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Agricultural human-water systems: challenges, advances, and knowledge gaps

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Dynamic interactions between humans and water have produced unanticipated feedbacks, leading to unsustainability. Current water management practices are unable to capture the relevant spatial and temporal detail of the processes that drive the coupled human-water system. Whereas natural and socioeconomic processes occur slowly, local communities and individuals rapidly respond to ensure supply-demand balance. In this context, agricultural human-water systems stand out, as roughly 70% of global water demand is for agricultural uses. Additionally, interactions between humans and agricultural water systems involve many actors and occur at multiple spatial and temporal scales. For example, farmers are influenced by risk perceptions, and decisions made at the farm level influence regional hydrologic and socioeconomic systems, such as degradation and depletion of water sources as well as prices of crops. Regional behaviors, in turn, affect national and international dynamics associated with crop production and trade of associated investments. On the other hand, global and national priorities can also percolate down to the regional and local levels, influencing farmer decision-making through policies and programs

supporting production of certain crops and local investments. Over the last decade, relevant phenomena in the coupled agricultural human-water systems have been described, as the irrigation efficiency paradox, reservoir effect, and river basin closure. Along with the globalization in the food market, attempts have been taken to developing and applying benchmarks for water-efficient food production, focusing on water productivities, water footprints and yield gaps for agricultural products. Furthermore, significant advancements have been achieved by incorporating social dimensions of agricultural human-water systems behavior. Fusion of quantitative datasets via observations, remote sensing retrieval, and physically-based models has been explored. Advancements have also been made to capture qualitative or relatively intangible concepts of community values, norms, and behaviors, by interacting with stakeholders, identifying the most important elements of their environments, and incorporating these insights into socio-hydrological models. Based on what has been done during the IAHS Panta Rhei decade and what we have learned, and despite recent efforts towards a more comprehensive understanding of the effects of human interventions in agricultural systems, several challenges persist, of which we highlight: 1) Identification of the cross-scale causal effect on agricultural water uses; 2) Quantification of human behavior uncertainties shaped by social norms and cultural values; 3) Development of a high spatial and temporal resolution global dataset.