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Current and future water balance in a Peruvian water catchment – combining hydro-climatic and socio-economic scenarios

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In the Santa River catchment (Cordillera Blanca) in Peru, water availability is threatened by climate change and socio-economic factors, but little is known about relations and interactions of multiple climatic and non-climatic stressors.

We developed a conceptual integrated water balance model that combines hydro-climatic and socio-economic scenarios, in order to analyze variability of water resources and water availability in the Santa River basin until 2050. The model is based on a lumped HBV model including a glacier - snow model (GSM) to simulate the hydro-climatic processes. In addition, the model was extended by feedback loops for agricultural and domestic water use. The model was calibrated and validated using the Peruvian Interpolated Data of SENAMHI's Climatological and Hydrological Observations (PISCO) temperature and precipitation data. To assess future water balance challenges we used monthly CORDEX scenarios for 2020-2050 for simulations of future changes in hydro-climatology. These climate scenarios are combined with possible socio-economic scenarios, which were based on stakeholder interviews, workshops and analysis of available data and information concerning water demand. The scenarios that describe changes in the future socio-economic conditions were developed by means of Cross-Impact Balance Analysis (CIB), a semi-formalized method from systems analysis which allows the construction of socio-economic scenarios based on an impact network of different (socio-economic) drivers.

The uncertainty in the climate projections is accounted for by using different global circulation model-regional climate model (GCM-RCM) combinations from CORDEX data. The uncertainty in the socio-economic scenarios was addressed by using possible ranges for future developments in water demand depending on the tendencies provided by the CIB analysis (e.g. increasing, constant or decreasing water demand). The climate and socio-economic scenarios are randomly combined in multiple model runs, which result in an ensemble of possible future discharges of the Santa River for each scenario combination.

Results suggest that the mean annual discharge is projected to increase by 10% (±12%) driven by

an increase in annual precipitation amounts of about 14% (RCP2.6) and 18% (RCP8.5), respectively. In contrast, mean dry-season discharge is projected to decrease by 33% and 36% (±24%) by 2050, for RCP2.6 and RCP8.5, respectively, mainly driven by diminishing glacier melt discharge. We found that the projected socio-economic changes compared to climatic changes are less pronounced mainly due to higher variations in the trends of the global climate models. Nonetheless, the socio-economic drivers have a major effect on dry-season water availability. The increase of wet season and the decrease of dry season discharge call for different adaptation measures including improvements in water use efficiency, infrastructure and storage capacities.