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RESEARCH HIGHLIGHTS

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GRACE reveals groundwater depletion in India

In many parts of the world, groundwater is the main source of fresh water. If people use up this resource faster than it is replenished, the shortages of food and drinking water can result.

Now scientists using NASA's Gravity Recovery and Climate Experiment (GRACE) satellites have determined that groundwater in north-western India is being depleted at an average rate of 4 cm a year equivalent height of water. This amounts to around 18 cubic km of water a year. Over the six year period of the study, the groundwater depletion was 109 cubic km, roughly double the capacity of India's largest surface-water reservoir, the Upper Wainganga.

"GRACE is unique in its ability to monitor changes in land water storage at all levels – from the top of the plant canopy to the base of the deepest aquifer," Matthew Rodell of NASA Goddard Space Flight Center told **environmentalresearchweb**. "When you look at a map of trends in land-water storage based on seven years of GRACE data, with increases in water depicted in blue and decreases in red, the first thing that the polar ice sheets are dark red – they are melting fast. One of the next things that catches your eye is a red bullseye over north-western India."

Rodell had heard stories of wells running dry in Delhi and people's daily struggles to find clean water, so the team decided to take a closer look at how groundwater storage was changing in the region. Together with colleagues from the University of California, Irvine, California Institute of Technology and the University of Udine, Italy, Rodell analysed GRACE data for the states of Rajasthan, Punjab and Haryana, which includes the city of Delhi, from August 2002 to October 2008.

"People in north-western India are aware of the problem – their wells have been running dry," he said. "What we did for the first time was to quantify the regional rate of depletion of groundwater."

The researchers estimate that the water table is declining at a rate of one metre every three years, averaged over the Indian states of Rajasthan, Punjab, and Haryana. Their figure of

18 cubic km a year of groundwater depletion is roughly 5 cubic km higher than the Indian Ministry of Water Resources' own estimate of the difference between annual available recharge and annual withdrawals in the region.

"We don't know how long this can go on, but residents are already feeling the effects, and it will only become worse until groundwater consumption is reduced to a sustainable rate," said Rodell.

Around 114 million people live in the region, where around 95% of groundwater withdrawals are for irrigation of crops – primarily rice, wheat and barley. "If farmers would shift away from water-intensive crops, such as rice, and implement more efficient irrigation methods, that would help," said Rodell. "Unfortunately, hard restrictions on groundwater use may be necessary as well."

Indeed, the Indian government has begun to propose regulations to reduce groundwater consumption. "Hopefully our research will give them the evidence they need to carry through," said Rodell.

Unlike radar-based methods, GRACE satellites are able to detect changes in the amount of water below the surface of the Earth. The researchers also modelled other terrestrial water storage components, such as soil moisture, surface waters, snow, glaciers and biomass, to show that they were not contributing to the decline in water levels measured by the satellites.

The team will continue to use GRACE to monitor water resources worldwide. "However, the GRACE data must be interpreted carefully, because there are many possible causes of an apparent trend, including natural interannual variability in the water cycle," added Rodell.

The researchers reported their work in **Nature**.

About the author

Liz Kalaugher is editor of **environmentalresearchweb**.