Assessment of Future Climate Change Impacts on Water Resources of the Upper Kabul River Basin, Afghanistan Using SWAT model.

Tooryalay Ayoubi [a]*, Christian Reinhardt-Imjela [a] and Achim Schulte [a]

[a] *Department of Earth Sciences, Institute of Geographical Sciences, Applied Physical Geography, Environmental Hydrology and Resource Management, Freie Universität Berlin, Berlin, 12249, Germany.*

*corresponding author: Tooryalay.ayoubi@fu-berlin.de; Tel.: (+49) 1786101342

1. Objective

To evaluate the climate change impacts on the water resources in the UKRB under RCP4.5 and RCP8.5 scenarios.

- Developing a hydrological SWAT model for UKRB.
- Evaluation of SWAT by calibration and validation.
- Performing bias correction of precipitation and temperature for baseline (1986-2005), and two future periods, 2040s and 2090s.
- Analyzing the future impact of climate change on water availability for the 2040s and 2090s compared to the baseline period.

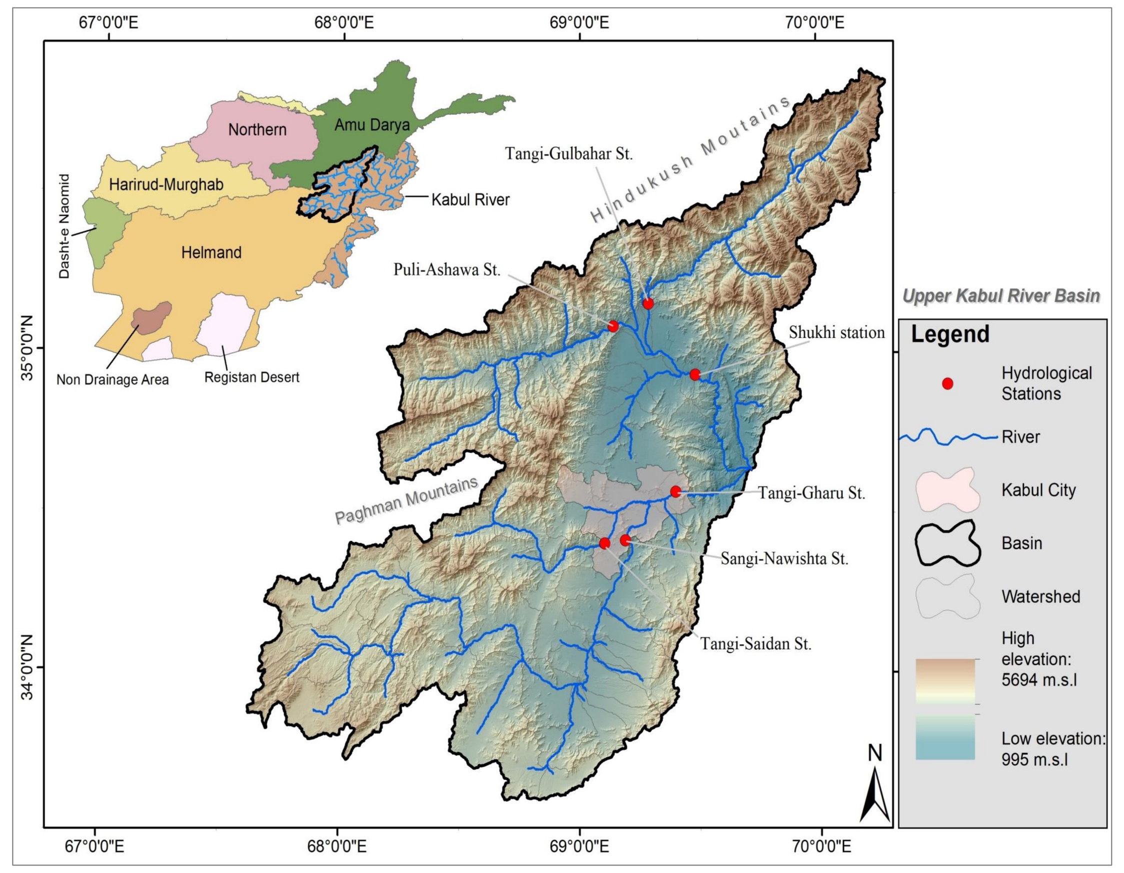

Fig.1: location of study area (Upper Kabul River Basin).

- **Area :** 26,043 km^2
- **Topography:** *Max elev 5,694 msl, Min elev 995 Msl.*
- **Precipitation:** annual 350mm
- **Snow melt** peaks in May and lasts until June or July.

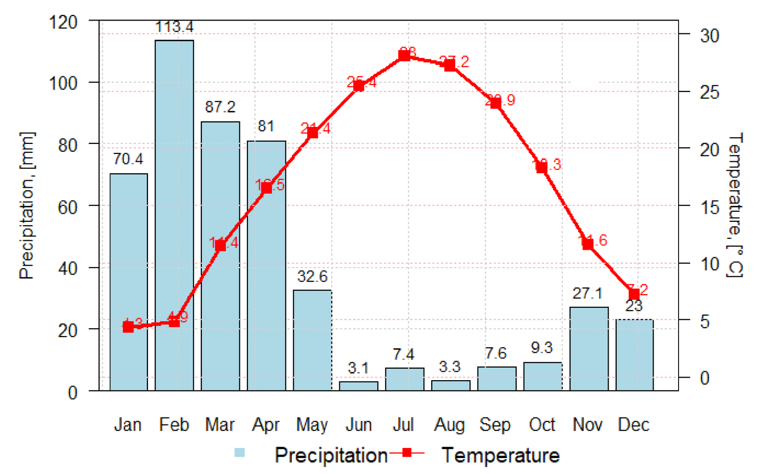

Fig.2: The climograph of Tangi Gulbahar station (2009-2019)

2. Input data to SWAT

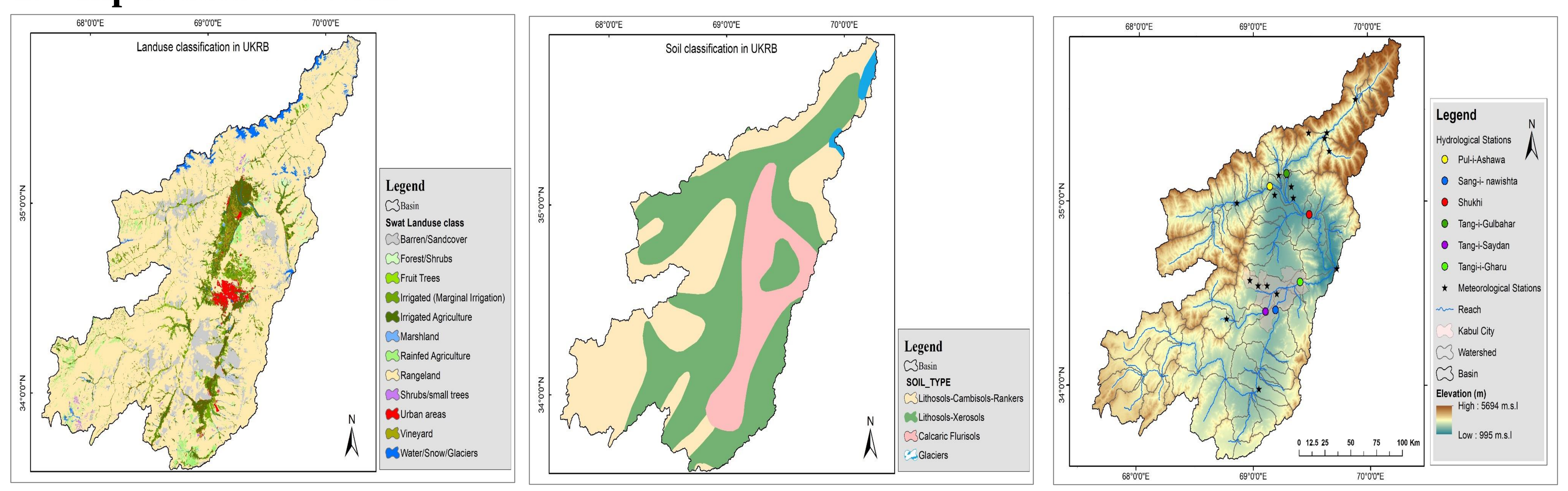

Fig.3: The land use/landcover map (a), Soil classifications map (b), Hydro-meteorological stations location (c).

3. Methodology

- SWAT model (2009-2019) https://swat.tamu.edu/
- Sufi-2 algorithm in SWATCUP tool https://swat.tamu.edu/software/swat-cup/

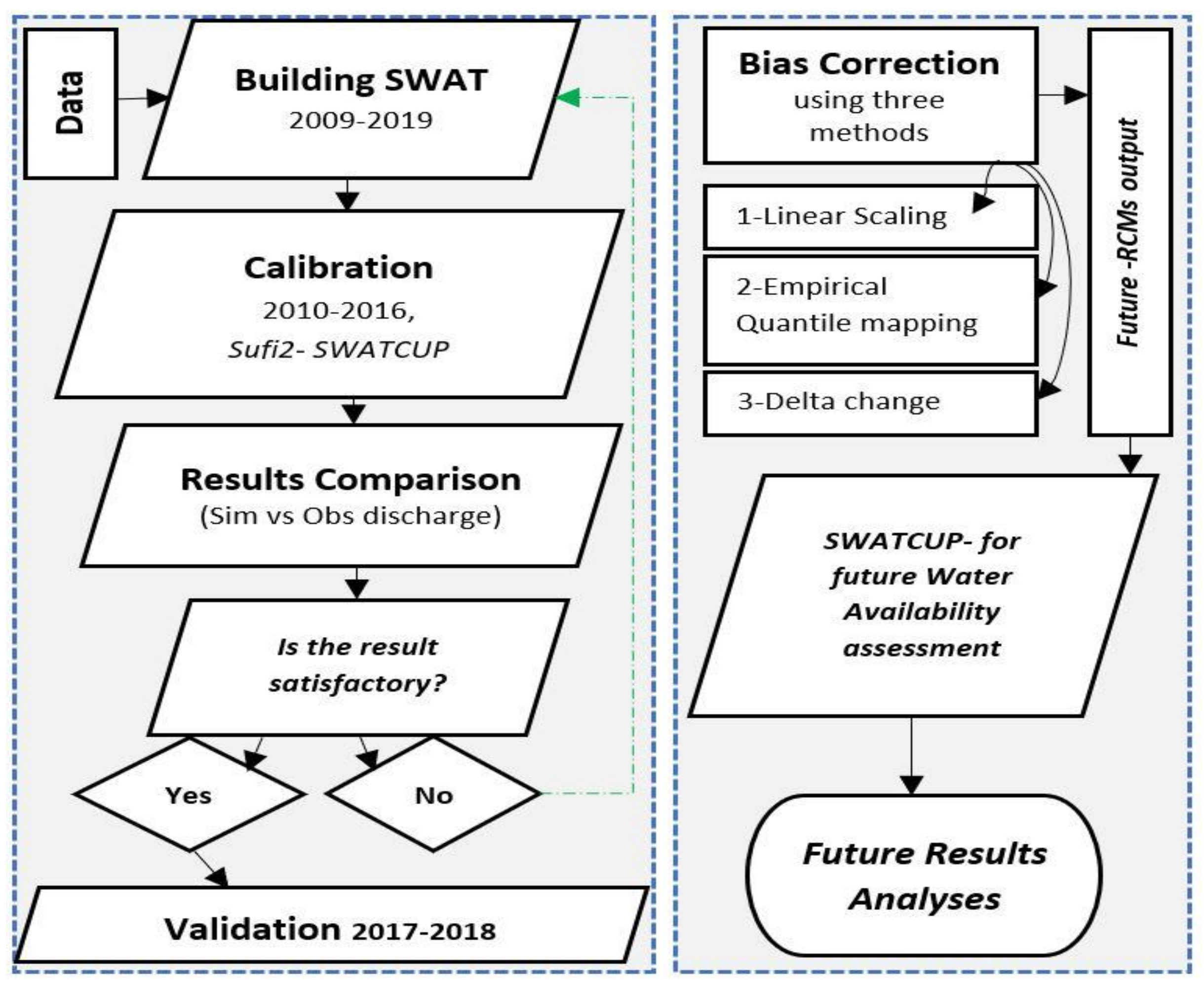

Fig.4: Flowchart for the model setup, calibration, validation and bias correction of RCMs in UKRB.

4. Bias-correction of temperature and precipitation

- Daily temperature and precipitation data for the baseline and future projections were obtained from the CORDEX South-Asia domain https://esgf-data.dkrz.de/search/cmip5-dkrz/.
- The global APHRODITE precipitation and temperature grid datasets were used as observed data, Ghulami et al. (2017).

***Table 1:** Description of regional climate models selected for this study.*

Domain	RCM	Driving GCM	Historical	RCPs 4.5 & 8.5	Institution	Resolution
WAS-44	RCA4	CanESM2-CCCma	1951-2005	2006-2100	SMHI [2]	0.44° x 0.44°
WAS-44	RegCM4-4	NOAA-GFDL-ESM2M	1951-2005	2006-2099	IITM [3]	0.44° x 0.44°
WAS-44i [1]	REMO2009	MPI-ESM-LR	1961-2005	2006-2100	MPI-CSC [4]	0.44° x 0.44°
WAS-44	RCA4	MIROC5	1961-2005	2006-2100	SMHI[2]	0.44° x 0.44°

5. Results

- Discharge hydrographs after calibration and validation of the model (Fig.5).
- Bias correction results of temperature and precipitation for the baseline and future periods (Fig.6, and Fig7).

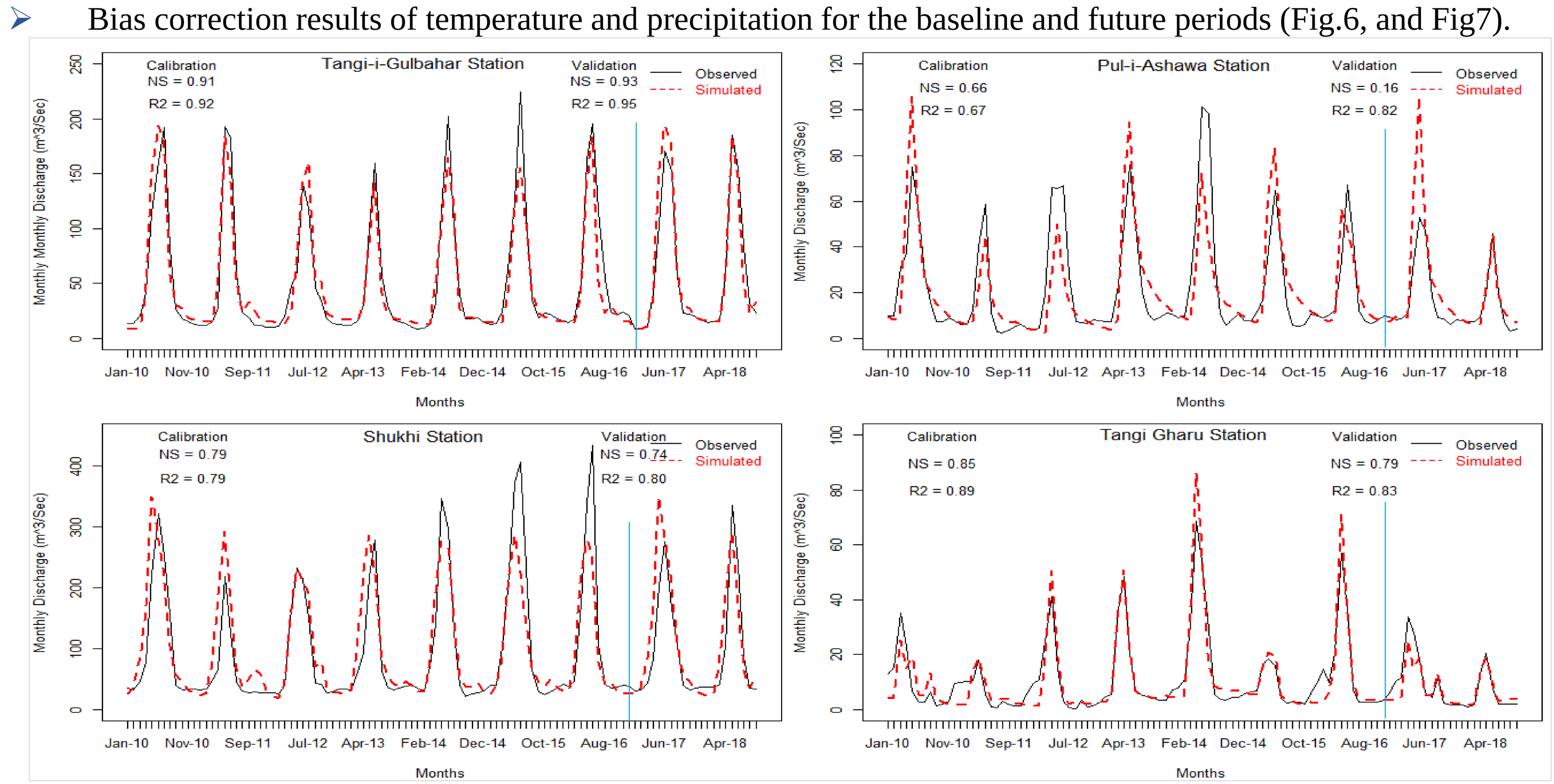

Fig.5: Comparison of monthly observed and simulated streamflow during calibration and validation at 4 stations located in UKRB.

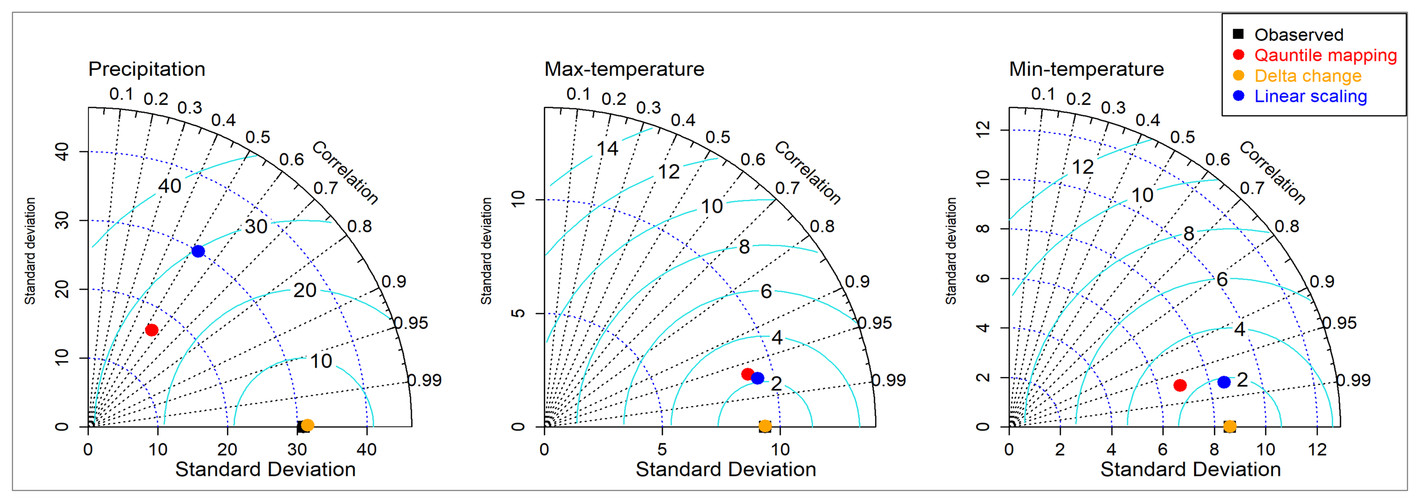

Fig.6: Taylor diagrams displaying a statistical comparison of bias-corrected for monthly precipitation, maximum temperature, and minimum temperature vs observations during the baseline period (1968-2005).

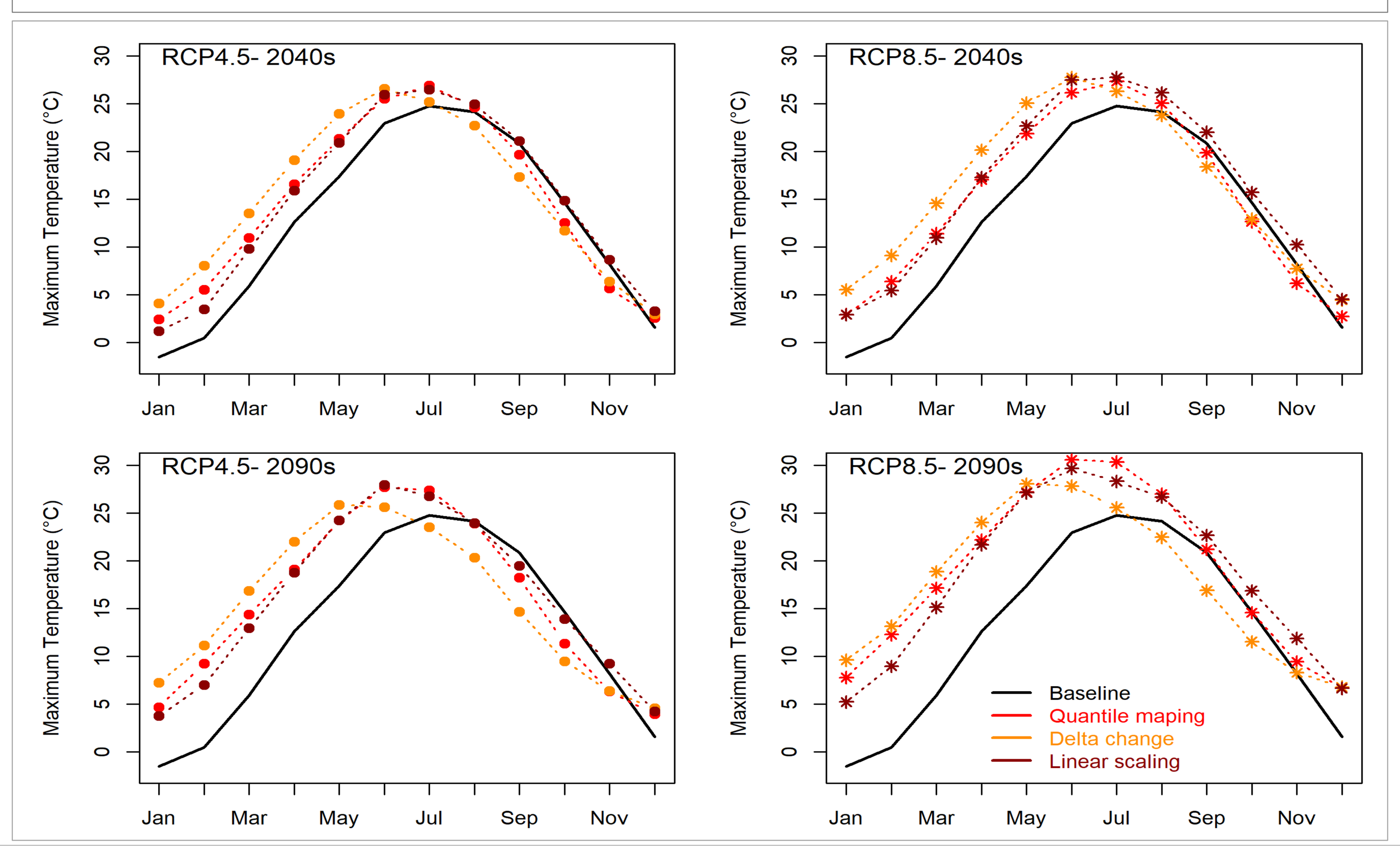

Fig.7: The mean monthly results of Maximum temperature for the future period of 2040s and 2090s under RCP4.5 and RCP8.5 in UKRB.

6. Future projected runoff results

- The future climate change impacts on water availibility were analyzed in UKRB. The long-term mean monthly runoff for the 2040s and 2090s under RCP4.5 and RCP8.5 compared to the baseline results are presented below.

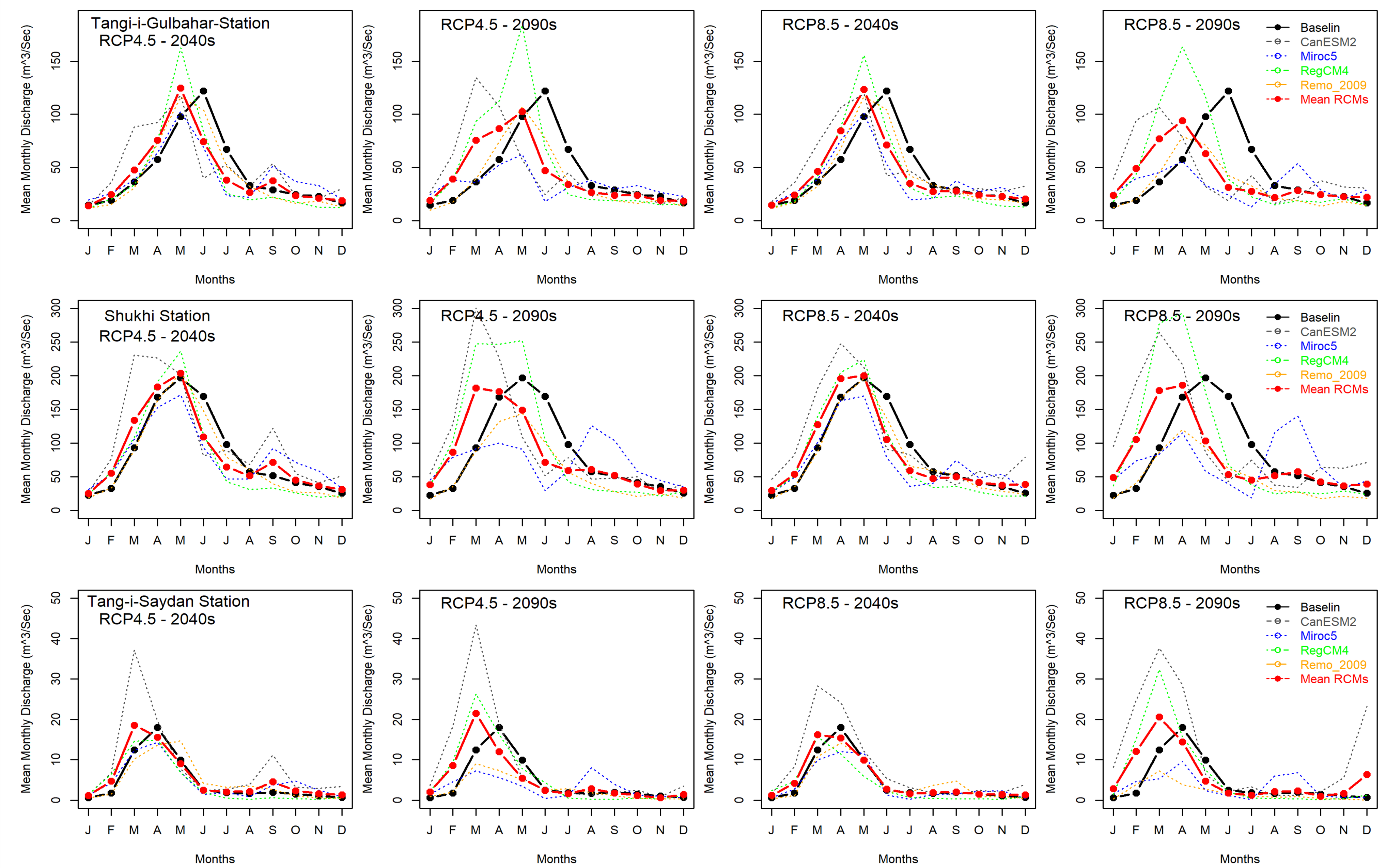

Fig.8: Future response of water flow compared to the baseline under RCP 4.5 and RCP 8.5 for Tang-i-Gulbahar, Shukhi and Tang-i-Saidan stations .

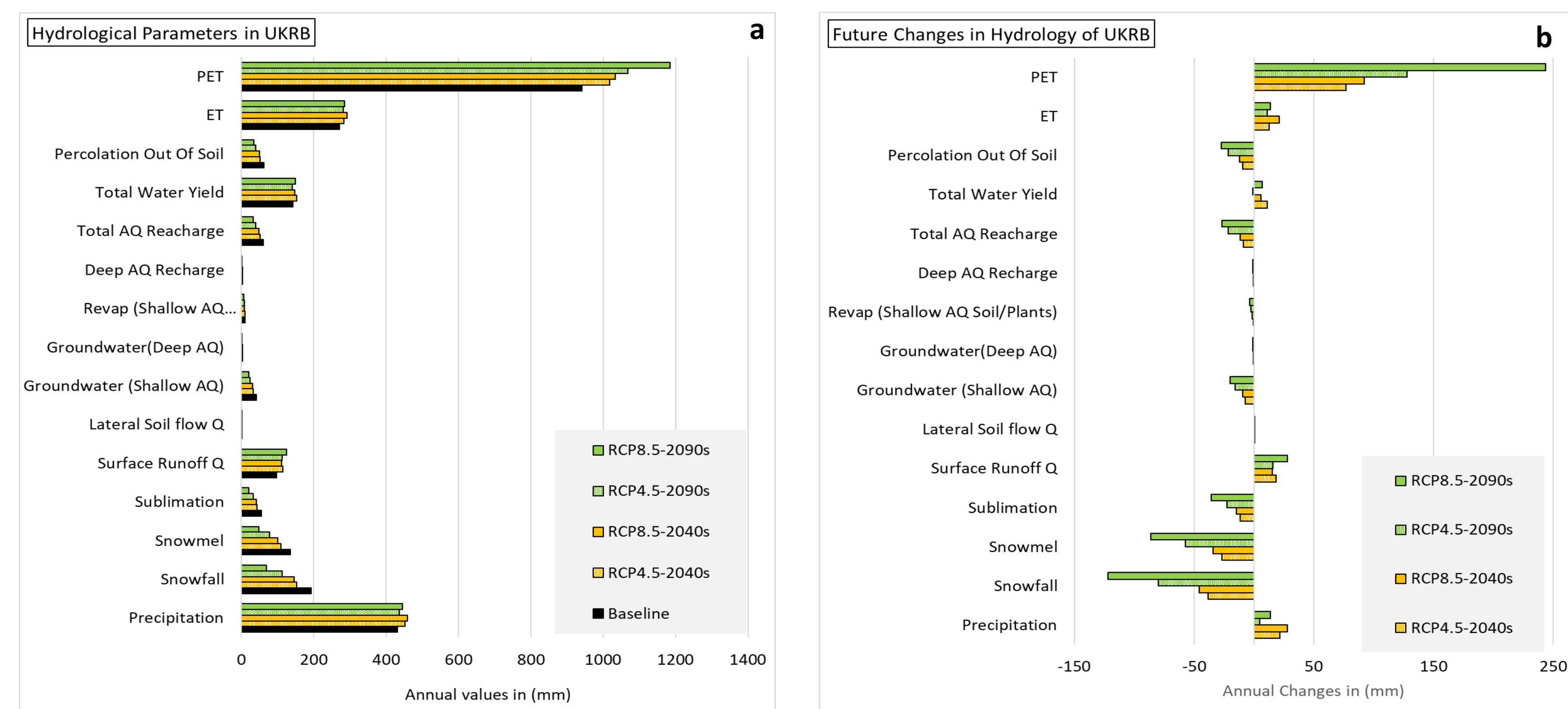

*Fig.9: **(a)** Annual hydrological parameters for baseline and future, and **(b)** Changes in annual hydrological parameters compared to the baseline under RCP 4.5 and RCP 8.5.*

7. Conclusion

- Climate model projections indicated that monthly temperature shows an earlier warming backward shift in June instead of July in upper Kabul river basin (UKRB).
- Climate change will impact the hydrology regime and will alter the pattern of snowfall to rainfall, increased surface runoff, and increased in evapotranspiration (ET) in UKRB.
- The mean annual surface runoff indicated an increase in both periods (2040s, 2090s) under both RCP4.5 and RCP8.5 scenarios, while a monthly decrease in summer runoff, and monthly increase in the winter and spring's runoff is expected.
- Consequently, frequent floods are expected to occur in the late winter and early spring, while droughts and less accessibility to water is expected in summer (high water demand) season.