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The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Groundwater

Valuing groundwater and aquifers

A Water Research Commission (WRC) funded study aimed to construct a comprehensive and integrated framework for the economic assessment of groundwater resources and aquifer systems.

Background

As groundwater gains increasing recognition in South Africa, so the efforts have been bolstered to detail the extent to which the unseen resource is utilised and consumed. As the emphasis for water resource development shifts away from surface water resources towards alternative supplies, there is an increasing need to understand the economic incentives/arguments for groundwater use.

In order to understand these incentives/arguments, it is necessary to consider groundwater resources and aquifer systems holistically, looking at their role in the freshwater supply value chain, and within the larger economic framework. Herein lays the challenge, and the objective of this study.

Defining the value of groundwater

In order to understand the economic contribution of a given groundwater resource to the water-supply system, and to the economy as a whole, it is first necessary to identify and isolate the particular sources of value attributable to groundwater resources, after which consideration needs to be given to their qualification.

Surface water and groundwater resources each make up distinct components of the hydrological cycle, with unique water inflow, retention and outflow profiles. In particular, the unique characteristics of the groundwater hydrologic profile (recharge, retention, discharge) attribute groundwater resources and their associated aquifer systems with a set of ecosystem services that possess certain advantageous benefits relative to surface water resources.

The field of research regarding groundwater ecosystem services is in its early phases of development. Ironically, it is not due to lack of data or real world experience that groundwater ecosystems are not thoroughly understood.

Rather, it was for lack of a suitable framework for the economic assessment and accounting of ecosystem services. This knowledge gap has been filled by the Millennium Ecosystem Assessment Framework (MEAF), which provides a comprehensive, evidence-based point of department for the categorisation of ecosystem services.

Using this framework, in combination with a work-shopping method known as a Comparative Risk Assessment (CRA), this study investigated the ecosystem services of groundwater resource through the expert analysis of three case studies. These case studies involved the fractured rock aquifer systems being utilised in the Hermanus area; the dolomitic aquifer systems in the Krugersdorp area; and the primary aquifer in the Sandveld region.

Prioritising ecosystem services

The exercise identified the following priority ecosystem services:

- **Provisioning services**: Provisioning of freshwater, provisioning of biodiversity and genetic resources;
- **Regulating services**: Water regulation, storage and retention, water purification and water treatment;
- **Cultural services**: Recreation and tourism

Although the field of understanding regarding groundwater ecosystem services is in the relatively early phases of research, there are several groundwater ecosystem services that are of particular interest, specifically water regulation, storage and retention.

The reason for these ecosystem services to be of particular interest is that they are uniquely responsible for the mechanisms that mute the fluctuations in the availability of water within an aquifer from the fluctuation of external inputs, i.e. rainfall.

The availability of water within an aquifer and the rate at which that water is recharged, is dependent on several prior recharge/rainfall events, as opposed to a surface water resource (i.e. dam) where the content of the resource is a function of only the previous recharge/rainfall event.

Ground retards the flow of water, retains it and slows its transit. This brings a particular benefit to a water-supply system whereby groundwater resources shield the availability of the supply of water from the volatility (frequency and intensity) of recharge/rainfall events, thereby increasing the efficiency of the system, all other things being equal.

However, in order to provide evidence for the efficiency gains attributable to groundwater resources, it is necessary to consider the water supply and demand network as a whole. Fluctuations in demand for water need to be modelled against the ability of a water supply system to meet that demand, while retaining consideration for the fluctuations in the frequency and intensity of recharge/rainfall events.

Stochastic model

In order to achieve this aim, a stochastic model was compiled, incorporating the key stock and flow elements of a conjunctive use water-supply system. The model was based on the parameters of one of the case study areas investigated, namely the Hermanus case study area.

The model was compiled in spreadsheet format, incorporating stochastic elements to model the random fluctuations of specific components of the system, including rainfall patterns and water demand patterns, among others. The relationships between rainfall, recharge and runoff were also incorporated stochastically.

The key components of the system, where possible, were modelled based on real-world historical data. Components for which historical data did not exist were modelled to express a functional interpretation of the specific components.

The model takes the form of a Monte Carlo Simulation, whereby successive randomly generated trials are generated by the model, with the multiple trials being collectively assessed to determine the performance of the overall system. By generating and analysing a sufficiently large sample of trials, it is possible to deduce the mean values and variances for certain indicators within the system, allowing one to quantitatively assess the risk profile of the system.

By varying the various components of the model, it is possible to alter the risk profile of the system. Thus two different systems configurations may be contrasted with one another, in order to ascertain which configuration may be more efficient.

Another aspect of the modelling that needs to be detailed is the logic-based system controls that govern the overall functioning of the water-supply system. These system controls are intended to simulate the governing institutional framework that manages the water-supply system.

The systems controls determine the allocations and restrictions of water usage within the system based on the relative availability of water supplies. They also control the relative contributions of surface water and groundwater towards meeting the demand simulated by the system.

Once the stochastic model had been compiled and scaled to approximate the Hermanus conjunctive use water-supply system, it was subjected to scenario analysis. Three basic scenarios were compiled, based around two sets of criteria, 'control' and 'supply'.

Control refers to the relationship between the water allocations/restrictions within a system, and the availability of water supplies within the storage component of the system.

Supply considered the availability of both surface water and groundwater resources to supply the system with water.

Further reading:
To order the report, ***The economics of sustainable aquifer ecosystem services: A guideline for the comprehensive valuation of aquifers and groundwater*** (**Report No. 2165/1/13**) contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.