# INFEWS/T1: Sustaining California's food production through integrated water and energy management

## A. Overview

Climate-change driven shifts in precipitation and water storage in the Sierra Nevada, a mountain range that provides over 50% of California's (CA) water supply, are stressing one of the nation's main food-producing regions. CA produces over a third of the nation's vegetables and two-thirds of the country's fruits and nuts. The regions water resources and energy infrastructure, developed to supply water and energy during a climate regime that no longer exists, is now facing alarming and unprecedented deficiencies in meeting the demands of agriculture and society. These deficiencies include reductions in seasonal surface-water storage, continued groundwater overdraft, reduced hydropower, more-intense storm runoff, and growing competition for water and energy demand. Taken together, they present a unique challenge for the future of irrigated agriculture. Recognizing the need for a sustainable future, CA is advancing both requirements and incentives for improvement of water and energy management. Through analysis of the food-energy-water system (FEWS) comprised of connected wildland-storage-cropland subsystems this research will analyze how different climate-adaption pathways affect resilience, vulnerability, and sustainability of CA's FEWS nexus. Management and alternative future scenarios will be analyzed using a Coupled Human and Natural System (CHANS) framework that fully integrates biophysical, engineering, socioeconomic, and human decision-making processes and feedbacks.

## B. Intellectual Merit

Aligning agriculture, groundwater sustainability, carbon neutrality, and the basin-integrated management of water-resources systems is a critical need for our nation's critical food-producing areas. Transforming the traditionally disjointed decision-making in these separate sectors, using an integrated framework that takes advantage of interdependencies and promotes shared understanding, is both challenging and achievable. Transparent data and information, integrated through credible, management-focused modeling tools, provide a foundation for conducting alternative futures analyses, building decision support, and ultimately promoting more resilient FEWS decision-making. Our proposed CHANS modeling framework will advance current FEWS paradigm in three different ways:

*1. Quantify feedbacks among CA's wildlands, water-storage, and croplands subsystems.* Models of hydrology, energy, and agricultural subsystems will be integrated using *Envision*, a GIS-based, spatially explicit, multiparadigm modeling-framework for analysis of CHANS and alternative future scenarios. This will advance integrated process understanding by identifying: interactions, feedbacks, nonlinearities, and thresholds within these subsystems and CA's FEWS as a whole.

*2. Evaluate the degree to which these subsystems are vulnerable to climate change.* The *Envision* model will simulate how agriculture can best adapt to the unprecedented changes in climate and water availability controlled, in part, by simultaneous changes in wildland and storage subsystems. This involves consideration of multiple climatic and non-climatic factors that influence vulnerability and resilience of coupled FEWS.

*3. Identify the management and policy strategies that best adapt this coupled FEWS to climate change*. Through this coupled FEWS modeling and climate vulnerability assessment, as well as stakeholder involvement via our facilitated knowledge-to-action network, we will identify stresses, risks, and effects of different management strategies and the opportunities therein for achieving co-benefits within this FEWS.

## C. Broader Impacts

The high value of water and agriculture in the region, the wide variety of stakeholders, the major projected impacts from climate change, and the recent regulatory pressures make this an ideal location to develop a FEWS-scale analysis. Proposed CHANS model results will be scalable to other regions, particularly across the semi-arid western United States and worldwide where integrated wildland, storage, and cropland systems are facing similar issues. CA is committed to transforming its economy to one based on renewable energy rather than on fossil fuels; and important knowledge gaps remain regarding how that will be achieved. The region will also need to adapt to the impacts of unpreventable climate change. The proposed research will inform contemporary decision-making on these issues and also will contribute to educating the next generation of environmental and water professionals. Using available and credible data from the region, selective modeling to extend those data, and an active program of stakeholder engagement, this research will go far beyond just the development of tools. It will provide a foundation for broader analysis that can drive regional cooperation in planning and decision-making toward a more sustainable future, with consequential impacts for the nation and the world.