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Sustainable Drought Risk Management Via Multi-Scale Drought Modeling with Multi-Output Artificial Intelligence

Mir Jafar Sadegh Safari[1,2]

[1]*Department of Geography and Environmental Studies, Toronto Metropolitan University, Toronto, Ontario, Canada*

[2]*Department of Civil Engineering, Yaşar University, Izmir, Turkey*

Abstract

In data-scarce regions, effective drought risk management is challenged by limited meteorological observations. This study addresses this gap by exploring a spatial drought modeling framework using Multi-Output Support Vector Regression (MOSVR) to predict the Standardized Precipitation Evapotranspiration Index (SPEI) across multiple target locations based on neighboring station data. The research investigates how spatial correlations among stations can be incorporated to model drought conditions at multiple sites simultaneously, rather than building separate models for each location. The methodology focuses on evaluating MOSVR's ability to predict SPEI at 3-, 6-, and 12-month timescales. Findings reveal that the MOSVR model effectively captures key drought characteristics such as intensity, duration, and frequency, under moderate, severe, and extreme conditions. Additionally, the model successfully tracks the seasonal evolution of drought including onset and recovery phases. These results highlight the model's capacity to learn complex nonlinear interactions among stations and highlight the potential of multi-output AI models for advancing drought risk prediction. This work offers valuable insights for sustainable water resource planning and climate adaptation strategies in vulnerable and data-limited settings.

Keywords: Artificial intelligence; Climate adaptation; Data-scarce regions; Drought prediction; Multi-Output Support Vector Regression, Spatial modeling