FEW Context Statement: "INFEWS/T2: Robust modeling of the FEW nexus for local development: Bridging optimality, risk, and community dialogues"

As in much of the western U.S, Colorado has experienced explosive population growth over the last several decades due to its rugged beauty, rich agricultural heritage, thriving economy, and abundant outdoor opportunities. However, most municipalities currently take a "piecemeal" approach to local development, which is largely based on outdated infrastructural concepts, density paradigms, and narrowly defined political/economic agendas. Consequently, rapidly sprawling urban/suburban/rural developments are negatively impacting the fragile balance of ecosystems and food, energy, and water (FEW) systems necessary to society. This lack of examining interconnected FEW-related impacts over long time spans threatens the very qualities that have given Colorado its attractive reputation.

To address mounting resource pressures due to this "short-sightedness," municipalities must formulate long term developmental strategies that acknowledge local and regional FEW systems to understand the impacts of rapidly increasingly population and development. According to Colorado's Department of Local Affairs (DOLA), the population of Colorado was nearly 5.5 million in 2015 and is forecast to be nearly 8.5 million by 2050. Suburban development will encounter increasingly significant environmental resource constraints, so strategic growth plans must engage scientific research and bridge a persistent knowledge/communication gap between the latest developments FEW nexus research, social-ecological systems (SESs), and community development decisions. By combining state-of-the-art optimization modeling of FEW systems with the latest advancements in public policy theory and computer visualization techniques, more sophisticated FEW integration strategies to better inform public dialogue and policy could positively impact local development, especially within contexts fraught with tradeoffs, capacity limitations, and complex interdependencies. Population growth is a global urban issue, and our research methods will be broadly applicable to other regions facing similar projections, resource limitations, and environmental pressures.

Specifically, this research project proposes to study FEW systems as integral pathways towards planning decisions about local (suburban/rural) development into a productive dialogue resulting in effective and robust resolutions. This aim is particularly critical in semi-arid to arid climates such as Colorado where local sources of water become seasonally scarce and land use decisions are intimately tied to access to water. These land use decisions in turn influence food production as range lands and agricultural areas are developed, and increasing suburban developments lead to increased energy demands in order to obtain water, produce and transport food, and meet local electricity needs. Through hypothetical scenarios based on existing conditions which will be constructed and tested in collaboration with local governments, we will apply our model of FEW dependencies on meteorological, economic, and technological inputs to provide insights into the sustainability of planned and existing developments. We will also consider the impacts of local to regional policy decisions, as they influence infrastructure, zoning, incentives, and sources, in our optimization framework, and translate these modeling findings to local communities through an innovative visualization tool.

A broad-ranging expertise spanning the sponsoring INFEWS directorates will be synergized into various interdisciplinary teams collaborating strategically throughout the project. In understanding the climatic, weather, economic, demographic and social constraints as well as variations influencing FEW nexus dynamics for robust optimization, experts in hydro-ecology (**GEO**), urban/peri-urban agricultural food systems (**SBE**), and multi-domain energy optimization systems (**ENG**) will work together. In developing robust modeling scenarios reflecting realistic barriers, incentives, and synergies between FEW resources under multiple sources of uncertainty, an optimization, numerical methods, and complementarity problems mathematician **(SBE*)*** and an electrical engineer **(ENG)** with expertise in network information theory, wireless communications, and machine learning will collaborate. The potential impact of the optimization scenarios to the policy decision making processes involving economic resource and allocation strategies will be investigated by two applied empirics and policy/resource valuation economists (**SBE**); and a community sustainability strategist (**SBE**) to create environmentally "balanced" resource allocation strategies at the FEW nexus. Finally, a sustainable technologies urban theorist (**SBE)** and visual artist/designer(**SBE)** will partner to research advanced visualization techniques to bridge a persistent knowledge/communication gap between researchers and community stakeholder dialogues to cultivate more integrative management strategies of FEW systems within local development.