HYDROLOGICAL MODEL FOR WATER AVAILABILITY ASSESSMENT IN THE KARNALI-MOHANA BASIN

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CHALLENGE

The Karnali and Mahakali basins account for 28% of water resources in Nepal. There are **150 identified hydropower projects** at various stages of development, with an estimated installed capacity totalling more than **21,000 MW**. Many projects are irrigating thousands of hectares of land. **Understanding water availability across location and time** of interest is crucial for enabling policy and decision-makers, implementing agencies, and practitioners to understand the different risks to water and environmental security; design policies and programs; and devise strategies for better allocation, utilization, and management of freshwater resources. Properly calibrated and validated **hydrological models**, with high spatial and temporal resolution, are useful to better understand water availability and evaluate impacts under various scenarios.

RESEARCH APPROACH

We set up a hydrological model in the Soil and Water Assessment Tool (SWAT), using both geospatial (e.g., land use/-cover, soil, topography) and time-series (rainfall, temperature, etc.) data as inputs; calibrated and validated the model at multiple locations against observed river flow; and used the model to assess water availability as well as water balance components at various sub-watersheds over the months.

INSIGHTS AND INNOVATIONS

- The new hydrological model is capable of reproducing the hydrological pattern, average flows, and flow duration curve at 111 locations in the Karnali-Mohana basin.
- The basin's diverse agro-ecological zones (i.e., Trans-Himalayan, Mountain, Hill and Tarai) have different bio-physical characteristics. Rainfall, for example, ranges from less than 500 mm in the Trans-Himalayas to above four-fold in the mountain and hill regions. Similarly, water generated in the mountain and hills are up to 2.5-folds compared to water generated in the Trans- Himalayas region.
- Nearly 36% of rainfall/year is evaporated from the Karnali-Mohana basin; however, it varies across the locations, with higher percentage in high mountains and then decreasing gradually towards Hills and Tarai.
- The monsoon season (Jun-Sep) contribution is more than two-third of the annual rainfall, evapotranspiration, and net water yield, respectively at the Karnali-Mohana basin.
- The total volume of water that Karnali basin carries in a year is estimated as more than 44,500 million cubic meters (MCM).

IMPACTS

- Hydrological simulation based on the hydrological model is further used for environmental flows assessment (in Environmental Flows Calculator) and evaluating trade-offs (in Hydro-Economic Modeling) among various water development pathways.
- These model results are used in the National Irrigation Master Plan being developed by Nepal's Department of Water Resources and Irrigation.
- The models are valuable for enabling water resources planners and managers to develop location-specific strategies, even within a single basin, for sustainable utilization and management of water resources.

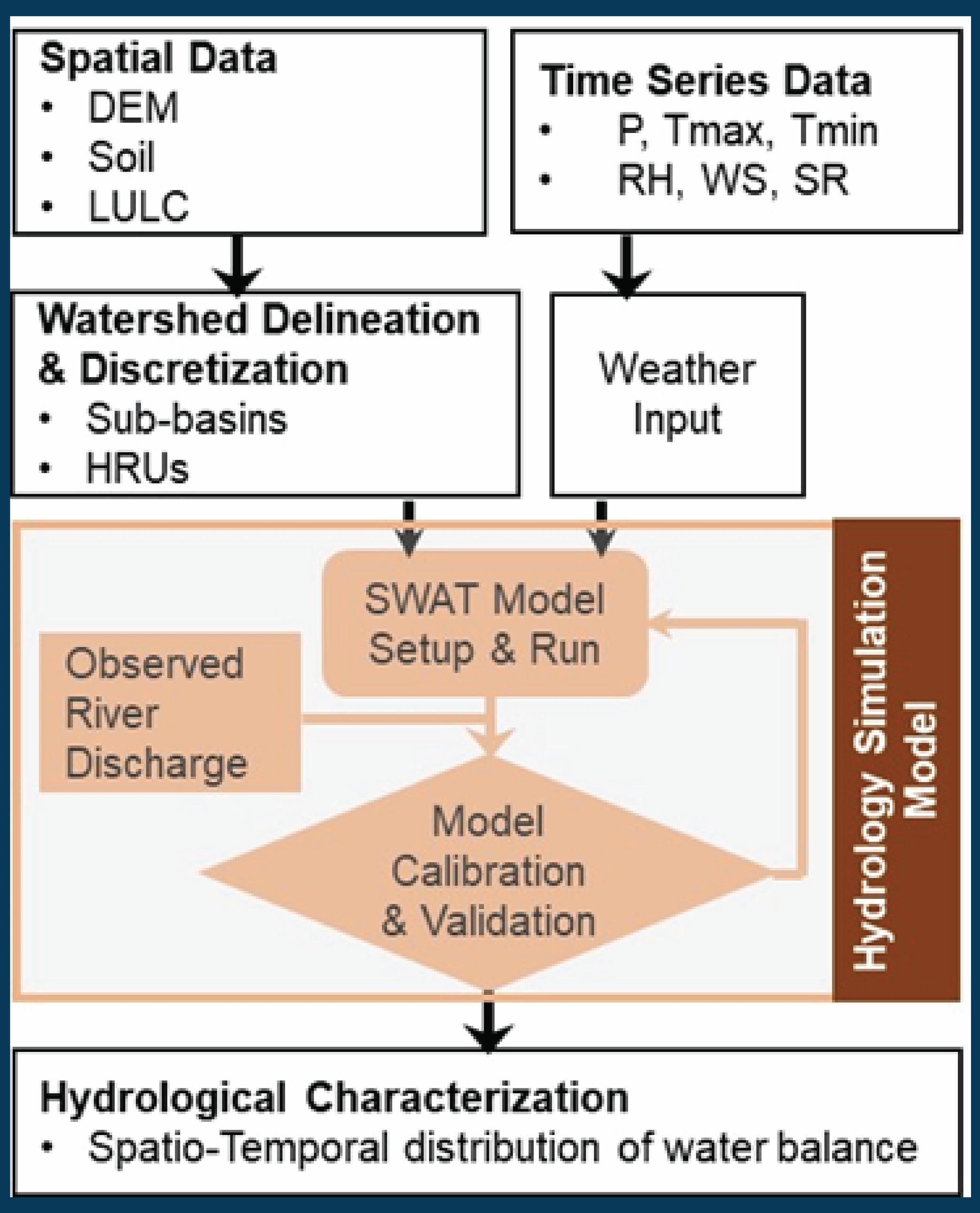

Figure 1: Methodological framework for developing and applying the hydrological model for characterization of the Karnali-Mohana (KarMo) basin. DEM – Digital Elevation Model; LULC – land use/cover; HRU – hydrological response unit; P – precipitation; T – temperature; RH – relative humidity; WS – wind speed; and SR – solar radiation

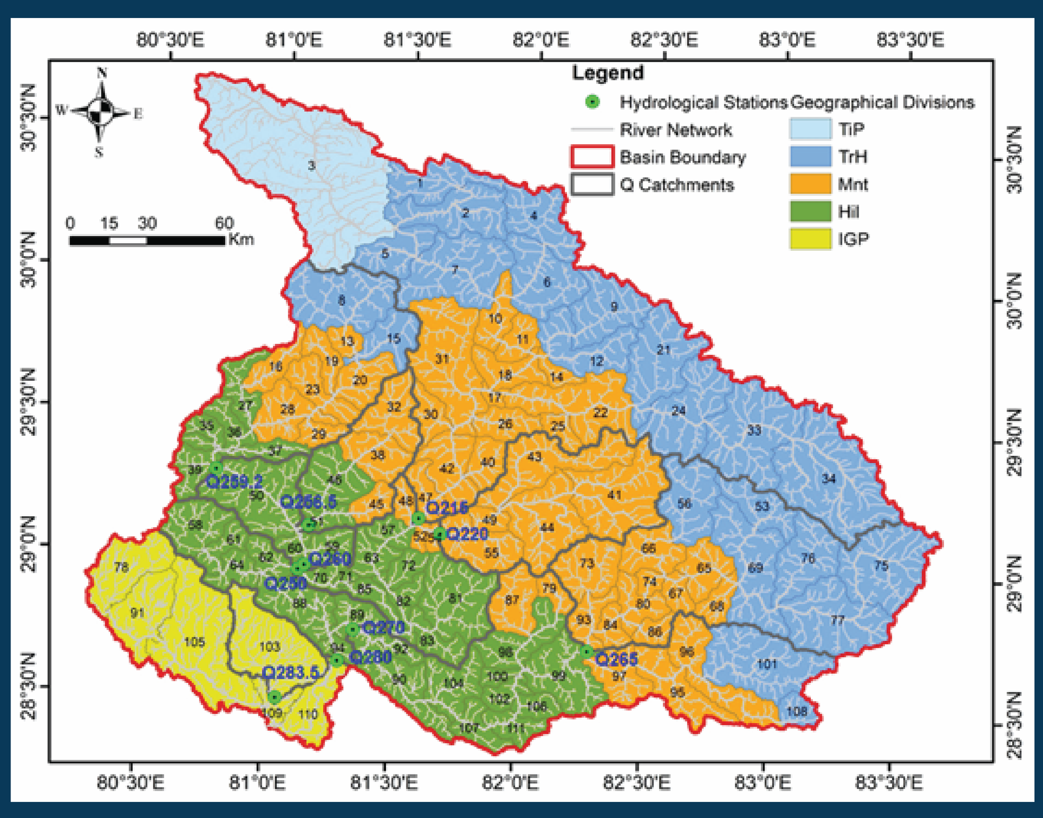

Figure 2: SWAT sub-watersheds and model calibration stations along with geographical divisions of the KarMo basin. TiP – Tibetan Plateau; TrH – Trans-Himalaya; Mnt – Mountain; Hil – Hill; IGP – Indo-Gangetic Plain.

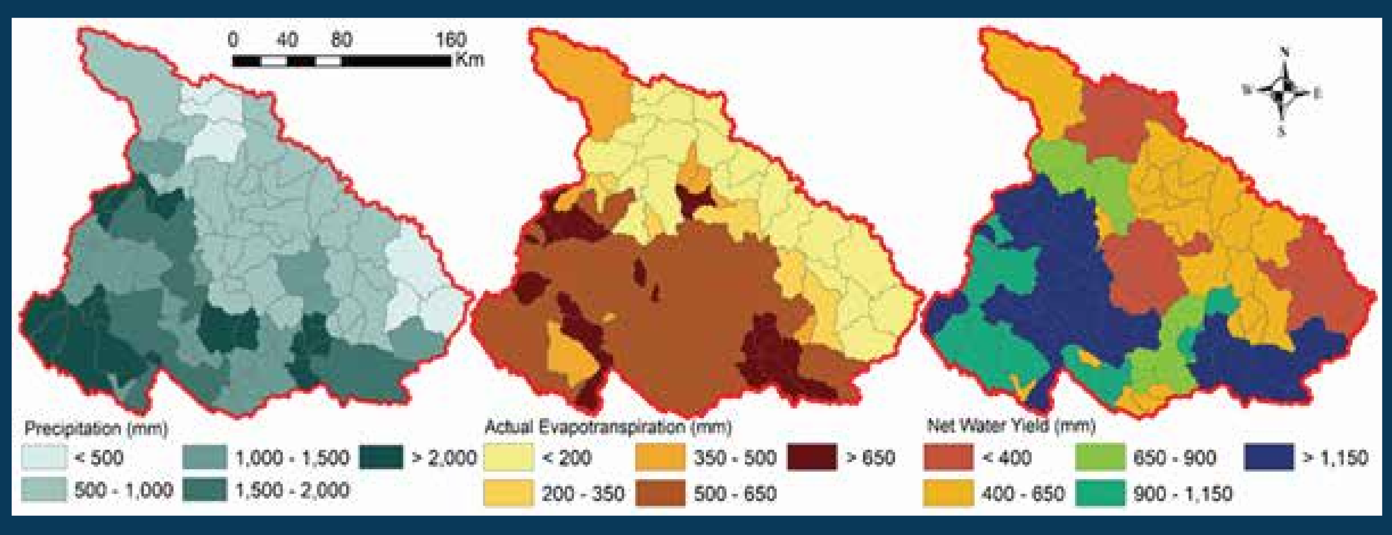

Figure 3: Spatial distribution of average annual precipitation (P), actual evapotranspiration (AET) and net water yield (Q) across sub-basins in the Karnali-Mohana basin.

Figure 4: Mean monthly simulated (1995-2009) water balance in the KarMo basin. storage is a collective term including groundwater recharge and change in soil moisture storage.

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