New study reveals irrigation's mixed effects around the world

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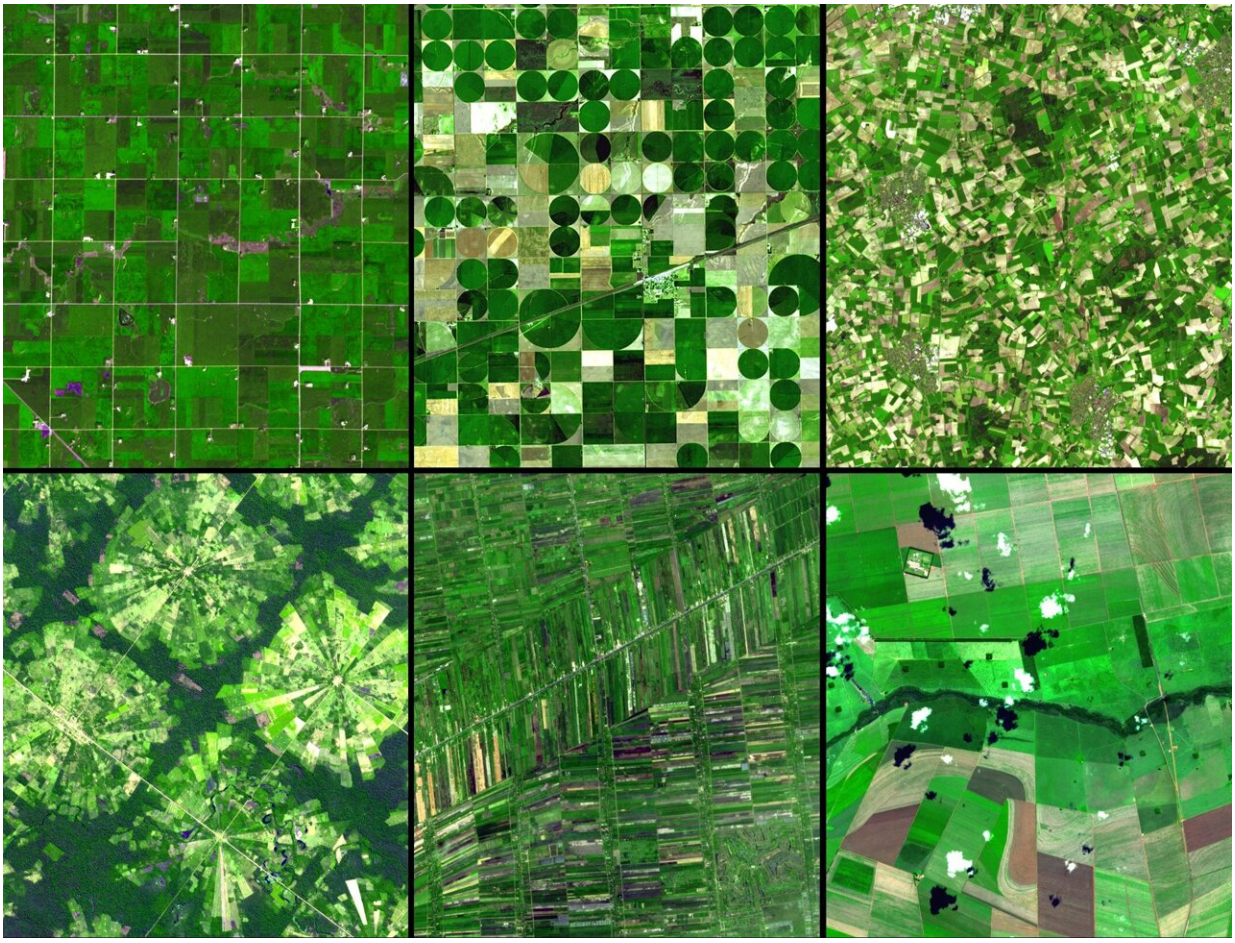

Around the world, agricultural practices have developed as a function of topography, soil type, crop type, annual rainfall, and tradition. In this montage of six ASTER sub-images, the differences are graphically illustrated by the variation in field geometry and size. In Minnesota (upper left) the very regular grid pattern reflects early 19th century surveying; the size of the fields is a function of mechanization and that dictates a certain efficiency. In Kansas

(upper middle), center pivot irrigation is responsible for the field pattern. In northwest Germany (upper right), the small size and random pattern of fields is a leftover from the Middle Ages. Near Santa Cruz, Bolivia (lower left), the pie or radial patterned fields are part of a settlement scheme; at the center of each unit is a small community. Outside of Bangkok, Thailand (lower middle), rice paddies fed by an extensive network of canals that is hundreds of years old, appear as small skinny rectangular fields. And in the Cerrado in southern Brazil (lower right), cheap cost of land and its flatness have resulted in enormous farms and large field sizes. Each ASTER sub-image covers an area of 10.5 x 12 km. Credit: *Nature Reviews Earth & Environment* (2023).

A new study by an international team of researchers shows how irrigation affects regional climates and environments around the world, illuminating how and where the practice is both untenable and beneficial.

The analysis, which appears in the journal *Nature Reviews Earth & Environment*, also points to ways to improve assessments in order to achieve sustainable water use and food production in the future.

"Even though irrigation covers a small fraction of the earth, it has a significant impact on regional climate and environments—and is either already unsustainable, or verging on towards scarcity, in some parts of the world," explains Sonali Shukla McDermid, an associate professor in NYU's Department of Environmental Studies and the paper's lead author. "But because irrigation supplies 40% of the world's food, we need to understand the complexities of its effects so we can reap its benefits while reducing negative consequences."

Irrigation, which is primarily used for agricultural purposes, accounts for roughly 70% of global freshwater extractions from lakes, rivers, and other sources, amounting to 90% of the world's water usage.

Previous estimates suggest that more than 3.6 million square kilometers —or just under 1.4 million square miles—of the earth's land are currently irrigated. Several regions, including the US high plains states, such as Kansas and Nebraska, California's Central Valley, the Indo-Gangetic Basin spanning several South Asian countries, and northeastern China, are the world's most extensively irrigated and also display among the strongest irrigation impacts on the climate and environment.

While work exists to document some impacts of irrigation on specific localities or regions, it's been less clear if there are consistent and strong climate and environmental impacts across global irrigated areas—both now and in the future.

To address this, a total of 38 researchers from the US, Australia, Austria, Belgium, France, India, Italy, Japan, South Korea, and Taiwan analyzed more than 200 previous studies—an examination that captured both present-day effects and projected future impacts.

Their review pointed to both positive and negative effects of irrigation, including the following:

- Irrigation can cool daytime temperatures substantially and can also change how agroecosystems store and cycle carbon and nitrogen. While this cooling can help combat heat extremes, irrigation water can also humidify the atmosphere and can result in the release of greenhouse gasses, such as powerful methane from rice.
- The practice annually withdraws an estimated 2,700 cubic kilometers from freshwater sources, or nearly 648 cubic miles, which is more water than is held by Lake Erie and Lake Ontario combined. In many areas, this usage has reduced water supplies, particularly groundwater, and has also contributed to the runoff of agricultural inputs, such as fertilizers, into water supplies.

- Irrigation can also impact precipitation in some areas, depending on the locale, season, and prevailing winds.

The researchers also propose ways to improve irrigation modeling—changes that would result in methods to better assess ways to achieve sustainable water and food production into the future.

These largely center on adopting more rigorous testing of models as well as more and better ways of identifying and reducing uncertainties associated with both the physical and chemical climate processes and—importantly—human decision-making. The latter could be done with more coordination and communication between scientists and water stakeholders and decision-makers when developing irrigation models.

"Such assessments would allow scientists to more comprehensively investigate interactions between several, simultaneously changing conditions, such as regional climate change, biogeochemical cycling, water resource demand, food production, and farmer household livelihoods—both now and in the future," observes McDermid.

More information: Sonali Shukla McDermid et al, "Irrigation in the Earth System", *Nature Reviews Earth & Environment* (2023). dx.doi.org/10.1038/s43017-023-00438-5

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