

Spatiotemporal Analysis of Rainfall Anomalies in Semi-Arid Regions: A Comparative Study of Tonk District Vs. Rajasthan Regional (Post Monsoon 2025)

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Abstract - This paper analyzes the weekly rainfall departures in the Tonk district of Rajasthan for the South-West Monsoon season of 2025 (June–September). Using weekly departure data, the study highlights extreme precipitation volatility in Tonk compared to the climatological norms of the wider Rajasthan state. The data reveals significant "Large Excess" events, specifically during late June (+627%) and late August (+466%), suggesting localized hyper-precipitation events. The study discusses the implications of such variability on the catchment areas of the Banas River basin versus the general state-wide rainfall trends.

Keywords: Rainfall Variability, Tonk District, Rajasthan Monsoon, Precipitation Anomalies, Climate Change.

1. INTRODUCTION

Rajasthan, characterized by its arid to semi-arid climate, relies heavily on the South-West Monsoon for its annual water budget. The variability of rainfall in this region is historically high, with a Coefficient of Variation (CV) often exceeding 50%. Tonk district, located in the eastern part of the state and housing the critical Bisalpur Dam, serves as a vital hydrological hub. While the state average rainfall often fluctuates between deficit and moderate excess, localized districts often experience distinct micro-climatic events. This paper examines the specific weekly departures of Tonk district for the 2025 monsoon season to understand the intensity of local anomalies compared to the broader regional average behaviour.

2. DATA AND METHODOLOGY

2.1 Data Source

Tonk district is situated in the heart of Rajasthan, between 25°43' to 26°34' North latitude and 75°00' to 76°16' East longitude. The district experiences a hot semi-arid climate (Köppen-Geiger classification: BSh), characterized by hot summers, mild winters, and highly concentrated rainfall during the monsoon season (June to September) table-2. The average annual rainfall in the district is relatively low, making it susceptible to droughts and water scarcity. The terrain is generally flat to gently undulating, with some scattered hillocks.

2.2 Data Source

The primary dataset consists of weekly rainfall departure percentages for Tonk District for the period **01-06-2025 to 03-09-2025**.

Metric: Percentage Departure from Long Period Average (LPA).

Table 1: Classification (IMD Standards):

S.N.	IMD Classification	Departure (%)
1	Deficit	-59% to -20%
2	Normal	-19% to +19%
3	Excess	+20% to +59%
4	Large Excess	+60% or more

3. RESULTS: ANALYSIS OF TONK DISTRICT RAINFALL (2025)

The weekly departure data for Tonk exhibits extreme volatility (figure-1). The season can be categorized into three distinct phases:

Phase 1: The Onset (June)

- **Week 1 (11.06):** The season began with a deficit of **-40%**, indicating a delayed or weak onset compared to the Rajasthan state average, which typically sees pre-monsoon showers in early June.
- **Week 3 (25.06):** A drastic shift occurred with a massive **+627%** departure. This suggests a flash-flood event or a depression stalling over the district, significantly outpacing the state-wide average which usually stabilizes around normal (+/- 19%) during this onset phase.

Phase 2: Mid-Season Intensity (July - Early August)

- July saw no negative departures. The lowest excess was **+55%** (02.07), while other weeks ranged from **+130% to +200%**.
- This consistent "Large Excess" differs from the typical Rajasthan monsoon pattern, which often experiences a "break monsoon" period (a dry spell) in mid-July or August. Tonk showed no such break in 2025.

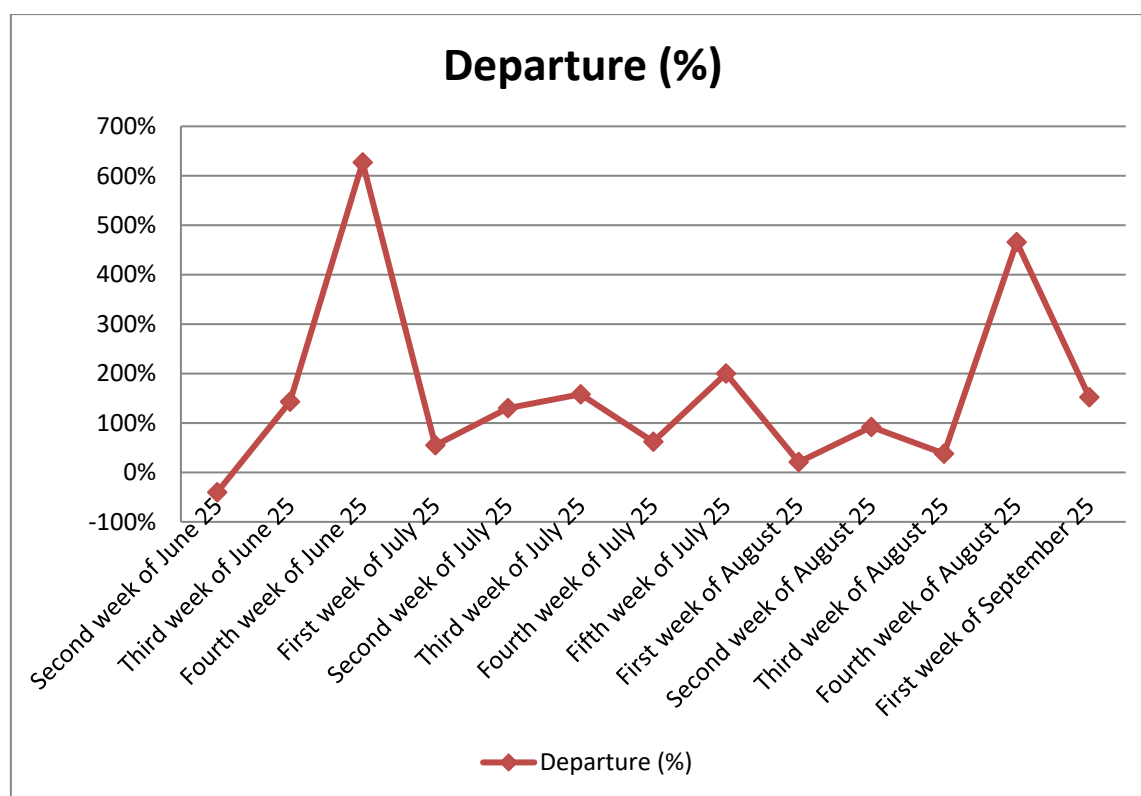
Phase 3: Late Surge (Late August - September)

- After a relative dip on 06.08 (+21%), the rainfall intensified again, peaking at **+466%** on 27.08.2025.
- The season concluded with a **+152%** departure in early September, contrasting with the withdrawal phase usually observed in Western Rajasthan during this time.

Table 2: Weekly Rainfall Departures - Tonk (Sept.2025)

Date (Week Ending)	Departure (%)	IMD Classification
Second week of June 25	-40%	Deficit
Third week of June 25	143%	Large Excess
Fourth week of June 25	627%	Large Excess (Extreme)
First week of July 25	55%	Excess
Second week of July 25	130%	Large Excess
Third week of July 25	158%	Large Excess
Fourth week of July 25	62%	Large Excess
Fifth week of July 25	200%	Large Excess
First week of August 25	21%	Excess
Second week of August 25	92%	Large Excess
Third week of August 25	38%	Excess
Fourth week of August 25	466%	Large Excess (Extreme)
First week of September 25	152%	Large Excess

Figure 2- Weekly Rainfall Departures - Tonk (Sept.2025)



4. COMPARATIVE DISCUSSION: TONK VS. RAJASTHAN AVERAGE

4.1 Magnitude of Departure

Climatological data for Rajasthan indicates that while the state is prone to variability, state-wide average departures rarely exceed +60% for prolonged periods due to the geographical spread (the arid West cancels out the wetter East).

- **Tonk (2025):** Maintained a "Large Excess" (>60%) for 10 out of 13 weeks.
- **Rajasthan (Typical Climatology):** Usually fluctuates between -20% and +20% (Normal) with occasional spikes.
- **Inference:** Tonk acted as a localized center of extreme precipitation in 2025, likely due to synoptic systems (low-pressure areas) tracking specifically over the Eastern Rajasthan or Banas basin.

4.2 The "Break Monsoon" Phenomenon

Typically, Rajasthan experiences a "break" in August where rainfall ceases for 1-2 weeks.

Comparison: The data shows Tonk experienced a dip on Aug 6th and Aug 20th (+21% and +38%), but never fell into the negative/normal range. This indicates that while the broader state might have experienced a lull, Tonk continued to receive excess moisture.

4.3 Impact on Water Resources

The extreme departures (+627% and +466%) in Tonk are significant for the Bisalpur Dam. While the Rajasthan average rainfall contributes to general groundwater recharge, the hyper-localized intensity in Tonk suggests rapid runoff and potential risk of flash floods rather than steady percolation.

5. CONCLUSION

The analysis of the 2025 rainfall data for Tonk district reveals a season defined by extreme positive anomalies. With departures peaking at 627%, Tonk significantly outperformed the typical hydrological characteristics of the broader Rajasthan region. The data suggests a shift toward high-intensity short-duration rainfall events, consistent with climate change projections for the Indian subcontinent.

6. REFERENCES

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