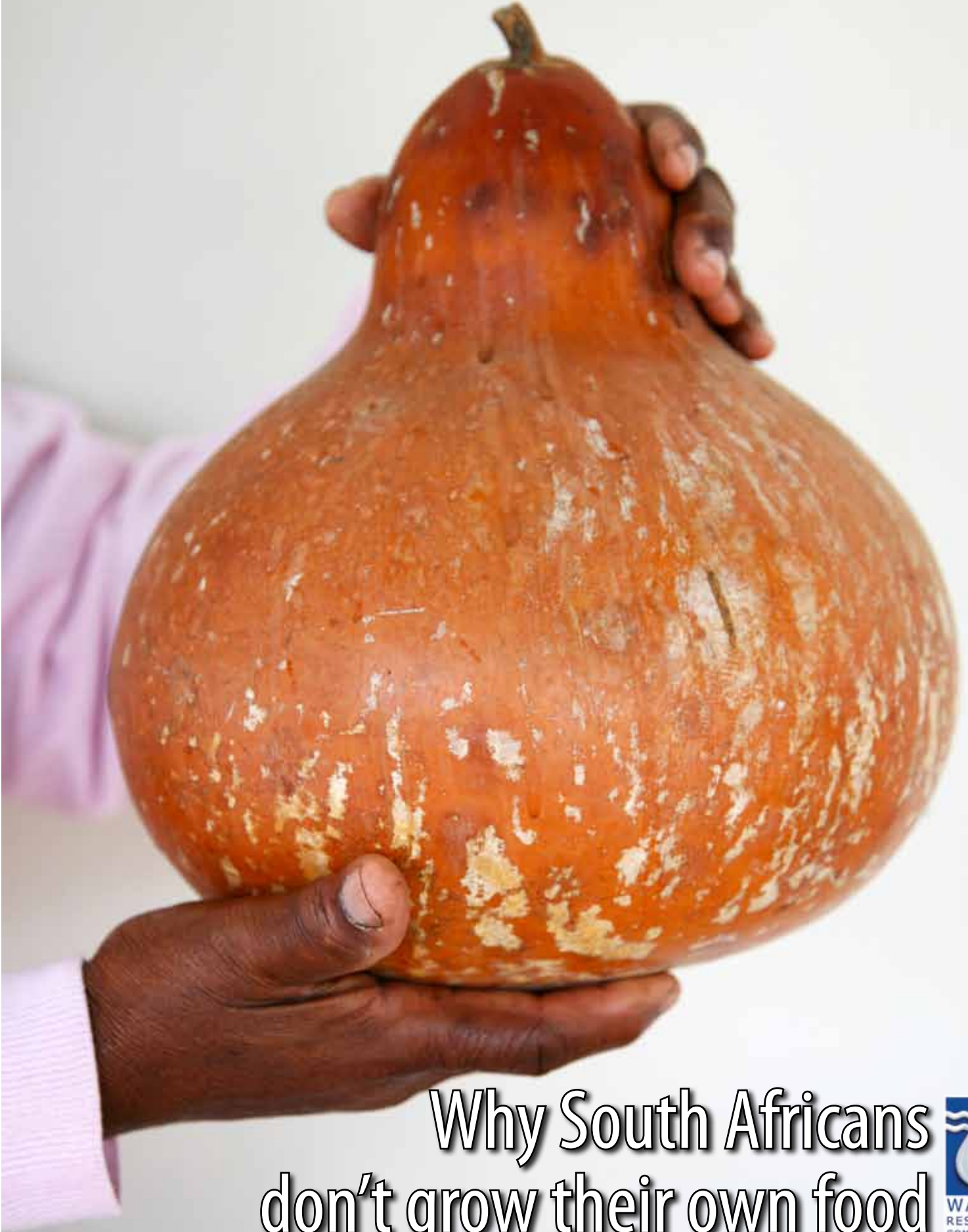


# THE WATER WHEEL

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Why South Africans  
don't grow their own food

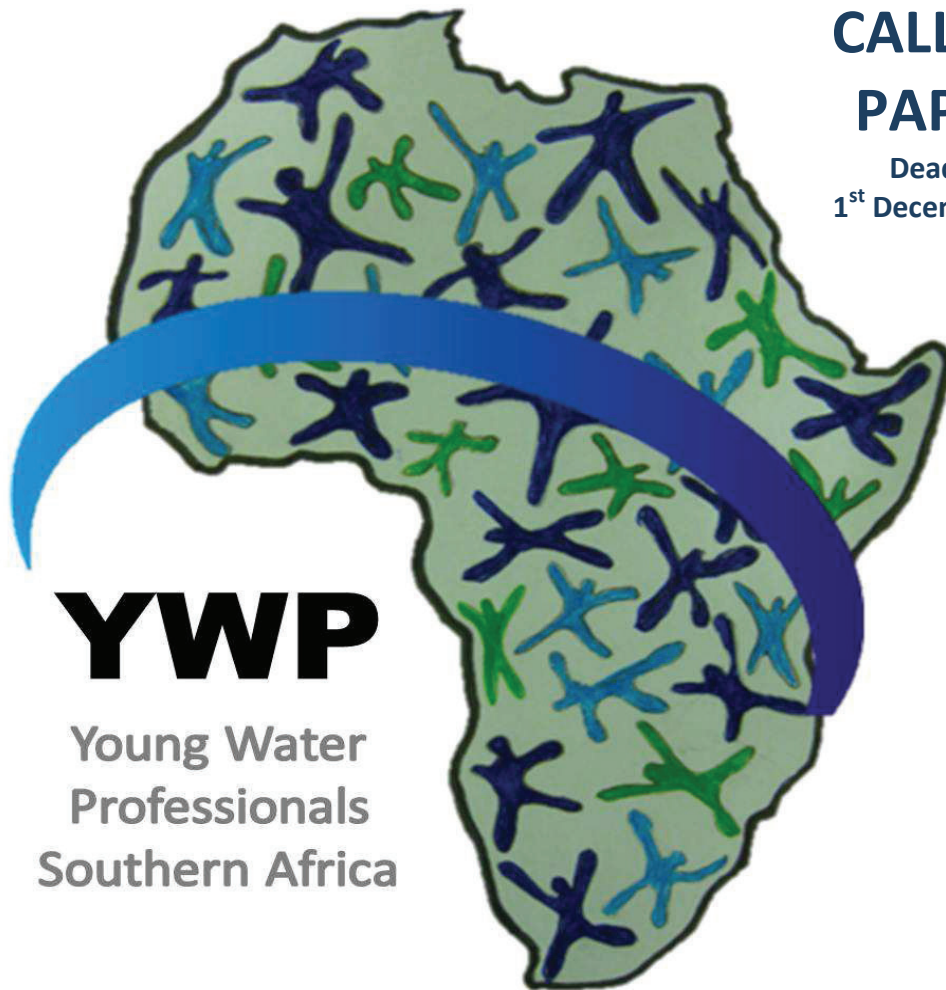


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16th - 18th July 2013 : Music Conservatorium, University of  
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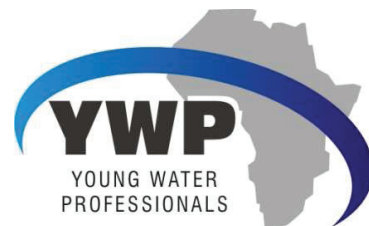
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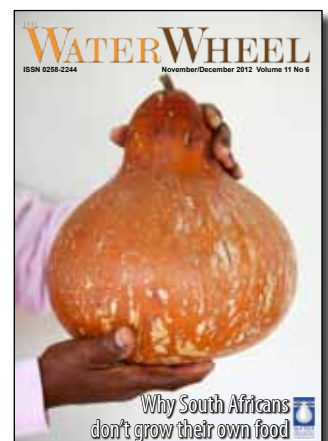
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**Cover:** Latest statistics reveal that millions of South Africans are still starving yet are not growing their own food. The Water Wheel reports on current food security trends on p.16. (Cover image by Earthstock/Africa Media Online)





## The National Water Resources Strategy – navigating a fork in the road

The South African water community is once again seized with a critical national conversation. The draft second National Water Resources Strategy (NWRS-2) has been gazetted for public comment. The discussions have been vibrant, informative and passionate in many forums, including parliament, where the parliamentary portfolio committee for water and the environment hosted four days of public hearings over the last two weeks of October.

Why is the conversation so important? Why have the levels of engagement already been so high? After all this isn't a law or a new policy – it's just a five-year strategy demanded as compliance requirement of the National Water Act after all – or is it?

In several ways for many this is, sixteen years later, the follow-up to the national dialogue led by former Water Affairs Minister, Kader Asmal,

that led to the promulgation of the National Water Act in 1998. The review that preceded the development of NWRS-2 is also timely. After eighteen years in this fledgling democracy characterised by continuous positive economic growth, concomitant population growth, tremendous extension of basic services to the previously marginalised majority, all of which has been very water intensive – we have stretched our resources. Of course, much of this has been done in a very carbon-intensive paradigm. Add to this mix the fact that some 200 years of poor mining and other industrial practices have finally come home to roost in the most dramatic way with the poisoning of our vital aquifers through acid mine drainage and related factors and the picture that emerges points in one direction. The burden on our water ecosystems has reached Gaia's

limits and the Earth Mother is expressing her displeasure.

We are at a fork in the road and the choices we make now will not only affect the next five years until NWRS-3, but the next 50 years as the knock-on effects will be profound. During the discourse thus far the notion of a South Africa in water crisis has been raised in many quarters and was, in fact, the lead question in a DWA sponsored *Mail and Guardian* Critical Thinkers Forum in October. Several countries that have lower natural water reserves and lower precipitation patterns when compared with us are not spoken about in the same terms – why? These countries and regions have been able to ensure their water security when many with much higher rainfall figures and much better storage options have not based on four factors.

Firstly, the water management in these more successful areas are informed by high levels of science, technology and innovation. The decision-making is highly informed and water is a critical upfront consideration in any development plan. The second is good, well maintained infrastructure. The third is the development and availability of large pools of skilled talent to plan, develop, operate and maintain the water management system at all levels. The fourth, and in many cases, differentiating factor in most systems is water use behaviours across the spectrum from large industry and agriculture to the individual at household level. Like electricity usage individual behaviour changes have an accumulative and almost immediate impact on the system both in positive and negative directions. What is different about water from electricity are the reuse possibilities.



That single litre of water can be used several times with the proper system design.

The WRC and the South African water research community has over the past forty years developed a knowledge repository that ensure that the NWRS-2 and its successors have a natural R&D partner as

illustrated in the figure on p. 4. The WRC believes strongly that a NWRS-2 that is developed further and implemented with strong scientific support, good social dynamics analysis and innovative technological and systems solutions is the pathway to ensure a wetter South Africa with much more comfortable

levels of water security than the current trajectories extrapolate. This will also create the virtuous cycle of R&D informing and ensuring good water management decisions and practice which in turn organises for the further development of water research and the growth of the water research community

through higher R&D investment and partnership in South Africa. The attainment of the goals that matter – equity of access, and water as an enabler of growth and sustainable development depends on us achieving this with a strong partnership between science and the economy.

## WRC research that informs and supports the NWRS-2

### Governance and regulation

The WRC has played a critical role in advising and supporting government in its national water policies and laws, from studies in the areas of environmental flows and water services delivery to integrated catchment management and transboundary water governance. Following the promulgation of the National Water Act (NWA) in 1998, the research focus has shifted to implementation and improvement of South Africa's groundbreaking water laws and policies.

The marked shift from central management of resources to a more localised scale is critical to the main founding concepts of integrated water resource management (IWRM) as set out in the NWA. The defined management boundary based on watershed boundaries is another fundamental provision in IWRM as a concept. The WRC supports research on tools and methodologies for IWRM decision support, which aims to provide strategic intervention for new policy development and to improve the understanding regarding the effective functioning of institutional structures for implementing IWRM through institutional governance and reforms; compliance and enforcement; pricing and financing of IWRM, transboundary water resources and future scenarios.

### Water resource assessment & planning

WRC research in this area is focused on developing a scientific understanding of the hydrological cycle (and inter-linkages) to promote systematic water assessment and planning. This includes the development of practical tools for a better understanding of the variability of the quantity and quality of water available for use and development in South Africa. The latest Water Resources Study (WR2012) is the sixth comprehensive national water resources assessment being undertaken in South Africa. WR2012 will assist decision makers at all levels of government to make informed choices about all policies concerning South Africa's water resources. In related projects, the WRC has funded the development of an approach to integrate water resources and water services management tools, as well as a generic integrated framework, which can incorporate relevant and appropriate water management tools that are used in both water resources and water services. Another WRC-funded study developed a framework for uncertainty assessments in water resources availability analyses in South Africa, its main objective being to contribute to the incorporation of uncertainty assessments in water resource decision making in South Africa.

### Water resources protection

Reliable supply of good quality water is required for the health, environmental, social and economic wellbeing of the country. Much of WRC-funded research focuses on protecting the country's water resources by reducing the quantity of

harmful materials reaching the water resources, within a broader framework for all uses. Broadly, research in this area focuses on the generation of knowledge and understanding of the catchment processes and land use activities that influence the quality and quantity, negatively or positively, of the water resources. Another main research thrust of research for the WRC addresses the management of ecosystems for sustainable utilisation for the provision of ecosystem benefits that people depend on. Central to this is the need to manage the social and economic requirements of society from ecosystems and the implementation of policy and legislation.

### Climate change

As a result of its naturally variable climate and scarce water resources, South Africa is particularly vulnerable to the potential effects of climate change. The WRC plays an important role in national as well as global efforts to resolve challenges associated with the impact of climate change of water resources. The organisation first recognised the potential impacts of climate change on the water resources of South Africa in the mid-1980s. Adaptation that reduces South Africa's vulnerability to climate change is critical. Accordingly, the WRC focuses on developing understanding of global climate change and hydro-climatic variability impacts, crafting methodologies for vulnerability assessments and development of appropriate adaptation options and solutions at various scales. WRC research also includes developing appropriate quantitative understanding, tools and strategies for managing the impacts of climate variability and change as well as human interventions on the hydrological cycle and related water resources.

### Equitable water use

The issues of gender and equity are key elements of the required change in the way we manage water. WRC-funded research focuses on ensuring that historically marginalised water users can actively participate on catchment management decisions while gaining sustainable access to at least basic water services. Among others, the WRC has funded studies aimed at investigating practical steps that have been taken by the government to create an enabling environment for women's participation in the management committees of water user associations. In addition, a study aimed at deriving principles that would enhance the impact of gender mainstreaming in the water services sector has been completed. Another recent study has focused on the achievement of redress of race and gender inequities as water allocation reform is implemented. It aimed to derive lessons from international experience and also from initial implementation of various processes and to make this information available for improving immediate interventions.





## American bird takes first trip ever to Africa

Local bird enthusiasts flocked to the Rietvlei section of Cape Town's Table Bay Nature Reserve in October for the rare sighting of a black skimmer (*Rynchops niger*), the first to be spotted in Africa.

According to the City of Cape Town, the bird was first thought to be an African skimmer when it was first sighted on 4 October. Later bird expert, Trevor Hardaker, together with Reserve Manager Cliff Dorse, confirmed it to be a black skimmer.

Since it was first seen, many other birders have come out to see it. The gate staff extended the operating hours from sunrise to sunset to accommodate birders

from as far as Gauteng who wanted to come and see the bird. According to Koos Retief, Area Manager: Milnerton Area, this is arguably by far the rarest sighting ever recorded at Rietvlei.

The black skimmer is a tern-like seabird that is native to the Americas. It breeds in North and South America. Northern populations usually winter in the warmer waters of the Caribbean and the Pacific coasts, while the South American populations make only shorter movements in response to annual floods. The bird is known for "skimming" the water surface in low flight as it searches for food.

## Calling all young water professionals

Young water professionals (YWP) still have time to submit papers to the Third Southern African Regional Biennial YWP Conference, to take place in Stellenbosch from 16 to 18 July, 2013.

The conference theme is 'Water, Africa, Youth'. Participation is open to all post-graduate students and young professionals (under the age of 35 who gained their qualifications less than five years ago) working in the water and wastewater sector in Africa. Around 500 delegates from all over Africa are expected to attend.

It is widely recognised that capacity building and sustainable knowledge transfer are critical concerns for several sectors in South Africa, and the water sector is no different. The loss of intellectual assets is a major threat to effective water management, particularly in water-scarce countries such as South Africa where the onus has always been on the scientific community to find technological

solutions for sectoral challenges.

The repercussions for the sector include high staff turnover as well as the loss of skills and institutional memory. YWPs in South Africa are therefore faced with the threefold challenge of developing their skills; finding mentors to help them do so; as well as grappling with the added responsibility of re-learning knowledge that could have been retained through sustainable knowledge transfer policies and programmes.

The YWP Programme, established by the International Water Association plays an important role in the continuous development of a workforce which is adequate in size, capable in skills and strong in leadership. In South Africa, the initiative is led by the Water Institute of Southern Africa.

The deadline for the submission of papers is 1 December. For more information, Visit: [www.sa-ywp.org.za](http://www.sa-ywp.org.za)

## New task team to look at water data collection

The hydrological sciences community is setting up a task team under the leadership of the Water Research Commission (WRC) to investigate and come up with recommendations regarding current challenges related to the collection of water data.

This is one of the main outcomes following a workshop, hosted by the South African National Committee of the International Association of Hydrological Sciences (SANCIAHS) and the WRC in collaboration with the Department of Water Affairs (DWA), in Pretoria, to examine the current status of data collection and access in South Africa. Around 140 participants, including water researchers, practitioners, water resource managers and decision-makers participated in the workshop held on 1 October. With presentations from main data collection agencies, namely DWA, the South African Weather Service (SAWS) and the Agricultural Research Commission (ARC), workshop participants evaluated the state of present observation networks, storage and access to data, as well as investment in data collection.

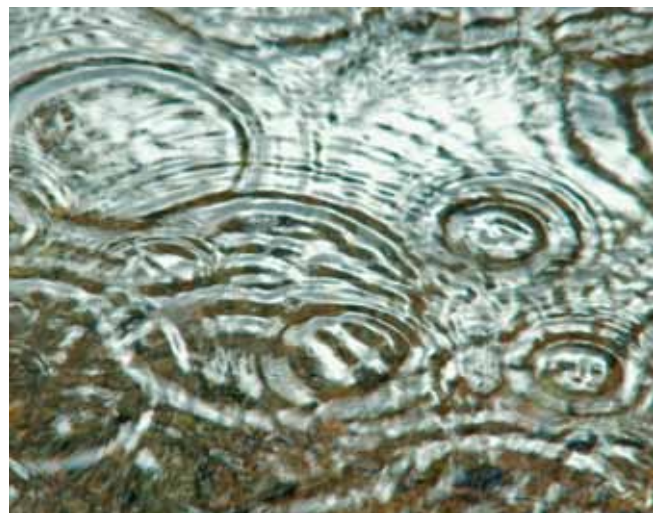
"Despite the availability of modern, high-power hydrological models, spatially representative, long-term consistent records of rainfall and streamflow data remain essential for achieving a high level of understanding about water resources," said SANCIAHS in a statement. "Of great

concern to the South African hydrological sciences community is that all data collection agencies are reporting a decline in their gauging networks as a result of budget cuts and staffing challenges. The fact that payment is now required to access some national data collection networks also affects hydrological science efforts."

Recent investigations revealed that the number of useful streamflow gauges in the country has decreased from a peak of 450 in the late 1980s to less than 350 in 2004. The number of weather stations has been reduced to around 1 800, with some water management areas now having less than half the number of stations open than was the case in 1920. Maintenance is reported as one of the main reasons for a declining in data networks.

Presentations from the data collection agencies confirmed that the perceived decline in data observation networks is real and that the situation is more critical than initially thought.

"This lack of investment in climate and water data collection is ironic in view of the country's water scarcity and high rainfall variability that will possibly be worsened by climate change realities," said SANCIAHS. "Additionally, it will be practically impossible to manage the country's water resources if there are no data collection efforts (of long-term, continuous datasets) to inform water resource management interventions."





## Cloud control could tame hurricanes, study shows

They are one of the most destructive forces on Earth, but now environmental scientists are working to tame the hurricane.

In a paper, published in *Atmospheric Science Letters* earlier this year, researchers from the University of Leeds propose using cloud seeding to decrease sea surface temperatures where hurricanes form. Theoretically, the team claims the technique could reduce hurricane intensity by category.

The team focused on the relationship between sea surface temperature and the energy associated with the destructive potential of hurricanes. Rather than seeding storm clouds or hurricanes directly, the idea is to target marine stratocumulus clouds, which cover an estimated quarter of the world's oceans, to prevent hurricanes forming.

"Hurricanes derive their energy from the heat contained in the surface waters



of the ocean," explained Dr Alan Gadian from the School of Earth and Environment. "If we are able to increase the amount of sunlight reflected by clouds above the hurricane development region then there will be less energy to feed the hurricanes."

Using a technique known as Marine Cloud Brightening (MCB), the authors propose that unmanned vehicles could spray tiny seawater droplets, a good fraction of which would rise into the clouds above, increasing their droplet numbers and thereby the cloud reflectivity and duration. In this way, more sunlight is

bounced back into space, thereby reducing sea surface temperature.

"Data shows that over the last three decades hurricane intensity has increased in the North Atlantic, the Indian and South-West Pacific Oceans," noted Dr Gadian. "We simulated the impact of seeding on these three areas, with particular focus on the Atlantic hurricane months of August, September and October."

- To access the original article, Visit: <http://onlinelibrary.wiley.com/doi/10.1002/asl.402/abstract>

## Biofuel algae may contain risk – US researchers

Algae – high on the genetic engineering agenda as a potential source for biofuel – should be subjected to independent studies of any environmental risks that could be linked to cultivating algae for this purpose.

So say scientists of Ohio State University, in the USA, writing in the August 2012 issue of the journal, *BioScience*. The researchers argue that ecology experts should be among scientists given independent authority and adequate funding to explore any potential unintended consequences of this technological pursuit.

A critical baseline concern is whether genetically engineered algae would be able to survive in the wild, said Allison Snow, professor of evolution, ecology and organismal biology at Ohio State University and lead author of the paper.

"If they are grown in big, open ponds, which are mainly what we are talking about, could the newer types of micro-algae get out into nature and mingle? We need to know if they can survive and whether they can hybridize or evolve to become more prolific when they get out of a controlled environment."

If they can survive, we also need to know whether some type of genetically engineered blue-green algae, for example, could produce toxins or harmful algal blooms – or both," Prof Snow continued. And became algae are so small and could be dispersed by rough weather or wildlife activity, biologists worry that any transgenes they contain to enhance their growth and strength could be transferred to other species in a way that could upset a fragile ecosystem.

The authors recommend, for starters, a comparative examination of genetically engineered algae strains intended for large-scale cultivation with their natural counterparts to determine the basic differences between the two. They also acknowledge that genetically engineered algae might be equipped with so-called 'suicide genes' that would make it impossible for the algae to survive a release into the wild.

"If such precautions are taken in lieu of thorough environmental assessments, more information should be required to ensure their long-term success and to prevent [genetically engineered] algae from evolving to silence or overcome biological traits that are designed to kill them," the authors note.

**Source: Ohio State University**

## Water by numbers

**0,007%** – The percentage of the world's water that is readily accessible for direct human use. That is equal to a volume of about 90 000 km<sup>3</sup> a year.

**R670-billion** – The approximate capital requirement for the entire water sector over the next ten years, according to the Department of Water Affairs (DWA).

**5 000** – The estimated number of job opportunities created through the City of Cape Town's Transport, Roads and Stormwater Directorate in the 2011/12 financial year. These job opportunities are focused on verge maintenance, open stormwater and catchpit cleaning as well as invasive plant control.

**R7-billion** – The annual Municipal Infrastructure Grant allocation for water and sanitation. According to the findings of the Sanitation Task Teak, appointed by Human Settlements Minister, Tokyo Sexwale, to investigate the state of sanitation services delivery, much of this allocation was being rerouted by local authorities to other priorities. As a result, municipalities are not adequately planning for the sanitation programme in their budgets.

**28** – The number of municipalities out of 229 who have no engineering professionals in its employ, according to the Municipal Demarcation Board's *State of Municipal Capacity Assessment 2011/2012*. A further 24 municipalities were found to employ only one technician or technologist. The geographical distribution of engineers remains uneven, with higher concentrations of engineering capacity in metros and secondary cities.

**780 million m<sup>3</sup>** – The total volume of water to be transferred from Lesotho to South Africa via the Lesotho Highlands Water Project (LHWP) during the 2012 calendar year. The infrastructure is currently undergoing routine maintenance to be completed before the end of the year.

## Farmers must lead irrigation efforts to stem hunger in Africa

A new study finds that small-scale irrigation schemes can protect millions of farmers from food insecurity and climate risks in sub-Saharan Africa and South Asia.

The study, *Water for Wealth and Food Security: Supporting Farmer-driven Investments in Agricultural Water Management*, was published by the International Water Management Institute (IWMI) earlier this year.

According to the report, expanding the use of smallholder water management techniques could increase yields up to 300% in some cases, and add tens of billions of US dollars to household revenues across sub-Saharan Africa and Asia. "We've witnessed again and again what happens to the world's poor – the majority of whom depend on agriculture for their livelihoods and already suffer from water scarcity – when they are at the mercy of our fragile global food system," says Dr Colin Chartres, IWMI DG. "However, farmers across the developing world are increasingly relying on and benefiting from small-scale, locally-relevant water solutions."



The assessment quantified the potential reach and possible additional household revenue for a number of different on-farm and local community water solutions. The initiative unearthed for the first time the scale at which enterprising smallholder farmers themselves are driving this revolution by using their own resources innovatively rather than waiting for water to be delivered.

"We were amazed at the scale of what is going on," reported IWMI's

Meredith Giordano. "Despite constraints, such as high upfront costs and poorly developed supply chains, small-scale farmers across Africa and Asia have moved ahead using their own resources to finance and install irrigation technologies. It is clear that farmers themselves are driving this trend."

In Ghana, for instance, small private irrigation schemes already employ 45 times more individuals and cover 25 times more land than public irrigation schemes.

## Students from Singapore win 2012 Stockholm Junior Water Prize

Three 18-year-old students from Singapore won the 2012 Stockholm Junior Water Prize for their research on how clay can be used to remove and recover pollutants from wastewater.

The compounds studied are so called non-ionic surfactants, soap-like additives which are used in industry and in household detergents and cosmetic products. They are common pollutants in wastewater and traditionally hard and expensive to remove.

The students, Luigi Marshall Cham, Jun Yong Nicholas Lim and Tian Ting Carrie-Ann Ng, seen in the photograph with HRH Crown Princess Victoria of Sweden, have developed a method where bentonite clay is used to remove

and recover the pollutants from the water without the generation of any waste products. The clay is able to absorb up to 100% of the non-ionic surfactants and can then be flushed clean with alcohol, allowing the compounds to be reused.

"This year's winning project shows the possibility of using a lower cost

method to decrease an important water environment problem, which is relevant all over the world. The study does not only present an efficient way to remove a toxicant, but also a novel way to recover and reuse materials which would otherwise be discarded as waste," said the International Jury in its citation.

The International Stockholm Junior Water Prize competition brings together the world's brightest young scientists to encourage their continued interest in water and the environment. This year, teams from 27 countries completed in the finals. The winners received US\$5 000 and a prize sculpture.



## Research predicts Spanish trout will be extinct within a century

Climate change, pollution, the extraction of water for irrigation and overfishing all threaten the survival of the common trout in the Iberian Peninsula.

According to a study by the Complutense University of Madrid (UCM), the fish is expected to completely disappear from Iberian rivers by 2100 as a result of the depletion of its habitat. The study was published in the journal, *Global Change Biology*.

Lead author, Ana Almodóvar, explained that the study dealt with how variations in temperature affect trout population both now and in the future. "The fish has very narrow physiological margins in which it can live and is therefore a good indicator of the highest stretches of our rivers."

Among others, the scientists analysed the temperature records of Navarra between 1975 and 2007 and using a mathematical model they calculated the temperature of the region's rivers. "We saw a clear tendency of temperature increases, which was particularly marked around 1986," outlined Almodóvar. In addition, the team monitored the trout populations of 12 rivers in the Ebro basin and saw that an increase in temperature was associated with a decrease in trout populations.

"In the best of cases, which would involve just slight climate change, the situation for the trout is disastrous," noted Almodóvar. The study indicates that the temperature increases in Spanish rivers will cause the trout to lose half of its habitat by 2040 and become practically extinct by 2100.

According to the research team, these results can be extrapolated to other regions of the Iberian Peninsula and the Mediterranean, such as Italian, Balkan and Anatolian Peninsulas.



## Solar-powered toilet shines in design challenge

The solar-powered toilet designed by the California Institute of Technology (Caltech) has won the Reinventing the Toilet Challenge issued by the Bill and Melinda Gates Foundation.

Caltech engineer, Michael Hoffman, and his colleagues were awarded US\$100 000 for their design, which they demonstrated at the Reinvent the Toilet Fair, a two-day event held in Seattle earlier this year.

The challenge is part of a US\$40-million programme initiated by the Gates Foundation to tackle the problems of water, sanitation and hygiene throughout the developing world. Hoffman's proposal – which won one of the eight grants given – was to build a toilet that uses the sun to power an electrochemical reactor. The reactor breaks down water and

human waste into fertilizer and hydrogen, which can be stored in hydrogen fuel cells as energy. The treated water can then be reused to flush the toilet or for irrigation.

The team built a prototype and after a year of designing and testing they were able to show off their creation. The Gates Foundation brought in 50 gallons of fake faeces made from soybeans and rice for the demonstration.

The US\$60 000 second-place prize went to Loughborough University in the UK, whose toilet produces biological charcoal, minerals and clean water, while the University of Toronto won third place with their design, which sanitizes faeces and urine and recovers resources and clean water.

**Source: Caltech**

## 'Wonder material' found to be toxic to aquatic animals

Carbon nanotubes (CNTs) are some of the strongest material on Earth and are used to strengthen composite materials, such as those used in high-performance tennis rackets.

However, while CNTs have potential uses in everything from medicine to electronics a joint study by the University of Missouri and the US Geological Survey found that they can be toxic to aquatic animals. The researchers urge that care be taken to prevent the release of CNTs into the environment as the materials enter mass production.

"The great promise of carbon nanotubes must be balanced with caution and preparation," noted Baolin Deng, professor and chair of chemical engineering at the University of Missouri. "We do not know enough about their effects on the environment and human health. The Environmental Protection Agency and other regulatory groups need more studies like ours to provide information on the safety of CNTs."

CNTs are microscopically thin cylinders of carbon atoms that can be hundreds

of millions of times longer than they are wide, but they are not pure carbon. Nickel, chromium and other metals used in the manufacturing process can remain as impurities. Deng and his colleagues found that these metals and the CNTs themselves can reduce the growth rates or even kill some species of aquatic organisms. The four species used in the experiment were mussels (*Villola iris*), small flies' larvae (*Chironomus dilutes*), worms (*Lumbriculus variegatus*) and crustaceans (*Hyalella azteca*).

"One of the greatest possibilities of contamination of the environment by CNTs comes during the manufacture of composite materials," said Hao Li, associate professor of mechanical and aerospace engineering at Missouri University. "Good waste management and handling procedures can minimise this risk. Also to control long-term risks, we need to understand what happens when these composite materials break down."

**Source: University of Missouri**

## Reduce risks posed by use of chemicals now, UN calls



Governments must urgently act to reduce the health and environmental hazards posed by the increase in use of chemicals in industries worldwide.

This is according to a United Nations (UN) report released earlier this year, which stresses that more sustainable management policies are needed to address this growing risk.

Produced by the UN Environment Programme (UNEP), the *Global Chemicals Outlook* report argues that a shift in the production, use and disposal of chemical products from developed to developing countries has made it essential to establish better management policies to avoid diseases and pollution caused by weak regulations.

"Communities worldwide – particularly those in emerging and developing countries – are increasingly dependent on chemical products, from fertilizers and petrochemicals to electronics and plastics, for economic development and improving livelihoods," said UNEP Executive Director, Achim Steiner. "But the gains that chemicals can provide must not come at the expense of human health and the environment. Pollution and disease related to the unsustainable use, production and disposal of chemicals can, in fact, hinder progress towards key development targets by affecting water supplies, food security, well-being or work productivity."

The report highlights not only the damaging consequences to the environment and human health, but also the economic burden of treating chemical poisoning for

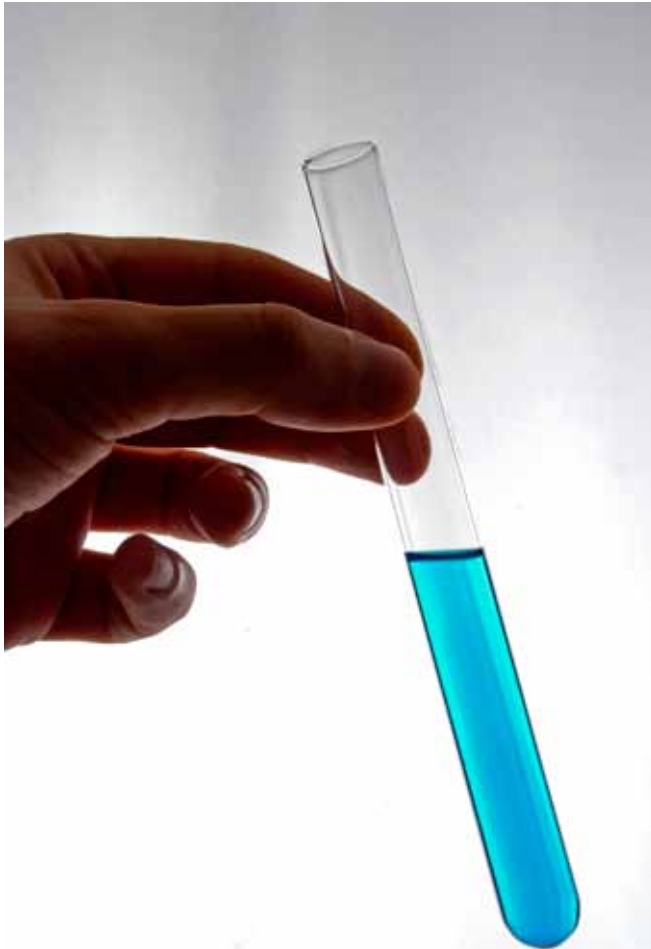
many countries. In sub-Saharan Africa, for example, the estimated cost of poisonings from pesticides now exceeds the total annual overseas development aid given to the region for basic health services, including HIV/AIDS.

From Sudan to Ecuador, to bigger economies such as China and the US, the costs of pesticide poisoning, water pollution and toxic waste, among other issues, are not being borne by manufacturers and industries, but by social welfare systems and individuals, the report notes. It calls for sustainable chemical management policies not just to combat these costs, but also to improve livelihoods and develop green technologies.

"The economic analysis presented in the *Global Chemicals Outlook* demonstrates that sound chemicals management is as valid an area as education, transport, infrastructure, direct health care services and other essential public services," said World Health Organisation Director for Public Health and Environment, Maria Neira. "This could foster the creation of many green, decent and healthy jobs and livelihoods for developed and developing countries."

Some of the recommendations put forward by the report include the integration of chemicals management into national social and economic plans, the development of policies focused on risk prevention and promotion of safer alternatives, and encouraging the private sector to play a more active role in development of safety policies in conjunction with governments.

## Water research going up, up and up, study shows



Research into water resources and the critical water for food nexus is growing faster than the average 4% annual growth rate for all research disciplines.

This is according to a new report published by Elsevier in collaboration with the Stockholm International Water Institute. The report, *The Water and Food Nexus: Trends and Development of the Research Landscape*, takes the first look at the state of water and food research within the larger field of water resources research, examining the state of research literature on both fields through 2011.

It indicates that between 2007 and 2011, the compound annual growth rate (CAGR) for water resources research published articles as 9.2% a year, while food and water research articles grew at 4.7% a year. The reports shows that in

2011, water resources research articles surpassed 6 000 articles per year and water and food research topped 4 000 articles per year.

Output is still highest in the USA, however, China is increasingly seeing the fruits of its steadily increased investment in water research and is expected to surpass the USA in a few years where growth has been slower. Interestingly, Iran and Malaysia have seen mercurial growth in water resources research, while Iran, Malaysia and South Africa have undergone the same growth in water and food research.

Remarkably, the research with the most impact did not come either from the most productive countries or from those exhibiting the highest growth rate in publication output. The most influential

scientific papers originated from the Netherlands, Switzerland, Denmark and Belgium for water resources research, and Sweden, Switzerland, Great Britain, the Netherlands and Denmark for water and food research.

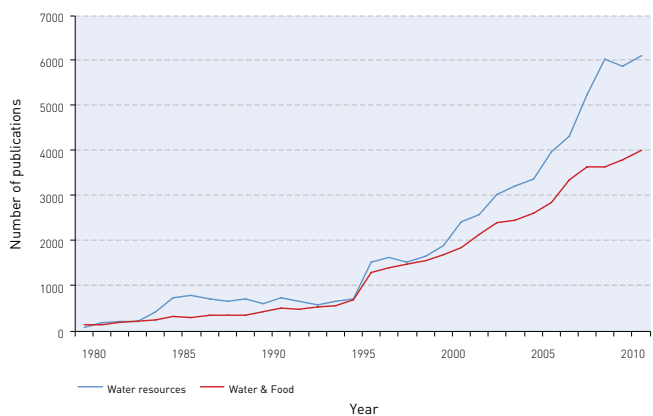
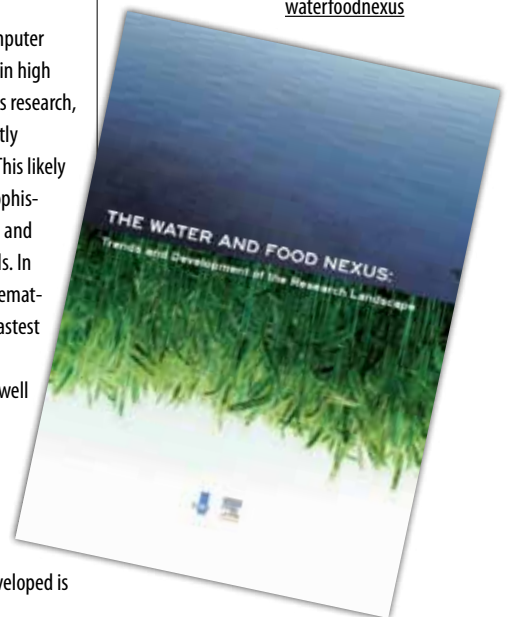
Since the flow of water respects no man-made boundaries, water problems are often international problems. And, as the water crisis touches nearly every corner of the globe, the search for solutions is a collaborative effort. Thus, more than half of all water resources and water and food research articles are produced by international collaboration among researchers.

According to the report, computer science and mathematics remain high growth fields in water resources research, while economics has significantly declined in the last two years. This likely reflects the growing use and sophistication of statistical modelling and quantitative measurement tools. In water and food research, mathematics and social sciences are the fastest growing fields. Agriculture and biological sciences account for well over half of all water and food research articles.

According to the report a critical challenge going forward is ensuring that this immense knowledge being developed is

translated into sustainable action. "Water research in itself will not help solve the world's water challenges – particularly how to produce more food with less water – unless this research is translated into informed leadership decisions and sustainable action. Building capacity for action can be supported by improved knowledge exchange of research findings and technologies best practices," the report concludes.

To access the report, *The Water and Food Nexus: Trends and Development of the Research Landscape*, Visit: <http://www.info.scival.com/resource-library/waterfoodnexus>



The number of papers published in the fields of water resources and water for food between 1980 and 2011.

## New from the WRC

### Report No. 2013/1/12

*Development of analytical sensors for the identification and quantification of metals in environmental samples (V Somerset; C van der Horst; B Silwana; C Walters; E Iwuoha & S le Roux)*

In this project the emphasis was mainly on assessing the aquatic environment around platinum group metals mining activities to determine which national water resources are in close proximity to these mines, and to determine whether the current analytical tools and techniques used to analyse heavy and precious metal containing effluent is adequate for the task at hand. The use of fast, reliable and continuous monitoring techniques for routine analysis of water quality and to quantify pollution events has become essential in order to manage the discharge of potentially harmful wastes to the environment.

### Report No. 1856/1/11

*Development of a revised desktop model for the determination of the ecological reserve for rivers (DA Hughes; D Louw; AY Desai; & AL Birkhead)*

The main objective of the project was to create a new version of the Desktop Reserve model that more explicitly includes the links and relationships between hydrology, hydraulics and ecological response. The previous version of the Reserve Desktop model, that has been in use for a number of years, was largely based on hydrology and regional model parameters that attempted to implicitly include variations in ecological response and the flow requirements needed to maintain different levels of ecological functioning.

### Report No. 1724/1/12

*Sustainable agricultural use of municipal wastewater sludge: Matching nutrient supply and demand (EH Tesfamariam; JG Annandale; PC de Jager; I Mbakwe; P van der Merwe; L Nobela & M van der Laan)* Management of sludge from both industrial and domestic origins is an ever growing challenge. The beneficial

utilisation of sludge is a better long-term waste management strategy than disposal. Municipal sludge is a source of essential nutrients and it is believed that its agricultural use will play an ever increasing role in future strategies. The beneficial use of sludge in both an agricultural and environmental context was the main impetus behind this project. This report (one of two emanating from this project) details the quantification of responsible sludge application rates in an attempt to match nutrient supply from sludge to actual crop uptake for sustainable agricultural use.

### Report No. 1448/1/12

*Grouted lining systems for the renovation of old steel pipelines and the design of new pipelines (SJ van Vuuren)*

In South Africa steel pipes have been installed as far back as 1930. Among others, steel pipes need to be protected against corrosion. This is normally achieved through the provision of an internal lining and external coating. Some of the liner systems that have been used in the past have to be replaced and, in the case of Rand Water, consideration is given to install grouted viscous-elastic liners to extend the pipes' useful life. The objective of this study was to investigate alternative lining systems applicable lining systems applicable for South African conditions.

### Report No. 1568/1/12

*Development of a generic model to assess the costs associated with eutrophication (M Graham; J Blignaut; L de Villiers; D Mostert; X Sibande; S Gebremedhin; W Harding; N Rossouw; S Freeze; S Ferrer*

*& Michelle Brown)*

Eutrophication causes excessive growth of phytoplankton (free-floating algae) and rooted macrophytes. The presence of large numbers of phytoplankton in water bodies diminishes the quality of water resources for many users and costly treatment is often required to overcome its negative effects. The costs associated with eutrophication need to be estimated in order to consider and justify, often expensive, preventative and ameliorative measures. The overall objective of the project was to develop a generic model to assess the economic costs associated with eutrophication in South Africa and to apply it to the Vaal River system.

### Report No. 1705/1/11

*An approach to estuary-based economic empowerment with a particular focus on the Eastern Cape Wild Coast (R Bowd; C Breen; D Hay; D Kotze; M Mander)*

This project is the concluding chapter of a long-term research and outreach programme focusing on supporting the management of estuaries in the Eastern Cape. Commencing in 1998 the Eastern Cape Estuaries Management Programme was informed, philosophically, by the identified need to develop local solutions to local problems and work upward and outward from there. Also, at a practical level, there was the recognition that estuaries are valuable ecological, social and economic assets and they require active management. During the programme it was observed that disadvantaged people living at or near estuaries were continually marginalised in the economic development process, leading to this research project. Among others, the research assessed the state of and opportunities for economic empowerment at Eastern Cape Wild Coast estuaries. A key finding was that, while there was evidence of economic empowerment in the public sector

through state employment, this had not translated into infrastructure delivery that might benefit 'private' economic employment. At the estuary landscape level the main drivers of economic empowerment were found to be resort hotels which provided employment and subsidiary business opportunities.

### Report No. KV 282/11

*Towards improving the assessment and implementation of the Reserve: Real-time assessment and implementation of the Ecological Reserve (S Pollard; S Mallory; E Riddell; T Sawunyama)*

The aims of this study were to assess the state of compliance with the Ecological Reserve – as a benchmark for sustainability – in the rivers flowing through the Kruger National Park (e.g. Olifants, Sabie, Crocodile, Letaba, Luvuvhu and so on) and some of their tributaries. It also explored the problems associated with an assessment of compliance. In short, these include the lack of planning and integration of Ecological Reserve determination methods with operations and the difficulties associated with real-time predictions of Ecological Reserve requirements. These factors severely constrain planning, monitoring and the management action to mitigate non-compliance.

### Report No. 1909/1/12

*Reducing uncertainties of evapotranspiration and preferential flow in the estimation of groundwater recharge (N Jovanovic; RDH Bagan; S Israel; S Dzikiti; E Kapangaziwiri; D le Maitre; A Rozanov; M Stander; D Mikes; F May; C Jarman & C Everson)*

The quantification of groundwater resources is of utmost importance for future water allocations and management. Groundwater is stored in aquifers that include a static zone (permeable portion of the aquifer below the zone of natural groundwater level fluctuation) with a dynamic zone (volume of groundwater available in the zone of natural groundwater level fluctuation, above the static zone). The key variable of the dynamic storage zone that determines



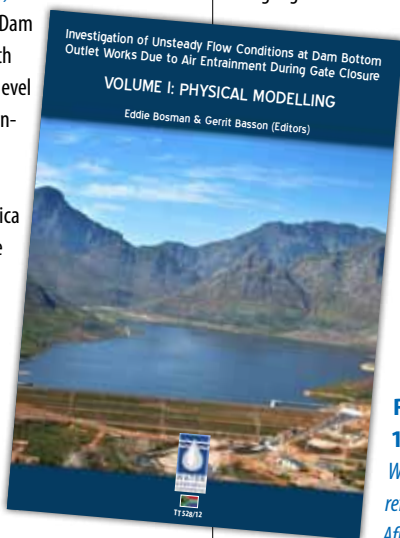


natural groundwater replenishment and water table fluctuations is groundwater recharge. This project aimed at addressing the knowledge gaps identified in previous research. Improved methodologies for the estimation of recharge were proposed, as well as the use of hydrological models verified with field data to predict the effects of weather, vegetation, soil and geology on groundwater recharge. Evapotranspiration of natural vegetation, in particular Sand Plain Fynbos and Sandstone Fynbos, was never measured before.

**Report No. TT 528/12 (Volume I) and TT 529/12 (Volume II)**

*Investigation of unsteady flow conditions at dam bottom outlet works due to air entrainment during gate closure Volume I: Physical modelling and Volume II: Computational modelling (Eddie Bosman & Gerrit Basson (Editors))*

The Berg River Dam is equipped with the first multi-level draw off environmental flood release outlet in South Africa and can release flows of up to 200 m<sup>3</sup>/s. The outlet is controlled by a radial gate and is protected by a vertical emergency gate. Commissioning tests of the emergency gate in 2008 found that large volumes of air were expelled from the air supply shaft designed to reduce expected negative pressures in the conduit during emergency gate closure. In 2009, Stellenbosch University was first commissioned by the WRC to investigate this phenomenon. That study, comprising tests on a 1:40 scale physical model and a two-dimensional numerical computational fluid dynamics (CFD) analysis, was inconclusive on the cause of the large air releases. Volume I covers a subsequent study using



1:14-scale physical model. The accompanying Volume II report covers a study using three-dimensional CFD analyses.

**Report No. 1766/1/12**  
*Field investigations to study the fate and transport of light non-aqueous phase liquids (LNAPLs) in groundwater (G Steyl; M Gomo; K Vermaak; J Bothwell; GL van Tonder; K Surridge; S Lorentz; J Ngaleka; S Sikosana; M Dlamini; N Zondi & S Revil-Bourdard)*

In this report the key features in characterising and evaluating a LNAPL contaminated site is presented. The characteristics which define LNAPLs are expanded on in this report, with special attention to the chemical and physical properties of these compounds. The influence that the local geology has on the distribution of these compounds has been discussed in regards to the type of aquifers present in South Africa. A review of geophysical methods was incorporated in this study to highlight the most effective methods available.

To conclude the review of LNAPL contamination at a site, the most important transport and remediation mechanisms are highlighted.

**Report No. 1855/1/11**  
*Water allocation reform in South Africa: History,*

*processes and prospects for future implementation (MI Msibi; PZ Dlamini)*

Following South Africa's democratisation, a number of programmes and policies have been launched to redress imbalances of the past. Among these is Water Allocation Reform (WAR) for which the National Water Act provides the legislative framework. WAR is aimed at promoting beneficial use of water in the public interest in a manner that supports fair and equitable allocation of water resources to all South Africans while promoting social stability and investor

confidence. A number of factors make water reform a necessity rather than an option, including the country's national water scarcity, the present and long-term effects of projected climate change, existing stressed and over-allocated water resources, and the persisting skewed distribution of water allocation. This WRC-commissioned study aimed to document available knowledge on WAR to facilitate its sharing and discussion with a view to informing policy.

**Report No. 1908/1/11**  
*The development of a hydrologically improved digital elevation model and derived products for South Africa based on the SRTM DEM (HL Wepener; HM van den Berg; M Metz & H Hamandawana)*

Digital elevation models (DEMs) represent the topography in a landscape and are an important data source used in numerous hydrological and geo-hydrological studies/projects. There are several DEMs available for South Africa, but usually they require significant editing before they can be used for hydrological modelling, therefore this project is trying to provide a readily usable set of data products for hydrological modelling. The aim of this project was to prepare a hydrologically improved DEM for South Africa from the Shuttle Radar Topography Mission (SRTM) DEM.

**Report No. KV 280/11**  
*A stable isotope approach for the early detection and identification of N loading in aquatic ecosystems (JM Hill; S Kaehler; MP Hill & J Coetzee)*

Global increases in urbanisation and anthropogenic activity within watersheds and catchment areas have resulted in excessive nitrogen loads in aquatic ecosystems. Increasing nitrogen loading can result in widespread aquatic ecosystem degradation, including harmful algal blooms, increased turbidity, hypoxia, loss of aquatic vegetation and habitat and fish kills. It is also one of the mechanisms driving aquatic weed invasions. Understanding the fate and processing of anthropogenic nutrients in natural systems is therefore critical for both preserving the well-being and biotic heritage for future generations as well

as providing a tremendous opportunity to improve the management driven by science. The objectives of this study were to evaluate the feasibility of mapping anthropogenic pollution through stable isotopes signatures of aquatic plants, to investigate the potential for identifying different pollution sources, concentrations and distributions in a freshwater environment and to determine the utility of these techniques in identifying early eutrophication.

**Report No. 15701/12**  
*Econometric model to predict the effect that various water resource management scenarios would have on South Africa's economic development (Conningarth Economists)*

The specific objective of this report was the development of an integrated macroeconomic model that considers the role of water as an input to the South African economy, and that can be used to predict and evaluate the likely effect of water management and policy interventions. This objective was directly linked to the WRC's research requirement for the development of an 'Appropriate and Scientifically Based Analytical Tool' that can be used for this particular purpose in the South African context. It is against this background that this project examined the available macro-econometric models that, inter alia, establish the functional relationships that exist between the various production sectors and the water sector.

**Report No. KV 295/12**  
*Faecal contamination source identification using a combination of chemical and microbial biomarkers (R Tandlich; CD Luyt; WJ Muller)*

In South Africa, the probability of water supply interruptions was 47,6% in 2010 and there was a 61,8% increase in deaths from intestinal infectious diseases between 2001 and 2007, possibly partly due to intermittent water availability. Some households are forced to supplement their drinking water from water resources of inadequate microbial quality. Contamination of the water bodies occurs via surface runoff from sanitation infrastructure, defecation by livestock and

laundry activities in the vicinity of water bodies, or seepage from landfills and manure deposits. Enumeration of E.coli forms the basis of the National Microbial Monitoring Programme. The analyses are performed using the Colilert®18 system at prioritised sampling sites. However, only 70% of relevant water resources were covered by the National Microbial Monitoring Programme in 2009 due to lack of accredited laboratories and skilled personnel and given financial limitations. This project aimed at reviewing and sampling alternative methods for the detection of the presence or absence of faecal contamination.

#### Report No. 1974/1/12

*Determining the socio-economic value of groundwater: Franschhoek case study (D Pearce; Y Xu; and E Makaudze)*

The Western Cape is facing increased pressure to develop new supplies of freshwater to cater for the region's rapidly growing demand. Groundwater is being explored as a possible contributor to the freshwater supply. Development of the resources has been slow despite the existence of significant potential groundwater resources in the form of several shallow primary aquifer systems and an extensive secondary aquifer formation known as the Table Mountain Group (TMG) Aquifer. This slow development may be attributed primarily to a lack of awareness among key stakeholders and general ignorance in the water market with regards to the potential of this resource. The purpose of this study was to develop and apply a valuation model that can estimate the value of groundwater from a demand-sided approach so that the socio-economic factors that drive its value can be identified.

#### Report No. 1694/1/12

*Towards a sampling and monitoring protocol of radioactive elements in fractured rock aquifers for groundwater resource security in Beaufort West (Y Xu; G Mahed; Y van Wyk; L Lin; X Sun; L Xiao & S Talma)*

The WRC granted this project to a consortium of researchers led by the University of the Western Cape to develop a sampling and monitoring protocol for radioactive elements in fractured rock environments. This report forms part of a suite of deliverables from that project and deals with sampling and monitoring of radioactive elements in aquifers for groundwater security in Beaufort West where radioactive elements were first detected in the groundwater in 1964.

#### Report No. 1760/1/12

*Measurement of the bulk flow and transport characteristics of selected fractured rock aquifer systems in South Africa (G Steyl; J Bothwell; GJ van Tonder; B Zhao & J Odiyo)*

In this research report the need for an effective method for regional bulk flow properties is discussed. An estimation method for transmissivity values in South Africa is given in respect to fractured rock aquifers with dual porosity properties. The influence of bulk regional transmissivity values for dual porosity medium is discussed in regards to the differences between the largest transmissivity value and the smallest.

#### Report No. 1351/1/12

*Effect of agroforestry and intercropping systems on fodder production in rural areas of South Africa (CS Everson; BE Mthembu & TM Everson)*

The major agricultural enterprises for small-scale farmers in the Upper Thukela region are livestock (mainly cattle) and crops (mainly maize and dry beans). These enterprises (cattle and crops) are the sources of their income and staple diets respectively. However, one of the major constraints in rural farming systems of the Upper Thukela region is the shortage of adequate and good quality forage during the dry winter season. Supplementation of feed using commercial supplements is expensive for resource poor farmers and not easily available in remote areas. Provision of

alternative sources of fodder such as tree leaves and pods can increase production. Among others, this project sought to determine the effect of different agroforestry systems on increasing fodder production in rural farming systems; the effect of agroforestry practices on soil water availability to traditional crops; and to determine whether the inclusion of trees in traditional cropping systems can enhance the infiltration of rainfall and prevent soil loss.

#### Report No. 1773/1/12

*The development of a performance management tool for the implementation of IWRM in South Africa (M Wade; C McKenzie & G de Jager)*

The vision behind this project was to provide a tool that could facilitate with the management of a catchment and the implementation of IWRM. The performance management tool aims to draw attention to areas where management targets for a water management area and/or catchment are not being met, providing possible reasons for this as well as recommendations for the way forward. This will enable the catchment management agency to track and measure its functions, as well as make management decisions and to allocate necessary resources to appropriate areas and activities.

#### Report No. KV 288/11

*Investigating water knowledge flow to communities (J Burt & R Berold)*

People working in the water resource management sector have found that very few knowledge/research resources are accessible to most people. This happens because resources are not disseminated properly (or at all), or because they are inappropriately technicist, or because potential readers are hampered by low education. This consultancy is the beginning of an enquiry into

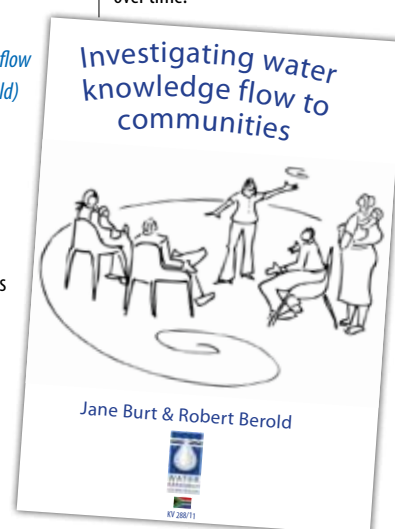
which resources work best and why.

Water communicators around the country were interviewed, followed by two focus groups meetings, which brought water communicators together.

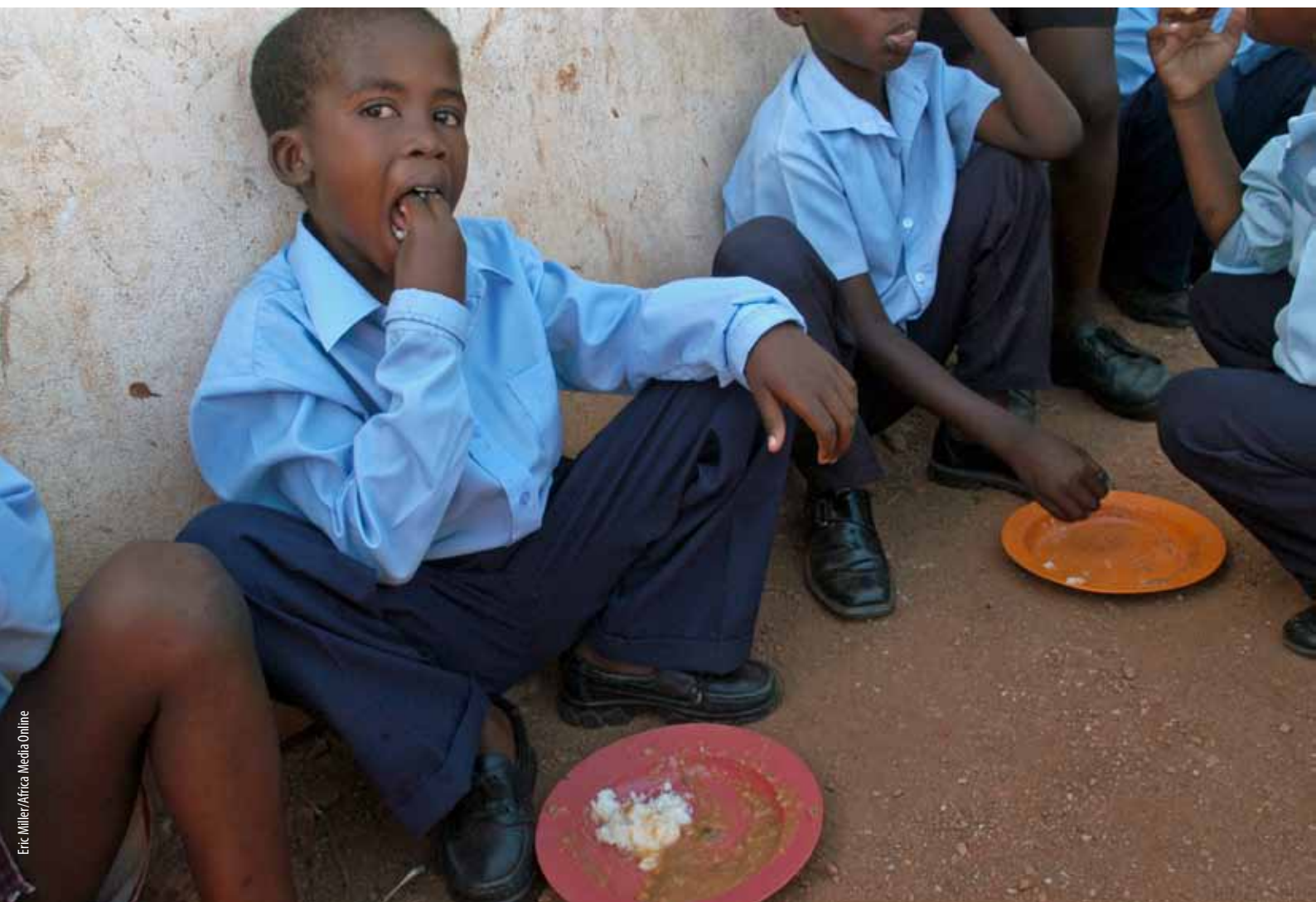
#### Report No. 1724/1/12

*Sustainable sludge land application and co-disposal strategies: The potential of sludge amended combustion coal ash residues as artificial plant growth media – A laboratory column study to assess the influence of weathering on the elemental release (PC de Jager; JG Annandale; I Mbakwe & BH Sukati)*

Management of sludge both from industrial and domestic origins is an ever growing challenge. The beneficial utilisation of sludge is a better long-term waste management strategy than disposal. This report focuses on the potential use of a petrochemically derived sludge for reclamation of a coarse ash dump. It includes a laboratory column study in which weathering, elemental release and water holding characteristics of co-disposed industrial sludge, fine and gasification mixtures are investigated to assess chemical and physical suitability as potential growing media for plants. The report highlights the benefits and risks of mixing various waste streams in certain ratios, as well as the expected end products as these mixes weather over time.



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Eric Miller/Africa Media Online

## Growing currency rather than carrots – Why are SA poor still hungry?

*While vulnerability to hunger has halved in South Africa over the last decade, households are becoming increasingly dependent on social wages to purchase rather than grow their own food. This is according to the latest report on food security and agriculture by Statistics South Africa (Stats SA). Article compiled by Lani van Vuuren.*

The right of every South African to food is not only captured as a basic human right in the Constitution; the eradication of hunger and poverty remains at the top of government's development agenda. This is particularly important as good nutrition is vital to ensure the improvements in health and human capital needed to achieve most of the country's other development goals.

Achieving food security requires that households have adequate

resources to obtain appropriate foods for a nutritious diet; that the aggregate availability of physical supplies of food is sufficient; and that households are able to utilise food. The latter requires that households have access to essential nutrients, potable water, adequate sanitation and the appropriate knowledge about optimum food utilisation.

According to the *Food Security and Agriculture 202-2011* report, published earlier this year South



Africa has managed to maintain its ability to meet national food requirements, yet large numbers of households still do not enjoy food security. While families' vulnerability to hunger has decreased from around 24% in 2002 to around 12% in 2011, one in five South African households still experience difficulty to access food (the latter being the focus of the Stats SA report).

Households in rural areas are more likely to experience difficulty to access food. Around a quarter of households in rural areas experience inadequate and/or severely inadequate access to food, compared to a fifth of urban households. Thus the provinces with the highest percentages of households that experience severe inadequate access to food are Mpumalanga, Northern Cape and North West. Interestingly, Limpopo, itself a relatively poor province compared to others, reports better access to food in comparison to any other provinces, including largely urbanised provinces such as Gauteng and the Western Cape.

Nearly 38% of households in South Africa are headed by women. According to the survey these households are more likely to be poor and thus more likely to experience inadequate access to food. Poorer households are also less likely to consume a diet that is sufficiently diverse to allow for adequate nutrition.

## WAGE ECONOMY

The survey confirmed that access to food generally improves with income. Urbanisation and declining agrarian activities have transformed the South Africa economy into one which is wage based. Household income and employment are the main drivers of better food access, dietary diversity and, per implication, food security.

While almost two thirds of households reported receiving salaries or wages, it is disconcerting to note that around 22% of South African households list social grants as their

main source of income. The latter is particularly pertinent in the Eastern Cape and Limpopo. The report notes that "social grants have become an indispensable safety net for poor households" and that "this current high level of dependence on social grants is arguably not sustainable."

It is interesting to note that households headed by elderly individuals are less likely to experience inadequate access to food. This is certainly linked to the availability of old age grants to qualifying individuals over the age of 60. This observation is supported by the finding that households with a larger percentage of elderly members are less likely to lack access to food than households with fewer or no elderly members.

The importance of social grants in terms of food security is also underlined by the fact that poor households who receive social grants are less likely to experience inadequate access to food than poor households without social grants. The latter set of households are usually smaller families located in urban areas, often living in informal dwellings and headed by younger males, who are dependent on remittances for survival. Often, they are labour migrants who seek work in

the city to send money home to their rural families.

## THE LINK BETWEEN FOOD AND SERVICES

The survey noted a strong correlation between access to services and access to adequate food. "Access to some basic services can be associated with higher socio-economic status, and particularly income." For example, households with access to piped or tap water on site or off-site were found to be less likely to have inadequate access to

**"Even households with sufficient access to food may become caught in the food insecurity cycle as a result of the risks of diarrhoea and malnutrition associated with the use of unsafe water."**

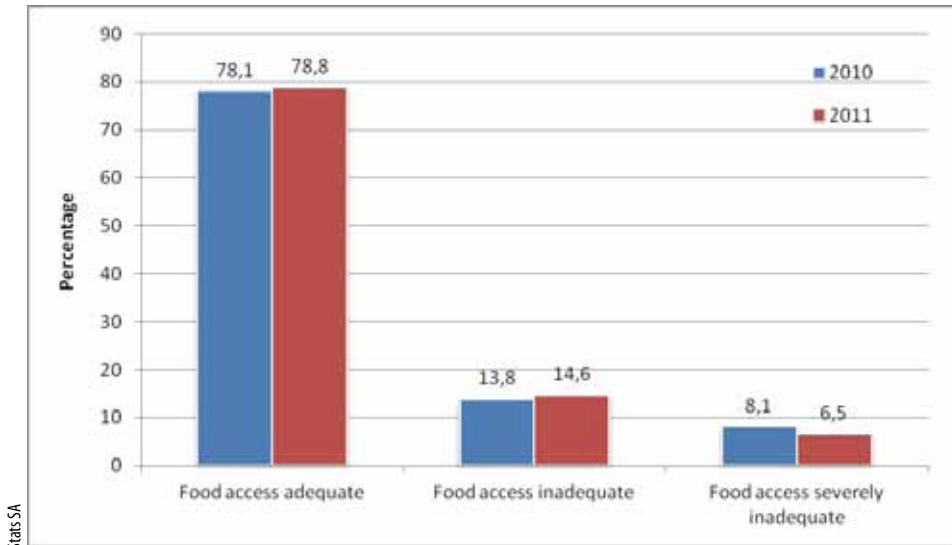
food while households that still use unsafe sources of water are more likely to be food insecure.

The lack of basic services in some areas locks households with inadequate access to food in a vicious cycle. "The use of unsafe water increases the risk of diarrhoea and infectious diseases, lowering

*Households headed by elderly individuals are less likely to experience problems with access to food, indicating a strong dependence of households on old age grants.*



Nikki Rixon/Africa Media Online



Stats SA

resistance and reducing nutritional status, which in turn impacts food security status negatively,” the report notes. “Even households with sufficient access to food may become caught in the food insecurity cycle as a result of the risks of diarrhoea and malnutrition associated with the use of unsafe water.”

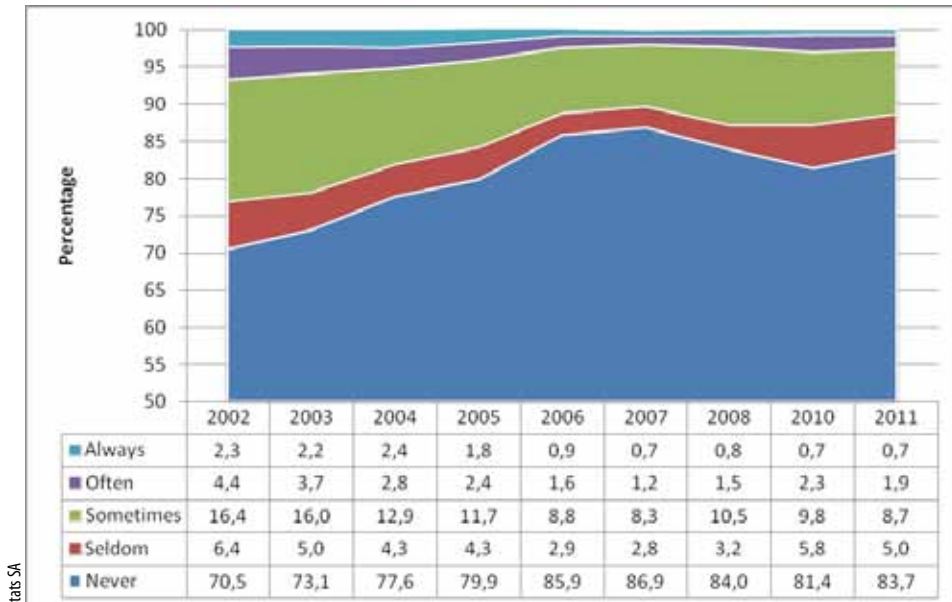
### BUYING FOOD VERSUS GROWING FOOD

While household food production is widely considered to be a potentially important approach to promote household food security, a major finding of the Stats SA report is that agriculture has apparently ceased to be an important component of household food security as households are far more likely to buy food than to grow their own. Ironically, one of the reasons could be the increased access to social grants, which is reducing the incentive to

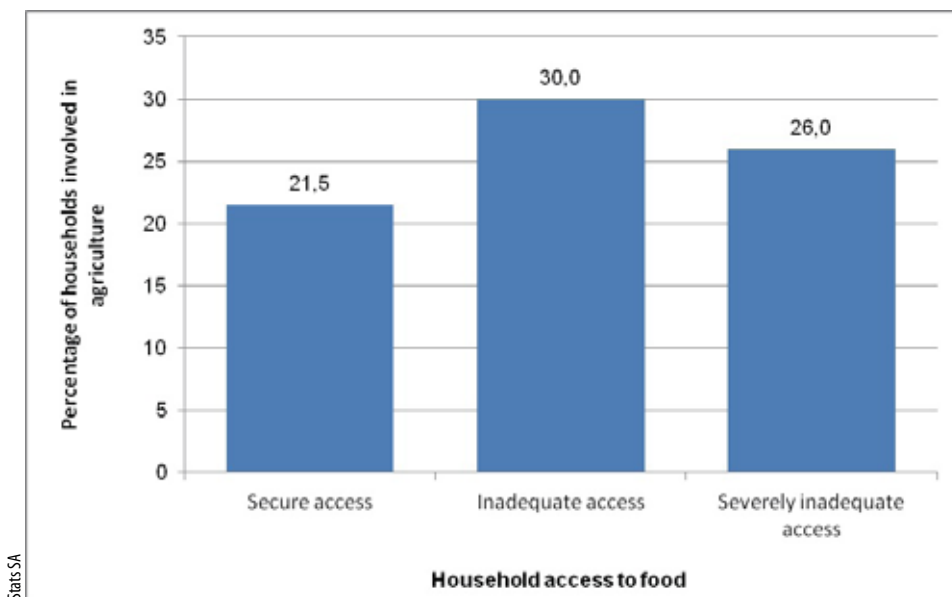
**“Around a quarter of households in rural areas experience inadequate and/or severely inadequate access to food.”**

households to use available land for food production. Less than a quarter of households in South Africa were found to be involved in agricultural activities, including doing agriculture as a hobby.

Unlike their counterparts in the rest of sub-Saharan Africa rural households were found to only grow their own food as a last resort to stave off hunger. “Households that say their agricultural activities serve as the main source of food are most likely to be food insecure. It might very well be that these households



Stats SA



Stats SA

**Top left:** Comparison of food adequacy status of households for 2010 and 2011.

**Middle left:** Household experiences of hunger, 2002-2011.

**Bottom left:** Household access to food by participation in agriculture, 2011.

start practising agriculture only once their access to non-agricultural sources of income area already limited.”

Nationally, more than 84% of households that are engaged in agriculture do so to produce extra food

**“Agriculture has apparently ceased to be an important component of household food security as households are far more likely to buy food than to grow their own.”**

for the family, while only 4% use agriculture to produce the majority of their food. While less than 2% of South African households practise agriculture as smallholders, subsistence farming is far more prevalent, with 18% of households practising this form of agriculture. Households in the Eastern Cape, Mpumalanga and Limpopo are most likely to engage in agriculture, with the latter province reporting that 53% of its households practice some sort of farming.

The report recommends that where there is access to land, it is vital that the opportunities provided by such access are exploited as much as possible in order to ensure advancement on the zero hunger and reduction of poverty agendas. “More households should make use of available land as a livelihood and income generation asset. This has the potential to reduce the current high dependence of households in especially rural areas on social grants. However, indications are that the sector needs to be significantly revitalised as those currently engaged in production have significantly poorer food access than the population as a whole.”

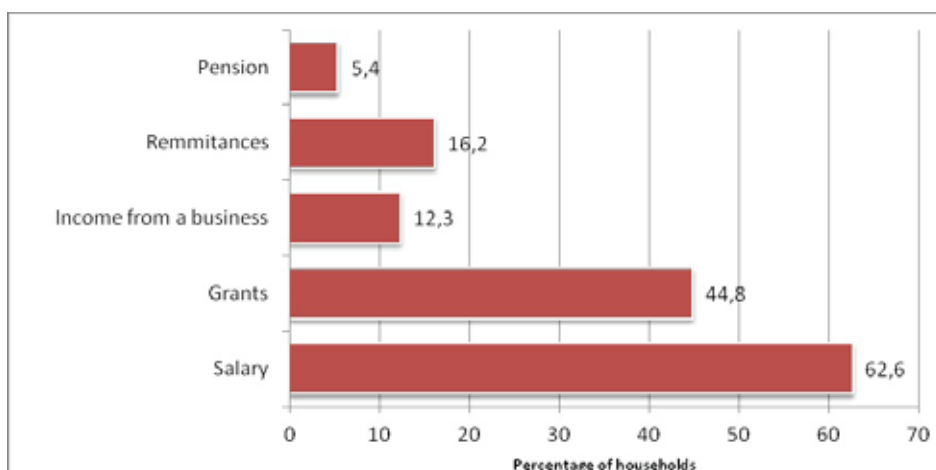
Structural constraints such as the costs of agricultural inputs and problems with access to land, markets and so forth will have to be dealt with before such a strategy



Guy Stubbs/Africa Media Online

**Above:** Women are increasingly taking responsibility for subsistence farming as an additional livelihood strategy.

**Below:** Percentage distribution of sources of household income, 2011.



Stats SA

will translate into reducing hunger, poverty and inequality. Stats SA also sees room for improvement in urban agriculture, which is only practiced to a very limited extent at present. “A greater involvement in and focus on local municipal developing planning and programmes on

the part of the national Department of Agriculture, Forestry & Fisheries may help to give greater impetus to this agenda.”

- To access to report, *Food Security and Agriculture 202-2011*, Visit: [www.statssa.gov.za](http://www.statssa.gov.za)





## Adapting to climate change – Keep uncertainty in mind, scientist urges

*While many forecasting models predict changes in the global climate with consequences for natural resources such as water, we need to heed the uncertainties of these predictions and structure our adaptation strategies accordingly. So says Vice President of the International Association of Hydrological Sciences, Prof Denis Hughes, Director of the Institute for Water Research at Rhodes University.*

There has arguably never been a topic in the natural sciences that has seen as much publicity and discussion in the social and political arenas as that of climate change. Perhaps this is inevitable given the projections of the consequences that are often reported in the popular press and governing briefings or policy documents from countries worldwide.

“It is almost as if the ‘science’ of climate change has been taken out of the hands of scientists and is now more driven by political agendas,” noted Prof Hughes. He was speaking at the 16<sup>th</sup> National Hydrology Symposium, held in Pretoria, in October.

“One of the consequences is that effective scientific enquiry into an extremely complex issue has been

partially suppressed to the extent that many papers submitted to journals start with the assumption that climate change and adverse consequences are known facts. This would have been a totally alien concept in the natural sciences of the past, where any assumptions would have to be clearly demonstrated by hard evidence.”

While some scientists conclude that such hard evidence is already available and therefore the assumptions are valid, there is also ample evidence (often ignored) that it is not true for other aspects and there remains a high degree of uncertainty associated with future projections.

Global climate models (GCMs) are used by various climate research centres throughout the world and their outputs down-scaled to provide regional or local impact assessments. As Prof Hughes pointed out, models are only mathematical abstractions of reality and depend on a whole range of assumptions about the real processes and boundary conditions and are therefore subject to varying degrees and causes of uncertainty.

“As the scale of modelling increases, so does the uncertainty, regardless of the complexity included in the model – we simply do not have sufficient understanding of complex natural systems (whether of the land surface or of the atmosphere) to be able to construct models that are perfectly reliable.”

This is true when scientists use models to simulate historical conditions for which there are some observations that can be used to condition the model outputs. It is even more true when models are used to forecast future conditions of which there is no experience.

For hydrologists dealing with the modelling of an inherently intricate and variable hydrological cycle, the added complexity of

climate change brings even more issues of uncertainty. This is especially so for a country such as South Africa which already has an extremely variable climate in time and space and where it is not unheard of to have droughts and floods simultaneously in different parts of the country. Current extreme weather phenomena can thus not necessarily be attributed to a changing climate. In addition, where past assumptions have assumed that, for example, a rise in temperature will necessarily result in a rise in evaporation, new observations are showing this to be not necessarily so.

**“At this stage there are far more things that we do not know about the future climate and its impacts on water resources than there are things that we do know.”**

Inadequate gauging records (of both climate and hydrology variables) make it more difficult to detect changes of time or to condition the outputs from models that are applied to fill in the variability in climate and natural water resource availability. Superimposed on this variability are poorly quantified development impacts related to water use, hydropower generation and land use changes. It is therefore always difficult to separate out these various effects over historical time periods and confidently conclude that trends can be detected.

The variability in rainfall and streamflow that exists in southern Africa has been well documented scientifically. “One of the important questions about possible climate change impacts is whether that variability will be changed, and if so in what direction?” noted Prof Hughes. Further questions relate to whether any changes in variability will make significant differences to the impacts of that variability, whether communities

and managers have learnt (or not) to adapt to it and whether we need to change our water resources management practices or infrastructure. It is therefore important to not only look at possible changes in hydrological response, but what these changes mean in terms of real impacts. The only answer at this stage is that we will be faced with more uncertainty.

The fact of the matter is that at this stage there are far more things that we do not know about the future climate and its impacts on water resources than there are things that we do know, noted Prof Hughes. “The danger is that ill-

informed policies will be formulated around potential threats of climate change that cannot be adequately justified using scientific analyses. While it is not suggested

that there should be no response to potential future threats of climate change, it is recommended that these responses should be considered in a context of existing known variability, as well as the uncertainties of the future. The responses should therefore be informed by the level of risk aversion that can be considered appropriate in different circumstances.”

For scientists this means improving their observation networks so that they rely less on uncertain model outputs, or at the very least have more real information to constrain model outputs. “We also need to develop consistent approaches for conveying scientific outputs to non-scientists,” said Prof Hughes.

He concluded: “We need to know more about possible changes to the climate before we can make some of the important decisions about how to adapt to them. In the meantime we should develop better ways of managing existing patterns of variability so that our approaches are robust in the face of future uncertainties.” □





*Clanwilliam yellowfish has been re-established in the lower reaches of the Rondegat River following eradication of invasive alien species.*

## ERADICATING INVASIVE ALIEN FISH – It can be done, project shows

*Scientists are cautiously optimistic that a unique pilot project aimed at removing the centuries-old invasive alien fish problem in one of the Western Cape's most critical rivers has been a success. Extensive monitoring and surveying formed a key part of the project. Lani van Vuuren reports.*

When the Western Cape introduced the first foreign fish to its waters for sport almost two centuries ago, the devastating consequences this would have on indigenous fish populations was little understood. Today, while invasive alien species

such as bass and trout still play an important role in generating tourism income, these predatory fish, along with habitat destruction and pollution, have all but wiped out several native fish communities in Cape rivers. Fish in the rivers of the Fynbos biome, which is home to 27 fish taxa (of which 24 are endemic, i.e. found nowhere else) are particularly threatened, with 16 species now either critically endangered or endangered.

Once established in a river system, invasive alien fish are almost impossible to eradicate because of the complexities and cost involved, explains CapeNature Scientist: Freshwater Fishes, Dean Impson. Mechanical removal through electric

fishing or netting, for example, is one method of controlling these fish, but this is highly labour intensive and rarely achieves complete eradication. How then to improve the status of South Africa's highly threatened indigenous fish and associated aquatic organisms?

"It is possible to eradicate fishes from stretches of rivers (usually upstream reaches), provided there are barriers such as weirs or dams and waterfalls that prevent re-invasion from downstream sources," notes Impson. "In the same way fish can be removed from farm dams, provided that water entering the dam is not from a 'contaminated' source, which allows for re-invasion. There



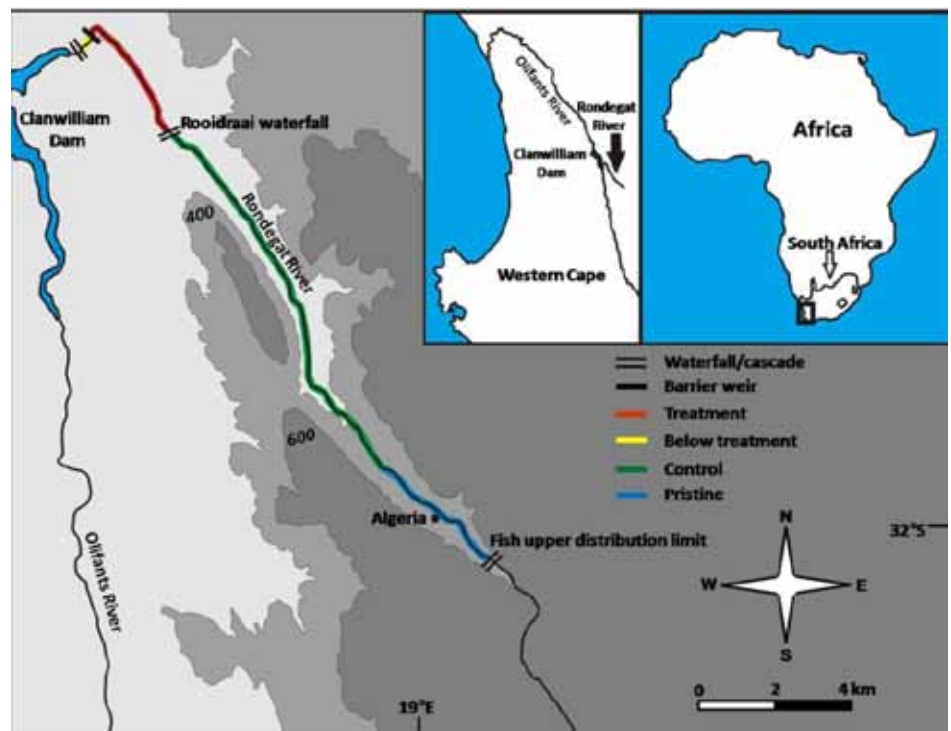
are many successful projects of both types from across the world, with piscicides (fish killing chemicals) most commonly used to achieve this.”

Almost a decade of investigations into alternative removal methods has led to the launch of a joint project between the Western Cape government and civil society organisations. The project, which involves the use of the piscicide rotenone, is being implemented by CapeNature. Several priority streams have been identified where alien invasive fish could be targeted for permanent removal, the first being the small Rondegat River, which rises in the Cederberg Wilderness before entering privately-owned farmland and flowing into the Clanwilliam Dam.

Rotenone has already been used successfully to eradicate invasive alien fish from reservoirs and streams in the US, Britain, Norway and New Zealand. Prior to the start of the South African project, a comprehensive environmental impact assessment was carried out, and the project was approved by all the relevant authorities. Independent biological monitoring both before and after treatment formed a key aspect of the project.

The project did attract much attention, both from the public and from angling bodies, as rotenone not only kills fish, but also non-target fauna, such as aquatic invertebrates. “The effect on aquatic invertebrates is dosage and species dependent, with certain groups, such as mayflies, being more sensitive even at low rotenone concentrations (e.g. 50-100 ppb),” explains Impson.

As he points out, however, any attempt to eradicate invasive alien species and re-establish indigenous species has trade-offs that have to be considered in terms of how the aquatic ecosystem should function and what its ecological value should be. “For example, do you want to leave part of your near pristine, priority river full of alien smallmouth bass, with few or any indigenous



fish species, and hence have a compromised in-stream biota, or do you want to eradicate the bass, allow the treated stretch of the river to recover and provide a home to thousands of endemic fishes?”

“One must accept that rotenone use may have some adverse or unexpected impact – that is why each rotenone project in public water must have a sound biological monitoring base so that we can get a very good idea of how the ecosystem responds to the treatment. If treatments are bad for their intended purpose (i.e. ecosystem recovery), they should not be undertaken,” maintains Impson.

It is acknowledged that the piscicide can be deadly if placed in untrained hands. For this reason, CapeNature invited international piscicide use experts Dr Brian Finlayson (recently retired California Fish and Game) and Dr Jarle Steinkjer (Norwegian Department of Nature Management) to assist with the supervision of the treatment and train its treatment team in the safe and effective use of rotenone. CapeNature is now preparing a rotenone use policy, which could

guide its future use in South Africa. Preparation and implementation of the Rondegat project was guided by the manual, *Rotenone Use in Fisheries Management* prepared under the auspices of the American Fisheries Society.

## SURVEYS AND MONITORING

The invasion of the Rondegat River by smallmouth bass (*Micropterus dolomieu*) has resulted in the local extinction of several native fish species in the lower reaches of the river. Rehabilitation

Map of the Rondegat River indicating the four areas: treatment (red) and below treatment (yellow) areas in the invaded zone and the control (green) and pristine (blue) areas in the non-invaded zone.

The lower Rondegat River, which was treated with rotenone to eradicate the invasive alien smallmouth bass.



Courtesy CapeNature

## Aquatic ecosystems

was focused on this particular 4 km-stretch, now dominated by small-mouth bass.

To monitor the project, independent surveys covering the fish, invertebrate and amphibian populations were carried out both before and after chemical treatment of the river. The surveys, funded by the Water Research Commission (WRC) and led by the South African Institute for Aquatic Biodiversity (SAIAB), were conducted over a two-year period from May 2010 to May 2012. Individual seasonal surveys were undertaken over three to five days, and were generally divided between a fish survey team and an invertebrate team.

According to WRC Research Manager, Bonani Madikizela, the project forms part of a key thrust of the Commission which is focused on reducing threats to indigenous species, thereby restoring ecosystem functions and processes, hopefully leading to improved biodiversity. "South Africa has the third-richest biodiversity in the world. This heritage is worth protecting for current and future generations."

**Right:** An underwater screen shot of the Rondegat River. Underwater video was one of the tools used to survey the river both before and after treatment.

**Below:** The alien invasive species, smallmouth bass, which has been successfully removed from the lower reaches of the Rondegat River.



The fish team was led by Dr Olaf Weyl (SAIAB) and Bruce Ellender (Rhodes University), assisted by two MSc and nine Honours students who gained valuable experience during the rotenone application. Dr Darragh Woodford of SAIAB/Centre for Invasion Biology (CIB), Terence Bellingan (Rhodes University) and Jeanne Gouws (CapeNature) made up the invertebrate team. Insect identification services were also provided by Dr Ferdy de Moor and Helen Barber-James of the





SAIAB/OlatWeyl

species driven to local extinction in the invaded zone,” explains Dr Weyl, Principal Scientist with SAIAB. “The only species capable of co-occurring with smallmouth bass was the Clanwilliam yellowfish (*Labeobarbus capensis*), but only those individuals that are too large to be eaten actually survived in the lower reaches of the river, and survey evidence suggested that no successful juvenile recruitment had occurred there for decades as a result of the smallmouth bass.”

**“Juvenile yellowfish were recorded in the first pool of the treatment area just three days after the operation, and two months later both yellowfish and redbin minnow (*Barbus callidus*) were recorded (the latter for the first time in probably 70 years).”**

Prior to rotenone operations, a fish rescue operation was conducted by CapeNature and volunteers, which removed significant proportions of the yellowfish and bass populations from the stream. The remaining fish were all apparently killed by the rotenone operations, and no live bass were found during the fish surveys conducted following treatment. Juvenile yellowfish were recorded in the first pool of the treatment area just three days after the operation, and two months later both yellowfish and redbin minnow (*Barbus callidus*) were recorded (the latter for the first time in probably 70 years) as far as 200 m downstream of the bass barrier, indicating recolonisation of the treatment area by native fish was underway. This indicates that the re-establishment of the 4 km of treated river should not only be successful but fairly rapid.

Three common species of frog were found to occur in the vicinity of river reach earmarked for rehabilitation, namely the Cape river frog (*Amieta fuscigula*), the clicking stream frog (*Strongylopus grayii*), and the FitzSimons’ ghost frog (*Heliphryne depressa*). Post-treatment surveys indicated no

Albany Museum, while Prof Jenny Day of the University of Cape Town provided support in the planning and design of the monitoring programme. Dr Michael Cunningham led the specialist amphibian study.

To ensure that all species present in the river were detected, the project teams used a combination of electrofishing, mask-and-snorkel surveys and underwater video analysis in all zones of the river. In the case of the frog study, aural encounter searches were also employed, with the bioassessment method

SASS5 and species level assessments being used to survey invertebrates. Food-web effects were also measured by assessing algal production on stone surfaces.

While the Rondegat River supports five species of indigenous fish, the surveys (both current and past) confirmed that alien fish dominated the lower reaches of the river. “Fifteen years of population monitoring on the Rondegat River has shown that the alien bass severely depleted the native fish community, with at least three and possibly as many as six



difference in the numbers of adult frogs, and the removal of fish from the treatment area actually resulted in a short-term increase of amphibian densities. However, these populations are expected to be restored to near pre-treatment levels following the re-colonisation of native fish.

Characterising the native insect population proved particularly challenging, as it consisted of many uncommon and incidental species which appeared to naturally occur in very small numbers and at only certain times of the year, explained SAIAB/CIB post-doctoral fellow, Dr Woodford. “The challenge was looking at the number of species ‘missing’ following the rotenone treatment and assessing how many of these absences actually were the result of the piscicide and not just an artefact of the low detectability of species. This challenge is one of

**“The insect team were pleasantly surprised by the speed at which some insect species appeared to recover, and by how many groups of insects were apparently unaffected by rotenone treatment.”**

the main reasons why long-term recovery monitoring is necessary to properly understand how rotenone ultimately affected this community.”

The insect team were pleasantly surprised by the speed at which some insect species appeared to recover, and by how many groups of insects were apparently unaffected by rotenone treatment. “Only five out of 29 common species were still missing when we re-visited the river two months after operations,” notes Dr Woodford. “In comparison, studies in American streams have shown up to half the insect species recorded pre-treatment can still be missing a year after treatment.”

## CAUTIOUSLY OPTIMISTIC

While initial concern was expressed over the potential impact of rotenone on other



SAIAB/Ofaf Meyl

(indigenous) aquatic species, results of the monitoring and surveying of the Rondegat River following the application of the natural chemical indicate that these concerns were unfounded. No significant changes in ecosystem health could be attributed to the rotenone operations, and the fundamental conclusion of the monitoring programme is that the river rehabilitation has been a success, in that all bass appear to have been removed from the treatment area

**Above left and right:** The monitoring team at work in the Rondegat River. Extensive surveys were undertaken both prior and after the treatment of the river with rotenone.

**Below left:** Honours students from the Department of Ichthyology at Rhodes University collected dead fish for further study. They were joined by CapeNature Acting CEO Dr Kas Hamman.

**Below right:** A treatment station administering rotenone. Several observers attended treatment, including personnel from Natural Resource Management Programmes, SANParks, the Department of Water Affairs, and water users.



Courtesy CapeNature





SAMBO/OfarWeyl

without significant long-term damage being accrued to other wildlife of the Rondegat River. “We are very confident that that bass will be eradicated using the methods used, and if we can prevent any re-introduction, then the pools and riffles of this lovely small river should have large numbers of indigenous fishes in the treatment area, just as it does above the waterfall that marks the start of the treatment area,” notes Impson.

CapeNature will be working with

the key landowner in the treatment area to establish a conservation stewardship site that elevates the conservation importance of the treated area. The organisation is also working with angling groups to ensure that bass are not re-introduced into the treatment area, or above it. Signage is also being established at recreation areas along the Rondegat River to highlight its importance to fish conservation and the need to prevent any foreign fish introductions.

A further treatment is scheduled for next February to ensure the river is completely free of bass. This is because two treatments, a year apart, seems to be standard operating practice for river treatments using rotenone in the USA and Norway.

According to Dr Weyl, the project has successfully demonstrated that insect communities in a South African stream are relatively robust to the potential negative effects of piscicides. “Given the significant threat posed by alien fish to the survival of endangered freshwater fish species in many places in the country, the positive outcome of removing the alien fish from streams with rotenone is likely to outweigh the short-term negative effects of using the piscicide.”

Dr Weyl points out that it is important that such projects to be assessed on a case-by-case basis. “Pre-treatment biodiversity monitoring will always be essential to establish the baseline situation before a decision regarding the use of rotenone can be made.”

For instance, the invasive alien fish on a river proposed for rehabilitation may co-exist with highly threatened fish or invertebrates, meaning the use of rotenone to remove alien fish may have negative conservation implications itself. Notes Dr Weyl: “This was clearly not the case on the Rondegat River where monitoring suggests the fish and insects will both benefit from the rotenone operation over time, as a more natural community develops in the previously invaded stream.”

It is hoped that long-term monitoring of the Rondegat River will confirm the success of the project, and that this method can be successfully (albeit carefully) replicated to help save what is left of our precious indigenous fish heritage. Natural Resource Management Programmes (previously Work for Water) is funding the Rondegat alien fish eradication project, and have expressed their intention to support further projects of this kind, given the positive results achieved so far. □



Courtesy CapeNature

# HARNESSING THE POWER OF CHANGE



*Professor Anthony Turton is a political scientist with 24 years of strategic level experience. In an exclusive interview, he shared his involvement in the water and mining industry with Debbie Besseling.*

## **What is your role in the water and mining industry in South Africa?**

The reality is that South Africa is a mining-based economy, which for the last 120 years of mining has been largely unregulated. As a result there are now a number of unintended consequences. Mining is useful, but it has been harmful in the past due to inadequate oversight and governance. The work that I am involved in is to assist the mining sector, to reposition themselves in

a way whereby they can harness the overall benefits of mining, which are many. In doing so, this will ultimately decrease the dis-benefits, in other words, the environmental footprint and associated impact. This will result in redistributing the benefits to society in a more equitable manner.

It is about understanding how to reinvent a business case that will enable you to still raise capital in mining, but in areas that are water constrained, and in many cases environmentally sensitive, as well as both culturally and extremely significant.

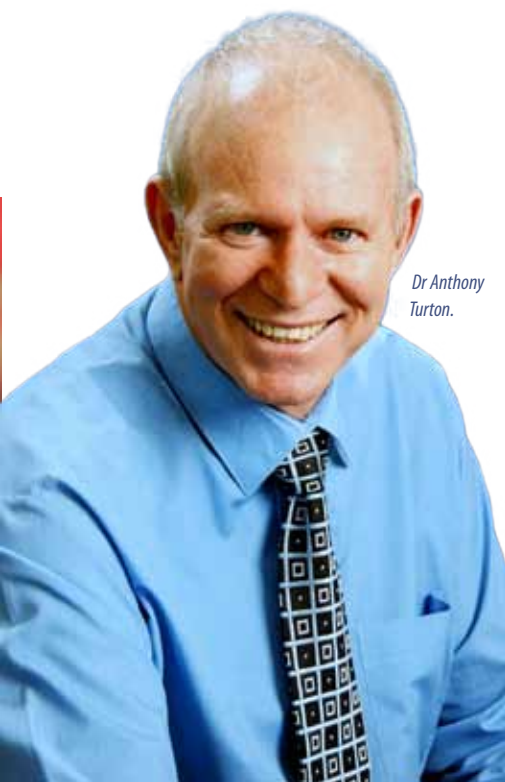
Overall the model brings about greater equity in mining, whereby mining then repositions itself from being a standalone entity that is extractive, to becoming a partnership for development. This involves resourcing the closure strategy

throughout the life of the mine. Three aspects are critical being, technology, capital and oversight known as governance. When you bring these three elements together you are planning for the entire life cycle of a mine.

## **What is your motto “harnessing the power of change” about?**

My entire life, I’ve lived under conditions of extreme uncertainty, for reasons of which I’ve had no control and the only thing that I know is that change is constant. If you can understand the magnitude of the change and the driver of the change, it will position you in such a way that you can actually, potentially, benefit from that change. In my role as a strategist, I help my clients to understand the power of change and how to harness that through strategy.





Dr Anthony  
Turton.

### What is your role in terms of being a strategic advisor?

The difference with strategic issues are that they typically have a very long time horizon, they typically have multiple drivers or entry points and they are typically very high impact if you don't get it right.

I advise my clients about the risks and opportunities that are arising from their changing world. Within that process of change, there are lots of risks, but there are also opportunities.

A good example of this is in the work that I am currently involved in, in the mining industry. Typically the business case for mining is such that you start off with an asset, the resource in the ground, and you end up over the life of a mine, with a liability. At the end of the life of the mine, you cannot sue the mine because there are no more assets.

One just needs to consider what is going to happen in South Africa with our water resources, 25 years from now, taking the impact of climate change into the equation. Why don't we use a mining void as an alternate method of strategic storage? Instead of having a liability at

the end of the life of mine, the liability can be converted into an asset? It is about understanding the unknown and stepping out of the box.

### Tell us about the Water Stewardship Council Trust of South Africa?

I am involved in a public-benefit organisation (PBO) of which I am a founding trustee, known as the Water Stewardship Council (WSC) Trust of South Africa. Overall, the WSC trust is about helping people to understand how we have to change our behavior from being consumers of water to becoming custodians of water, and doing that in a way that's underpinned by positive inducement. The Mission statement is: incentivising behavioural change from consumption to the custodianship of water through structured stewardship programs that are based on a set of clearly articulated core values.

### You have been developing a mine closure strategy that will inform the design criteria of future mining operations in water-constrained areas. Can you provide an insight into this project?

Mine closure is a serious problem not only in South Africa, but globally. In South Africa, there are some 12 000 mines that have reached the end of their life, but have not been closed according to legislation, i.e. there are no formal closure certificates.

Mine closure is something that I am deeply involved in now, whereby we plan the entire life of mine upfront. Part of the closure strategy is to limit the negative impact of mining and to turn water infrastructure into a useful asset.

I have been involved in developing what is called a Legacy policy for a client of mine. The significance of this is that it changes the business case for mining. Instead of now having to set aside a massive amount to pay for the liability at the

end, if it is turned into infrastructure or even an engineered aquifer that is useful, the result is a nett benefit to society post-mining. This makes mining more attractive from an investment perspective while reducing the negative impacts and thus opening up a broader basket of benefits to be shared by a larger range of beneficiaries. Overall it creates a good environmental outcome and social outcome and it is a good business transaction. I call this the new social charter for mining.

### Which individual has had a great influence on your life?

I attribute part of the success in my career to the fact that I have adopted mentors throughout my life. I have accepted that I cannot know everything and have associated myself with people that are outstanding in their particular field of expertise.

One of those people is Malin Falkenmark. She is a remarkable woman who I first got to know from her work in the 1980s when she was doing her post-graduate research. At that time, she asked a simple question that no man had ever thought to ask: Is there a finite limit to number of people that a given unit of water can sustain?

In 1989, the work she did on this topic was published in a paper in *AMBIO – A Journal of the Human Environment*. That paper was one of the most important papers that I have ever read in my life. It explained what she called the water barrier. Malin undertook a global study and her findings were that there is no evidence of a country retaining its social cohesion and economic stability where there are more than

**“One just needs to consider what is going to happen in South Africa with our water resources, 25 years from now, taking the impact of climate change into the equation.”**

A paddock below a large tailings dam filled with acid mine drainage and inside a large wetland that is severely degraded. Turton is currently developing a closure strategy that will rehabilitate this wetland by using the existing aquatic ecosystem as the foundation of the rehab.



Photo supplied

**Below:** Hydraulic mining of a large tailings dam as part of a rehabilitation programme.

**Bottom:** Dr Anthony Turton at an abandoned mine shaft that has been opened by illegal miners.

2 000 people per million m<sup>3</sup> of water, per annum. I am therefore alarmed that in Limpopo we are already double that value and will be two-and-a-half times over it by 2025, which could drive the loss of social cohesion if left unmanaged. This is central to my current thinking on mine closure strategies.

In 2011, Malin was awarded a lifetime achievement award by the

Royal Swedish Academy of Sciences (RSAS). I was invited to come to Stockholm as a guest of the RSAS to celebrate the lifetime achievement of Marlin. Unbeknown to me, part of her prize was that she could invite up to 10 scientists from anywhere in the world that she thought had made a difference. I was one of seven scientists that she had chosen and was humbled with this honour.

### What research projects have you worked on more recently?

I have been involved in significant international research work and in this year have had a large publication output, with four major international publications. Overall, the research that I have been involved in is based on preventative outcomes and is very much goal specific.

One of the four high impact projects that I have undertaken this year is a research project that is being published in the *International Handbook of Engineering Hydrology*. This is the first paper on engineering an aquifer as part of the deliberate mining act that I am aware of. We are describing what is called an anthropogenic aquifer. This concept involves taking an opencast mine, and as part of the formal closure strategy, turning it into an engineered aquifer. I conceptualised the idea and it forms part of the mine closure strategy for one of the mines in South Africa. This is one of the

first mines that I know of that has been planned for closure before it has even been opened. It has gone in as part of the definitive feasibility study, to raise capital for the mine and has given rise to a whole new way of thinking, but there are still many engineering problems to overcome as the concept has not been tried before. These are baby steps in a new direction.

A team of researchers being led by Malin Falkenmark, of which I am one, have written a paper entitled: *Water Source Management in Anthropocene*, also being published in *AMBIO*. The paper focuses on the geological epoch in which the earth formation processes are being impacted on by humans. We have transitioned from the Holocene to the Anthropocene. We are thus 1<sup>st</sup> generation Anthropocenians. Management of water in the Anthropocene is going to differ fundamentally from what it was in the Holocene. Therefore all our science and technology is no longer adequate, as it is based on Newtonian physics and reductionist Holocene logic.

The *Bulletin of Atomic Scientists* currently has a round table underway. The topic is the role of nuclear energy in water resource management under conditions of climate change, and they commissioned me to write a series of articles. People worldwide may participate in the discussion. My comments on this have been that whilst I am not necessarily pro-nuclear, I don't see a future in which the survival of the species will not depend on us understanding nuclear energy and doing useful things with it, and one of these technologies will be desalination.

I am co-author to two chapters of the *UN World Water Development Report 2012* (Chapters 5 & 11). This forms part of Volume 1: *Managing Water under Conditions of Uncertainty and Risk*.

- To view the interview with Dr Anthony Turton, Visit: <http://youtu.be/xRULvoVzU1Q> 



Photos supplied





## Farmers get more out of DRIP IRRIGATION with new guidelines

dreamstime.com

*A new set of guidelines available from the Water Research Commission (WRC) is helping farmers and irrigation designers get more out of drip irrigation technology. Compiled by Lani van Vuuren.*

The application of drip irrigation (the frequent application of small amounts of water as directly as possible to the roots of crops), might be as old as irrigation itself. However, while plastic pipes and nozzles have long since replaced ancient clay containers, drip irrigation is still considered the most efficient form of irrigation. This makes it particularly applicable to South Africa with its semi-arid climate and amid increasing competition for water from various users. South African irrigators especially,

are under increased pressure to use the available water resources more effectively, while increasing productivity amid rising input costs.

Recent figures (2007) indicate that around 22% of land under irrigation in South Africa is already making use of drip irrigation. The technical development of irrigation equipment over the last couple of years has been immense. Like any irrigation technology, drip irrigation is only efficient when it is correctly selected, planned, designed, managed and properly maintained.

The WRC has funded numerous studies into drip irrigation technology over the last decade, including research projects on surface and subsurface drip irrigation and filtration. While the research confirmed the technology as one of the most efficient methods of applying irrigation

water, the studies also highlighted the critical importance of maintenance and the requirements it places on management practices, explains WRC Director: Water Utilisation in Agriculture, Dr Gerhard Backeberg "Since drip irrigation is also the most capital intensive and thus costly method of irrigation, technology exchange of these findings was considered essential."

The WRC's consequent knowledge dissemination drive has resulted in the compilation of two new manuals on *Technical Aspects and Cost Estimating Procedures of Surface and Subsurface Drip Irrigations Systems*, one for irrigation designers and the other for irrigation farmers. "The purpose of the manuals is to guide irrigation designers and farmers through useful information to make the most productive use of drip





Lani van Vuuren

*In the arid Northern Cape, drip irrigation is successfully being applied to produce export-quality grapes.*

irrigation,” notes Dr Backeberg. “A balance, therefore, has to be found between cost-effective and water efficient irrigation for food production, given the competing demands on water currently used for irrigation.”

## TESTS AND RECOMMENDATIONS

*The WRC has funded numerous investigations into drip irrigation technology.*

The manuals provide comprehensive information on drip irrigation from technical aspects of surface

and subsurface drip irrigation systems; filtration equipment and cost estimating procedures. In addition, the manuals include recommendations and guidelines regarding the suitability and management of soil and water for drip irrigation, as well as the principles, selection, costing, design, operation and maintenance of drip irrigation and filtration equipment. The manuals are specifically aimed at drip irrigation in field and permanent crop applications,

and therefore do not apply to greenhouses or specialised fertigation units.

Various laboratory and field studies have informed the manuals. For example, the WRC funded investigations into the performance of South African drip irrigation technologies by the Agricultural Research Council Institute for Agricultural Engineering (ARC-IAE).

Popular driplines were selected and tested as new and used (old) pipes. Information on clogging problems experienced by farmers was collected. Sampling of driplines from various regions of South Africa was based on perceived and reported problems. Dripper type and age were also used as criteria for sampling. The used drip systems were evaluated in the field before laboratory testing. This procedure was repeated over two years.

It was found that clogging of emitters is one of the major problems associated with drip irrigation, usually as a result of poor maintenance or poor water quality. Among others, it is therefore recommended that regular water quality analysis be carried out to identify potential clogging problems. Other preventative measures, such as the use of root growth inhibitors against root intrusion, are also discussed. The information generated by the ARC-IAE study can also assist in emitter type and filter selection. Proper maintenance schedules and their implementation are underlined as being of utmost importance for the long-term efficient operation of drip irrigation systems.

Along with the manuals, a CD-based knowledge base system has been compiled which captures information on the various types of drippers and filtration equipment, together with their technical performance characteristics and design information. This information can be sorted and searched in a number of ways, and all the information in the database (including pictures) can be printed.



Photo supplied



## THE ADVANTAGES OF DRIP IRRIGATION

- Sophisticated technology
- Maximum production per megalitre of water
- Increased crop yields and profits
- Improved quality of production
- Less fertiliser and weed control costs
- Environmentally responsible, with reduced leaching and runoff
- Labour saving
- Application of small volumes of water more frequently

## INFORMATION DAYS

The WRC, along with its research partners, have already held several information days and training workshops throughout South Africa to disseminate the information captured in the drip irrigation manuals. There has been great interest both from parties already using drip irrigation

and those considering using drip irrigation. Participants have included irrigation designers, commercial, large- and small-scale farmers, and managers. Continuous professional development courses were organised to train designers on the technical and economic principles of the selection and usage of surface and subsurface drip irrigation systems. Field days were used to practically demonstrate the principles of economics, operation and maintenance of drip and filtration systems to farmers and irrigation managers.

It is hoped that the manuals will find further use for practical short courses or as part of demonstrations. In this way support can be provided to those farmers that have already installed drip irrigation or to farmers who are considering changing from flood or sprinkler irrigation to drip irrigation.

According to Dr Backeberg, the success of the manuals lies in the fact that they are a practical example of the way the WRC manages



Lani van Vuuren

the innovation process, i.e. taking scientific research to practical application and then to commercial use which is socially beneficial. "In the case of drip irrigation, technologies are already commercially available in a very competitive South African market. The purpose of undertaking this technology exchange project on drip irrigation was to provide guidelines to designers and farmers to make the best use of the available technology."

The key to the continued growth and success of drip irrigation technology in South Africa is the understanding of the principles, using of appropriate technology, applying good design practices, correctly costing of the system and managing the drip irrigation system according to best practice. It is anticipated that the new drip irrigation manuals will go a long way to ensuring South African farmers can produce more with less for a food and water secure South Africa. □

*With drip irrigation water is applied slowly to the roots of plants, either on the soil surface or directly to the root zone, through a network of valves, pipes, tubing and emitters.*



To order the guidelines, *Technical Aspects and Cost Estimating Procedures of Surface and Subsurface Drip Irrigations Systems* Volume 1: Main Report (Report No. TT 524/12), Volume 2: Manual for irrigation designers (Report No. TT 525/12) and/or Volume 3: Manual for irrigation farmers (Report No. TT 526/12) contact Publications at Tel: (012) 330-0340; Email: [orders@wrc.org.za](mailto:orders@wrc.org.za) or Visit: [www.wrc.org.za](http://www.wrc.org.za) to download a free copy.



# FROM SCIENCE TO SOCIETY – Finding innovative solutions towards deep rural water supply

*Working in deep rural communities from the Eastern Cape to Limpopo, a group of scientists from various disciplines are harnessing science and technology in a way which effectively engages with – and responds to – people’s values, beliefs and cultural practices at the nature-society interface.*

*Article by Wiida Basson.*



*Led by the CSIR, scientists are seeking ways to provide safe, secure water supply to deep rural communities.*

Guy Stubbs/Africa Media Online

**F**unded by the CSIR, the aim of the ‘Sustainable water for rural security’ project is to link different research disciplines together to provide the appropriate science base to enable the provision of clean water to rural communities. This must be achieved in partnership with the communities and local municipalities involved, to ensure uptake and the long-term sustainability of the intervention.

This is easier said than done, however. Over the past three years, three case studies in Limpopo, the Eastern and Northern Cape have delivered more than its share of what sustainability scientists call ‘wicked problems’. A ‘wicked problem’ is the term used for problems that are unique, very difficult to define and constantly changing.

Such problems, which defy any single, final solution, typically arise in complex systems, explains sustainability expert Dr Michelle Audouin. “A complex system is different from a complicated system. Although a complicated system may have many parts, it can be understood through an analysis of those parts – like taking apart a computer and putting it back together again to understand how it works.”

A complex system, in turn, is an open system with intricate sets of non-linear relationships. These relationships give rise to emergent properties that cannot be investigated through analysis. For example, the smell and beauty of a rose cannot be found by taking apart the rose and examining it, Audouin wrote in a 2011 user guide on ‘Transdisciplinary research for sustainability’.

To sum it up, problems that arise in complex systems are ‘wicked’ in every sense of the word. Access to drinkable water in rural South Africa is not only a wicked problem but it is also in a crisis. Of the six million South Africans who lack reliable drinkable water, and the 13 million who lack decent sanitation, the rural poor are the most affected and vulnerable, says CSIR microbiologist and project leader, Bettina Genthe.

Rural areas are the most difficult to service and maintain. This leads to high incidences of waterborne diseases (up to 90% in areas lacking services), with diarrhoea being the third-highest cause of natural death after HIV and Aids and respiratory illnesses. In many instances this creates a poverty trap for individuals in these communities, impacting on

**“We have to ensure that community members take ownership and responsibility for whatever we are going to do to ensure sustainability of the intervention.”**

the country’s economic growth and development.

So how does one address a wicked problem like rural water security and free communities from this poverty trap? In this project, researchers selected three representative rural areas in South Africa where they knew there were problems with access to safe drinking water.

## THE CASE OF FOUR EASTERN CAPE VILLAGES

**T**he four villages of Nqileni, Folokwe, Tshezi and Mgodjweni in the Mbashe Local Municipality are situated in one of the most remote and poorest districts in South Africa. In 2011, researchers approached the community through the district municipality and a non-governmental organisation (NGO) – the Bulungula Incubator – working in the area. After several workshops with the villagers, and additional



CSIR geohydrologist Sumaiya Clarke (fourth from left) with a group of villagers from Nqileni, Tshezi and Folokwe.





## KAMIESBERG IN THE NORTHERN CAPE

In the remote Kamiesberg Local Municipality in Namakwaland, researchers were faced with several of the typical rural water supply challenges facing district municipalities, exemplified by the dramatic drop in their Green Drop status from 83% in 2009 to only 5.4% in 2011. According to Ashton Maherry, leader for the Northern Cape case study, this is a typical example where things were starting to go wrong in terms of poor maintenance and lack of funding, capacity and especially skills.

“The artificial groundwater recharge site at Tweerivier is one of the oldest in South Africa and a signature example of its type – small scale, but effective and easy to maintain. Yet it failed. The same goes for the reverse osmosis plant at Soebatsfontein. This area has the highest density of reverse osmosis plants in the country – these plants are extremely expensive to erect, yet there are no long-term funding in place for maintenance.”

A third typical challenge has to do with the repair and upgrade of the Nourivier Dam wall: “Local farmers at Nouwrivier need a water license to get water from the dam. But in order to get a water license, the dam first needs to be registered with the Department of Water Affairs. But the dam cannot be registered because the dam wall first needs to be fixed,” Maherry explains.

One of the main problems identified was the fact that these issues were not part of the municipal framework or any of their development plans. In other words, a municipality cannot obtain funding from the Department of Water Affairs unless water infrastructure and maintenance is part of their integrated development plans.

“We are now at the stage where we will present an implementation

*Women and children in Kgotlopong, in Limpopo fetching water from a communal tap.*

input from the municipality and the NGO, researchers were faced with seemingly insurmountable problems and challenges.

“The area is incredibly rural,” explains case study leader and geohydrologist Sumaya Clarke. “There are no toilets, no taps, no electricity, and the only source of water – from a few springs in the area – is polluted by grazing animals and children playing in the water.”

An immediate concern, and something that needed to be addressed urgently, was the high infant mortality rate: “Through household surveys, the Bulungula Incubator NGO concluded that the child mortality rate in the villages is high, with a minimum mortality rate of one child per household, and a maximum of nine children in one household.

“And yet people do not always make the link between specific health issues and lack of clean water. We first had to understand the issues from the community’s perspective, and then to work with them to find workable and sustainable solutions,” Clarke says.

While the Bulungula Incubator is running health awareness days, showing the villagers the ‘unseen’ bacteria and viruses in their water

through microscopes, the CSIR project team will be working with volunteers from the community to secure the springs by using raw material from the area.

The springs are vulnerable to pollution with the children playing in them and animals drinking water directly from the springs. People typically use the ‘bush system’ for excreting bodily wastes as there are no toilet facilities in these parts. Heavy downpours in the summer months wash human and animal excretions from the surrounding hills into the springs and the river.

Planned intervention have to be acceptable to the community: “We have to ensure that community members take ownership and responsibility for whatever we are going to do to ensure sustainability of the intervention. With a number of volunteers from the community, we plan to walk through the villages and identify sources of pollution. The plan is then to collect raw materials, such as cobbles and boulders, and pack these around the springs to protect them.”

Other interventions include promotion of the use of water-filters, addressing community questions and identifying their effectiveness.

plan to the elective council so that it becomes part of the formal special development framework and integrated development plans. And hopefully we will be able to get that Green Drop score back to where it belongs,” Maherry concludes.

## A TRULY ‘WICKED’ PROBLEM: THE CASE OF KGOTLOPONG, LIMPOPO

The third case-study site, Limpopo, epitomised the concept of a ‘wicked’ problem, with the following ingredients:

- Very remote area with little water supply and rainfall, and as such susceptible to droughts and sporadic floods;
- Individual households do not have water connections;
- Water from the Kgotlopong River is used for domestic purposes, compromising community health;
- Lack of municipal funding and skills to effectively implement water supply systems;
- Measures that have been undertaken are frequently vandalised and infrastructure is stolen;
- Area is governed by both a tribal authority and an elected local municipality, who often do not see eye to eye.

As a first step, researchers worked with the local water committee during multiple workshops and follow-up meetings to craft a shared vision for effective water provision. According to case study leader Karen Nortje, the next step is to determine which technologies will work best in the context of the community: “There are boreholes, but no pumps. Some may have to make use of water from the river or springs, but these have to be kept clean and protected from outside contaminants. We now need to work with the community to determine what would work best for them.”



*A typical unprotected spring from where villagers collect water for household use.*

At the same time two anthropology students from the University of Johannesburg are working with the project team in this community: “There is very little capacity in the social sciences to work on this level. By involving the students, we hope to interest more and more students in this kind of work,” Nortje concluded.

## SCIENCE AT THE COALFACE

Currently in its third year, the research team will now focus on monitoring the sustainability of current interventions, as well as the implementation of site-specific interventions. This will be done in close partnership with the communities and municipalities involved.

From a research perspective, the team plans to identify critical design criteria that can ensure the sustainability of rural water supply systems in South Africa. This, concludes Audouin, is what the emerging field of sustainability science is all about, namely to harness science and technology in a way which effectively engages with – and responds to – people’s values, beliefs and cultural practices at the nature-society interface:

“As we increase our understanding of coupled social-ecological systems, we can better address the sustainability concerns of particular places and regions. These concerns are the practical problems facing human beings at the nature-society interface, such as access to water, food, housing and energy. □



*At times simple maintenance rather than complex scientific solutions are required to provide sustainable services. Here CSIR geohydrologist, Sumaiya Clarke, is assisting to repair a handpump.*



## Discover the wonder of the WATER WHEEL



Lani van Vuuren

Ever wonder where this magazine gets its name? *The Water Wheel* magazine is named for one of the most powerful and enduring innovations since the history of man. The humble water wheel has been credited for being the inspiration behind cogs and gears – the basic building stone of almost all modern machinery.

Everybody knows that water is life – without water we will have nothing to drink, we cannot grow food or keep healthy and clean. But history has shown us that we can also use water for other purposes – water can also be used to create power and drive industry. Before there were mighty coal-fired and hydroelectric power stations, before even the power of steam was discovered, people understood the power of water. They learned to harness this power through the water wheel.

A water wheel can basically be described as a device that uses flowing or falling water to create power by means of a set of paddles or buckets mounted around a wheel. The force of the water moves the paddles, and the consequent rotation of the wheel is transmitted to machinery via the shaft

of the wheel. In this way the energy of the falling water is converted into useful forms of power.

Water wheels can either be horizontal or vertical (although the latter is most common). Early water wheels were manufactured from wood and other natural materials, such as bamboo. Later water wheels were manufactured of metal. Modern hydroelectric dams can be seen as the descendants of the water wheel as they too take advantage of the movement of water downhill.

No-one knows exactly when or by whom the water wheel was originally invented. References to water wheels can be found in literature thousands of years old. All the ancient civilisations made use of water wheels – albeit of different designs, from the Chinese, the Greeks (and later the Romans), to ancient Middle Eastern civilisations. Water wheels were probably the first method of creating mechanical energy that replaced humans and animals.

It was during the early Industrial Revolution that water wheels really came into their own. From monasteries to commercial factories, water wheels were used for everything from grinding flour, to hammering wrought iron, machining, ore crushing, crushing sugarcane, and pounding fibre for use in the manufacture of cloth. Water wheels also led to the first large-scale dam construction in Europe, as mill ponds (or dams) and canals were constructed to feed the wheels.

Even after the invention of steam power water wheels remained in use, although they are no longer common, and many are only for aesthetic purposes.

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## Make your own Water Wheel

### You will need:

- An empty two-litre fizzy drink bottle
- A cork
- Two cocktail sticks
- A pair of scissors
- A jug of water
- A craft knife and a small screwdriver

### Instructions

1. Cut the bottle in half and ensure the edges are smooth
2. Take the lower half of the bottle and make two small v-shaped cuts on opposite sides of the rim. This is necessary to support the wheel on top of the base
3. Take the top of the bottle and cut a strip of plastic about the same width as the length of the cork. From this strip cut individual paddles about 3 cm in width.
4. Mark the end of the cork with a pen, dividing it into six sections. Cut an incision down the length of the cork from each of these marks. These incisions should be a few millimetres in depth.
5. Make two holes in the centre at either end of the cork. This can be done with a small screwdriver or nail.
6. Slide each of the six paddles into the slits into the cork. Ensure that all the paddles are curving the same way. It is best to start at one end of the cork and gently push the paddles through.
7. Carefully inserts a cocktail stick in either end of the cork and place the completed wheel on the base.
8. Gently pour water over the paddles and make any final adjustments.

*(Explanation – the weight of the water creates a pressure that pushes the paddles of the water wheel. If you pour water onto the wheel from a greater height the wheel spins faster than if the water falls from just above the blades. This is because water releases more stored energy as it falls).*

Source: [www.wessexwater.co.uk](http://www.wessexwater.co.uk)

## WATER WHEELS IN SOUTH AFRICA

While South Africa is not endowed with the one ingredient that make water wheels work really well – large volumes of fast-running water – the country has had its own share of water wheels. The water wheels located in the Northern Cape towns of Kakamas and Keimoes are as much part of the culture of the farming communities as the grapes and raisins the region is famous for.

Unlike Europe, water wheels in South Africa were not used so much in industry. The most popular application of this technology was to lift irrigation water from lower to higher irrigation fields. The design of the South African water wheel is based on that of the noria, a water wheel which probably originated in Persia and that is basically a wheel fitted with buckets on the peripherals for lifting water (for this reason, the old folk also used to refer to water wheels as 'bakkiespompe').

Muslim engineers used norias to discharge water into aqueducts which carried the water to towns and fields. Some of the norias used in the medieval Islamic world were as large as 20 m in diameter. Today, there are surviving norias at Hama, in Syria.

A source of inspiration and innovation, the water wheel forever changed the



Dating back to ancient times, water wheels are said to have been the inspiration for modern machine gears.

industrial landscape of the world, allowing people to move ahead technologically. For that we salute this humble contraption and hope that it will inspire others to kick their lives up a gear. □



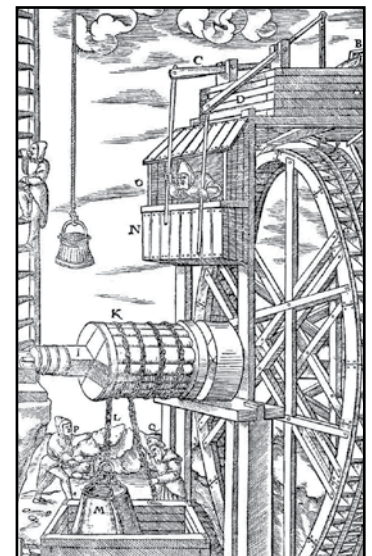
For many years the faithful water wheels at Kakamas have been used to move water from one irrigation canal to another.



One of the most famous water wheels in South Africa is situated at Keimoes in the Northern Cape. The design is based on the Noria water wheel created in the Middle East during ancient times.

### Did you know?

In around 1086, the then King of England, William of Normandy, ordered an inventory of all the potentially taxable property, including around 6 000 mills spread across 3 000 different locations.





# Climate change focus for SA

Hydrologists from all over the country gathered in Pretoria for the 16<sup>th</sup> National Hydrology Symposium, held at the University of Pretoria, in October. The conference was presented by the South African National Committee of the International

Association of Hydrological Sciences (SAN CIAHS) and organised jointly by the Water Research Commission (WRC) and the Department of Water Affairs (DWA). The event offered a unique opportunity for students to rub shoulders with some of the greatest names in the South

African hydrology sector. With the theme 'Hydrology in a Changing Environment: Science and Policy Interface', the symposium paid particular attention to the management of the country's finite water resources in the face of potential climate change impacts.

*All photographs by Lani van Vuuren*



*Mwinyi Malisawa of the University of Pretoria (UP), Munyaradzi Chitakira of UP and Manuel Magombeyi of the University of the Witwatersrand (Wits).*



*International keynote speaker Christopher Dunn of the US Army Corps of Engineers with Wandile Nomqophu of the WRC.*



*Mehleketo Bamuza of Wits; Olma Makonto of the UP; and Nebuhle Majozi of CSIR.*



*Johan van Zyl, Ruan Gilau and Johan Hefer, all of Aurecon.*



*Prof Roland Schulze of the University of KwaZulu-Natal, Dennis Dlamini of DWA and Prof André Görgens of Aurecon.*



*Gold winner for best presentation, George van Zijl; silver winner for best presentation, George Waswa; best posted winner, Faith Jumbi; and silver winners for best presentation, Mathew Becker and Lauren Bulcock.*

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