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Integrating intermittent renewables via hydropower alone adversely impacts other sectors

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Large-scale integration of intermittent renewable sources in Africa, such as solar and wind, can accelerate the transition to low-carbon energy systems, which is critical to mitigate the impacts of climate change and increase electricity access. Hydropower can support this transition because its operational flexibility can be used, in a cost-effective manner, to counteract the variability and seasonality of intermittent renewables. However, using hydropower to provide energy system flexibility services can affect aquatic ecosystems and create intersectoral conflict. We use a multi-objective design framework to address this issue and demonstrate it on a national-scale case study for Ghana. This case study shows that available hydropower flexibility can be deployed to support expanding intermittent renewables by 38%. However, this would increase the sub-daily flow variability of the main national river (Volta) by up to 22 times compared to the historical baseload hydropower operation that does not support intermittent renewables. The increase in sub-daily flow variability is estimated to damage the river ecosystem and reduce national crop yield revenue by up to US$169 million per year. We propose an alternative approach that uses a diversified investment strategy, including intermittent renewables, bioenergy, and transmission network expansion in addition to existing hydropower, and show that such designs can maintain acceptable flow variability and agricultural performance while meeting future national energy service goals and reducing CO_2 emissions. The proposed framework can support governments and power system planners by designing efficient diversified energy investment portfolios and highlighting their sectoral and emission trade-offs.