Assessing Climate Change Impacts on Hydroelectric Trade: A Case Study of the Tamakoshi River Basin, Nepal

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Introduction:

The Tamakoshi River Basin (TRB), situated in the Himalayan region of Sino-Nepal, has been facing significant hydro-meteorological shifts due to climate change during the last three decades. This research aims to evaluate how climate change may further impact the hydrological patterns of the TRB by utilizing future climate projections derived from downscaled CMIP6 data. A hydrological model - Soil and Water Assessment Tool (SWAT) was applied for simulating the future hydrological processes. The model is well calibrated and validated at monthly as well as daily time scales for the baseline period (1985-2014). Combination of increased rainfall and snowmelt due to higher temperature in the future will most likely lead to an increase in the discharge of the Tamakoshi River. This study assesses climate change impact on river hydrology particularly on future energy generation and how the hydroelectric trade is expected to impact due to climate change in run-off-the river hydroelectric plants in Mountainous basins of Nepal.

Study Area

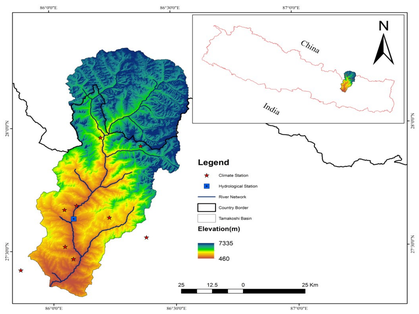
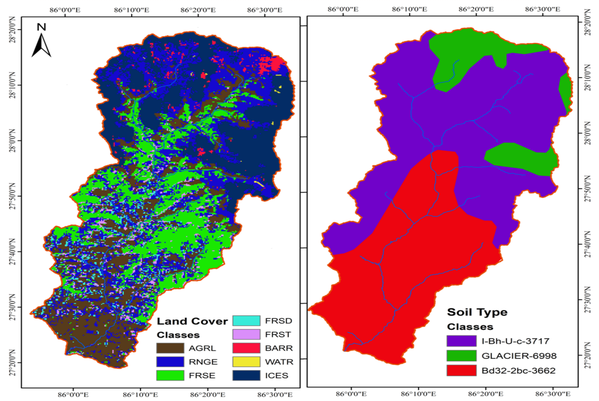
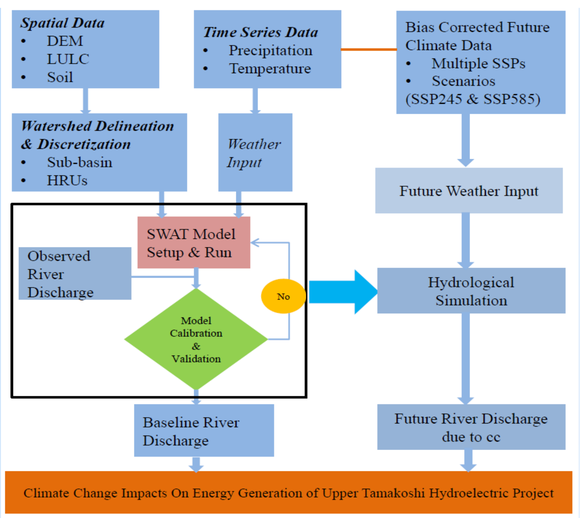


Fig. 1. : Tamakoshi River Basin



Methodology



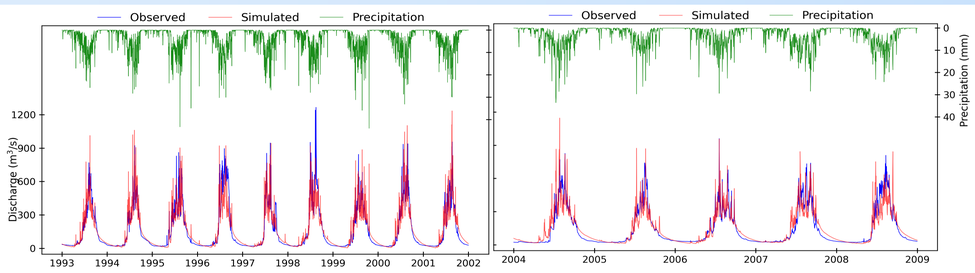


Fig. 2: Monthly Calibration and Validation of Tamaskshi River at Busti hydrological station

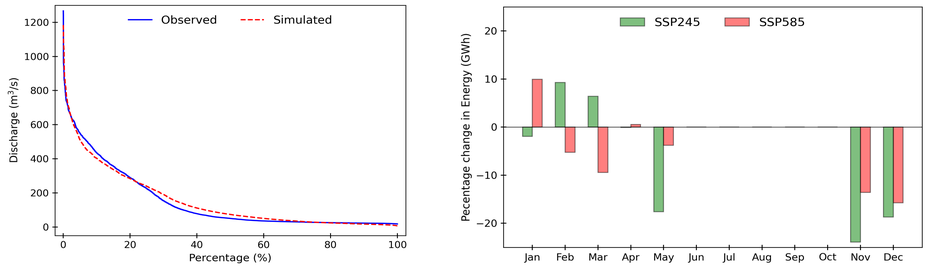


Fig. 3: Projected change (%) in Energy in the SSP245 and SSP585 scenarios for the future period(2031-2060).

Table 1: Statistical performance for Busti

Statistics	NSE	R^2	RSR	PBAIS	KGE	Performance
Calibration	0.78	0.79	0.47	-3.8	0.88	Very good
Validation	0.77	0.77	0.48	-4.19	0.86	Very good
Entire Simulation	0.78	0.79	0.47	-4.0	0.87	Very good

Conclusion :

- The annual water availability in the basin is likely to increase during (2030-2060) due to the hydrological shift in both monsoon seasons. However, the river discharge is expected to decrease in January, February, and March by 2 to 9 %, while it is expected to increase by up to 13 to 40% in both SSP 245 and SSP 585 scenarios.
- Dry season energy generation is expected to decrease (11%) under SSP 245 while decreasing (8%) under SSP 585. Total energy is more or less the same (2300 GWh).
- Uncertainty of dry season energy due to climate change will significantly impact the energy trade plan of Nepal.

Results and Summary:

- Five different CMIP6 models—ACCESS-ESM1, BCC-CSM2-MR, CNRM-CM6, GFDL-ESM4, and INM-CM5—were used for the future climate analysis.
- Mean annual precipitation under SSP245 and SSP585 scenarios for the future period (2031–2060) is projected to increase by 2% and 8%, respectively, compared to the baseline period (1980–2014).
- Annual average daily maximum and minimum air temperatures are expected to rise by 1.0–1.1°C and 1.4–1.7°C, respectively, under SSP245 and SSP585.
- Annual average runoff is estimated to increase by 2% and 9% under the SSP245 and SSP585 scenarios for the same period, depicting changes in future climate conditions.
- Future average annual discharge is projected to rise in both scenarios. However, river discharge is expected to decrease in the dry season and increase in the wet season.
- Dry season energy generation is likely to decrease in both scenarios; 11% in SSP245 and 8% in SSP585. A significant decrease (14% to 24%) is expected in November and December in both scenarios.