INFEWS/T1: Advancing FEW system resilience in Corn Belt watersheds using integrated technology-environment-economics modeling of nutrient cycling

Food production, water supply, water quality, energy supply, and economic growth and financial stability in the Corn Belt depend on each other while competing for resources. In particular, recent increases in corn-based ethanol production in the region have increased interdependencies among food, energy and water (FEW) in the region and made the integrated FEW system more vulnerable to risks and threats. Among various concerns, phosphorus (a key component of fertilizers used in agriculture and a major pollution contributor to the "Dead Zones" in the Gulf of Mexico) plays a unique and under-recognized role within the FEW nexus. It is estimated that if recovered efficiently, the phosphorus (P) contained in ethanol coproducts, in-process stream, or wastewater in the US could recycle up to one-third of the fertilizer P needs of corn in the US while reducing water pollution. To help decision makers in Corn Belt watersheds address such interrelated challenges and opportunities, we will develop an Integrated Technology-Environment-Economics Modeling (ITEEM) tool to be used to understand how changes in one sector may cause changes in other sectors. To identify and implement the most effective combinations of practices in different areas, policy makers will need new knowledge about technological, environmental, and economic aspects which will be incorporated into the ITEEM. The ITEEM will be used to compare whether and how different approaches to addressing problems and opportunities in the integrated FEW systems, including: i) recovering nutrients from grain processing and wastewater treatment facilities, ii) strategic integration of perennial grasses (e.g., Miscanthus, switchgrass) into annual grain landscapes for biofuel feedstock production and nutrient and sediment loss reduction, and iii) adjusting farm management practices that influence nutrient and sediment loss to surface water. The ITEEM will also be used by stakeholder communities of the food, energy and water sectors to identify and exploit strategies for enhancing watershed system sustainability.

This project will conduct hypothesis-driven research activities for the development, dissemination and application of an integrated modeling tool (ITEEM) for Corn Belt watershed resilience analysis. Specific objectives include: 1) filling critical knowledge gaps in the interrelations between environment, technology and economics; 2) establishing the ITEEM tool for system resilience analysis; 3) testing ITEEM via multiple testbed studies that represent a range of FEW stressors across the Corn Belt; 4) fostering FEW nexus understanding in the Corn Belt via extension and education activities. The overall hypothesis is that the ITEEM approach will allow us to quantify the impacts of various nutrient management strategies and technologies, and to identify particular policies that are incentive compatible and enhance FEW system resilience in the Corn Belt. Both analytical (for generic integrated FEW systems) and numerical (for testbed watersheds in the Corn Belt) modeling analyses will be conducted to understand how watersheds respond to various types of threats subject to multi-source uncertainties, and address how FEW nexus relations influence watershed resilience. Potential early signals of critical transitions of watershed systems will also be evaluated from ITEEM simulations. Among the various strategies to enhance FEW system resilience, the role of such emerging technologies as phosphorus removal and recovery from process water and adopting perennial grasses for biomass production will be systematically assessed in terms of their

environmental impacts and economic costs/benefits, as well as the extent the technologies can mitigate tradeoffs and enhance positive synergies in order to build more resilient FEW systems. Finally, a shared-vision modeling approach (SVMA) will be undertaken to incorporate researchers, extension experts, outreach working groups, and stakeholder representatives throughout the entire project for problem specification, model development and testing, and solution exploration.