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Agricultural Drought Propagation over India: A Complex Network Theory Approach

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Agricultural drought has emerged as a significant threat to global food security and sustainable development. Despite the progress made in the identification and analysis of various characteristics for the assessment and early warning of agricultural drought, our knowledge of the mechanisms governing agricultural drought propagation remains limited. This study aims to address this gap by employing complex network theory. Specifically, the study uses complex network measures to investigate the spatial propagation of agricultural drought propagation across India during 1950–2014. Spatial drought networks are constructed using event synchronization (ES) for mild drought conditions derived from the Standardized Soil Moisture Index (SSMI) at a 3-month aggregated scale (SSMI-3). The investigation delves into the mechanisms of spatial propagation of drought, including propagation source and sink, distance and orientation using directed networks. Several metrics, including network divergence, in-degree, and out-degree, inward and outward distance, inward and outward orientation are used. These metrics play a crucial role in identifying specific locations, namely source and sink regions, propagation distance and orientation, where drought onsets extend to other areas within the regional spatial networks. The results indicate that the northwest India acts as the source region and the west central India and peninsular India act as sinks. The central and east India are identified as vulnerable regions playing crucial roles in spatial drought propagation. The results also reveal that the dominant directions of propagation lead towards the northwestern parts of India. For inward distances, shorter propagation distances of less than 50 km are observed in the peninsular, central, and some parts of the northeastern regions, while longer propagation distances are observed in the western parts of India, exceeding 150 km. For outward distances, shorter propagation distances below 20 km are observed in hilly regions, while longer propagation distances are observed in the peninsular regions of India, exceeding 80 km. These results suggest that most regions propagate droughts inward and outward, covering distances of even hundreds of kilometres. Understanding the dominant inward and outward orientation of drought propagation could play a crucial role in developing early warning systems for droughts.