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Of Fish, Monsoons and the Future

A Push to Save Cambodia's Tonle Sap Lake

By CHRIS BERDIK JUNE 9, 2014

AKOL, CAMBODIA — As the sun rises on Tonle Sap Lake, fishermen head out from floating villages like this one, past half-submerged mangroves and flooded shrub land, to check their nets, much as they have for centuries.

Every year, the lake yields about 300,000 tons of fish, making it one of the world's most productive freshwater ecosystems. That and the floods that pulse through it in monsoon season, swelling it to as much as five times its dry-season size, have earned the lake the nickname "Cambodia's beating heart."

But the Tonle Sap is in trouble — from overfishing to feed a fast-growing population, from the cutting of mangrove forests that shelter young fish, from hydroelectric dams upstream, and from the dry seasons that are expected to grow hotter and longer with climate change.

Keo Mao, a 42-year-old fisherman from Akol, says he hopes his five children can find a way out of the life that has sustained his family for generations. "The lake now is not really so good," he said. "There are too many people."

Now an international team of researchers has joined local fishermen in an ambitious project to save the Tonle Sap. The scientists are building an intricate computer model that aims to track the vast array of connections between human activity and natural systems as they change

over time. Begun in 2012, the model will take several years to complete, while threats to the Tonle Sap continue to mount.

But the hope is to peer into the lake's future to predict how different developmental, economic and regulatory choices may ripple through this interconnected and fast-changing ecosystem, and to plan a sustainable way forward.

Charting a Changing Cambodia

Henri Mouhot, the 19th-century French explorer who crossed the Tonle Sap on his way to Angkor Wat, said the lake resembled a violin lying diagonally across Cambodia. At its neck, a tributary flows southeast to the Mekong River. On the laptop of Roel Boumans, an ecologist who helped develop the modeling project, the lake and its flood plain are divided into 16 watersheds that he fills with shades of green, yellow and brown, based on vegetation and land-use data from satellite images.

"The model tells us stories," he said, "and it tests the stories we, as scientists, tell about the how different parts of the system work."

Along with attributes like soil composition, elevation and vegetation, the digital Tonle Sap will soon have what the scientists call "agents," including fish and people. Agents make choices. They change the lake and react to those changes, depending on factors like when enough fish swim into an area to attract predators and fishing boats. Local fishermen are critical to the Tonle Sap modeling project. They have been collecting fish from small research nets, jotting down their species, lengths and weights, and snipping tails for DNA testing. They will also take part in other fieldwork, including water and sediment sampling, household surveys and economic research.

Cambodia's population is growing rapidly, at a rate of nearly 2 percent a year. Many rural Cambodians, including subsistence farmers displaced by land grants to large agribusinesses, have migrated to the Tonle Sap from upland areas. Others come after selling their farmland to pay off debt. From 1998 to 2008, the most recent period studied, the number of full-time Tonle Sap fishermen grew by 38 percent to 38,200,

and the number of lakeside farmers, many of whom fish part time, increased 33 percent to 520,800.

The computer model does not yet account for the surging population, but it already has years of data on water levels. By sending blue pulses across the map on his laptop to simulate flooding, Dr. Boumans can calculate where floodwater sediments, shown in oranges and reds, are likely to settle.

He developed the modeling approach a decade ago with Robert Costanza, an environmental economist now at Australian National University. They called it Mimes, short for multiscale integrated models of ecosystem services.

It is among the most ambitious of several models to emerge from the movement among ecologists to assign economic values to nature and its processes. Critics warn that such models can lead scientists to discount important data that disagree with their forecasts; others say focusing on "services" puts price tags on nature, undervaluing things like biodiversity that aren't bought and sold. The idea's supporters, however, say it aligns nature's interests with our own.

"In the past, it was a conservation and environmental argument pitted against the economic argument," said Lewis Incze, a marine ecologist and oceanographer at the University of Maine who is not part of the Tonle Sap project. "You can still argue about valuation and importance, but these models recognize that this is not one class of argument against another, but a whole family of processes that need to be recognized and accounted for together."

Dr. Boumans said the Mimes model "lets you explore the decisions you're making about a landscape and seascape, showing you what's gained and lost over space and time."

One set of decisions involves the big dams planned upstream of the Tonle Sap, often portrayed as a trade-off between electricity and food. Fewer than half of Cambodians have reliable access to power; blackouts are common, and costly electricity slows business development and job

growth.

But tropical dams typically generate power for just a few decades, while the Tonle Sap has been feeding Cambodia for centuries. Fish are carved in the walls at Angkor Wat, and they supply three-quarters of the animal protein in a country where nearly 40 percent of children are chronically malnourished.

About 60 percent of Cambodia's inland fish catch comes from the Tonle Sap, which also supports migratory fish caught upstream, said Chheng Phen, acting director of Cambodia's Inland Fisheries Research and Development Institute, which is taking part in the modeling project.

"If the Tonle Sap does not function," he said, "then the whole fishery of the Mekong will collapse."

The Coupling of People and Nature

Traditionally, ecologists have viewed humans in an ecosystem as something of a nuisance — contaminating samples, skewing data and clouding scientific analyses. "But the human aspect of an ecosystem is crucial," said Jianguo Liu, who leads the International Network of Research on Coupled Human and Natural Systems, or Chans-net, a network of 1,300 ecologists, economists, and sociologists.

"The central message of Chans is that humans and nature are coupled, just like husband and wife," says Dr. Liu, director of the Center for Systems Integration and Sustainability at Michigan State University. "They interact, work together, and the impacts are not just one way. There are feedbacks."

The Tonle Sap project is designed to capture those interactions and look for their consequences, often unintended. For instance, increased fishing could actually lead to more fish in the lake, at least for a while. Kevin McCann, an ecologist at the University of Guelph in Ontario, says that if fishermen take everything they bring up in their nets, the species that suffer most will be the larger fish that grow and reproduce slowly. With fewer big fish eating the fast-multiplying, small fish, the results will be more fish over all, but reduced biodiversity.

Over the past decade, data suggest that the lake has been losing its biggest fish — quarter-ton catfish, stingrays with six-foot wingspans, Siamese carp bigger than the fishermen who caught them — while the catch of the tiny trey riel, or money fish, has risen slightly. (They are used primarily for prahok, the fermented fish paste that is a staple of Cambodian cooking.)

Climate models forecast longer, hotter dry seasons for Southeast Asia, and more intense monsoon floods. Both changes could disrupt the migration and spawning patterns of Tonle Sap fish, said Sovan Lek, an ecologist at Paul Sabatier University in Toulouse, France, who is a native of Cambodia and a principal investigator in the Tonle Sap project. "In Europe, the water can go from very cold to very warm, from winter to summer," he said. "Here, the temperature is stable over the whole year, so adaptation to a change will be more difficult."

1.5 Million Depend on the Lake

Thol Thoeun, a 27-year-old Tonle Sap fisherman, sat on the floor of his floating house and recounted how rats devoured his vegetable garden, how all his money goes to home repairs after monsoons, and how his rickety fishing boat continually takes on water.

His family came here in 2002, fleeing hard times inland, but times are hard here, too. More than 70 percent of households earn less than $1,000 a year, and many fishermen are in debt, owing nearly $780 on average, according to the Cambodian fisheries administration.

"Everyone faces difficulties," Mr. Thoeun said. "Everyone is suffering."

The 1.5 million people who depend directly on the Tonle Sap, mostly fishers, farmers and their families, are one of the biggest factors in forecasting the lake's future. They can't do much about the dams, most of which are planned beyond Cambodia's borders, nor can they stop global warming.

But how they react to changes on the lake will be critically important. If fish catches were to drop by a third, for example, fishermen might have to spend even more time on their boats, or venture into illegal "no take"

waters, or turn to rice farming. Each choice would affect the ecosystem in different ways.

Evan Fraser, a geographer at the University of Guelph, will explore these sorts of scenarios with Tonle Sap residents in surveys, interviews and workshops, to begin later this year. His findings will become part of the model. A food-security expert, Dr. Fraser has studied some of history's worst famines, as well as those prevented by tactics like stockpiling food and distributing drought-resistant seeds. His research suggests that no matter how the Tonle Sap changes in the coming years, the right adaptive strategies could mean the difference between a tolerable transition and a disaster.

"The policy and development challenge is one of managing the transition," he said. "There's no way to stop it."

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