Appendix 7: Proposal Summary:

NRT-INFEWS: The DataFEWSion Traineeship Program for Innovations at the Nexus of Food Production, Renewable Energy and Water Quality

Overview:

The theme of this project is systems modeling and data analytics for innovations at the nexus of food production, renewable energy and water quality. Sustainable provision of food, energy and clean water requires understanding of the interdependencies among systems as well as the motivations and incentives of farmers and rural policy makers. Effective innovations at the nexus of these food, energy and water (FEW) systems requires data-rich system modeling with analytic capabilities for diverse types of data. The vision of this Traineeship program is to build a community of researchers that explores, develops and implements effective data-driven decision-making to efficiently produce food, transform primary energy sources into energy carriers, and enhance water quality.

Agriculture occupies the epicenter of the FEW nexus. It is an increasingly energy intensive enterprise, but is also a growing source of energy. Agriculture places large demands on water supplies while poor practices can degrade water quality. Each of these interactions creates opportunities for modeling driven by sensor-based and qualitative data collection to improve the effectiveness of system operation and control in the short term as well as investments and planning for the long term. The large volume and complexity of the data collected creates challenges for decision support and stakeholder communication. This technical expertise, coupled with communication, entrepreneurship and teamwork skills, will enhance the impact of the research by promoting effective solutions. Training activities are aimed at preparing graduate students for a variety of career paths.

The proposed Traineeship has four key components. Through completion of (1) a new graduate certificate, trainees will gain technical skills and knowledge of FEW system issues. They will (2) conduct interdisciplinary research at the nexus of food production, renewable energy and water quality. While doing so, they will participate in a new graduate learning community (GLC) to consist of (3) a two-year series of workshops that focus in alternate years on the context of the Midwest agricultural FEW nexus and professional development, and (4) small-group experiences to promote collaboration and peer review. Each trainee will create and curate a portfolio that combines artifacts from coursework and research with reflections on the broader impacts of their work. We anticipate 24 funded PhD student trainees, an additional 24 unfunded MS or PhD trainees, and approximately 20-30 other MS and PhD students to obtain the graduate certificate.

Intellectual Merit:

Research efforts led by interdisciplinary groups of faculty from engineering, agriculture and social science will address current problems at the FEW nexus with systems modeling and data-driven approaches. The education efforts are designed according to a stewardship framework for graduate education, which posits that PhD holders in any career path act as disciplinary stewards in activities characterized by conservation, generation, and transformation. Our proposed GLC is based on a persistence model, which consists of a feedback loop from graduate school experiences to influence student commitment to goals. GLCs have been shown to increase student engagement in the full spectrum of academic and professional development activities.

Broader Impacts:

Inherent broader impacts derive mainly from engaging trainees in research to better understand the interdependencies between FEW systems; to enable the collection, management and interpretation of data associated with the FEW system nexus; and to enable informed decision making that reflects not

only the preferences of the individual FEW system stakeholders, but also societal and ethical implications. The proposed project will include specific activities and strategies aimed at preparing graduates for industrial (including entrepreneurial), policy, research or academic career paths. The portfolio concept could serve as a model for other NRTs, while providing potential employers with persuasive evidence of the training obtained.

A. Theme, Vision, and Goals

This project's overarching **theme** is systems modeling and data analytics for innovations at the nexus of food production, renewable energy and water quality. Sustainable provision of food, energy and clean water for the long term requires understanding of the interdependencies among supporting systems (Fig. 1). Stakeholders such as government bodies, consumers and investors may focus too much on short-term fixes, while researchers tend to focus too narrowly on tractable problems with limited scope. Providing implementable solutions requires understanding the motivations and incentives of farmers and rural policy makers. Expanding the scope and fostering a long-term perspective in research efforts aimed at effective innovations at the nexus of these food, energy and water (FEW) systems exposes the need for data-rich system modeling with analytic capabilities for diverse types of data.

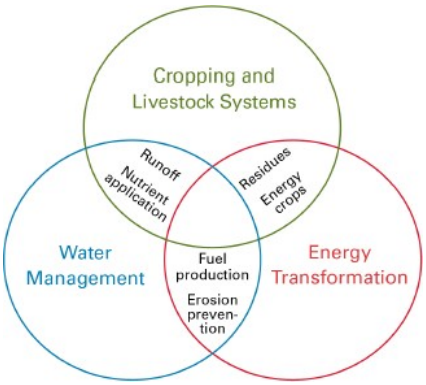
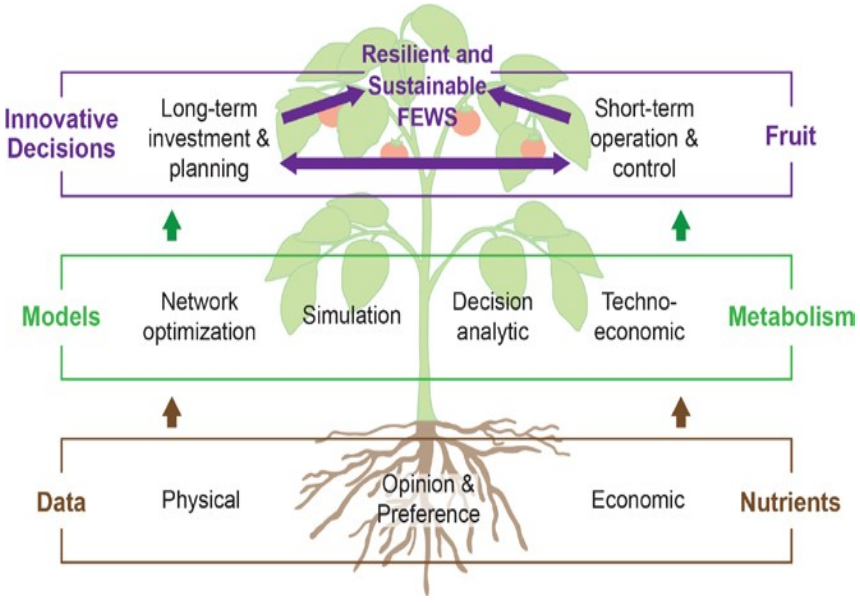


Figure 1: Midwest agriculture FEW system interactions

Agriculture occupies the epicenter of the FEW nexus. It is an increasingly energy intensive enterprise, but is also a potential source of energy. Agriculture places large demands on water supplies while poor practices can degrade water quality. This project will focus on the impacts of agricultural practices in the Midwestern US on the interactions of food, energy, and water systems. Crop and livestock production for food uses water and generates runoff that degrades water quality with implications for public health, water treatment costs, and downstream ecosystems. It also requires energy to power vehicles, maintain livestock habitats, and manage wastes. Renewable energy production from biomass can compete with food production for land and water resources. Management of water supply and quality requires an intricate balance between demand from agriculture and energy for water and other societal and ecosystem needs for water. Each of these interactions creates opportunities for modeling driven by sensor- based and qualitative data collection to improve the effectiveness of system operation and control in the short term as well as investment s and planning for the long term (see Fig. 2). However, the large volume and complexity of the data collected creates challenges for visualization, decision support, and stake- holder communication.



The **vision** of this Traineeship program is to build a community of re-searchers and prepare professionals who explore, develop and implement effective data-driven models for decision-making to efficiently produce food, transform primary energy sources into energy carriers, and enhance water quality.

The **goals** and associated objectives are:

G1. Foster interdisciplinary research based on data-intensive methods.

O1.1. Increase collaboration between researchers in FEW system domains and those in decision modeling and analytics.

O1.2. Expand research that leads to workable, synergistic solutions for food production, renewable energy and clean water in the social, economic and geographic context of Midwest agriculture.

G2. Educate STEM graduate students for a range of research, research-related and entrepreneurial careers employing data-driven modeling at the FEW nexus.

O2.1. Train students in the effective use of systems modeling to understand the interactions among food production, renewable energy generation and water quality along with their business and policy con- texts.

O2.2. Improve decision science and analytics skills in FEW systems researchers to improve their use of heterogeneous data from biological, hydrological, chemical, thermal, social and economic processes.

G3. Prepare STEM graduate students to work effectively in multidisciplinary teams, communicate effectively with stakeholders, and identify economically sustainable innovations.

O3.1. Develop and test mechanisms and structures for mentoring, social support and team-building that aid retention, productivity and timely degree completion of STEM graduate students.

O3.2. Develop and test mechanisms and structures for providing professional and communication skills relevant to careers in academia, government, or industry, including startups.