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THE Current

March 20, 2026

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Why some regions are winning the fight against groundwater depletion

For half the world's population, the water in their drinking glasses comes from below them. Groundwater also supplies 40% of global irrigation projects.

Alarmingly, more than a third of the planet's aquifers, or groundwater basins, are dropping. Declining water tables leave entire regions vulnerable to drought, land subsidence or seawater intrusion while damaging ecosystems and reducing water access. Properly securing this resource is a matter of social, humanitarian and environmental security.

Fortunately, there have been some success stories. UC Santa Barbara professor Scott Jasechko dove into the details of 67 cases of aquifer recovery in a study published in Science. He found that most successful initiatives incorporated multiple intervention categories, and over 80% involved sourcing an alternative water supply. The paper provides many insights on the strategies that communities and resource managers can use to address declining groundwater resources.

"The cases in this review are a reminder that groundwater depletion is not inevitable," said Jasechko, a professor at the Bren School of Environmental Science & Management. "They highlight how humans have solved this problem in different places around the globe."

Addressing an alarming trend

In 2024, Jasechko and his colleagues compiled the largest assessment of groundwater levels around the world, spanning nearly 1,700 aquifers. The paper presented a picture of dwindling resources and accelerating declines. But it also offered a few instructive examples of where things were going well, which served as the basis for the current study.

Jasechko poured over these success stories, arranging interventions into categories that he could then sort and compare. Three broad recovery strategies emerged: finding alternative water sources, implementing policies and environmental markets, and artificially replenishing aquifers.

Aquifers are like groundwater bank accounts replenished by deposits from rain, snowmelt and surface infiltration. Right now, there are a lot of dangerously low balances. We can address these by changing our lifestyle and consumption; in other words, enacting policies and creating infrastructure to reduce the demand on groundwater. We can also get a side hustle. Alternative water sources can offset groundwater demand or even be deposited back into our account through aquifer recharge.

The current paper has a lot of nuanced comparisons and discussions since each case study has a unique combination of factors. However several trends appeared. Two-thirds of the cases involved interventions from multiple categories. “I think this emphasizes the value of multi-pronged strategies to address groundwater level declines,” Jasechko said. The moral here is don’t put all your eggs in one basket. Or in this case, don’t carry all your water in one bucket.

Meanwhile, 81% included an alternative water source that helped offset groundwater demands. Jasechko suspects part of this strategy’s appeal is that it requires the least behavioral change. “If another water source is available, accessing it can help meet water demands and offset the need to pump groundwater,” he said. “This can sidestep more challenging conversations about reducing total water use, but accessing alternative supplies can have its own drawbacks.” Specifically, this solution is often expensive and can end up displacing the issue to another location.

In contrast, policy changes benefit from low overhead and energy costs. They also most directly target the behaviors that led to drawdown in the first place. However, they often have major impacts on local economies that have relied on groundwater use for a long time.

Groundwater recharge can obviate the need to reduce pumping, “which can be a viable strategy for communities that have built their economies around groundwater use,” Jasechko remarked. But, again, the water needs to come from somewhere, and getting it into the aquifer requires energy.

Jasechko summarized his findings in ten key themes:

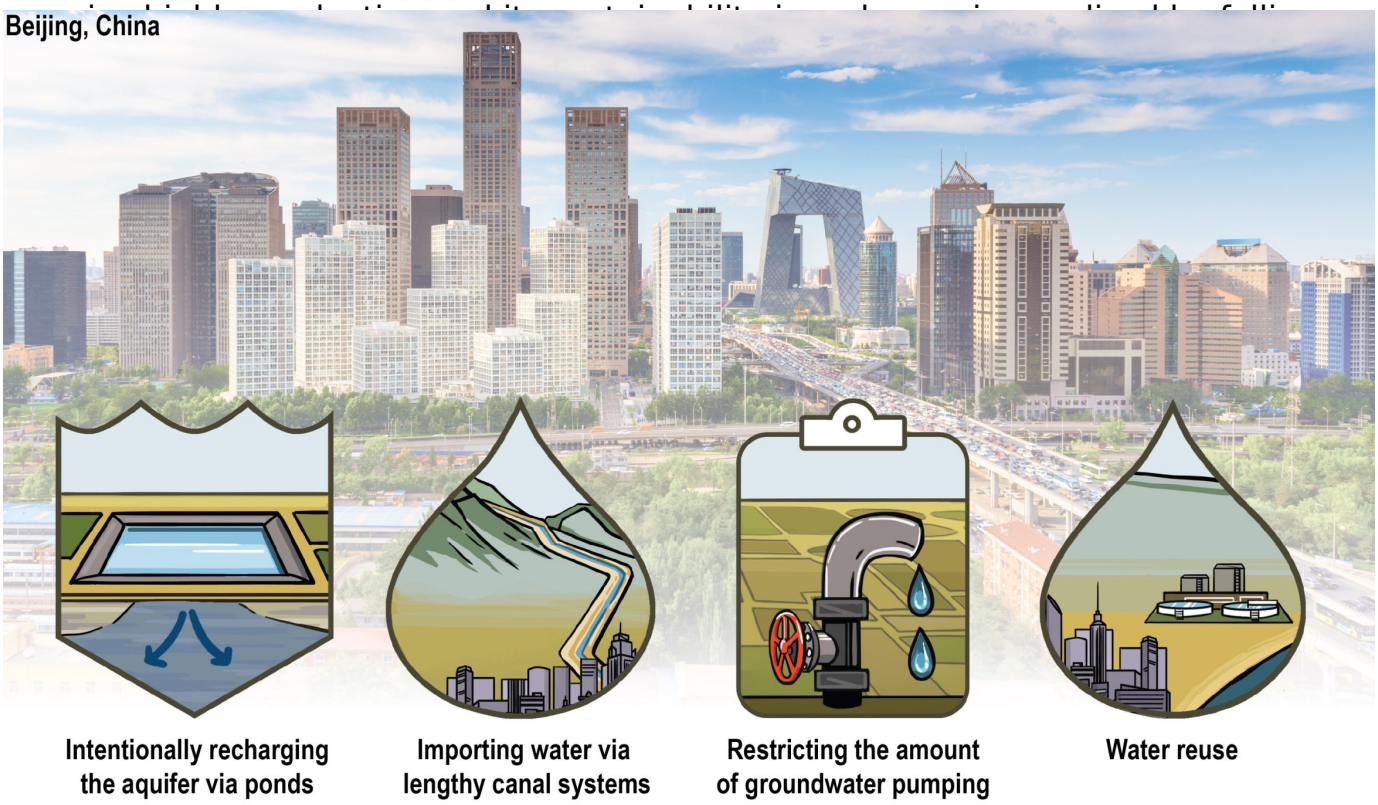
1. Most success stories involved multiple kinds of interventions.
2. The majority included accessing alternative water sources.
3. Interventions that reduced pumping often helped aquifers recover.
4. Good policies still require sound implementation and enforcement.
5. Sometimes recovery can happen over just a few years.
6. When recovery is slow, gradual policy phase-in can be helpful.
7. Recovery can vary widely within a given area.
8. Improvements aren’t permanent, and can easily reverse.
9. It’s important to manage groundwater quality alongside quantity.
10. Interventions should consider the direct and indirect impacts of climate change.

Some examples

Beijing provides a great illustration of how combining different strategies can tackle even a megacity's water woes. Between 1950 and 2000, groundwater pumping around Beijing had caused the water table to plummet by more than 20 meters in some places.

In 2003, the government started construction of canals and pumping stations, and by 2015 it was delivering water to the city and surrounding areas from wetter regions farther to the south. At the same time, the city began using more reclaimed water in the 21st century, with much of this allocated to environmental uses like watering trees and grasslands as well as replenishing lakes and rivers. Furthermore, the authorities banned pumping from the region's deep confined aquifers for industrial uses after the water deliveries began.

Both the area's shallow and deep aquifer has begun to recover, and land subsidence rates have slowed down in and around Beijing. Springs that had previously dried up have begun flowing once again. Meanwhile, the region's irrigated agriculture



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J. Spahr and Scott Jasechko
By selecting several interventions from a menu of strategies, Beijing was able to reverse their declining groundwater.

“However, just because groundwater is recovering at any given moment in time doesn't mean that the work is done,” Jasechko warns. In 1957, Green Bay, Wisconsin constructed a 43-kilometer pipeline to augment their groundwater supply with water from Lake Michigan. This helped restore their stressed aquifer for a while, before additional demand sent it falling again for decades. In 2006, the city built another, 100 km-long pipeline to bring in more water from the Great Lakes, which has brought their aquifer back on the path to recovery.

“It's important to keep monitoring after an initial phase of groundwater recovery so that managers can adapt to changing conditions,” Jasechko said.

At the moment, Jasechko is investigating why recovery speed and distribution can vary so widely across different basins. And these case studies will help develop better predictions of how quickly groundwater levels may recover under different interventions. “An important question is: What scope and scale of intervention is required for depleted aquifers to start recovering?” he said. These are important questions for communities and resource managers who would like to improve the situation, but just don't have a sense as to what magnitude of intervention is required.

Inherent limitations

Jasechko acknowledges that this is not a comprehensive analysis, or even a correlative study. For one, the paper only considers places previously studied by other scientists and resource managers. “It likely overrepresents places where groundwater science has been published in English-language academic journals,” he said.

It also doesn’t start with actions and follow them to their effects. “We need a database of all the places where comparable interventions were implemented, and the groundwater levels before and after,” Jasechko said. This is actually a goal that his longtime collaborator, UCSB professor Debra Perrone, is working toward.

This all means there’s no guarantee that the solutions detailed in this paper will work in other places. At the very least they will need to be adapted to local conditions.

But Jasechko still sees value in outlining the success stories. “This study can help create a menu of options for managers and stakeholders to consider as they develop locally relevant strategies to try to make things better,” he said. These examples and analysis, he believes, can provide the activation energy to begin addressing this problem more widely.

“Groundwater depletion is widespread globally. These cases highlight that there are ways to turn things around,” Jasechko said. “Globally, there are many more bad news cases than good news cases. Yet, I am somewhat encouraged by the clever ways that certain managers and stakeholders have addressed the problem of groundwater depletion in specific places, because they show that the menu of strategies is longer than I originally anticipated.

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