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Quantifying the feedbacks between climate change and the WEFE nexus in the transboundary Syr Darya basin

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The Syr Darya River Basin is a transboundary glacier-fed river system, supporting the livelihoods of millions of people across Central Asia. The sustainable allocation of water resources in this basin has become a pressing concern due to the increasing demands coupled with environmental degradation and climate uncertainty. Consequently, developing robust water allocation mechanisms that acknowledge the Water-Energy-Food-Environment-Nexus (WEFE) is vital for sustaining human and ecosystem needs. This study scrutinizes the relationship between upstream and downstream water users in the upper Syr Darya Basin, which encompasses the Uzbek and Kyrgyz Republics, including the Fergana Valley, Central Asia's "breadbasket".

Whereas the individual effect of climate change on either water demand or supply is widely studied, the interaction between these two, considering local nexus-related systemic dependencies, requires a better understanding to improve sustainable water allocation in the region. For example, climate change may reduce upstream hydropower demands in winter, favouring water supplies in summer elsewhere. Recognizing the intricate relationships among water, energy, food, and the environment, especially in regions with geopolitical complexities like Central Asia, we aim to uncover the feedback mechanisms shaping the WEFE nexus by defining and assessing storylines representing climate and socio-economic change in a coupled cyrospheric-hydrological and water allocation model (SPHY-WEAP).

First, we assess the influence of climate change on reservoir inflows of Toktogul and Andijan, key reservoirs regulating water availability within Ferghana Valley. We force the model with CMIP6 climate simulations to assess changes in reservoir storage and inflows for multiple future time horizons, thereby focussing on potential storage gaps as glaciers shrink and its effect on existing reservoir release patterns. Secondly, we assess the future evolution of water, energy, food, and environmental demands under the combined influence of climate and related socio-economic changes. Hereto, we define representative storylines, integrating insights from policy documents and local stakeholder consultations to depict plausible future pathways. Finally, forcing the coupled SPHY-WEAP allocation model with quantitative storylines, we explore local feedbacks in the intricate relationship between climate change and water availability, supply, and demands.

Specific focus will be on how the equilibrium between water supply and demand shifts for varying storylines, thereby pinpointing tipping points where water demands can no longer be met for a given season or throughout the year.

The results of this study are expected to provide a systematic assessment of water-energy-food-environment storylines, revealing how these storylines either facilitate or impede sustainable water management practices in the basin. This study aligns with SDG 6 and lays the groundwork for promoting efficient water allocation strategies and decision-making under climate change to promote transboundary cooperation and long-term water security for all.