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Human Adaptation to Drought: An Agent-Based Agricultural Water Demand modeling

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As extreme events, such as drought, have become increasingly widespread, human behaviors have evolved, impacting both water supply and water demand. Most importantly, farmers have adapted to drought using several strategies, including water-saving technology and changing crop patterns, reducing agricultural water demand. These evolving behaviors have significantly reduced the system determinism, thus creating uncertainty on long-term water planning and should be included in the future water demand prediction. Although urban water demand modeling has been recently studied through socio-hydrological models, modeling agricultural water demand with a non-stationary structure remains elusive. In this study, we attempt to address this challenge by developing an agent-based agricultural water demand model. Using the concept of collective behavior, emergent farmers' water use behavior, we assess the effects of both water-saving technologies and changing crop patterns for the drought policies on estimates of agricultural water demands. We focus on the Bow River Basin (BRB) in Alberta, Canada, as a case study. The government of Alberta has recently managed to improve water conservation, productivity and efficiency in the agricultural sector, leading to a decrease in water demand. The crop patterns in the BRB have been switched from forage to other crops like cereals, oil seeds and specialty crops, which require 150 to 200 mm less water during growing seasons. In addition, the observations indicate the increase in using more efficient on-farm irrigation systems. We model agricultural water demand to capture the complexity of this socio-hydrological system about how individual farmers decide to adopt a new on-farm irrigation system and change crop patterns to reduce their water demand. The findings are broadly consistent with the observed diverted agricultural water, crop patterns and water-saving technology trend in the BRB. This model can lead to a better understanding of agricultural water demand, thereby enabling policy makers to enhance long-term water planning through applying other new water-saving technologies or crop pattern changes.