

# **Drought variability and characteristics in the Muda River Basin of Malaysia from 1985 to 2019**

## **ABSTRACT**

This study aimed to analyze the spatiotemporal changes of historical droughts over the Muda River basin (MRB), Malaysia, from 1985 to 2019 using the Standardized Precipitation Index (SPI) and the Standardized Streamflow Index (SSI). The Mann–Kendall test and Sens' slope were used to evaluate the trends and magnitude changes in the droughts, respectively, while Spearman's rho was applied to understand the relationships of the droughts with large-scale atmospheric circulations, such as the El Niño Southern Oscillation (ENSO), the Indian Ocean Dipole (IOD), and the Madden–Julian Oscillation (MJO). The results show that the intense droughts in the MRB mostly occurred in 1991–1992, 1995, 1998, 2002–2003, 2005–2006, 2008, 2012–2013, and 2016. In addition, a declining SPI trend was found from May to December at most of the stations. About 80% of the stations experienced about 10 severely dry droughts, while almost all stations experienced at least 5 extremely dry events. Moreover, a higher response rate of the SSI than the SPI was found during low-rainfall months from January to May. Lastly, ENSO had a larger impact on the drought formations over the MRB compared to the IOD and MJO, especially during the dry period.

**Keyword:** Drought; Standardized Precipitation Index (SPI); Muda River; Malaysia; Tropical rainfall; ENSO; Extreme weather; Climate