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Ministry of Energy, Water Resources and Irrigation
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# Analysis of Water Balance in Dudhkoshi River Basin, Nepal

## Background

Nepal is enriched with abundant water resources which are acts as the catalyst for socio-economic development of the country. Moreover, it's strategic location between two large energy growing markets, India and China offers additional value to the natural resources. Natural and anthropogenic activities causes negative impact on water resources posing the risk of flood and drought by changing the hydrological regime.

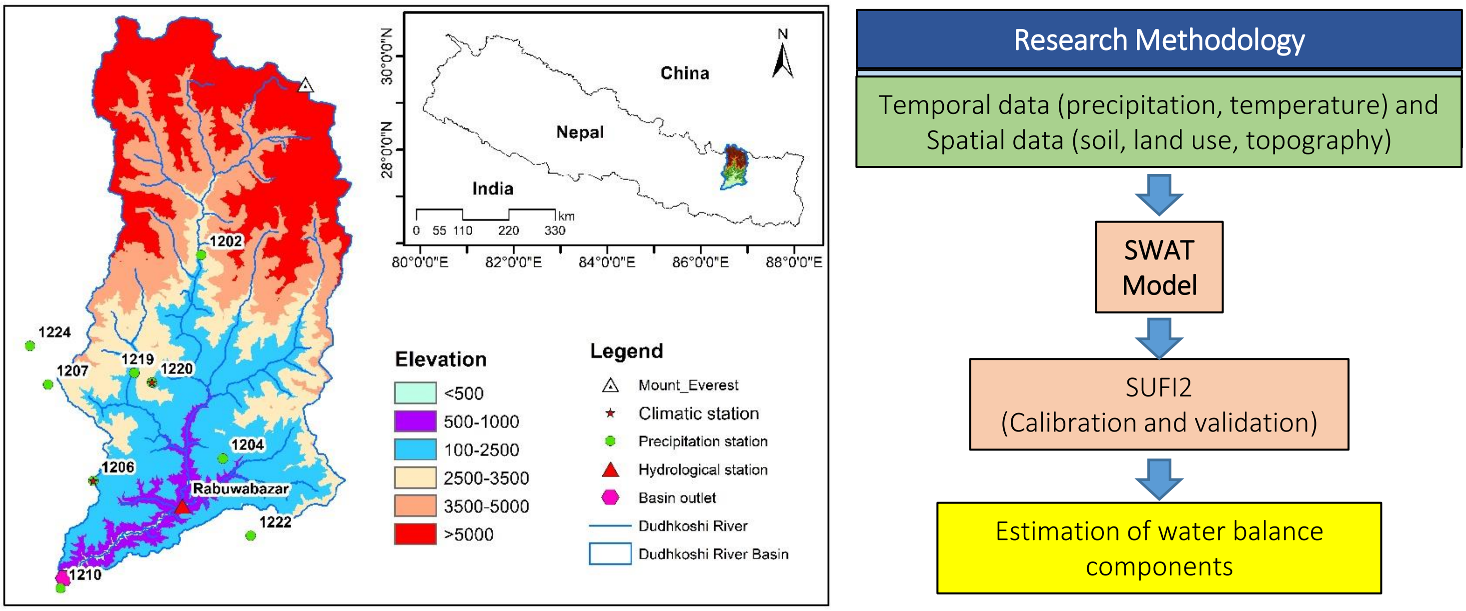


Figure 1: Location Dudhkoshi River Basin with stream network and topography (left) and research method (right)

Dudhkoshi River Basin (DRB) is located in Northern part of Eastern Nepal with catchment area 4068 km$^2$ between 27$^0$15’ to 28$^0$5’ latitude and 86$^0$30’ to 87$^0$0’ longitude and it is one of the major tributary of Koshi River (Figure 1). The elevation of the basin ranges from 227 to 8848.86 m asl (Mount Everest).

## Conceptualization and compilation

This study aims to assess the water balance components in DRB. Soil and Water Assessment Tool (SWAT) (Arnold et al., 1998) was used to setup hydrological model which simulates hydrology based on water balance equation. Nine precipitation and two climatic station were used for model setup. Daily precipitation and climatic data were collected for 1984 to 1999. Hydrological data of Rabuwabazzar stations (3854 km$^2$) was collected for 1986 to 1999. Hydro-meteorological data were collected from Department of Hydrology and Meteorology (DHM), Nepal. Advance Spaceborne Thermal Emission and Reflection Radiometer Global DEM (ASTER- GDEM) version 3 of 30 m resolution (https://portal.opentopography.org/datasets) was used to define topography of the basin and stream generation. The land use map at 30 m resolution (ICIMOD, 2010) and Soil and Terrain Database (SOTER) for Nepal at 1:1 million spatial resolution (Dijkshoorn and Hunting, 2009) was used for model setup. The model was calibrated and validated at Rabuwabazzar hydrological station using SWAT Calibration Uncertainty Program (SWAT-CUP). Calibrated model was used for the estimation of water balance components for DRB. The location of hydro-meteorological stations along with stream network and topography is presented in Figure 1.

## Results

**i) Sensitive analysis**

Among the 28 chosen parameters, base flow Alpha factor for bank storage (ALPHA_BNK) followed by length of main channel (CH_L2), effective hydraulic conductivity in main channel (CH_K2) and threshold depth of water in shallow aquifer (REVAPMN) were the most sensitive parameters with p-value ≤0.05. ALPHA_BNK was the most sensitive parameter indicating bank storage as a dominant process in the basin.

### ii) Performance of SWAT model

Model was calibrated (1986-1994) and validated (1995-1999) with initial three years (1983-1985) as warmup period at Rabuwabazzar hydrological station. Performance of the model is presented in Figure 2. The simulated daily streamflow at hydrologic stations was consistent with observed stream flow and daily rainfall. Nash-Sutcliffe Efficiency (NSE), Coefficient of Determination ($R^2$) greater than 0.70, and Percentage Bias (PBIAS) within ±15 % were observed during calibration and validation showing the good prediction capability of the model.

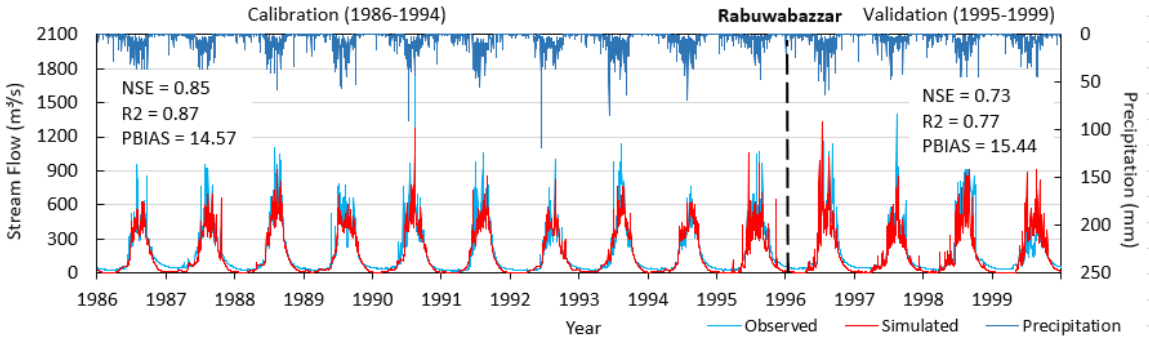


Figure 2: Comparison of simulated and observed streamflow

### iii) Estimation of water balance

Mean annual precipitation over basin was estimated to be 2874 mm. Mean annual snow fall over the basin was estimated as 1547 mm of which 73 mm snow melts contributing to the streamflow. Mean seasonal precipitation estimated as 344 mm, 2295 mm, 105 mm and 130 mm for pre-monsoon (Mar-May), monsoon (Jun-Sept), post-monsoon (Oct-Nov) and winter season (Dec-Feb), respectively. The actual evapotranspiration (AET) is also high during four months of monsoon season. Annual evapotranspiration from the basin is estimated to be 154 mm which is about 6 % of annual precipitation. The net water yield is the aggregated sum of surface runoff, lateral flow, ground water with deduction of losses including transmission and pondage losses. Change in storage is the aggregated sum of ground water recharge, soil water content and losses joining deep aquifer. The change in storage is 384 mm in July exhibits ground water recharge whereas, 11 in December indicates storage contributing stream flow. Annual water yield at basin outlet is estimated to be 1325 mm.

## Conclusions

Average flows are well simulated by the model which can be use for the design of hydropower projects. Low flows are also well simulated which can be use for the design of water supply and irrigation projects in the basin. Annual water yield at basin outlet was estimated as 1325 mm. The results of this could be useful for policymakers, designers and investors.

### References


Arnold, Jeffrey G., et al., 1998, Large area hydrologic modeling and assessment part I: model development 1. JAWRA Journal of the American Water Resources Association 34.1: 73-89.

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**FOR FURTHER INFORMATION:**


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