CLIMATE CHANGE AND ITS IMPACT ON STREAMFLOWS IN MANGLA WATERSHED USING GIS BASED HYDROLOGICAL MODELING

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ABSTRACT

Pakistan's economy is based on agriculture that is highly dependent on water resources originating in the mountain sources of the Upper Indus Basin. Climate change may have serious implications for the management of water resources. The aim of this study was to examine the variability analysis in temperatures and precipitation and its impact on streamflows of Mangla Basin, UIB Pakistan using GIS based hydrological modeling. Trend analyses were performed by applying parametric and non-parametric tests and Sen's method was applied to estimate change values in time series. The influence of serial correlation was eliminated from time series by applying the Trend-Free Pre-Whitening (TFPW) method prior to the trend analysis. Firstly, a trend analysis was performed to examine whether climate is really changing in the study area. This trend analysis was performed on discharge, precipitation and maximum and minimum temperatures for the period 1961-2010 and investigates the relationship between trends in hydrological variable (streamflows) and trends in meteorological variables (precipitations & temperature). The spatial maps of hydro-meteorological variables were also developed to examine hydro-climatologically variability in the study area. The future climate change scenarios were developed with the help of SDSM model, a statistical downscaling approach based model, by using the outputs of the HadCM3 model. The river flow in Mangla basin depends on seasonal snowmelt and rainfall. So, the streamflow was simulated using the SWAT model, a physically based distributed hydrologic model that uses a GIS interface and readily available input data such as Digital Elevation Model (DEM), climate, soil and land-use data. The future stream flows were also simulated based on future developed climate change scenario using calibrated SWAT model.

Results of this study revealed that warming trends were observed in the southern part (lower part) of study area whereas in northern part (higher part), cooling trends were found. Precipitation in low elevated basins Poonch and Kanshi has decreased whereas in high elevated Kunhar and Neelum basins have the significant increasing trends. Trends were more common in mean and low streamflows compared to high streamflows. The annual minimum flow at the outlet of Mangla watershed has decreased whereas mean and maximum flow has increased. The streamflow in winter and spring seasons has increased whereas in summer and autumn seasons have decreased. The changes in annual maximum temperature for future periods (2020s, 2050s and 2080s) in the whole basin would be increases by about 0.4, 0.7 and 1.2 °C respectively under A2 high emission scenario. Decreasing trends in maximum temperature were observed for the high elevated subbasins in northern region of Mangla watershed (Kunhar and Neelum) while low elevated subbasins (Poonch and Kanshi) have the increasing trends. The annual minimum temperature for future periods (2020s, 2050s and 2080s) in the Mangla basin would be 0.3, 0.5 and 0.9 °C respectively. The annual precipitation would be increased by 6, 10, and 19 % in Mangla basin in 2020, 2050 and 2080 respectively whereas in Kunhar, Neelum, Poonch and Kanshi basin may be increased by 16, 11, 13 and 59% respectively in 2080s. The future climate change scenarios have impacts on hydrological system resulting in 15% increased annual streamflows whereas for the winter, spring and summer seasons would be increased upto 16%, 19% and 20% respectively while for the autumn would be decreased upto17% in 2080s.. The prevailing trends and variability, caused by climate change, have an effect on the flows that should be considered by the water managers for better water management in a water scarce country like Pakistan.