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The rainfall characteristics in Srikalahasti Revenue Division, Andhra Pradesh, India

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Abstract

Rainfall is a critical climatic element influencing agriculture and water resources in monsoon-dependent India. The present study examines the rainfall characteristics in the Srikalahasti revenue division located in Tirupati district, Andhra Pradesh, India. The present study examines the rainfall characteristics between 2014 and 2023 using statistical parameters like average/mean rainfall, rainfall intensity, rainfall ratio, and rainfall variability. Based on the study, the average rainfall was 992.92 mm. The highest intensity of rainfall was 20.72 mm in the North-eastern monsoon season for Thotambedu Mandal, and the lowest was 6.14 mm during the winter season for Srikalahasti mandal. The highest rainfall ratio was 221.41% during the winter season for KVB Puram Mandal, and the lowest rainfall ratio was 42.48% during the south west monsoon season for KVB Puram mandal. The highest rainfall variability was 73.55% during the winter season for KVB Puram Mandal, and the lowest rainfall variability was 14.27% during the south west monsoon season for Renigunta mandal.

Keywords: Mean rainfall, rainfall intensity, rainfall ratio, rainfall variability, south west monsoon season, north east monsoon season

1. Introduction

Rainfall is a vital climatic parameter that significantly influences agriculture, water resources, and regional development in monsoon-dependent regions of India. The spatial and temporal variability of rainfall affects cropping patterns, groundwater recharge, and the occurrence of hydrological extremes such as droughts and floods (Gadgil, 2003; Subrahmanyam & Raju, 2012) ^[14, 15]. Understanding seasonal rainfall behavior is therefore essential for sustainable agricultural and water resource planning.

Andhra Pradesh exhibits considerable rainfall variability due to the combined influence of the Southwest and Northeast monsoons. The Srikalahasti Revenue Division in Tirupati District represents a unique climatic region classified under the tropical monsoon with dry summer (As) climate, where agricultural activities are highly sensitive to rainfall fluctuations. Despite its importance, detailed mandal-level studies focusing on seasonal rainfall characteristics in this region remain limited.

In this context, the present study analyzes the seasonal and annual rainfall characteristics of the Srikalahasti Revenue Division using ten years (2014-2023) of rainfall data from eight rain-gauge stations. The study examines rainfall distribution, intensity, and variability across winter, summer, Southwest Monsoon, and Northeast Monsoon seasons, with the objective of providing scientific inputs for effective water resource management and sustainable agricultural planning.

2.1 Objective

- To study average/mean rainfall, rainfall intensity, rainfall ratio, and rainfall variability.
- To study the rainfall characteristics seasonally.

2.2 Study Area

Srikalahasti revenue division is in Tirupati district, Andhra Pradesh, India. The study extends between 13°61' 75" N to 13° 88' 29" N Latitude and 79° 50' 02" E to 79°85' 25" E Longitude covering 2112 sq.km of area. It consists of eight mandals, namely, 1. KVB. Puram, 2. Nagalapuram, 3. Narayanavanam, 4. Pichaturu, 5. Renigunta, 6. Srikalahasti,

7. Thotambedu, and 8. Yerpedu. According to Koppen's climatic classification the study area is present in the 'As' climatic zone which represents tropical monsoon with dry summer. This is the only region in the world which receives rainfall during both south west monsoon season and north east monsoon season. Of these 8 mandals, 7 mandals are

rural districts heavily dependent on the agriculture and Srikalahasti mandal being the only urban mandal and a municipality in the revenue division. Srikalahasti municipality is famous for temple tourism in Andhra Pradesh where the famous shiva temple is located which is widely renowned for the vayulinga present there.

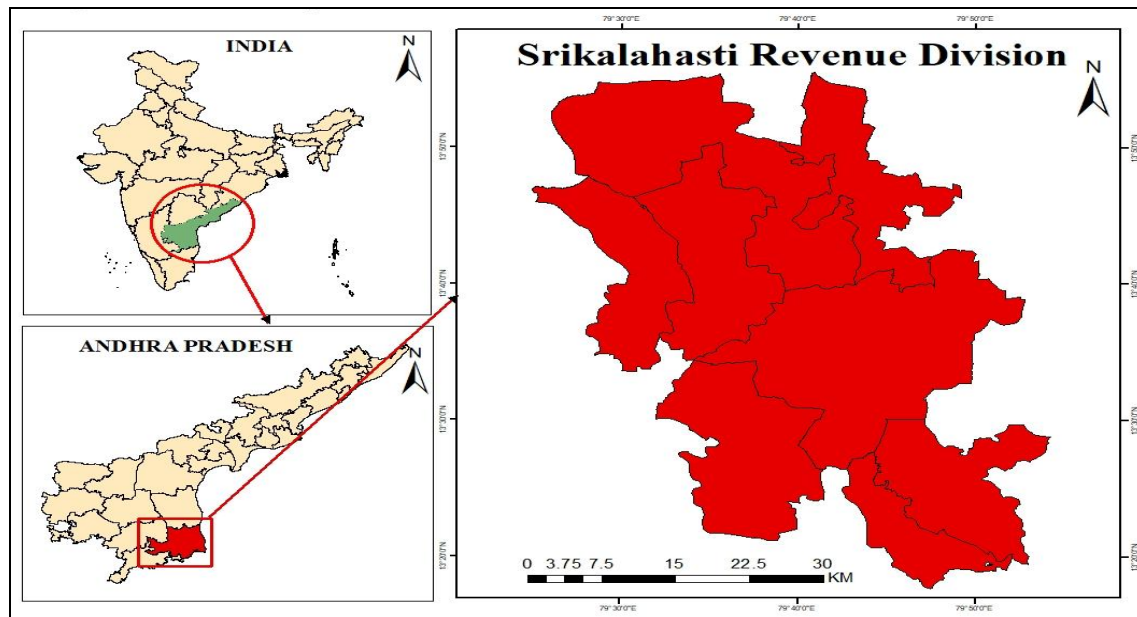


Fig 1: Location Map of Srikalahasti Revenue Division, Andhra Pradesh, India

3. Data and Methodology

The data has been collected from 8 rain gauge stations situated in the 8 mandals of the revenue division as mean monthly rainfall from the Indian meteorological department (IMD) for 10 years between 2014 to 2023. This study aims to analyze the temporal distribution and availability of rainfall on seasonal basis, with specific emphasis on winter, summer, Southwest Monsoon, and Northeast Monsoon seasons as per the classification given by IMD. The study uses statistical methods like rainfall intensity, rainfall variability, rainfall ratio, and mean rainfall.

a) Mean rainfall: The normal rainfall of a station is generally defined as simple arithmetic mean of rainfall figures.

$$\text{Normal rainfall} = \frac{\sum x}{N}$$

Where;

- $\sum x$ = total rainfall over the period
- N = Number of rainy days

A. Intensity of rainfall: Rainfall intensity is defined as the rate at which rainfall occurs expressed in depth units per unit time usually millimeters (mm) per hour.

$$\text{Intensity} = \frac{\text{mean rainfall}}{\text{average number of rainy days}}$$

b) Rainfall ratio: The rainfall ratio denotes the abnormalities in the occurrence of rainfall at any location.

$$\text{Rainfall ratio} = \frac{Px - Pn}{Pm} \times 100$$

Where;

- 'Px' represents maximum amounts over a series of years
- 'Pn' represents minimum rainfall amounts over a series of years
- 'Pm' is the average rainfall.

c) Rainfall variability: This analysis highlights the degree of fluctuation in rainfall distribution.

$$\text{Co-efficient of Variation or C.V} = \frac{SD}{AM} \times 100$$

Where;

- SD = Standard Deviation
- AM = Arithmetic Mean

4. Data analysis

4.1. Winter Season Rainfall Analysis

From the analysis of the winter seasonal rainfall given below in the table 1 it is evident that the normal/mean rainfall for the winter season during 2014-2023 is 21.4 mm. The normal rainfall varies from a minimum of 15.82 mm for Yerpedu mandal to a maximum of 34.13 mm for Narayanavanam mandal. The average number of rainy days for the winter season during 2014-2023 is 2.75, ranging from a minimum of 2.6 days for Srikalahasti mandal, Thotambedu mandal and Yerpedu mandal to a max number of rainy days of 3.1 days for Kvbipuram mandal. The intensity of rainfall in the study region for winter season

during 2014-2023 is 7.75 mm per rainy day, and varies from a minimum of 6.08 mm in Yerpedu mandal to a maximum of 12.19 mm for Narayanavanam mandal. The rainfall ratio or the abnormalities in the occurrence of rainfall in the study area is ranging from a minimum of 131.94% in Renigunta mandal to a maximum of 221.41% in Kvbipuram mandal and the average rainfall ratio for the winter is 170.67%

during 2014-2023. From the study of analysis of co-efficient of variability in the revenue division, it is evident that it ranges from a minimum of 57.5% in Srikalahasti mandal to a maximum of 73.63% in Pichaturu mandal, the average rainfall variability of the study area is 64.85% for the winter season during 2014-2023.

Table 1: Winter Season Rainfall Analysis in Sri Kalahasti Revenue Division during 2014-2023

Winter Season Rainfall Analysis In Sri Kalahasti Revenue Division During 2014-2023					
Name of the rain Gauge station	Mean seasonal rainfall (mm)	Avg no of rainy days	Rainfall intensity (mm)	Rainfall Ratio (%)	Rainfall Variability (%)
KVBPURAM	23.44	3.1	7.56129	221.4164	73.55504
Nagalapuram	25.752	2.8	9.197143	184.6459	69.63766
Narayanavanam	34.132	2.8	12.19	181.0325	65.15545
Pichaturu	20.789	2.8	7.424643	217.3746	73.63136
Renigunta	18.227	2.7	6.750741	131.9471	57.65725
SRI Kalahasti	15.977	2.6	6.145	136.1332	57.56809
Thotambedu	17.4	2.6	6.692308	147.931	59.60684
Yerpedu	15.822	2.6	6.085385	144.9248	61.99378

Source: Computed from the data collected.

4.2. Summer Season Rainfall Analysis

From the analysis of the summer seasonal rainfall given below in the table 2 it is evident that the normal/mean rainfall for the summer season during 2014-2023 is 82.14 mm. The normal rainfall varies from a minimum of 60.27 mm for Thotambedu mandal to a maximum of 106.9 mm for Narayanavanam mandal. The average number of rainy days for the summer season during 2014-2023 is 6.73 days and ranges from a minimum of 6.2 days for Thotambedu mandal, to a max number of rainy days 7.1 days for Renigunta mandal. The intensity of rainfall in the study region for summer season during 2014-2023 is 12.15 mm per rainy day, and varies from a minimum of 9.63 mm in

Pichaturu mandal to a maximum of 15.96 mm for Narayanavanam mandal. The rainfall ratio or the abnormalities in the occurrence of rainfall in the study area is ranging from a minimum of 120.90% in Thotambedu mandal to a maximum of 139.18% in Pichaturu mandal and the average rainfall ratio in summer season during 2014-2023 is 128.15%. From the study of analysis of co-efficient of variability in the revenue division, it is evident that it ranges from a minimum of 40.71% in Thotambedu mandal to a maximum of 44.02% in Pichaturu mandal, the average rainfall variability of the study area is 42.37% during the summer season for 2014-2023.

Table 2: Summer Season Rainfall Analysis in Sri Kalahasti Revenue Division during 2014-2023

Summer season rainfall analysis in sri kalahasti revenue division during 2014-2023					
Name of the rain Gauge station	Mean seasonal rainfall (mm)	Avg no of rainy days	Rainfall intensity (mm)	Rainfall Ratio (%)	Rainfall Variability (%)
KVBPURAM	84.043	6.8	12.35926	128.3867	42.14571
Nagalapuram	74.717	6.7	11.15179	126.4906	41.39571
Narayanavanam	106.946	6.7	15.96209	130.6921	43.16956
Pichaturu	62.764	6.7	9.367761	139.1881	44.02305
Renigunta	100.037	7.1	14.08972	123.6842	42.94734
SRI Kalahasti	80.703	6.9	11.69609	126.1044	42.01984
Thotambedu	60.278	6.2	9.722258	120.9065	40.71297
Yerpedu	87.682	6.8	12.89441	129.7644	42.60036

Source: Computed from the data collected.

4.3. South West Monsoon Season Rainfall Analysis

From the analysis of the South west monsoon seasonal rainfall given below in the table 3 it is evident that the normal/mean rainfall for the South west monsoon season during 2014-2023 is 382.39 mm. The normal rainfall varies from a minimum of 337.72 mm for Thotambedu mandal to a maximum of 419.06 mm for Pichaturu mandal. The average number of rainy days for the South west monsoon season during 2014-2023 is 36.05 days and ranges from a minimum of 33 days for Thotambedu mandal, to a max number of 37.4 rainy days for Yerpedu mandal. The intensity of

rainfall in the study region for South west monsoon season during 2014-2023 is 10.60 mm per rainy day, and varies from a minimum of 9.70 mm in Kvbipuram mandal to a maximum of 11.51 mm for Pichaturu mandal. The rainfall ratio or the abnormalities in the occurrence of rainfall in the study area is ranging from a minimum of 42.48% in Kvbipuram mandal to a maximum of 64.71% in Pichaturu mandal and the average rainfall ratio in South west monsoon season during 2014-2023 is 51.30%. From the study of analysis of co-efficient of variability in the revenue division, it is evident that it ranges from a minimum of 14.27% in

Renigunta mandal to a maximum of 18.96% in Pichaturu mandal, the average rainfall variability of the study area is

16.01% for the south west monsoon season during 2014-2023.

Table 3: South West Monsoon Season Rainfall Analysis in Sri Kalahasti Revenue Division during 2014-2023

South west monsoon season rainfall analysis in Sri Kalahasti revenue division during 2014-2023					
Name of the rain gauge station	Mean seasonal rainfall (mm)	Avg no of rainy days	Rainfall intensity (mm)	Rainfall Ratio (%)	Rainfall Variability (%)
KVBPURAM	361.831	37.3	9.700563	42.48392	14.67681
Nagalapuram	394.187	36.4	10.82931	61.55708	17.96238
Narayanavanam	401.585	36.4	11.03255	58.27658	17.1462
Pichaturu	419.067	36.4	11.51283	64.71757	18.96804
Renigunta	404.576	37.2	10.8757	43.64816	14.27179
Sri Kalahasti	360.495	34.3	10.51006	46.32519	15.36582
Thotambedu	337.728	33	10.23418	47.05858	15.18563
Yerpedu	379.689	37.4	10.15211	46.35109	14.55886

Source: Computed from the data collected.

4.4. North East Monsoon Season Rainfall Analysis

From the analysis of the north east monsoon seasonal rainfall given below in the table 4 it is evident that the normal/mean rainfall for the north east monsoon season during 2014-2023 is 506.93 mm. The normal rainfall varies from a minimum of 442.16 mm for Renigunta mandal to a maximum of 573.28 mm for Nagalapuram mandal. The average number of rainy days for the north east monsoon season during 2014-2023 is 27.07 days and ranges from a minimum of 25.3 rainy days for Thotambedu mandal, to a max number of rainy days 28.3 for Nagalapuram mandal. The intensity of rainfall in the study region for north east monsoon season during 2014-2023 is 18.71 mm per rainy

day, and varies from a minimum of 17.20 mm in Renigunta mandal to a maximum of 20.72 mm for Thotambedu mandal. The rainfall ratio or the abnormalities in the occurrence of rainfall in the study area is ranging from a minimum of 109.19% in Renigunta mandal to a maximum of 116.73% in Thotambedu mandal and the average rainfall ratio in north east monsoon season during 2014-2023 is 113.24%. From the study of analysis of co-efficient of variability in the revenue division, it is evident that it ranges from a minimum of 40.35% in Pichaturu mandal to a maximum of 43.39% in Thotambedu mandal, the average rainfall variability of the study area is 42.39% for the north east monsoon season during 2014-2023.

Table 4: North East Monsoon Season Rainfall Analysis in Sri Kalahasti Revenue Division during 2014-2023

North east monsoon season rainfall analysis in sri kalahasti revenue division during 2014-2023					
Name of the rain gauge station	Mean seasonal rainfall (mm)	Avg no of rainy days	Rainfall intensity (mm)	Rainfall Ratio (%)	Rainfall Variability (%)
KVBPURAM	517.632	27.6	18.75478	112.9374	41.92623
Nagalapuram	573.282	28.3	20.25731	115.2312	40.63861
Narayanavanam	490.007	28.3	17.31473	116.0004	43.07563
Pichaturu	559.703	28.3	19.77749	116.5082	40.35765
Renigunta	442.161	25.7	17.20471	109.191	42.82718
Sri Kalahasti	478.064	26.4	18.10848	110.6756	43.54236
Thotambedu	524.35	25.3	20.7253	116.7731	43.63241
Yerpedu	470.31	26.7	17.61461	108.6305	43.12878

Source: Computed from the data collected.

5. Conclusion

The present study provides a comprehensive analysis of the seasonal and annual rainfall characteristics of the Srikalahasti Revenue Division in Tirupati District, Andhra Pradesh, using ten years (2014-2023) of rain-gauge data. The analysis clearly brings out the spatial and temporal variability of rainfall across the eight mandals, highlighting the unique climatic setting of the region which receives rainfall from both the Southwest and Northeast monsoon systems. The results indicate that winter rainfall is meagre, highly erratic, and unreliable, as reflected by low mean rainfall, fewer rainy days, high rainfall ratios, and very high coefficients of variability across all mandals. This makes winter rainfall insignificant for agricultural planning. Summer rainfall, though higher than winter rainfall, also shows moderate variability and localized intensity, making it supportive only for limited pre-monsoon agricultural and groundwater recharge activities. The Southwest Monsoon season contributes a substantial share of rainfall with low variability, indicating relative stability and dependability.

However, the Northeast Monsoon emerges as the dominant rainfall season, contributing the highest rainfall with greater intensity but moderate variability, underscoring its crucial role in sustaining agriculture, surface water resources, and reservoirs in the region. Mandals such as Nagalapuram, Pichaturu, and Narayanavanam consistently record higher rainfall amounts during the monsoon seasons, whereas Renigunta and Srikalahasti exhibit comparatively lower rainfall and higher variability. Overall, the study underscores the importance of the Northeast Monsoon as the backbone of the regional hydrological regime, while also highlighting rainfall variability as a key constraint. The findings have significant implications for crop planning, groundwater management, and drought mitigation strategies in the Srikalahasti Revenue Division.

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