Most detailed maps yet of Africa's groundwater

A scattergun approach to borehole drilling in Africa is likely to be unsuccessful.

This is the message from a group of UK researchers who have, for the first time, quantified the amount, and potential yield, of groundwater across the whole of Africa.

They estimate the total volume of groundwater to be around 0,66 million km^3 – more than 100 times the available surface freshwater on the continent – and hope that the assessment can inform plans to improve access to water in Africa, where 300 million people do not have access to safe drinking water.

The results have been published in the 20 April edition of the journal, *Environmental Research Letters.*

The researchers, from the British Geological Survey and University College London, warn that high-yielding boreholes will not be found using a scattergun approach and a more careful and exploratory approach that takes into account local groundwater conditions will be needed, which they hope their new study will encourage.

Their results show that in many populated areas in Africa there is sufficient groundwater to supply hand pumps that communities can use for drinking water. These hand pumps can deliver around 0,1 to 0,3 litres per second. Opportunities for boreholes yielding 5 ℓ/s or more are not widespread and limited to specific areas, such as countries in the north of Africa.

Central to the researchers' methods was the collation of existing national hydrogeological maps as well as 283 aquifer studies from 152 publications. The vast amount of data was compiled into a single database in which the researchers were able to make their calculations.

The amount of groundwater present in a certain region is reliant on the interplay between the geology of the area, the amount of weathering and the amount of rainfall experienced both in the past and the present. All of these factors were considered to estimate the volume and potential yield of groundwater in each aquifer.

As a result of population growth in Africa and a planned increase in irrigation to meet food demands, water use is set to increase markedly over the next few decades. Climate change will pose a huge threat to this increase; however, groundwater responds much more slowly to increasing climatic variability as opposed to surface water, so will act as a buffer to climate change.

The lead author of the study, Dr Alan MacDonald said: "Groundwater is such an important water resource in Africa, and underpins much of the drinking water supply. Appropriately sited and developed boreholes for low-yielding rural water supply and hand pumps are likely to be successful and resilient to climate change. However, high-yielding boreholes should not be developed without a thorough understanding of the local groundwater conditions."

Geophysicists develop new method to identify 'sea level fingerprints'

Researchers from the University of Toronto, Harvard and Rutgers universities have reportedly found a way to identify the 'sea level fingerprint' left by a particular sheet of ice – and possibly enable a more precise estimate of its impact on global sea levels.

As the Earth's climate warms, a melting ice sheet produces a distinct and highly non-uniform pattern of sea-level change, with sea level falling close to the melting ice sheet and rising progressively farther away. The pattern for each ice sheet is unique and is known as its sea level fingerprint.

"Our findings provide a new method to distinguish sea-level fingerprints in historical seal levels, from other processes such as ocean waves, tides, changes in ocean circulation and thermal expansion of the ocean," said Carling Hay, a PhD candidate in the Department of Physics at U&T and lead author of a study published in the *Proceedings of the National Academy of Sciences*. "It may indeed allow us to estimate the contributions of individual ice sheets to rising global sea levels."

Scientists around the world are trying to estimate both the current rate of sea level rise and the rates of ice sheet melting, and yet little work has been done to combine the two problems and answer these questions simultaneously.

Hay and colleagues, Jerry Mitrovica and Eric Morrow of Hansard University and Robert E Kopp of Rutgers University, sought out statistical techniques that had not previously been applied to this problem, and began developing the new method using data analysis techniques common in other fields such as engineering science, economic and meteorology. The researchers then tested and refined the method by applying it to synthetic data sets – i.e. data sets with the same amount of noise as real data, but with known melting signals. The tests provide important guidance for the application of the method to actual sea-level records.

"We are now applying our methodology to historical sea level records to provide a new estimate of total sea level rise and the melt rates of the Greenland and West Antarctic ice sheets, over the 20th century," said Hay. "Preliminary results show intriguing evidence for acceleration of globally averaged sea level rise in the second half of the period, along with simultaneous rise in temperature. Once our study of historical records is complete, the next step will be to incorporate satellite-based measurements of sea-level changes."

Source: University of Toronto

Common fungicide wreaks havoc on freshwater ecosystems – study

Chlorothalonil, one of the world's most common fungicides used pervasively on food crops and golf courses, is lethal to a wide variety of freshwater organisms, according to researchers from the University of South Florida.

Biologists Taegan McMahon and Jason Rohr, co-authors of the study published in the journal *Ecology Letters,* report that chlorothalonil killed amphibians, snails, zooplankton, algae, and aquatic plants below estimated environmental concentrations previously deemed safe by the US Environmental Protection Agency. The loss of these herbivores and plants freed the algae from predation and competition, which eventually resulted in algal blooms that were similar to the effects of eutrophication.

"Some species were able to recover from the chemical assault, but the ecosystem was fundamentally changed after its exposure to chlorothalonil," Rohr said. The four-week study was conducted in a series of 300-gallon tanks used to mimic pond conditions.

It follows a 2011 laboratory study conducted by McMahon and Rohr that found that ecologically-relevant concentrations of chlorothalonil killed four species of amphibians.

"Although our new study is the only reported community- and ecosystem-level experiment on chlorothalonil, our results are consistent with several direct toxicity studies conducted in the laboratory and with observations in the field," McMahon said. Chlorothalonil kills molds and fungus by disrupting cellular respiration, an essential process for most multicellular organisms on the planet. Like the infamous DDT, chlorothalonil is a member of the organochlorine chemical family. Fifty years after the ban on most forms of the pesticide DDT, chlorothalonil is one of a few organochlorine pesticides still registered for use in the US, Europe and Australia.

In addition to reducing biodiversity and altering ecosystem functions, chlorothalonil reduced the decomposition of waste, an important service that freshwater ecosystems provide to humans, McMahon added. "Interest in the relationship between biodiversity and ecosystem functions stems at least partly from the concern that anthropogenically-driven declines in biodiversity will reduce or alter the benefits offered by ecosystems," Rohr said. "Surprisingly, however, this is one of the first studies to actually manipulate an anthropogenic factor and link it to changes in ecosystem functions mediated by declines in biodiversity. This is important because many species in ecosystems might contribute little to ecosystem functions or are functionally redundant with other species, and thus declines in biodiversity do not always affect the functions and services of ecosystems."

New study chronicles the rise of agriculture in Europe

An analysis of 5 000-year-old DNA taken from the Stone Age remains of four humans excavated in Sweden is helping researchers understand how agriculture spread throughout Europe long ago.

According to Pontus Skoglund and colleagues from Uppsala University in Sweden, the practice of farming appears to have moved with migrants from southern to northern Europe.

Agricultural know-how was not the only thing that early European farmers introduced to the region. Based on their genetic data, Skoglund and the researchers say that Europe's first farmers eventually mixed their genes with the hunter-gatherers who lived there – a relationship that set the stage for today's modern European genome.

"We analysed genetic data from two different cultures – one of hunter-gatherers and one of farmers – that existed around the same time, less than 400 km away from other," Skoglund explained. "After comparing our data to modern human populations in Europe, we found that the Stone Age hunter-gatherers were outside the genetic variation of modern populations but most similar to Finnish individuals, and that the farmer we analysed closely matched Mediterranean populations."

These findings likely have something to do with the expansion of farming across Europe, according to the researchers. "When you put these findings in archaeological context, a picture begins to emerge of Stone Age farmers migrating from south to north across Europe," noted Skoglund. "And the result of this migration, 5 000 years later, looks like a mixture of these two groups in the modern population."

Most experts agree that the agricultural way of life originated about 11 000 years ago in the Near East before it reached the European continent some 5 000 years later. But this new study helps scientists understand the impact of that agricultural revolution on human diversity. "The results suggest that agriculture spread across Europe in concern with a migration of people," said Skoglund. "If farming had spread solely as a cultural process, we could not expect to see a farmer in the north with such genetic affinity to southern populations."

The researchers suggest that Europe's early, intrepid farmers travelled north across the continent, settled in the northern regions and eventually mixed with resident hunter-gatherer populations. Consequently, the genomes of most modern Europeans were likely shaped by this prehistoric migration that first brought farming to the continent, they conclude.

Researchers map fish species at risk from dams

Dams are believed to be one of the biggest threats to freshwater organisms worldwide: they disrupt normal patterns of water and sediment flow, impede migration, and alter the character of spawning and feeding grounds.

A shortage of data has until now prevented a thorough global assessment of the threat dams pose to fish species, however, a study described in the June issue of the journal, *BioScience*, attempts just that.

The report by Catherine Reidy Liermann of Umeå University, Sweden, and three co-authors, analysed 397 ecologically distinct freshwater regions around the world and plotted the occurrence of dams greater than 15 m high. This approach enabled the researchers to assess the amount of obstruction the dams caused.

The authors then examined location data for fish species believed to be at risk of extinction because they are restricted to a specific region or because they have to migrate up rivers as part of their lifecycle. This allowed the researchers to identify regions where dams pose the biggest risk to fish species. Factoring in where there has been additional habitat alteration – a known risk for many fishes – allowed the authors to further refine their list of the danger zones.

The results pointed to the Murray-Darling province in Australia, southern Italy, the Lower and Middle Indus basin, West Korea, the Upper Paranà (southern Brazil), the South Atlantic coast of the United States, and Mobile Bay ecoregions as having notable numbers of fish species at risk and heavy dam construction. Much of the Danube, Iberia and the Southern Temperate Highveld in South Africa are also on the list. These 18 ecoregions, according to the co-authors, "merit immediate conservation attention." Eels, shads, lampreys, sturgeons and salmonids stand out as being especially vulnerable.

The authors explain that their findings will help researchers and planners in identifying important regions where conservation is feasible because the watercourses are relatively unobstructed and are home to at-risk species. The results also flag regions where restoration – possibly even including dam removal – is desirable if fishes are to be conserved.

New from the WRC

Report No: 1561/1/11

Persistent organic pollutants (POPS) in the water environment (C Roos; R Pieters; B Genthe & H Bouwman)

Currently, South Africa's available freshwater resources are nearly fully utilised and under severe stress. The quantity and quality of available water will increasingly become a limiting resource, and supply will become a major factor restricting the country's future socio-economic development. The Stockholm Convention on Persistent Organic Pollutants (SC POPs), of which South Africa is a party, carries a number of obligations and expectations. Based on the obligation to develop a National Implementation Plan, the State is obliged to reduce or terminate all sources of POPs within the SC provisions. This therefore implies that a state should know the environmental levels of these POPs whereby priority sources and hotspots can be targeted for interventions. This study, therefore, focused on a group of highly persistent, toxic pollutants which is ubiquitous in terrestrial and aquatic environments all over the world. Here, the research team characterised the scale and significance of certain organic pollutants, especially persistent organic pollutants in selected water bodies of South Africa, specifically targeting sediments as matrix, which are the main reservoirs of these pollutants in aquatic environments.

Report No: TT 507/11

Guidelines on water services infrastructure risks management (U Jack; P de Souza & G Mackintosh)

Recent national studies have highlighted that the operation and maintenance of water services-related infrastructure is in many cases not ideal with, for example, 65% of water services authorities (WSAs) performing maintenance on a crisis management basis (i.e. no scheduled maintenance). Infrastructure asset management has been identified as an effective means

of enabling such water services institutions to efficiently monitor and manage their systems within the constraints of limited resources. In particular, water services-related infrastructure needs to be managed within an integrated social, economic and environmental context. This guideline document has been developed to assist water services institutions to conduct vulnerability and risk assessments with the purpose to identify, prioritise and manage vulnerabilities and risks associated with their water services infrastructure.

Report No: KV 277/11

A guide to complexity theory and systems thinking for integrated water resources research and management (S Pollard; D du Toit & H Biggs)

The objective of this project was to explore progress in and barriers to the internalisation of complexity in integrated water resources management, and to do this through a scoping synthesis of early lessons. In essence then the report seeks to provide a guide to complexity for integrated water resources management and research endeavours based on the issues identified from interviews with key stakeholders. In these interviews with academics and practitioners, a number of issues were raised regarding the internalisation of complexity and we hope that these have been addressed.

Report No: 1845/1/11

A comparison of the cost associated with pollution prevention measures to that required to treat polluted water resources (SHH Oelofse; S Roux; W de Lange; BK Mahumani; W le Roux; M du Preez; HA Greben & M Steyn)

Pollution of water resources is largely as a result of human activity and therefore could be prevented to a large degree. The quality of our water resources is deteriorating and downstream water users have to deal with the pollution impacts caused by upstream uses. This situation has resulted in a debate as to whether it will not make more economic sense for water users to treat water for use rather than to meet discharge standards. The hypothesis that pollution prevention is preferable as compared to a pollution clean-up regime, but also that unnecessarily strict regulation will have negative consequences for the economy, was tested. It was therefore necessary to determine the cost of pollution prevention as well as the cost of pollution to downstream users. Four prominent water pollution issues, namely salinisation, nutrient enrichment, microbial degradation and sediment migration, were identified as the focus of this research.

Report No: 1313/3/11

Development of chronic toxicity test methods for selected indigenous riverine macroinvertebrates (WJ Muller; AR Slaughter; N Ketse; HD Davies-Coleman; E de Kock & CG Palmer)

Toxicity tests are accepted worldwide as suitable for managing environmental water quality within water resources management and in South Africa this trend has been followed. Water quality guidelines are most often derived from acute toxicity test results, and from using results derived from a range of species from different trophic levels in freshwater ecosystems. There are concerns that most ecotoxicological tests are too simplistic to reflect real-life dose-response relationships, since most ecotoxicological tests have evolved more from the field of toxicology than ecology. The aims of this project were to, among others, develop chronic toxicity test methods for indigenous riverine invertebrates using non-lethal experimental and end-point assessment criteria; use the newly-developed toxicity test methods for indigenous invertebrates to evaluate the current method of determining water quality criteria for the ecological Reserve; assess effluent standards by testing the new toxicity test method; and undertake a scoping study of the use of stress proteins and morphometric analyses.

Report No: KV 293/11

An overview of surface water quality in the Olifants River catchment (PJ Ashton; JM Dabrowski)

The Olifants River is one of South Africa's major river systems and is an important tributary to the Limpopo River. It is also recognised as one of the hardest working rivers in South Africa. The need for this study arose during discussions between the WRC and the CSIR. It was clear that while a lot of information was available on water quality issues across the Olifants River catchment, much of this information was contained in a variety of confidential project-specific documents, consultancy reports, theses and papers. This study collated and evaluated all available water quality data as a basis for an overview of water quality across the entire Olifants River catchment, and has also identified many of the likely sources of poor water quality. This will enable water resource decision-makers in central, provincial, and local government, industry and agriculture to define those areas that require priority attention and urgent remediation.

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Report No: 1738/1/11

Health impact of water, sanitation and hygiene services in relation to home-based care for people living with HIV and AIDS in the Limpopo province (N Potgieter & M du Preez)

The objective to meet the water and sanitation needs of people living with HIV and AIDS underestimates some of the biggest challenges in basic access. The people with the greatest needs often are the most disenfranchised and have the fewest resources available for solving problems in sustainable ways. Limpopo was considered as one of the poorer provinces and presented a worst case scenario with regards to education standards, water provision services and economic development when compared to other provinces. The aims of this project were therefore to investigate home-based care practices with regards to the experiences of care givers looking especially at water, sanitation and hygiene aspects and to perform a health risk assessment of the water used for domestic purposes in households in the caring for those living with HIV/AIDS.

Report No: 1741/1/09

Review of sanitation policy and practice in South Africa from 2001 to 2008 (N Mjoli)

The South African government has prioritised the provision of basic water and sanitation services. Between 2001 and 2008, about 73% of the population had access to basic sanitation services and the basic sanitation backlog was reduced to 27%. This represented significant progress in the eradication of the basic sanitation infrastructure backlog. In spite of all these efforts, there were, however, still millions of households that lacked access to a basic sanitation service level. The main objectives of the study were, among others, to investigate the understanding of current sanitation policy and programmes relating to the subsidy, ownership of infrastructure, responsibility for O&M, responsibility for monitoring issues of new pits etc, among national government departments; local government; service providers; and communities; and to provide recommendations for bridging understanding on policy, responsibilities and practice.

Report No: 1893/1/11

Determining vulnerabilities and risks of water services infrastructure (U Jack; P de Souza & G Mackintosh)

Despite the availability of numerous asset management texts, a general current lack of effective asset management (and associated water service delivery) still exists at many water services institutions (WSIs). A need therefore exists to further support WSIs through the provision of simple, easy to use guidelines and tools which enables WSIs to initiate good asset management practice at their institutions. To address these needs this study was commissioned with the aim of developing guidelines to assist water services institutions to identify and prioritise the vulnerable areas and risks associated with their water services; translating the developed guidelines into software tools; and testing and piloting the developed guidelines and tools, subject to voluntary participation at a number of institutions, among others.

Report No: 1813/1/11

How does the HIV and AIDS epidemic in South Africa impact on water sanitation and hygiene sectors? (E Makaudze; M du Preez & N Potgieter)

The overall aim of this project was to gain a better understanding of the special needs of people living with HIV and AIDS in respect of water, sanitation and hygiene and the impact these needs have on provision of such services. The impact of HIV and AIDS is, however, not confined to family communities only but is rather spread and felt at every fabric of society, including places of work. Hence, part of the study was to highlight broadly the impact of HIV and AIDS at municipal workplaces and gain insights from the responsible authorities how the disease is constraining service delivery with water, sanitation and hyiene sectors.

Report No: 1850/1/11

An assessment of the toxicity of cyanobacteria in the Kruger National Park (MG Masango; RG Matshoga; G Catharina; H Ferreira; & M Sandvick)

It is possible that significant numbers of wild animals succumb to cyanobacterial poisoning every year as no formal data on mortality are recorded. The major problem in diagnosis of cyanobacterial poisoning in wild animals is that carcasses of these animals are usually found decomposed or partially consumed by scavengers and therefore the cause of death can seldom be established. The lack of continuous assessment of the surface waters for cyanobacteria and their toxins in the Kruger National Park is a major challenge. Assessment of the surface water for cyanotoxins occurs only when there are deaths of wild animals in the Park, and sometimes the levels of cyanobacterial toxins of the nearby rivers/dams to which the animals were exposed, may have changed completely by the time of sampling, thus not reflecting the toxin levels that may have caused mortality. The main aim of this project was to generate information on the extent to which cyanobacteria (blue-green algae) and their toxins affect wildlife in the Kruger National Park.

Report No: 2099/P/11

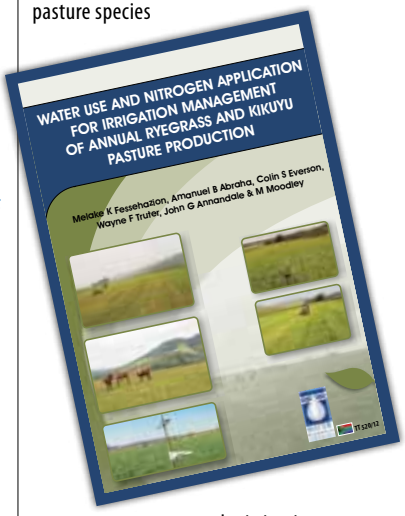
Literature review for the applicability of water footprints in South Africa (E Hastings & G Pegram)

In South Africa and other water-scarce countries, tools which can inform efficiency and raise awareness and create dialogue with people not previously involved in water debates are potentially very useful. Water footprints have the potential to contribute in this way, bringing new and important decision-makers into the water debate in a way that is intuitive and cuts across sectors. Additionally, water footprints create an opportunity for companies to join a global process of disclosure, understand risk and integrate an understanding of water into planning decisions. With this potential, the concept of water footprint has gained significant traction in the past 10 years in the private and public spheres across a variety of sectors. The purpose of this project was to understand how water footprints may contribute to sustainable management of water in South Africa, primarily in the industrial sector, and to explore linkages between water and energy and the concept of water offsetting.

Report No: TT 520/12

Water use and nitrogen application for irrigation management of annual ryegrass and kikuyu pasture production (MK Fessehazion; AB Abraha; CS Everson; WT Truter; JG Annandale & M Moodley)

To meet the increasing demand for animal protein as human populations increase, there is a need to increase water (and land) productivity. Natural veld cannot fulfil this need alone and must be supplemented with irrigated and fertilised planted pastures. This requires intensive use of fertilisers and water, which leads to a higher cost of production and a greater risk of environmental pollution. In South Africa, annual ryegrass (*Lolium multiflorum*) and kikuyu (*Pennisetum clandestinum*) are the most widely grown pasture species



under irrigation. They are mainly used in dairy farming enterprises. The main aims of this project were to promote efficient irrigation management of grass pastures by synthesizing available knowledge and generating new knowledge for improve water use efficiency by pastures. Among others, detailed field trials were undertaken at Cedara, Pietermaritzburg, and the University of Pretoria's Hatfield Experimental Farm. Also available as part of this project is *Irrigation guidelines for annual ryegrass pasture* (**WRC Report No: TT 521/12**).