Groundwater Development for Localized Water Supply in South Africa

Ola Busari and Jeremiah Mutamba
Trans-Caledon Tunnel Authority, Centurion, South Africa
Email: obusari@tcta.co.za, jmutamba@tcta.co.za

***Abstract*—This paper captures the outcomes of a collaborative initiative between the national Department of Water Affairs in South Africa and the Trans-Caledon Tunnel Authority, a state-owned water infrastructure enterprise, on the development of groundwater as a source of localized water supply in two municipalities in the north-eastern portions of the country. The paper reviews the pre-existing situation of water supply in the project communities, presents the resulting benefits of, and challenges to, the interventions, and makes practical recommendations for going to scale with more effective harnessing of groundwater in similar settings.**

***Index Terms*—community water supply, groundwater, South Africa**

I. Introduction

Across the globe, there are worries about the achievement of sustainable socio-economic development, with water resource planners focusing their attention on the increasing vulnerability related to the availability and use of water resources [1]. Water scarcity is mainly influenced and exacerbated by increasing demand due to a fast growing population, industrial development, unabated pollution and the effects of climate change [2]. Ref. [3] indicated that "a world water crisis seems likely to emerge in the 21st century as demand for water is rising at a fast rate". This perceived "water crisis" is also thought to have implications for the situation in South Africa. Notwithstanding the possibility of some form of crisis, additional and alternative water resources are required – with groundwater being one of the less utilized water resources available for consideration.

Groundwater is the most valuable freshwater resource on earth [4], and it is the main reliable source of good quality water for rural supplies [5]. However, despite its relatively widespread availability, groundwater has long played second fiddle to surface water in terms of importance for human use and the attention devoted to it by the general public and water sector managers [5]. This state of affairs has resulted in remote rural communities failing to get access to clean drinking water, as water resource planners fail to prioritize the harnessing of groundwater for rural supplies.

Some regions, particularly in developing countries such as South Africa, have often struggled to access freshwater resources. This is particularly so in some remote rural areas. Surface water resources, usually the first-considered source of water supply, may not be adequately available in remote rural communities. Even when surface water is available, in the form of perennial rivers, storage and distribution infrastructure necessary to transport the water to communities are frequently lacking, as they could be quite costly and not economically viable to develop. As a result, many poor communities have been excluded from meaningful access to water. Under such circumstances, groundwater resources can be a sustainable alternative source of supplies, since groundwater may be available in sufficient quantity and quality; be subject to comparatively low development costs; and enjoy high drought reliability [4].

Viewed in the foregoing light, this paper advises a number of approaches for scaling up the optimal exploitation of groundwater in unserved and underserved communities, following an overview of the common constraints to such initiatives and the specific experiences from a collaborative project in the north-eastern portions of South Africa.

II. Groundwater Development Potential and Use in South Africa

There is consensus that groundwater has been the main source of rural water supply in South Africa, accounting for about 65% of the water supply in rural communities [6], [7]. Thus, the country realized long back that it would be practically impossible to cost-effectively meet all national water needs using surface water sources only. Despite this realization, only 10% of South Africa's current water supply is from groundwater, with as little as 4% of that being for urban use and 84% for agricultural irrigation and stock-watering. Only just over 300 towns and villages are dependent on groundwater in South Africa [7]. From the aforementioned figures, it can be inferred that a large proportion of the groundwater underlying the country remains untapped.

The country's average potable groundwater exploitable potential is estimated to be 14 802 Mm^3 per annum, and this amount declines to 12 262 Mm^3 per annum during drought periods [7]. It is important to note that in South Africa, 98% of the groundwater resources are found in fractured crystalline basement aquifers. Thus, South Africa's groundwater resources are predominantly found in secondary aquiferous media – with primary aquifers

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being highly restricted. In large part, primary aquifers are only found around the Province of KwaZulu Natal in the east and portions of the Western Cape Province in the south-westernmost corner (Fig. 1).

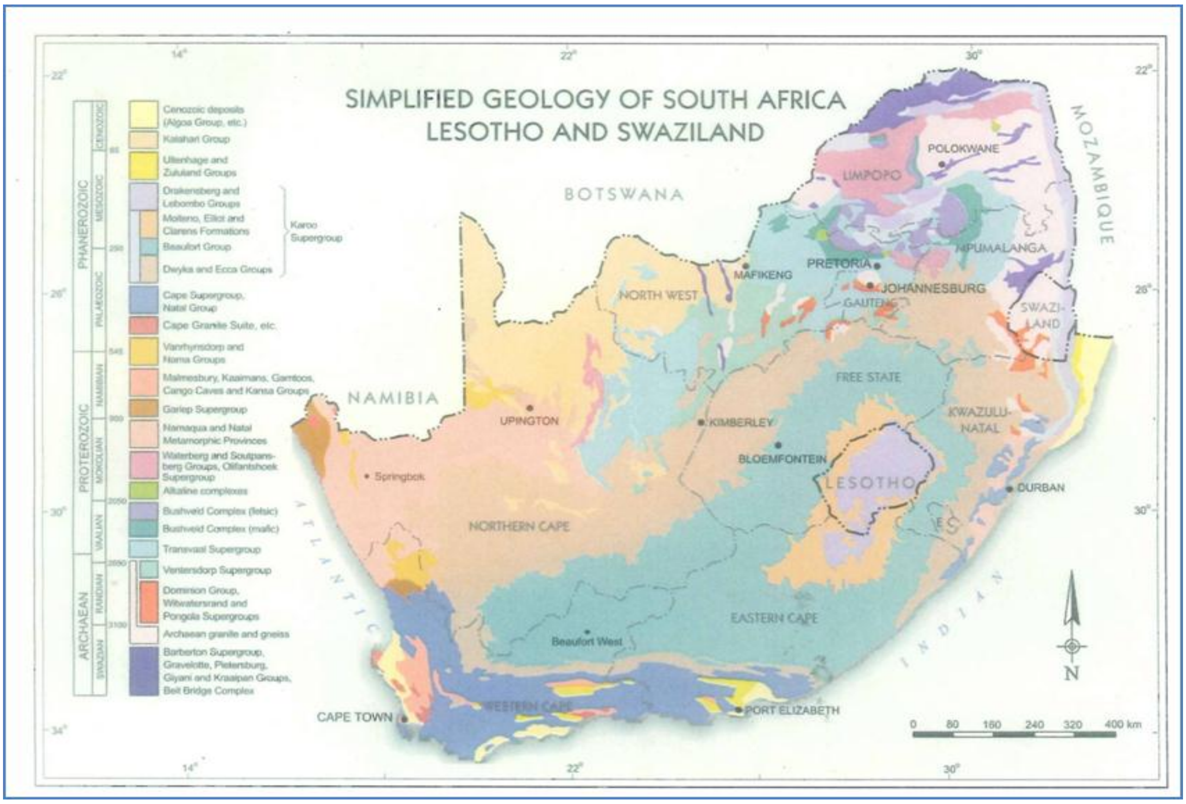

Figure 1. Groundwater occurrence in South Africa

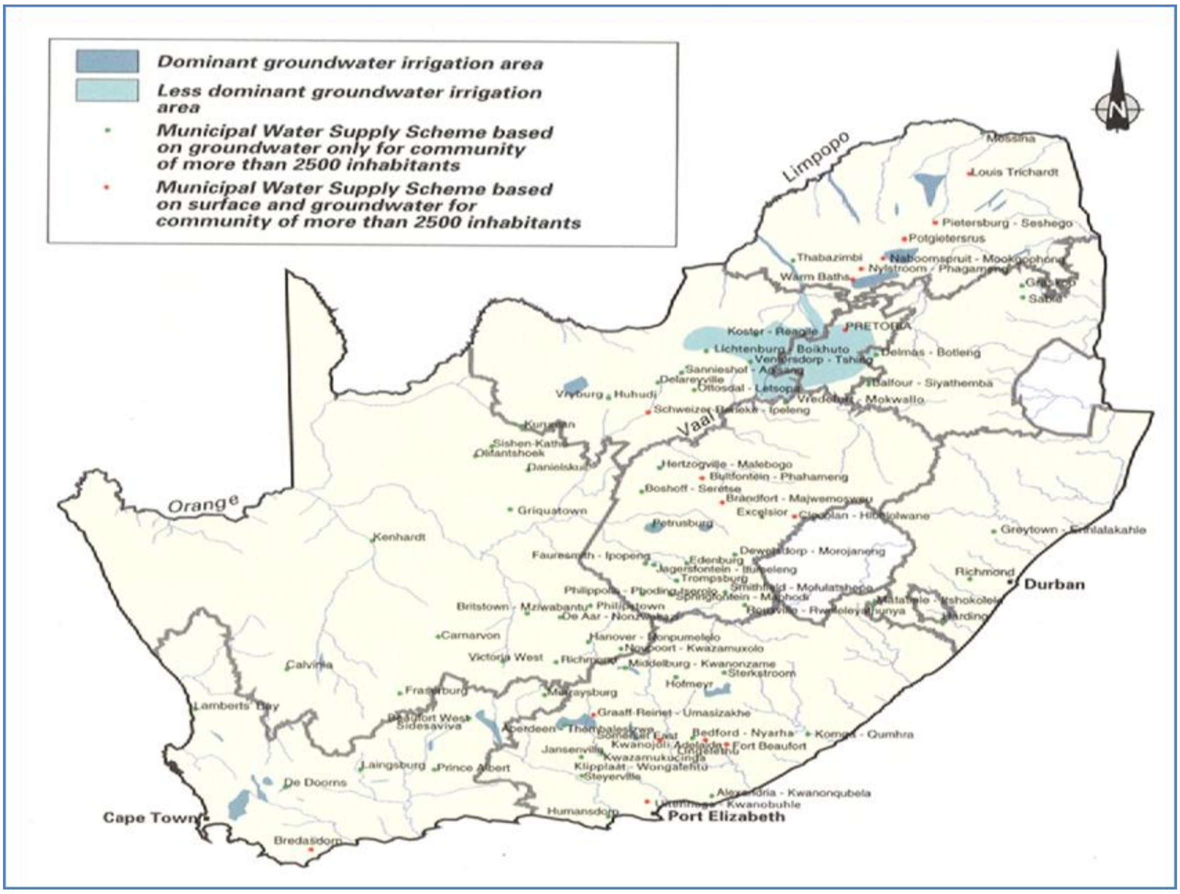

Figure 2. Groundwater use in South Africa

The estimated level of groundwater use in South Africa is indicated in Fig. 2, pointing to predominant municipal groundwater use to the east in the Eastern Cape, to the north-east in Mpumalanga, to the north in Limpopo, and centrally in the Free State. In the same vein, most of the groundwater irrigated areas are found in the geo-political Provinces of Eastern Cape, the Free State and Limpopo.

III. Review of Typical Project Constraints

Prior to developing groundwater resources, it is critical to have a sound understanding of the geo-hydrology of the target areas. Such knowledge and appreciation are important for the safe exploitation and sustainable management of groundwater supply systems.

Due to the advantages of using groundwater in dispersed rural settings, several community water supply schemes have come to rely on the development of aquifers. However, many of such projects have failed because they were implemented with little regard to the nature of the sources and their potential to store and yield water, as well as the requirements for sustaining operation and maintenance.

Boreholes are often sited at random, or adopt socio-economic and political criteria without due consideration of the appropriate scientific and management philosophies. In addition, the water supplies are often assumed to be safe and sustainable, with no scientific evidence on aquifer yield and water quality. The results of such limited approaches have been an unnecessarily high rate of failure of groundwater supply schemes, with concomitant cost implications and frustration among rural residents.

It was essential that the groundwater project at the center of this paper take cognizance of the common constraints described hereunder in its planning, design and implementation.

A. Limited Technical Information

Although the distribution of aquifers is now reasonably mapped over large areas, reliable quantitative information on aquifer characteristics and recharge rates, and groundwater flow regimes, abstraction rates and quality trends could be very scant and uneven, and often times, incomplete.

Questionable data sets almost always lead to incorrect assumptions about groundwater potential, use and sustainability. Further, research needs for groundwater are not loudly expressed – the result being a poor information base to inform successful groundwater supply schemes. The effects of this situation are high uncertainty in groundwater resource development, with poor design and implementation of groundwater supply schemes. Recognition that geo-hydrological factors may, in some instances, be overriding is important, calling for better use of related data and expertise in order to overcome problems of system under-performance or outright failure.

B. Poor Understanding of the Extent of Water Use

There is a lack of reliable and comprehensive data on groundwater use in many parts of the world, including South Africa. Yet, there remains a high dependence on groundwater for domestic water supply, rural livelihoods and livestock rearing. Lack of properly documented information on existing use and user experiences, does not help in the planning and development of new groundwater supply schemes, particularly if the new schemes are planned to be large-scale, and/or require special motivation for funding.

C. Presumed High Development Costs

Groundwater development in support of livelihoods and poverty alleviation has been impeded by the perception that borehole development costs are high in many countries. Factors attributed to what are considered relatively high costs include the following:

- Lack of economy of scale and competition in borehole construction, especially in developing countries; this is thought to be related to the absence of a large private sector market for borehole schemes;
- High excise duties on imported drilling equipment and pumping plant;
- Inappropriate borehole design and excessive drilling depth for some geological and hydro-geological conditions;
- Sunken costs for dry boreholes.

D. Strong Negative Perceptions about Groundwater

Negative publicity on resource scale and suitability limits the interest in the use of groundwater. Such perceptions are also exacerbated by the unbalanced attention to the successes and failures of groundwater supply schemes, frequently tilting in favour of the latter.

E. Inadequate Post-development Service

Often, successfully developed groundwater supply schemes fail because of poor or non-existing operation and maintenance programmes. In many cases, this is a result of the lack of capacity at the local community level to manage the schemes, including difficulties with accessing spares and technical support, as well as appropriate training in operation and maintenance.

F. Mismatch between Areas of Demand and Availability

Uneven geographical distribution, in relation to the likely zones of high demand, is not unique to groundwater resources, but may also be relevant to surface water. The result is that groundwater schemes are frequently put in place in arid or semi-arid regions where surface water is scarce or seasonal. Such regions may be underlain by slowly replenishing aquifers unfit for intensive exploitation, putting a natural break to unlimited growth in use.

IV. Project Setting: Two Municipal Areas

The groundwater development project is centered in two municipalities in the Mpumalanga Province, northeast of South Africa, namely, the Umjindi Local Municipality and Albert Lithuli Local Municipality. The specific localities of project interest are, respectively, the communities of Emjindini and Robinsdale.

A. Umjindi Local Municipality

This municipality has an estimated population of 54 000 [8]. Almost half of the population is classified as urban, with the rest as rural and farming communities. A large portion of the population is based at the Emjindini community. The area is host to a significant population of poor households – 72% of residents live on a monthly income of less than R1500 (1US$=R10.00). Agriculture, mining, industrial manufacturing, construction and trading constitute the economic backbone in the region.

Prior to the project, most of the urban and dense rural settlements were already provided with reticulated surface water. As of 1996, 83% of the population had access to piped water, increasing to 86% by 2001 [9]. However, a number of rural villages lacked access to any services, prominent among them the Emjindini community [10], prioritized for improved access to water in the project in focus.

B. Albert Lithuli Municipality

The municipal area is estimated to have a population of 188 000, and 98.5% of households are classified as previously excluded [11]. In 2007, the level of unemployment was reported to be a high 52.2%, with 89.5% of residents living in rural areas [11]. More than 60% of the population live on less than R400 per month and, in terms of the poverty index, 43% of the population are considered as experiencing utter poverty [11], [12]. Agriculture forms the economic mainstay for Albert Lithuli communities, with limited activities in coal mining, conservation and tourism.

While the water supply level in the area is reported to be over 95%, several households, considered as constituting about 73% of the population, are underserved, experiencing poor or non-existent operation and maintenance services, leading to infrastructure collapse in some cases. In particular, some rural communities such as Robinsdale, identified for groundwater supplies in the project in focus, simply had no easy access to reliable water sources.

V. Groundwater Development Results: Benefits and Challenges

The intervention led to nine borehole-driven water schemes – six in the Emjindini community and three in the Robinsdale area. Therefore, reliable and safe supplies were extended to a total of 172 households, 127 of them in Emjindini and 45 in Robinsdale, translating to a newly served population of about 860.

A. Project Benefits

Important benefits accrue to the two communities served by the new groundwater schemes, chief among them the following:

- *Enhanced access to drinking water*, following several years of fetching water over long distances, from streams of questionable drinking quality.
- *Increased reliability of water supply*, considering that the previous sources of water for the communities were non-perennial streams that disappeared during winter and spring.
- *Improved water quality*, meeting drinking water quality guidelines both from the microbial and hydro-chemical perspectives, with positive implications for public health.
- *Savings in time spent collecting water*, especially for young school-age girls and women who previously made a huge investment of their time and energy walking long distances to carry home limited amounts of water.
- *Potential for community ownership* of their water systems, propped on local-level operation and maintenance and with a likelihood to catalyse the effectiveness of community structures.

B. Challenges to Sustainability

A number of challenges have been highlighted for the attention of the municipalities and residents, to ensure that the water schemes continue to serve the communities into the future. They are as follows:

- *Malfunctioning of new infrastructure*, due to lack of requisite system operation and maintenance, a situation that had previously been experienced in several parts of the Albert Lithuli municipality, including the community of Robinsdale. Active community participation in planning and executing operation and maintenance is critical for sustainability.
- *Risk of vandalism*, involving familiar actions by rogue elements in the communities themselves, targeting boreholes for scrap metal and copper cables. Such practices emphasize the need for a greater role for community members and their structures in managing the water schemes.
- *Over-abstraction* may occur as demand increases in tandem with population expansion or as new livelihoods opportunities requiring water are exploited by households. In order to avoid a situation where boreholes dry up, groundwater drawdown and availability need to be continuously monitored against rising water needs.
- *Groundwater contamination* remains possible in spite of the groundwater protection elements built into the project, in the light of the intensity of human activities around hand-pumped schemes and the unsupervised location of pit latrines and soak-away sanitation systems.

VI. Conclusions and Recommendations

Sustaining and scaling up water supply from project schemes require that the challenges raised in the previous section are adequately addressed on an ongoing basis. In this regard, the following recommended actions are important for the project undertaking in South Africa, as well as for other groundwater development interventions in similar settings:

- Capacity building is critical for community-level operation and maintenance, as is the raising of awareness in communities on the need to own and manage local water systems. Local level management would benefit from the use of appropriate technology in schemes, as well as access to spares and specialized technical support when required.
- Moderate abstraction levels, guided by the sustainable yields determined for each scheme, need to be maintained to avoid drying-up boreholes from over-abstraction. Municipalities and their agents should implement sound groundwater management programmes that promote the sustainable use of groundwater, including the monitoring of drawdowns in relation to demand pressures.
- Groundwater management programmes should also emphasize the protection of aquifers and developed well-heads, to safeguard the quality of water. In particular, sanitation facilities, especially in the form of scattered pit latrines in communities, need to be sited appropriately to minimize the potential to contaminate groundwater.
- In the march towards going to scale in groundwater development for rural supplies, efforts to raise community awareness for system care should be coupled with those to promote the significance of groundwater as a reliable water resource.

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Ola Busari, erstwhile Professor of Hydrology and Water Resources, is currently Executive Manager for Knowledge and Strategic Programs at the Trans-Caledon Tunnel Authority, a state-owned enterprise in South Africa, mandated to finance and develop bulk water infrastructure. Previously, Ola was Divisional Executive at the Development Bank of Southern Africa, heading up the provision of specialized advisory services across all economic and social sectors in the fifteen countries in the region. Before joining the Bank, Ola served as Director with the national Department of Water Affairs in South Africa.

As a full-time UN Expert for virtually all of the 1990s, he worked closely with several governments, business entities and civil society organizations. Ola's publications profile includes over 150 papers and commissioned reports. A licensed civil engineer and an alumnus of the Henley MBA Program, University of Chicago Advanced Environmental Isotopes Program, and Cambridge University Business and Environment Program for Senior Executives, Ola holds a doctoral degree in the optimization of water use.

Jeremiah Mutamba is Senior Manager for Water-Centred Knowledge at the Trans-Caledon Tunnel Authority, and holds a master's degree in water resources engineering from the University of Dar es Salaam, Tanzania as well as another master's degree in business leadership from the University of South Africa.

He has extensive experience working in the water and environment sectors, and previously served as the Group Water Manager at Lonmin Platinum, a South Africa-based global company active in the PMG sector.