

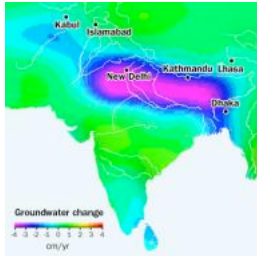
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## BIG GULP, ASIAN STYLE

### Increased irrigation is rapidly depleting India's groundwater

By Sid Perkins

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Enlarge

Drink up

Dramatic increases in the irrigation of crops across northern India have substantially depleted the region's groundwater. Between April 2002 and August 2008, aquifers lost a total of more than 54 cubic kilometers per year (larger amounts from the areas depicted in pink).

Tiwari et al./*Geophysical Research Letters* (in press)

Irrigation in northern India in recent decades has pulled water from the ground faster than the region's soaking monsoon rains can replenish it. And satellite data reveal that the pace of extraction has accelerated in recent decades, scientists report in two new studies.

In an area that's home to about 10 percent of the world's people, that could be a recipe for disaster, policy experts say. A growing population with an increasing standard of living will only boost the demand for groundwater, a trend that could eventually lead to a reduction in agricultural yields, shortages of potable water and an increase in societal unrest.

Northern India and the surrounding areas — a 2,000-kilometer-long swath that rims the Himalayas from Pakistan to Bangladesh — are home to more than 600 million people. The region is also one of the most heavily irrigated areas in the world, says Virendra M. Tiwari, a geophysicist with the National Geophysical Research Institute in Hyderabad, India, and coauthor of a new report to appear in an upcoming *Geophysical Research Letters*. Government policies put in place in the 1960s to boost agricultural productivity nearly tripled the amount of irrigated acreage in India between 1970 and 1999.

In the mid-1990s, India's Central Ground Water Board estimated that farmers pulled more than 172 cubic kilometers of water each year from aquifers in the study region of northeastern India, southern Nepal and western Bangladesh,

says Tiwari. That's more than three times the volume of India's largest surface reservoir. New data gleaned from gravity-measuring satellites suggest that the annual rate of extraction in that region has jumped more than 60 percent since then, Tiwari and his colleagues report.

Researchers estimate that monsoon rains supply, on average, 246 cubic kilometers of precipitation to the region each year, says Tiwari. So, during the mid-1990s, groundwater supply — which largely comes from rainfall that soaks into the ground — was sufficient to meet agricultural demands. But data gathered between April 2002 and June 2008 by the two satellites of the Gravity Recovery and Climate Experiment show that irrigation now extracts substantially more water than is replenished each year.

GRACE, a joint mission of NASA and DLR, the German Aerospace Center, is



Enlarge

Back story: Mining aquifers for farming

View larger version | Underground water supplies in many of the globe's most heavily irrigated regions, highlighted here in shades of purple, are draining faster than they can be replenished. Overall only about 10 percent of the world's agricultural food production depends on groundwater for crop irrigation, but some regions are much more reliant on aquifers for farming.

Adapted from United Nations Food and Agricultural Organization

designed to map Earth's gravitational field and to detect changes in that field over time (*SN*: 1/4/03, p. 6).

The craft can discern movements of groundwater — which, after it was pumped from aquifers to irrigate northern India, either flowed away from the region or evaporated, says Tiwari. Across the region, the net loss of groundwater averaged 54 cubic kilometers per year between April 2002 and June 2008, he and his colleagues estimate. As a result, the water table — the upper surface of the water in the aquifers — fell about 10 centimeters per year. Coincidentally, this net loss of groundwater is about the same as that lost from melting glaciers in Alaska during the same period, he notes.

A separate analysis of GRACE data, this one focused on northwestern India, reveals that groundwater depletion there is even higher. Between August 2002 and October 2008, farmers pumped an average of 17.7 cubic kilometers of water per year from aquifers beneath three states in India's northwest, says Matthew Rodell, a hydrologist at NASA's Goddard Space Flight Center in Greenbelt, Md. In that arid region, home to more than 114 million people, the water table fell an average of 33 centimeters per year, he and his colleague report online August 12 in *Nature*.

Because rainfall in the region was normal during the study period, all of the loss of water mass detected by the GRACE satellites is presumed to have come from groundwater depletion, says Rodell. The net loss of groundwater from

northwestern India's aquifers is equal to three times the volume of Lake Mead, which supplies water for many parts of the U.S. Southwest.

The pace of groundwater depletion in northern India is greater than anyone expected and mirrors trends seen in many other regions, including China and the western United States, says Sandra Postel, director of the Global Water Policy Project, based in Los Lunas, N.M. When groundwater disappears or becomes too difficult to pump, people who now support themselves on the land will become economic refugees, she contends. In many parts of the world, Postel adds, "water problems are becoming very serious, very fast."

Governments in many parts of the world often aren't forthcoming about groundwater or other resources within their borders, so using remote sensing data is the only way to track usage trends for those resources, says Jay Famiglietti, a hydrologist at the University of California, Irvine and coauthor of the *Nature* report. "Big movements of water can't hide from GRACE," he notes.

GRACE detects shifts in water storage indirectly. The two craft orbit the planet along the same path, with one traveling about 200 kilometers ahead of the other. As the first craft in the pair approaches a gravitational anomaly on Earth's surface — say, a mountain range made of dense rock — it is pulled forward in its orbit. After the first craft passes over the mountains, it is pulled backward. The second craft is simultaneously pulled forward as it approaches the mountains. The magnitude of subtle changes in distance between the two craft reveals the size of the gravitational anomaly.

Data gathered by the GRACE craft are versatile. Scientists have used the pair to measure ice loss from Greenland and Antarctica (*SN*: 12/17/05, p. 387), changes in water levels in the Amazon Basin (*SN*: 8/7/04, p. 94), and even the movement of tectonic plates that occurred during the massive quake that occurred off the western coast of Indonesia in December 2004 (*SN*: 1/7/06, p. 6).

Analyses using GRACE data "are an incredible tool," Postel says. Groundwater data for most regions are notoriously poor, she notes. "Even in industrialized countries we don't measure groundwater well."