

# Groundwater depletion rates in India could triple in coming decades as climate warms, study warns

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A bore well pumping groundwater to irrigate fields in Gujarat, India. Wells in this region can pull groundwater from up to 800 feet below ground, and water tables are falling rapidly due to overexploitation. Credit: Meha Jain, University of Michigan.

A new University of Michigan-led study finds that farmers in India have adapted to warming temperatures by intensifying the withdrawal of groundwater used for irrigation. If the trend continues, the rate of groundwater loss could triple by 2080, further threatening India's food and water security.

Reduced water availability in India due to [groundwater depletion](#) and climate change could threaten the livelihoods of more than one-third of the country's 1.4 billion residents and has global implications. India recently overtook China to become the world's most populous nation and is the second-largest global producer of common cereal grains including rice and wheat.

"We find that farmers are already increasing irrigation use in response to warming temperatures, an adaptation strategy that has not been accounted for in previous projections of [groundwater](#) depletion in India," said study senior author Meha Jain, assistant professor at U-M's School for Environment and Sustainability. "This is of concern, given that India is the world's largest consumer of groundwater and is a critical resource for the regional and global food supply."

The lead author is Nishan Bhattarai of the Department of Geography and Environmental Sustainability at the University of Oklahoma, formerly a postdoctoral researcher in Jain's U-M lab.

The study, published in the journal *Science Advances*, analyzed historical data on groundwater levels, climate and crop water stress to look for recent changes in withdrawal rates due to warming. The researchers also used temperature and precipitation projections from 10 climate models to estimate future rates of groundwater loss across India.

Previous studies have focused on the individual effects of climate change and groundwater depletion on crop production in India. Those

studies did not account for farmer decision-making, including how farmers may adapt to changing climate through changes in irrigation decisions.

The new study takes into account the fact that [warmer temperatures](#) may increase water demand from stressed crops, which in turn may lead to increased irrigation by farmers.



A farmer plows his irrigated cotton field in Gujarat, India. Credit: Meha Jain, University of Michigan.

"Using our model estimates, we project that under a business-as-usual scenario, warming temperatures may triple groundwater depletion rates in the future and expand groundwater depletion hotspots to include south and central India," Bhattarai said.

"Without policies and interventions to conserve groundwater, we find that warming temperatures will likely amplify India's already existing groundwater depletion problem, further challenging India's food and [water security](#) in the face of climate change."

Previous studies found that climate change could decrease the yield of staple Indian crops by up to 20% by mid-century. At the same time, the country's groundwater is being depleted at an alarming rate, primarily because of water withdrawal for irrigation.

For the newly published study, the researchers developed a dataset that contains groundwater depths from thousands of wells across India, high-resolution satellite observations that measured crop water stress, and temperature and precipitation records.

Most [climate models](#) call for increased temperature, increased monsoon (June through September) precipitation and decreased winter precipitation in India over the coming decades. The U-M-led research team found that warming temperatures coupled with declining winter precipitation more than offset added groundwater recharge from increased monsoon precipitation, resulting in accelerated groundwater declines.

Across various [climate-change](#) scenarios, their estimates of groundwater-level declines between 2041 and 2080 were more than three times current depletion rates, on average.

In addition to Jain and Bhattarai, authors of the study are David Lobell



of Stanford University, Balwinder Singh of the International Maize and Wheat Improvement Center in India and the Department of Primary Industries and Regional Development in Western Australia, Ram Fishman of Tel Aviv University, William Kustas of the U.S. Department of Agriculture and Yadu Pokhrel of Michigan State University.

**More information:** Nishan Bhattarai, Warming temperatures exacerbate groundwater depletion rates in India, *Science Advances* (2023). [DOI: 10.1126/sciadv.adi1401](https://doi.org/10.1126/sciadv.adi1401).  
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