Rainfall variability in Gujarat is influenced by several factors, including geographical diversity, climate change, and regional climatic zones. Here's an overview:

Climatic Zones in Gujarat

1. Southern Heavy Rainfall Area & Hilly Area: Receives high rainfall, especially during the monsoon season.
2. South Gujarat: Semi-arid to dry sub-humid climate, with moderate rainfall.
3. Middle Gujarat: Semi-arid climate with moderate rainfall.
4. North Gujarat: Arid to semi-arid climate, receiving low rainfall.
5. North-West Gujarat: Arid climate with very low rainfall.
6. North Saurashtra: Dry sub-humid climate.

7. South Saurashtra: Dry sub-humid climate.
8. Bhal & Coastal Area: Semi-arid to dry sub-humid climate

3.1 Arithmetic mean

The arithmetic mean, or simply, the mean of a variable, it is defined as the sum of the observation divided by the number of observations. It is denoted by the $\bar{x}$. If the variable x assume n values X1,X2 ….Xn, then the mean is given by

$$\bar{x} = \frac{x_1 + x_2 + \cdots \ldots x_n}{n}$$

3.2 Standard Deviation

Standard Deviation is a number used to say how measurements for a group are separated from the mean or expected value. If the Standard Deviation, a low value, denotes that the entire set of numbers is very close to the mean.

Large Standard Deviation mean that the no. is scattered or wide meaning a large difference from the mean. It is defined as the positive square- root of the arithmetic mean of the square of the deviations of the given observation from their arithmetic mean.

$$\sigma = \sqrt{\frac{\sum(x-\mu)^2}{n}}$$

Where, σ = Standard Deviation

N = No. of observation

X = Value

μ = mean

3.3 Coefficient of variation

The CV is an indicator of how much the data in a given data series deviates from the mean on average. The coefficient of variation describes the ratio of the standard deviation to the mean. This statistic is useful for comparing the degree of variation from one data series to another, even if the means are drastically different from one another.

$$CV = \mu/\sigma$$

Where, CV = Coefficient of Variation

μ = mean

σ = Standard Deviation

For the comparison of the variability of two or more series, C.V. is used. In other words the C.V found greater for the series or groups of data suggest that the group is more variable, less stable, less uniform, less consistent or less homogeneous. If the C.V. is less then mean then it means that the group is less variable, or more stable, or more uniform, or more consistent or more homogenous.

3.4 Coefficient of Skewness

Skewness coefficient is calculated to determine the asymmetry of the distribution. Long tail on the right side is depicted by positive skew while a long tail on the left side is depicted by negative skew. The skew of a perfectly symmetric distribution such as the normal distribution is equal to zero. When using a small data sample, this measure is quite inaccurate.[1]Type equation here.

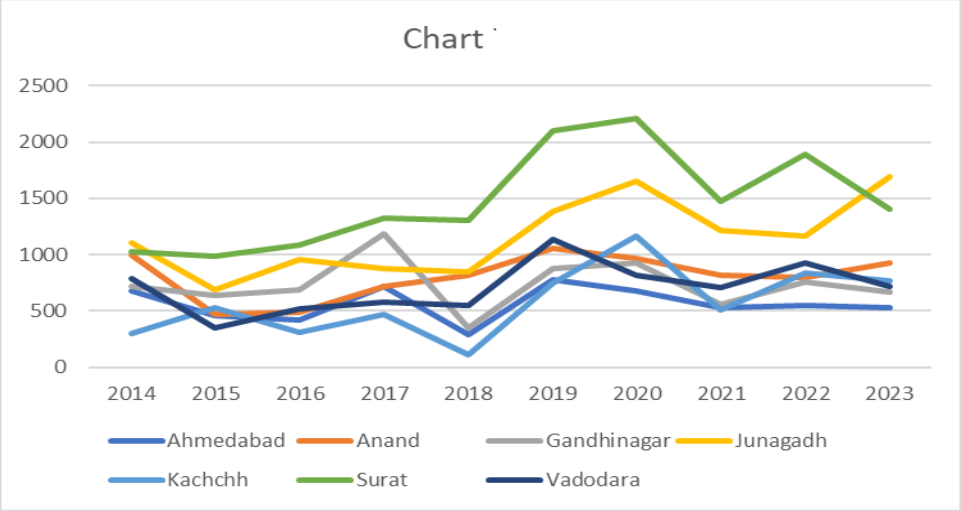
$$y_1 = \frac{1}{N\sigma^3}\sum_{i=1}^{N}(x_i - \mu)^3$$

Data

The district wise data is provided in Table 1 of rainfall for the city of Ahmedabad, Anand, Gandhinagar, Junagadh, Kachchh, Surat and Vadodara city of Gujarat state. The following data is annually (mm).

District	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Ahmedabad	676	458	419	721	292	773	677	532	551	532
Anand	998	470	492	715	821	1053	962	821	799	928
Gandhinagar	712	641	690	1184	348	877	925	553	754	668
Junagadh	1105	687	959	879	842	1380	1650	1217	1168	1690
Kachchh	298	531	307	464	111	746	1162	511	839	764
Surat	1023	989	1085	1325	1307	2095	2208	1477	1892	1402
Vadodara	787	344	514	578	543	1139	821	709	928	721

Table 1: Rainfall data from 2014-2023



District	Mean	Std. Deviation
Ahmedabad	563.1	149.851
Anand	805.9	199.267
Gandhinagar	735.2	225.339
Junagadh	1157.7	336.634
Kachchh	573.3	309.372
Surat	1480.3	440.196
Vadodara	708.4	227.937

Table 2: Average mean and standard deviation of district for 2014-2023

The data from Table 2 shows that Junagadh district has highest rainfall over the past 10 years from 2014-2023 where as Ahmedabad has lowest rainfall. This shows that Junagadh has higher population in agricultural sector.

District	Variance	Skewness	Kurtosis
Ahmedabad	22455.211	-0.332	-0.509
Anand	39707.211	-0.733	-0.406
Gandhinagar	50777.511	0.422	1.244
Junagadh	113322.233	0.422	-0.803
Kachchh	95711.122	0.444	0.043
Surat	193772.678	0.655	-0.969
Vadodara	51955.156	0.35	0.27

Table 2: Variance and coefficient of skewness of district for 2014-2023

For a normal distribution skewness is zero or any symmetrical data should have skewness near to zero. Negative skewness indicates that the data is left to the curve while positive skewness indicate right side of the curve. Ahmedabad and Anand show negative skewness means mean is less than the mode, meaning longer tail towards left side.

Conclusion

Agriculture is the primary livelihood in this region, with cultivation largely reliant on monsoon rainfall for irrigation. However, the area's climate is highly variable, and the frequent occurrence of droughts and floods poses significant challenges to stable agricultural output and consistent income for the population. To understand these fluctuations, this study applies rainfall variability analysis and data analytics techniques to historical rainfall data from the Saurashtra region for the period 2014 to 2023.

References

[1] P. P. A., P. S. H., G. G. D., and vadalia D. D., "Rainfall Variability Analysis of Saurashtra Region of Gujarat," *Int. J. Adv. Res. Biol. Sci.*, vol. 10, no. 6, pp. 1–5, 2023, doi: 10.22192/ijarbs.

[2] H. Dave and M. E. James, "Characteristics of intense rainfall over Gujarat State (India) based on percentile criteria," *Hydrol. Sci. J.*, vol. 62, no. 12, pp. 2035–2048, 2017, doi: 10.1080/02626667.2017.1357818.

[3] S. S. Nandargi, A. Kumar, and P. Warwade, "Analysis of Rainfall and Rainstorms Over the Gujarat State, India," *J. Res. Eng. Appl. Sci. Anal.*, vol. 04, no. 01, pp. 43–56, 2019.

[4] K. Sodha, P. P. Pati, D. Rajput, and H. Solanki, "Review Of The Study Climate Change Impact Assessment On The Gujarat Coastline: The Role Of Artificial Intelligence, Statistical, Mathematical And Geographic Information Systems (Gis)," *Int. Assoc. Biol. Comput. Dig.*, 2023, [Online]. Available: https://api.semanticscholar.org/CorpusID:258725269

[5] A. Gangarde, S. Dauji, and S. Londhe, "Comparison of long-term and short-term trends of annual rainfall in India: a case study," *ISH J. Hydraul. Eng.*, vol. 29, no. 3, pp. 411–424, May 2023, doi: 10.1080/09715010.2022.2084351.