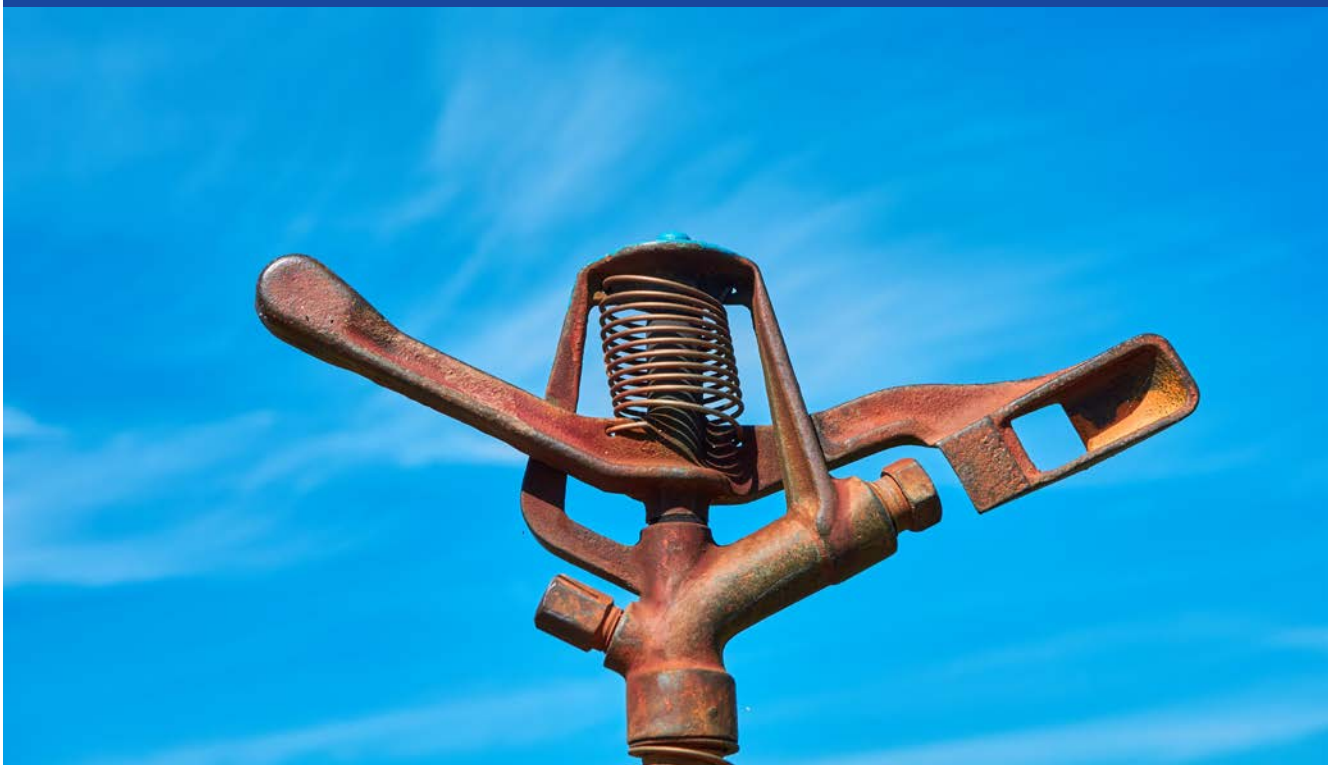
IRRIGATION WATER MANAGEMENT

From irrigation pioneer to global impact: the SAPWAT legacy lives on

Celebrated developer of SAPWAT, Dr Pieter van Heerden, remembers a lifetime of work as the renowned irrigation planning and management tool passes to a new home at the University of the Free State. Article by Petro Kotzé.



Behind most water allocation decisions in South Africa lies SAPWAT, a decision support tool developed by South Africa's own esteemed water expert, Dr Pieter van Heerden. For more than two decades, the South African Plant Water Model has been the national standard for irrigation planning, widely used by farmers, advisors, researchers, managers and the government. Dr van Heerden has been a custodian of the software since the early days of the tool's development, a choice that would define his internationally celebrated career and change the face of water allocation across many parts of the globe.

Close to his eightieth birthday, Dr van Heerden and his close collaborator, wife Gela, with the continuous support of the Water Research Commission (WRC), have now handed the baton over to the University of the Free State (UFS), ending a historic chapter and heralding the next, which will bring critical updates in line to the tool, with new climate variability and change, and operating environments.

Prof Sylvester Mpandeli, WRC Senior Research Manager and South African National Committee on Irrigation and Drainage (SANCID) Chairman, says SAPWAT is not just a technical model but part of South Africa's sustained response to its water-scarce status: as much a decision-support tool for water use and allocation in irrigation as it has been driven by the innovative people who made it happen, and who continue to use it to

Today, SAPWAT's users span the globe, as the tool is used in most countries south of the Sahel, as well as around the Mediterranean, in Central Asia, India and the Americas.

conserve water efficiently and effectively. Chief among them is Dr van Heerden.

From the farm to the first line of code

Dr Pieter Schalk van Heerden was born on 24 November 1946 on a farm at Cradock. After passing first class in Matric, he completed his BSc in Agriculture (Sheep and Wool, Animal Physiology) at Stellenbosch University. This was followed by two Honours degrees – a first in Agricultural Extension at the University of Pretoria and a second in Agriculture (Agronomy) at UFS.

To meet the stipulations of his bursary, Dr van Heerden initially worked as an agricultural extension officer in Karasburg, Namibia (then South West Africa). After a period on the family farm, he then worked in Cradock, again as agricultural extension officer, advising some 300 farmers across roughly 27 000 hectares in the Cradock, Hofmeyr and Great Fish River valley irrigation areas, recommending cropping patterns, cultivars, irrigation water management, fertilisation, saline soil reclamation and pest control, all grounded in proven experimental results.

In 1988 he moved to the Department of Agriculture's head office as Management Advisor (irrigation), coordinating around 100 irrigation development projects nationally and publishing the department's first computer program for irrigation bed design. Between 1991 and 1999 he served as Deputy Director for Research, then Extension, in the national and Free State agricultural departments, acting as director for nine months, helping to integrate the Free State's provincial agriculture departments, and contributing to a new national irrigation policy.

In 1999 he joined prominent South African agricultural engineer and researcher Charles Crosby's independent irrigation consultancy, planning water requirements for farms and schemes nationwide. Crosby was already working on the first version of SAPWAT. Together, Crosby, affectionately known as the "Wise Old Man of Irrigation", and Dr van Heerden continued to develop the program into the definitive computer-based planning model for estimating crop irrigation water requirements in South Africa.
This journey was not without a few curveballs.

Placing water on a curve

In the early nineties, methods for determining water requirements were limited. The Green Book (named after author Dr George Green), South Africa's accepted standard since 1973, was based on models too rigid for newer, short-cycle irrigation methods, and its outputs were losing credibility. A pilot study funded by the WRC in 1996 set out to establish a decision-making procedure for estimating crop water requirements, with "built-in" databases removing the need to seek climate or crop data elsewhere. It led to the pilot program SAPWAT 1.0, released in 1999, which has since been continuously upgraded and eventually replaced by SAPWAT 4.

"The one big breakthrough at this stage was that the ET_0 values (the reference crop evapotranspiration values) were statistically placed on a curvilinear regression curve," Dr van Heerden says. "Thus, one could choose any planting date and always be on the curve, applicable worldwide to any weather station with at least monthly weather data. What gave me the biggest headache was making sure that the regression curve worked everywhere in the world. For most places it fitted nicely, but in the monsoon regions the curve shifts away from the normal, and along the Red Sea there are areas where the climate variation is too big for successful application of SAPWAT."

A further breakthrough came from the University of KwaZulu-Natal (specifically, Prof Roland Schulze of the Agricultural Engineering Department), which held daily weather data for South Africa's roughly 1 900 quaternary drainage regions: fifty years of data per region, fed into SAPWAT to calculate not just an average water requirement but a standard deviation, so users could work with the 70% or 90% probabilities irrigation developers need.

This meant that SAPWAT became more than a crop growth model, rather developing into a planning and management tool that relies on an extensive climate and crop database, is general enough to cover vegetables, field crops, annual and perennial crops, and pasture and tree crops, and can simulate wide-bed planting, intercropping, and different irrigation methods. It also draws on crop-specific research, including how long a crop takes to move through its growth stages, plotted onto its four-stage crop curve, and has been continuously upgraded over the years, mainly with WRC funding.

Lani van Vuuren

Dr Pieter van Heerden (right) with Prof Giel Viljoen (then of UFS) at the celebration of the WRC's 40th anniversary.

Lani van Vuuren

Dr Pieter van Heerden (second from left) was awarded the SANCID Lifetime Achievement Award during the organisation's symposium in 2025. With him are the other award winners Prof Chris du Preez (Capacity Building and Research Development Award), Prof Sylvester Mpandeli (Leadership Award) and Prof Leon van Rensburg (Capacity Building and Research Development Award).

On the road with *Oom* Charles

In SAPWAT's early years, Dr van Heerden and "Oom Charles" (Charles Crosby) presented courses on irrigation areas across the country, bringing irrigators together with town and city water managers for day-long symposiums, preceded by tours of purification works, wetlands, and farms. "We loaded the whole lot of people together into one bus," Gela recalls, "established large farmers, men from water affairs and the mines, and small-scale farmers." At the start of the journey the atmosphere was very stiff, she recalls, because people were sitting together with others they were not usually in contact with, but by the end of the bus ride, the conversations flowed.

They genuinely tried to understand one another. Dr Van Heerden recalls one farmer who demonstrated his margins by drawing lines across a standing sack of wheat. Each cumulative line representing a cost factor, for example for fertiliser, seed, and weed control, until only a narrow line remained: "That is now my share," he said.

"In the end it really was far-reaching stuff," Gela says. "We built a matrix, a good one, and in the end ***Oom*** Charles took our model and held it up to the rest of South Africa." He knew, she says, what he had in Pieter.

Still, initial reactions to the tool were mixed. Some started using the tool immediately; others were reluctant, wary of ending up with less water than they believed they needed. "We know of people who went in among the farmers and said: look here, ***oom***, this thing doesn't lie, this is how much water you need," Dr van Heerden says. But SAPWAT's use gradually spread from designers to co-operatives, banks, valuers, and environmental impact practitioners.

International renown from small beginnings

The model was continuously updated over time. SAPWAT 3 was released in 2008, and an improved version, SAPWAT 4, was released in 2017. The tool has now been applied by countless users around the globe, including most countries south of the Sahel, as well as around the Mediterranean, in Central Asia,

Historically, SAPWAT users have reported water savings of between 33% and 50%.

India and the Americas. Since around 2000, SAPWAT has also underpinned South Africa's irrigation licensing system, and it is endorsed by the Department of Water and Sanitation (DWS) for issuing water use licences and quantifying optimal allocations for specific command areas.

"To get a water use licence, users have to be able to prove how much water they're going to need, and that's where SAPWAT is used," Dr van Heerden notes. "New applicants must show that the water requirement of their intended crops matches the total water use they're applying for."

As such, because it bridges the gap between official national policy and day-to-day scientific research, SAPWAT remains one of the WRC's greatest practical and academic success stories. SAPWAT documentation and software are among the most heavily utilised and sought-after outputs of the WRC, which enabled the free distribution of the software and its accompanying literature via its Knowledge Hub.

On ResearchGate, SAPWAT papers enjoy massive citation and download volumes, driven in part by local universities that use the program as a primary undergraduate teaching tool for agricultural modules. Additionally, researchers in sub-Saharan Africa frequently download SAPWAT documentation to study the impacts of climate change on crop yields, water footprints, and regional irrigation schemes.

Milestones amid personal difficulty

Not long after SAPWAT 3's release, Dr van Heerden began to develop macular degeneration. "At a certain stage I could no longer read normal print," he explains. Gela took the strain of the growing correspondence. It was against this backdrop that Dr van Heerden completed his doctorate, which he could apply for without first completing a Master's. Due to his outputs, publications, and contributions to the agricultural irrigation community, he was instead allowed to proceed directly to his PhD.

Gela recalls this work as her husband's greatest achievement. "The perseverance he has in spite of his limitation is astounding." He was awarded his PhD in Irrigation Management under Prof Sue Walker's supervision on 10 December 2015, the oldest person at that year's higher-degree graduation ceremony.

We laughed so much, Gela remembers, when their neighbour, a ***tannie*** in her nineties at the time, congratulated Pieter, then pulled up short and asked, "But what are you going to do to keep your mind going now?" Dr Van Heerden was very far from done, keeping at it for another decade. Numerous local and international recognitions have marked the value of his work.

Well-deserved recognition

In 2011, the International Commission on Irrigation and Drainage (ICID) awarded South Africa a WatSave Award in the Technology category at the 21st International Congress on Irrigation and Drainage in Tehran, Iran, presented to SAPWAT's project managers, Dr van Heerden and Charles Crosby.

That year, the South African Irrigation Institute also recognised Dr van Heerden for his contribution to irrigation technology, and in 2013 he received a South African Society for Agricultural Extension (SASAE) silver medal for his special contribution to the promotion of agricultural extension.

Last year, SANCID also honoured him for his lifetime contribution to the sector. "For me, the most important [of all the accolades] is the ICID award, notes Dr van Heerden. "It means a tremendous amount to get that kind of recognition: to say, the work you did for irrigation isn't forgotten, and it reaches beyond the irrigation industry too. I'm proud of it."

Gela remembers the SANCID's lifetime achievement evening warmly. "When the presenter announced Dr Pieter van Heerden, the developer of…, the room answered in one voice, "SAPWAT!" before his CV could even be read," she recalls. She was recognised alongside him that evening. "It really was a great treat."

Handing over the baton

The van Heerdens describe the handover to UFS, under the custodianship of Prof Bennie Grové (Associate Professor in the Department of Agricultural Economics), as a relief. "Amen," Dr van Heerden says simply. "We can relax now, and we're very grateful that the university can give SAPWAT a permanent home."

The work is not done. Crop coefficients and growth periods need revising in light of new research and changing crop patterns, "in some cases quite different from what people have in their heads," Dr van Heerden says. SAPWAT's climate dataset does not cover the last 25 years of climate data, casting doubt on its water-use estimates, and it is unclear how far the model has kept pace with newer methods, such as the FAO 56 dual-crop coefficient approach.

Yet, the coming work is integral. "I can't see irrigation being able to carry on without SAPWAT, or without an updating of SAPWAT," Dr van Heerden says.

Prof Mpandeli explains that, for this next phase, the WRC deliberately sought an institution that would build on Dr van Heerden's work rather than start over: "We wanted to hand the tool and its development to an institution that would be able to add value on the work that Dr van Heerden has already done." UFS was the natural choice, both for its technical capacity and its connection to Dr van Heerden, who did his own PhD there. For now, until the WRC has finalised the Water Observatory system, UFS will be SAPWAT's de facto custodian.

Prof Mpandeli's vision for SAPWAT's next chapter has two parts: a practical tool for the water and agriculture sectors, and a teaching platform "used at both undergraduate and postgraduate level… because this is a national product contributing towards our national priorities and the Sustainable Development Goals (SDGs)." He is also pressing the DWS to formally adopt SAPWAT and has committed WRC resources to capacity building across the country.

A fond farewell

"I'd like to add a thank you," Dr van Heerden concludes. "Firstly, to the WRC, for all the years of support and funding of SAPWAT." Charles Crosby's contribution, he says, was immense. Dr Van Heerden describes him as an inspiration, motivator, mentor, leader and friend, he says, "who also put me through my paces." Dr Van Heerden also thanks all the people in the irrigation and plant production industries who contributed to SAPWAT's development.

Prof Mpandeli describes him as one of the sharpest minds he has worked with, and generous with what he knows: "He is one of the sharpest knives in the drawer. He's not afraid to share his knowledge, experience, and expertise. He has been there for the country, for the water and agriculture sector." Senior scientists of his calibre, Prof Mpandeli argues, deserve to be kept involved for as long as possible: "My belief is that he still has got a role in this country."

The van Heerdens are now both fully retired. Between them they have five children and eleven grandchildren, five in New Zealand and six in South Africa. "We really got to know wonderful people and saw wonderful places," Gela says. "It has made us rich in experience. It has been a beautiful, wonderful time."

SAPWAT enquiries can be directed to Prof Bennie Grové at groveb@ufs.ac.za

Main benefits of the SAPWAT tool

- Accurate water estimation: Uses the FAO-endorsed Penman-Monteith equation and long-term weather data to calculate precise crop water needs on a month-by-month basis.
- Extensive database: Includes decades of historical weather data and crop databases tailored for South African and international conditions.
- Improved water efficiency: Helps planners, farmers, and irrigation designers optimise water use, reducing resource waste, waterlogging, and soil salinity.
- Economic decision-making: Features enterprise budget modules that link water requirements directly to production costs and potential profits.
- Versatile Application: Works across various crop types, including field crops, vegetables, orchards, pastures, and small-scale rainwater harvesting modules.