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Sub-seasonal Prediction of Agricultural Drought in India Using Long-Short-Term Memory Networks

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Agricultural drought (AGD), defined by a deficit in soil moisture, is a complex natural hazard phenomenon that causes extreme damage to water supply, food production, and socio-economic loss at different time scales. India is a developing country, and 60% of its population depends on agriculture. India has experienced frequent extreme drought conditions in the last few decades, for example, the 2015-16 North Indian and 2017-18 Southern Indian drought, where more than 330 million people were affected due to food unavailability and shortage in groundwater resources. The spatial patterns of AGD vary significantly in India due to uncertainty in regional climatic conditions caused by the immense increase in global warming. The prediction of agricultural drought at a sub-seasonal scale would help the farming community to plan appropriate crops for the season and conserve water for irrigation.

This study proposes a statistical framework to predict the agricultural drought with 1-, 2-, and 3-month lead times over the Indian subcontinent. Soil moisture percentiles (SMP) are utilised as a drought index where values less than 20th percentiles represent drought conditions. SMP is a widely used drought index in research because it directly represents the water content in the soil and responds relatively quickly to changes in soil water content due to variations in rainfall and irrigation. The variation of SMP depends on various hydroclimatic parameters at local and non-local scales. Thus, this study has considered the air temperature (max. and min.), Potential Evapotranspiration, Vapour Pressure Deficit, Rainfall, soil moisture percentile, Normalised Difference Vegetation Index, El-Nino southern oscillation, North Atlantic Oscillation, Indian Ocean Dipole, Pacific Decadal Oscillation, and Madden Julian Oscillation as a predictor (or feature) from the various satellite (NOAA-19, 20, and AVHRR) and observational (IMD – Indian Meteorological Department) data sources. The Long-Short-Term Memory (LSTM) model, with an MSE custom loss function, is used to forecast agricultural drought. The model was trained from June 1981 to May 2015 and tested at each grid point cell between June 2015 and May 2022. The model performance is examined using Pearson's correlation > 0.6 for a 1-month lead and further decreased for a 2 and 3-month lead. The forecasting matrices such as percentage porrect, POD, FAR, and ETS indicated that the predictability of AGD is comparably high over northern, southern, and north-eastern India. At last, the trained models are used to discover variables that, depending on feature relevance, influence agricultural drought predictability on a sub-seasonal scale. The result shows that vapour pressure deficit followed by maximum temperature, Pacific decadal oscillation, and

soil moisture percentile are the primary features that control drought predictability.