Reorganization of crop production and trade could save China's water supply

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China's rapid socioeconomic growth continues to tax national water resources -- especially in the agricultural sector -- due to increasing demands for food. One solution to this growing problem, however, might be to partially reorganize the country's crop production and trade, according to new report issued by Princeton University's Woodrow Wilson School of Public and International Affairs. Credit: Woodrow Wilson School/Ticiana Jardim Marini

China's rapid socioeconomic growth continues to tax national water resources – especially in the agricultural sector – due to increasing demands for food. And, because of the country's climate and geography, irrigation is now widespread, burdening rivers and groundwater supplies.

One solution to these growing problems, however, might be to

reorganize the country's crop production and trade, especially in agricultural provinces such as Inner Mongolia, Heilongjiang and Hebei, according to new report issued by Princeton University's Woodrow Wilson School of Public and International Affairs and School of Engineering and Applied Science and scientists in China and Japan.

The researchers report in the journal *Proceedings of the National Academy of Sciences* that reducing agricultural production in these provinces and importing food commodities from other provinces or nations instead could help China conserve more water. These provinces all use large volumes of water to produce crops that are later exported to wetter regions. If balanced with more water-efficient irrigation systems locally, restructuring these regions could reduce national water use while avoiding an excessive geographically centralized agricultural production.

"Our analysis provides a framework for understanding how such policies would benefit China's water use in the future," said study co-author Denise Mauzerall, professor of environmental engineering and international affairs. In particular, corn production and trade at the domestic level might be an area to target as changes could significantly reduce national water use for irrigation."

"Overall, China may want to consider a targeted investment in agricultural research and development," said lead author Carole Dalin, a Princeton University Ph.D. student studying environmental engineering.

Of China's industries, agriculture is the most water-intensive in terms of production and covers most of the country's northern provinces. Crops like corn, rice and wheat thrive best in these drier regions, but rainfall is limited, and stores of underground water are diminishing. To fulfill high production demands, water is drawn from underground reservoirs (aquifers) in the northern provinces and used for irrigation more rapidly than it is replenished.

Water used during crop production is referred to as "virtual water." Through food trade, these water resources are transferred across borders in what's called a "virtual water trade." The researchers found that, in China, these transfers mostly occur from dry agricultural areas to wetter provinces. This situation places strain upon China's water reserves and will only intensify as China's economy and consumption of water-intensive food continues to boom. While growing crops in the wetter regions would be more water efficient, land in those places is either urban or industrial or difficult geographically (mountainous terrain, etc.), the researchers report.

"The need for China to include 'virtual water' in its national policy has been pointed out. Our provincial-scale domestic analysis of the country's virtual water trade is key to guiding such policy planning," said Dalin, who is a former Princeton Environmental Institute Science, Technology and Environmental Policy fellow.

To this end, the research team – which also includes Ignacio Rodriguez-Iturbe, the James S. McDonnell Distinguished University Professor of Civil and Environmental Engineering, and co-authors from China and Japan – combined a hydrological model with domestic and international trade simulations to determine the efficiency of China's food trade in terms of water use as well as the role of foreign trade in this virtual water-trade system. In particular, the researchers sought to answer one question: Is there a way to reduce China's water use without decreasing national food security?

The researchers looked at domestic and international trade of corn, rice, soy and wheat, along with such livestock products as ruminant (animals like cattle, goats and sheep that subsist on plant matter), pork and poultry. These products accounted for 93 percent of China's domestic food supply in 2005, the last year with available data. The researchers combined this information with water use across provinces – from both

rainfall and irrigation sources – and determined how much water was transferred between provinces through food trade.

To obtain estimates of these water transfers, the researchers analyzed how much food was traded between provinces and the water amount needed to produce each type of food. They determined the amount of water transferred in kilograms by multiplying the traded volume of a specific food item by the water used to produce a unit of this item (the item's "virtual water content") in the exporting province.

The researchers found that irrigation accounts for about 25 percent of water used to produce crops and for 16 percent of water used in meat production in China. However, those numbers skyrocket in Xinjiang, Ningxia and Inner Mongolia, where irrigation water is used predominantly for crop production (85 percent, 69 percent and 49 percent, respectively.) These numbers indicate that such provinces see little rainfall during the growing season and rely heavily on sometimes non-renewable water resources, such as groundwater.

"This shows us that water is being used faster than it is being replenished, which cannot go on indefinitely," Mauzerall said.

Finally, the researchers investigated whether Chinese food trade leads to global water savings. They found that domestic corn trade leads to significant losses of irrigation water resources (such as rivers, reservoirs and groundwater). However, the provinces of Hubei, Henan, Jiangsu and Anhui, produce wheat quite efficiently, and their exports lead to large national water savings for both rainfall and irrigation water.

"Our work highlights opportunities for addressing water scarcity in China by adjusting where water intensive crops are grown and how they are traded" said Mauzerall. "Policies which encourage such adjustments can help conserve water while maintaining China's food security."

More information: www.pnas.org/content/early/201 … /1404749111.abstract

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