EGU2020-16454
https://doi.org/10.5194/egusphere-egu2020-16454
EGU General Assembly 2020

Integrating Climate and Socio-Economic Scenarios in a Hydrological Model for the Santa River Basin, Peru

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High mountain regions, like the Andes, face various risks due to climate change. In the Santa River catchment in Peru which includes the glaciated Cordillera Blanca, water availability is threatened by many climatic and non-climatic impacts. The water resources in the catchment heavily rely on seasonal precipitation and during the dry season glacier melt water plays an important role. However, both, precipitation patterns and glacier extent are affected by climate change impacts. Additionally, socio-economic changes put further pressure on water resources and hence on water availability.

Within the AguaFuturo Project we established a conceptual integrated water balance model based on a semi-distributed HBV model for the data scarce Santa River catchment. The hydrological model processes are extended by feedback loops for agricultural and domestic water use. The model runs on daily time scale and includes two hydrological response units. One includes the irrigated agricultural areas which are predominately located in the valley of the catchment; the other includes non-irrigated areas and domestic water use.

To assess future water balance challenges we downscaled and disaggregated monthly CORDEX scenarios for 2020-2050 using information from the new Peruvian precipitation dataset PISCO (Peruvian Interpolated data of the SENAMHI's Climatological and hydrological Observations) for simulations of future changes in hydro-climatology. In the model, these climate scenarios are combined with possible socio-economic scenarios which are translated into time series for domestic and agricultural water demand. The socio-economic scenarios are developed by using the Cross-Impact-Balance-Analysis (CIB), a method used for analyzing impact networks. Using CIB, the interrelations between 15 social, economic and policy descriptors were analyzed and as a result a total of 29 possible consistent scenarios were determined. For further analysis and validation of these scenarios a participatory process was included, involving local experts and stakeholders of the study region.

The climate and socio-economic scenarios are independent and can be combined randomly. The uncertainties of the climatic and socio-economic scenarios are quantified by Monte Carlo simulations.

The output of the model runs is an ensemble of possible future discharges of the Santa River, which can be further analyzed statistically to assess the range of the possible discharges. This evaluation provides an estimate of the probability of water shortages, especially with regard to conflict potential with hydropower production and the large scale irrigated agriculture areas in the adjacent coastal desert which also rely on water from the Santa River.