Groundwater: The world's neglected defence against climate change

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Water scarcity in 2022

Currently, millions of people across the globe don't have safe water to drink. As climate change continues to wreak havoc, communities will see their homes and means of survival washed away, their drinking water contaminated or dry up, their crops wither and fail, their health devastated by infectious diseases, and their children forced out of school.

Communities need sustainable and safe water and sanitation to have the best chance of combatting the devastating impacts of extreme weather, like heatwaves, droughts and floods. Yet one in four people across the globe do not have safely managed water in their homes.

However, new analysis by the British Geological Survey (BGS) and WaterAid, reveals that many countries in Africa – including most parts of sub-Saharan Africa – and parts of Asia, have enough water to meet everyone's daily needs. And this hidden resource is often right under our feet – groundwater.

Groundwater – which exists almost everywhere underground, in gaps within soil, sand and rock – has the potential to save hundreds of thousands of lives and be the world's insurance policy against climate change.

It would help communities cope with slow onset climate impacts like drought and irregular rainfall, and provide broader resilience after floods by ensuring there is safe water available for all.

But groundwater will only be able to lessen the impacts of climate change if it is carefully managed and if we invest in mechanisms to ensure that it gets to the people who need it most. All too often, this is not the case.

In some regions, there isn't enough investment in the services needed to find, capture, treat, manage and distribute groundwater – so it remains largely untouched. In others, we see rampant over-extraction with far too much groundwater being used, particularly by the agricultural sector. In both cases, only a limited amount of this life-saving resource gets to those who need it most.

BGS and WaterAid assessed data on the amount of groundwater there is, how quickly it is replenished by rain, and how much the rocks can store.

Our experts concluded that, on a national level, most countries in Africa have sufficient groundwater for people to not only survive, but to thrive. This includes countries such as Ethiopia and Madagascar, where only half the population have clean water close to home, and large parts of Mali, Niger and Nigeria.

Although, on a sub-national level, there are some places where groundwater is more difficult to get to or is contaminated, our research estimated that today's total groundwater on the continent could provide people with enough drinking water for at least five years in the event of a drought – and in some cases even decades.

This calculation is based on 130 litres of domestic water use a day per capita, which would provide people with more than enough to drink, cook and wash with.[i]

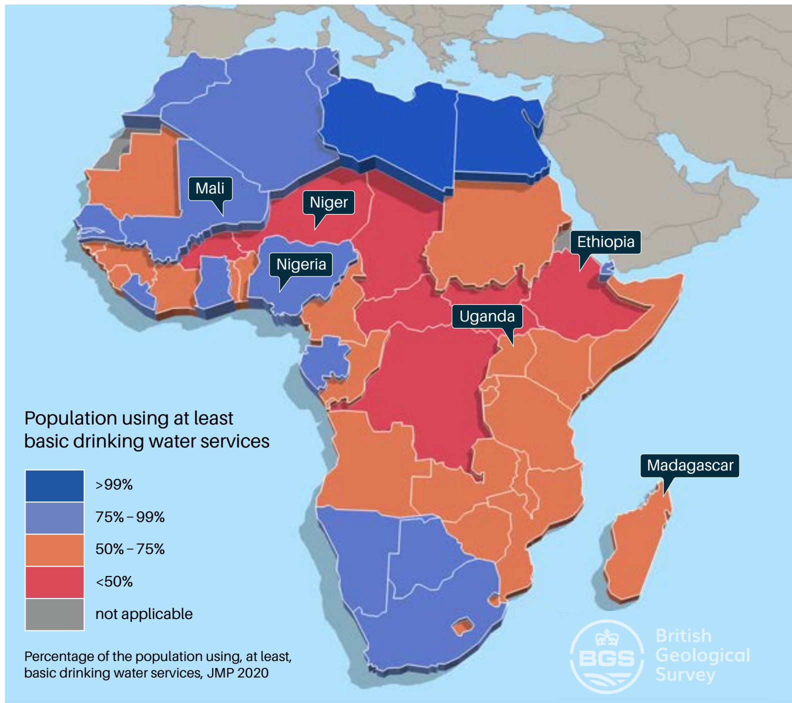
What's more, as groundwater is below the surface, it is more resilient to extreme weather than other water sources – such as lakes, rivers, streams and dams – and is largely protected from evaporation and less susceptible to pollution.

This means that even if our weather becomes more extreme and unpredictable, there is enough groundwater stored in aquifers[ii] to provide a buffer for many years to come for the millions of people living on the frontline of climate change. For them, daily life is already a struggle simply because they do not have access to sustainable and safe water and sanitation.

▲ Ram Yadav rides a mule as his feet hurt when he walks due to arsenic contamination of the groundwater, in a village on the outskirts of Bhagalpur, India. April 2021.

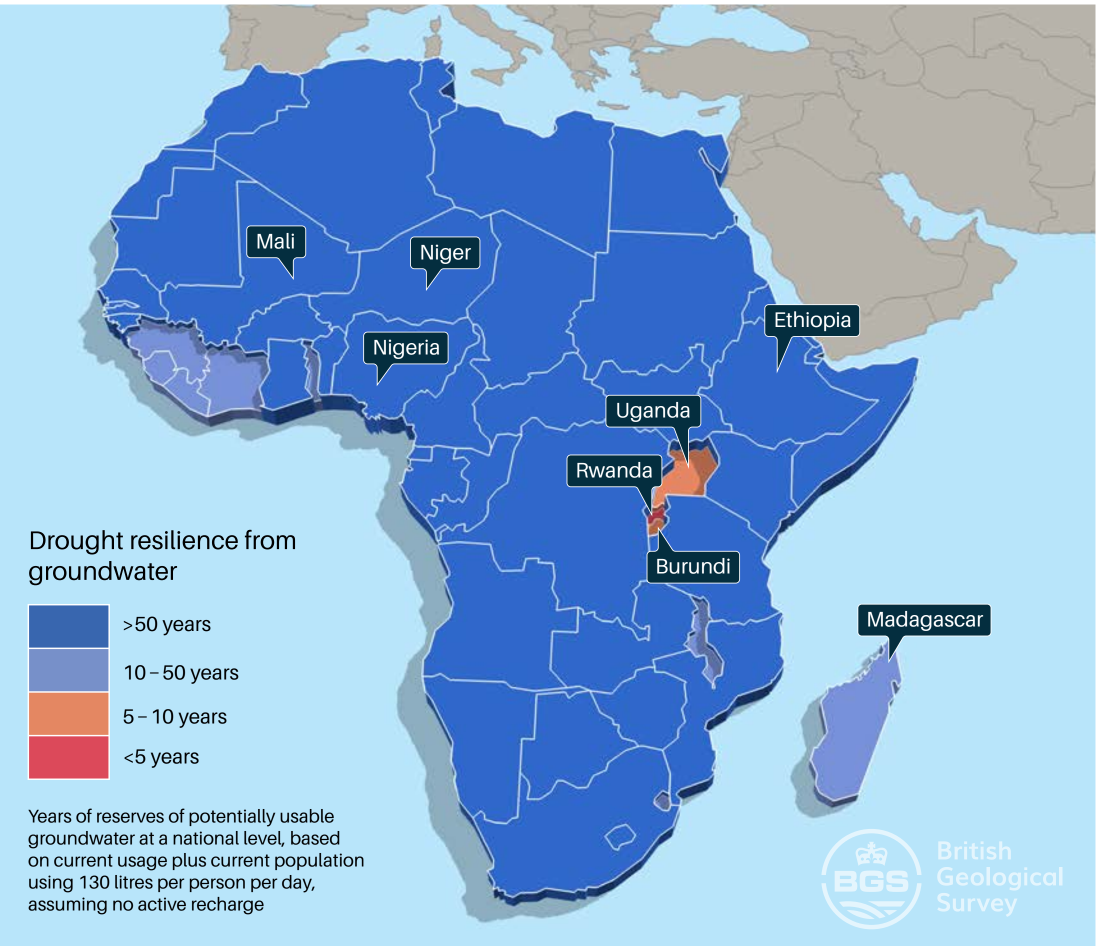
◀ A boy walks past a wheat thrasher in a village on the outskirts of Bhagalpur, India. April 2021.

▼ Basic services are sources of drinking water that have been improved to lower the risk of contamination. To be considered 'basic', a source must have a collection time of no more than 30 minutes for a round trip. These sources do not necessarily provide a reliable service; in fact many provide an intermittent supply of unclean water.



i. The average UK use is currently 141 litres a day, but the aspirational target is 130 litres. In Germany, the current average daily use is 121 litres.
ii. An aquifer is a body of rock, and, or sediment, that holds groundwater.

Africa findings



▲ Many countries in sub-Saharan Africa have enough groundwater reserves to face at least five years of drought, and often more – provided there is enough investment in services to get water from the ground to people.

Uganda, Rwanda and Burundi are showing up as anomalies as they have large populations residing on relatively low storage aquifers.

- On a national scale, there is at least five years of groundwater storage for drinking water available in most African countries, that could buffer any prolonged droughts caused by climate change.[iii]
- Every African country south of the Sahara could supply 130 litres of drinking water per capita per day from groundwater without using more than 25% of the long-term average recharge, and most less than 10%.[iv]
- There are hotspots within individual countries where high abstraction around cities (for example, Addis Ababa in Ethiopia and Nairobi in Kenya) or in highly populated areas (for example, some parts of Nigeria), that can lead to depleting local groundwater, particularly aquifers with low storage, such as granites or volcanic rocks. Despite this, groundwater storage could still act as a buffer for one to two years of drought in these areas.

iii. Assuming groundwater is not used for other purposes.
iv. On a national scale, assuming groundwater is not used for other purposes.

Groundwater challenges

Contrary to popular belief, our findings confirm that Africa isn't running out of water.

But the potential of groundwater can only be realised if we overcome the complex global problems around accessing it. In parts of sub-Saharan Africa, for example, groundwater remains largely untapped, while in parts of South Asia overuse is rife. This, along with insufficient expertise and investment, often leads to poor regulation, mismanagement, contamination and pollution – with potentially devastating consequences.

1. Untapped

Groundwater is an invisible resource, so tapping it, particularly in places where it is harder to get to, relies on knowledge about the geology beneath our feet.

The quantity and quality of the groundwater also varies and, in some areas, we simply don't know how much there is or its suitability.

Without this detailed knowledge, well-meaning attempts to deliver groundwater to communities can, unfortunately, be a waste of time and money. Boreholes[v] can end up in the wrong place and fail to hit water at all, or when they do, the supply may quickly run dry.

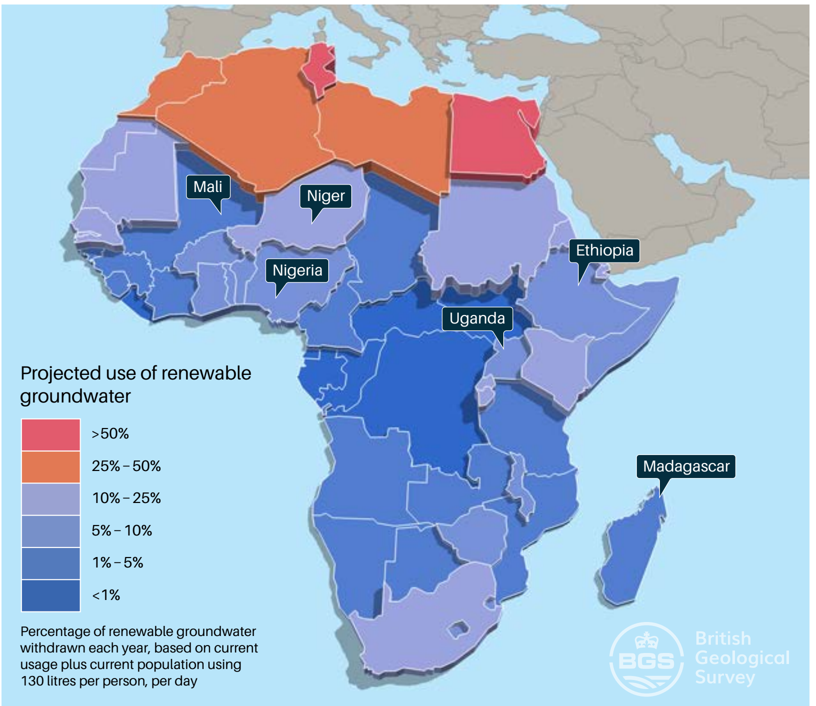
For example, it is difficult to find suitable locations to drill boreholes in parts of Enugu State in Nigeria because the underground rocks are made mainly of clay, which doesn't hold much water. This means you need to search for areas where the rock does hold water, like sandstone. But such exploration is expensive.

Pockets of shallow groundwater in Enugu can also be contaminated and only available for part of the year. By contrast, it is much easier to find suitable locations to drill boreholes in Jigawa State, Nigeria, as the rocks underground store large quantities of water.

Another example is in the Mpologoma Catchment in Uganda, which has sufficient groundwater resources to meet long-term domestic water supply needs. Yet in some districts within this area, three in ten people don't have water close to home.

▶ Renewable groundwater is recharged by rainfall and surface water. Fossil groundwater on the other hand was deposited many years ago, and is not currently recharged by rainfall or surface water.

The current use that is mentioned on this map, includes water used for farming, households and industries.



v. Boreholes are deep, narrow holes drilled into the ground from which water is drawn.

2. Overused

Outside sub-Saharan Africa, groundwater is over-exploited. Our research team's findings show that in contrast to the challenges in sub-Saharan Africa, in much of northern India, Pakistan and Bangladesh, groundwater extraction is usually greater than the expected annual recharge from rainfall.

Therefore, during periods of drought, water supplies become unsustainable and may run out at a time when people need them most.

Large-scale agriculture in some south Asian countries uses up to 90% of extracted groundwater. As a result, wells in villages may run dry and communities, healthcare centres and schools may be without enough water for their daily needs.

In Pakistan, for example, 94% of pumped groundwater is for irrigation. The desire to further boost agricultural productivity to provide food for Pakistan's growing population and export, has led to the overuse and deterioration of groundwater resources.

Coupled with urbanisation and the impact of climate change, Pakistan is now on its way to becoming one of the most water-stressed countries in the world. And despite recent positive legal and policy developments in Pakistan, the majority of laws largely ignore provisions to protect or recharge groundwater resources.

▲ Somari Devi at her house in Bicchu ke Dera, where the local community are struggling with severe arsenic contamination. Bihar, India. February 2021.

▼ A farmer bathing near his field on the outskirts of Bhagalpur, India. The area is affected by harmful levels of arsenic and fluoride in the groundwater. April 2021.

◀ Clay pots for collecting water in Rab Dino Khaskheli village, Pakistan. July 2021.

3. Poorly regulated or mismanaged

Groundwater is often over-extracted by people, companies or governments when it is not regulated. This drives competition for water, increases the cost of abstraction and impacts the amount of water available for drinking and washing. A major consequence of unregulated and unsustainable groundwater use is that it deepens inequality. When shallow wells dry up, only people who can afford to sink deeper wells have sufficient water for their needs.

Overuse of groundwater can also damage the structure of soil and allow salts to build up. This damages the roots of plants and reduces the ability to grow crops. Salinity can also be caused by rising sea levels that pollute groundwater in some coastal areas. This makes the water undrinkable and extremely difficult to treat. A long-term fall in groundwater levels can also lead to permanent ground subsidence, which in turn can increase the risk of flooding and reduce the capacity of aquifers to store water.

For example, this year's G20 host, Indonesia, is considering moving its capital because ground levels are dropping due to the over-extraction of groundwater from shallow aquifers. This, along with rising sea levels, is putting Jakarta at risk of catastrophic flooding.

The introduction of licensing and the reformation of legal frameworks can help tackle the over-extraction of groundwater. But there is no one-size-fits-all solution. Local contexts and individual needs of the groups accessing the groundwater must be taken into account in order to ensure it is used sustainably.

Unlocking the potential of groundwater requires investment in knowledge, infrastructure and maintenance (such as drilling and pumping equipment) to access and deliver it to the people who need it most. Further institutional support to manage existing water supplies and regulate groundwater will also ensure it is accessible to all and protected for future use.

4. Pollution

Groundwater is also vulnerable to pollution. Excess fertilisers and pesticides from intensive farming can leach into aquifers, and poorly regulated industry can lead to a cocktail of toxic chemicals soaking through the soil.

The pollution of groundwater from poorly managed sanitation is also a huge problem in many rapidly developing cities, where the sewerage infrastructure can't keep up, and in rural areas if toilets are located too close to boreholes.

For example, a recent survey of boreholes in Ethiopia, Uganda and Malawi saw E. coli present in the water from 20% of rural handpumps, likely as a result of poor seals around the boreholes, allowing contaminated water from nearby toilets to drain into the pump intakes.

Climate change often worsens this problem when floods overwhelm vulnerable sanitation systems and contaminate drinking water supplies further.

One way to stop this from happening is to use hydrogeological studies and sanitation inspections to make sure that handpumps are only put in places where they will not pollute the groundwater.

5. Contamination

In some regions, such as parts of South Asia, groundwater is naturally contaminated with arsenic and fluoride. If untreated, it can lead to illness or even death.

For example, in India, arsenic contamination affects the northern states of Uttar Pradesh and Bihar, and West Bengal in the east. Several districts of Odisha are affected with high fluoride, iron and salinity. Parts of central and South East India also show higher levels of nitrate and iron contamination.

WaterAid India is partnering with Halma Plc to train communities in Bihar who are affected by arsenic and fluoride contamination.

▲ Manohar, who lives on the outskirts of Bhagalpur, suffers from Arsenical Keratosis due to poor water quality and high arsenic content. India, April 2021.

▶ Manohar bathes in the contaminated water on the outskirts of Bhagalpur, India. April 2021.

Recommendations

◀ Karimatu, 17, walks back home after collecting water from the pond in her community in Adamawa, Nigeria. February 2021.

▼ A team of WaterAid experts test the quality of water at a community school on the outskirts of Bhagalpur, India. April 2021.

Clean water, decent toilets and good hygiene are human rights.

That is why we need to act now to protect climate-vulnerable communities from the impacts of climate change and reach the UN's Sustainable Development Goal (SDG) 6 for everyone, everywhere to have sustainable and safe water and sanitation by 2030.

WaterAid and BGS therefore emphasise the importance of:

1. Recognising the role that groundwater must play in adapting to climate change and investing in sustainable infrastructure and service management in areas with sufficient supplies of groundwater so that people can access sustainable and safe water.

2. Increasing water and sanitation financing for communities who are marginalised from these essential resources through a fixed percentage of annual government budgets and increased international donor and private sector investment.

3. Investing in better mapping and monitoring of the Earth's subsurface to determine where good-quality groundwater is not only available but also extractable in a sustainable and economical way, to unlock its full potential.

4. Mitigating the risks to groundwater supplies (such as pollution or unregulated extraction) through stricter regulation and the monitoring of supplies to avoid overuse.

5. Ensuring qualified supervision of borehole drilling and adherence to regulations governing the quality of the borehole.

6. Using groundwater data and local expertise to develop comprehensive and investable water programmes that can best serve climate-vulnerable communities.

7. At COP27 in November 2022, agreeing that investment in responsible groundwater development and the knowledge, expertise, finance and institutional support this requires, is key to securing life-saving sustainable and safe water and sanitation for communities living on the frontline of the climate crisis.

Methodology

At the end of 2021 and early 2022, WaterAid and the BGS analysed different datasets to explore hidden groundwater resources in Africa and parts of Asia as a mitigating factor for the impacts of climate change.

The data for the available groundwater storage was taken from MacDonald A M, et al. (2012)[1] for Africa, and MacDonald A M (2016)[2] for the Indo Gangetic Basin (IGB) aquifer in South Asia, based on conservative estimates.

Current groundwater abstraction was estimated for Africa using modelled abstraction from a global water resource model (Sutanudjaja E H, et al., 2018,[3] Wada Y, et al., 2014)[4] which accounts for all groundwater uses, and for the IGB from reported data (MacDonald A M, et al., 2016)[2]. The potential domestic groundwater abstraction for Africa was estimated using gridded population data (World Urbanization Prospect, 2018)[5] and 130 litres per day per capita.

The long-term average groundwater recharge from rainfall was taken for Africa from the open access datasets from MacDonald A M, et al. (2021)[6], and approximated for the IGB aquifer using 15% of the annual precipitation. Total groundwater recharge for the IGB is estimated to be double this due to the recharge from returning irrigation water from the large-scale canal network.

Water stress is shown in BGS maps as the *projected use of renewable groundwater*. It was calculated using actual groundwater abstraction for South Asia and current plus potential domestic groundwater abstraction for Africa, and dividing it by the annual recharge. In the indicators for achieving SDG 6, water stress is defined as low – where less than 25% of the available renewable water is withdrawn. For Africa, the water stress was summarised for individual countries, and included current and projected groundwater abstraction.

The ability to buffer drought is shown in BGS maps as the *annual use of stored groundwater* and calculated by dividing the available effective groundwater storage by the annual abstraction (ignoring the recharge). *Drought resilience from groundwater* was illustrated for each African country by calculating the number of years abstraction could continue with no recharge until 10% of the national effective groundwater storage is used up. Environmental damage to surface water can occur by depleting groundwater storage even by only 10%, but the aquifer should still be able to provide water for drinking.

WaterAid/Dennis Lupenga

▲ Women and children collecting water at a borehole on Chisi Island, Malawi. October 2020.

References

1 MacDonald A M, Bonsor H C, Dochartaigh B É Ó, Taylor R G (2012). Quantitative maps of groundwater resources in Africa. *Environmental Research Letters*. vol 7, no 2), p.024009. Available at: doi.org/10.1088/1748-9326/7/2/024009 (accessed 15 Feb 2022).

2 MacDonald, A M, Bonsor H, Ahmed K, et al. (2016). Groundwater quality and depletion in the Indo-Gangetic Basin mapped from in situ observations. *Nature Geoscience*. vol 9, pp 762–766. Available at: doi.org/10.1038/ngeo2791 (accessed 15 Feb 2022).

3 Sutanudjaja E H, et al. (2018). PCR-GLOBWB 2: a 5 arcmin global hydrological and water resources model. *Geoscientific Model Development*. vol 11, no 6, pp 2429-2453. Available at: doi.org/10.5194/gmd-11-2429-2018 (accessed 15 Feb 2022).

4 Wada Y, Wisser D, Bierkens M F (2014). Global modeling of withdrawal, allocation and consumptive use of surface water and groundwater resources. *Earth System Dynamics*. vol 5, no 1, pp 15-40. Available at: doi.org/10.5194/esd-5-15-2014 (accessed 15 Feb 2022).

5 United Nations Department of Economic and Social Affairs Population Dynamics (2021). *World Urbanization Prospects 2018*. Available at: population.un.org/wup/ (accessed 15 Feb 2022).

6 MacDonald A M, et al. (2021). Mapping groundwater recharge in Africa from ground observations and implications for water security. *Environmental Research Letters*. vol 16, no 3, p.034012. Available at: doi.org/10.1088/1748-9326/abd661 (accessed 15 Feb 2022).

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WaterAid is an international not-for-profit, determined to make clean water, decent toilets and good hygiene normal for everyone, everywhere within a generation. Only by tackling these three essentials in ways that last can people change their lives for good.

The British Geological Survey is a world-leading geological survey and global geoscience organisation, focused on public-good science for government and research to understand earth and environmental processes. Our vision is for a safer, more sustainable and prosperous planet and a future based on sound geoscientific solutions.

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#WorldWaterDay

Front cover top: Karimatu, 17, walks back home after collecting water from a pond in her community, Adamawa, Nigeria. February 2021.

Front cover middle: Locals in the Kissa community in Adamawa collect water from a stream. In the dry season, the water in the stream slowly dries up. During this period, locals are forced to dig the ground further to make way for a new and often temporary source of water. Adamawa, Nigeria. February 2021.

Front cover bottom: MaJharni Devi displays the effects of arsenic contamination on her hands. Water in Bicchu ke Dera, has been severely contaminated with arsenic. Bihar, India. February 2021.

March 2022

WaterAid