The value of citizen science for a just and sustainable water future

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In this Commentary, we reflect on advances regarding citizen science monitoring of water systems in South Africa and how research into water-related citizen science can shape just transitions to a water secure future.

South Africa is characterised by a triple challenge of multidimensional poverty, inequality, and unemployment. The official unemployment rate is 32%, which worsens when considering that youth (ages 15 to 34) unemployment stands at 46%. The most recent General Household Survey reports that 23.1% of South African households have less than adequate access to food, and that almost 40% of households now receive a social assistance grant.[1] South Africa also has the highest Gini coefficient (i.e., the disparity between rich and poor) in the world.[2] These issues challenge our ability to make sustainable, equitable, efficient, and just transitions toward a food and water secure future. A bleak portrait! However, this background is important to appreciate because, although these issues may seem solely socio-economic, they are intricately intertwined with environmental health and the state of and pressure on our natural resources.

Everything starts with water: it is the life support system that underpins everything else. Yet, globally, freshwater systems are in crisis from pollution and mismanagement.[3] Healthy people and food security, foundational for uplifting people from poverty and inequality, require healthy, functional freshwater ecosystems and, especially, good-quality water.

At the source, poorly treated wastewater, sewage leaks, illegal dumpsites, mismanaged mining waste, poor agricultural practices, and invasive alien plants are combining as a potent medley for degrading natural freshwater sources. At the supply end, the most recent South African Department of Water and Sanitation (DWS) No Drop Report shows that an estimated 47% of South Africa's clean, potable water is non-revenue.[4] Essentially, nearly half of South Africa's clean, processed drinking water is either lost, wasted, or supplied without payment.

Problems with water are not uniquely a South African issue – approximately 2.1 billion people lack access to safe drinking water and 3.6 billion lack access to safely managed water-related services. These issues typically most severely affect marginalised communities, which usually have the least agency over their environmental conditions or water resources and the least access to quality education regarding water, sanitation, and hygiene. In this way, communities exposed to poor water quality or water pollution face compounded hardships. This is especially the case for rural and peri-urban women and youth, who are often the most vulnerable in society.[5]

The upside of this situation is that marginalised and vulnerable people have the most to gain from social inclusion in the water commons. Unemployed young people stand to benefit significantly from learning to understand and care for water, soil, food, and nutrition, engaging in science and sustainability practices and, as they learn, developing 'green skills' that could help them gain employment within the Green Economy and improve livelihoods. This is possible through citizen science (also discussed using other terms such as community-based monitoring or participatory science).

Citizen science has been around, in various forms, for a long time. From tracking the flowering dates of trees in the ninth century, to monitoring the arrival dates of migratory birds in the early 20th century and helping map the night sky today, citizens have been making important contributions to science for hundreds of years. Over the last decade, citizen science has begun to boom, as greater value is placed on co-developing knowledge and solutions both for *and* with people across sectors. Recent advances in citizen science for water quality monitoring present a particularly exciting vehicle for accelerating citizen science into the mainstream scientific discourse and national monitoring regimes, and into progress towards sustainability and transitional objectives such as the Sustainable Development Goals (SDGs).[6]

Worldwide, there has been a surge in the number of citizen science initiatives focused on water, supported by the development and refinement of various innovative tools and techniques.[7] This growth has been in response to recognising that conventional science approaches are simply not adequate for generating the volumes of data, both spatially and across time, required to inform efficient and effective adaptive management strategies for critical water resources. Moreover, citizen science engages people in identifying and solving local problems with their water and environment – a far more potent method for eliciting meaningful change than traditional top-down approaches.[8] Citizen science water quality monitoring has the potential to improve people's environmental awareness, scientific literacy, and understanding of the mechanisms and importance of water-related concerns, and opens channels for communication with water authorities. Ultimately, this gives them agency around monitoring and governance in the water commons. Citizen science also allows for qualitative data generation and understanding, for example, capturing indigenous knowledge of the cultural value of certain water resources – data which are vitally important but typically not captured through conventional methods.[9] These are all critical features of just transitions towards an inclusive, resilient, and sustainable future for all.

The advances made in South Africa, in particular regarding citizen science monitoring of water systems (i.e., rivers, streams, wetlands, groundwater, and estuaries), especially over the last decade, have been substantial.[10,11] Examples include: the formation of the Water Research Observatory by the Water Research Commission (WRC), which serves as an interoperable repository for water-related data to assist in centralising a usable database from which to make management decisions; research by the Agricultural Research Council (ARC) and WRC piloting the inclusion of citizen science water quality data from smartphone apps for measuring nitrate or phosphate concentrations, such as the Deltares Aquality app, into the national monitoring programmes; development of a citizen science version of the WET-Health Assessment tool for wetlands, miniWET-Health; pioneering the use of clarity tubes for monitoring total suspended solids and water clarity of wastewater treatment works effluent and rivers[12]; refinement of transparent velocity head rod (i.e., velocity planks) for estimating stream discharge[13]; the Habitat Condition Scale (HCS) and African Dragonfly Biotic Index (ADBI) biological indices for assessing ecological condition and water quality[14]; the Diamonds on the Soles of Their Feet initiative for groundwater monitoring[15]; the inclusion of the Virtual Museum OdonataMAP and FrogMAP citizen science distribution databases within the Freshwater Biodiversity Information System (FBIS)[16]; and recent upgrades to the citizen science biomonitoring tool mini stream assessment scoring system (miniSASS), including a refurbished website with open access data interaction and visualisation paired to a new miniSASS app[17].

The developments with miniSASS are exciting in terms of global scaling, given that miniSASS has been highlighted by the United Nations (UN) as a potential tool for monitoring and reporting against SDG 6.3.2 and 6a-b[18], with linkages to the powerful Freshwater Watch global freshwater monitoring environment, another citizen science water quality monitoring system advocated by the UN[18]. The miniSASS mobile app is also piloting the use of artificial intelligence (AI) to assist the user in identifying aquatic macroinvertebrates sampled during a miniSASS survey to improve data credibility and enhance data integration potential into national water monitoring schemes.[19] This represents an exciting avenue for upscaling citizen science water quality monitoring data validity and accessibility, both vital to global uptake and trust building within scientific discourse.

Despite the progress, both technologically and regarding scientific perception, the challenge in scaling up the power and utility of citizen science water quality monitoring remains. There is a requirement for social policy enablers that will contribute to bottom-up community-based solutions and practices for better management of water and environmental resources and sustainable development. In this regard, it is important that citizen science tools are applied in a multitude of contexts and are continuously adapted and refined through research to stay relevant and aligned with local and global goals. These tools and techniques need to facilitate meaningful engagement within communities, allowing them to monitor their freshwater ecosystems and to contribute credible data to their local water authorities.

One of the prime South African examples of the use of multidimensional citizen science to co-engage communities to gather data and contribute to the governance of their local environments is the Enviro-Champs (also known under other names, for example, the Amanzi-Champs, Witzenberg Water Savers, or Eco-Champs).[20] The Enviro-Champs initiative co-engages people situated in communities who are in touch with local environmental challenges and builds capacity amongst them to monitor their water resources. The initiative empowers the participants to use their data to interact with water authorities and bring about positive change within their communities. Over the last 15 years, the efforts of the Mpophomeni Enviro-Champs in KwaZulu-Natal, South Africa, using citizen science tools to monitor their streams and report overflowing sewerage manholes, water leaks, and illegal dumpsites to uMngeni-uThukela Water (i.e., the local water authority) elicited the attention of the South African National Biodiversity Institute (SANBI) and other institutions that collectively assisted in addressing local environmental issues.[21]

The advances made in citizen science for water monitoring and the documentation of Enviro-Champ style models have collectively built an understanding of how to improve learning about these citizen science tools. This has increased the potential for scalability of citizen science for the biomonitoring of water systems. The development of online learning modules, initiated through a research project supported by the WRC, in which a learning programme was piloted and co-adapted within a rural community in Northern KwaZulu-Natal, is a case in point. This case involved facilitating online learning about citizen science tools within a community that had limited access to the Internet and building an understanding of the obstacles to learning and how those could be overcome. The outcomes highlighted the importance of maintaining social learning processes through the application of the Action Learning Framework, open discourse, and practical hands-on activities, all of which combined to enable participants to develop meaningful relationships and co-create solutions to the challenges they faced.[22]

What these examples show is that when citizen science is truly co-created, supported, and recognised by local government, it can generate vital data for often data poor regions and initiate positive change within a community. There are now citizen science tools that have been developed, recognised, or refined to become widely applicable within the sub-region. There are systems in place that allow more people to learn how to use these tools and which improve the understanding of how to best support this learning. From a data perspective, researchers and practitioners should continue to work on improving the validity and credibility of citizen science data to increase the acceptance and inclusion of the data into standard reporting methods at local, national, and global levels. However, citizen science engagement goes beyond data collection. It is a co-learning and co-development pathway for people that generates significant benefits for people and livelihoods. Through engaging with citizen science, young people acquire situated learning knowledge and significant career pathway skills, which will stand them, and their communities, in good stead for the rest of their lives. These benefits may be hard to measure, but we encourage all citizen science initiatives to attempt to document them. These processes of co-learning and co-developing solutions may prove vital for creating just and sustainable water and food security for all in the future.

Declarations

We have no competing interests to declare. We have no AI or LLM use to declare. All authors read and approved the final version.

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