CITIZEN SCIENCE AND CLIMATE CHANGE

Project builds bridge to climate resilience through citizen science

A recently concluded project, funded by the Water Research Commission (WRC), is showing how indigenous knowledge, citizen science, and modern technology can work together to strengthen climate resilience and build more effective early warning systems for communities. Article by Lani van Vuuren.

Peter Luhanga/Groundup

In many South African communities, the signs of changing weather have long been read not from satellites or smartphone apps, but from the land itself. The movement of birds, the flowering of certain trees, the appearance of stars, and even the behaviour of insects have helped communities predict rainfall, droughts, storms, and seasonal shifts for generations.

But climate change is beginning to disrupt these age-old signals. Rain now arrives later than expected or in great angry bursts that cause flooding and devastation. Droughts last longer. Heatwaves are becoming more intense. Plants flower at unusual times and animal behaviour is changing.

A three-year research project led by the South African Weather Service (SAWS), together with the universities of KwaZulu-Natal and Cape Town, has worked to preserve indigenous knowledge about weather and climate while integrating it with modern science to improve climate resilience and early warning systems. The project, titled ***Citizen science early warning tools for weather and climate risk awareness*** (**WRC report no. 3244/1/26**), was carried out in communities across Limpopo, KwaZulu-Natal, the Eastern Cape, Gauteng, and the Western Cape. (An article on the first phase of the study is available in the Water Wheel November/December 2023, https://bit.ly/4udPLcE)

Climate change is rewriting local weather knowledge
For generations, indigenous knowledge systems have helped communities understand weather patterns and survive in harsh environments. Farmers observed the timing of bird migrations, the flowering of trees, the behaviour of livestock, and the position of the moon and stars to guide planting, harvesting, and preparation for extreme weather.

The project found that communities in Swayimane (KwaZulu-Natal), Cofimvaba (Eastern Cape), and Malamulele (Limpopo) still rely heavily on this knowledge. Participants shared meteorological, ecological, and astronomical indicators used to forecast changing weather conditions. These local forecasting systems are deeply rooted in lived experience and cultural practice. In many cases, they provide highly localised observations that scientific forecasts may not always capture.

However, the researchers found that climate change is increasingly disrupting these traditional indicators. Communities reported that seasons are no longer behaving predictably. Rainfall patterns have shifted, temperatures are rising, and extreme weather events such as floods, droughts, hailstorms, and heatwaves are becoming more frequent and severe.

This has serious implications for indigenous knowledge systems. "Climate change disrupts environmental cycles that indigenous knowledge is based on, making traditional weather forecasting less accurate," explains project leader Dr Michael Mengistu, of SAWS. "Astronomical indicators, such as seasonal star alignments, cloud patterns and biological indicators (plant and animal behaviours) that indigenous communities have relied on for generations no longer match the predicted weather outcomes as historical baselines shift."

The project further identified several threats to the survival of traditional climate knowledge. These include climate change itself, urbanisation and modernisation, weak transfer of knowledge between generations, loss of experienced knowledge holders, disappearance of important indicator species and land-use change and environmental degradation.

GCIS

Damage caused by floods in Nkomazi, Mpumalanga, earlier this year. Extreme weather events such as floods, droughts, hailstorms, and heatwaves are becoming more frequent and severe in South Africa.

In some cases, species traditionally used as weather indicators are disappearing or behaving differently because of changing environmental conditions. Elders who hold valuable climate knowledge are ageing, while younger generations are increasingly disconnected from traditional environmental practices. The researchers warn that without active documentation and preservation, valuable indigenous knowledge could be lost.

The study thus sought not to replace indigenous knowledge systems in these communities, but rather to enhance it. "Indigenous communities in South Africa employ a combination of meteorological, ecological and astronomical indigenous knowledge systems (IKS) to monitor local weather patterns, extreme events, and seasonal climate variations. These traditional knowledge systems are particularly valuable for predicting and interpreting climate phenomena in areas where formal forecasts may be unavailable," notes Dr Mengistu. "Integrating indigenous and scientific weather forecasting knowledge offers a practical pathway for enhancing climate resilience, providing more precise, context-specific forecasts that can guide local decision-making and policy."

Communities on the frontline of climate impacts
The project highlighted how vulnerable many South African communities are to climate-related disasters. The five study sites, namely Swayimane in KwaZulu-Natal, Cofimvaba in the Eastern Cape, Malamulele in Limpopo, Cullinan in Gauteng, and Manenberg in the Western Cape, have all experienced severe weather events that damaged homes, infrastructure, crops, and livestock.

These events have had devastating consequences for livelihoods and food security. Communities reported crop losses, weakened livestock, water shortages, damage to homes and infrastructure, and rising farming costs. Farmers, in particular, stressed the need for reliable and localised early warning systems that can help them prepare for extreme weather.

The study found that communities already possess strong local knowledge about climate risks and coping strategies. What is often missing is access to accurate, timely, and understandable weather information.

"The biggest challenges communities face in accessing and understanding early warning information during extreme weather events include lack of awareness of risks, communication and dissemination of warning to remote communities, language barriers, distrust in forecasting systems, and inadequate community response capabilities," says Dr Mengistu.

Instead of a purely top-down approach where experts issue warnings from afar, the project promoted a people-centred model where communities help generate, interpret, and share information. This creates stronger ownership, greater trust, and more meaningful local action.

Photo supplied

A major component of the project involved installing low-cost citizen weather stations in communities and schools. These stations allowed citizen scientists to collect real-time local weather data, including rainfall, temperature, humidity, wind speed, and solar radiation.

Citizen science gives communities a voice

This led to one of most innovative aspects of the project, namely the use of citizen science. Citizen science involves ordinary people participating in scientific research by collecting observations, monitoring environmental conditions, and sharing local knowledge.

In this project, citizen scientists included learners, youth, teachers, farmers, extension officers and science communicators. Around 15 to 25 volunteers were selected from each study site (more than 400 people in total) and trained to monitor weather conditions, interpret forecasts, and share climate information within their communities.

Rather than treating communities as passive recipients of information, the project placed them at the centre of climate monitoring and early warning efforts. Workshops were held to help participants understand, among other things, weather and climate terminology; seasonal forecasts; climate change projections; early warning systems; disaster preparedness; and indigenous weather indicators.

Importantly, the project also focused on simplifying technical weather information so that communities could engage meaningfully with forecasts and warnings. The project team recognised that scientific terminology can often be inaccessible, limiting public understanding and preparedness. Through training and engagement, citizen scientists became active contributors to climate resilience rather than simply recipients of expert advice.

An important feature of the project was its strong focus on youth engagement. Schools and science centres served as major hubs for citizen science activities, with learners participating directly in weather monitoring and climate discussions. This helped build scientific literacy while also encouraging intergenerational knowledge sharing.

Building local climate monitoring networks

A major component of the project involved installing low-cost citizen weather stations in communities and schools. These stations allowed citizen scientists to collect real-time local weather data, including rainfall, temperature, humidity, wind speed, and solar radiation. "Citizen scientists provided observations and local weather data using the stations. The data was used to verify the forecast issued by SAWS for the study sites," explains Dr Mengistu. "This empowered communities to understand their local weather and use this knowledge to prepare for and respond to weather-related hazards."

The results were encouraging. Measurements for temperature and humidity showed strong agreement with professional stations, demonstrating that low-cost technology can provide valuable local climate information. While rainfall and wind measurements were less accurate in some cases, the study concluded that several of the citizen weather stations performed well enough to support community-based weather monitoring.

Citizen scientists used platforms such as WhatsApp to share warnings, observations, and weather updates. Communities identified WhatsApp as one of the most effective tools for rapid communication during extreme weather events. This is especially important in South Africa, where mobile phone access is widespread even in many low-income communities.

However, the study also cautioned that technology alone is not enough. Information overload, limited internet access, language barriers, and digital exclusion can still prevent warnings from reaching vulnerable groups. As a result, the researchers recommended using multiple communication channels, including radio, schools, community leaders, and local organisations.

The project has important implications for South Africa, where many rural and underserved areas have limited weather monitoring infrastructure. By expanding local monitoring networks through citizen science, communities can help fill critical data gaps while improving the accuracy of local weather forecasts and warnings. "This local weather data will enhance national forecasting models through verification and validation, and will assist vulnerable communities by providing impact-based forecasts of extreme weather events," explains Dr Mengistu.

Indigenous knowledge and modern science can work together

One of the project's strongest messages is that indigenous knowledge and scientific forecasting should not compete; they should complement each other. The researchers found that integrating local knowledge with scientific weather systems can improve both trust and relevance.

For example, citizen scientists in Malamulele reported that a rainfall warning issued for their area proved inaccurate because the weather remained sunny and dry. This type of local feedback is valuable because it helps meteorologists verify forecasts and understand highly localised conditions that national systems may miss.

The project highlighted the importance of combining scientific forecasting models, local environmental observations, indigenous weather indicators and community experiences and feedback.

The final report recommends that future work should focus on systematically documenting indigenous indicators such as animal behaviour, plant changes, and astronomical observations, while linking these with formal meteorological systems. This approach could create more inclusive and culturally grounded early warning systems that communities trust and understand.

One of the project's most important contributions is its recognition that indigenous climate knowledge is both scientifically valuable and culturally significant. As climate change accelerates, communities are not only losing environmental stability, they also risk losing generations of accumulated wisdom about living with nature. The project argues that documenting and preserving indigenous knowledge is urgent.

Perhaps the main message is that climate resilience is strongest when communities, scientists, educators, and institutions work together. In a rapidly changing climate, no single system has all the answers. Satellites and weather models are essential, but so too are the lived experiences of people who know their landscapes intimately.

"South Africa has many communities that remain highly vulnerable to extreme weather and climate-related hazards. The lessons and insights generated through this citizen science project should be scaled up and replicated across additional schools and communities to strengthen people-centred early warning systems in diverse geographic and socio-economic contexts," maintains Dr Mengistu. "Future research should prioritise community-based disaster risk education programmes delivered in local languages and through culturally appropriate platforms. Integrating indigenous and local risk knowledge with scientific and technical information is essential to improving hazard awareness, risk perception, and preparedness at the community level."

By bringing together indigenous knowledge and modern science, the project offers a powerful model for how South Africa can build more inclusive, localised, and effective responses to climate change. And in communities where the weather has always spoken through the land, the challenge now is ensuring those voices are not lost.

On 5 June, a special event was held in Cofimvaba, Eastern Cape, to celebrate community members who had been trained during the project on monitoring weather and climate change. The event was hosted by the WRC and attended by, among others, WRC Board member, Dr Harrison Pienaar, CEO, Dr Jennifer Molwantwa, and Executive: Research, Development and Innovation, Dr Stanley Liphadzi.