

M.Sc. THESIS

**CLIMATE CHANGE IMPACT ON HYDROLOGIC PARAMETERS  
AND RIVER FLOWS OF INDUS BASIN**



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## ABSTRAC

The specific objective of this study was to analyze the climate change and its impact on hydrological parameters and river flows of Upper Indus Basin (UIB). The daily temperature (minimum & maximum), precipitation and flows data was collected from Surface Water Hydrology Project (SWHP), WAPDA and Pakistan Meteorological Department (PMD) from 1961-2011. The monthly maximum, minimum and mean temperatures were computed from the daily maximum, daily minimum and daily mean temperatures. Seasons divided as three months and six months. Six month seasons were as winter (October to March) and summer (April to September) and three month seasons were as winter (December, January, and February), spring (March, April and May, pre-monsoon), summer (June, July and August, monsoon) and autumn (September, October and November, post-monsoon). Annual mean is the average of January to December monthly means. Trends were investigated for 16 climatic stations of upper Indus Basin (UIB) for the period 1961-2011 by applying the Mann-Kendall test and Sen's method. The analysis was also done for the periods 1961-1990, 1971-2000 was 1981-2011, 1961-1985 and 1986-2011.

The overall analysis of sixteen climatic stations of Upper Indus Basin with Mann-Kendall test and Sen's method indicated that there is an increase of annual maximum and mean temperatures and winter (DJF) maximum and minimum for period 1961-2011. Minimum annual, summer (JJA), spring (MAM) and autumn (SON) whereas mean summer (JJA) and autumn has decreased in most of the region of Upper Indus Basin (UIB) for the period (1961-2011). The results of temperature analysis for different periods show that last period (1986-2011) has more warming trends and high slope of

trends. The analysis of rainfall in winter (DJF), summer (JJA) and autumn seasons represents that rainfall has increased in twelve stations of Upper Indus basin (UIB). The correlation coefficient ( $r$ ) between the annual runoff and temperature was positive at Chitral, Yogu, Shigar, Kachura, Alam Bridge and Dainyor Bridge. The mean temperature in all sub-basins of Upper Indus basin has the positive trends and temperature has increased for the period (1961-1990) and impact of this increased temperature shows the increased streamflow at most of the sites. The annual runoff has increased for rivers Shoyk (at Yogu), Shigar (at Shigar) Indus (at Kachura) up-to 9%, 7% and 5 % respectively due to warming trend of annual temperature upto 5% ( $1^{\circ}\text{C}$ ) whereas the annual and summer (JJA) streamflow in river Kabul at Nowshera has decreased to upto 22% and 11% by increasing 4% and 1% ( $0.96$  &  $0.22^{\circ}\text{C}$ ) temperature. A seasonal correlation coefficient between temperature and streamflow has the positive correlation in most of the sub-basins of Upper Indus Basin (UIB) for both spring (MAM) and summer (JJA). In summer (JJA) the streamflow in river Gilgit, Hunza, Chitral, Swat, Shoyk and Shigar with increasing percentage of 15%, 12%, 8%, 1%, 13% and 10% (difference of 1st 1961-1985 and 2nd 1986-2009 period) respectively. But there was reverse situation in case of river Kabul and Astore that streamflow has decreased upto 16% and 9% (difference of 1<sup>st</sup> and 2<sup>nd</sup> period) with 7% increase in temperature. On average with increased  $1^{\circ}\text{C}$  temperature in spring yields increased runoff for rivers Gilgit, Chitral, Astore, Shoyk, Shigar, Indus at Kachura & Khar Mong and Hunza with percentage of 19, 5, 11, 15, 9, 7, 1 and 12% respectively by analyzing the data from 1961-2009.