PROJECT SUMMARY

Overview:

This INFEWS project will identify and articulate science-based resource management policies to sustain food-energy-water systems in the lower Mekong River Basin (MRB). The Mekong is one of the last major tropical rivers to remain undammed for much of its length. The South Asian Summer Monsoon drives the river's natural flood-pulse and connects it to the floodplain, which, in turn, controls nearly all ecosystem processes in the region, from rice production to fisheries. The river's enormous discharge could also generate over 40 GW of power, power that is key to the region's economic development. Future hydropower development and climate change will impact the flood-pulse, and the goods and services derived from the flood-pulse, in yet unknown ways. Despite the dominant role floodplain ecosystems play in the region, serious information gaps exist related to hydropower, climate, hydrology, ecological processes, resource users, and governance. To fill these gaps, the ASU-UW Sustainable Mekong Livelihoods Project (SMLP) will build analytical frameworks, collect critical field data, and construct a toolkit for scenario planning as an aid to sustainable development.

Intellectual Merit:

The SMLP will provide a quantitative framework for predicting the effects of hydropower development and climate change on the MRB flood-pulse, freshwater biodiversity, and both yields and nutritional quality of fish and rice, two key aspects of food security. The Variable Infiltration Capacity (VIC) macrohydrology model will serve as the foundation of the quantitative framework. VIC will be parameterized with new remote-sensing analyses predicting evapotranspiration as well as land-cover change from riparian forest to irrigated rice paddy. CMIP5 climate simulations and future dam development and operations scenarios will force VIC and provide estimated future streamflow, which will then drive a water-resources development model, a hydropower generation model, and a hydrodynamics model of the Tonle Sap Lake in the lower MRB. The SMLP will link aspects of hydrology with food production in the Tonle Sap in two ways: 1) via multivariate autoregressive state-space analyses of new catch per unit effort data to quantify how timing, magnitude, and the decadal-scale sequence of the flood-pulse drives relative fish abundance and ecosystem processes; and 2) via a crop model (CropSyst) linked to VIC that generates rice yields from a physically based land-surface scheme. Dynamics of the flood-pulse are also likely to control food quality, specifically fluxes of key nutrients and harmful contaminants to people in fish and rice through its effect on redox biogeochemistry. The SMLP will establish this relationship for the first time and, using nutrient-profiling techniques, incorporate both positive (nutritional) and negative (contaminants) effects of fish and rice into a single metric, thereby quantitatively linking the flood-pulse to human well-being. The research team will use metrics of food-system yield and quality to identify best management practices for dam development and operations using multiobjective optimization (MO) approaches that analyze tradeoffs between hydropower generation and food yield. Finally, the SMLP will develop one of the first quantitative institutional analyses using a cooperative game-theoretic approaches to unearth best practices in creating international coalitions at multiple scales of governance. The SMLP will integrate these system components by measuring robustness of tradeoffs (from MO) under climate extremes and given bargaining among institutions that might force local solutions to diverge from the global (basin) optima.

Broader Impacts:

SMLP Project impacts will be fourfold: 1) train three US-based postdoctoral researchers, six graduate students, multiple undergraduates, and at least two Cambodian students; 2) share critical data and models through broad stakeholder engagement within the Mekong. These frameworks are essential if UN Sustainable Development Goals are to be met for all inhabitants of MRB; 3) develop a novel online curriculum that enhances STEM capacity in sustainability by engaging 20 fisheries managers in quantitative modeling and tradeoff analysis led by ASU's EdPlus online learning program; and 4) improve scientific capacity in the region as MRB scientists develop and apply the project's advanced modeling systems. Local scientists and students will be trained in both field and statistical methods so that the research can be sustained beyond the project's duration.