Securing a resilient future for Pakistan: How hydro-economic modeling guides evidence-based adaptation

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Pakistan's water crisis has steadily evolved into a binding constraint on economic growth, food security, and climate resilience. Behind this crisis lie the tightly coupled challenges of rapid groundwater depletion, rising energy costs for pumping, overreliance on water-intensive crops such as rice and sugarcane, and increasing climate variability. This calls for solutions that recognize the water–energy–food–environment (WEFE) nexus. For years, policy discussions acknowledged these interlinkages; yet decision-making largely relied on sector-by-sector evidence, making it difficult to anticipate economywide consequences of water-related reforms. What was missing was a nationally relevant hydro-economic framework capable of quantifying trade-offs, synergies, and distributional effects of alternative policy pathways. Policymakers and researchers have long understood this need but have taken limited steps to develop such a framework until recently – with the development and launch of the Hydro-Economic Decision Support System.

Providing the evidence for difficult policy choices

Policymakers in Pakistan are being increasingly called upon to make investment and policy choices in the water and food sectors, often with limited evidence on their wider economic consequences. They must anticipate how changes in water or agricultural policies affect farm incomes, agricultural production and exports, and employment – guided mainly by sector-level studies with little assessment of economywide effects. During ministry-level consultations facilitated by IWMI and IFPRI, officials stressed the need for forward-looking and integrated evidence to support planning and policy design, particularly under growing water scarcity and climate pressures. For instance, the Ministry of Water Resources wanted to understand the impact of reducing the area of water-intensive crops. While such shifts could ease pressure on scarce water resources, policymakers lacked clear answers on the wider consequences, such as implications for national food supplies. The WEFE nexus approach has also become a priority for the Pakistan Institute of Development Economics (PIDE), as it seeks to develop a suite of new models to fulfill its mandate to provide analytical support to the Ministry of Planning, Development & Special Initiatives.

Beyond sector-specific planning

- **Co-evolving the modeling system:** Responding to demand from policymakers to understand economywide trade-offs, IWMI and IFPRI updated a Computable General Equilibrium–Water (CGE-W) model using recent datasets and collaborating with relevant departments.
- **Hands-on training:** Researchers (including from PIDE) have attended several workshops on the model, where step-by-step creation of scenarios linked to actual policy options were designed, and then policy assessments based on the simulations were produced.
- **A live dashboard:** PIDE now hosts Pakistan's Hydro-Economic Decision Support System (CGE-W portal), enabling analysts and non-technical stakeholders to interact with model outputs and scenarios through a visual dashboard.
- **Boosting national capacity:** Researchers within PIDE are moving from reliance on external sources for model runs to operating and customizing the CGE-W framework itself – expediting policy analysis and strengthening ownership.
- **Improved dialogue:** The dashboard has been used in cross-sector meetings to demonstrate economywide consequences of water policies, making trade-offs easier to discuss and negotiate.

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Overcoming data and institutional barriers

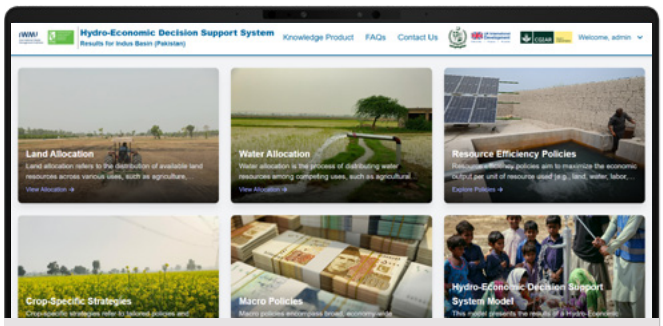
A key challenge was to update the existing Computable General Equilibrium–Water (CGE-W) model in the context of a data-scarce and highly fragmented information environment, particularly for agriculture and water. Where key parameters – such as irrigation intensity, groundwater pumping costs, and energy use in agriculture – were unavailable, the team had to reconstruct data from partial surveys, project reports, and expert consultations. Meanwhile data inconsistencies across provinces had to be approached using systematic triangulation of administrative records, remote sensing data, and secondary literature. This was done in close collaboration with national institutions to validate assumptions and ensure policy relevance.

The researchers first assembled a social accounting matrix (SAM) showing how money flows across the economy. That encompasses everything from farmers selling crops, through to households buying food and government spending on irrigation – and how those expenditures affect incomes in related non-agricultural sectors. The SAM was built using data from household surveys, government statistics, and special studies, ensuring that the sources align and the national economy is depicted comprehensively and consistently. The SAM was then linked to biophysical data across 16 agroecological zones based on local climate and farming conditions.

Crucially, this system thus connects biophysical data, like how much water is in a canal, to economic data, like the cost of pumping groundwater when the canal runs dry. The tight connection of biophysical and economic systems allows policymakers to understand how a change in cropping patterns in a water-scarce area of Balochistan, for example, has a different economic impact than the same change in a water-rich area of Punjab.

Scaling impact

Building on the successful launch of the Hydro-Economic Decision Support System, the next phase of the program shifts from model development to full-scale operationalization. The strategy for scaling revolves around three critical areas: broadening the scientific lens through more complex policy scenarios; deepening national capacity within government and academic institutions; and expanding the reach of the digital dashboard to make data and results accessible to more levels of decision-makers, supporting more evidence-based policy changes. To this end, the researchers are co-designing scenarios with stakeholders to inform actionable reforms that are owned and implemented by those participants. Future work will also expand scenarios to include climate extremes, groundwater governance options, and distributional impacts – thereby coupling outputs to equitable and resilient policy choices. Immediate next steps include linking the CGE-W outputs to subnational planning tools and training additional staff across key ministries and research institutions. This will ensure that the WEFE nexus approach moves from a research output to a routine pillar of Pakistan's governance.



The Hydro-Economic Decision Support System dashboard allows decision-makers to assess trade-offs and optimize resource allocation. Image: IWMI

Further reading

Davies, S., I. Akram, and M. T. Ali. "Water Resources Using Hydro Economic Models for Decisions in Water, Energy, Food and Environment (WEFE): Examples from Pakistan." Presentation at the NEXUS Gains International Winter School, Islamabad, Pakistan, December 23–27. IFPRI, 2024.

Davies, S., I. Akram, M. T. Ali, M. Hafeez, and C. Ringler. *The Economywide Impacts of Increasing Water Security through Policies on Agricultural Production: The Case of Rice and Sugarcane in Pakistan*. IFPRI Discussion Paper 2226. IFPRI, 2023.

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