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Studying spatial agreement of catchment response to climate and landuse change under uncertainty for prioritizing investment into hydropower catchments

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Joint climate and land cover change can significantly alter catchment hydrologic response, e.g., in terms of runoff and sediment delivery, and thus key determinants for downstream hydropower outcomes. While many studies highlight climate risk for hydropower operation, it is less clear how climate and landuse change together will impact hydropower outcomes, if managing landuse can reduce those impacts, and how to prioritize effective investments in the face of uncertainty about the future climatic drivers.

In this study, we use Chaglla Dam, Peru's third largest electricity generator, to develop an ensemble approach to identify parts of Chaglla's contributing area with consistent changes in runoff and sediment under climate change. Those areas could then be targeted for maintaining or restoring natural land cover to increase baseflow and decrease sediment. We use SWAT to model catchment response for a large ensemble of climate trajectories based on latest CMIP 6 data, downscaled using multiple state-of-the-art algorithms and high-resolution regional weather observations (Figure 1 A and B). Based on the results, we identify parts of the catchment with greatest changes in water yield. We find that 35 % of the watershed area shows consistent trends in water yield and sediment across all climate scenarios.

Climate risks will increase in the near and midterm future with increases the length of low-flow periods (up to 40 %) and increases in sediment (up to 17 %). Compared to that, additional changes in water and sediment because of projected land use change are relatively minor (+ 0.3 % in low-flow length and + 0.7 % in sediment).

Yet, our study introduces a spatially-explicit framework for analyzing large ensembles of climate and landuse projections to identify where future change will translate in most change in hydrologic parameters related to hydropower. Results enable to study if investing in catchment conservation in those areas will significantly improve hydropower outcomes and will thus help to

develop management plans for hydropower catchment that are robust under future change.