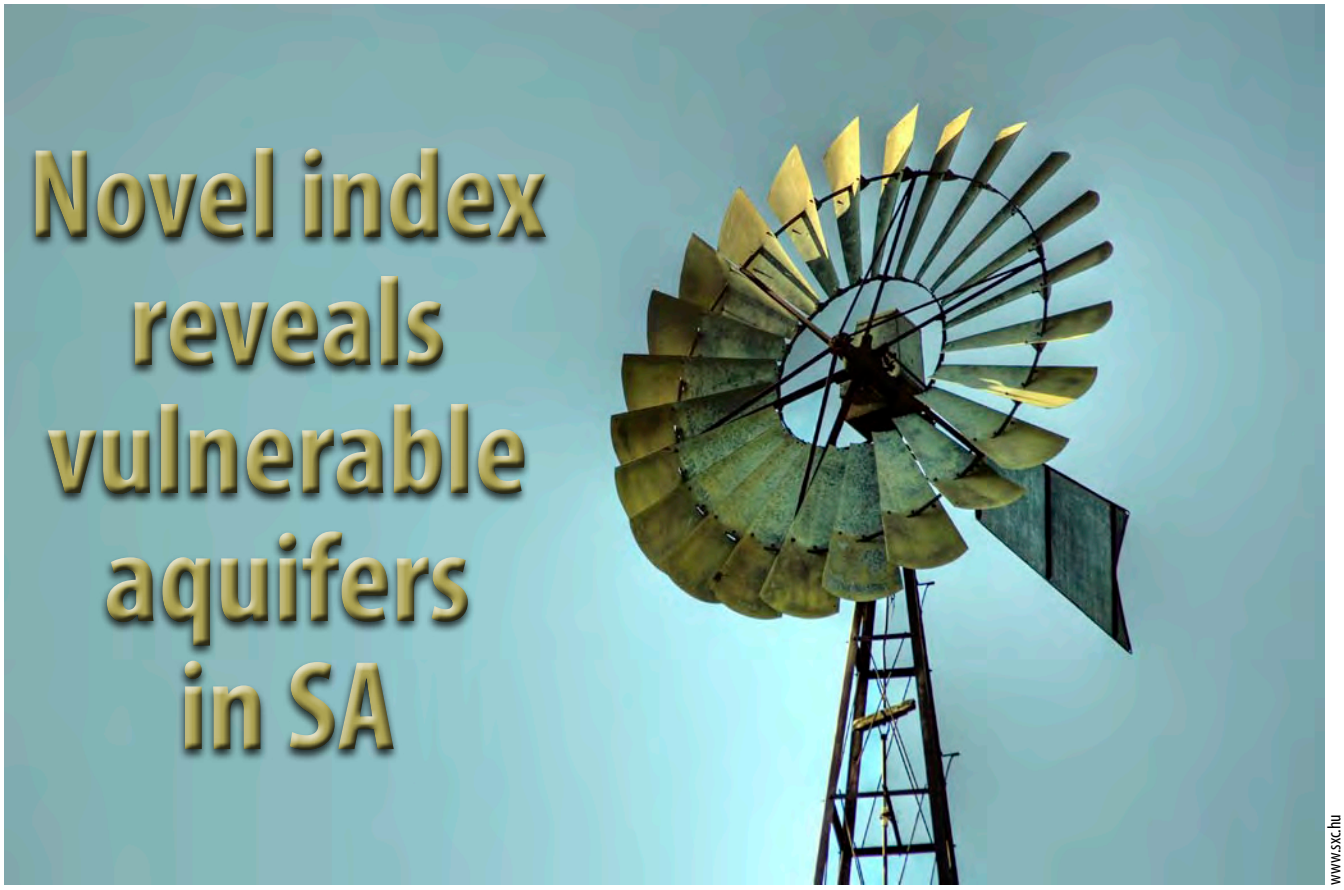
Novel index reveals vulnerable aquifers in SA



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The potential impact of climate change still leaves more questions than answers. One area of research that is only now being explored is the potential effect of a changing climate on South Africa's groundwater resources. Article by Lani van Vuuren.

The recent United Nations Conference on Climate Change or COP17, held in Durban during December 2011, again emphasised the challenges South Africa faces in adapting and mitigating against the potential effects of climate change. South Africa already is a water scarce country and, while the exact nature of our future climate remains uncertain, further changes in respect of water availability as a result of changing rainfall patterns, extreme weather events and increased evaporation are predicted.

The potential impacts of climate change on water resources and hydrology in southern Africa have received considerable attention from hydrologists during the past decades. In areas such as the western parts of the country, where rivers are expected to become potentially drier in future, alternative sources such as groundwater have been put forward to keep up with future water demand. Yet, while groundwater forms an inextricable part of the hydrological cycle and is bound to be potentially impacted by shifting climate patterns in the same way as surface water resources, hardly any research has been done on the subject to date.

"The question of the likely impact of climate change on renewable groundwater resources is highly relevant," explains Dr Rainier Dennis of the Centre for Water Sciences and Management at North West University. "Climate change can potentially affect groundwater levels, recharge and groundwater contribution to the baseflow of rivers."

One possible reason for the dearth of knowledge regarding the potential impact of climate change on groundwater is that such studies normally require extensive time series records. "Traditionally, hydrological records are more easily available due to the fact that the resource is visible as opposed to groundwater," explains Dr Dennis. "The longest South African time series record with respect to groundwater levels does not exhibit any behaviour that can conclusively be attributed to any form of climate change."

REGIONAL INDICATOR

Dr Dennis and his research team have now successfully developed a regional screening tool with funding from the Water Research

Commission (WRC). This is seen as a first step in assessing the impact of climate change on South Africa's aquifers on a regional scale. "Aquifer recharge and groundwater levels interact, and depend on climate and groundwater use," explains Dr Dennis. "Each aquifer has different properties and requires detailed characterisation and eventually quantification."

The so-called DART methodology uses different parameters (**D**epth to water level; **A**quifer type (storativity), **R**echarge and **T**ransmissivity) to come up with an index that serves as a regional indicator of areas that are potentially vulnerable to the effects of climate change with respect to groundwater. Datasets of each parameter are generated over the whole of South Africa for the generation of this index for every month of the year for a certain climate change scenario.

The team considered two scenarios – one current and one future. The current scenario is representative of present precipitation patterns while the future scenario is representative of the predicted scenario based on a selected global circulation model (GCM). The future scenario selected assumes a moderate to high growth in greenhouse gas concentrations. GCMs are the primary tools for the projection of climate change from which data is downscaled for specific regions. The downscaled datasets for this project were made available by the Climate System Analysis Group at the University of Cape Town.

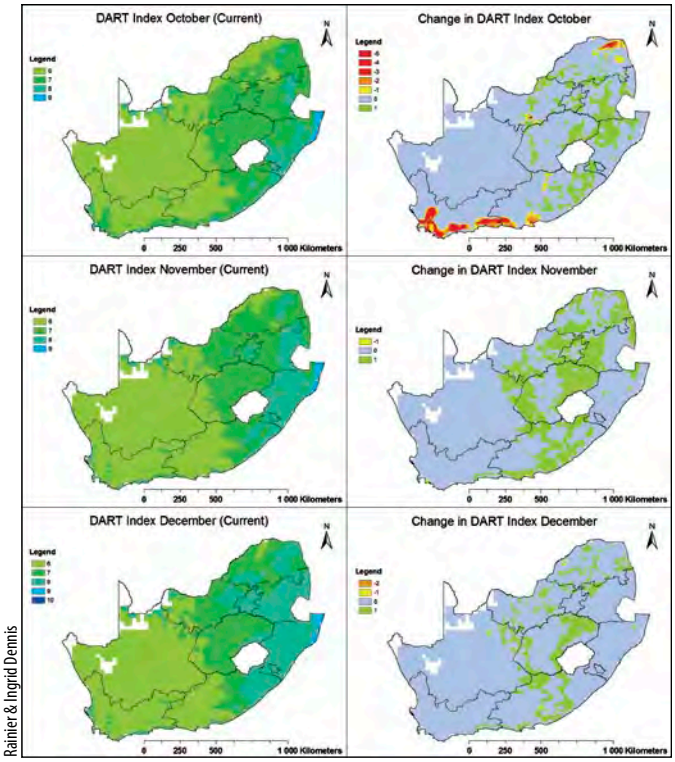
At first, it does not seem as if the country's aquifers will be that vulnerable to the potential effects of climate change. However, a closer look at the index reveals a different tale. "If the annual average change in the DART index is calculated then we do not see such a big variation in figures," notes Dr Dennis. "However, the index does show a substantial change for certain areas if one examines the results per month for the scenario tested. This implies that groundwater in affected areas will be more vulnerable in certain months than in others. Detailed studies on local scale will have to be performed, however, to verify that vulnerability can be managed."

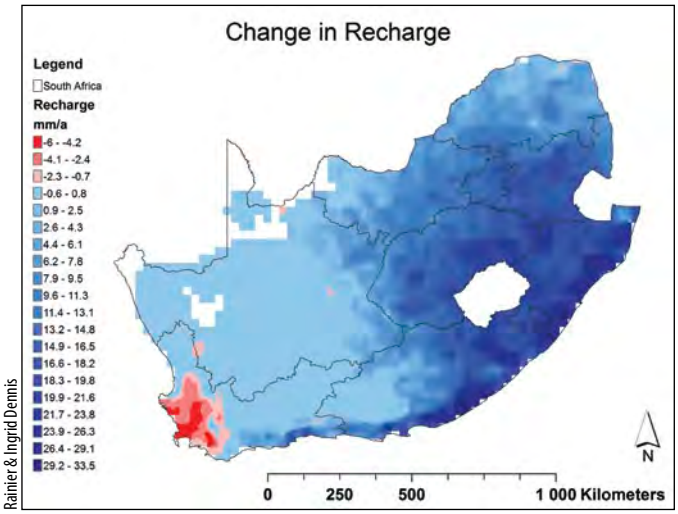
By far the greatest challenge of the project was the lack of available groundwater data. The availability of regional data to support the DART index was a major consideration in the selection of parameters. "Initially the index calculation required more parameters than the current four that are being used, but in the end we had to simplify the calculation based on the dearth of available data," Dr Dennis tells *the Water Wheel*.

SUSTAINABLE MANAGEMENT

Regardless of the future climate scenario, for groundwater to remain a reliable resource it has to be sustainably used and managed. "Sustainable management, in turn, is based on sound monitoring of the resource," says Dr Dennis. "It is quite simple to verify if a borehole is being used in a sustainable manner if long-term water level measurements are available. Therefore we encourage all groundwater users to undertake regular water level monitoring as a general rule of thumb."

More research is required to say for sure if and how South Africa's groundwater resources will be affected by climate change. Due to the current lack of groundwater monitoring records, present research is dependent on the output of climate change models to produce possible future scenarios. There are quite a number of climate models available, each with its own suite of potential climate change scenarios. To complicate things further the output of these models are downscaled to the area of interest. This introduces a whole lot of uncertainty with respect to which model and which scenario to use. "Methodologies developed around climate change can be tested with various scenarios but we need more certainty as to which scenario we can expect for us to appropriately react to the expected changes," notes Dr Dennis.





Top: *The DART index showing the expected change between current and future climate scenarios for the period October to December.*

Above: *The projected change in annual recharge between current and future climate change scenario.*

It is expected that the knowledge generated by this study will contribute greatly to South Africa's adaptation to climate change, particularly the management of the country's water resources. The methodology is already being used in another WRC-funded study looking at adaptation to climate change. It is hoped that in the end, South Africa will be prepared whatever the scenario. ❑