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Challenges and opportunities in modeling cross-scale, cross-sector feedbacks to inform critical decision-making in food-energy-water systems

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Feedbacks among water availability, irrigated agriculture, and electric power generation pose significant challenges for institutions and individuals who must make decisions subject to uncertain—and potentially cascading—risks from resource disruptions. For example, in California, snowpack fuels hydropower production and provides water for irrigation to the Central Valley, the most agriculturally productive area in the U.S., making this region highly vulnerable to hydrologic drought. During drought, irrigators pump groundwater to recoup lost surface water, increasing electricity demand; at the same time, reduced hydropower production is replaced by more expensive natural gas generation, increasing electricity prices precisely when farmers' pumping requirements are highest. It remains a fundamental challenge to understand how these drought feedbacks and their associated financial risks impact decisions at the farm scale, particularly regarding irreversible capital investment in new perennial crops (nut and fruit orchards) and irrigation infrastructure (groundwater wells)—two individual decisions that carry significant implications for regional water resources sustainability. Meeting this challenge requires first modeling the flow of physical resources (water and energy) across multiple sectors and capturing system behavior on temporal and spatial scales that matter for decision-makers. A second major hurdle is representing the agency of key human institutions (irrigation districts, water banks, and electric utilities), who can either transfer drought shocks to end users (farmers) via price changes, or absorb these shocks via a combination of physical and financial mitigation strategies (groundwater banking during wet years, financial insurance). The third challenge is how to incorporate deeply uncertain future states of the world that cannot be described probabilistically, like changes in climate, regulations (groundwater pumping limits), and technology (renewable energy penetration). This talk will review these challenges and opportunities drawn from an ongoing NSF INFEWS project, highlighting reasons for optimism in modeling complex food-energy-water systems.