Assessment of Hydro-meteorological and Cryospheric Changes Driven by Climate Change in the Upper Indus River Basin Hindukush Karakorum Himalaya

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Abstract

Pakistan is one of the most vulnerable countries to the adverse effects of climate change. The Upper Indus River Basin (UIB) is particularly susceptible because of its freshwater resources. Pakistan's agriculture and power sector are dependent on the UIB. For a sustainable agriculture and power sector, the continuous monitoring of hydrosphere and cryosphere is important. The snow-covered area (SCA) of UIB of Gilgit Baltistan was studied for the last 17 years using the Moderate Resolution Imaging Spectroradiometer (MODIS) snow products. Ground based monthly hydrological data of 8 gauging stations and monthly meteorological data of 20 weather stations were investigated and correlated with the SCA data. Meteorological data from two sources, Pakistan Meteorological Department (PMD) and Water and Power Development Authority (WAPDA) were merged together to get a representative climatic dataset of the UIB. Mann Kendall's trend test and Spearman's correlation tests were utilized for statistical analysis. The results indicated that the basin's wide SCA has slightly increased over the period of observation. Statistically significant increasing trends were observed in total monthly precipitation and monthly runoff data. The slight increase in basin-wide SCA has a negative correlation with the annual temperature. As the SCA increases more sunlight is reflected back, it causes a cooling effect. On the other hand, a strong positive correlation between SCA, temperature and monthly runoff revealed that the Indus River Basin is highly dependent on continuous melt down of seasonal snow and glaciers driven by summer temperature. While, a weak positive correlation between monthly precipitation and runoff indicated that rainfall contributes less to seasonal Indus River flow. Seasonal and annual SCA data is correlated with seasonal and annual hydrometeorological data in more details. These results have serious implication to the sustainability of hydropower, agriculture and flood risk management in downstream areas.