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Kenya's Giant Aquifer Highlights Groundwater's Critical Role

Aquifers water an increasingly thirsty world, but are they sustainable?

A villager carries a jug filled with well water in the Turkana region of Kenya.

Photograph by Lynn Johnson, National Geographic

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The Turkana region in Kenya is not the type of place that would come to mind when picturing a wellspring bursting with water.

The area is dry and desolate. It is one of the most arid regions on this planet, with soaring temperatures that burn the earth and suck out moisture. The local people are nomads and follow water to survive. They and their livestock are often plagued by famine, thirst, and poverty.

But last month, surprising news came from this oft-ignored part of the world: Below their feet, below the land that is so parched, flowed water in an aquifer that was so large, it would be able to quench the thirst of the country's 41 million people for the next 70 years.

Officials like Judi Wakhungu, Kenya's secretary for the environment and natural resources, touted the find as a possible solution to the region's humanitarian and socioeconomic problems.

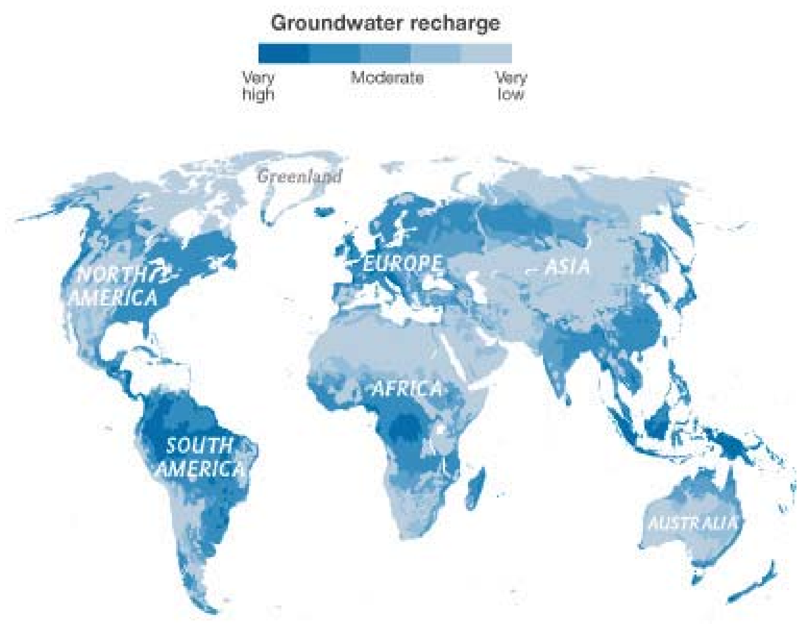
But is it?

"Lots of studies need to be done [to determine the sustainability of the water]," said Saud Amer, a remote sensing and water resources specialist with the U.S. Geological Survey (USGS) and a member of the team that found the aquifer.

"Without studies, if people start digging wells, it's like you have a car and you have gas in it but you don't know how much," he said. "When will the car stop? You don't know.

"People had to go kilometers, 50 or 60 kilometers [31 to 37 miles], to get water," continued Amer. "There is no agriculture in the area. We have to figure out the replenishment rate and whether the water is good for agriculture and the type of agriculture [before allowing the aquifer to be accessed]."

Water experts warn that, around the world, many aquifers are being depleted much faster than they can be "recharged," or refilled with water from natural sources, such as a stream or rainwater. (See "Saudi Arabia's Great Thirst.")



Since the mid-20th century, extraction of groundwater for human use has accelerated, often faster than the natural rate of recharge.

Map by NGM Maps, Source: BGR/UNESCO; University of Frankfurt

And herein lies the debate: In a civilization that increasingly strains for water, how can aquifers be sustainably accessed without depleting the Earth of its last bastion of water? (See "Grabbing Water From Future Generations.")

Sufficient Water?

Aquifers are, quite simply, stores of water that are trapped underground in geological formations. Often tapped by wells, aquifers have been a source of water for centuries.

Though initial reports have estimated that the water in the newly discovered aquifer below Kenya can be used to provide for the region's residents for the next 70 years, experts argue that the aquifer itself is not necessarily impressive, pointing to the substantially larger Nubian sandstone aquifer, which clocks in at 150,000 billion cubic meters, compared with Kenya's 250 billion cubic meters.

Groundwater isn't very picky about what geological formation it collects in, but it's better when the surfaces are porous, says Bill Cunningham, acting chief of USGS's office of groundwater.

Cunningham likened the process to a sponge that holds plenty of water despite being relatively dry at first glance.

"The best aquifers are sand or have enough pore space between the grains for rock to hold water," Cunningham said. "Aquifers can also be solid rock if that rock has a lot of fractures in it."

But not all water sourced from aquifers is safe to drink.

"It can be contaminated by man, or it might naturally have things in it that make it unfit for drinking," Cunningham said. "In general, as you go deeper, the water has been in the ground longer and has an opportunity to dissolve constituents in the rock."

But going farther into the earth requires more advanced tools—and a little ingenuity.

An MRI of the Earth

Evolving technology has made it possible to find sources of water farther and farther underground. In fact, finding aquifers often takes a combination of radar signals, surface geophysics, and drilling.

It's not unlike oil, says Robert Swanson, director of the USGS's Nebraska Water Science Center. He has focused on searching for aquifers in Nebraska's Ogallala area—one that is incredibly important given the region's breadbasket status and its water depletion issues.

"You can determine what type of rock you are drilling through," he said. "We relied on that early on. We have thousands of these.

"But you can miss the [actual] size of an aquifer."

Swanson likens it to putting a syringe into a human body and trying to understand the form of a person.

"It's [as if] you stuck [in] a syringe and pulled out a plug of body tissue from 20 places in the human body and then [tried to describe] what the body was and what it looked like," he explained. "But with an MRI or an x-ray, you get a more conclusive look at who they are."

In a way, the search for water is like getting an MRI on available lands that are suspected to hold water.

The preferred and most popular method of finding aquifers is to do airborne electromagnetic surveys, or AEMs. Swanson said this method is common in the United States, particularly in his home state of Nebraska. The idea is that the radar will measure the electrical resistance of sediments below the surface.

To make such a survey, a helicopter flies over 100 feet (30 meters) above the surface.

With an instrument package, it sends electromagnetic rays into the earth and measures the resistance, explained Swanson.

Sand and gravel tend to be more resistant to electrical flow than silts and clays are. That means that the most porous of geological formations, or the ones that are most likely to hold a well of water, show more resistance to electrical flow.

The data collected from the AEMs are combined to generate three-dimensional models. The next step? Finding out how much water is actually there.

Hydrologists and geologists use nuclear magnetic resonance to determine how much "free water"—water that can be sustainably used—is in the aquifer. Free water means there must be a "recharge," or some form of refilling of the aquifer, normally from rainwater or a stream.

Typically, the deeper the aquifer, the longer it takes to recharge. Large systems can also get quite complex, and can be tied into the health of surface water.

"[Sometimes], streams cease to flow or flow less if you deplete the groundwater resource," Swanson said, unlike in the eastern United States, where river levels are determined by rain. Dryer, more severe weather in some parts of the country makes aquifer recharging more of a guessing game than a science, and that worries experts.

How long can an aquifer keep recharging? "For a few years? A lifetime? A hundred lifetimes? It makes a huge difference in how you are going to manage an aquifer," Swanson said.

Water as Nexus

Swanson notes that water security will be extremely important in the next few decades as people adjust to climate change and increasing modernization.

"It's one of the most important issues," he stressed. "To grow food, [to generate] electricity... Even if you're not doing hydropower, you have cooling towers. Water is the nexus."

Aquifers have been depleted by the demands of big farming and increased use of electricity, forcing geologists to look deeper—and elsewhere—for new sources of water.

"There's a lot of irrigation going in now where traditionally, [aquifers] depended on rainfall," Swanson said. "But as the population grows, [people] will turn to whatever they can get to."

He emphasized that scientists still have a lot to learn about how aquifers work.

An African Miracle?

In the dusty plains of Turkana, the United Nations is working with a French company called Radar Technologies International (RTI), which has experience finding aquifers in drought-ridden, water-challenged areas like Sudan, Ethiopia, and Afghanistan.

The company's WATEX technology combines "satellite and radar imagery with geographical surveys, climate maps, and seismic data ... to provide a comprehensive snapshot of what may lie beneath a given area of land," according to Karen Villholth, senior researcher in groundwater management in the southern African office for the International Water Management Institute.

Intended originally for finding mineral deposits, WATEX looks for water reserves without drilling intrusive—and often inaccurate—boreholes.

"Combining remote sensing technology plus traditional algorithms result in a very good way to detect moisture and the potential presence of groundwater," said Saud Amer of USGS, who was in Kenya when the aquifer was located.

Despite the promise of the newly discovered Lotikipi aquifer, as it has been named, experts are cautiously optimistic. Africa has seen water demand increase exponentially, said Villholth, who points to population growth, better living standards, increased meat diets, urbanization, and drought as drivers.

Amer warns that the water needs more study before it should be used, though the Kenyan government would like to tap into this resource as soon as possible.

Villholth agrees, pointing to local obstacles as well. "Some of these areas are inflicted with civil unrest between different populations or ethnic groups, which could slow down or even impede immediate development," she said. "Oil has also been detected in the Turkana region, showing that integrating the development of these resources will be crucial"—and may lead to disputes about resource management and ownership.

Regardless of where an aquifer is located—in wealthier nations like the United States or poorer, drought-stricken areas like Kenya's Turkana region—sustainability remains an ever-present goal for managers, Swanson said from Nebraska.

"We need to be able to get information to managers and rely on them to make wise choices so that [aquifers] are stable not just for the next crop or for the lifetime of whoever the managers are, but for our grandkids and their grandkids," he said.

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