Water resources: Defusing conflict, promoting cooperation

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Mega-dam on the Omo River: Gibe III (2016). Credit: Mimi Abebayehu/Wikimedia Commons

Rivers are lifelines for many countries. They create valuable ecosystems, provide drinking water for people and raw water for agriculture and industry. In the Global South in particular, there is strong competition for access to freshwater resources. The increasing use of hydropower has recently intensified this competition further.

Take Ethiopia, for example: when the country began filling the mega-dam Gibe III on the Omo River in 2015, downstream users saw a drop in water volumes. Natural flooding declined, reducing the volume of fertile mud washed onto the floodplain. The level of Kenya's Lake Turkana, into which the Omo flows, fell temporarily by two meters, resulting in significant consequences for people and agriculture.

Addressing the nexus

The network of interactions between water, energy, food and ecosystems—referred to by experts as the "water-energy-food (WEF) nexus"—often leads to wide-ranging disputes in the catchment areas of transboundary rivers. Large-scale infrastructure construction projects such as dams and irrigation schemes have caused political tensions between neighboring states at various points in the past.

An international research team led by ETH Zurich has now developed a strategic toolkit that can help to defuse such conflicts over water use, through an objective analysis of stakeholder's interests. In the EU's Horizon 2020 project DAFNE, 14 research partners from Europe and Africa worked together to find approaches to a more equitable management of water resources.

"We wanted to show how it is possible to sustainably manage the nexus between water, energy, food and ecosystems, even in large and transboundary river basins with a wide range of users," says Paolo Burlando, Professor of Hydrology and Water Resources Management at

ETH Zurich.

Integrating and balancing different interests

While it is now recognized that watershed planning should take a holistic approach that respects the needs of all stakeholders, multidimensional decision-making problems with significant numbers of stakeholders make it difficult to negotiate generally accepted solutions.

"Conventional planning tools are usually overwhelmed with challenges such as these," explains Burlando, who has led the DAFNE consortium for the past four years. This is why the project team developed a novel method to map and quantify trade-offs in the WEF nexus.

The approach is based on the principles of the participatory and integrated planning and management of water resources, which focuses on the role and interests of stakeholders. The DAFNE methodology is designed to engage stakeholders and find compromises and synergies in a joint approach. "The key is to find solutions that benefit everyone, take the environment into account and also make economic sense," explains Burlando.

Enabling dialog through models

DAFNE uses state-of-the-art modeling techniques and digital solutions to enable participatory planning. A strategic decision tool allows the social, economic and environmental consequences of interventions to be assessed in a quantitative approach, enabling users to identify viable development pathways. Stakeholder selected pathways are simulated in detail using a hydrological model driven by high-resolution climate scenarios, in order to accurately analyze the impact on the respective water resources. Additional sub-models can be used to model other

aspects of the nexus. Finally, a visualization tool helps to illustrate interrelationships and assess problems from various user perspectives.

"The models aim to facilitate continuous negotiation between stakeholders—which is a key element of the DAFNE approach," says Senior Scientist Scott Sinclair, who co-developed the modeling approach.

Case studies with local stakeholders

The DAFNE project focused on two large river basins in East, and Southern Africa—the Omo-Turkana and Zambezi—where the researchers tested their methodology in two case studies. In both case studies, real stakeholders were involved in the development of the DAFNE approaches, working with them to test alternative operating modes for the power plants and irrigation schemes, to design more sustainable use scenarios for their catchment areas. They exchanged their different perspectives in simulated negotiations to illustrate the process.

In the Omo-Turkana basin, the scientists also used their methodology in a retrospective analysis of the controversial two-year filling phase of the Gibe III mega-dam in Ethiopia. "We observed that the negative impact on downstream neighbors was exacerbated by a prolonged drought," reports Burlando. The DAFNE consortium partner from Politecnico di Milano were able to show in a study published in *Nature Communications* together with Burlando and Sinclair, that such problems can be reduced by combining DAFNE tools with seasonal drought forecasts and flexibly adapting the filling regime to hydroclimatic conditions.

Dams on the advance worldwide

The results of the study are highly topical: Ethiopia is currently building another mega-dam in the Omo-Turkana catchment area, and filling the Grand Ethiopian Renaissance Dam on the Blue Nile. Worldwide, around 500 dam projects are being planned in regions affected by climate feedbacks through teleconnections. Growing populations and increasing prosperity will continue to boost demand for energy, food and water. The researchers hope that the DAFNE methodology will one day become a reference.

"We designed the modeling tools to be transferable to other regions with competing water needs," says Burlando. Follow-up projects are already under way to apply and further develop the technology in several river basins worldwide.

More information: Marta Zaniolo et al, When timing matters—misdesigned dam filling impacts hydropower sustainability, *Nature Communications* (2021). DOI: 10.1038/s41467-021-23323-5

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