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Urban groundwater use in Tropical Africa – a key factor in enhancing water security?

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Abstract

A regional scoping study has reviewed the limited data on groundwater use for 10 cities in Tropical Africa. In those cities where the water utility has been able to develop groundwater rationally, the public water-supply usually offers a better service at lower cost by enabling phased investment and avoiding advanced treatment, and offers greater water-source security in drought and from pollution. Urban dwellers obtain water from multiple sources, according to availability and affordability. Among the more affluent, private water-supply boreholes are increasingly used to improve security and reduce cost but in the absence of international charity finance groundwater access is beyond the financial reach of the urban poor, except where the water table is shallow allowing the use of low-cost dugwells. The way forward must be to integrate more effectively utility and private investments, and piped and non-piped solutions, for urban water-supply provision, and for water utilities to establish low-income ('pro-poor') policy and technical units to pursue ways of supporting alternative water-supply provision, including advisory services and regulatory functions (where appropriate) for private borehole and dugwell use. To facilitate this, water utilities will need to partner with resource regulators and knowledge centres, which may require modifications to their mandate.

Keywords: Groundwater; Private boreholes; Tropical Africa; Urban water security; Water-utility policy

Context of paper

Urban water-supply security concerns

'Water security' is an all-embracing concept (Grey & Sadoff, 2007), but one which takes on sharper meaning when used in a specific context – for example relating to a given city and explicit service, such as its water-supply (Foster & MacDonald, 2014). It can then be objectively assessed on the basis of accessibility, affordability, acceptability and sustainability for all urban dwellers.

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The water-supply security of many African cities urgently needs to be improved. This reality has been brought starkly into relief by the current crisis in Cape Town, South Africa, where (as a result of a serious surface-water drought and escalating water demand) an urban conurbation of over 3.0 million population is under threat of having its main water-supply shut down with the inhabitants having to queue at policed standpoints to collect and carry 25 lpd/capita. There are believed to be more than 20,000 private boreholes in the area, whose supply is not as critically affected. Thus groundwater resources are still available in extreme drought and could perhaps be requisitioned as a 'public good', if effective governance arrangements and distribution procedures can be established.

Importance of urban groundwater use

Groundwater has been vital for urban water-supply since the first settlements of human history, when it was captured at springheads and by manually excavated waterwells. And the world has witnessed major growth of groundwater use for urban supply in many industrialised nations since the 1950s and in the developing world since the 1980s. The present-day drivers of urban groundwater use are accelerating rates of urbanisation, increasing per capita water use, higher ambient temperatures and reduced river-intake security due to water pollution and climate change, and the relatively low cost of waterwell construction and operation (Foster *et al.*, 2015).

To understand the dynamics of water-supply development (Figure 1), and water-resource accounting, of any given urban area, it is important:

- to recognise that water utilities in developing nations have high levels of 'unaccounted for' water (unauthorised connections and physical losses);

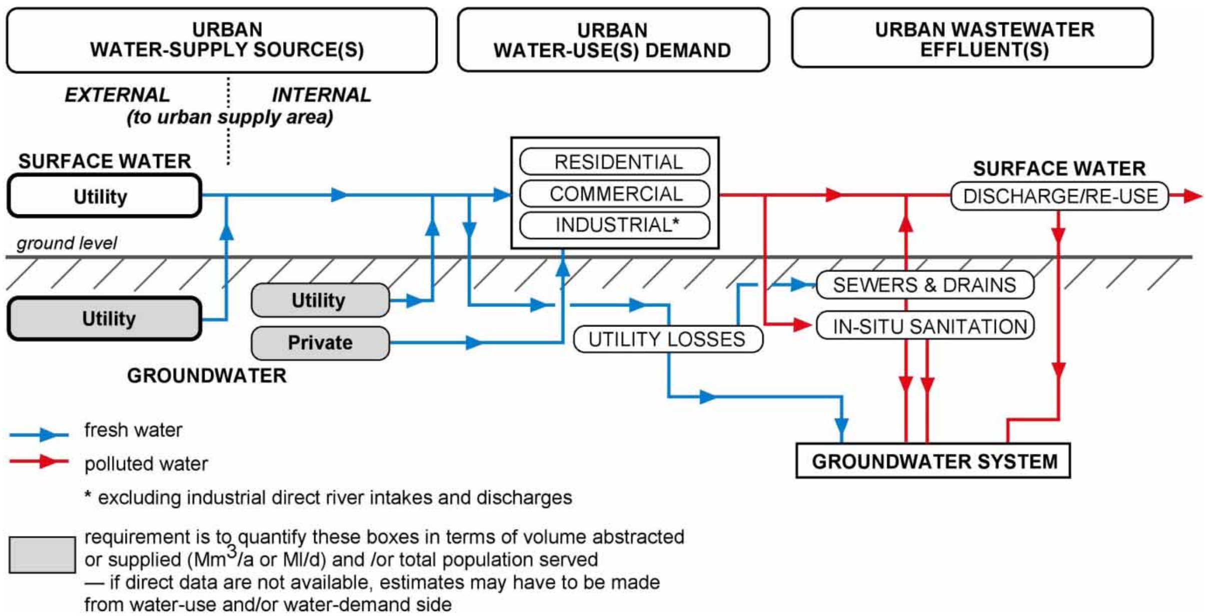

Fig. 1. Schematic overview of urban water-supply sources, uses and interactions.

- to distinguish, under utility groundwater use, between waterwells constructed within the urbanised area and protected external wellfields or springheads;
- to recognise when taking stock of urban groundwater dependency that in any given area it is in a continuous state of evolution on a decadal timescale.

Urban centres underlain and/or surrounded by high-yielding aquifers usually have better mains water-service levels and lower water prices – because of the potential to expand water-supply production incrementally in response to rising demand at modest distribution and treatment cost (Foster, 2009). Thus most towns and smaller cities located in favourable hydrogeological settings will initially have a very high dependence on groundwater for their water-supply.

Urban groundwater use includes not only utility withdrawals, but also private self-supply for residential, commercial and industrial uses, together with irrigated peri-urban agriculture in some instances. In-situ residential self-supply is a growing phenomenon in African cities (Foster, 2009), and in developing nations more generally (Foster *et al.*, 2012). Private supplies from groundwater widely represent a significant proportion of water actually received by users, and their presence has major implications for planning and investment in municipal water utilities. This growth in private urban groundwater use is not restricted just to cities with ready access to high-yielding aquifers.

Urbanisation impacts on groundwater

The processes that comprise urbanisation greatly modify the 'groundwater cycle' – with some benefits and numerous threats. There are rarely sufficient groundwater resources within urban areas themselves to satisfy the water demand of larger cities, and resource sustainability often becomes an issue. Serious localised aquifer depletion can result (especially in semi-confined aquifer systems), with risk of induced seepage of contaminated water, land subsidence or coastal saline intrusion. When confronted by concerns about groundwater resource sustainability and faced by escalating growth in urban water demand, water utilities usually consider both:

- import of additional surface water-supplies from distant sources (usually at high associated capital and revenue cost);
- establishment of municipal wellfields outside cities with capture areas being declared drinking-water protection zones (which requires a high level of inter-agency coordination).

Decisions about urban sanitation and drainage arrangements exert a major influence on groundwater – both as regards recharge rates and quality. For example, planning the change from in-situ to sewered sanitation needs to consider carefully (among numerous factors) groundwater resource sustainability and groundwater pollution vulnerability – although often this is not the case. Where unconfined groundwater systems in use for urban water-supply underlie cities, it will be important to route storm water drainage from roofs and paved areas to soakaways so as to maximise groundwater recharge.

Principal sources of information

Comprehensive, up-to-date and reliable information on groundwater use is not available for the majority of Tropical African cities. Even for water-utility sources (and their operation) available information is at best dispersed, poorly collated, only partial and often dated. And for private in-situ self-supply the situation is even more difficult, with the only information of high reliability coming from a few one-off social-research surveys. The remainder of this section describes in some detail the approaches to data acquisition used in the present scoping study.

IUSSP public-health survey statistics

The IUSSP (International Union for Scientific Study of Population) promotes country-level public-health surveys, which include consideration of domestic water-supply provision and attempt to capture how water-supplies are procured, their temporal reliability and quality hazards. Such surveys of urban water-supply are now more widely available, and generated from systematic sampling of different types of district (involving interviews with 5,000–30,000 households), which are then grossed-up according to population statistics. They represent the best datasets currently available on urban water-supply at national scale. The major source of compiled data for Africa is the World Bank AICD (Africa Infrastructure Country Diagnostic) Databases (Foster & Briceño-Garmendia, 2010; Banerjee *et al.*, 2017).

Unfortunately, all such survey statistics have a number of shortcomings and limitations when it comes to extracting data on urban groundwater use and dependency:

- only the main source of drinking water is recorded, and in many cases householders use two or more sources of water-supply for different purposes or at different times of the year;
- only the proportion of users in each category is estimated, and no indication of the total volume of water used is given;
- there is no explicit indication of which water-supply categories are ultimately derived from groundwater – whilst this is clearly the case for the 'waterwell' category (collection from private or community wells), it is also often the ultimate source of other types of water-supply (such as piped and stand-post water-supplies);
- the surveys tend to focus on formal water-supply systems – and there is a tendency for households not to report direct groundwater use if they perceive waterwells to be illegal.

International AQUASTAT and IBNET databases

AQUASTAT (of the UN-Food and Agriculture Organization) contains information on a country-basis for 'municipal and industrial withdrawals', which is supplemented by limited statistical modelling. This was used to generate 2000 and 2005 estimates for residential water use (AQUASTAT Working Paper of 2011), but the approach does not lend itself to identification of that part of overall water-use supplied from groundwater sources.

UN-Habitat encourages water utilities to compile, share and compare core-cost and performance indicators through IBNET. The main objective is to facilitate access to comparative information that will help promote best practice among water-supply and sanitation providers worldwide, because the sector offers limited scope for direct competition. The IBNET website has a powerful database, but its structure does not make it easy to collate statistics. The only dataset that appears relevant to urban groundwater use assessment is that which refers to water production ('total volume of water produced by and delivered from sources'), but this does not specify sources or identify urban areas explicitly.

Direct approach to local specialists

The serious limitations of the above approach to data acquisition make it necessary to request specific information and datasets directly from local (individual and organisational) contacts. In this study the contacts were identified from the International Association of Hydrogeologists, the African Groundwater Network and the Global Water Operators Partnership Alliance (of UN-Habitat). This direct approach is time-consuming (and to some degree hit-and-miss) but is probably the only one at present that can provide data that have been adequately verified.

Appraisal of groundwater use and dependency

An overview from the AICD

For Sub-Saharan Africa as a whole the most detailed surveys of household water-supply have been undertaken by the AICD Program (Foster & Briceño-Garmendia, 2010), which incorporated 63 large-scale surveys in 30 countries. The AICD employed the IUSSP periodic statistical survey approach, but collected more data on affordability and attempted to assess how water-supplies are procured, their relative cost, temporal reliability and quality hazard.

Scaling-up of AICD surveys provided the first Africa regional estimate of water-supply provision for the rapidly expanding urban population of some 310–340 million (Table 1) and concluded that:

- only 38% of urban dwellers were served by mains water-supply piped to their dwelling, but a further 29% had access to a stand-post within 500 m;
- some 24% of all urban water-supplies are collected directly from waterwells (boreholes or dugwells constructed either privately, communally or by the municipality).

Urban dwellers have to get their basic water-supply from somewhere, and the key question is how suitable are alternative sources from the perspective of the individual householder and of the community

Table 1. Evolution of urban water-supply coverage in Africa (after Foster & Briceño-Garmendia, 2010).

PERIOD	PIPED SUPPLY (all sources)	WATERWELLS (boreholes/dugwells)	STAND-POSTS (all sources)	SURFACE WATER
1990–1995	50%	20%	29%	6%
1996–2000	43%	21%	25%	5%
2001–2005	39%	24%	24%	7%

as a whole. A more up-to-date AICD survey (Banerjee *et al.*, 2017) suggests that urban water-services have declined since 2010, and the proportions dependent on alternative improved sources principally include the following:

- collection from utility water stand-posts and kiosks served from the mains (reaching 35% of the total in some countries);
- pumping of private in-situ water-supply boreholes which in some cases also supply neighbours (often exceeding 20% of the total urban supply, sometimes considerably);
- purchase from licensed private water vendors, which has grown dramatically in some countries of West Africa in recent years to exceed 10% of total urban water-supply.

The main reason for this appears to be rapid urban population growth (averaging 3.6% p.a.) compounded by decreasing household size, resulting in an average growth rate of 5.2% p.a. in dwellings requiring water-supply services.

The latest AICD survey (Banerjee *et al.*, 2017) also suggests notable differences between middle- and low-income countries in the region, and that mains water-supply access is almost universally confined to the 'upper income quintiles'. This appears to be a consequence of the fact that many water utilities have had to strive to recover their investments in expanding water-supply infrastructure and this has required water tariffs that are beyond the financial reach of many urban households. Most households can afford to spend US$2/month on water-supply (equivalent to a subsistence household being charged US$0.4/m^3 for 5 m^3 to cover operational-cost recovery), but when costs exceed this bill, non-payment becomes an acute problem. It is also clear that classic block-tariff structures (with cross-subsidy of basic social provision) are not adequately targeted to help the poor, and in the end often underwrite all household water costs.

Current position in selected cities

Reliable data on urban groundwater use and dependency, both by water-service utilities and private users in Tropical Africa, are for the most part very patchy and poorly collated. To assess the dynamic of utility groundwater use and private waterwell self-supply, it was found necessary to take a city-by-city approach – as far as possible establishing links with local groundwater specialists and/or water-utility contacts. This approach generated data for 10 selected cities for dates during 2012–2016, which are summarised in Table 2. Major groundwater use was reported from the utilities of Abidjan, Dakar, Addis Ababa and Lusaka, whilst numerous other smaller cities (Mombasa, Benin City, Arusha and Dodoma) also reported high groundwater dependency (Table 2). However, the extent to which engineered conjunctive use is practised to improve water-supply security remains very limited. Even in cities currently with only minor utility groundwater use (such as Dar-es-Salaam and Nairobi), a history of poor water-utility service levels has led to the construction of a very large number of private waterwells and significant dependency on groundwater resources.

Quantitative information on private waterwell use was difficult or impossible to obtain and Table 2 is therefore limited mainly to qualitative estimates. To make an objective assessment of direct groundwater use by poorer urban households, it is necessary to make detailed surveys in representative sectors of cities, such as those undertaken in parts of Lusaka (Grönwall *et al.*, 2010) and Accra (Grönwall, 2016).

Table 2. Summary of groundwater use and dependency in selected cities of Tropical Africa.

			WATER UTILITY			PRIVATE WATERWELLS*	
CITY	YEAR of DATA	POPLN (million)	Total supply (Ml/d)	Groundwater (Ml/d)	Service level (coverage/ reliability)	Importance (Ml/d est)	Relative Cost
Abidjan	2013	4.1	285	285 (100%)	good	moderate	moderate
Dakar	2015	3.1	300	210 (70%)	excellent	minor	moderate
Addis Ababa	2013	3.8	300	120 (40%)	moderate	minor	very high
Lusaka	2012	2.8	280	140 (50%)	moderate	major (100–300)	low
Mombasa	2013	1.4	95	95 (100%)	poor	major	low
Arusha	2015	0.6	65	50 (80%)	good	minor	high
Dodoma	2015	0.6	60	60 (100%)	moderate	minor	low
Dar-es-Salaam	2013	3.6	300	30 (10%)	poor	major	low
Nairobi	2016	3.2	550	30 (5%)	poor	major (80–240)	very high
Benin City	2015	1.5	90	45 (50%)	poor	major	low

*Ranging from dugwells where feasible to deep boreholes.

The case of Nigeria is particularly significant in view of its very large and rapidly growing urban population. Here, the level of dependency on private water boreholes is extremely high – having reached some 38–43 million of the total urban population (75–80 million) by 2008–2009, despite the fact that the coverage of public mains water-supply also expanded. In Lagos only about 20% of the population of 18–20 million are served by piped utility water-supply, with about 50% owning private boreholes and another 30% obtaining water from these sources (Healy *et al.*, 2017). There are at least 160,000 (and perhaps considerably more) private water boreholes in operation. Most borehole construction is very low-cost and poor quality by manual augering, with failures being commonplace. This leads to the existence of large numbers of abandoned, unsealed boreholes.

Groundwater use by water utilities

Wherever high-yielding aquifers exist say within 30 km of an urban demand centre, their managed and staged development by the water utility can significantly increase water-supply security (in extended drought or during river-water pollution incidents). Moreover, the modest and phased capital cost of groundwater development will make it more feasible to meet rising water-demand, to reduce water-mains connection charges and to include social ('pro-poor') tariffs.

Given the escalating rates of urbanisation, urban water-service systems will need in future to be both decentralised and planned as 'closed-loop' operational cells (Foster & Vairavamoorthy, 2013). This is particularly relevant for servicing new suburbs with populations in the range of 10,000–50,000. Such systems can be operated to minimise infrastructure costs, energy use, and water losses, since they reduce the distance between household use and water treatment. The natural drought resilience and quality security of deep waterwells mean that they are well suited to be the water-supply source for such systems, and since these systems will also treat wastewater as a resource (with urine separation and recovery as fertiliser and faeces reuse for energy generation), urban subsurface contaminant loads from in-situ sanitation should be substantially reduced. Nevertheless, it will be necessary to put special effort into on-the-ground inspection and control of other forms of urban groundwater contamination (such as petrol stations, small-scale motor shops, dry-cleaning laundries, etc.) to prevent the pollution of important waterwell sources.

Moreover, to make best use of such opportunities will require more water-resource awareness in water utilities, and closer partnership with resource regulators and knowledge centres. Some major African cities (e.g. Dar-es-Salaam and Addis Ababa) have embarked on this course in recent years to explore the development of major new groundwater resources (Kalugendo, 2009; Foster *et al.*, 2012). Elsewhere, even if only lower-yielding aquifers are available, there are strong operational arguments for water-utility expertise to be guiding the construction of individual waterwells, even if not for mains distribution but for communal use by low-income households.

There are also strong arguments for national governments to utilise the organisational and logistic capacity of water utilities by commissioning them to collaborate in the regulation of private urban groundwater use in view of its many potential side-effects on utility operation and finance (Foster *et al.*, 2010). This includes effects on the distribution and trend of water-demand, the opportunities and impediments to revenue collection and the influence on sewer flows and treatment plant. There is also considerable scope for utilising water-utility laboratory capacity to provide a 'water-quality monitoring and advisory service' for private waterwell users and water vendors.

Self-supply from groundwater

In-situ self-supply from groundwater, by private residential, commercial and industrial users, is a major and growing phenomenon in African cities (Foster, 2009; Furey, 2017). Self-supply usually commences during periods when the municipal water-supply service is (or has been) inadequate and not kept pace with growth in demand as a result of very poor service levels (intermittent supply) and/or incomplete coverage. In such circumstances self-supply from groundwater provides a rapid solution by those who can afford it, and soon widely represents a significant proportion of water 'actually received by users'. And once private capital has been invested in waterwell construction and pump acquisition, the use often continues as a means of escaping increasing tariffs, even when water-utility supplies are augmented (Foster *et al.*, 2012).

An important question in relation to urban private domestic self-supply from groundwater is whether it is essentially a 'pro-poor phenomenon' or favours only wealthier households. The answer to this question is far from straightforward – and it involves consideration of physical accessibility, financial affordability, resource sustainability and quality vulnerability, compared to other available sources of basic water-supply.

At first sight one might imagine that the poor would be major beneficiaries of low-cost water-supply technology, at least where usable shallow aquifers provide easy access to groundwater in urban areas. This is to some degree the case but in the majority of hydrogeologic settings the cost of water borehole construction (US$2,000+) is still usually beyond the reach of individual poor households, and they are therefore totally dependent on communal non-governmental organisation (NGO) action and/or neighbour agreement to gain access to the resource. Moreover, detailed surveys reveal that:

- many households in affluent areas are resorting to boreholes (as improved technology reduces waterwell drilling costs) to overcome the poor service-levels offered by many water utilities and later to avoid paying the higher tariffs levied on elevated consumption (Bousquet, 2008; Foster *et al.*, 2012);

- in those low-income districts where the groundwater table is shallow enough, most households are dependent upon 'less safe' hand-dug waterwells, which are far more prone to faecal and chemical pollution from on-site sanitation systems and surface drainage (Grönwall, 2016; Healy *et al.*, 2017; Lapworth *et al.*, 2017).

Urban pro-poor access to safe water-supplies

A regional trend of decreased rates of improved urban water-supply provision has been observed in Tropical Africa during 1990 to 2015 (Banerjee *et al.*, 2017). The urban population that remain 'unserved' with improved water-supply can be usefully divided into:

- those (70–80%) living physically close to the existing infrastructure but who are not willing to meet the connection cost, because of either prohibitive connection costs and/or the insecurity of tenure at their dwelling place;
- those (20–30%) living outside the existing infrastructure where the capital cost for the water utility of extending coverage is too high given the poor prospect of capital cost recovery;
- a third (less well-defined) category whose continuity and reliability of utility water-supply are so poor that they have to make regular recourse to alternative solutions.

Since the urban poor cannot readily afford the cost of either borewell construction (usually US$2,000+) or utility hook-up/connection to dwelling (US$80–200), in general terms they cannot access improved drinking-water sources unless they live within 500 m of a reliable utility stand-post, water-kiosk or community borewell (provided by municipality or NGOs), or a regulated water-vendor is offering a reliable local service. All of these options require quality-control procedures and an affordable tariff.

Groundwater resources – regulated use or 'open access'

The regulation of groundwater use in Tropical African countries is still in its infancy. While in many cases a legal provision will exist such that larger-scale abstraction should require a licence, the operational capacity for enforcement of most water-resource regulatory agencies is extremely weak, and in most cases the operation of small-scale private water boreholes is exempted. Thus, in practice, in most urban areas the current situation can best be described as one of 'open (unregulated) access' – and regulation is becoming more difficult because of both rapid waterwell construction by modern drilling equipment and the fact that waterwell pumps and motors can easily be housed in underground chambers.

In most situations, the main beneficiaries of 'open access' to groundwater are high-income water-users, who benefit from investing in private boreholes to increase water-supply reliability and reduce cost for large-volume use compared to standard water-utility tariffs. A loss of high-tariff revenue by the water utility and thus no economy of scale in urban water-service investments are inevitable consequences. Private self-supply can generate large additional flows to the sewage system and sewage-treatment works (where these exist or are in project), for which no revenue has been generated (unless regulatory provision is made for private waterwells to be licensed and charged) (Foster *et al.*, 2010). Moreover, if private urban waterwells are later abandoned, they can become a major groundwater pollution hazard if not effectively sealed.

A significant public-health hazard can also arise where (as is often the case) urban groundwater quality is seriously compromised (Foster, 2009; Sorensen *et al.*, 2015a, 2015b; Phiri, 2016). Groundwater is widely regarded by the general public and private waterwell users as being of good quality, and household-level treatment (boiling, filtration, disinfection, etc.) of private water-supplies is rarely practised. And while this is usually the case under pristine conditions, in urban areas inadequate sanitation arrangements and industrial wastewater discharge will often have polluted shallow groundwater. Moreover, private water boreholes are often not adequately sited and effectively sealed, which greatly increases their vulnerability to microbiological and/or chemical pollution. Abandoned private waterwells also represent an additional groundwater pollution hazard if not appropriately sealed (Healy *et al.*, 2017). Pollution impacts are greater on poorer households because of their dependence on shallow dugwells. The situation therefore needs to be carefully managed with periodic analytical surveys, and clear recommendations being made in situations where private water-sources should only be used for non-sensitive purposes.

Concluding summary

Water-user perspective

For those in higher-income groups of African cities, the ownership of a private water-supply borehole is a common social aspiration and is widely regarded as:

- greatly enhancing personal water-supply security in the face of an unreliable public water-supply, and properties with operational boreholes or favourably located as regards groundwater access attract higher market-value with estate agents;
- not posing a significant health hazard, because of the widespread perception that groundwater is always of excellent quality, as well as providing drought resilience.

While there is ‘some truth’ in these perceptions, an adequately performing water utility could provide an equally secure water-supply at a comparable cost through making major economies of scale, when compared to the enormous numbers of individual boreholes, pumping plant and fuel tanks involved in urban self-supply. Moreover, the potability of groundwater supplies from private in-situ boreholes in urban areas is always open to question, since they are often polluted from sanitary latrines and/or fuel-oil storage on the same property, and by other processes.

Water-utility perspective

The presence of significant aquifers in and around urban centres offers water utilities the opportunity to develop their groundwater resources progressively and in conjunction with existing surface-water sources to offer greater water-supply security at only modest capital cost. However, it also requires that water utilities become much more active stakeholders in sustainable groundwater management (Foster & Sage, 2017), and in this sense may constrain their selection of appropriate techniques of domestic sanitation and wastewater handling.

However, easy unregulated access to groundwater in urban areas may also result in large numbers of affluent dwellers opting for in-situ self-supply, whose knock-on effects are complex. On the one hand this 'frees up' utility water-production capacity to meet the needs of more marginal low-income neighbourhoods – but on the other hand it seriously impacts utility revenue collection and makes it more difficult for them to mobilise new infrastructure investments and to maintain highly subsidised social tariffs for minimal water use. Moreover, if mains sewerage is (or is planned to be) provided, the operation of self-supply boreholes will generate additional sewer flow for which no charge has been collected.

Public policy perspective

In the developing world in general, and in Tropical Africa in particular, it is important that groundwater resources be used more widely on an efficient and sustainable basis for urban water-supply, since they can play a key role in water-utility adaptation strategies to climate change. In this context it will be important that the large groundwater storage of some aquifers is managed as a strategic reserve and used conjunctively with surface-water sources to improve water-supply security, rather than for base-load municipal water-supply. For this to occur, it will be essential to improve the monitoring, assessment and data accessibility for groundwater resources, commission applied research programmes to improve the understanding of key hydrogeologic processes, and greatly improve political and public awareness and understanding of the critical role of groundwater in climate-change adaptation.

In relation to groundwater management and protection, the following need to be promoted:

- detailed hydrogeological surveys of the resource and quality status of urban aquifers, so as to evaluate directly, on a periodic basis, their sustainability and quality hazards;
- assessment of groundwater pollution vulnerability and drinking-water protection needs, which should be incorporated in the design of more integrated approaches to urban water-supply, sanitation/sewerage and storm-water drainage;
- economic and technical evaluation of direct private self-supply from groundwater, and how it can be better harmonised with utility water and sanitation services.

The results of such work are urgently needed to inform public opinion and policy decisions on the planning of future urban water services.

Governments need to proactively explore ways in which water-utility operations can be expanded so as to include a wider range of 'pro-poor' technical and policy interventions, including all or some of the following:

- structuring connection charges and consumption tariffs to favour a minimum supply of low-income households;
- assessing 'unaccounted-for' water, and especially physical system leakage, and approaches to recovering this resource;
- services to monitor and manage direct self-supply from groundwater (including use metrics, sewer discharges, quality hazards/use suitability);

and in which water utilities can become much more active in working closely with water-resource regulatory agencies on groundwater evaluation and quality monitoring. It is recognised that to make these activities possible the current governance provisions and mandates of some utilities will need to be revised.

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