A critical overview of transboundary aquifers shared by South Africa

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Abstract

Transboundary groundwater commonly implies a body of groundwater intersected by a political border with the attendant potential threat of dispute over a shared resource. Due to low transmissivities, this definition is inadequate in many parts of southern Africa. Approximately 96 % of South Africa's borders are underlain by low-yielding aquifers and, coupled with a low demand for water attendant on low population density, the risk of over-pumping or pollution leading to dispute is low, and a modified understanding is required. Examples of transboundary aquifers are used to illustrate implications for policy and management of southern African transboundary groundwater resources, both where transmissivities are low and less commonly where over-pumping may indeed be a problem. The general lack of technical cooperation, data sharing, training and research between the riparian states on hydrogeology hampers a mutual understanding of transboundary groundwater resources. The concept of transboundary groundwater must necessarily include aquifers where little cross-border flow occurs, but where cross-border cooperation will help to ensure sustainable cooperative utilisation of shared aquifer resources. This is imperative if future disputes over shared aquifer resources are to be averted. Agreement between scientists is a necessary precursor to broader transnational governance agreements in regard to shared water resources, and recent initiatives by the Orange-Senqu River Commission promise closer integration.

Keywords: transboundary aquifer, southern Africa, groundwater management

Introduction

Transboundary groundwater as a discourse has become prominent in recent years, and is increasingly linked to transboundary surface water resources in attempts to understand and manage regional water resources. Also referred to as shared aquifer resources (ISARM 2004), the subject is often included in international groundwater project proposals and addressed in transnational research or resource development projects (Turton et al. 2005). This development is positive and long overdue, though certain assumptions that are implicit in the global discourse on transboundary groundwater do not necessarily apply in southern Africa. This may unintentionally divert scarce funds and resources away from where they are most needed.

A preconceived concern is that a transboundary groundwater resource that is not managed in a cooperative and holistic way by one state, may be over-exploited to the detriment of another state (Godfrey and van Dyk 2002; Jarvis et al. 2005). Alternatively, pollutants might migrate across the border to contaminate a neighbour's aquifer (Puri 2001). Transboundary water resource management seeks to avoid disputes that might arise from uncontrolled development of such resources (Turton et al. 2006a). The approaches that promote prudent assessment and management of transboundary surface waters also inform the management of transboundary groundwaters (Phillips et al. 2006).

Turton et al. (2006b) observe that there are fewer legal agreements concerning transboundary groundwater compared with surface water. Rather than implying that groundwater lags behind surface water in this regard, this situation reflects the distribution and characteristics of transboundary groundwater resources and the requirement that effective management of such resources should be based on high quality information. Unlike surface water, groundwater movement is governed by the hydraulic properties of the aquifer. Where transmissivities are low, groundwater movement is greatly reduced, and the concept of a shared resource as it is commonly understood becomes problematic. This situation is exacerbated by uncertainty regarding water demand trends, the impact of over-exploitation on riverine ecology, and the impact of groundwater resource development in tributary catchments on recharge of downstream shared aquifer resources. There is a clear need for groundwater specialists to define the precise information required to ensure sustainable use of these groundwater resources so that they receive the recognition they deserve. Here, it is important to recognise the great heterogeneity in transboundary aquifer properties and the inadequacy of a “one-size-fits-all” approach.

Background

Since the early 1990s, the importance of transboundary groundwater in sustaining human development and preventing dispute has gained wider appreciation (Puri 2001), leading to increasing discussion and attention by technical specialists and policy-makers alike. In 1997 the International Association of Hydrogeologists (IAH) established a specialist commission (Transboundary Aquifer Resources Management, or TARM) on transboundary groundwater, followed in 2000 by the establishment of the International Shared Aquifer Resource Management (ISARM) initiative (Puri and Aureli 2005). Studies commissioned as a result of these initiatives include a map titled “Groundwater Resources of the World – Transboundary Aquifer Systems” produced by Struckmeier et al. (2006). Since the initiation of the ISARM-Africa project in 2000 more than 40 transboundary aquifers have been identified in Africa (Struckmeier et al. 2006), and the final total is likely to be higher.

The world transboundary aquifer map (Struckmeier et al. 2006) recognises “major groundwater basins”, “areas with complex hydrogeological structure” and “areas with local and shallow aquifers”. Each of these is assigned a “high”, “medium” or “low” recharge characteristic and allocated a number. Seven systems that intersect South Africa’s borders have been identified as requiring further investigation (Figure 1), only one of which (No. 439) is indicated as an area with only local and shallow aquifers. The other six systems are considered to encompass a mixture of major, complex and/or local systems with a combination of “medium” (15 to 150 mm/a) and “low” (< 15 mm/a) recharge. This map is explicitly aimed at non-specialist users (Struckmeier et al. 2006), who might conclude that the transboundary aquifers on South Africa’s border (Figure 1) have similar resources and properties to, for example, the British Cretaceous Chalk or the North African Nubian Sandstones. However, transmissivities in the southern African aquifers are considerably lower, with correspondingly smaller borehole yields.

A world map cannot convey fine detail. The reasons for choosing recharge as opposed to, say, transmissivity or porosity to classify aquifers are sound, but it is important that the management or governance response is appropriate for the southern African situation. Few sub-Saharan aquifers are highly productive. Most aquifer transmissivities are low and regional (i.e. transboundary) water movement is either slow, or groundwater occurs within disconnected “pockets” determined by geology and weathering processes (e.g. basement aquifers). Non-specialist impressions of large, mobile, interconnected and high yielding shared aquifer resources are, therefore, inappropriate. While hydrogeologists appreciate the diversity in aquifer types worldwide, this is not always true for policy-makers and legal specialists (Puri and Aureli 2005).

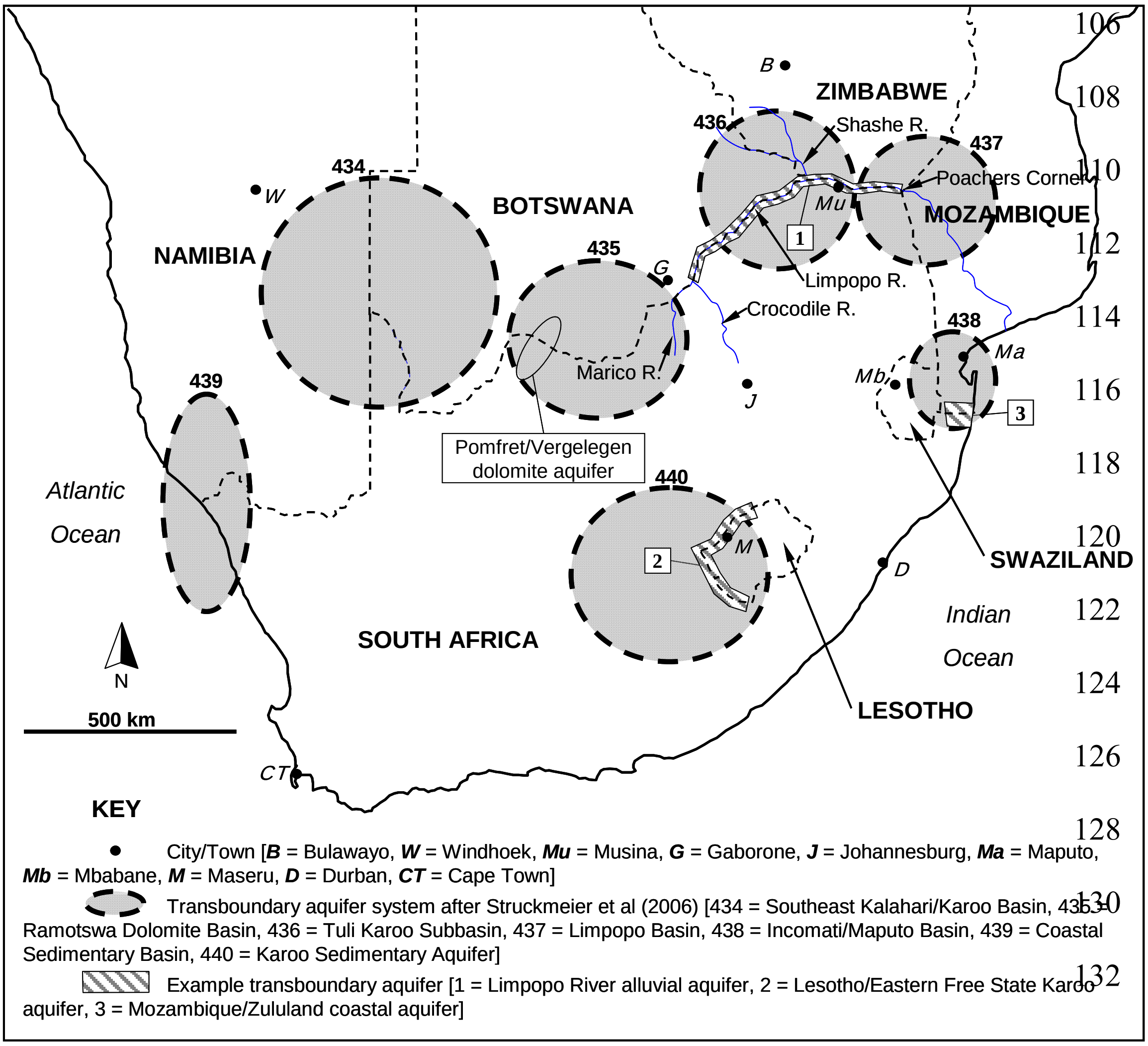

Figure 1. Map of southern Africa showing the approximate locations of seven transboundary aquifer systems (after Struckmeier et al. 2006), and the positions of the systems addressed in this paper.

Overview of South Africa's transboundary groundwater resources

South Africa (SA) shares approximately 5 116 km of land border with Namibia, Botswana, Zimbabwe, Mozambique, Swaziland and Lesotho. In order to characterise the aquifers underlying this border, the 1:500,000 hydrogeological maps produced by the SA Department of Water Affairs and Forestry (DWAF) were analyzed. Twelve of these maps span South Africa's international borders and groundwater occurrences are identified by an alphanumeric code based on aquifer type and borehole yield class, as shown in Table 1.

Table 1. Aquifer classification as per the DWAF hydrogeology map series.

Aquifer Type	**Borehole Yield Class* (l/s)**				
	Class “1” 0 - 0.1	Class “2” 0.1 - 0.5	Class “3” 0.5 - 2.0	Class “4” 2.0 - 5.0	Class “5” >5.0
Type “a”: Intergranular	a1	a2	a3	a4	A5
Type “b”: Fractured	b1	b2	b3	b4	B5
Type “c”: Karst	c1	c2	c3	c4	C5
Type “d”: Intergranular & fractured	d1	d2	d3	d4	D5

* Median borehole yield, excluding dry boreholes

The length of each aquifer type/yield class combination along the South African border was determined from these maps. Where a combined symbol appears, e.g. a3/b2, the length was assigned to the higher yield class. Such combined classes accounted for less than 5 % of the total border length. The results indicate the groundwater potential along the SA border (Figures 2 and 3, and Table 2), allowing preliminary conclusions to be drawn regarding the most appropriate type of international cooperation needed.

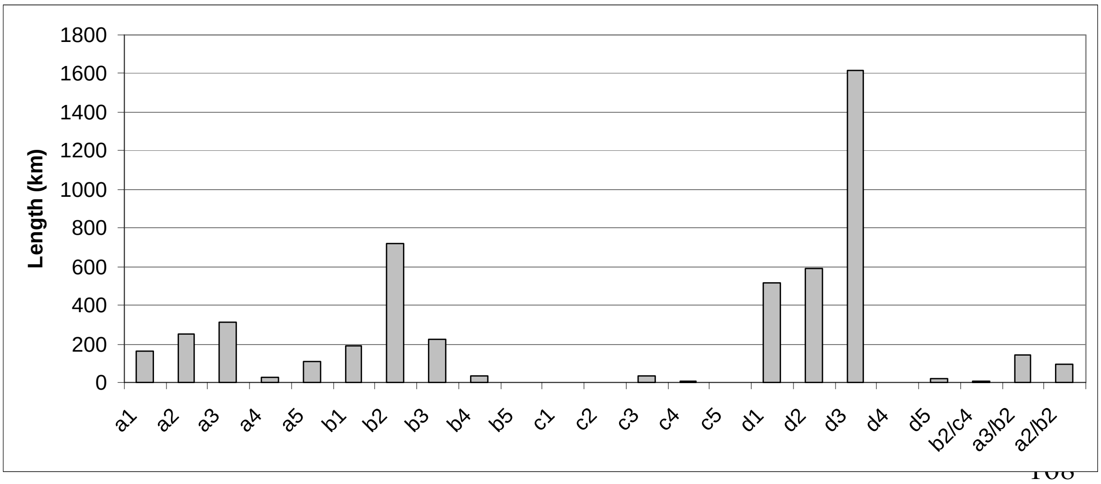

Figure 2. Groundwater occurrence by DWAF aquifer classification classes along South Africa's inland borders.

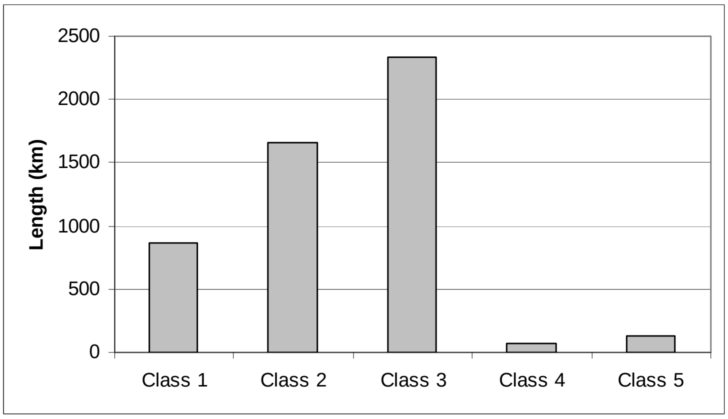

Figure 3. Borehole yield class (see Table 1) distribution along South Africa's inland borders.

Table 2. Relative proportions of borehole yield class per neighbouring country.

Neighbouring Country	Class 1	Class 2	Class 3	Class 4	Class 5	Total
Namibia	42.1 %	32.9 %	22.5 %	2.5 %	0 %	100 %
Botswana	13.9 %	35.5 %	45.0 %	2.7 %	2.9 %	100 %
Zimbabwe	0 %	2.9 %	66.2 %	0 %	30.9 %	100 %
Mozambique	12.4 %	67.8 %	19.3 %	0 %	0.5 %	100 %
Swaziland	0 %	53.7 %	46.3 %	0 %	0 %	100 %
Lesotho	12.4 %	6.9 %	80.7 %	0 %	0 %	100 %

The analysis indicates that 50 % of South Africa's border is underlain by class 1 or 2 aquifers with a median yield < 0.5 l/s. A further 46 % of the border is underlain by class 3 aquifers (median yield 0.5 to 2 l/s). Class 4 and 5 aquifers account for only 1 and 3 %, respectively (Figure 3). The majority of groundwater along South Africa's border occurs in aquifers of low transmissivity. Table 2 indicates that only the border with Zimbabwe is underlain to a significant extent by class 5 aquifers. Therefore, it is likely that only those boreholes located close to the border (say ≤ 1 km) might contribute to groundwater depletion in the neighbouring country.

The Pomfret/Vergelegen dolomitic aquifer (Figure 1) most closely approaches the "classic" definition of a transboundary aquifer in South Africa, although its presence in Botswana probably has yet to be proven. Parts of this aquifer were already over-exploited for irrigated agriculture in 2002 (Godfrey and van Dyk 2002), with the annual demand of 11.1 Mm^3 for 1 495 ha under irrigation far exceeding the 6.9 Mm^3/a available. The resulting drawdown of up to 60 m is believed to have caused partial dewatering of the overlying and lower-yielding unconfined Kalahari aquifer (Godfrey and van Dyk 2002) that sustains local rural communities and stock farms. Uncertainty regarding the transboundary nature of this aquifer compared with the examples listed below, discounts its further examination. The following three examples better conform to systems identified by Struckmeier et al. (2006), and are examined in more detail to illustrate the points made above and indicate where the regional analysis should be modified.

Example One: Limpopo River alluvial aquifer

The so-called sand rivers of southern Africa have long been recognised as a source of (ground) water (Mulder 1973; Owen 1989; Jacobson et al. 1995; Herbert et al. 1997; Davies et al. 1998). In Namibia, this recognition extended to the design and construction of artificial sand reservoirs (Wipplinger, 1958). The Limpopo River is a prime example of a natural sand river and also forms the arcuate northern border between South Africa, Botswana and Zimbabwe (Figure 1). The unconsolidated alluvial deposits that fill the river channel and build the irregular adjoining floodplain constitute an international transboundary aquifer.

The seasonal flow regime of the Limpopo River is characterised by wet season runoff that recharges the alluvial aquifer; surface flows decline during the dry winter months, reducing to dislocated pools of standing water connected by sub-surface flows. The larger pools hold water for extended periods of time - often spanning more than one dry season - confirming their sub-surface hydraulic continuity. Rock outcrops or shallow bedrock in the river channel act as natural impounding structures; water collects behind these structures and can be abstracted by surface pumps. Mean annual precipitation (MAP) reduces from 400 to 500 mm in the upper reaches to 200 to 300 mm at Poacher's Corner (Midgley et al. 1994). Sustainable utilisation of the Limpopo River alluvial aquifer therefore also depends on the management of surface water runoff and river flow in the 328 450 km^2 basin that incorporates four riparian states.

The aquifer is broadest east of the Limpopo/Shashe confluence, increasing gradually from 500 m to 700 m where it enters Mozambique. The comparatively thin mean saturated thickness of 3.5 m reported by Mulder (1973) near Musina, is compensated for by the specific yield (effective porosity) of 24 % and hydraulic conductivity of 120 m/d, equating to a transmissivity of 420 m^2/d. Upstream, the maximum width reduces to approximately 50 m near the Limpopo/Crocodile confluence. Du Toit et al. (2000) report a mean saturated thickness of 6 m (maximum 24 m) for a 40 km reach either side of the Limpopo/Shashe confluence, and Hobbs and Esterhuyse (1983) report sporadically developed thicknesses of 10 to 12 m (maximum 30 m) for the upper reaches. The aquifer is tapped by a variety of methods including hand-dug wells, wellpoint systems, infiltration galleries and boreholes. The latter, generally located on the river bank, may support yields $\geq$ 15 l/s (Hobbs and Esterhuyse 1983, Du Toit et al. 2000). The use of appropriate drilling methods and borehole design criteria (e.g. mud rotary drilling, screens and filter packs) could increase the capacity of boreholes but are seldom used. Wellpoint systems are generally more productive with yields in the order of 40 l/s (Hobbs and Esterhuyse 1983). The groundwater quality data presented by Hobbs and Esterhuyse (1983) and Du Toit et al. (2000) return mean electrical conductivity values of 214 and 174 mS/m, respectively.

The town of Musina (with a 2006 population of 25 582) meets its current municipal water demand of 5.8 Mm^3/a from boreholes and wellpoints on the Limpopo River (J. du Toit, Musina Local Municipality Technical Manager, personal communication, 2007). Similarly, the Venetia diamond mine in South Africa obtains its supply of 4 Mm^3/a (Du Toit et al. 2000) from a wellfield on the right bank of the Limpopo River. In regard to agriculture, Du Toit et al. (2000) estimated the area under active winter irrigation for a 40 km reach either side of the Limpopo/Shashe confluence at 2 000 ha. The median annual gross irrigation requirement (GIR) in the region is 2 000 mm (Schulze et al. 1997). Assuming a conservative seasonal GIR of 1 000 mm, then dry season water use on the SA side for agriculture alone amounted to 20 Mm^3/a. By comparison, agricultural use of water from this aquifer in neighbouring countries is negligible; this situation is exacerbated by the dereliction of irrigation farms in Zimbabwe.

The length of the Limpopo River from the Limpopo/Crocodile confluence to Poacher's Corner is approximately 750 km. Assuming conservative values of 20 % for effective porosity, 100 m for channel width and 10 m for saturated thickness, this yields a hypothetical storage of 150 Mm^3 for this reach. This volume reduces to 105 Mm^3 at the 70 % exploitation limit, which makes the resource equivalent to an impoundment with a volume in the top 8 % of surface water impoundments in South Africa. More significantly, this figure suggests that the water demand of 5 900 ha of irrigated land - shared between the riparian countries – could be met from this resource. Thus the aquifer is a potentially valuable water source for resource-poor farmers, able to meet and sustain small scale irrigation demands even during dry periods when surface flow ceases.

Fortunately, no disputes have yet arisen between the riparian states over the alluvial water resources of the Limpopo River. However, growing pressures for water in this arid region mean that the potential for such dispute cannot be ignored. To avert this situation, water resource managers in the four countries need to agree on the aquifer characteristics, equitable apportionment of use, and appropriate limits to the use of this shared aquifer resource.

Example Two: Lesotho/Eastern Free State Karoo Aquifer

The transboundary area of south-eastern South Africa and lowland western Lesotho has a semi-arid to temperate climate, receiving annual rainfalls of 500 to 1 150 mm that fall mainly during October to April. The international boundary is marked by the perennial Caledon, Senqu, Mohokare/Clarens and Makhaleng rivers, many of whose tributaries are episodic or ephemeral.

The Beaufort and Stormberg Groups of the Karoo Supergroup underlying the transboundary area, comprise horizontal to sub-horizontal dipping sedimentary rocks of the Burgersdorp, Molteno, Elliot and Clarens Formations. These include fluvio-deltaic mudstones, siltstones and sandstones with dolerite ring dyke intrusions. Formation groundwater storage and flow are functions of porosity. Primary effective porosities are low due to sediment cementation and the fine grained nature of the sediment, as well as compaction and high mudstone contents; secondary porosities are enhanced by fracturing and dolerite dyke intrusion. Formation groundwater occurrences in Lesotho and South Africa are reviewed by Davies (2003) and Woodford and Chevallier (2002). Whilst groundwater quality is mainly good, aquifer characteristics are summarized as follows.

The 200 m thick Burgersdorp Formation found in much of the transboundary area is composed of low permeability mudstones and siltstones with minor sandstones. It is a semi-confined to confined aquifer with a mean transmissivity of 20 m^2/d supporting borehole yields < 0.5 l/s, except where intruded by dolerite dykes. Within the Burgersdorp Formation, many boreholes have been drilled into the baked margins of dolerite ring dyke intrusions to supply water to farms and small rural communities.

The Molteno Formation varies in thickness from > 250 m in the south to < 50 m in the north. It is the best aquifer present, especially where permeability is enhanced by intruded dolerite dykes or fracturing. This semi-confined aquifer with mean transmissivity of 20 m^2/d has been developed at Roma and Teyateyaneng, where wellfields with individual borehole yields of > 3 l/s have been installed. Outcrops of the Molteno Formation also form an important spring line with individual spring discharges as high as 0.5 l/s.

The Elliot Formation varies in thickness from 200 m in the south to 100 m in the north, and is often in hydraulic continuity with the underlying Molteno Formation. Although good water strikes are recorded at the contact between these formations, the Elliot Formation is regarded as a poor aquifer due to its compact nature. Given the fractured nature of the main aquifer units, the few available aquifer parameter values (mean transmissivity of 24 m^2/d and storativity of 0.0005) determined from the analysis of test pumping results for these aquifers should be applied with extreme caution, since they probably overestimate sustainability. The 130 m thick Clarens Formation supports the lowest mean borehole yield of 0.9 l/s and transmissivity of 5 m^2/d.

The low transmissivities and consequent low borehole yields of the Karoo Supergroup rocks straddling the Lesotho/South Africa border mean that the transboundary impact of groundwater abstraction is likely to be very small. The area is designated as a “major groundwater basin” with medium recharge on the world transboundary aquifer map (Struckmeier et al, 2006), yet is likely to need management approaches that are different to those applied to transboundary aquifers with much higher transmissivities.

Example Three: Mozambique/Zululand coastal aquifer

The Zululand coastal plain along the northeast coast of South Africa has a surface area of approximately 7 000 km^2 in South Africa. It extends some 250 km south of the border, and for at least another 1 000 km northwards into Mozambique. In South Africa, rainfall varies from about 600 mm/a inland to ≈ 1 200 mm/a at the coast (Midgley et al. 1994). An area of ≈ 50 km east-west by ≈ 120 km north-south straddling the border is described as being endoreic. Isotope techniques returned effective groundwater recharge figures ranging between 5 % and 18 % of MAP across the plain (Meyer et al. 2001). The area is sparsely populated, and apart from subsistence farming, land use is limited to nature conservation, irrigation farming further inland using surface water, and limited commercial forestry.

The entire plain is underlain by a primary aquifer. The aquifer comprises unconsolidated to semi-consolidated Quaternary sand underlain by calcareous sandstone and calcarenite of Miocene age. Reaching a maximum thickness of 110 m at the coast, the sediments were deposited on an erosional peneplain of low permeability Cretaceous siltstones dipping east at roughly 3 degrees. The wedge-shaped primary aquifer contains good quality groundwater, while that in the Cretaceous floor rocks is of extremely poor quality. Groundwater levels are generally shallow, giving rise to several fresh water lakes that range in size up to ≈ 65 km^2 (Miller 2001). These lakes serve the water requirements of the majority of the population.

A confirmed north-south groundwater divide located on the South African side is expected to continue northwards into Mozambique, and separates flow towards the Pongola River (west) and the coast (east). The westerly flowing groundwater contributes to the base flow of the Pongola River, while that on the eastern side of the divide results in an estimated annual outflow along the coast of between 5.4 and 22 Mm^3/km of coastline (Meyer et al. 2001). Coastal dunes rise to 130 mamsl which, although not supporting a groundwater mound, maintain a groundwater elevation of approximately 20 mamsl. The very steep gradient (1:50 to 1:100) towards the coast results in numerous fresh water seeps along the coast (Meyer et al. 2001).

The calcarenite Uloa Formation (Miocene) is the most productive aquifer with transmissivity values of > 1 000 m^2/d and borehole yields up to 30 l/s. The radius of influence around production boreholes is small and, unless very large well fields are developed close to the international border, the transboundary impact of groundwater abstraction would be negligible. The natural outflow to the coast is equivalent to between 170 and 700 l/s continuous extraction from boreholes over a one kilometre wide corridor. Based on the 25 l per capita per day minimum basic water supply adopted for rural populations in South Africa, the groundwater could hypothetically support a population of > 500 000. The current population within a 50 km wide zone south of the border is approximately 200 000, or 50 people/km^2.

It is clear that there is a large groundwater resource on the South African side of the border. Although there is limited information available for the aquifer in Mozambique, similar conditions are expected there. In addition to being sparsely populated, three large game and nature reserves (including the Greater St Lucia Wetland Park, a UNESCO World Heritage Site) occupy roughly 50 % of the border area. It is likely that the rest of the area spanning the border could in future be incorporated in planned extensions of these parks, and that similar reserves may be developed on the Mozambique side of the border. This will "sterilise" a further 25 km for the development of wellfields, and secure a larger area where the delicate groundwater dependent ecosystems can be maintained.

Given the circumstances described above, it is unlikely that the demand for (ground) water from this aquifer on the northern Kwazulu-Natal/Mozambiue border (Struckmeier et al. 2006) will expand significantly in future and impact negatively on the available water resources. This transboundary aquifer is therefore not believed to be at risk of competition for water between South African and Mozambique; neither will the aquifer require the development of management plans, governance structures or interventions from political powers.

Implications for policy and management

The literature suggests that the key features of transboundary groundwater include "*……water transfers from one side of the boundary to the other…….*", and that the first task of interested parties should be identification of "*…….flow and movement of water followed by its quantification……..*" (Puri 2001). With few exceptions, it is apparent that the perceptions of extensive shared aquifer resources located along the South African border being vulnerable to over-abstraction by one country to the general detriment of the neighbour are invalid. Where "major groundwater basins" in southern Africa are placed in the same category as "true" transboundary aquifers (e.g. Struckmeier et al. 2006), it is easy for non-specialists to conclude that the same type of urgent governance response is needed for transboundary groundwater as is advocated for transboundary surface waters. This does not mean that transboundary groundwater is unimportant in southern Africa. There is indeed a transboundary groundwater crisis in southern Africa, but it is related to limited knowledge, training, cooperation and access to the data needed to ensure sustainable utilisation by the states concerned.

It is proposed that management attention should rather be focused on general technical cooperation over transboundary technical groundwater, since transmissivities and demands are often too low to lead to disputes over the resource in the traditional sense. Most of the issues in exploiting, managing and protecting shared aquifers are mutual even where cross-border hydraulic continuity is weak. Therefore, instead of mobilising political opinion behind what is sometimes framed as a potential tug-of-war over a finite water resource or a “race to the pumps”, attention should be given to strengthening those mechanisms that promote technical cooperation, capacity-building and data-sharing between neighbouring African countries. Institutions such as the Southern African Development Community (SADC) and the New Partnership for Africa’s Development (NEPAD) are well-placed to contribute to this change, and indeed already endorse many of these issues. Rather than advocating new approaches, it would be prudent to strengthen existing initiatives and institutions, e.g. the Joint Permanent Technical Committee on Water Affairs of the Republics of Botswana and South Africa. If this broadening of focus can be achieved, then Africa and southern Africa stand to benefit directly from the international attention afforded to transboundary groundwater.

In certain instances, however, it is also apparent that South Africa’s transboundary groundwater could be a potential source of dispute with its neighbours. In these areas, the South African situation is aligned with the “traditional” model of transboundary groundwater, i.e. subject to competition for resources. In both the Limpopo River alluvial aquifer and the Lesotho/Eastern Free State Karoo aquifer examples, an understanding of surface water/ groundwater interaction is fundamental for the effective management of resource utilisation and effluent disposal if these systems are to be used sustainably. In the case of the former, for example, the impact of over-exploitation on riverine ecology needs to be established. In the latter instance, consideration must be given to the extent to which a misunderstanding of the groundwater resources on both sides of the border has led to practices that are detrimental to all users.

Conclusions

An examination of three South African transboundary aquifer systems suggests that each possesses good development potential. However, the development potential of each aquifer needs to be assessed against factors such as surface water / groundwater interactions and groundwater dependent ecosystems before establishing the sustainable utilisation as a transboundary resource. Such assessments will inform the joint development and management of these resources to the mutual benefit of the riparian states.

Based on this study of South African transboundary aquifers, it is proposed that the traditional understanding of transboundary groundwater issues as a potential source of conflict be modified. For most of the length of South Africa's border, potential dispute over transboundary groundwater is not a major concern. In general, transboundary aquifers such as the "Coastal Sedimentary Basin" or the "Karoo Sedimentary Aquifer" (Struckmeier et al. 2006) are potentially misleading in terms of the level of management required. Given the sparse data on southern African transboundary aquifers and the relatively low levels of technical cooperation between the riparian states, the region would be better served by using transboundary groundwater as a vehicle to improve technical cooperation, data sharing, training and research. This is crucial if potential future disputes over shared groundwater resources are to be averted. Agreement between scientists is postulated as a necessary precursor to broader transnational governance agreements. Appropriate institutional arrangements already exist. Recent initiatives by Water Commissions such as the Orange-Senqu River Basin Commission (ORASECOM), will focus on these and other issues. Whilst this paper refers specifically to South Africa and her neighbours, many of the conclusions drawn apply to other parts of sub-Saharan Africa where similar circumstances prevail.

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