Researcher creates method to measure resource tradeoffs in times of drought

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Postdoctoral scholar Debra Perrone visited Kotmale Dam, Sri Lanka, as part of her research on weighing food and energy tradeoffs when water is scarce. Credit: Dawn Ruth

Sri Lanka's Mahaweli River is the country's lifeblood. When the river is flowing well, it powers dams and irrigates rice paddy systems to support

many of the country's 20 million residents. But in times of drought, the country must manage difficult tradeoffs between energy and food production.

A study released today in Environmental Research Letters examines the relationships among food, energy and water in Sri Lanka, and provides a tool for resource managers around the world to balance tradeoffs during times of water scarcity.

"Water is the driving force behind the interdependence of Sri Lanka food, energy and water sectors," said study lead author Debra Perrone, a postdoctoral scholar at the Stanford Woods Institute for the Environment. "This trend is not unique to Sri Lanka. In fact, we have found that water often drives the tradeoffs among food, energy and water around the world."

As a developing country with a growing population, Sri Lanka's energy and food demands are ever increasing. During dry conditions, water managers face a choice of diverting water to irrigate paddies for rice production or to let water flow through turbines of major hydroelectric plants. While there is still some paddy production and some hydroelectricity production despite water diversions, these diversions make a large impact.

Determining which tradeoffs to take requires consideration of the costs and benefits of what it means to cut down production of one resource and import it instead. For example, cutting down on hydroelectricity and importing coal is expensive and results in air pollution. Alternately, Sri Lanka's food production is tied strongly to a cultural attachment to paddy irrigation and a political focus on rice self-sufficiency. Choosing to import rice would also make the country reliant on the volatile rice market.

"Often, there's no perfect solution. A tradeoff has to happen," said George Hornberger, director of the Vanderbilt Institute for Energy and Environment at Vanderbilt University and co-author of the study.

Modeling costs and benefits

The authors adapt a model called a "tradeoff frontier," often used in economics, to visualize tradeoffs among food, energy and water in times of water scarcity. With a restricted amount of water there is a tradeoff between how much water is used for electricity production and how much is used for irrigation. The model shows that production of energy or food cannot increase without decreasing the production of the other.

In addition to assessing various productions of food and energy, the model is useful in identifying political and social constraints that move production away from what is feasible with existing technology. For example, production of energy and food might not reach maximum output because farmers might be planting less to avoid an economic loss due to crop failure during times of drought.

The researchers' analysis of Sri Lanka's food, energy and water systems indicates that actual water management leans closer to favoring paddy production even though the economic value of rice is very small in comparison to electricity. These results help show how people value water in intangible ways, and may be used to inform future studies that aim to price water.

Applying tradeoff frontiers globally

The agriculture and energy sectors are often the two largest users of water across the globe, making Sri Lanka's food, energy and water challenges reflective of similar problems in other countries. As climate

change exacerbates water scarcity and competing demands between food and energy production become more prominent, resource managers worldwide can use the study's concept to assess tradeoffs among these resources.

For example, California has high water demands from both the thermoelectric sector and the irrigation sector, and the state has been facing a multiyear drought. Applying the tradeoff frontier concept would help illustrate how different water management portfolios could influence the productions of food and energy within the state. Comparing where actual productions fall on a tradeoff frontier would provide insight into how the current management scheme values water resources.

"An important takeaway is that there are no specific rules for managing water resources successfully – the insights gained in one location can be different than the insights gained in other cases," Perrone said. "Tradeoff frontiers can help us gain a basic understanding of the main constraints to allocating water, so we can take informed approaches to water management."

The study, which was funded by the National Science Foundation and an EPA Science to Achieve Results fellowship, represents some of the latest research in the growing field of the food-energy-water nexus.

More information: Debra Perrone et al. Water, food, and energy security: scrambling for resources or solutions?, *Wiley Interdisciplinary Reviews: Water* (2014). DOI: 10.1002/wat2.1004

Debra Perrone et al. Frontiers of the food–energy–water trilemma: Sri Lanka as a microcosm of tradeoffs, *Environmental Research Letters* (2016). DOI: 10.1088/1748-9326/11/1/014005

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