Farms, tables and vast impacts between and beyond

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Farming plots in northern China. Credit: Sue Nichols, Michigan State University Center for Systems Integration and Sustainability

Bountiful harvests in one location can mean empty water reservoirs and environmental woes far from farmlands. A unique study in this week's *Nature Communications* examines how food, energy, water and greenhouse gases create a vast front in the battle to feed the planet.

Scientists at Michigan State University (MSU) and colleagues have used new sustainability science tools to understand how the increasingly irrigating farm fields to grow food reverberates through the biggest drivers of sustainability. Further, they show It's not just the farmlands that shoulder environmental impacts. Effects are felt faraway as massive water redirects gobble energy and spew emissions. And the biggest reveal: Sometimes, it's places that have no major stake in the plant-water-eat game that end up paying an environmental price.

"Ensuring food security while safeguarding the environment is one of the greatest challenges for the world today, yet as the world has become so globalized, it is an incredibly complicated process, and misunderstanding it or missing impacts can allow major setbacks in achieving sustainability," said Jianguo "Jack" Liu, MSU Rachel Carson Chair in Sustainability. "We need to deploy the new ways of looking at the world in a way that embraces its complexity."

So, the scientists used the framework of metacoupling, which helps look not only at the irrigated farmlands, but also the massive projects to move water from one region to another. The metacoupling framework allows scientists from many different disciplines look at the interactions between socioeconomics and environmental forces—like climate change, diet change, irrigation technologies, crop planting strategies, water diversion—both within and across borders.

They used the North China Plain (NCP), which is a major food production region, and the rest of China, which has seen significant spikes in food demand, as a demonstration, as well as one segment of China's massive South-to-North Water Transfer Project. While China was the study site, the authors note these methods for examining sustainability would be applicable in the United States and across the world.

Meeting soaring food demands, the crops—primarily wheat and maize—require massive amounts of water. The world's largest and longest water transfer project in this study draws from Hubei Province's water reserves in southern China. The people in Hubei aren't farmers on the scale in the NCP, nor do they buy a significant portion of their cereal crops from the NCP. They are what the scientists call a "spillover"—meaning they are not direct players in this providing/consuming food network. Yet Hubei lost significant amounts of land and water to the project dedicated to keeping the NCP wet and growing. The water transfer also generated a substantial energy footprint.

The team of scientists took the food supply issue from the simplicity of solving a problem of producing food by transferring water, to a more complex one that recognized the many causes and effects that fan out far beyond the farms and tables.

"This study demonstrates the importance of understanding our increasingly connected world in a way that quantifies the often missed and unrecognized connections involved in feeding the world," said Elizabeth Blood, program director of the National Science Foundation's Ecosystem Science and Dynamics of Integrated Socio-Environmental Systems, which supported the work.

"The world is very focused on solving critical environmental problems," said Zhenci Xu, an MSU research associate and the paper's first author. "We are declaring that we cannot cherry-pick the problem we want to solve because growing crops is about more than irrigation and more about the plot of cropland. You cannot have water at this scale without using energy and changing how land is used. Which then means CO_2 emissions are generated, and climate change is exacerbated. We say this is complicated, but it's also an opportunity to help make real change."

The paper calls for policies to help address multiple aspects of

environmental impacts in different areas simultaneously affected by the transfer of water. They also note that instead of focusing only on the supply side of the issue—in this case the farmlands—it can be useful to also include consumption-based policies—such as encouraging shifts in diets that depend less on resource-intensive crops.

"We need to get used to looking at the many sides of every issue and be prepared likewise to come forward with many different solutions," Liu said. "We no longer live in a one-issue world."

More information: Zhenci Xu et al, Impacts of irrigated agriculture on food–energy–water–CO2 nexus across metacoupled systems, *Nature Communications* (2020). DOI: 10.1038/s41467-020-19520-3

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