WATER AND TECHNOLOGY

App for hydrocensus and groundwater monitoring – A citizen science approach

With financial support from the Water Research Commission (WRC), researchers from the North-West University's Centre for Water Sciences and Management have developed a mobile application (app) that will allow ordinary citizens to add borehole locations and other characteristics to the app databases. The simple technology will place the power of groundwater monitoring in the hands of all citizens, over and above professionals and groundwater experts. Article by Petro Kotzé.

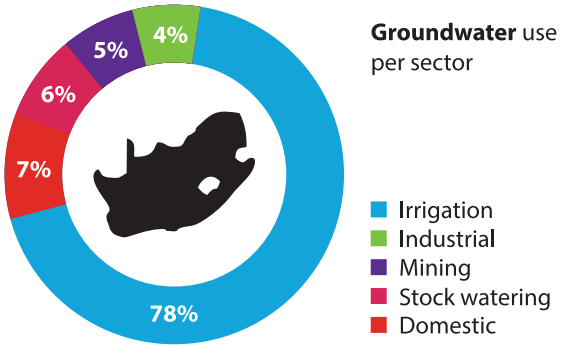
"You can't manage what you don't measure" is a common saying, but one that is increasingly relevant to South Africa's groundwater resources. Once known as the country's Cinderella of water resources, we are increasingly shining the spotlight on groundwater for potential water supply, especially when supplies run low. Cape Town's close shave with Day Zero is a case in point. An estimated 30 000 boreholes were reportedly drilled in and around the Mother City during the 2016 to 2018 drought, but how much groundwater was abstracted, and the impact thereof, are largely unknown.

The situation is not unique to the Western Cape. The national database for borehole information has progressively developed a backlog, and contains limited time series data, with serious consequences for future groundwater resource management.

In a dry country such as South Africa, adequate information on the status and trends of groundwater resources is paramount for strategic development. We need it to help plan how to provide water for the people, to monitor our water resources, provide drought relief and mitigate against the impact of climate change. Without specific and accurate borehole information, we cannot ensure that groundwater is managed well, or protected from over-abstraction and contamination.

It is hoped that the new groundwater app could go a long way towards alleviating the situation.

Storing groundwater information in South Africa



South Africa's predominant fractured rock groundwater system contributes about 15% of the bulk water supply. This plays a major role in domestic water supply, contributing 45% to 60% and in rural areas, possibly as much as 90%.

Groundwater-related data is captured in the National Groundwater Archive (NGA), which is managed and owned by the Department of Water and Sanitation (DWS). The NGA is part of the larger National Groundwater Information System (NGIS).

The NGA dates back to the sixties, and allows registered users to capture, view, modify and extract groundwater-related data. It contains comprehensive information on specific geosites like boreholes, dug wells, seepage ponds and springs. Site names, locations, descriptions and types, drilling details like water strike depth and blow yield, test pumping and abstraction data, groundwater levels and water quality have been logged for thousands of geosites, including at least 270 000 boreholes, spread across 1 225 986 km^2 of South Africa.

However, the NGA is known as much for the backlog of information that needs to be captured in the database, as the necessity of the data that it must store. Rainier Dennis, project leader and senior lecturer at the NWU says an analysis of the NGA dataset showed a sharp decrease in new information captured over the past two decades.

The NGA's unraveling is likely due to several reasons. For one, the platform is not very user-friendly, says Yazeed van Wyk, WRC research manager in groundwater hydrology. The cumbersome process involves data being emailed to users in spreadsheets, from where coordinates must be plotted on a map or uploaded to a GPS, so the user can find the geosite location in the field.

Electronic data can be directly uploaded in bulk, but others must be recorded on a detailed, paper-based field form which, back at the office, must be captured electronically and submitted to the DWS, where an official has to capture the information and upload it to the NGA. Due to system failures, hard copies from mines sometimes need to be posted to the DWS.

The data also has to be checked and validated and ideally, monitored, which could involve many kilometres of travelling each month. It becomes an impossible task for an institution such as the DWS, Dennis explains. Most of the monitoring has been delegated to regional offices across the country's provinces, but many lack the capacity to complete these tasks.

Over and above the backlog of information that needs to be uploaded, a lack of repeat monitoring has resulted in the NGA database containing a very limited time series data, van Wyk says. The location, water level and quality parameters of some boreholes might only have been logged once, decades ago.

Another problem is that users will typically download data from the NGA, but they won't upload data, van Wyk says. Dennis adds that many consultants hold onto their databases instead of uploading them to the national system, as it gives them a competitive advantage for future work. Some borehole users are also just unwilling to share the information for fear of attracting the attention of authorities.

"While we do have a very good understanding of what's happening with our groundwater resources," van Wyk says, citing the many farmers that keep exceptional data sets for their water resources as another example, "the data is sitting in private hands".

An exception is the Limpopo Province, for which "a very thorough and detailed data set" exists, Dennis points out. The Limpopo Groundwater Resources Information Project (GRIP) was regularly updated by consultants, by means of a term contract set up by the DWS. However, though it should ultimately form part of the NGA, it's uncertain if all of it has been merged, reportedly because the persons running GRIP feel their data set is superior and prefers to keep it separate from the NGA.

How to manage what you don't measure?

The impact, especially in terms of monitoring, is massive, van Wyk says. "If we have good quality data we can make more informed decisions. For example, hydrogeologists usually monitor and collect water quality data of aquifers from boreholes. By the time contamination is picked up, it might already be too late as it takes a considerable amount of time for pollution to spread in the aquifer with the next step generally being remediation. Groundwater contamination can be prevented if efficient near real-time monitoring takes place.

"Should we all be prepared to share the data and have an updated national groundwater database, it would put us all in a better place overall for managing groundwater."

Even basic geohydrological work is affected. A common task is to conduct a hydrocensus, which involves the gathering of information on water features, water supply and potential pollution sources in a particular site or area under investigation. Over a large area, with outdated data, finding a borehole is like trying to find a needle in a haystack, Dennis says. Large distances need to be travelled, with no certainty that there is still an actual borehole at the end, adding unnecessary costs and time to the job.

Petro Kotzé

Groundwater is increasingly leaned upon as water resource in South Africa, especially in times of drought. Monitoring is integral to ensure that its use remains sustainable.

Petro Kotzé

Though a near 30 000 boreholes were drilled in and around Cape Town during the so-called Day Zero drought, the impact thereof is largely unknown.

"Should we all be prepared to share the data and have an updated national groundwater database, it would put us all in a better place overall for managing groundwater," Dennis says. Proposed by the local groundwater community, the new app can go a long way to help achieve this.

A solution in the palm of your hand

The app is built around the concept of citizen science, and allows both experts and the general public to upload and access groundwater information. Developed with ArcGIS AppStudio and able to run on both Android and iOS operating systems, the database can accommodate common data between the NGA and GRIP. All data are stored in the cloud making use of an ArcGIS Online server, which the mobile app connects to. Desktop software allows users to perform bulk uploads and downloads.

The app provides easy access to the information in the NGA and GRIP databases. Users can see a map of where boreholes are, and immediately access all the information available to them, on their phones, with the tap of a finger. New information can also be captured and submitted on the spot. This will then be uploaded to a database that can be linked straight to the NGA.

The app takes the onus of groundwater monitoring out of the hands of only experts. In fact, part of its success will lie in the hands of any citizen. Though specialised equipment is necessary for borehole measurements, the public can still easily obtain a GPS location, take a photo, and answer some basic questions about the state of the borehole in the form of selection lists. Even if you only log the position of your borehole or any that you come across, it can give a groundwater professional an idea of where the boreholes are that should be included when studies are done, and they can then submit more specialised information, Dennis explains. This alone will be "a major game changer."

The app allows for data validation and verification through a star-rating system. Ranging from zero to five, new or novice users will initially be allocated a zero-star rating, while professionals and expert users will be assigned a five-star rating. The rating is also affected by how many times the localities that a user logged were verified by other users.

The developers also incorporated a user credit system that allows you to download data if you are also a contributor. The system will allocate a certain number of credits for each type of record uploaded and consume a certain number of credits for each record downloaded.

Van Wyk reports that the app has worked very well for him during a test run out in the field. However, the real impact will only be derived when the app goes "live "and people actually start using it and populating the databases.

"The challenge of this project moving forward is how to keep the general public interested in taking part in the data collection," van Wyk says. "Boreholes are not very exciting," Dennis admits. Motivating groundwater professionals to use it is not an issue, he says, but we want those people sitting on isolated farms, those who live in rural areas and small towns to use it too.

This challenge was also picked up in the pilot study conducted as part of the project. Moreso than a general responsibility to help take care of water resources, people wanted to know what was in it for them. "They wanted us to provide incentives," Dennis explains.

"The irony is if they do it, and log their water levels even just once a month, then, when there's a problem, and I've got that data, we can actually advise him."

For now, the more immediate challenge is where the app will be housed. "We had a high-level discussion with the key stakeholders on how to best to store and manage the app but these discussions have not yet been finalized," van Wyk says. However, the app could potentially be managed by the WRC itself "We are in the process of developing a water research observatory that will be a centralised hub for all water-related data," he says.

If so, the app can play an integral role in South Africa's future water security. Though there is a popular narrative that groundwater is readily available in sufficient quantities, it still needs to be carefully regulated, van Wyk says. "If not, we might be over-abstracting from deeper groundwater resources, which might not necessarily be renewable."

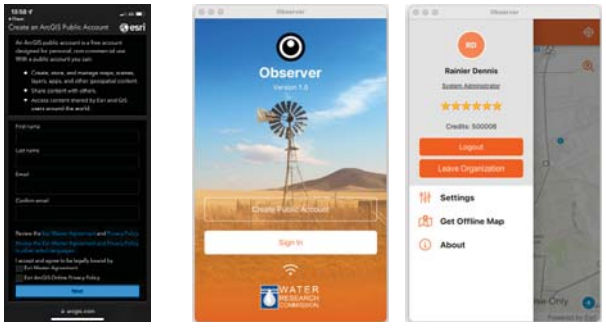
In the long term, it boils down to issues of water security, and

Petro Kotzé

A new app could allow all South African citizens to add information on boreholes to the national database, and so help to safeguard the resource.

the various challenges the state faces to achieve this. We need to assist government, he says. And, this project is a fine example of what the WRC constantly tries to achieve. "Fundamental to whatever we do is how effectively science gets translated to inform policy," van Wyk notes. "That's the only way that we can really help society."

To access the final report of this research project, ***Mobile App for Hydrocensus and Groundwater Monitoring*** (**WRC Report No. 2827/1/22**) visit: https://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/2827%20final.pdf



Screenshots of the new groundwater app
1) You need to register an ArcGIS Account to use the app. 2) Start-up screen where you log-in with your ArcGIS account. 3) System makes use of a star rating to express data confidence and a credit system for fair data use.

Groundwater and the law

Under the country's previous water Act, promulgated in 1956, people that owned the land above where the groundwater was found, owned it. The Water Act of 1998 (the NWA), however, fundamentally reformed any water laws in the country that were discriminatory and not appropriate to South African conditions, specifically the 1956 Act.

Water, and groundwater, are no longer privately owned, but fall under the management of national government. The ultimate aim of water management is, according to the NWA, "to achieve the sustainable use of water for the benefit of all users." Furthermore, the law recognizes that the "protection of the quality of water resources is necessary to ensure sustainability of the nation's water resources in the interests of all water users."

According to the law, water use licenses for boreholes used for low-volume, low-impact activities such as domestic use, livestock, recreation, and emergencies are not legally required. In reference to the mentioned near-30 000 boreholes that were sunk around the Day Zero drought, researchers ask in the report, Mobile App for Hydrocensus and Groundwater Monitoring, if 30 000 boreholes near each other is still considered a low-impact activity.

Since these boreholes were not required to be licensed and registered, most of their positions and water levels at the time, or after, will not be known or likely monitored.