Impact of 21st Century Climate Change on Surface Water Availability of the Transboundary Kabul River Basin

Key Messages

- Kabul River contributes 15.5 km^3 annually to the Indus River flows which makes it crucial to analyze climate-induced variations in the stream flows in order to secure the livelihoods of 20 million people that benefit from it.
- A study on two climate scenarios (RCP 4.5 and 8.5) for two future time periods i.e. near future 2020s (2011-2030) and far future 2040s (2031-2050) reveals that temperatures will rise by 1.2-3.1°C and the annual maximum flows in the order of 6000 m^3/s will have a higher frequency in the Kabul River Basin.
- Dwindling surface water resources in addition to increased variability call for sustainable management of groundwater to act as a buffer against climate shocks. Groundwater replenishment through rainwater harvesting is one of the solutions that should be taken into account.
- In order to prepare communities for the imminent extreme climatic events such as flash floods, early warning systems should be developed with international cooperation. It is essential to build trust so the weather and flood forecasting institutes in both countries can share data and mutually devise inclusive action plans.

This brief introduces the surface water challenges facing the Kabul River Basin and highlights the modeling based analysis of future scenarios of the flows in the transboundary Kabul River Basin to assess future water availability in this basin. It attempts to quantify the climate change impacts on water availability in the Basin that lacks reliable long-term observations of the climate.

In terms of climate change data, an ensemble of four GCMs' RCP 4.5 and RCP 8.5 scenarios were used in this study. It was concluded that there are serious concerns in terms of climate change implications for water availability patterns. Installation of gauge sites in both the countries will improve the data collection and hence more multi model approaches and robust modeling analysis in future could be used to further improve the reliability of the results. The brief finishes with a series of policy recommendations for strengthening adaptation to climate change and determining the future water availability in the basin.

Introduction

In transboundary river basins, climate change is being considered as a concern of higher degree than it is in other parts of the world. It is likely to exacerbate the prevailing timing, quantity and quality of river flows across the globe, and transboundary basins are no exception. This may lead to ineffectiveness of traditional practices of water resources management being reliant on past records of different components of the hydrological cycle (Milly et al. 2008). Hence, the nation states will feel more inter-dependency in terms of their shared water resources (Biermann and Dingwerth, 2004), particularly in the highly populated South Asia region.

Kabul River basin, a sub-basin of Indus River System, is one such transboundary river basin in South Asia that is currently facing the aforementioned challenges. Kabul River is a right bank tributary of the Indus River and an important transboundary river basin in South Asia between Afghanistan and Pakistan. It has a total catchment area of about 91,297 square kilometers in both Afghanistan and Pakistan territories. The geographic location of the river makes both these countries lower and upper riparian simultaneously. The source of the Kabul River is mainly the melt of seasonal snow which covers most of the basin during winter and some glacier-melt from the northern high mountains of the basin. On average, the Kabul River contributes about 15.5 km^3 annually to the Indus River flows (FAO, 2011) which makes it very critical to analyze climate-induced variations in the stream flows of this river to better plan downstream uses of the Indus River flows.

Snow and ice melt mainly control the runoff regimes in Himalayan basins which are chiefly governed by air temperature fluctuations. The progress in satellite remote-sensing technology of the cryosphere made it possible to apply those hydrological models that depend on snow coverage data for the basin, such as Snowmelt Runoff Model (SRM) which can now be considered for simulation of larger basins.

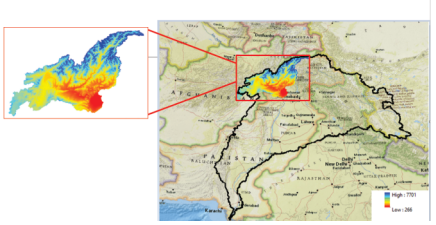

Figure 1 Geographic location of KRB within the Indus Basin and the inset image shows topographic elevation ranging from 266m to 7701m

The purpose of the study was to analyze the performance of SRM for simulation of daily stream flows in the snow and glacier fed transboundary Kabul River basin and to determine whether the rising temperature would have a significant impact on its stream flows under different future climate change scenarios. The analysis was performed for two selected future time periods i.e. 2020s (2011-2030) called 'near future' and 2040s (2031-2050) termed as 'far future'.

Methodology

Methodology of the study involved acquisition of data: Snow Cover (MODIS10A2) 8 Daily

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images, Shuttle Radar Topography Mission (SRTM) 30 meter digital elevation model (DEM). The second step involved mosaicking DEM tiles and delineating the Kabul River basin watershed. Snow cover tiles where then added to delineate water shed and mask snow cover data. Calibration and validation of the hydrological model (SRM) was carried out using daily snow cover data and daily hydro-meteorological data (observed precipitation, temperature and river discharge). The validated SRM model was then run with different sets of future climate data time series representing different scenarios (RCP 4.5 and RCP 8.5) and different future time slices (Near future and Far future) to simulate the projected flows of the Kabul River.

In terms of hydro-meteorological data, ideally the study needed long term (at least 25 to 30-year data as is a requirement in a climate analysis) daily data in different elevation zones of the basin and spatially well spread. Only two climate observation stations with long term daily data were available in Pakistan namely Peshawar (Elevation: 500 meters above sea level (masl)) and Chitral (Elevation: 1500 masl) and daily data from Afghanistan for the early 21st century period of the study analysis was not available. Hence, gridded AP-Cor daily precipitation and temperature data (Burhan et al., 2015) available with Pakistan Meteorological Department (PMD) was used for the study.

Key Findings

a. Snow Cover

MODIS data analysis for assessing snow cover variations over a 16-year period suggests that the cryosphere area in the Kabul River basin has a slight decreasing tendency. In zone-7 and zone-8, there is a stable snow cover extent, which we say indicates the presence of stable glacier cover in these zones.

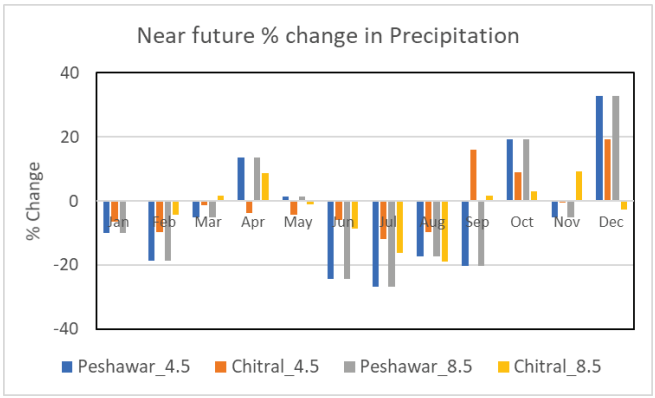

Figure 2 Projected trends of precipitation change for near future at Peshawar and Chitral stations

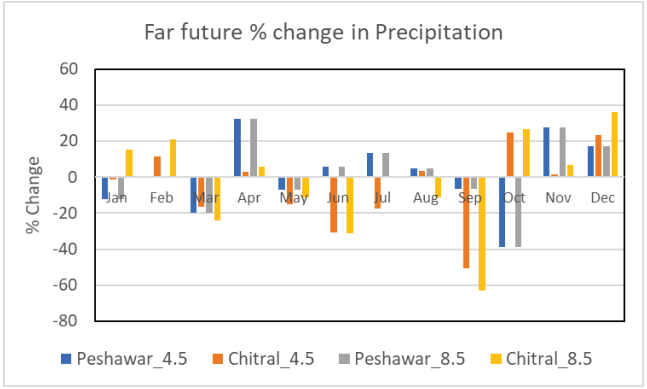

Figure 3 Projected trends of precipitation change for far future at Peshawar and Chitral stations

The trend of the snow covered area for Kabul River basin for the time period 2001-2016 can be termed as cyclic as the area increases from August up until February after which it starts to decrease – July, August and September represent minimum snow cover while December, January and February report the highest snow covered area.

b. Projected Future Precipitation

The comparison between the projected monthly trend of precipitation in Chitral and Peshawar station under two climate scenarios for near and far future time slices reveals that the precipitation decreases in both regions against each climate scenario with some months as exceptions, as shown in Figure 2 and 3.

c. Projected Future Temperature

The average temperature is projected to increase for both the stations, climate scenarios and future time slices. Average temperature for both Peshawar and Chitral stations is projected to increase within the range of 0.2-1.7°C for near future under RCP 4.5 and 8.5 scenarios, while it is projected to increase within the range of 1.2-3.1°C for the far future scenario.

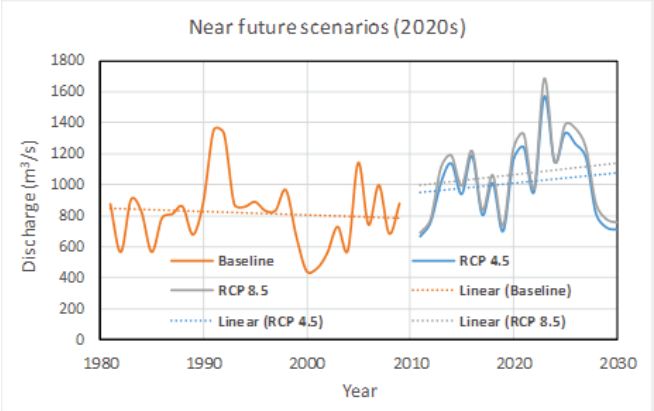

Figure 4 Mean annual discharge: comparison of baseline and near future

d. Future water availability

Daily time scale future projections' data of precipitation and temperature for the two selected climate scenarios (RCP 4.5 and RCP 8.5) and two future time slices were used as input in the validated hydrological model (SRM) of the transboundary Kabul Basin to determine the projected future flows. T Baseline period for this analysis was selected as 1981-2010, which was used to analyze changes in each future time slice.

The projections indicate an increase in river discharge in the near future with higher variability. Figure 11 depicts the projected trends, comparing the mean annual discharge for baseline period with that of the near future time frame under the two climate scenarios.

With respect to the far future time period, a greater increase in annual average discharge is predicted with increased variability of the Kabul River flows. Under both RCP scenarios, the annual maximum flow values in the order of ≥6000 m^3/s have a higher frequency which is alarming considering these flows will take shape of floods in the settled areas of this watershed.

The analysis of changes in intra-annual (monthly) flow patterns under near and far future scenarios shows that the monthly average discharges for the near future period (for both the RCPs) are increasing with marked upsurge during the summer season where rising temperatures are causing an earlier start of snow melt leading to a higher peak flow occurring one month earlier as compared to the

baseline period. Also, the minimum monthly flow month is shifted to a later month i.e. December.

Results and Conclusion

Analysis of the future climate time series shows an increase in temperatures of the two climate stations (i.e. Peshawar and Chitral) within a range of 0.2 - 3.1 under RCP 4.5 and 8.5 scenarios as well as in the near and far future time periods which in combination with an increased winter precipitation suggests a resultant increase in the rate of snow and snowmelt thereby producing increased amount of melt water that becomes available earlier as compared to the baseline period.

Climate change impact assessment in terms of changes in river flows indicate that basin's hydrologic regime will alter considerably under different climate change scenarios and future time slices. Some key findings related to the alteration in the hydrologic regime are:

I) Higher annual average discharge with more variability in near future as well as far future scenario.

ii) More frequent extreme events of higher magnitude in near and far future e.g. annual maximum values of magnitude ≥ 5000 m^3/s and ≥ 6000 m^3/s are expected to occur more often in near and far future respectively, as compared to the baseline period.

The study indicates that snowfall will increase by 1.0-8.5°C, while temperatures will increase by 1.0-3.0°C for the 'far future' time period. These higher temperatures, in addition to increased winter precipitation, will inevitably increase the snowmelt rate, thereby enhancing the likelihood of floods in the region. Based on the findings of this research paper by GCISC and historical events, it is seen that flood prone areas in the lower part of the basin e.g. Nowshera will receive more threats of frequent flooding and inundation which requires some solid and concrete flood forecasting mechanisms in place.

This study does not account for impacts on groundwater as the scope of the project mainly focused on understanding the impact of climate change on surface water flows. Similarly, the snow cover area was assumed to be constant against each scenario in this study therefore future areas of research should explore the impacts of climate change on snow cover area through the use of multi-model approaches.

Policy Recommendations

This study has attempted to quantify the climate change impacts on water availability in the Kabul River Basin using limited climate data (only two climate observation stations provided long term data and there was no daily data available from Afghanistan). While climate change poses additional risks to the already serious challenges facing Pakistan and Afghanistan over the sharing of Kabul River waters, there are a number of options which can be considered to help communities in both countries.

Water conservation to address increasing uncertainty due to enhanced variability

- Water conservation and climate-smart agricultural practices can be adopted by transforming the irrigation sector through promotion of water efficient technologies and practices. Measures include shifting towards water-efficient crop varieties, adjusting cropping pattern and sowing window to match water availability and suitability of climatic conditions.
- Policy integration is needed at all levels in order to avoid repetition and duplication of national and provincial policies.
- Establish unlined floodwater ponds at farm level and mini-dams/check dams with community participation.
- Installation of gauging sites in the basin by both the riparian countries to improve data collection and availability for hydrological studies and climate change research.

Demand management with rising temperatures and population

- Improve water management through policy reform to bring about sustainable water management, whilst also targeting policies pertinent to the agricultural sector in order to ensure farmers gain access to the right technology.
- Improve demand management and efficiency particularly in the supply, distribution and use of irrigation water.
- Conserve groundwater aquifers - sustainable management of groundwater aquifers is needed to provide buffer against climate shocks, for example by introducing supply side solutions such as rainwater harvesting to help aquifer recharge.

Disaster management and coping strategies

- Develop efficient early warning systems with international cooperation and participation of the vulnerable communities, especially to deal with flash floods.
- Create artificial wetlands as a flood mitigation strategy, as being practiced with great success in China. Improved storage capacity of the system may improve natural ecosystems, resilience against floods and droughts, and the sustainability of the system as a whole.
- Revisit existing water infrastructure regulation practices, to enhance their efficiency and resilience under altered climate conditions.
- Measures to improve trust and coordination between national and transboundary weather and flood forecasting agencies through enhanced knowledge and data sharing.

Transboundary Waters
Sustainable Cities
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DRR
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References

- Biermann F, Dingwerth K (2004) Global environmental change and the nation state. Global Environ Polit 4(1):1–22
- Milly PCD, Betancourt J, Falkenmark M, Hirsch RM, Kundzewicz ZW, Lettenmaier DP, Stouffer RJ (2008) Climate change - Stationarity is dead: whither water management? Science 319(5863):573–574
- Pervaz, I. & Khan, S.M., 2014. Brewing Conflict over Kabul River: Policy Options for Legal Framework. The Journal of Of Climate Change In Large Himalayan Basins. , (July).
- Seidel, K., 2013. Modelling Runoff And Impact Of Climate Change In Large Himalayan Basins. , (July).
- Tahir, A.A. et al., 2011. Modeling snowmelt-runoff under climate scenarios in the Hunza River basin, Karakoram Range, Northern Pakistan. Journal of Hydrology, 409(1–2), pp.104–117. Available at: http://dx.doi.org/10.1016/j.jhydrol.2011.08.035.
- Wi, S., Yang, Y. C. E., Steinschneider, S., Khalil, A., and Brown, C. M.: Calibration approaches for distributed hydrologic models in poorly gaged basins: implication for streamflow projections under climate change, Hydrol. Earth Syst. Sci., 19, 857-876, https://doi.org/10.5194/hess-19-857-2015, 2015.

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About the Policy Brief

This policy paper is based on the research paper 'Impact of the 21st century climate change on surface water availability of the Transboundary Kabul River Basin' authored by Dr. M. Zia ur Rahman Hashmi and others from Global Change Impact Studies Center (GCISC). The contents of this brief have been gleaned solely from the research study.

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