Assessment of Droughts and their Linkage to Environmental Flow Conditions over a Large Indian River Basin

Presented by:

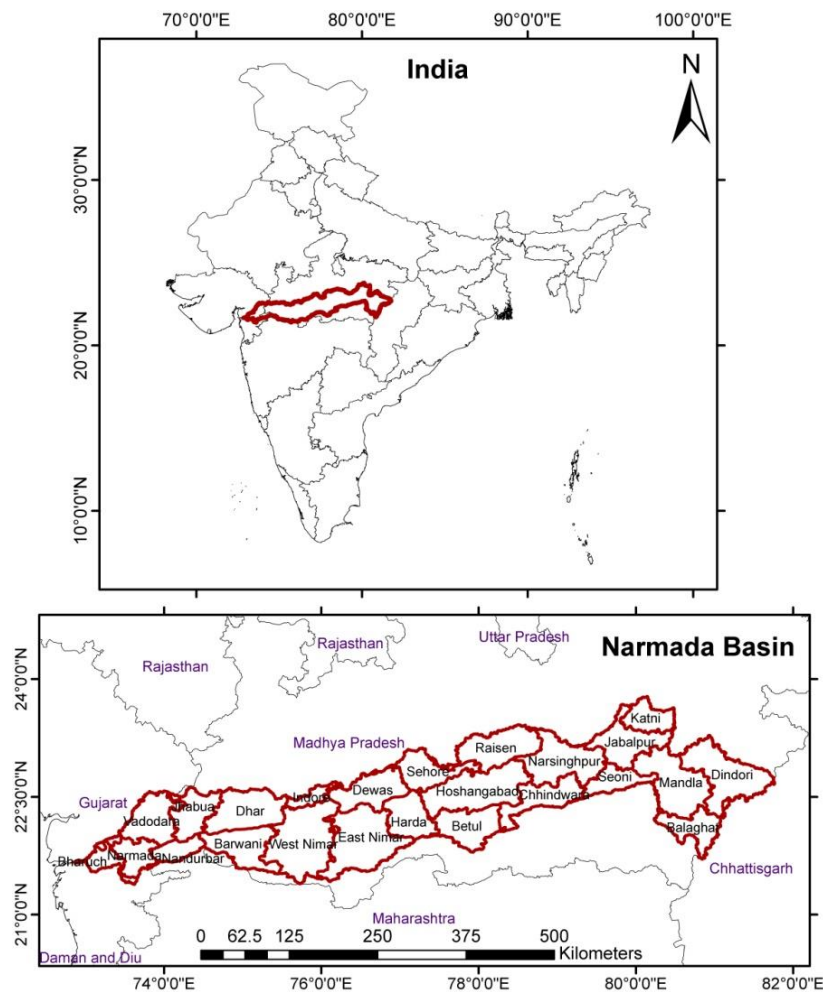**Sabyasachi Swain*, S. K. Mishra, Ashish Pandey**

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Study Area

Fig. 1. Location of the Narmada Basin

- **Basin:** Narmada River Basin

- Life Line of Gujarat and Madhya Pradesh

- **Length of River:** 1300 Km

- **Location:** 21.33^0 to 23.75^0 North latitudes and 72.53^0 to 81.75^0 East longitudes

- **Area:** 99000 square kilometers

- **Average Annual Rainfall:** 1100 to 1300 mm

- **No. of Stations:** 24

Standardized Precipitation Index (SPI)

- A mixed distribution function (zeros and continuous precipitation amount) is employed, and the CDF is given by,

$$F(x) = q + (1-q)\, G(x)$$

- The SPI is given by inversely transformed probability of Standardized F(x)

$$SPI = \varphi^{-} [F(x)]$$

- A positive (negative) value of SPI denotes precipitation is above (below) to its average.
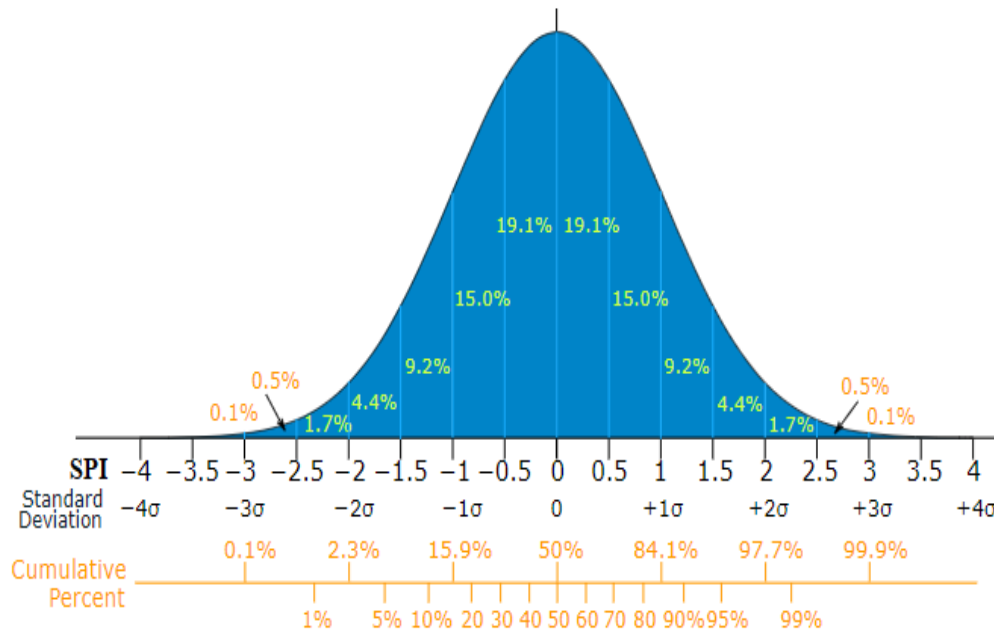
Standardized Precipitation Index (SPI)

Fig. 2. Normal Distribution (for SPI computation)

Table 1. Categorization of SPI values into different classes

SPI Values	Class
≥ 2	Extremely Wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
−0.99 to 0.99	Normal
-1.0 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
≤ -2	Extremely dry

SPI - % AAF Relationship
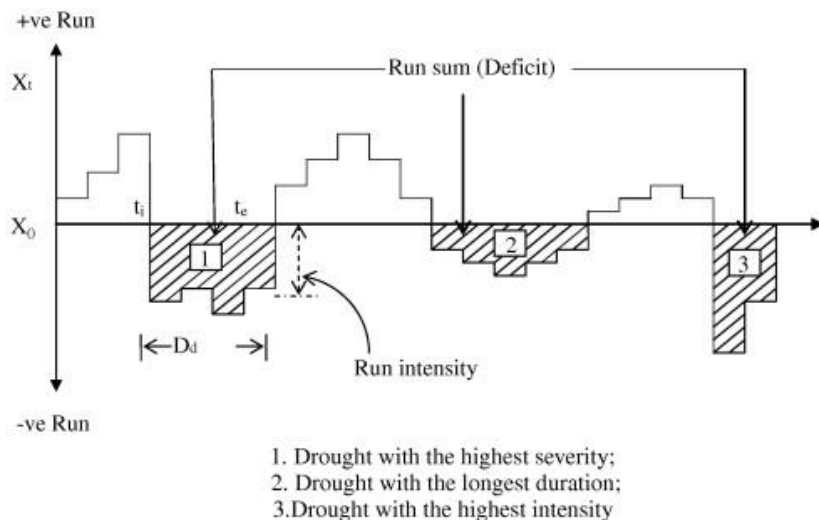
Fig. 3. The drought characteristics for a given threshold level X_0 on the basis of Run Theory

1. Drought with the highest severity;
2. Drought with the longest duration;
3. Drought with the highest intensity

Drought Characteristics:
- Drought Onset
- Drought Termination
- Drought Duration
- Drought Severity
- Drought Intensity

**Table 2.** Proposed Coupling of Tennant and SPI Concepts for Low-Flow Season

| Tennant		SPI	
Flow Condition	**Criteria**	**Criteria**	**Drought Condition**
Flushing Flow	200% AAF	2.0 or more	Extremely Wet
Optimum range-of-flow	60-100% AAF	1.5 to 1.99	Severely Wet
Outstanding	40% AAF	1.0 to 1.49	Moderately Wet
Excellent	30% AAF	-0.99 to 0.99	Near Normal
Good	20% AAF	-1.0 to -1.49	Moderately Dry
Fair or degrading	10% AAF	-1.5 to -1.99	Severely Dry
Poor or minimum	< 10% AAF	-2.0 or less	Extremely Dry

Study Area (SPI - %AAF Relationship)
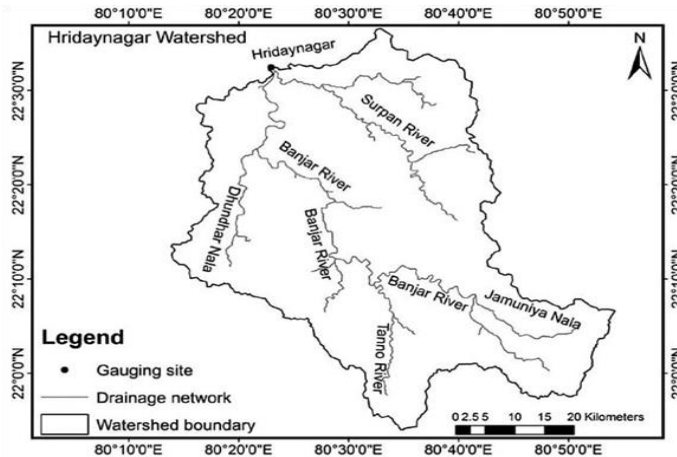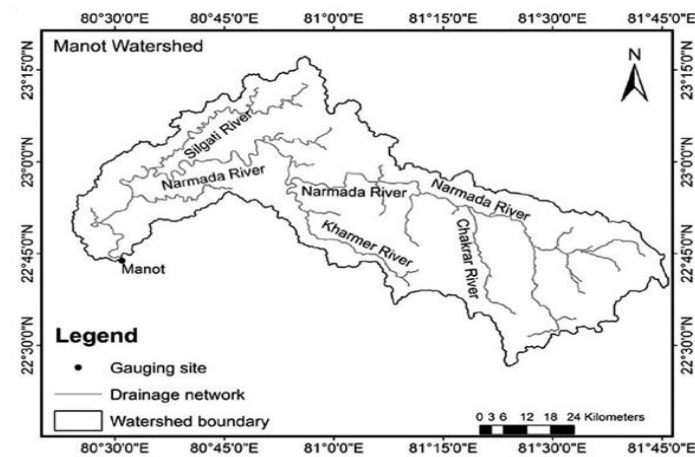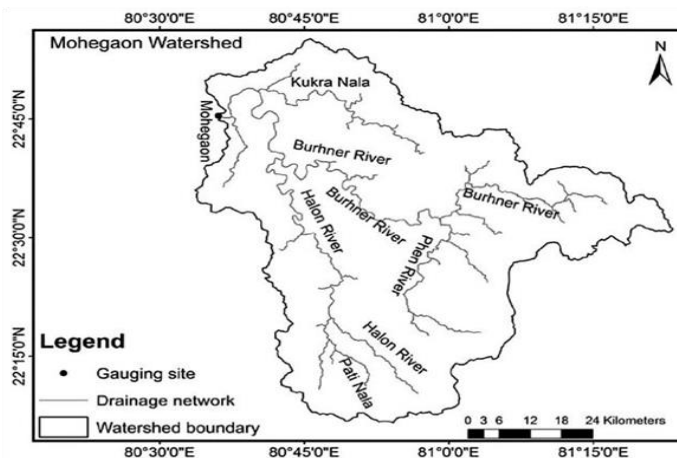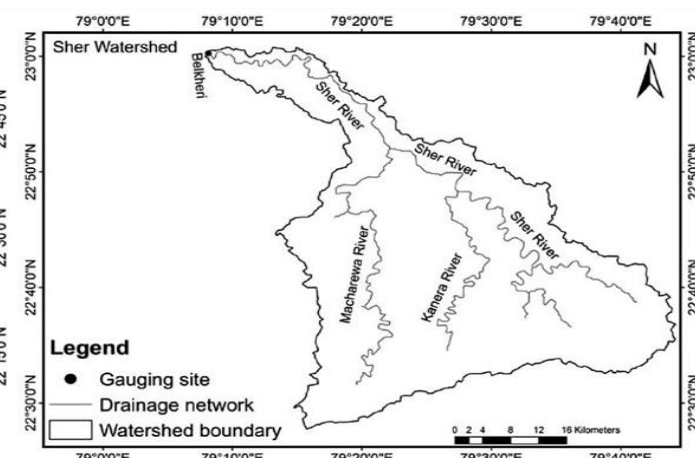
Fig. 4. Sub-catchments of Narmada Basin, India
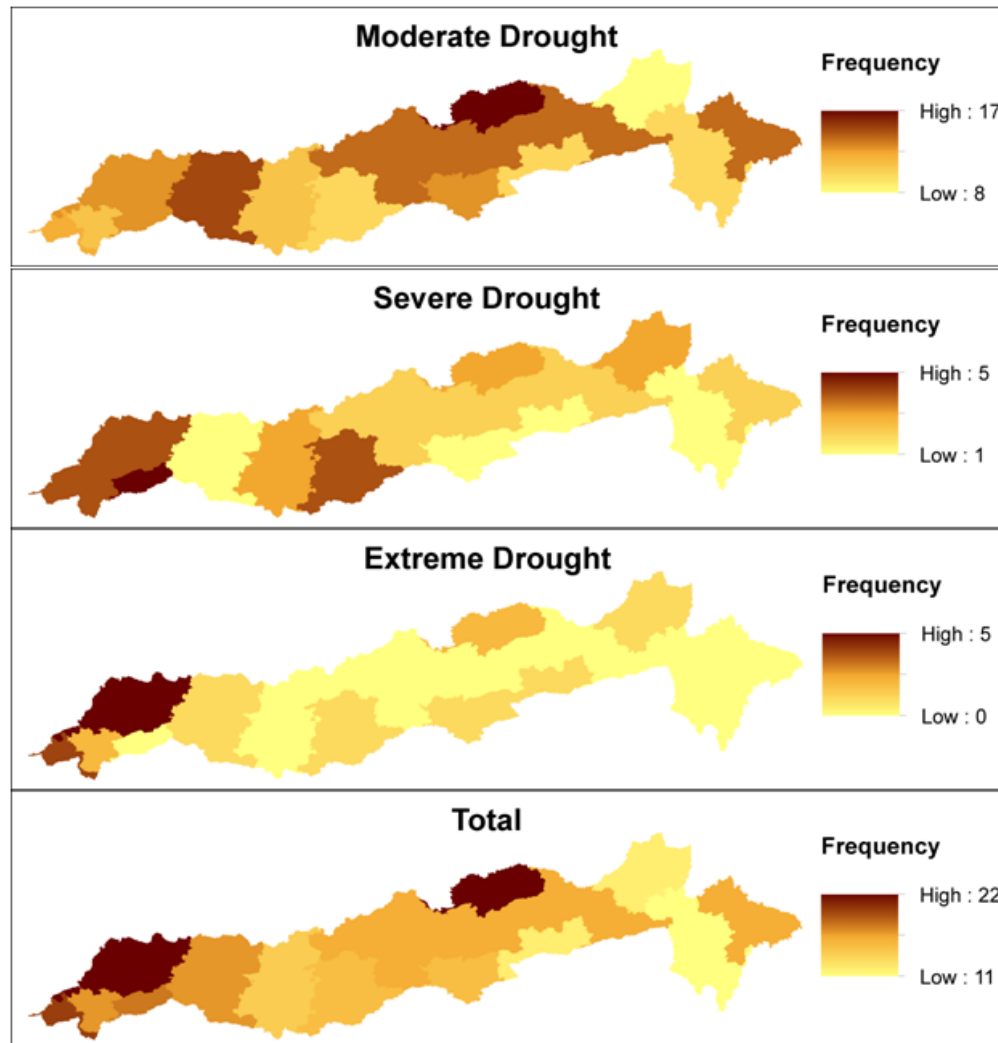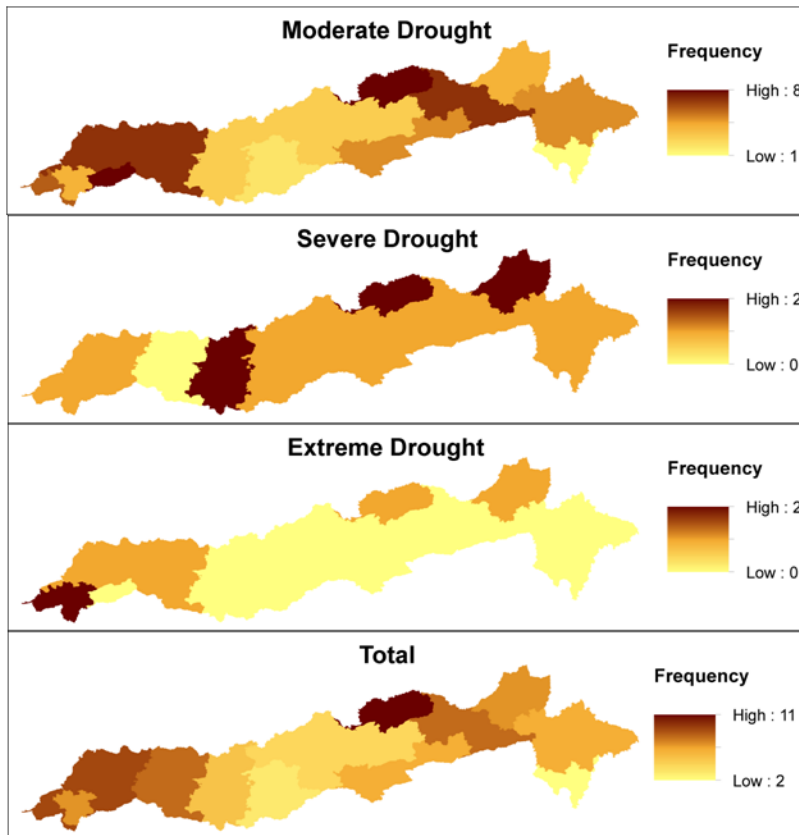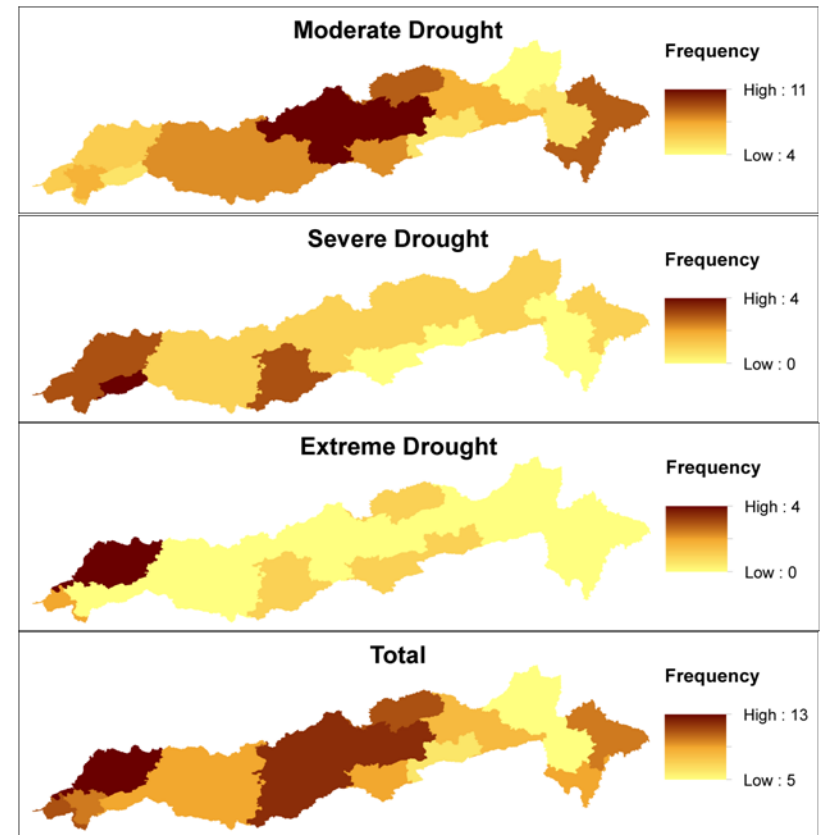
Results

Fig. 5. Frequency of droughts in different severity classes during 1952-2013

Results

(a) 1952-1982   (b) 1983-2013

Fig. 6. Frequency of droughts in different severity classes during the two epochs i.e.,1952-1982 and 1983-2013
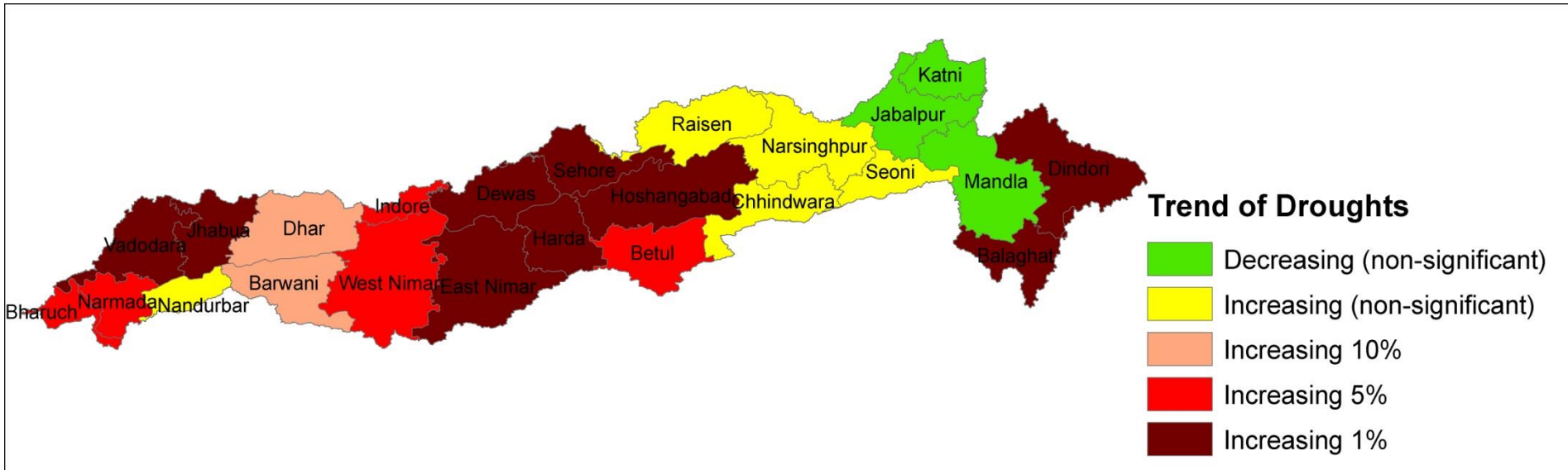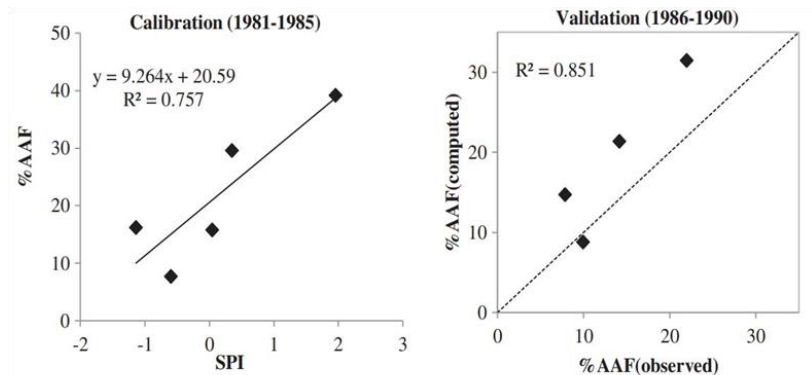
Results

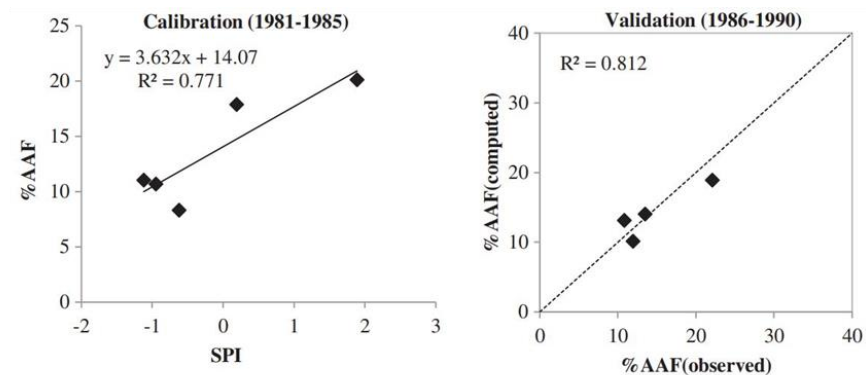**Fig. 7.** Trend of droughts over the districts of the Narmada Basin using Mann-Kendall Test

- 21 out of 24 districts possesses an increasing trend.

- 16 districts exhibits significantly increasing trend.
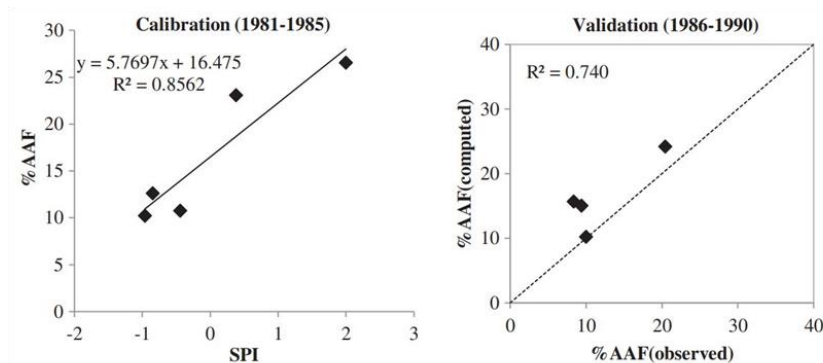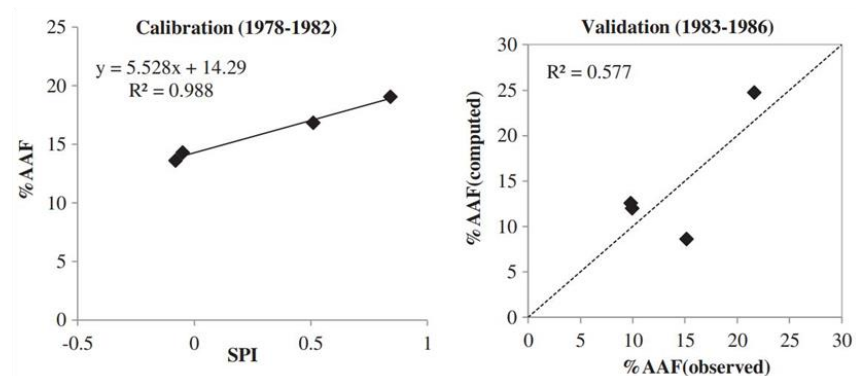 (9 districts at 1%, 5 districts at 5% and 2 districts at 10% significance level)

Results

(a) Hrudaynagar

(b) Manot

(c) Mohegaon

(d) Sher

Fig. 8. Calibration and validation of %AAF-SPI relation for four sub-catchments of Narmada Basin

Summary

- SPI at large time scales is able to capture the persistence of droughts better than that in shorter time scales.

- The frequency of droughts over different districts in Narmada Basin varies between once in 3 to 5 years.

- A comparative assessment of two epochs i.e., 1952-1982 and 1983-2013 reveals the droughts to possess higher frequency, severity, persistence and areal extent in the latter epoch.

- The Mann-Kendall test reveals a significant increasing trend of droughts at annual scale for most of the districts.

- The %AAF and SPI exhibits a good linear relationship for low-slow season over all the four sub-catchments of Narmada Basin during calibration and validation period.

- The reliability of SPI- %AAF relationship needs to be checked with more data. The limited data availability was a limitation of this study.

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Thank You ☺