Study finds 11 percent of disappearing groundwater used to grow internationally traded food

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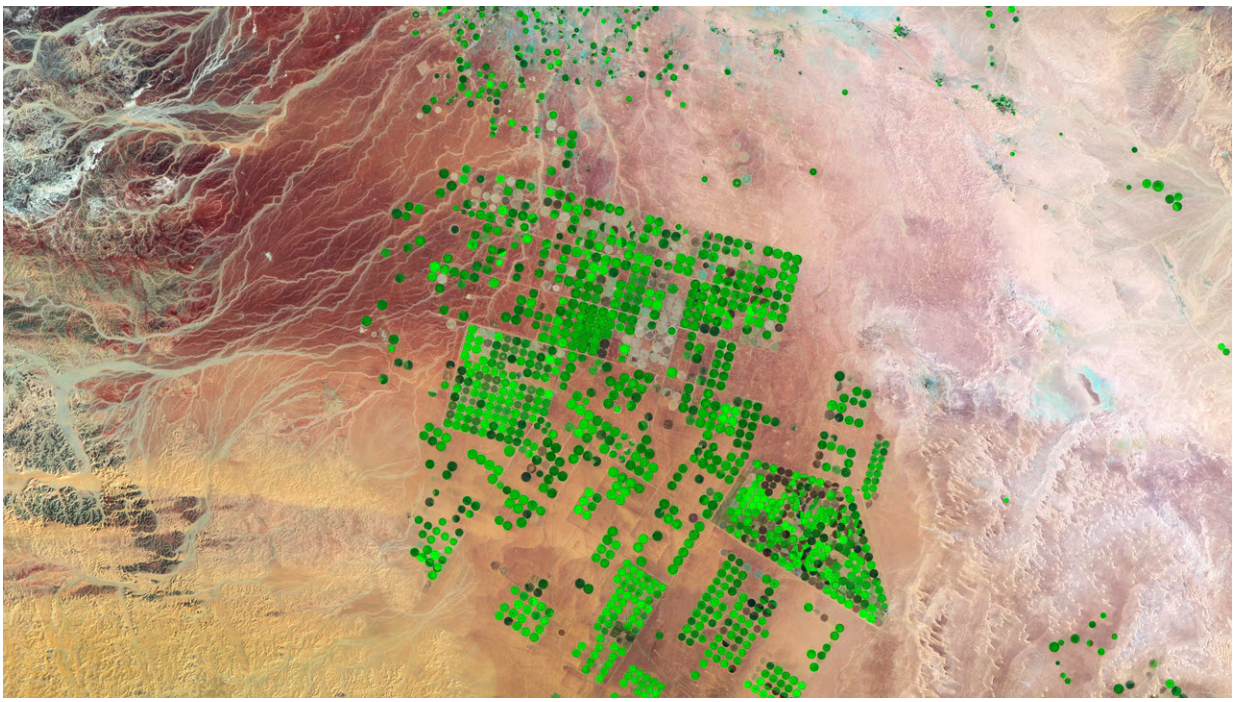

This Landsat satellite image of Saudi Arabia's Wadi As-Sirhan Basin was captured on March 12, 2000. The circles are fields irrigated by water from aquifers as much as 1 kilometer under the desert. Credit: NASA/Landsat/Robert Simmon and Jesse Allen

Wheat, rice, sugar, cotton and maize are among the essential

internationally traded crops in the global economy. To produce these crops many countries rely on irrigated agriculture that accounts for about 70 percent of global freshwater withdrawals, according to the United Nations Water program. One freshwater source is underground aquifers, some of which replenish so slowly that they are essentially a non-renewable resource.

A new study by researchers at the University College London and NASA's Goddard Institute of Space Studies in New York City shows that 11 percent of the global non-renewable groundwater drawn up for irrigation goes to produce crops that are then traded on the international market. Additionally, two-thirds of the exported crops that depend on non-renewable groundwater are produced in Pakistan (29 percent), the United States (27 percent), and India (12 percent).

"It's not just individual countries that experience groundwater depletion, but also their trade partners," said lead author Carole Dalin of the University College London. "When people consume certain imported foods, they should be aware that they can have an impact on the environment elsewhere." The results were published March 30 in *Nature*.

Dalin and her colleagues used trade data on countries' agricultural commodities from the United Nations Food and Agriculture Organization. They then combined it with a global hydrologic model—validated with ground information and NASA satellite data—to trace the sources of water used to produce 26 specific crop classes from their country of origin to their final destination. Their analysis is the first to determine which specific crops come from groundwater reservoirs that won't renew on human time-scales and where they are consumed.

"Say I'm in Japan, and I'm importing corn from the United States," said co-author Michael Puma of NASA's Goddard Institute for Space Studies and Columbia University in New York City. "It's important from Japan's

perspective to know whether that corn is being produced with a sustainable source of water, because you can imagine in the long term if groundwater declines too much, the United States will have difficulty producing that crop."

Globally, 18 percent of all crops grown are traded internationally. The remaining 82 percent stays in country for the domestic market. However, the amounts of various exported crops produced using unsustainable groundwater rose significantly between 2000 and 2010. India, for example, saw its exports of groundwater-depleting crops double in that period, while Pakistan's rose by 70 percent and the United States' rose by 57 percent.

Countries that export and import these crops may be at risk in the future of losing the crops, and their profits, produced with non-renewable groundwater. Importers may need to find alternative sources, possibly at a higher cost.

Major importers of crops raised with non-renewable groundwater include the United States, Iran, Mexico, Japan, Saudi Arabia, Canada, Bangladesh, the United Kingdom, Iraq, and China, which went from a net exporter in 2000 to a net importer in 2010. Countries on both lists often export different commodities than they import.

Aquifers form when water accumulates in the ground over time, sometimes over hundreds or thousands of years. Non-renewable aquifers are those that do not accumulate rainfall fast enough to replace what is drawn out to the surface, either naturally to lakes and rivers or in this case by people via pumping. Once that groundwater is depleted, it will effectively be gone for good on the scale of a human life-time, and will no longer be available for relief during crises such as droughts, Dalin explained.

Drawdowns in aquifers worldwide have been observed over the last fifteen years by NASA's Gravity Recovery and Climate Experiment (GRACE), a pair of satellites that detect changes in Earth's gravity field to see the movement of masses such as ice sheets and, in this case, underground water.

"What's innovative about this study is it connects groundwater depletion estimates with country level data," said hydrologist Matt Rodell at NASA's Goddard Space Flight Center in Greenbelt, Maryland, who was not involved in the study. More research needs to be done which considers population growth, changing diets, climate change, the implementation of irrigation technology and policy changes to understand when these aquifers may begin to run dry, he said.

The absolute amount of water in many of these aquifers is difficult to quantify, though experts in many regions are already looking at better methods to determine how much water remains and how long it may last, Dalin said. Now and in the future, decision makers and local farmers will need to decide on a strategy for using this non-renewable water that balances the needs of short-term production versus long-term sustainability, she said.

More information: Carole Dalin et al, Groundwater depletion embedded in international food trade, *Nature* (2017). DOI: 10.1038/nature21403

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