HYDRO-ECONOMIC MODELLING OF WATER USE TRADE-OFFS IN WESTERN NEPAL

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CHALLENGE

In developing countries that are rich in water resources, harnessing these resources for productive use offers a pathway to economic development. The opportunities include energy generation, irrigation for agriculture, and industrial development, among others. These uses often entail complex and inter-sectoral trade-offs, however, including those with non-market livelihood needs and environmental conservation. A cohesive method for evaluating the advantages and disadvantages of various options in water resource management is essential for effective planning. This paper offers one such approach for the Karnali and Mahakali River Basins in Western Nepal.

RESEARCH APPROACH

A hydro-economic model (HEM) was developed for these basins and used to maximize the total economic benefit across the (i) energy and (ii) agriculture sectors, subject to meeting environmental and municipal demands, each of which are included as separate but interconnected modules. The HEM was parameterized using hydrology data from a SWAT model of the basins, information from national and local plans and policies, and documentation from specific hydropower and irrigation projects.

Four development scenarios were developed and analyzed: (i) status quo conditions, (ii) full infrastructure development, (iii) limited infrastructure development and (iv) environmental development. These scenarios were analyzed for mean, high, and low flow years. Sensitivity analyses were conducted for environmental flows, institutional withdrawal constraints, and electricity distribution.

INSIGHTS AND INNOVATIONS

Results from the HEM demonstrate that irrigation and hydropower infrastructure offer high potential value as development priorities in Western Nepal.

The economic value generated through large-scale infrastructure depends in part on power trade agreements between Nepal and its neighbors, notably India. If the value of electricity in domestic markets is higher than export prices, then electricity generated in the basin should be used to contribute to meeting demand in Western Nepal. However, once this value dips below export prices, excess potential exists in the region that can best be allocated to export markets.

There are substantial trade-offs between institutionally mandated diversion constraints and agricultural productivity.

While the incorporation of more stringent environmental constraints does imply costs, these can be reduced by careful determination of protected waterways. They can also be offset by ecotourism and recreational benefits, which we were unable to value in this study.

More stringent environmental flow constraints result in some trade-offs with both energy generation and agricultural production. In the absence of these constraints, however, flows are permitted to fall below levels that may be dangerous for preserving aquatic ecosystems.

NEXT STEPS

Hydro-economic modeling is a useful tool for basin management planning, which offers important insights into potential economic benefits from productive water use. The model can be modified to examine potential outcomes of management plans and policies beyond the main and sensitivity analyses conducted so far.

Next steps include running the HEM for an extended time horizon to account for lifespan operations of irrigation and energy infrastructure investments, incorporating infrastructure costs into the model explicitly, ascribing economic value to environmental conservation and municipal demands within the HEM, and expanding the focus on agriculture. Furthermore, as additional data from the Karnali and Mahakali River Basins become available, the model parameters can be updated.

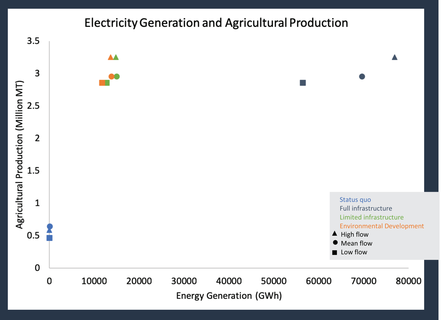

Figure 1: Electricity generation and agricultural production in the base HEM model.

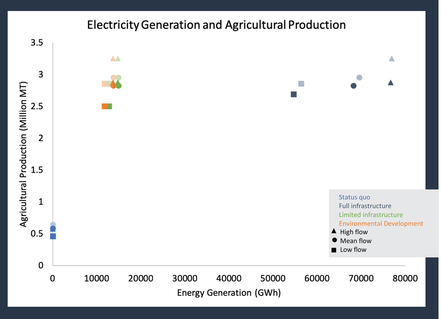

Figure 2: Electricity generation and agricultural production with more stringent environmental flows.

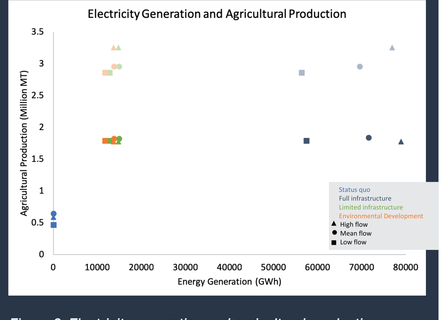

Figure 3: Electricity generation and agricultural production with institutional withdrawal constraints.

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