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Assessing the impact of climate change on Hydrological regime of Afghan catchments

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Rapid climate change is impacting water resources in Afghanistan, a country in the western Himalaya that is poorly developed in terms of scientific research and environmental monitoring. It is a semi-arid to arid country of Central Asia where livelihoods and economies have developed to be strongly dependent upon mountain water resources, and where snow- and glacier-melt delivers 80% of Afghanistan's water supply. Rising average global temperatures and glacier shrinkage pose a significant threat to water supply. Once glaciers shrink to a certain size, "peak water" will be reached. Water supply will decline. If winter snowfall declines, or becomes more variable, glaciers are less likely to compensate for the associated water shortage that results, a process that will be compounded by continuing population growth and groundwater over-abstraction.

In order to understand the implications of glacier recession now and in the future with relative contributions of ice, snow and other components to water supply for Afghan water resources, three representative catchments were selected based on their locations and data availability. The TaqchaKhana catchment (264.4 km^2 area with 3.1% glacier cover) in the north; the Sust catchment (4609 km^2 area with 16% glacier cover) in the east; and the Bamyan catchment (325.3 km^2 area with 0.7% glacier cover) in the center of Afghanistan. Climate and streamflow data for 2012 to 2019 obtained from Ministry of Energy and Water of Afghanistan.

In this study the glacier and snowmelt – soil contribution (GSM-SOCONT) hydrological model was modified to allow a simple representation of the effects of debris cover development on ice melt which is commonly overlooked in hydrological models of mountain water resources. The model was individually calibrated for each catchment based on Shuffled Complex Evolution Algorithm (SCE-UA), with the best parameters taken after 20,000 iterations. Eight regional climate models (RCMs) under two scenarios (2.6 and 8.5) were used in the model to simulate future streamflow in the catchments. The RCMs were bias corrected using non-parametric statistical transformation. Future glacier evolution was introduced to the model using a very simple propagation of current measured glacier recession rates into the future. After calibration on data for the periods 2012-2019 and an associated uncertainty analysis, the models were deemed sufficient to understand the relative importance of different sources to water supply and to predict future

water supply. The current contributions from glacier melt were observed to be 70% for the Sust catchment, 49% for the TaqchaKhana catchment, and 11% for the Bamyan catchment. Future climate conditions initially increased the ice melt contribution for the Sust and the TaqchaKhana but reduced it for the Bamyan, confirming our hypothesis that direct effects of changing temperature and precipitation in Afghanistan are likely masked by a glacial subsidy.