Gauging the effects of water scarcity on an irrigated planet

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At Michigan State University's W. K. Kellogg Biological Station, Great Lakes Bioenergy Research Center researchers are evaluating the performance of a variety of novel bioenergy crop production systems for crop yield and quality, impacts on microbial-plant interactions, biogeochemical and biodiversity responses and water use. Credit: Kurt Stepnitz/Michigan State University Office of Biobased Technologies

Growing global food demand, climate change, and climate policies favoring bioenergy production are expected to increase pressures on water resources around the world. Many analysts predict that water shortages will constrain the ability of farmers to expand irrigated cropland, which would be critical to ramping up production of both food and bioenergy crops. If true, bioenergy production and food consumption would decline amid rising food prices and pressures to convert forests to rain-fed farmland. Now a team of researchers at the MIT Joint Program on the Science and Policy of Global Change has put this prediction to the test.

To assess the likely impacts of future limited water resources on bioenergy production, food consumption and prices, land-use change and the global economy, the MIT researchers have conducted a study that explicitly represents irrigated land and water scarcity. Appearing in the Australian Journal of Agriculture and Resource Economics, the study is the first to include an estimation of how irrigation management and systems may respond to changes in water availability in a global economy-wide model that represents agriculture, energy and land-use change.

Combining the MIT Integrated Global System Modeling (IGSM) framework with a water resource system (WRS) component that enables analyses at the scale of river basins, the model represents additional irrigable land in 282 river basins across the globe. Using the IGSM-WRS model, the researchers assessed the costs of expanding production in these areas through upgrades such as improving irrigation efficiency, lining canals to limit water loss, and expanding water storage capacity.

They found that explicitly representing irrigated land (i.e., distinguishing it from rain-fed land, which produces lower yields) had little impact on their projections of global food consumption and prices, bioenergy production, and the rate of deforestation under water scarcity. The impacts are minimal because in response to shortages, water can be used more efficiently through the aforementioned upgrades, and regions with relatively less water scarcity can expand agricultural production for export to more arid regions.

Moreover, the researchers determined that changes in water availability for agriculture of plus or minus 20 percent had little impact on global food prices, bioenergy production, land-use change and the global economy.

"Many previous economy-wide studies do not include a representations of water constraints, and those that do fail to consider changes in irrigation systems (e.g. construction of more dams or improvements in irrigation efficiency) in response to water shortages," says MIT Joint Program Principal Research Scientist Niven Winchester, the study's lead author. "When these responses are included, we find that water shortages have smaller impacts than estimated in other studies."

Despite the small global impacts, the researchers observed that explicitly representing irrigated land under water scarcity as well as changes in water availability for agriculture can have significant impact at the regional level. In places where rainfall is relatively low and/or population growth is projected to outpace irrigation capacity and efficiency improvements, water shortages are more likely to limit irrigated cropland expansion, leading to lower crop production in those areas.

The study's findings highlight the importance of improvements in irrigation efficiency and international trade in agricultural commodities. The research may also be used to identify regions with a high potential to be severely influenced by future water shortages.

More information: Niven Winchester et al. The impact of water scarcity on food, bioenergy and deforestation, *Australian Journal of*

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