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Use of Coupled Human-Water Model for Evaluating the Impacts of the WEF Nexus on the Energy Potential of Crop Residues in Pakistan

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Failure to consider interactions in the Water-Energy-Food (WEF) nexus can lead to unintended outcomes. In Pakistan, research has suggested that agricultural residues are a viable alternative renewable energy source to address the persistent energy shortfalls and reliance on imported diesel and heavy fuel oil. However, these studies assess the viability from a broad scale and do not adequately account for nexus interactions. For example, a quarter of irrigated land in Pakistan is salt-affected, adversely impacting crop (and residue) yields. Failure to consider climate change impacts on water availability and agricultural productivity also increases uncertainty. Finally, the effects of socioeconomic feedbacks and water management policies are not understood. To address these challenges, this research applies a coupled physically-based (SAYSMOD), and group (stakeholder) built system dynamics model (P-GBSDM) of the agricultural system in the lower Rechna Doab, Pakistan, to assess the sub-regional viability of residue-based energy production in salt-affected and non-salt-affected lands. The modelled area (750 km2) is within a district found highly suitable for residue-based energy. The P-GBSDM, developed by Inam et al. (2017), captures the socioeconomic and spatially-distributed environmental feedbacks related to agricultural productivity, hydrological parameters and farmer's livelihood indicators. The P-GBSDM is amended for this research to estimate crop residue yield and potential energy production and feedbacks related to farmer income (from selling residues) and crop residue removal. The model is simulated for the years 2000-2030 under different climate change scenarios and stakeholder-suggested salinity management practices. Crop (and residue) yield, equivalent collection radius, farmer income, and soil salinity are used to evaluate the residue-based energy production in this area. Results are compared to literature values. Preliminary results suggest that estimates that do not consider the WEF nexus overestimate residue-based energy generation's potential.