Framework helps local planners prepare for climate pressures on food, energy & water systems

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As the world faces increasingly extreme and frequent weather events brought on by climate change—such as droughts, floods, heatwaves, and wildfires—critical civic resources such as food, water, and energy will be impacted. Local and regional planners need to anticipate those impacts and evaluate what measures can be taken to prepare.

Now, a multidisciplinary, multi-institutional team of researchers has built a detailed framework to provide guidance to these planners. After two years of in-depth consultation with stakeholders in various affected communities, the team prepared a set of analytical tools that can be used to forecast the kinds of strains on resources that may be coming in the next few decades—and how best to address them.

The "toolkit" they developed, called the C-FEWS framework (for Climate-induced extremes on Food, Energy and Water Systems) is being published in a series of papers in a special edition of *Frontiers in Environmental Science*. Charles Vörösmarty, professor of environmental sciences at the City University of New York, is lead author of the introductory paper describing this new framework, and Jerry Melillo, distinguished scientist at the Marine Biological Laboratory (MBL), Woods Hole, Mass., is second author. The project was funded by the National Science Foundation.

The work focuses on two specific U.S. regions, the Northeast and the Midwest, which together account for about 40 percent of the nation's population and GDP. Melillo says that in developing the framework, "we've held a number of meetings with regional stakeholders, trying to develop a sense of what they really care about, and then seeing how our modeling framework can be used to help them think through those issues."

The framework "provides guidance for evaluating options and making decisions related to specific local conditions," Melillo explains. "We are particularly interested in how people respond to climate change in these two U.S. regions given their various interests—and the focus was on the nexus of food, energy, and water."

One disaster affects many interconnected systems

Three critical needs—food, energy, and water—often interact in a disaster, complicating planning, yet are often treated separately in developing policies and contingency plans. Part of the motivation for this work was to bring together people with expertise in different areas to work toward a more integrated understanding of the challenges and potential solutions.

"It's not hard to see that there are intersections between food, energy, and water that could create some pinch points or constraints in the behavior of one part of the system versus another," says Vörösmarty. "We need to look at how these systems are interacting when they all get hit at the same time by these climate changes."

The team looked at two broad categories of infrastructure systems that are affected by weather extremes: "gray" infrastructure, including sewage and water delivery systems and power plants, and "green" infrastructure such as floodplains, cropland and forests. They studied the past 40 years of data on how these systems have been affected by weather extremes, in order to calibrate their models to reflect likely future impacts.

As examples of how the new analysis works, the team looked at several specific cases. One dealt with the way typical coal- or gas-fired power plants use river water for cooling. As temperatures rise, the warmer water becomes less efficient at cooling, and power plant output goes down—just when it's needed for air-conditioning demand. But analysis showed that with the addition of cooling towers, already used in some plants, this efficiency decline could be almost eliminated.

Even though it's a global climate that's changing, the manifestations of those changes are national, if not regional, if not state level, in their scope," Vörösmarty says. "We're learning how to tackle a regional perspective where we are focusing on these macro-scale dynamics.

Changes over the past four decades in Midwestern and Northeastern forests, which provide a range of services that affect the energy and water balances of the two regions, is the focus of another article in this special edition of *Frontiers in Environmental Science.*

Since 1980, that study found, these regions' forests functioned as a net atmospheric carbon sink; the Midwestern trees stored more carbon than Northeastern trees, but both helped to mitigate climate change and create new wood biomass for future fuel and wood products. Runoff from forests also provided more than 4.6 billion cubic meters of water for potential use by humans during the study period, with the Northeastern forests providing about 2.4 times more water than the Midwestern forests.

But climate variability, particularly as influenced by heat waves, impacts the ability of these forest ecosystems to sequester CO_2 and provide runoff, reports the study, which was led by David Kicklighter, a research associate with Melillo at the MBL. Therefore, when planners are developing policies for climate stabilization, energy production and water security, "it will be important to consider how evolving forest infrastructure modifies ecosystem services and their response to extreme climate events over time," they write.

An adaptable framework

The authors hope this type of localized analysis and planning can serve as a model to be adapted to other regions or nations. Other articles in this special edition address climate-induced pressures on food, energy, and water systems in other places, such as Mexico and Bangladesh.

"What we're trying to do," Melillo explains, "is to provide policymakers with a tool to think quantitatively about how best to manage these systems, with some optimum goal of minimizing unintended consequences, and promoting intended consequences… We're trying to provide a clear picture of appropriate policy levers for doing this management."

More information: Charles J. Vörösmarty et al, The C-FEWS framework: Supporting studies of climate-induced extremes on food, energy, and water systems at the regional scale, *Frontiers in Environmental Science* (2023). DOI: 10.3389/fenvs.2023.1069613

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