



Scarred Earth

Monitoring land degradation

The German-funded research project SALDi aims to develop new tools for assessing land degradation in South Africa so that the problem can be addressed

Large areas of South Africa have experienced a decline in soil productivity, reduced vegetation cover and increased soil erosion – sometimes evident as deep gullies that scar the landscape. But to what extent is this land degradation because of human impacts, such as overstocking cattle, clearing bush to plant crops or incorrectly channelling stormwater run-off from roads, rather than climate-induced changes, particularly due to periodic droughts?

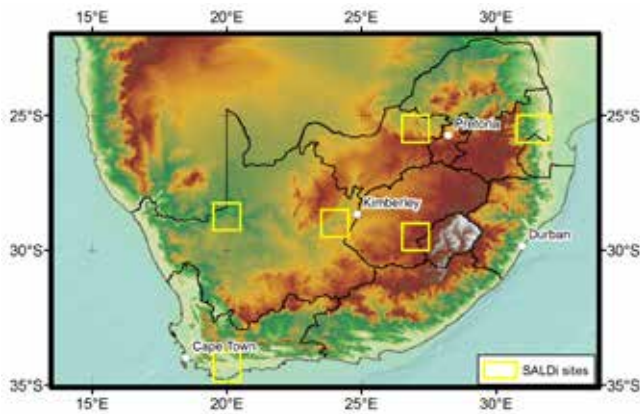
A new German-South African collaboration aims to increase understanding of this conundrum in the long term by implementing novel tools for assessing land degradation. The three-year project – known as the South African Land Degradation Monitor, or simply SALDi – will build upon earlier research on the topic by a variety of local scientists. Much of this was collated by the Agricultural Research Council's Institute for Soil, Climate and Water (ARC-ISCW) in developing a Land Degradation Index, which takes into account soil erosion by water and wind, soil salinisation and acidification, hydro-climatic parameters, land cover and the loss of biodiversity.

The SALDi project can improve interpretation of such information and better assess the land degradation problem by taking advantage of the high-resolution Earth

observation data that is now available from the European Sentinel satellites, as well as recent advances in modelling approaches.

“For instance, the USLE [Universal Soil Loss Equation] model that has been used in South Africa up to now works well for long-term averages, but not the kind of erosion damage that a farmer might see after one storm,” explains project coordinator Dr Jussi Baade, from Germany's Friedrich Schiller University Jena. “So with the input of local partners we will adapt a physically based soil erosion model from Germany to apply in South Africa.”

Six study sites, each covering an area of 100 km by 100 km, have been identified countrywide to represent a range of climatic conditions, geological substrates, vegetation cover and land-use practices. In addition, a modelling exercise will apply the WRF-Hydro (Weather Research and Forecasting Hydrological) Regional Earth System Model to the whole of southern Africa. The model essentially combines recorded precipitation data and predicted weather forecast data with a land surface model for a variety of uses, including flash flood prediction, river flow forecasts, seasonal water resource



The six SALDi study sites.

forecasts and land-atmosphere coupling studies. In this case, the model's output will be used as input data for soil erosion modelling.

By the end of the project, it is anticipated that an automated observation system to monitor aspects such as soil moisture, vegetation cover and potential land degradation will have been developed. This would be a freely accessible, online system allowing anyone – from school learners to farmers to local and international scientists – to zoom into a map, down to a resolution of 10–30 m, and view information derived from bi-weekly satellite data.

A kick-off meeting for the project was held in Pretoria at ARC-ISCW in March, attended by collaborating scientists, other potential partners and representatives of stakeholder government agencies. After the meeting, the research team headed out on their first fieldwork campaign. One of the first stops was the Welbedacht Dam, which was built in the early 1970s as part of Bloemfontein's water supply but has silted up to such a degree that it now has only a fraction of its original storage capacity.

The visiting German scientists were joined here by Dr Jay Le Roux, a soil erosion scientist from the University of the Free State, and his PhD student Mrs Marike Stander, who will be conducting research on erodible soils in the dam's catchment.



The project's kick-off meeting was held at the Agricultural Research Council's Institute for Soil, Climate and Water in Pretoria in March.

"We are collaborating to learn and assist each other where possible," says Dr Le Roux, who had suggested this as a SALDi site based on previous research he had done in the area. "Networking with the SALDi team will assist our development of the required capacities in terms of sediment measurement and mapping techniques. We also plan to apply for funding from the SPACES DAAD scholarship programme 'Capacity Building / Development'."

If successful, this would allow Mrs Stander to spend time at a German university as an exchange student, increasing her exposure to cutting-edge erosion science.

On a future field trip, Dr Baade intends surveying about 15 dams in three of the SALDi study sites to compare the siltation estimates with those of Rooseboom, published in a Water Research Commission report in the early 1990s. These surveys will be done from a boat, using an echosounder and GPS, to calculate the volume of accumulated sediment in the dam and hence the reduction in storage capacity.

"We're really looking forward to seeing whether siltation rates went up or down, because in certain areas where there are good soil conservation measures in place you could maybe expect that siltation in reservoirs has decreased," says Dr Baade. "This would be useful for showing farmers that they can do things to maintain their water storage capacity, because when that is lost they will be worse off in a drought."

Another component of the fieldwork is the surveying of erosion gullies, and this work began during the recent trip. Dr Baade explains that a South African company was contracted to do drone-based surveys, providing data used to construct highly detailed digital terrain models.

"At the end of the project we'll fly these areas again to see how things have changed," he says. "We're doing that mainly in the national parks because – given that they are directly protected by park management – it's basically just the rainfall or run-off signal that creates the dynamics of the gullies. In certain areas they are not a sign of land degradation, but we want to learn how they evolve naturally."



Some erosion gullies in the study sites have been surveyed using drones, and the resulting digital terrain models will allow changes to be monitored over time.



A moisture probe network consisting of eight sensors attached to a central unit has been installed at each site so that satellite-derived soil moisture data can be validated.

During the recent field campaign, a moisture probe network was also installed in each of the six study sites so that the soil moisture data derived from Sentinel-1 radar imagery can be validated. Each network consists of eight sensors placed in a 20 x 20 m area and attached to a central unit. Since these need to be protected from vandalism or theft, and the data downloaded every three months, they have been installed either in national parks or on the property of willing landowners. More specifically, one is at the Kruger National Park's sampling station near Lower Sabie, where there are a number of other monitoring instruments, another in Mokala National Park and a third in Augrabies National Park, while the others are on private farms near Pilanesberg, Ladybrand and Elim near Cape Agulhas.

This equipment will remain on site after the completion of the project, so that it can continue to be of use to South African scientists, together with all the processors, algorithms and models developed during the project. The German research team hope that the project outputs will ultimately assist in improving land degradation management in South Africa, but they point out that the scientific exchange with local scientists is also of benefit in addressing research questions they are working on in their own country.

Some of the relationships supporting such exchange go back many years, and there is an especially long history of cooperation with SANParks scientists. For example, Dr Baade did a reconnaissance survey of 15 reservoirs in the Kruger National Park a decade ago to establish whether their siltation could be used to assess spatial variation of soil loss. He has published a number of papers on this and related land management research in the park in the intervening years.

"One might be wondering why a land degradation monitoring project is being conducted inside a national park," says SANParks abiotic scientist, Tercia Strydom. "Well, there are two main reasons. Firstly, fully functional soils inside our parks will act as reference points for



degraded sites outside our parks for comparison purposes for the countrywide project. And secondly, with greater relevance for SANParks, many of our parks include previously utilised land that was incorporated into our parks in order to increase the area under conservation. Often, this recently acquired land has a history of farming and therefore has some degree of degradation. Since soils are critical in supporting a range of ecosystem processes, it is of utmost importance that degraded soils are rehabilitated and restored."

"SANParks invests a lot of time, money and effort into various types of rehabilitation techniques aimed at restoring some newly acquired land into fully functioning ecosystems. It is for this reason that this SALDi project will be very useful for park management – it will help monitor land degradation and evaluate whether our rehabilitation and restoration programmes are working."

Article by Sue Matthews; images courtesy of the SALDi project team.

The project is funded by the German Federal Ministry of Education (BMBF) and forms part of the programme known as SPACES, an acronym for Science Partnerships for the Assessment of Complex Earth System Processes. The SPACES programme has its roots in the 2012/2013 German-South African Year of Science, which had the theme 'Strengthen research partnerships for innovation and sustainable development'. Climate research was one of seven subject areas identified for collaboration, with the main priority being to investigate the causes and consequences of climate change. The SPACES programme was subsequently developed to implement scientific cooperation projects in the broader southern Africa region. The four projects that were funded in the first phase, starting in July 2013, have been completed, and in July 2018 the second phase began, with nine projects funded – among them the SALDi project.