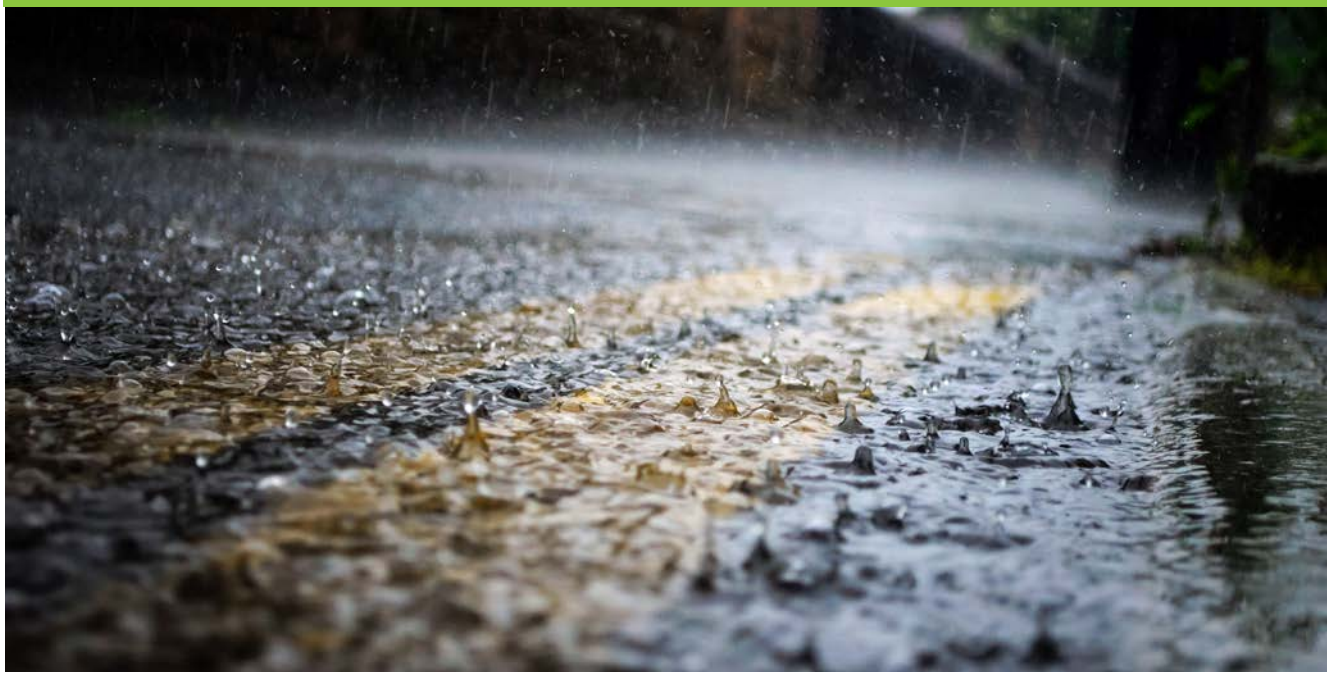
CITIZEN SCIENCE

Citizen science: Community-based early warning tools improve weather and climate risk awareness and resilience

Current experiences of weather and future projections of climate change and variability indicate the need for building adaptive capacity of governments, private sector and communities to prepare and respond accordingly. The impact of extreme weather is felt mostly at the community level and can vary a lot within a very short distance, therefore severe weather warnings need to be timely. So writes Michael Mengistu and Miriam Murambadoro.



Reflecting on the recent floods in Durban and Cape Town, Bonani Madikizela, research manager at the Water Research Commission (WRC), highlights that "Citizen science and early warning bottom-up approaches have been overlooked not only in South Africa but globally, as everyone has assumed a top-down approach would work to save lives during extreme weather events."

To overcome this oversight, the WRC is funding a three-year project on citizen science in support of weather and climate risk awareness for five vulnerable communities in South Africa. Currently in phase two, the project will run until March 2026. The project aims to develop a monitoring network for early detection of weather- and climate-related disasters to adapt and mitigate the impacts on livelihoods as well as build community resilience. The project team is led by Dr Michael Mengistu from the South African Weather Service (SAWS), along with scientists from SAWS and collaborators from the University of KwaZulu-Natal (UKZN), the University of Cape Town (UCT), and the United Nations Educational, Scientific and Cultural Organization (UNESCO).

The project aims to perform an intercomparison field study of low-cost citizen weather stations (CWSs) against standard professional weather stations to quantify bias and errors associated with CWSs; engage communities to assess risk knowledge and response capability based on indigenous knowledge systems (IKS); develop training materials for stakeholder outreach activities to build the capacity of citizen scientists and community knowledge of highly technical

concepts and information on weather, climate, and early warning; co-design disaster early warning monitoring tools and networks; test or simulate the proposed disaster warning tools developed to improve community-based early warning systems and the community's response procedures.

The role of citizen science in weather and climate risk awareness

Weather and climate-related extreme events such as heatwaves, storms, floods, droughts, and wildfires are a threat to economic stability, natural systems, and human health, well-being, and safety. Marginalised communities at the rural and peri-urban levels are the most vulnerable to high-impact weather events. Communities in South Africa have had varied experiences with climate change-related extreme weather events, including the recent floods in KwaZulu-Natal and droughts in the Eastern Cape that have highlighted the social vulnerability of these communities. There is therefore a need to enhance policy and decision-making as well as community disaster risk reduction initiatives for both slow and rapid onset hazards. Other stakeholders such as private sector and civil society need to support citizen scientists as they learn about weather and climate change in their communities and develop an appropriate early warning system.

Scientific weather data and knowledge are crucial for monitoring and providing early warning services and systems, particularly in the most climate-vulnerable communities. The interaction between science, society, and technology is critical for weather, climate, and environmental monitoring, disaster risk reduction and management, and policy and decision-making thereof. Early warning system (EWS) aspects of risk prediction, monitoring and issuing of warnings have traditionally been conceived and produced in the traditional way of producing knowledge with hydromet services and disaster management authorities disseminating these to users (top-down), with limited input from users who are direct observers that live in the space in which the impacts of extreme weather are felt. The linear process, however, usually fails to align user needs with what science has to offer to stimulate shared learning and build the users' capacity to respond.

Through citizen science, communities can contribute to managing and reducing extreme weather risks that affect them by supporting bottom-up and top-down knowledge transfer and learning approaches. Citizen science is the practice of public participation and collaboration in scientific research to increase scientific knowledge. The citizen science approach allows the public to be more proactive and will assist in building resilience to extreme weather events through bottom-up and top-down knowledge sharing and learning.

Citizens also bring different knowledge types, including value-based information, such as that concerning people's perceptions, belief systems and cultures that influence how they perceive and respond to risks. Indigenous and local peoples' in-situ knowledge practices also have the potential to make significant contributions towards the citizen science approach for early warning knowledge and weather and climate risk awareness.

Citizen scientists could contribute to the early warning value chain by providing local data through observations and verification of forecasts. Therefore, weather data collected by citizen scientists can improve SAWS' local weather forecasts, and enable communities to respond more efficiently to extreme weather events. Through this citizen science project, SAWS will connect with the public and build capacity for communities' responses to impact-based forecasting. SAWS will provide support to citizen scientists by offering training on weather data collection, analysis, interpretation, quality control, and archiving. Additionally, citizen science has the potential to help improve the accessibility and sharing of warnings as well as provide disaster management officials, decision-makers, and scientists with ground-truth data to verify and disseminate warnings.

Co-designing and co-production of early warning tools

This study is being implemented in five study areas in KwaZulu-Natal, Limpopo, Gauteng, the Eastern Cape, and the Western Cape provinces in collaboration with communities, volunteers (citizen scientists), government departments and civil society organisations to co-design disaster early warning monitoring tools and networks that will improve community-based early warning systems and the community's response procedures. The enrolment of citizen scientists from the study sites is being undertaken using citizen science engagement, which comprises four phases.

The first phase, which has been completed, was the initiation/crowdsourcing phase where workshops were held with participants to co-create an early warning shared vision for their respective communities, share the objectives of the study and identify volunteers. The second phase of the citizen science process (underway at the time of writing) is the development phase, whereby community engagement workshops are held to assess their knowledge of climate risks in their respective communities (community risk assessment), drivers of vulnerability, early warning, and current adaptation or response mechanisms (assets and capabilities) available, which includes the knowledge from local IKS.

The third phase is the live phase where citizen scientists will be trained on how to collect, interpret, and disseminate weather information from their simple automated weather stations. Participatory community engagement tools will be used to co-design and co-develop early warning tools for each community,

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The project team training Viva Foundation School learners in Mamelodi (Gauteng Province) on weather and climate monitoring during phase 1 of the citizen science project.

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The project team and citizen scientists at Viva Connect School in Cullinan, Gauteng, demonstrating how the citizen weather station (CWS) works.

including how best to disseminate impact-based warnings from SAWS. The fourth phase of the citizen science approach will be the reporting phase, whereby the activities and lessons drawn from the study sites will be compiled into a report and other community preferred communication platforms, including social media. Citizen scientists will also receive certification to commend them for their role and competence in citizen science.

In addition, the citizen scientists will be trained to monitor the stations and will continue with this role with support from relevant local government departments and other stakeholders upon completion of the project to ensure the sustainability of the early warning system. The project will also include a component of building interest among the youth and schoolchildren in meteorology, hydrology, and environmental science so that more students enrol in these fields of study at universities to meet the critical skills gap in South Africa. Future work should include incorporating these lessons learned into an education curriculum statement so that every school in South Africa has access to information on weather extremes, preparedness and resilience within the global change context.

Intercomparison of low-cost citizen weather stations

The study will also include an intercomparison field study of low-cost citizen weather stations (CWSs) against standard professional weather stations. This intercomparison analysis is necessary to identify instrument performances (validation and quality control/assurance), biases, and dependencies. Different models of popular low-cost automatic weather stations (AWS), locally made weather monitoring tools, and standard SAWS AWS will be used in the intercomparison study. The sensor intercomparison study will be conducted in collaboration with a team from the universities of KwaZulu-Natal and Cape Town.

Please contact Dr Michael G. Mengistu [michael.mengistu@weathersa.co.za] or Dr Miriam Murambadoro [Miriam.murambadoro@weathersa.co.za] for more information on the project.

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Local weather information collected from CWS stations will also benefit small-scale farmers. Here the project team is engaging small-scale sugarcane farmers in Swayimane (KwaZulu-Natal Province).