THE WATER WHEEL
Your water knowledge hub
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WRC - YOUR WATER KNOWLEDGE HUB

Mission

The WRC is a dynamic hub for water-centred knowledge, innovation and intellectual capital. We provide leadership for research and development through the support of knowledge creation, transfer and application. We engage stakeholders and partners in solving water-related problems which are critical to South Africa's sustainable development and economic growth, and are committed to promoting a better quality of life for all.

Vision

To be a globally recognised leader in providing innovative solutions for sustainable water management to meet the changing needs of society and of the environment.

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Message from Dr Rivka Kfir

CEO, Water Research Commission

Water is generally associated with rain, rivers, lakes, waterfalls and oceans. You may also think about daily activities such as drinking, cooking, washing, cleaning, swimming or simply playing in the rain. As learners, you would have encountered a lesson on the water cycle. Recently, the media has been abuzz with the drought that has gripped our country and then we realize that water is precious indeed!

Water as an overexploited resource is a universal problem. *Time Magazine* (*Time Magazine, May 7 2001*) reported that "Water, not oil is the most precious fluid in our life, the substance from which all life on earth has sprung and continues to depend. If we run short of oil and other fossil fuels, we can use alternative energy sources. If we have no clean, drinkable water, we are doomed."

In the developed world, human-centred activities and the increased reuse of water have created an endless source of new problems. These include the emergence of new water-borne diseases (such as protozoan parasites) to biological pollutants (such as green-blue toxic algae) and chemical pollutants (such as endocrine disruptive chemicals: hormone-like structures suspected of harming the human reproductive system).

In the developing world (including some rural areas of South Africa), many people do not have access to clean drinkable water. While 1 billion people have no safe water to drink, about 2.4 billion people- 40% of the world's population- have no adequate sanitation.

As safe drinking water and sanitation are crucial to human health, the situation above is mirrored by high incidences of water-borne diseases and epidemics. About 3.4 million people world-wide, many of whom are children, die each year from water-related diseases.

The world's water-linked ecosystems are suffering: we have already destroyed about half of the world's wetlands and many countries are experiencing water crises. If current practices continue, the degradation of ecosystems and the loss of biodiversity will pose a major threat to the lives of future generations.

In South Africa we are located in a semi-arid zone which means that our water is not just a limited resource, but a scarce one. It is crucial to know at all times what the state and availability of water is. It is also crucial that every drop be used as productively as possible to improve the quality of lives. Where we pollute water, it is crucial that we purify it to the best of our ability.

Caring for limited water resources while using water beneficially poses complex questions for which answers must be sought. In 1971 the Water Research Commission (WRC) was established by an Act of Government, with the aim of supporting, promoting and co-ordinating water research in South Africa. With the support of the WRC, the research base addressing water issues in South Africa has grown from strength to strength. Today the WRC addresses water research via 4 key strategic areas:

- Water resource management
- Water-linked ecosystems
- Water use and waste management
- Water utilization in agriculture.

The WRC also supports knowledge dissemination and information management as its fifth key strategic area. As a water-centred knowledge "hub" the WRC operates through extensive networks. The WRC creates local networks and forms links between local and international organizations. Its mission is to be a dynamic hub for water-centred knowledge, innovation and intellectual capital, providing leadership for research and development through the support of knowledge creation, transfer and application. Stakeholders and partners are engaged in solving water-related problems which are critical to South Africa's sustainable development and economic growth, and the WRC is committed to promoting a better quality of life for all.

I urge you to spend time on reading water-related articles (especially the articles that have been carefully selected for you in this publication) during National Water Week and become more aware of water-related issues. After all, the future of South Africa and that of the world are at stake!

Clouds on tap

Previous experiments have shown that other sites in South African could yield more than four times the volumes of water recorded at Tshanowa.

It's an innovative solution to the problem of water shortage - one that researchers have been quick to latch onto, but which many countries have been surprisingly slow to implement.

Professor Jana Olivier of the University of South Africa's Department of Anthropology, Archaeology, Geography and Environmental Studies, explains that the idea of harnessing fog as a source of drinking water has been studied for decades.

"The first experiments were conducted in 1901, on Table Mountain. But it was only in 1987, in the arid coastal desert of northern Chile, that it was implemented on a large scale."

For years the remote fishing village of Chungungo relied solely on trucked-in water. In 1987 it was transformed by the installation of a fog collecting system. With a dependable and affordable water supply, not only did the growing population have domestic water, they were also able to cultivate commercial crops and plant trees.

Although unconventional, the technology behind fog collection is amazingly simple: massive vertical shade nets are erected in high-lying areas close to water-short communities. As fog blows through these structures, tiny water droplets are deposited onto the net. As the droplets become larger, they run down the net into gutters attached at the bottom. From there, water is channeled into reservoirs, and then to individual homes.

In Chungungo, this system saw water flowing from local taps for the first time ever, in 1992, providing more than 40ℓ of water per person, per day.

Like Chile, South Africa is an arid country in which large sections of the population have inadequate water supply. Only 35 % of the country gets more than 500 mm of annual rain, and - with few unpolluted surface water sources, many contaminated ground water supplies and water tables that drop out of reach during drought - the advantages of an effective alternative water source are obvious.

Professor Olivier, who has been involved in fog collection research since 1995, says the potential for fog collection in South Africa is clearly shown by what has already been achieved at two fully operational sites - one in the Limpopo Province and the other on the West Coast.

Water for thought

Tshanowa Junior Primary School in Limpopo is frequently shrouded in dense mist and rain, but the nearest water sources are a non-perennial spring located 2km away, and a dam, 5km away. Since most water sources in the province are contaminated, the quality of the dam water is suspect. The 130 school children rely on what water they can carry with them to school each day.

The school is located at the crest of one of the easternmost promontories of the Soutpansberg, at 1004 m above sea level. Despite its relatively low elevation, this region is ideal for fog collection in that moist maritime air from the Indian Ocean moves over the escarpment and against the mountains during the night and early morning. This cloudiness sometimes persists throughout the day.

Permission was obtained from the

– By Sophia Dower –

WHERE FOG HARVESTING WILL WORK IN SOUTH AFRICA

- For fog collection to be effective, the site must be in an area where fog occurs frequently throughout the year, and lasts for a few hours at a time. The water content of the fog should be high, and the fog must be accompanied by wind to ensure that a large enough volume of moist air is blown through the collecting screens.
- South African Weather Bureau records show that a number of places in South Africa have over 90 days of fog per annum. These are mostly located along the West Coast of southern Africa and in mountainous regions.
- Rain clouds have the highest water content, followed by advection sea fog. Radiation fog has too little water to be successfully collected.
- Ideally, sites should also be more than 1 000 m above sea level. Sites in many parts of South African have elevations of more than 2 000 m, and according to previous experiments, these sites could yield more than four times the volumes recorded at Tshanowa in the Soutpansberg.

The giant fog screens at Tshanowa Junior Primary School in Limpopo province are providing pupils and members of the community an average of between 150ℓ and 250ℓ of water per day.

relevant local and tribal leaders to erect a fog water collection system on vacant land adjacent to the school. Construction commenced in 1999 and local inhabitants were employed to assist.

Each fog collector consists of three 6 m-high wooden poles, mounted 9 m apart. Steel cables stretch horizontally between the poles, and from each pole to the ground. A double layer of 30 % shade cloth is draped over the cables, and fixed to the poles on each side. Water dripping from the net into the gutter runs through a sand filter and is then emptied into a tipping bucket. From there, it flows into a 10 kℓ storage tank further down the slope. Two additional tanks were erected at the school to collect the overflow from the first. An automatic weather station was also installed to record rainfall, wind speed and wind direction.

Within four days of completion, school children and members of the local community were drinking water collected by the fog screen. Although weather conditions have made accurate data collection difficult, daily yields of as much as 3 800ℓ of rain and fog combined, have been recorded. The average collection rate from March 1999 to April 2001 is over 2,5ℓ per square metre of fog screen.

Heavy clouds, but no rain

The same system was also set up at Lepelfontein, a small missionary station about 400 km from Cape Town, and about 5 km inland of the West Coast. Although groundwater here is abundant, it is of such bad

AGE-OLD PRACTICE

In ancient times, fog water was often collected for domestic and agricultural use.

- The inhabitants of what is now Israel used to build small, low, circular honey-combed walls around their vines, so that the mist and dew could precipitate in the immediate vicinity of the plants.
- Historically, in the Atacama, both dew and fog were collected by means of a pile of stones, arranged so that the condensation would drip to the inside of the base of the pile, where it was shielded from the day's sunshine. The same technique was employed in Egypt, with the collected water stored underground in aqueducts.
- In Gibraltar, a similar technique is used: a large area on the slope of the rock has been covered with cement blocks. Fog and rainwater runs downwards and is collected underground where evaporation is minimised.
- On a smaller scale, rain, fog and dew are collected on enormous granite rocks at Cape Columbine lighthouse, on the West Coast. Low retaining walls have been cemented onto the sloping rock surface to channel the water into a reservoir at the base of the outcrop.
- The first fog collection installation in South Africa - prior to the Chilean project - was at Mariepskop in Mpumalanga, in 1969/70. It was used as an interim measure to supply water to the South African Air Force personnel manning the Mariepskop radar station. Two large fog screens, constructed from plastic mesh and measuring about 28m x 3,5m each, were erected at right angles to each other and to the fog and cloud-bearing winds. These yielded more than 11ℓ of water per square metre of collecting surface, per day. Unfortunately, the project was terminated once an alternative water source was found.

Hannes Rautenbach, of the University of Pretoria's Department of Geography, Geoinformatics and Meteorology), beside one of the 36 m^2 screens. Water drips from the net into a gutter, and runs through a sand filter before being channelled into the storage tank. The automatic weather station (the white box) records rainfall, wind speed and wind direction.

"The costs of fog collection are low, the technology is simple and the source is sustainable for hundreds, even thousands of years."

quality that it is considered a health risk. A small solar distillation plant was installed in 1998 to provide limited drinking water, but most water is still transported to the village from elsewhere.

The fog screens were installed in 1999, and the overflow from one of the 10 kℓ tanks is now being used to supplement the water from the desalination plant. At least 80 % of the water collected at this site is from fog alone, as the region receives very little rain. Fog conditions are mostly associated with onshore breezes originating either from the South Atlantic anticyclone to the south of the continent, or from north westerly and westerly winds on the northern perimeter of a coastal low.

Again, daily yields of over 3 000 ℓ have been recorded, with a daily average of about 5 ℓ of water collected per square metre of fog screen.

While Lepelfontein's water initially showed high levels of sodium - possibly due to the proximity of the ocean and wind-blown spray - Professor Olivier says that water quality at both sites is good, with no disease-forming organisms present in samples.

"In fact, at Tshanowa, water was rated as Class 0 - ideal quality," she says. "Since the water is used for drinking purposes, quality is tested regularly." She adds that experiments conducted at other high elevation sites around the country have yielded more than 10 ℓ per square metre of collecting surface per day. "This shows that in terms of quality and magnitude of yield, fog harvesting could go a long way to alleviating water shortage problems in the fog-prone mountainous regions of the country. "The costs are low, the technology is simple and the source is sustainable for hundreds, even thousands of years."

Virtually all of the materials needed to construct, operate and maintain the system are available locally. And yet, fog harvesting is a rarely used technique in Africa. Despite education and information programmes initiated by the fog collection project team, there seems to be little awareness of it, and even less support in terms of corporate funding or involvement.

WHAT TO DO WITH WASTEWATER

AN INTERVIEW WITH DR EUSTINA MUSVOTO, A DIRECTOR OF NINHAM SHAND

It takes a broken sewerage pipe for one to realise the important role water and waste workers play in society. "Sewage spills are awful," says Dr Eustina Musvoto, director of the purification division for engineering consulting firm Ninham Shand, "and a very good reminder why water and waste management is such a critical field."

"Can you imagine what our lives would be like without people taking responsibility for sewage and waste-water?" she asks.

Yet very few young people ever imagine a career in water and waste management and those who do find themselves in the profession tend to fall into this hidden field by accident.

This is exactly what happened to Musvoto who, after completing her undergraduate degree in engineering at the University of Zimbabwe, went to work for the Gweru City Council's water and waste division.

"It was then that I realised how dynamic a career in water could be," she says, "it's an essential component in any community and has a huge human impact."

Water is a scarce resource in southern Africa and needs management to ensure it remains in good supply.

Zimbabwe

Musvoto grew up in the rural village of Mashingo in Zimbabwe about 400 kms north of the Beit Bridge border post. Both her father, Rangarayi and her mother, Benhilda were teachers. For her high school education she was sent to a former Catholic boys' school which had just started taking girls. It was here at Gokomere High School that she received the excellent mathematics and science education that enabled her to study to become a civil engineer.

"The career guidance at Gokomere was still geared at boys which is why I was exposed to a very male-orientated

"There are huge challenges in disposing of industrial wastewater," she says, "it's an involved process that requires a high level of technical expertise."

profession like engineering," she says, "it's not a career that is usually suggested to girls."

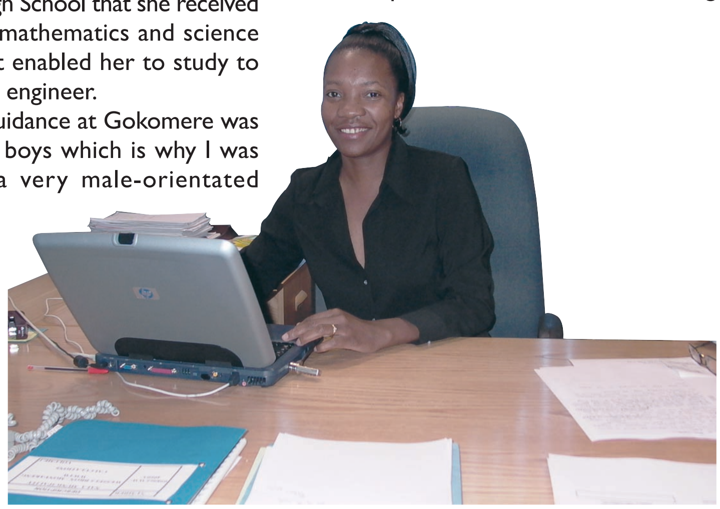
Musvoto graduated with a BSc honours degree in engineering in 1987 and went on to pursue her masters degree in South Africa at the University of Cape Town. This she achieved in 1992 and, six years later, was awarded her doctorate in civil engineering from the same university.

Her research into the treatment of anaerobic digestion supernatants during her doctoral thesis earned her the Water Institute of Southern Africa prize for best contribution by a student in the field of anaerobic digestion.

"The critical subjects for an engineering degree are mathematics and science. Civil engineering is an excellent foundation degree because there are so many variations on the type of career one can pursue," she says.

Over the past fifteen years Musvoto has worked on 14 major projects including working as the design engineer on the Kariba water augmentation scheme, the Mutare-Odzi pipeline, the upgrade of the Zandvliet wastewater treatment works and the Athlone wastewater treatment works.

Since moving to Ninham Shand in 2002 much of her work has been as a consultant to government departments and municipalities on how best to manage industrial and domestic wastewater.



"There are huge challenges in disposing of industrial wastewater," she says, "it's an involved process that requires a high level of technical expertise."

She explains that in the past, many industries pumped wastewater into the municipal sewerage system, ultimately loading the rate payer with the cost of treating it before it could be released back into the environment.

"Nowadays there is far more awareness of the impact wastewater has on the environment and, because of the high costs of releasing wastewater into the sewerage system, many companies are treating it themselves or reusing their own waste."

The scarcity of water in southern Africa means that all wastewater must be treated before it can be released into rivers, unlike Europe where sewage is often pumped into rivers.

"The high nutrient content of waste stimulates plant growth on water courses and very soon our rivers would be blocked by invading plants."

Despite a hectic work schedule, Musvoto still contributes to professional journal writing and co-writing articles on water-related issues.

She is also a council member of the Water Institute of Southern Africa and chairs the Institute's nutrient management division. She is on the Water Research Commission's steering committee for research into the bulking of activated sludge.

Shingi, 14, her son has yet to decide which direction his career will take, but his mom is encouraging him to work hard at maths and science.

Most of Musvoto's bedside books are technical journals, but she does enjoy reading psychology books and the odd novel. She is an avid ballroom dancer with a special flair for Latin American rhythms.

Eustina Musvoto has played a vital role in resolving the issues that dominate the disposal of wastewater in Southern Africa. Without people like her 21st century life would not be so comfortable.

FULFILLING THE DREAM OF WATER FOR ALL

AN INTERVIEW WITH TORISO TLOU - A DIRECTOR IN THE ENGINEERING FIRM TLOU MATJI

As a child, growing up in the Zvimba district of Mashonaland West in rural Zimbabwe, Toriso Tlou would walk for kilometres, bucket in hand, to the place where he knew he could find water. On his hands and knees he would dig deep into the soft red soil eventually stopping to let the bottom of the hole gradually fill with water. When there was enough he would painstakingly scoop water into the bucket being careful not to dirty it with mud.

The precious water which he delivered to his mother was used for cooking, drinking and washing the whole family.

Today Tlou is a consulting engineer, a partner in Tlou and Matji Engineering and Management Services in Pretoria. There is no doubt in his mind that those long hours in the sun lugging water home for his family shaped his career choice and gave him a passion for providing water to rural communities.

"I understand their need," he says, "I know how much water impacts on the quality of life in these communities."

Over the last decade Tlou has been involved in dozens of projects to provide water to people across Southern Africa. Since opening Tlou and Matji with partners Petrus Matji, Stephen Mallory and Jeremy Cooke, these projects have included: preparing

"I learned from Wilbert that one cannot study for a Maths exam. He told me his secret was to revise after every lesson. Once you grasp the concept and know what you are doing, follow it up by practising examples.

the Olifants and Doring Water Conservation and Water Demand Strategy; working on the Thukela River project management team and preparing the catchment management strategy for the Mtata River. The list of projects Tlou has been involved in is endless, but there is a single underlying theme – to provide water to people who have never known the luxury of turning on a tap.

Tlou completed his O-levels at the Howard Secondary Missionary School, a boarding school in Mashonaland East, far from his village. English and Mathematics were compulsory subjects. During these early years his fascination and love of mathematics was encouraged by his best friend, the late Wilbert Kamhoti who was a year ahead of him at school.

"Wilbert was a maths genius," says Tlou, "He set the pace and I followed." For their A-levels the boys were sent to St Augustine's, a boarding school in Mutare where they both focused on Physics, Chemistry and Mathematics.

"I learned from Wilbert that one cannot study for a Maths exam. He told me his secret was to revise after every lesson. Once you grasp the concept and know what you are doing, follow it up by practising examples. From then on I always achieved an A for Maths."

With excellent A-level results Tlou was accepted by the University of Zimbabwe to study towards a BSc in engineering.

Choices

"My choices were medicine, computer science or engineering. I didn't like medicine and had never seen a computer before so I thought the best option would be civil engineering."

Throughout his university career Tlou's excellent results meant his government study loan was always converted into a bursary. During the holidays a relative arranged for him to work for a construction company which was building a railway container terminal in Harare. Here he gained invaluable work experience on a construction site. "It was my job to optimise use of the plant and equipment, particularly the dump trucks, as part of my work study function," he says, "It was quite stressful sometimes as most aspects were still new to me having had no experience in this field.
When he graduated he went to work for Zimbabwe's Department of Water Affairs where he surveyed for new pipelines. His training included substantial hands-on experience for which he is ever grateful.

"Now if a pump breaks down I know exactly how to fix it and give guidance to people working on it."
Only when his bosses were satisfied he had sufficient construction, operational and maintenance experience was Tlou given the opportunity to work on designs.

After a short spell at a steel company he moved to South Africa – the birthplace of his father and grandparents.

It was the early 1990s and he went to work for the Department of Water Affairs in Mmabatho in the former Bophuthatswana. When the homeland was incorporated into South Africa Tlou moved to Pretoria where he continued working for the government.

"It was not all plain sailing. I had quite a time convincing other sections of the profession of my competence and capabilities," he chuckles.

In 1998 he moved into the private sector and a year later opened his own business.

Technically Tlou was excellent, but he felt the business side of his education was lacking. He enrolled for an MBA with the Wits Business School which he completed in 2002. While he was working towards his MBA he learned that he had lung cancer and struggled to overcome the effects of the chemotherapy . Now, in remission, he is well enough to once again focus on his goals of providing water for rural people.

One project that is particularly close to his heart is a sustainable small irrigation scheme for farmers which he is doing in partnership with the Water Research Commission.

"We are development orientated," he says, "I want to see the socio-economic impact of our work."

Water has always played a major role in Tlou's life. On a wall in his office he has a poster of a man relaxing while it is raining outside. The next image is of the same man becoming anxious when the weather is dry. Then his cattle begin dying of thirst and his face is one of worry. Panic follows.

The point of the picture is that it is too late to start worrying when there is no water.

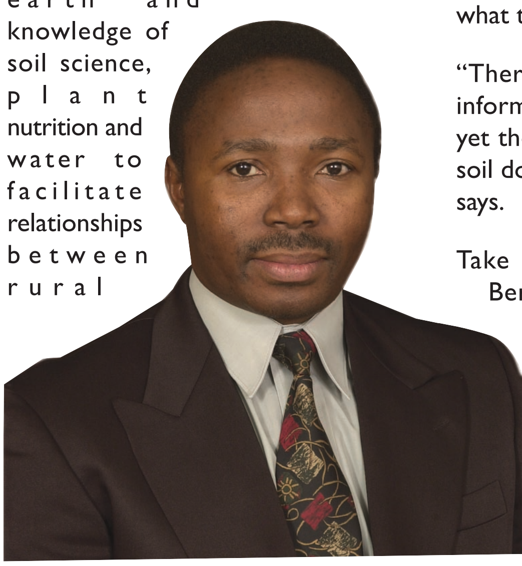
"We always have to plan ahead," he says, "if we don't, the consequences will be devastating.

OPENING DOORS FOR SA'S RURAL COMMUNITIES

AN INTERVIEW WITH DR SIZWE MKHIZE , ASSISTANT DIRECTOR- GENERAL, DEPT OF AGRICULTURE

When Dr Sizwe Mkhize was a boy one thing was absolutely certain in his mind. He loved the rich brown soil in the fields around the family's kraal near Wartburg, 35 kms south east of Pietermaritzburg in KwaZulu-Natal. Sugar-cane, maize and timber grew wonderfully on the fertile, well-watered hills around his home. He wanted to grow his own crops and become a farmer.

Today Mkhize still dreams of working the soil but is using his love of the earth and knowledge of soil science, plant nutrition and water to facilitate relationships between rural communities, scientists, the private sector and the government.



As the former head of Water and Society for the Water Research Commission his major task was to help communities find solutions to problems and to recognise opportunities. As someone who understands the plight of the rural poor his role is to link them with the structures that can help them improve what they do.

"There is so much knowledge and information about farming available, yet the people who are working the soil don't know how to access it," he says.

Take one small community near Bergville in the KwaZulu Natal Midlands where the staple diet is mealie-meal – the average household is consuming just less than a ton each year.

"They grow mealies and then spend an exorbitant amount of money transporting their harvest to a miller in exchange for mealie-meal," he says, "the cost of transport doesn't make this arrangement worthwhile."

There is a huge market for mealie-meal in this community, yet almost all their money, sent mostly from sons and daughters working in Gauteng, is spent on transporting mealies to a miller.

"Why couldn't they mill the mealies themselves?" asks Mkhize. "They have access to power and water." In this case Mkhize helped the community establish a mill but, when he left KwaZulu-Natal to work for the Water Research Commission in Pretoria, the project ran into trouble.

"It was too much too quickly for this community. We have to build people's capacity to help themselves and then ensure they have support until the project is up and running."

Mkhize's hunger to understand the science behind agricultural issues blossomed when he reached grade 11. It was then that science (as a subject) was offered, for the first time, at Swayimana High School. The pupils who excelled in the seemingly impossibly difficult subjects of science and maths held great status at Swayimana High. The young Mkhize was one of the brightest, winning school awards for science and maths every year. There was no question he was destined for university and his older brother, Nkosinathi, sacrificed his own education so that his brother could complete matric.

"There was not enough money for both us to go to school."

Although the University of Natal was just a few kilometres away, Mkhize was forced, by apartheid, to travel to the University of Fort Hare in the Eastern Cape to study. In 1989 he graduated with a BSc Agriculture degree – funding his studies with a full scholarship. It was here, at Fort Hare, that his interest in water and irrigation grew.

"Just about every lecturer we had stood in front of us saying South Africa faced a water shortage. I thought if it was that important, I had better study water resource management – particularly irrigation."

The pupils who excelled in the seemingly impossibly difficult subjects of science and maths held great status at swayimana high.

The student's talent was recognised at Fort Hare and he was awarded a second scholarship to study for his masters degree at Pennsylvania State University in the United States.

"My mother, Suzan, didn't fancy me moving away to the United States at all," he chuckles. Before going to Fort Hare he had a job as a lab technician at Smith and Nephew (LTD) and she was more than satisfied with his achievements. After earning his first degree, Suzan felt the time had come for her son to settle down and earn some money.

"I already had the degree, she didn't know why I wanted more." The young student left for America and, had it not been for the political strife at home, would have remained there to complete his doctorate.

"While I was in the US our home was destroyed in the fighting that was going on in the Midlands at that time." With a Masters degree from Penn State under the belt he came back to help his family build a home again.

Mkhize's old university professors had not forgotten him though and, when one of his former lecturers, Professor MC Laker, moved to Pretoria University, he encouraged him to finally complete his doctoral studies. In 1995 he was made a Doctor of Agriculture (Soil Science and Plant Nutrition) by that university.

In the years since he graduated Mkhize's work has remained focused on development issues. He spent time with the KwaZulu Training Trust, the KwaZulu Finance Corporation, the Water Reseach Commission and now the Department of Agriculture. Now, he is finally in an environment where his love of the earth has been coupled with a deep appreciation and respect for the rural farmers he so longed to be like as a child.

BRINGING WATER TO THE PEOPLE

AN INTERVIEW WITH HYDROGEOLOGIST THOLEKA MAFANYA

Nqamakwe is a small town like many others in the Eastern Cape. Early in the morning women and children, mostly girls, balancing buckets on their heads, can be seen making their way through the green hills to the spring to fetch water. For several hours they walk back and forth to the family's kraal, lugging their heavy loads. The water is for drinking, washing and cooking. Since the beginning of time it has been the role of the rural women to fetch water. Even now, in the age of space travel, washing machines and the Internet, their days are shaped by the endless path to the spring.

Tholeka Mafanya knows all to well the heavy labour demanded in fetching water. She grew up in Nqamakwe and with her sister Cikizwa would spend hours every day tramping home bearing splashing buckets.

Today Mafanya is a hydrogeologist working with Southern African GeoConsultants and is based in East London. The major focus of her work is providing potable water, on tap, to rural communities.

"I knew when I went to university that I wanted to learn how to bring water to my people," she says.
As a hydrogeologist her role is assessing the feasibility of groundwater as a source for water supply in geographically remote areas and working with communities to assess their needs. She is also involved in educating people about the responsibility of having water on tap.

"It is tremendously challenging work but so rewarding," she says, "I know how these women's lives are going to be improved by having a standpipe in their village."

The infrastructure backlog is overwhelming, says Mafanya. Until the change in government in 1994 absolutely no services were provided to these communities in the former "homelands". One of the first goals of the new government was to provide free basic water and already it has wiped out more than 50% of the backlog in the delivery of water.

"We cannot give up now," says Mafanya, "these communities know that water is coming and they are all waiting for their turn."

Clean water is also crucial for good health and in areas where water-borne diseases like cholera and gastro-enteritis claims so many lives, especially young children, it is essential.

"Drilling and putting pipes into the ground are the first steps," says Mafanya, "We must ensure that the water continues to flow once the projects are completed."

University

Mafanya graduated from the University of the Western Cape with a Bachelor of Science, majoring in Geology. She chose to travel the long distance from Nqamakwe to study in Cape Town to be with Cikizwa who was at UWC studying for a BSc in Physiotherapy. Both girls' love of science and maths was instilled at an early age and by the time Mafanya reached grade nine her parents decided to send her to boarding school in Umtata to ensure

"I knew when I went to university that I wanted to learn how to bring water to my people,"

she earned a good matric. It was here at St Johns College that she decided she would study towards a BSc. As the daughter of a forestry worker (her dad Lizo had a forestry diploma) and a teacher (her mom Nompucuko is retired) she had always enjoyed geography and opted to make this the focus of her degree.

The young student thrived at university and after completing her undergraduate studies went on to study for her honours and then her masters degrees.

For her MSc, which she completed in 2002, she focused on monitoring and protecting groundwater resources focusing on water quality. Her goal now is to complete her PhD possibly at a university overseas. For Mafanya her role in ensuring provision of potable water to rural South Africa is both fulfilling and challenging. She has set out on a career that looks set to make her one of the country's leading water experts. This is a hydrogeologist who has been on the other side – she knows what it means to carry water along endless winding paths. Understanding this need ensures her passion to bring water to the people will never die.

NO EASY RIDE FOR CHAMBER OF MINE'S WATER MAN

An interview with environmental advisor Nikisi Lesufi

An academic interest in thermophilic bacteria living in the hot water springs at Warmbaths and Messina stimulated Nikisi Lesufi's interest in water quality, eventually launching his career as an environmental advisor to the Chamber of Mines.

Nowadays Lesufi is instrumental in coordinating efforts by mines to improve their water management including ways of managing their polluted water. He also works to keep the channels of communication open between the mining houses, government and the communities affected by mining operations.

His study of thermostable enzymes in the hot water springs was for his masters thesis which he completed through the University of London, obtaining his MSc in Microbiology in 1991.

"To understand how the enzymes could exist I had to understand their habitat which is when I began to take an interest in water quality," he says.

On his return to South Africa Lesufi began lecturing in the microbiology department at his old university (the University of the North) encouraging his students to carry on where he left off with the ecology of hot water springs.

When he saw how quickly these young microbiology graduates were being snapped up by industry, he began to appreciate how important the role of a water scientist was becoming in South Africa.

Lesufi's own plunge into water quality management was by default. He matriculated from Tembisa High School on the East Rand in 1980, a troubled time in South African history.

"Even so I had a brilliant maths teacher, Mr Kgosietsile, and a wonderful science teacher, Mr Mmethi, at Tembisa High School. Their knowledge inspired me to pursue a career in science," he said.

To make extra money to fund his future studies Lesufi took on a job as a laboratory assistant at Eli Lilly Laboratories in Isando.

"The Lab people came to our school looking for people to take on as technicians. I wanted the opportunity to be involved at the laboratory, but I also knew I wanted to study towards science at university."

After working for Eli Lilly for some time he was sure that he wanted to study towards a B Pharm degree. He was a self-financing student (also working on a till in Checkers to raise money for university) so he enrolled at the University of the North because the fees were cheaper than at Wits University.

Inevitably the bright young student was drawn into politics and, just a year before he was due to graduate, he was arrested and held in detention for nine months. He was also expelled from the university.

Refusing to give up the scientific career he had dreamed about for so long, he approached the SA Council of Churches for help.

Scholarship

"I realised then that the only way I was ever going to finish studying was if I left the country," he said. He was awarded a scholarship from the World University Service and in 1986 left to study for a BSc in Biological Services at the University of Leicester in England.

"The university wouldn't allow me to carry on with my B Pharm but rather offered me the opportunity to do a more general degree."

When he graduated in 1989 he applied to the University College of London to study for his masters and was accepted. The hot water springs back home had always interested him and this was the opportunity to study them in greater detail.

Lesufi still wanted to complete his B Pharm degree though and, when he came back to South Africa, he went back to his former *alma mater* to try and regain his lost year.

Work and family commitments over took him and he eventually accepted that he would never graduate as a pharmacist.

"I had also become used to working in some of the best university laboratories in Britain and now, when I saw how poorly the University of the North was equipped, I realised there was no way I could finish my degree there."

For a time he worked in government, first as a regional director for the Department of Water Affairs (Water Resources Management) and for the Department of Health as Deputy Director, Environment Health.

He also threw himself into helping other students, and still regularly returns to Tembisa High School to encourage other young people to pursue careers in science.

"What concerns me now is the lack of passion and commitment from many teachers at township schools like Tembisa. What happened to teachers like Mr Kgosietsile and Mr Mmethi who were so determined to give a good education?"

"This culture of entitlement has to go and in its place we must develop enthusiasm and passion so that we can grasp opportunities when they come."

It was an apathy that Lesufi witnessed among the black community in Leicester too.

"I would see these mothers walking children in push chairs and their men hanging out on street corners smoking dope and I would think, you have the opportunity to do so much better and look how you are squandering it."

Today Lesufi spends much of his spare time trying to make young people understand that nothing worth having in life ever comes easy. He also serves on the Council of the University of the North where he represents the Chamber of Mines.

"This culture of entitlement has to go and in its place we must develop enthusiasm and passion so that we can grasp opportunities when they come."

WATER HARVESTING:

A KEY TO FOOD SECURITY FOR AFRICA?

A team of Free State researchers believe they have found an affordable and effective tool to significantly increase food production in Africa. With the water harvesting technique they have enhanced, the productive potential of millions of the continent's semi-arid hectares can be unlocked. Marleen Smith reports.

One may just as well describe it as a wage which is sweeping across the former homeland villages of Thaba Nchu, east of Bloemfontein.

A water harvesting technique being developed by a team of researchers from nearby Glen is making productive again village land which has been lying fallow for ages. Probably the most talked about part of this revolution is how it provides food and income where there was either none or too little before.

Best of all is that it costs very little apart from manual labour in an area where jobs and wage money are almost as scarce as food.

Researcher Cobus Botha says the evident success of the technique is selling it fast among villagers.

Botha is leader of the water harvesting research projects executed by the Agricultural Research Council's Institute for Soil, Climate and Water at Glen.

The research project, with a total investment of more than R10 million, is being funded by the Water Research Commission, and has been expanded to focus on other techniques and provinces within South Africa.

One of the backyard farmers, Daniël Mutaung from the village Feloané near Thaba Nchu, on his maize plot which was cultivated conventionally (without the use of the water harvesting technique).

Daniël Mutaung on his maize plot in which he used the water harvesting technique. Both pictures were taken on the same day.

Botha says the six villages who employed the technique as part of the research project during the previous production season, has increased to 32 this year. More than 230 backyards in these villages have been prepared by their owners to use water harvesting in the coming season to grow food crops.

Technique

The technique is simple: A field is divided into 3 m wide contour strips. The 3 m strips are further divided into two areas – a 2 m run-off strip and a 1 m water-collection strip, consisting of a shallow furrow No tillage is practised on the run-off strips. One of the most important farming activities is to keep these strips clean of weeds.
Crops are planted in rows on both sides of the basins.

During a rainstorm, run-off water from these 2 m strips is collected in the basins.

In the basins, the water percolates deep into the soil, from where it does not evaporate.

Botha says this is critical, especially during the fallow period between crop growing seasons. Rainwater stored in the soil during this period gives the crop a significant pre-planting water advantage.
Further adaptations of the technique include the use of organic mulches and/or stones to prevent evaporation and facilitate infiltration in the basins.

Run-off, and therefore soil erosion, is completely stopped by the basins. Evaporation is reduced significantly by the mulch and stones, which lower the temperature of the soil surface.

Stones can also be used on the run-off strips between the crop rows to improve movement of the water to the basins, Botha says.

The technique is especially suitable for the Thaba Nchu and neighbouring Botshabelo area, where soils are predominantly marginal, with a high clay content and low infiltration rate. Surface crusts form easily on the soil, inducing runoff. Annual rainfall is low and erratic, with low humidity levels and high temperatures during the summer. Around 75% of the rainfall in the area occurs during high intensity thunderstorms, which increases runoff and crust-formation.

With the water harvesting technique these environmental attributes, which normally have a negative impact in conventional crop production systems, are turned into benefits for the farmer.

The technique capitalises on the negative soil characteristics such as low infiltration rate and crusting. It also optimises the use of soil's high water storage capacity and fertility.

Furthermore, the technique frees farmers from unaffordable mechanical dependence to produce crops.

Oxen

As Esau Motlalile, one of the villagers, explains "livelihoods in the area had depended for years on croplands and livestock farming. Oxen were mainly used to prepare the croplands. Modernisation then changed this into the use of tractors, with oxen being considered outdated. This was also due to the deteriorated quality of their livestock.

However, very few had the money to continue farming due to the high mechanical costs.

Masses of our people neglected the

Homestead trials

Homestead trials are far more convincing to villagers than the ARC team's initial cropland trials in water harvesting, says team leader Cobus Botha.

"The backyards are the most effective point of departure, from where villagers can be convinced to employ the technique on their croplands as well," he says.

This is because the villagers are more involved in the homestead production than in crop production on fields far away from their houses.

"When they open their doors in the morning, they look onto their water harvesting plots. In the evenings it is the last thing they see before turning in."

"When it rains, they see exactly how the water collects in the basins on their plots outside. They discuss with guests and neighbours how their backyard crops are growing."

Given the fact that no demonstrations with vegetables were provided by the ARC research team, the villagers became 'researchers' in their own right. They themselves proved that vegetables could also be successfully grown with the new technique.

use of their cropland due to a lack of finance and agricultural equipment."

Many of the farmers also stopped producing crops due to continuous crop failures, attributed it to the low and erratic rainfall and marginal soil quality.
"The water harvesting technique overcame these problems, making their land productive again," Motlalile says. So much so that the communal and backyard farmers experience yield increases described by some as miraculous. They have even moved from planting mainly traditional crops such as maize and sunflower to a range of vegetables.

In demonstration trials on village croplands the water harvesting technique out-yielded conventionally produced crops with as much as 50% for maize and 55% for sunflower.

In general, the average improvement was 40% on maize croplands, and 25% on sunflower croplands.

Consequent demonstrations in village backyards proved to be even more convincing. During one such trial, maize produced with the water harvesting technique yielded 1438% more than plots which were conventionally treated. For dry beans a mean increase of 322% was obtained in the backyards.

Income

The new technique not only improves the area's food security as far as both quantity and quality are concerned; it also provides additional financial income.

Last season, Samuel, a backyard farmer, harvested 45 large watermelons from an area of 150 square metres. He sold them for an

Dr Malcolm Hensley initiated the water harvesting research projects at Glen.

average R14 each, earning a total of R630. Several other villagers earned extra money by selling what they could not eat themselves.

Veteran soil scientist, Dr Malcolm Hensley, initiated the water harvesting projects at Glen six years ago.
Hensley, now retired from his ARC post, believes this technique can make not only large tracts of sub-Saharan Africa, but of the whole continent self-sufficient in food production.

He quotes Nobel Prize winning agronomist Norman Borlaug, who has estimated that 600 million hectares of unploughed land in Africa is actually arable. A considerable part of this vast area is probably suitable for application of the water harvesting technique, Hensley believes.

Currently cultivated land in South Africa comprises around 12 million hectares, which is enough to make the country self-sufficient in its food production.

If Borlaug's estimate is correct, it seems that Africa can easily be self-sufficient with regard to food production - if only the correct cultivation methods are employed and the necessary fertilisers are

Dr Leon van Rensburg, head of the ARC group of researchers at Glen, in an on-station trial plot used for the water harvesting projects.

The water harvesting research team of the ARC's Institute for Soil, Climate and Water at Glen. From the left are, in front: Naphtaly Mokgohloa, Tshepo Moshonyane, Daniël Thuthane and Elias Sebolai, all technical assistants; behind: Dr Leon van Rensburg, head of the ARC researchers at Glen, Cobus Botha, leader of the water harvesting projects, Trix de Bruin, administrative assistant, Kobus Anderson, Malerata Macheli and Petrus van Staden, researchers, and Thomas Mandries and David Thamae, technical assistants.

available, Hensley says.

He started researching water harvesting in the late eighties, after realising there was not enough food and work for all in South Africa. He realised that this age old principle, which has been used for centuries in regions like the Middle East, could just as successfully be introduced to African conditions.

For the future, Hensley also wants to see more work being done on techniques to harvest water from outside a field, like from rooftops, streets or adjacent kopjes. Water harvested in this way is already being used successfully in other countries. For Botha, a further avenue is integration of the water harvesting crop production with villagers' existing stock farming.

He also wants to work towards commercialisation of the technique so that it could also be employed in larger scale farming enterprises. Taking into account the large tracts of marginal land not being cultivated currently by commercial farmers, water harvesting on a commercial scale might well be just as big a success as in rural villages.

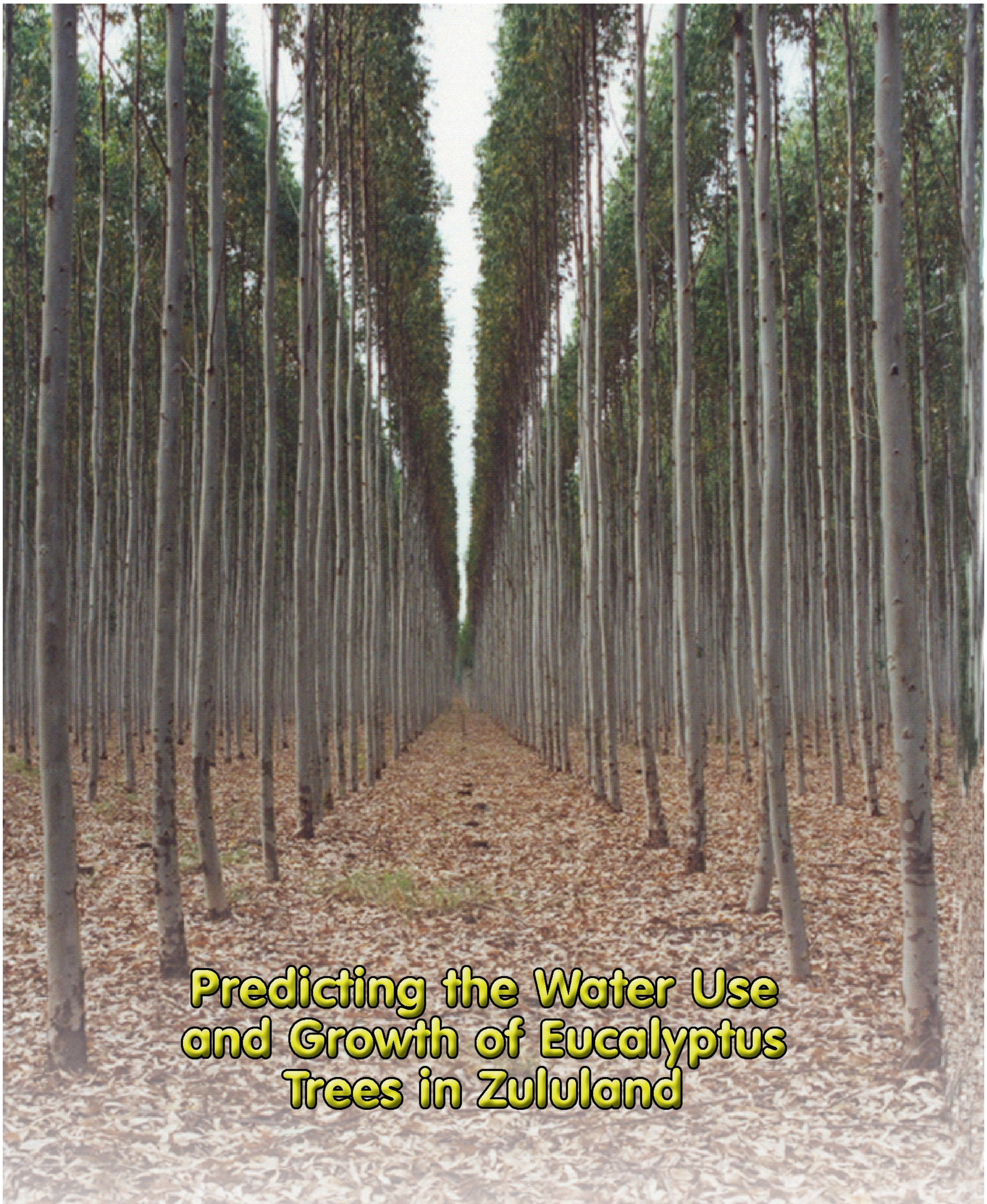
SA'S POVERTY PROBLEM

Water harvesting technology is very important in South Africa, where the majority of the poor rely on rainfed agriculture, says Ex-Water Research Commission research manager Dr Sizwe Mkhize.

"If they can effectively use rainwater, we'll directly or indirectly address the country's poverty problem."

Mkhize says most homesteads have corrugated iron roofs and water tanks which were used in the past to harvest rainwater for domestic use. This is not necessary any more as the majority of settlements now have potable water schemes.

"That investment in corrugated iron roofs and water tanks has to be redirected now, and if it could be to produce food, all the better," Mkhize says.



Predicting the Water Use and Growth of Eucalyptus Trees in Zululand

"How much water does a Eucalyptus tree use?" This question is frequently asked of the CSIR Land Use Hydrology group in Pietermaritzburg. Providing a concise and definitive answer is very difficult, since it depends on many variables such as the species and age of trees, their planting density, the availability of soil water, and weather conditions. A similar question might be "how much does a man drink?", and we all know that this is a highly variable quantity!

Questions on tree water use reflect the widespread and longstanding concern in South Africa over the effects of forest plantations on water availability. Our forests are necessarily concentrated in the higher rainfall areas of the country, which also provide a major proportion of the total quantity of water in our streams and rivers. Experience over the past century has shown that streamflows decline when catchments are converted from grassland or Fynbos to forest plantation. This has much to do with the fact that the seasonally dormant grasses or Fynbos are replaced by evergreen trees that maintain a high rate of transpiration throughout the year. Eucalypts are generally perceived to be particularly thirsty trees. This view may have been shaped by an earlier controversy over *Eucalyptus* plantings in India, but is supported locally by the extraordinary vigour of these trees, their known ability to extend their roots to great depths, and the speed with which they reduce stream flows and groundwater supplies.

Given the wide variety of tree species and growing conditions in South Africa, it is important to get better information on the impacts of forest plantations on water resources. However, it is also important to take into account the productivity of forest plantations, and the overall economic and productive efficiency of water use. Forest plantations are efficient producers of biomass, and sustain an enormous wood products industry. Water used by forest plantations may be more efficient than for some other land-use or industrial purpose further downstream. Catchment Management Agencies will be tasked in future with regulating water resources in 19 different Water Management Areas around the country. Efficiency of water use will become an increasingly important criterion in deciding on optimum catchment water allocation. A clear picture of growth and water use of forest plantations is therefore required to assist in this evaluation.

Measuring transpiration

How does one set about measuring transpiration and growth in trees and forests? The answer is with great difficulty! Evaporation from leaves is an invisible process that varies continuously as the trees adapt to changing atmospheric and soil conditions. Even predictions of tree growth rates are not straightforward. Growth may slow down or stop during and after droughts and dry periods. When soil water is ample for the trees, growth may still be strongly affected by such factors as soil fertility, tree density and weather conditions. In response to these complexities, forester researchers resort to the use of computer models that keep track of changing growing conditions, often on a daily or monthly basis.

Pc model

One recently developed model (3-PG; Physiological Principles of Predicting Growth) appears to have struck the right balance between simplicity and realism, and shows great promise as a useful PC-based tool for predicting water use and growth in South African forest plantations. A recently completed Water Research Commission report (K5/1194) describes a project in which the 3-PG model was evaluated on 12 diverse clonal *Eucalyptus* stands on Mondi Forest estates in the Kwambonambi and Hluhluwe districts of Zululand. The purpose of the project was to test the practicality of setting up 3-PG for a range of tree stands over a short space of time, and also to evaluate

Peter Dye, Author

Shayne Jacobs, Author

Dave Drew , Author , measruring the leaf area of Eucalyptus stands with an instrument that measures light interception beneath the canopy

MEASURES SAP FLOWING IN TREES

The heat pulse technique was used to measure the flow of sap in the sapwood of the tree

Plants need to take up soil water and transport it to the leaves where it is transpired though microscopic pores called stomata. In trees, this transport of water (sap) occurs in the outer, sapwood part of the stem. The older, inner part of the stem is called heartwood, and is blocked by resin-like substances that prevent the flow of water. The heat pulse velocity method allows one to measure the rate of sap movement in the sapwood. A metal probe is inserted into the wood and electronically regulated to briefly heat up at specified intervals during the day. This heat is absorbed by the wood and sap close to the probe. A second type of heat-sensing probe is implanted a fixed distance above the heater probe. An attached data logger then records the time it takes for the pulse of heat to be transported by the moving sap over the known distance to the sensor probe. The faster the rate of water use by the trees, the quicker the sap flow and the shorter the time it takes for the pulse of heat to be registered by the sensor probes. Various other sapwood characteristics are taken into account to permit calculation of the total flow of water through the tree.

the accuracy of the model predictions. An important additional objective was to test the usefulness of satellite remote-sensing data in spatial applications of 3-PG. Efforts were focused on predicting the total leaf area of forest stands, since this is a very important feature of forests that influences the rate of growth, and transpiration of water.

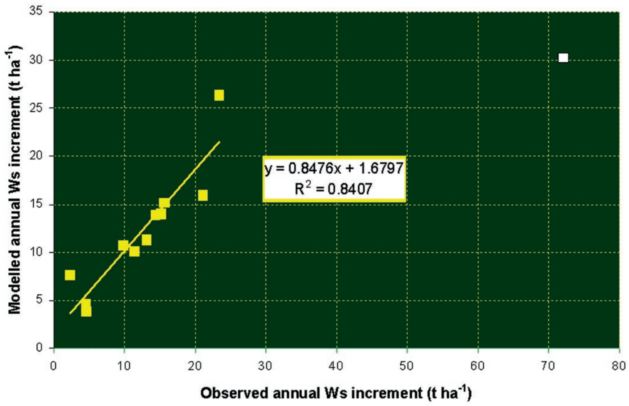
Over a 12-month measurement period, the research team recorded various properties of the soil, trees and weather conditions in each stand. Changes in stem, branch and leaf biomass were calculated from measurements of tree diameters and heights, as well as from field measurements of stem, branch and leaf mass of a sample of harvested trees. The leaf area of the whole stand was estimated using an instrument that compares sunlight measured above and below the forest canopy. The loss of old leaves from the canopy was recorded in collection trays sited in random positions on the forest floor. Tree transpiration rates were measured with the heat pulse velocity technique, which provides information on the flow of sap through the sapwood portion of the tree trunk. The availability of soil water to the trees was estimated at intervals during the dry winter months. The tree physiological technique used for this purpose requires measurements to be performed on leaves before dawn, when the trees have had an entire night to reach equilibrium with the water content of the soil. Two weather stations and several additional rain gauges were used to gather information on those weather conditions that have an effect on transpiration rates.

All available field information was used to set up the model to predict monthly growth and water use for each stand. The modelled annual growth increment was then compared to the measured growth difference after 12 months, while the modelled monthly water use rates were compared to observed sap flow measurements.

Results

3-PG yielded good predictions for 11 of the 12 stands of trees. The one exception was a stand of trees that showed an exceptionally high growth rate and also very high leaf areas. These trees were known to have easy access to a shallow water table, and may therefore have adapted physiologically to this situation.

Landsat imagery was purchased for two periods that coincided with leaf harvesting in the field. The exact



Landsat imagery of the Hluhluwe district showing the location of six stands

position of the experimental stands was located on these images. The spectral properties recorded at these precise points were then analysed and correlated to the observed measurements of leaf area. These correlations proved to be disappointingly poor, indicating that we need to continue estimating leaf areas at ground level for the foreseeable future.

The project was successful in demonstrating that the 3-PG model can be set up relatively easily to produce realistic predictions of growth and water use in a wide range of tree stands. A current project funded by the Innovation Fund is extending the use of the 3-PG model to all the major forestry species in South Africa, and aims at providing the forestry industry with useful decision support tools to improve predictions of tree growth and water use throughout the forestry regions of South Africa.

HOW CAN ONE DETERMINE IF A TREE IS WATERSTRESSED

The Scholander pressure chamber

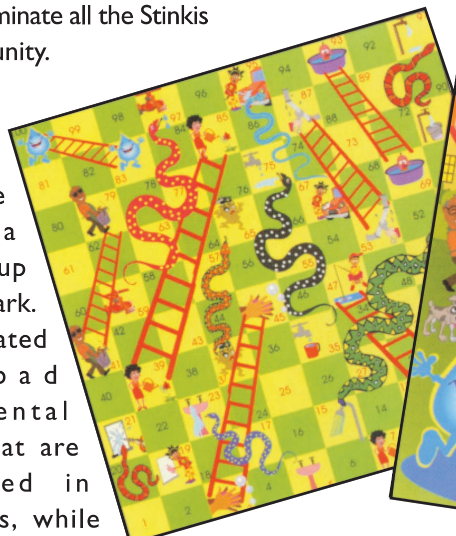
One method involves measurement of the water tension within the conducting plant tissue using a device called a Scholander pressure chamber. As trees transpire during daylight hours, the water within the conducting cells of the roots, stem and branches comes under tension, behaving somewhat like a stretched rubber band. During the night when transpiration stops, the tree continues to absorb soil water and is therefore able to release this tension. If there is insufficient soil water for this equilibration process, then the tension may be only partly relieved. One can measure how complete this equilibrium process has been by cutting a leaf from the tree just before dawn. If the sap is still under tension, it withdraws away from the cut surface back into the leaf tissue. By applying a counter pressure to the leaf suspended in a sealed pressure chamber with the stalk protruding through a rubber bung, one can measure how much pressure is required to push the sap out again to the cut surface. The greater the shortage of soil water, the greater the required pressure to counteract the sap tension in the leaf. Some problems encountered in our use of this technique included: Getting out of bed early enough in the morning!

- Finding sites in the pre-dawn darkness. It is often difficult to navigate around forestry estates even during the daytime.
- Obtaining leaves from tall Eucalyptus canopies. We resorted to using a catapult to knock down leaves. Finding these leaves required following their descent to the ground with torches!

Stinki-Buster Family bursts onto environmental scene

They're are here to stay and fight every practice that is detrimantal to water and peoples health!

The Stinki-buster family first appeared on a colourful poster in Mogale City (Krugersdorp) during National Water Week in March this year. The concept is that Blinki represents all that is good and clean, especially as far as water and health are concerned, and Stinki stands for dirty, contaminated water and an unhealthy environment. The family, developed for Rand Water was created to eliminate all the Stinkis in the community.



Theatre

Along with the poster came a theatre group from Ivory Park. They illustrated the bad environmental practices that are encountered in communities, while educating the spectators as to how to ensure good practices. The two main characters, Stinki – the embodiment of all that is bad and Blinki, the water-wise, paying for services, protagonist, treat the spectators to digestible solutions to environmental nightmares! But, the whole Stinki-buster family is involved in the daily running of community life with its hazards and challenges, doing the right thing! They apply all the water-wise principles endorsed by Rand Water's Water-Wise campaign with the grandfather as the Solomon (wise man) of the environment. Together, the family is 'busting' all the Stinkis in the community.

Snakes and ladders

And then came the game! The traditional 'Snakes and Ladders' was used as model. This board game using the Stinki-buster characters works as follows: *If you do the right and positive things regarding water you will climb the ladders of success, but if you succumb to wasting water or other negative behaviour such as pollution, wasting water, you will be swallowed by the nasty snakes!* Says Willie Potgieter of Water Resources Planning (WRP), this game is a very effective educational tool that can be used in many learning areas of outcomes-based education in a classroom environment. While playing, learners can pick up the important life skills that can lead to sustainable living. Through this game, our precious water resources are getting the exposure needed to ultimately ensure water-wise living.

colouring book

The Stinki-buster family did not forget our little people. For the purpose of getting the water messages to the pre-schoolers and lower grades, a beautiful bright colouring book was created. It depicts Stinki and Blinki and the rest of the family doing their daily chores. This book aims to assist learners to better understand good and bad practices for water use. With the assistance of a teacher/adult person these concepts can be conveyed to the little ones while they are busy with a creative action, also acquiring "water-wise" life skills.

The use of these materials in a project run by Rand Water in Sedibeng has been very successful in so far as it is really changing people's lives for the better! Learners are prepared to associate with the friendly Blinki (and the Stinki- buster family), rather than to team up with the destructive Stinki and its crew.

For more information, contact WRP, tel: 012 346-3496; e-mail: williep@wrp.co.za

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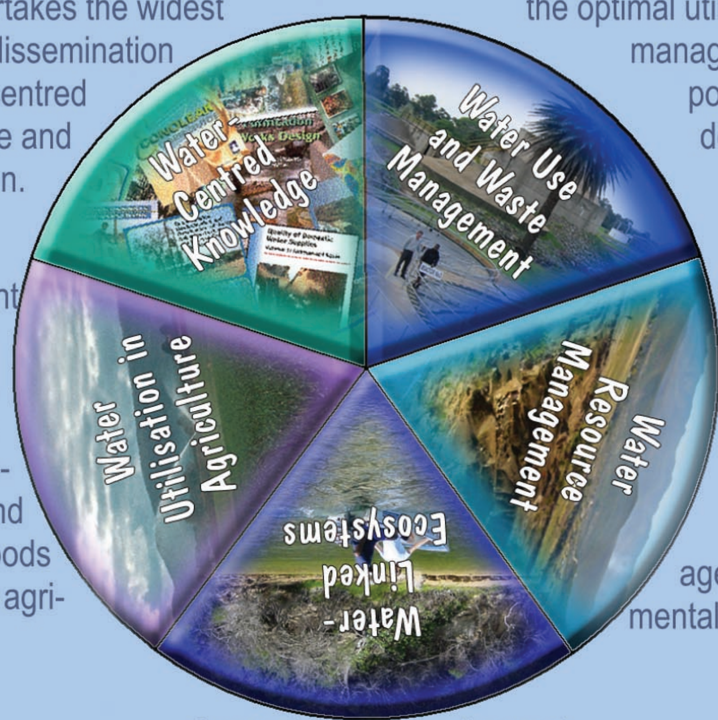

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