Assessing drought trends and predicting future patterns using SARIMA and ANN models across meteorological stations in the north dry zone (Bidar district) of India

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Drought poses a significant environmental challenge, especially in semi-arid regions, where comprehending its temporal dynamics and developing predictive models are crucial for effective water resource management. The present study investigates drought trends and forecasts standardised precipitation index (SPI) values at multiple timescales across five stations in the north dry zone of India (Bidar district: Aurad, Bhalki, Humnabad, Bidar and Basavakalyan). The Mann-Kendall test was employed for trend analysis, while auto-regressive integrated moving average (ARIMA) and artificial neural network (ANN) models were used for SPI prediction. The results revealed no statistically significant trends across all stations and timescales, though marginally significant positive trends were observed at longer timescales in Basavakalyan and Bhalki, suggesting a potential improvement in drought conditions. The seasonal auto-regressive integrated moving average (SARIMA) model effectively captured seasonality and autocorrelation, with varying autoregressive and seasonal moving average components across stations. The ANN model, structured with a '25-13-1' architecture, demonstrated superior performance during model training by capturing non-linearities, outperforming SARIMA across all statistical metrics. However, during model testing, SARIMA exhibited superior predictive accuracy with lower root mean squared error and higher Nash-Sutcliffe efficiency values compared to ANN, indicating its robustness in real-time drought forecasting. These findings underscore the importance of integrating statistical and machine learning approaches for drought prediction. While the ANN model effectively captures complex patterns, the SARIMA model remains more reliable for modelling temporal drought dynamics. The results provide valuable insights into drought dynamics, supporting informed water resource management and proactive drought mitigation strategies in the Bidar district.

Keywords: ANN, ARIMA, drought, Mann-Kendall, SARIMA, SPI.

DROUGHT is a multifaceted natural disaster, with its onset and length varying significantly across different areas, influenced by a range of climatic and meteorological conditions[1]. Beyond the primary lack of rainfall, drought conditions are typically worsened by elevated temperatures, powerful winds and diminished soil moisture. These factors have far-reaching consequences, disrupting natural ecosystems, reducing agricultural productivity, depleting water resources and threatening livelihoods[2]. Globally, an estimated 55 million people are affected by drought each year, posing critical challenges to food security, livestock health and human well-being[3]. Reduced income, elevated risks of disease, death and mass migration are some of the socio-economic effects of drought[4]. In order to address these issues and guarantee the resilience of communities that are at risk, it is necessary to have a thorough understanding of the causes, effects and patterns of drought.

'Every year, drought affects millions of people in India, particularly in semi-arid regions'. Because of unpredictable rainfall patterns, warming temperatures and groundwater depletion, states like Rajasthan, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu regularly endure protracted dry periods. Despite being an agrarian economy heavily reliant on the monsoon, many parts of India face severe droughts even during average or above-average rainfall years due to uneven distribution of rainfall and poor water management practices. The socio-economic implications of drought in India are profound, affecting food security, agricultural yields and rural livelihoods while increasing the pressure on already scarce water resources.

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