

JOHAN VAN TOL

From landslides to wetlands: digging into water security

Why a Free State soil scientist digs what he does and how his research is aiding efforts to better manage our scarce water resources.

Matthew Hattingh reports.

What do deadly landslides, ill-conceived tree-planting schemes, and overgrazing have in common? For our purposes, the answer is Dr Johan van Tol, who over the past two decades has been applying his considerable energies to the study of these and an impressive variety of other environmental problems or phenomena, some with the support of the Water Research Commission (WRC).

Van Tol is a youngish soil scientist and a specialist in the youngish discipline of hydropedology. As he put it in his inaugural lecture marking his appointment to full professorship at the University of the Free State last year: "Hydro 'is obviously water, and 'pedo' or 'pedon' – which has nothing to do with 'paedophile' – means soil or ground in Greek."

Speaking to the *Water Wheel*, Van Tol explained that hydropedology bridges the gap between more established fields dealing with surface water and groundwater. It focuses on the relationship between soil and water, examining what happens after the rain hits the ground – whether the water flows overland or sinks down, and the bearing soil properties have on this. Hydropedology took off internationally around the turn of the millennium, and is today important in efforts to understand, protect and manage South Africa's scarce water resources.

Lengthy lobbying of the Department of Water and Sanitation by a handful of soil scientists, Van Tol among them, led to a better appreciation of the significance of soil to water flow. Finally, in 2019, a hydropedological assessment was added to the requirements of the country's water use license application process. These regulations set out the steps to be followed before any significant changes may be made to land use.

Thus, before a mine can be opened, infrastructure built, or a big tract of veld cleared for housing, the mandatory impact assessments must include not only surveys from hydrologists, geohydrologists, and other specialists, but from hydropedologists too.

As Van Tol quipped in his inaugural address, "Pretty cool, not only

did we change or improve the policy, but we also created a lot of opportunities (for ourselves), as well as for other soil scientists.”

In 2023, Van Tol and co-authors Nancy Job, Darren Bouwer, Simone Murugan and Pieter le Roux completed *Hydropedological Assessment Guidelines: Theory and application in a South African wetland management context* (WRC Report No. TT 925/23). The report provides a theory primer, taking practitioners through the ins and outs of doing a survey, and offers suggestions on interpreting the results. The theory part draws on the South African Soil Classification System. The system, revised in 2018 with contributions from Van Tol, describes more than 1 600 soil forms and families and their key characteristics. It's used to identify soils.

Armed with an understanding of soil characteristics and their interplay with topography, climate, and vegetation, consultants can work out the likely path water will follow, and at what rate, be it surface runoff, subsurface lateral flow, or bedrock flow. The report's decision tree can be applied to different land use changes, such as mining, agriculture, forestry, and residential.

Wetlands are a central focus because their protection is crucial to the country's water resources, with hydropedology helping to identify how they are recharged. According to Van Tol, many of the hydrological concepts we use were developed in the Northern Hemisphere. These frequently assumed groundwater and surface water intersect, causing streams to flow. Yet in South Africa, particularly in semi-arid areas and the higher reaches of river systems, where the groundwater was perhaps 60 to 70 metres beneath the surface, this wasn't the case.

Many wetlands (a major source of rivers), besides playing a vital role in regulating flow, preventing erosion and purifying water, were fed not by groundwater or surface water, but by lateral flows within the slope. This has implications. “If you're going to mine through that, then you're cutting off a source of water to the wetlands,” explains Van Tol.

Another scenario he mentioned was forestry in KwaZulu-Natal.

“We've got a policy in forestry to have buffer zones around wetlands. But if your source of water is from the crest, and you've got a recharge area, it drains directly through the soils. And if you're planting the crest with trees, you're going to dry up your wetland.” Which was why it was crucial for wetland protection to understand how the water gets to it, and why Van Tol was excited about hydropedology, the “new science now embedded in the national water policy”.

Apart from informing land use choices and suggesting steps to reduce harm, or perhaps offset it with rehabilitation work elsewhere, hydropedology is being used to map and model pollution pathways, sources and sinks. Landslide prediction is another area where Van Tol has put his expertise to good, potentially life-saving, use. We are speaking here of the shallow movement of soil layers above bedrock, and not of falls, topples and flows, to say nothing of landslides triggered by seismic activity or glaciers unleashing avalanches (as happened in Nepal and Tibet recently).

When we think of flooding in South Africa, we imagine swollen rivers and torrents of water. But we should be thinking of soils too. Consider the calamitous April 2022 floods in the Durban region that claimed more than 440 lives and caused more than R17 billion in damage to infrastructure. Some 12 000 homes were also destroyed – from middle-class dwellings in the hilly, stream-dissected suburbia of Westville, to Clare Estate shanties clinging to steep slopes. Hundreds of localised slope failures, earth slips, and mudslides played a big part in the devastation.

The city and relief agencies were overwhelmed. It didn't help that South Africa lacked a dedicated landside early warning system. Meteorologists issued a series of increasingly severe flood warnings as Subtropical Depression Issa gathered up her skirts and ran rampant over coastal KwaZulu-Natal, dumping a deluge on Durban, with the city's Virginia Airport recording 304 mm over 24 hours on 11-12 April.

But general alerts, even at a regional level, don't cut it. “How do warnings to avoid low-lying bridges prepare you for a mudslide?”

Photo supplied



Johan van Tol is professor and head of Soil Science at the University of the Free State.



Van Tol sampling soils on the Amphitheatre summit in the Drakensberg to quantify carbon stocks in Southern African alpine soils.

said Van Tol. The hydrological factors driving landslides differed from those causing floods. Precipitation is only part of the tale; soil has a story to tell too, to borrow a phrase from Van Tol. The landslides that did so much damage in Durban were a consequence of soil properties and soil conditions. Soil moisture levels before the storm were particularly significant. Topography, geology, and land use were other contributing factors.

"So, if you understand how the water flows through the soils, you should be able to detect or predict where landslides should be expected." Van Tol said this was the approach to a study he and University of the Free State colleagues, Jaco Kotzé and Jay le Roux, pitched to the WRC. This led to a recent project titled ***Towards a landslide early warning system for South Africa*** (Project No. C2023/2024-01184).

In the final report, the Bloemfontein team drew on the literature and case studies in Durban's Pinetown area, and in Port St Johns-Lusikisiki, in the Eastern Cape. They mapped landslide scars with the aid of satellite imagery. Multiple satellite data sources were used to estimate the crucial soil moisture values.

Combined with soil and climatic information, they were able to build a hydrological model. This was coupled with a slope stability model, a mathematical tool used to calculate the likelihood of a slope, or a structure on it, staying put. Their predictive modelling proved a success, improving the accuracy of identifying landslide risk. It marked progress towards a national landslide early warning system, capable of issuing alerts several days before slope failures occur. However, developing and implementing a national system would likely be a long, complex process. The report highlighted the need to incorporate the presence of any hard infrastructure into the model. Considerable stakeholder engagement and capacity building were also needed.

Positive responses to their work include that of the Eastern Cape's Department of Cooperative Governance and Traditional Affairs. They expect to sign a memorandum of understanding with the department in November 2026 to develop and implement a landslide prediction system in the province.

Meanwhile, Van Tol has been busy with research and consultancy

work elsewhere in South Africa and neighbouring countries. In the Lesotho Highlands, he is running a project mapping soils and quantifying soil carbon stocks to aid alpine wetland restoration. The “terrible state” of Lesotho’s wetlands, says Van Tol, the result of overgrazing, poor road drainage, and destructive ice rats, is “probably the most pressing” concern facing South African water scientists. The project is seeking financial support, possibly from the international owners of Lesotho’s diamond mines, in the form of carbon footprint offsets.

Van Tol is also involved in a hydropedological study in the Western Cape. A keen birder and bird photographer, Van Tol used the opportunity to visit the Strandfontein Sewage Works, a mecca for waterbirds. There he was “very excited” to spot a rare Purple gallinule, adding to a Southern Africa life list now exceeding 720 species.

Birds, or rather their absence, featured in a recent [paper](#) Van Tol co-authored on afforestation in Zimbabwe’s Eastern Highlands. It exposes the perverse incentives that can arise from ill-conceived environmental schemes, underlining the importance of proper studies before land use changes.

“Tobacco companies cleared Miyombu veld in the lowlands. And then they felt guilty about it. So, they decided to plant eucalyptus trees in the grasslands of the Highlands... some of the last breeding grounds of the blue swallow. So, the blue swallows are not there anymore. You’ve got eucalyptus that drinks up all the water and the tobacco companies got funding... green funding.”

Still, Van Tol describes himself as an optimist by nature. It’s a quality that buoyed him on a journey starting at undergrad Agriculture studies at the University of the Free State (the *boitjie* from Vanderbijlpark said he warmed to soils when he found it was one of the few subjects where his farmboy classmates didn’t have a head start on him), to completing his PhD in hydropedology under Prof Peter Le Roux at the same university.

Academic positions followed at Fort Hare University before he eventually returned to the University of the Free State, attracted by career prospects as much as a more family-friendly environment. Van Tol, 42, and his wife, Ronel, have three boys, Ivan, Wihan, and Simon. Van Tol was impressed by the quality of post-graduates; however, he had reservations about the effects



Cowan McLean

The soil tells a story. Soil morphology reveals the interactive relationships between soils and water — the focus of hydropedology. A Manguzi soil form in the Mpumalanga Highveld.

of artificial intelligence on students in general and wondered whether it might be blunting their ability to write and reason, and to sift fact from fiction.

Johan van Tol



Combining two passions — birding and soils: A Southern Carmine Bee-eater takes flight from a Dundee soil form along the Kwando River in Namibia.

Johan van Tol



Degradation of peat wetlands in the Lesotho highlands poses a major threat to water resources in southern Africa.

Nevertheless, he values AI as a productivity tool. For example, ChatGPT allowed him to do all the modelling himself for the landslide early warning project, after a budget cut left the team without a programmer. "We are busy with a paper on the risk, potentials and pitfalls of AI in soil science," he notes.

This will join nearly 100 peer-reviewed journal articles Van Tol already has under his belt. Apart from those already mentioned, he's had a hand in WRC projects encompassing efforts to develop a national soil map, mooted damming of the Mzimvubu River, hillside hydrology, a Mokolo River case study, fracking, and pollution from on-site dry sanitation systems. Nevertheless, Van Tol points out there's more to science and a life of service than journal counts and citation numbers, the stuff of publish-or-perish metrics.

He suggests a more useful measure might be whether the work was changing people's lives or improving the environment. "I

love nature, and as a Christian, to me one of the first assignments that God gave us is to look after the Earth, and I think it's embedded in most of us."

He feels that soil (and water, for that matter) scientists are as much mentors and promoters of good citizenship to their students, particularly postgrads. "They see your ethics in terms of science, and they go and replicate that. The postgraduate guys very often go into high positions and then that dribbles, dribbles down."

To the ground, you might say.



To read more on Johan van Tol's research, visit: <https://orcid.org/0000-0002-0222-8119>

Johan van Tol



Landslides — or 'manslides'? Human activities can destabilise slopes and contribute to slope failure. This scene in Umdloti, following the April 2022 KwaZulu-Natal floods, captures the scale of the devastation that prompted Prof Johan van Tol and colleagues to develop a landslide early warning system for South Africa.