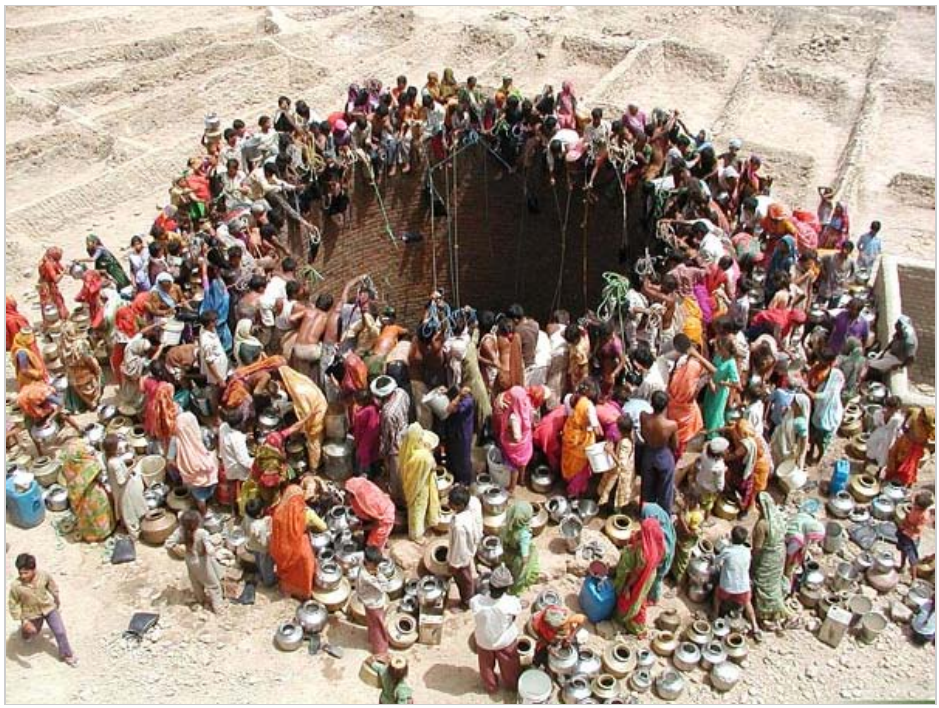
Growing Food Demand Strains Energy, Water Supplies



Excessive water pumping has strained both water and energy supplies in India, China and other hot spots around the world. Here, people gather to get water from a huge well in a village in the western Indian state of Gujarat.

Jeff Smith
For National Geographic News
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The northern region of Gujarat State in western India (map) is semi-arid and prone to droughts, receiving almost all of its rain during the monsoon season between June and September.

But for the past three decades, many crop and dairy farms have remained green—even during the dry season.

That's because farmers have invested in wells and pumps, using massive amounts of electricity to extract water from deep aquifers. The government has

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artificially propped up the agricultural sector through power subsidies and price supports.

The pumping hasn't occurred without dire environmental impacts. Groundwater tables have fallen precipitously, 600 feet below the ground in some places, requiring even more powerful pumps to bring water to the surface. Over-consumption has taxed the power grid, constraining the electricity available for others.

Rising Thirst for Energy on Farms

North Gujarat is a well-documented, extreme example of groundwater depletion and an unsustainable agricultural sector. But there are many other hot spots in places such as India, China, and the Middle East where energy demands are rising so enough water can be pumped to produce food. In essence, experts warn, agriculture in those areas is in peril because of its unsustainable relationship with energy and groundwater.

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Potential impacts include not only dry aquifers and failing farms, but increased soil salinity and carbon dioxide emissions. Climate change exacerbates the situation. Poor farmers often are hit the hardest, because they can't afford to invest in expensive technologies to drill wells and pump water from them.

"I think what is forgotten—the farmers themselves [in Gujarat] are facing constraints," said Vijay Modi, a professor at the Columbia Water Center, part of Columbia University's Earth Institute. "This is their livelihood, so figuring out a way that is a win-win-win for the farmer and the utility and the environment is key."

Modi said there is reason for concern, but he believes the problem can be fixed.

The challenge for Gujarat and other areas lies at what is commonly known these days as the water-energy nexus. Broadly speaking, the term refers to the ways in which water and energy resources are interdependent.

(Related Quiz: "What You Don't Know About Water and Energy")

The goal is to find solutions to the constraints of both—to optimize resource use and eliminate the "slack," or inefficiencies in the system, said Holger Hoff, senior research fellow at the Stockholm Environment Institute (SEI), an independent international research institute.

The knowledge largely is there, "but implementation is very difficult," Hoff said, given the long history of the energy and water sectors, as well as various government ministries, sticking within their own silos rather than working together.

Meanwhile, as world population burgeons, demand for resources continues to rise. Agricultural production will need to increase by about 70 percent by 2050, and primary energy by 50 percent by 2035, barring significant changes to the way food and energy are produced and consumed on the planet, according to an SEI briefing paper and data by the U.N. Food and Agriculture Organization.

An Unsustainable Trend

In China, the use of groundwater to irrigate crops has grown more than tenfold since 1950, according to research released in March by the University of East Anglia in England. The researchers estimated that pumping systems—operating from an average depth of 230 feet (70 meters) in some areas—emitted more than 30 million tons of carbon dioxide a year, roughly equivalent to the amount emitted in all of New Zealand every year. The researchers blamed the massive expansion of groundwater pumping on cheap energy and improved access to pumping technology.

In India, the largest groundwater user in the world, agricultural electricity consumption increased more than 25-fold between 1970 and 2009, more than twice the pace of overall electricity consumption, according to government figures.

(Related: "India Maps Out a Nuclear Power Future, Amid Opposition")

New research by the International Water Management Institute characterizes nine states in India, including Gujarat, as having "critical" groundwater condition, where pumping exceeds the long-term recharge of the aquifers.

"Agriculture, groundwater and electricity sectors in much of India are now bound in an invidious nexus of mutual dependence where the growth of one sector (agriculture) is being supported by unsustainable trends in the other two sectors

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(groundwater and electricity), so much so that even growth in agriculture is now threatened," wrote IWMI senior researcher Aditi Mukherji in Delhi.

The phenomenon is driven by the use of millions of electric pumps that run on cheap power. Farm power subsidies in India are estimated at $9 billion annually, up from $6 billion a decade ago. In Gujarat, tariffs have been raised over the years, but farmers still pay only about 20 percent of the true cost of electricity, according to Modi of the Columbia Water Center.

Jon Strand, senior economist for the World Bank's environment and energy team, said in a policy research working paper that the optimal scheme to combat aquifer depletion would be tariffs that cover the full cost of electricity, with an extra charge to cover the "external cost" of groundwater pumping. That refers to the additional electricity costs to bring groundwater to the surface as water tables fall because of over-pumping.

"When a groundwater basin is exploited by a large number of farmers, acting independently, each farmer has little incentive to practice conservation that would primarily benefit other farmers," Strand wrote.

(Related Blog Post: "The Power of a Radically Affordable Irrigation Pump")

India's government is in the process of revising its national water policy, and a draft recommends changing the "heavy under-pricing of electricity" to more closely reflect actual costs. But if farmers in north Gujarat paid for the full cost of their electricity, the agricultural sector wouldn't be economically viable, according to Columbia Water Center.

Stemming the Flow

In north Gujarat, changes have occurred, although it may be too early to draw firm conclusions.

A decade ago, the region was marked by rapidly depleting aquifers, a nearly bankrupt utility, and an agricultural lobby strong enough to fight efforts to meter electricity. Electricity theft and unreliable power were issues.

Researchers at the International Water Management Institute recommended a scheme to supply uninterrupted power on a rationing schedule designed to match the supply to irrigation needs as closely as possible.

The state government of Gujarat acted on IWMI's recommendation by investing about $260 million for separate electrical feeder lines for farming and non-farm uses. While that may seem like a wasteful investment to make, the "Jyotigram Yojana" or "Lighted Village" initiative met the government's goal of developing rural electrification to stimulate the region's economy. The feeder lines also were metered to curb theft.

(Related: "Smart Meters Take a Bite Out of Electricity Theft")

"While the economics of the Jyotigram program is unclear, it is certainly smart politics," Madar Samad, IWMI principal researcher for water policy and institutions, said of the investment to split the electricity lines.

The scheme made it possible for farmers to keep to certain irrigation schedules and, at least theoretically, conserve water depending on how much they pumped during the rationing period.

Gujarat experienced 9.6 percent annual growth in its gross domestic product from agriculture between 2000 and 2007—the highest in India—compared with less than 3 percent for India as a whole, according to a joint publication by IWMI and the International Food Policy Research Institute.

But groundwater continues to be depleted, and the Institute for Resource Analysis and Policy in Hyderabad, India, countered that the growth was more the result of a strong recovery from a "major dip" in production that had occurred during droughts of 1999 and 2000. The institute argued that the "real growth" in agricultural production in Gujarat already had occurred between 1988-1999.

Additional efforts are being made to improve the groundwater situation in Gujarat. The Columbia Water Center, for example, has been advising a local utility and government on a pilot project that meters water and energy use (meters are attached to wells) and rewards farmers who cut consumption to a certain historical baseline. The project, which started last year, also helps farmers identify ways to save water, such as using tools to measure moisture content in soil, drip irrigation, and planting crops more suitable to the area. More than 800 farmers have agreed to be part of the project.

Preliminary results are encouraging, but Modi of the Columbia Water Center is

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cautious. He said that before conclusions are reached, the project must measure rigorously the energy use of a larger group of farmers over multiple years. That's now under consideration by the utility.

Hoff of the Stockholm Environment Institute and Potsdam Institute for Climate Impact Research also is cautious when it comes to solving such water-energy nexus issues as groundwater depletion. He recently attended the Planet Under Pressure conference in England where, he said, one message was that there's about a 10-year window of opportunity to deal with some of these problems.

He said he wants to be optimistic, but "my experience tells me that action only happens if things become urgent."

This story is part of a special series that explores energy issues. For more, visit The Great Energy Challenge.

An earlier version of this story featured a photo of a diesel irrigation pump that was incorrectly identified as an electric pump.

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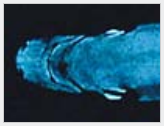
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