Groundwater decline occurs globally but is not universal

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A new study by Jasechko et al[1] highlights the widespread challenge of groundwater decline, using data from 170,000 monitoring wells across the world, but demonstrates that groundwater depletion is not inevitable under a changing climate, providing a glimmer of hope for a more resilient water future.

Groundwater accounts for approximately 99% of freshwater on earth[2] and is crucial for water and food security. Groundwater's role as a climate buffer and resilient resource is well established and likely to become more important as climate change accelerates[3]. While climate change influences groundwater availability, human impacts are perhaps more important[4]. Half of the world's population is estimated to rely on groundwater for drinking[2] but most groundwater (70%) is used for irrigation[5] which has rapidly increased in the last 30 – 40 years[5,6] leading to serious concerns about depletion[7,8]. Until now most global studies of groundwater storage change have relied on satellite observations[9] or models[7], both with inherent limitations[10,11]. Thus, the extensive new study by Jasechko et al is a timely and welcome contribution to our understanding of the state of groundwater resources globally.

Jasechko and colleagues have compiled, with the help of machine learning, an impressive global dataset of groundwater levels from 170,000 monitoring wells installed in 1,693 aquifers. Although the data are not evenly distributed across the globe, being concentrated in 40 countries where monitoring has historically been undertaken, they cover about 75% of global groundwater withdrawal. The authors used various statistical methods and a minimum of 8 years of groundwater level data in the 21st century to determine whether groundwater levels were declining, stable or increasing and at what rate. In 542 of the aquifers, it was possible to compare groundwater level trends in the 21st century with trends between 1980 and 2000.

In 30% of aquifers groundwater level declines accelerated in the 21st century. Groundwater level declines were most common and rapid in cultivated drylands. The authors found significant declines in India and California where threats to groundwater are well known, but they also found accelerating declines in areas where the problem is less well known (e.g. West Qazvin Plain in Iran). Accelerating declines were partly explained by reduced recharge and increased groundwater abstraction as a result of changing rainfall patterns.

Importantly, the authors found that in approximately half of aquifers, groundwater level declines slowed, reversed, or rose continuously. This is important because most studies have focussed on areas where groundwater is under severe threat (e.g. India and California). Declines slowed in 20% of aquifers, in 16% declines reversed, and in 13% of aquifers groundwater levels rose continuously. A mix of demand management (e.g. Eastern Saq Aquifer Saudi Arabia), regulation (e.g. Bangkok Basin Thailand), basin transfer (e.g. Abbas-e Sharghi Basin Iran) and artificial recharge (Tuscon, Arizona USA) improved the outlook for these aquifers. Such interventions could be used, along with holistic surface and groundwater management, to slow or reverse declining groundwater levels elsewhere. Increased precipitation can also slow declines or raise groundwater levels as shown using satellites[4]. However, in general rates of increase (0.05 m/year) are much slower than declines (0.2 m/year), emphasising the precarity of groundwater in a changing climate even where the situation appears more positive.

Jasechko and colleagues' study is important because it provides an overview of the status of global groundwater resources using data obtained from monitoring wells and compliments, and is broadly consistent with (excluding some notable exceptions, e.g. peninsular India), lower resolution global analysis using satellites[4,12]. The increased spatial resolution that can be achieved using monitoring well data enables a more nuanced interpretation of hydrological processes and management interventions and reveals areas where rising and falling groundwater levels occur in close proximity, for example in North India and Pakistan. Important lessons can be learned from the, roughly 50% of, aquifers in the same or better state, to reverse the loss of this valuable resource in areas where groundwater decline appears unmanageable. Groundwater is often neglected in global water security or scarcity assessments, so Jasechko et al provide a basis to incorporate it in future. Given the importance of groundwater as a climate buffer and resilient water resource, the study is timely as we plan for a post +1.5°C world of more frequent drought and variable rainfall.

While the analysis of the status of global groundwater resources is on a scale not previously achieved using monitoring well data, the dataset compiled by the authors only covers a small percentage of the earth's surface, in part because groundwater use is so dominated by a relatively small number of countries. Notable gaps include central China, much of Southeast Asia and Latin America, and almost all of Africa, areas experiencing rapid population growth and likely increased dependence on groundwater to underpin people's basic needs and wider economic development. Thus, the study highlights the urgent need to better understand groundwater globally[2], particularly where future trajectories of groundwater use are upward and where data gaps exist. The partial coverage of the monitoring wells analysed by Jasechko et al, both globally and in some cases within the aquifers studied, highlights the poor spatial coverage and variable quality of much of the groundwater data available and the urgent need to better monitor this crucial resource[2]. The study considers groundwater decline but it does not assess whether the decline is unsustainable as groundwater pumping inevitably leads to decline. However, eventually, groundwater levels reach a new equilibrium[13]. Furthermore, the quality of groundwater is often more of a risk to water security than depletion[14,15]. Thus, global groundwater quality and sustainability of groundwater extraction are important future research directions.

Jasechko and colleague's study provides a timely warning that in many areas groundwater level decline is accelerating. However, they also find areas where groundwater declines are slowing, have been reversed, or have continuously risen through the late 20th and early 21st century. Lessons must be learned from these areas to help halt accelerating groundwater decline elsewhere.

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