ASSESSMENT OF METEOROLOGICAL DROUGHT CHARACTERISTICS DURING 1980-2020 OVER THE MARATHWADA REGION, INDIA

Surendra Kumar Mishra*, Sabyasachi Swain, Ashish Pandey
Department of Water Resources Development and Management, Indian Institute of Technology Roorkee, India
*s.mishra@wr.iitr.ac.in

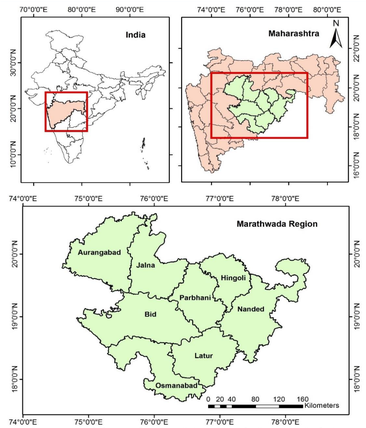
ABSTRACT

This study presents a thorough spatiotemporal assessment of drought trends and variabilities over the agriculture-dominated Marathwada Region, Maharashtra, India. Standardized Precipitation Index (SPI) is used to characterize drought occurrences at multiple time frames, whereas Modified Mann-Kendall (MMK) test is employed to detect trends. The results reveal the region to be prone to droughts and SPI at longer time frame (i.e., 12-monthly moving frame) can capture drought occurrences better than the shorter time frames, which can be attributed to the lesser randomness in the time series at longer frame. A mix of positive/negative trends of SPI series are found for the monsoonal months; however, they are relatively more concentrated towards negative Z_{MMK}. Hence, the Marathwada Region can be inferred to have exhibited a relatively increased tendency towards drought occurrences. The seasonal differences in mean values and trends of rainfall, evapotranspiration (ET) and Evaporative Stress Index (ESI) are also observed.

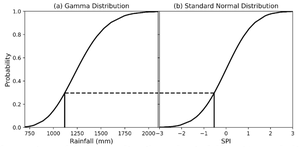
DATA

Data type	Details
Precipitation (1980-2020)	Source: India Meteorological Department (IMD) gridded product Link: https://www.imdpune.gov.in/Clim_Pred_LRF_New/Grided_Data_Download.html Resolution: 0.25° × 0.25°, daily
Evapotranspiration (ET), Evaporative Stress Index (ESI) (1980-2020)	Source: Global Land Evaporation Amsterdam Model (GLEAM) Version: GLEAM v3.5a Link: https://www.gleam.eu/ Resolution: 0.25° × 0.25°, daily

STUDY AREA & METHODS



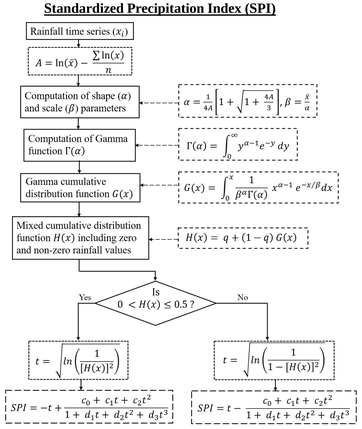
Location of the study area (Marathwada Region, India)



Transformation of Gamma-distributed rainfall to Normal-distributed SPI

Class	Criteria
Non-drought (Wet)	SPI ≥ 0
Mild drought	0 < SPI < -1
Moderate drought	-1 ≤ SPI < -1.5
Severe drought	-1.5 ≤ SPI < -2
Extreme drought	SPI ≤ -2

Standardized Precipitation Index (SPI)



c_0 =2.515517; c_1 =0.802853; c_2 =0.010328; d_1 =1.432788; d_2 =0.189269; d_3 = 0.001308

SPI computation procedure

Mann-Kendall Test

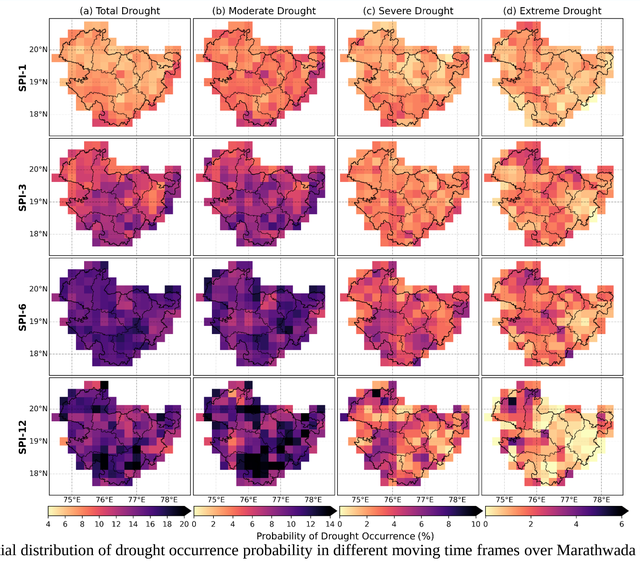
$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \operatorname{sgn}(x_j - x_i) \quad (1)$$

$$VAR(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{m} t_i(t_i-1)(2t_i+5)}{18} \quad (2)$$

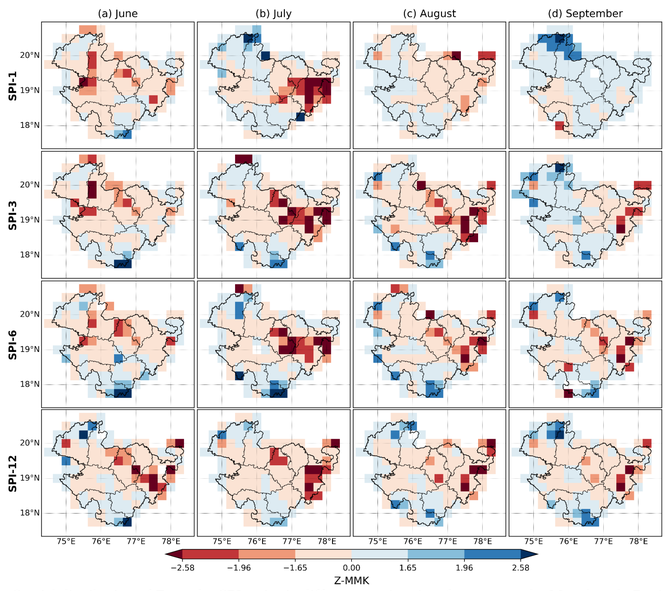
$$Z_{mk} = \begin{cases} \frac{S-1}{\sqrt{VAR(S)}} & \text{if } S > 0 \\ 0 \text{ if } S = 0 \\ \frac{S+1}{\sqrt{VAR(S)}} & \text{if } S < 0 \end{cases} \quad (3)$$

Z is assumed to follow the standard normal distribution. However, since SPI is the reduced variate of rainfall, a positive (negative) value of Z represents decreasing (increasing) trend of meteorological droughts.

RESULTS

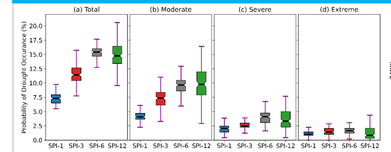


Spatial distribution of drought occurrence probability in different moving time frames over Marathwada Region

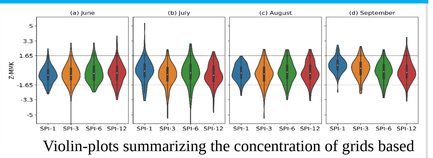


Spatial distribution of Z_{MMK} for SPI series in different moving time frames over the Marathwada Region

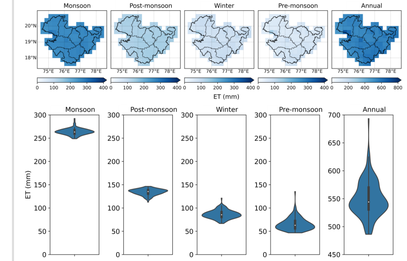
RESULTS (CONT.)



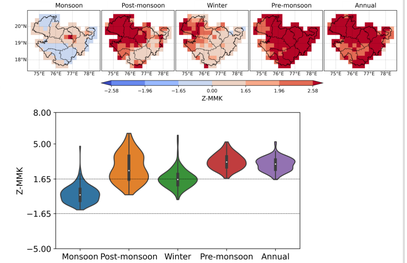
Boxplots summarizing the drought occurrence probability in the severity categories and in total



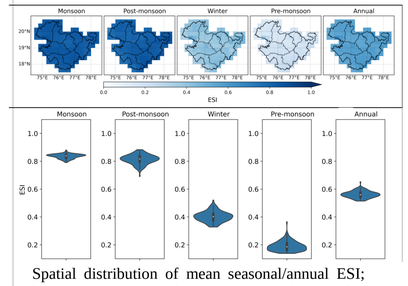
Violin-plots summarizing the concentration of grids based on Z_{MMK} for SPI in different moving time frames



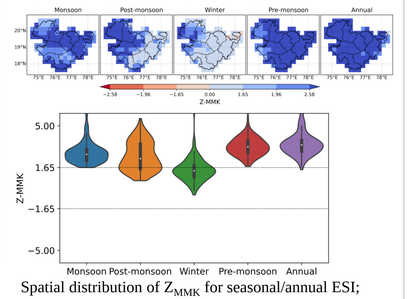
Spatial distribution of mean seasonal/annual ET; Violin plots summarizing the concentration of grids based on mean seasonal/annual ET



Spatial distribution of Z_{MMK} for seasonal/annual ET; Concentration of grids based on Z_{MMK} for seasonal/annual ET



Spatial distribution of mean seasonal/annual ESI; Violin plots summarizing the concentration of grids based on mean seasonal/annual ESI



Spatial distribution of Z_{MMK} for seasonal/annual ESI; Conc. of grids based on Z_{MMK} for seasonal/annual ESI

CONCLUSIONS

- The region is found to be prone to droughts. SPI at longer time frame (i.e., 12-monthly moving frame) is found to capture drought occurrences better than the shorter time frames, which can be attributed to the lesser randomness in the time series at longer frame.
- The trend analysis of SPI series for the monsoonal months revealed a mix of positive and negative trends over different grids; however, they are relatively more concentrated towards negative Z_{MMK}, indicating a relatively increased tendency towards drought occurrences or increased drought severities.
- The seasonal differences in mean values and trends of rainfall, ET and ESI are also observed.
- The information reported in this study will help devising water management strategies to minimize the repercussions of droughts over the agriculture-dominated Marathwada Region.

ACKNOWLEDGEMENT

The authors express their sincere gratitude to IIT Roorkee for providing the financial support to present our research at the EGU General Assembly 2023.

Assessment of meteorological drought characteristics during 1980-2020 over the Marathwada Region, India

Surendra Kumar Mishra[1*], Sabyasachi Swain[1,2], Ashish Pandey[1]

[1]Department of Water Resources Development and Management, Indian Institute of Technology Roorkee, Roorkee, Uttarakhand- 247667, India

[2]Deltaic Regional Centre, National Institute of Hydrology, Kakinada, Andhra Pradesh- 533003, India

*Corresponding Author Email: s.mishra@wr.iitr.ac.in

Abstract: Drought is a meteorological phenomenon that occurs when there is a prolonged period of below-average precipitation, leading to a shortage of water. It can have serious consequences, particularly for agriculture, as plants and crops depend on water for their growth and survival. In this study, we conducted a spatiotemporal assessment of drought trends and variabilities in the Marathwada Region of Maharashtra, India, which is dominated by agriculture. We used precipitation data from the India Meteorological Department for 1980-2020 and characterized drought occurrences using the Standardized Precipitation Index (SPI) at different time frames (1-, 3-, 6-, and 12-months moving windows). Further, we used non-parametric tests, such as the modified Mann–Kendall (MMK) and Sen's slope (SS) tests, to detect trends in precipitation as well as in Evaporative Stress Index (ESI) and actual evapotranspiration (ET). The results of the study indicate that the Marathwada region is prone to droughts, and the SPI at a 12-monthly moving frame is more effective at capturing drought occurrences than shorter time frames due to the lesser randomness in the time series. We also found a mix of positive and negative trends in the SPI series for the monsoonal months, with more concentration towards negative trends, thereby indicating an increased tendency or severity of drought events. A detailed discussion is also provided on the seasonal variations of precipitation, ESI and ET. The information from this study can be used to develop water management strategies to mitigate the effects of drought in the region.

The link to EGU Abstract: https://meetingorganizer.copernicus.org/EGU23/EGU23-1669.html

The extended version of this work is published recently in the ***Environmental Monitoring and Assessment*** journal (Link: https://link.springer.com/article/10.1007/s10661-022-10532-8). The bibliographic detail of the publication is given below. The readers are encouraged to go through the article for further details. We hereby also provide the SharedIt link so that anyone with the link will be able to read this content (Thanks to *Springer Nature SharedIt content-sharing initiative*). The link is also provided in the 'Supplementary material link' of my EGU 2023 presentation.

Swain, S., Mishra, S. K., Pandey, A., & Dayal, D. (2022). Assessment of drought trends and variabilities over the agriculture-dominated Marathwada Region, India. *Environmental Monitoring and Assessment*, *194*(12), 883. https://doi.org/10.1007/s10661-022-10532-8

SharedIt link (free to read): **https://rdcu.be/dasVs**