Project seeks sustainable blueprint for hydropower dams

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A young fisher prepares to go out on Cambodia's Tonle Sap Lake. Credit: Jonathan Armstrong/Oregon State University

In the Pacific Northwest, the conversation about hydroelectric dams is complicated: Dams hamper the natural migration of salmon, yet they are an important source of cheap, renewable energy for the region.

In other parts of the world, gray areas still exist, but the conversation about dams is very different, brought on by a critical need for reliable food and energy sources. In tropical river systems such as the Amazon, Congo and the Mekong, river and lake fishing provide food security in some of the world's poorest regions and would be negatively impacted by an onslaught of new dams. At the same time, existing and future dams planned on these rivers hold the promise of renewable energy in places that arguably need it the most.

There, the debate is over when and how—not whether—dams will be built and operated.

In Southeast Asia, the Mekong River and its tributaries support what is likely the largest inland fishery in the world, worth more than $2 billion annually, that over 60 million people rely on for daily food and livelihoods. Nearly 100 hydropower dams are planned for construction along the tributaries and main stem of the river's 2,700-mile stretch.

In a study published Dec. 8 in *Science*, researchers from the University of Washington, Arizona State University and others institutions have proposed a solution that allows dam operators to generate power in ways that also protect—and possibly improve—food supplies and businesses throughout the Mekong River basin. The proposed solution, the first of its kind, can be applied to other large river systems around the world facing similar tradeoffs.

Mekong River basin. Credit: University of Washington

"One of the challenges in dealing with these systems and environmental change is the conversation is largely stuck in, 'don't build dams,' or 'yes, build dams,'" said Gordon Holtgrieve, a UW assistant professor of aquatic and fishery sciences. "What this does say is, let's try to find ways we can work together. This won't solve all the problems, but let's work to find solutions."

The paper represents a first step in a large, multiyear project involving researchers across the UW and ASU campuses. Funded by the National Science Foundation's Innovations at the Nexus of Food, Energy and Water Systems program, the project will use findings in the Mekong River basin as an example of how three critical issues—feeding people, generating energy and maintaining functioning ecosystems—can be addressed thoughtfully and progressively in the developing world.

Every summer in the Mekong River basin, monsoon rains flood the river and delta, increasing by six times the flooded area of Cambodia's Tonle Sap Lake, the largest lake in Southeast Asia and frequently called the "heart" of the Mekong. The rise and eventual fall of the water triggers the migration of dozens of fish species, which spawn in the upper tributaries during low water. Fish larvae return to the lake on the next flood to grow and mature in its highly productive waters. This yearly pattern provides a critical source of animal protein, and an economy, for the people of Cambodia and other countries along the Lower Mekong.

But with new dams coming online soon, there is no basin-wide effort to coordinate how each dam's release of water will impact the hydrology of the basin or fish, said Faisal Hossain, a UW professor of civil and environmental engineering and a collaborator on the project.

Children in Cambodia gather and process Boeseman croaker fish. Credit: Jonathan Armstrong/Oregon State University

The goal of the project, involving researchers from fisheries, forestry, engineering, public health and the UW's Freshwater Initiative, is to gather information about how dam water flow interacts with fish, rice production and nutrition in this region and provide the most useful information to individual countries so that they can decide how best to operate their hydropower dams, he explained.

"We are trying to find a sweet spot for the many stakeholders, who often compete for resources, that can maximize the overall benefits in a way that doesn't do too much damage to the environment, fish and livelihood of the region," Hossain said.

One promising option is to use hydroelectric dams to mimic the flood of water from monsoon rains each spring that bring fish to the lake. The team's algorithm, outlined in the Science paper, recommends long, low-flow periods punctuated by rapid flooding, which would allow dam operators to manage their power generation priorities while protecting fishing economies downstream.

The researchers found that seasonal periods of drought before the annual flood are crucial to producing abundant fisheries in the lake and surrounding streams. When the soil is dry, trees and plants grow, organic matter is produced and the soil is filled with nutrients. When floodwaters rush in, those nutrients are suspended in the water and fish are able to exploit them—drawing more fish to the feast, which in turn benefits fishers.

Fishers in Cambodia unload snakehead fish before heading to the market.
Credit: Jonathan Armstrong/Oregon State University

Holtgrieve, along with several UW colleagues, will study the flooding cycle in connection with the nutritional value of fish and rice, both staples in Southeast Asian diets, to help prioritize certain species and timing for harvesting the most nutritious food. Specifically, he will analyze tissue samples from 50 different fish species covering a range of habitats in the Mekong, measuring for beneficial fatty acids, vitamins and minerals, as well as for harmful elements like mercury.

"We as a society view fish as generally good for you," Holtgrieve said. "This project recognizes that not all fish are the same in terms of their nutritional value."

With the knowledge of which fish are the healthiest to eat, the researchers can work backward by figuring out what those fish like to eat, and then what flood and drought regime is most likely to produce those plants and organisms—controlled by dams releasing water—that produce more fish of high nutritional value.

Similarly, UW professors Rebecca Neumann (civil and environmental engineering) and Soo-Hyung Kim (environmental and forest sciences) will look at beneficial nutrients, such as zinc, and harmful contaminants, such as arsenic, in rice to measure whether the length of time that rice paddies are flooded makes a difference in the presence of these elements in the crop. Again, water releases from hydropower dams could be programmed to optimize for rice that is high in zinc and low in arsenic.

A fisher unloads netted fish in Tonle Sap Lake, Cambodia. Credit: Jonathan Armstrong/Oregon State University

Hossain has used satellites to reverse engineer the blueprint of dam operations on about 20 dams in the Mekong region, and his lab will apply those findings to dozens of the planned dams to try to predict their likely water releases and storages, and how they may impact the surrounding landscape.

"Satellites are immune to political boundaries on the ground," he said. "Information is key, and I think it should be a fundamental right for everyone to know what's happening with the water around them, but that's not the case here, unfortunately."

In other aspects of the project, Bart Nijssen (civil and environmental engineering) will help forecast future floods under hydropower and climate change scenarios, while Adam Drewnowski (public health) will integrate the fish and rice nutrient data with information on the nutritional needs of the local population.

The project will run for three years, and the researchers intend to share results along the way.

Credit: Jonathan Armstrong/Oregon State University

More information: J. L. Sabo et al. Designing river flows to improve food security futures in the Lower Mekong Basin, *Science* (2017). DOI: 10.1126/science.aao1053

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