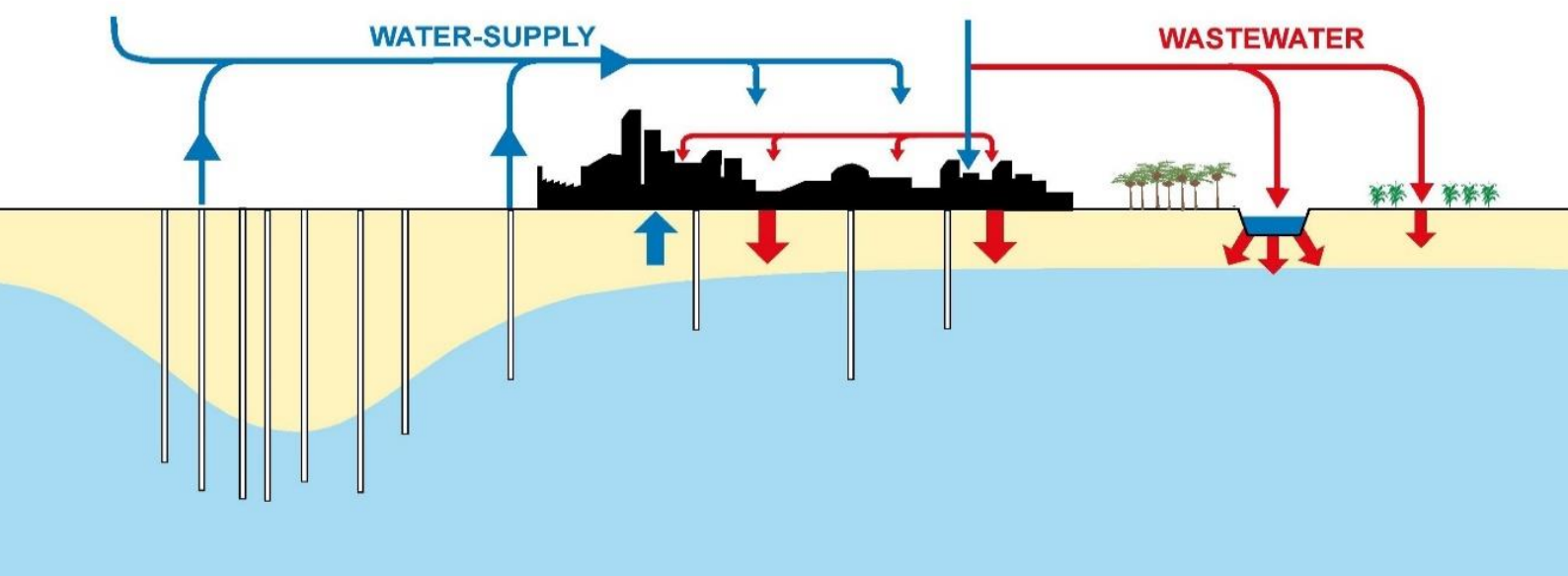


UPGro Working Paper (March 2017)



URBAN GROUNDWATER DEPENDENCY IN TROPICAL AFRICA

a scoping study of pro-poor implications

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produced on behalf of Skat Foundation (UPGro Knowledge Broker) project
number 40805.40-2017; funded by NERC

EXECUTIVE SUMMARY

The AICD provides an excellent overview of trends in urban water-supply in Africa during 2010-15, and addresses in general terms the issues of accessibility and affordability. This scoping study reveals that, within that picture, reliable data on urban groundwater use and dependency, both by the water-service utilities and private users, are for the most part very patchy and poorly collated. To assess the general situation and dynamics of utility water-service versus private self-supply, it was found necessary to take a city-by-city approach, where possible establishing links with local groundwater specialists and water utility contacts. Although time-consuming this approach has been attempted on a pilot scale for the 6 selected cities featured in this report (Lusaka & Kabwe, Dar-es-Salaam & Arusha, Accra & Kumasi). For the appraisal of whether 'open access' to groundwater favours or impedes water-supply provision for poorer households specific surveys in this regard, where they existed for example in parts of Lusaka (2009) and Accra (2015), were found to be of greatest relevance.

Urban dwellers obtain their domestic water-supply from multiple sources, according to availability, cost and season. Among the more affluent private boreholes are increasingly used to improve water-supply security and reduce water-supply cost, where the utility mains service is relatively unreliable and/or expensive for larger consumptions. The effect of this can be either negative (reducing financial income of utilities and thus their ability to fund infrastructure and cross-subsidise tariffs) or positive (easing demand on utility supplies and enabling great mains coverage from existing capital investment).

The presence of high-yielding aquifers surrounding major urban centres unquestionably makes the task of expanding utility water-supply a lot easier, since it enables phased investment, requires much lower capital cost (avoiding advanced water treatment) and provides greater supply-security in drought and from pollution. Water utilities that have developed groundwater rationally are usually able to provide better service continuity at lower operating cost – and this will be to the benefit of all users, especially poorer households if tariff structures and water charging can be appropriately structured.

However, in general, water utilities have struggled to expand water-mains coverage, in response to extremely rapid rates of peri-urban growth. While in the absence of NGO finance, the drilling of water-supply boreholes is widely beyond the financial reach of the urban poor, in peri-urban areas with no other service available there has been major growth in the construction of low-cost dugwells for basic water-supply (often with only poor sanitary protection), together with a spectacular growth in the activities of water vendors (in many cases unregulated and whose product often derives from private waterwells).

The way forward must be to integrate more effectively utility and private investments in urban water-supply expansion, and piped and non-piped solutions to safe water-supply provision. This should involve the establishment of low-income ('pro-poor') policy and technical units in water utilities tasked with pursuing appropriate alternative routes to water-supply provision in poorer neighbourhoods such as:

- efficient construction, operation and maintenance of community boreholes, including the possibility of using appropriately-protected waterwells to supply local distribution networks in fast-growing peri-urban areas
- providing registration and advisory services on the use of private boreholes and dugwells, including quality hazards (whilst recognizing the importance of non-potable water-uses), and charging for private abstraction where effluent discharge to sewers is involved.

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has over 40 years of experience worldwide in groundwater research, policy and advisory work. During 2001-10 he directed the World Bank Groundwater Management Advisory Team (GW-MATE), whose work is now in a dissemination phase under GWP patronage. He received a D Sc from University of London in 1983 and has 7 awards from British, American and international professional societies. In 1993 he was named Visiting Professor-University of London and Foreign Member-Spanish Real Academia de Ciencias, and has received numerous awards from British and international professional associations. Other previous senior appointments include WHO-Groundwater Advisor for Latin America & Caribbean (1986-89) and British Geological Survey-Divisional Director (1990-99). In 1995 he co-founded the UK Groundwater Forum (for multi- stakeholder cross-sector dialogue) and is very active in IAH (worldwide professional groundwater organisation) having been Vice President-Europe (2000-04) and President (2004-08). During 1998-2006 he participated in the EC-DGE Groundwater Working Group on Water Framework Directive Implementation.

Disclaimer: This work was supported by a NERC International Development Innovation and Impact Award 2017 to the existing Skat Foundation mandate as Knowledge Broker for the UPGro programme. The views expressed are not necessarily those of NERC, DFID, ESRC or Skat Foundation.

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1. TERMS OF REFERENCE FOR REPORT

The urban population of Tropical Africa get their water-supply from a mix of sources but failed to achieve the UN-MDG (Millenium Development Goal) in respect of water-supply service. Within this broad context, and conscious of UN SDG-6 (Water) for 2030, the objectives of this rapid scoping study are:

- to assess from existing databases the proportion of the urban population obtaining their water (a) from utility supply piped to their dwelling (b) by collection from utility or municipality operated stand-posts and water-kiosks (c) from communal or private waterwells (boreholes or dug-wells) (d) from water vendors (who may derive their supply from utility or private sources) and (e) from other sources (such as rainwater harvesting or polluted surface water)
- to discuss the implications of these water-supply realities and to assess the groundwater dependence of low-income communities within the urban environment – considering such questions as (a) to what extent is poverty associated with a specific type of water source (b) how dependence on different types of urban domestic water source has changed since 1990 (c) how are changes in groundwater resource status and water-demand trends impacting the poor and (d) who are the winners and losers when access to groundwater changes over time
- to provide the outline a new research proposal to address the issue in a more comprehensive manner, identifying key partners and modes of working.

2. PRINCIPAL SOURCES OF INFORMATION

A number of sources of relevant 'processed information' were explored before making recourse directly to professional contacts in the national water sector of the countries concerned.

2.1 DHS Survey Statistics

The IUSS (International Union for Scientific Study of Population) promote country-level DHS-type surveys, which include consideration of domestic water-supply provision. Urban dwellers must obtain water from somewhere – even if only from inadequate unprotected sources or from over-priced water vendors, and the survey campaigns attempt to capture how water-supplies are procured, their temporal reliability and quality hazards.

Historically, attempts to monitor national progress on access to adequate water-supply were fraught with difficulty, and relied on government estimates which in some cases were notoriously unreliable. With the advent of the UN-MDGs a serious attempt was made to bring empirical evidence to bear on the issue, and the WHO/UNICEF Global Water-Supply & Sanitation Assessment of 2000 provided governments with statistics based on DHS-type household surveys (Foster & Briceño-Garmendia, 2010).

Unfortunately the internationally-available statistics have a number of shortcomings. Some countries have not had regular or recent surveys, and more generally there will also sometimes be doubt about how statistically-representative were the selection of sampling areas and whether the interviewer adequately explained to respondents the choice of water-supply categories and captured any specific local variants. There are also inconsistencies in the terminology used from year-to-year (Table 1) and between countries – which can complicate comparative and/or trend analysis.

The information generated by DHS surveys also have a number of significant 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, including groundwater from unreticulated waterwells for non-potable domestic use (which is thus under reported)
- only the proportion of users in each category is estimated, and no indication of the total volume of water used and for what purposes is given
- no explicit indication of which water-supply categories are ultimately derived from groundwater – whilst this is clearly the case for the 'waterwell' category (which implies collection from private or community wells), groundwater is often the ultimate source of other types of water-supply also (notably the piped water-supply itself and that collected from stand-posts)
- government surveys tend to focus on formal water-supply systems – and there is a tendency for households not to report direct groundwater use when they perceive their waterwells to be illegal.

Table 1: Categories of household water-supply used in questionnaires of successive DHS exercises in Zambia

Year of Survey	1992 & 1996-97	2001-02	2007
Categories of Household Water-Supply used in DHS Surveys	<p>piped to residence</p> <p>public tap or stand-post</p> <p>well at residence</p> <p>public shallow well</p> <p>traditional dugwell</p> <p>springhead</p>	<p>connection to dwelling</p> <p>piped to dwelling plot</p> <p>communal tap*</p> <p>neighbour piped supply</p> <p>open well at dwelling</p> <p>public open well</p> <p>open well of neighbour</p> <p>protected well/ borehole at dwelling</p> <p>protected public well</p> <p>springhead</p>	<p>connection to dwelling</p> <p>piped to dwelling plot</p> <p>communal tap</p> <p>open well at dwelling</p> <p>public open well</p> <p>protected well/ borehole at dwelling</p> <p>protected public well</p> <p>springhead</p>

DHS surveys of the water-supply of urban dwellers are now more widely available, and generated from systematic sampling of different types of district which are then grossed-up according to population statistics. The major source of such data is the UNICEF-WHO JMP (Joint Monitoring Programme) Database and the World Bank AICD (Africa Infrastructure Country Diagnostic) Databases (Foster & Briceño-Garmendia, 2010; Banerjee et al, 2017). Such surveys represent the best datasets currently available on urban water-supply at national scale.

The surveys are undertaken about every 5 years and designed to be nationally representative, involving interviews with 5,000-30,000 households in each country, with the urban/rural ratio depending on the level of urbanization. The surveys are intended to reveal the 'main source of household drinking water' (not necessarily overall water-supply). However, many countries do not include slum settlements because of their 'illegal' or 'informal' status, and thus appear likely to underestimate the urban population without reasonable access to adequate water-supply and sanitation, with the extent of this underestimation varying between countries.

Given these limitations, in some countries communities have organised themselves into what are known as 'federations of the poor', which deploy 'community mapping methods' to collect information on access to water and capture of different water sources, and then use this information to negotiate with authorities for improved services. In some countries local authorities have actually adopted federation data because they are more detailed than those collected by government agencies.

2.2 AQUASTAT Databases

The terms 'urban' and 'water-use' as such do not appear in AQUASTAT – but it does contain information for 2000 & 2005 on a country-basis for 'municipal and industrial withdrawals'. AQUASTAT is essentially a global database that documents statistics reported by countries – but this information is supplemented by limited statistical modelling. This approach was used to generate 2000 & 2005 estimates for affluence-based per capita use to allow estimates for residential water use. The indices used in statistical modelling were 'regional averages', with the exception of the BRIC-nations that were treated separately (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.

It is possible that a very rough estimate of urban groundwater use could be generated from existing AQUASTAT information, if data on the capacity of water treatment plants operated by water-service utilities is

accessed. Their combined production in a given country would equate with the supply from surface-water sources, which when deducted from the total figure would yield the proportion provided by groundwater.

2.3 IBNET Water-Utility Database

IBNET is an initiative promoted by UN-Habitat to encourage water and sanitation utilities to compile, share and compare core cost and performance indicators. It sets forth a common set of data definitions, a minimum set of core indicators and provides software to allow easy data collection, indicator calculation and result presentation. The main objective of IBNET is to facilitate access to comparative information that will help promote best practice among water-supply and sanitation providers worldwide. Inter-utility performance comparison is needed in the water sector, because the sector offers limited scope for direct competition – but efficient, financially-viable, utilities are needed to respond to the challenges of urban growth and connecting the poor.

The IBNET website has a powerful database, but this is currently geared to facilitate benchmarking between water utilities using specific performance indicators and the structure does not make it easy for collating statistics. The database includes a wide-variety of indicators related to water-utility performance mainly in terms of financial efficiency and customer service. But the only dataset which appears relevant to urban groundwater use assessment is that which refers to water production (specifically the 'total volume of water produced by and delivered from sources'). These data are potentially valuable but do not distinguish between groundwater and surface water sources, nor does it identify urban areas explicitly. It may be possible to request this additional information directly from the large number of water utilities listed, but this would require a significant effort on communication and on quality control.

A further problem with IBNET data is that there is no independent verification of data provided by water utilities, with the possibility that some utilities may provide misleading returns to cover certain performance deficiencies, especially as regards extent of urban service coverage and/or service-levels (in terms of supply availability). It would be thus be preferable to integrate IBNET datasets with those obtained from DHS-type surveys.

2.4 Direct Approach to Local Organisations & Specialists

The serious limitations of the above approaches to data acquisition made it necessary to request specific partial information and datasets directly from organizational and individual contacts selected from the following networks: Skat-RWSN, AFGW-Net, IAH and GWOPA-AFWA. This direct approach is time-consuming (and to some degree hit-and-miss) but was extensively used in the current scoping study.

3. URBAN WATER-SUPPLY STATUS & TRENDS

3.1 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 (Africa Infrastructure Country Diagnostic) Program (Foster & Briceño-Garmendia, 2010), which incorporated 63 large-scale surveys in 30 countries. The AICD employed similar surveys to the WHO/UNICEF-JMP (Joint Monitoring Program), namely the IUSS-DHS 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.

In 2010 scaling-up of AICD surveys for the Sub-Saharan African region provided the first regional estimate of water-supply provision (Tables 2 & 3) for the rapidly-expanding urban population (some 310-340 million) with the following conclusions:

**Table 2: Evolution of urban water-supply coverage in Africa
(after Foster & Briceño-Garmendia, 2010)**

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

- 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 500m
- some 24% of all urban water-supplies are collected directly from waterwells (boreholes or dugwells constructed either privately, communally or by the municipality) – the fastest growing category increasing at an estimated average rate of 1.5%/a (and at 2.5-6.5%/a in some countries) but not always 'improved' – and the balance of supply was purchased from water-vendors or collected from 'unsafe surface-water sources'.

**Table 3: Sources of urban household water-supply
– AICD results for selected countries in Sub-Saharan Africa**

COUNTRY * (urban popIn M)	DATE OF LAST SURVEY	PRINCIPAL HOUSEHOLD		WATER SOURCE	
		unreticulated waterwell	Municipal piped	Standpost access	Water vendors
Ethiopia (13)	2005	6%	52%	37%	1%
Ghana** (12)	2003	21%	34%	38%	3%
Nigeria** (73)	2003	48%	15%	17%	11%
Tanzania (9)	2004	19%	22%	45%	8%
Uganda (8)	2001	35%	14%	47%	2%

* data on a further 25 countries are available, but above appear to be the most complete

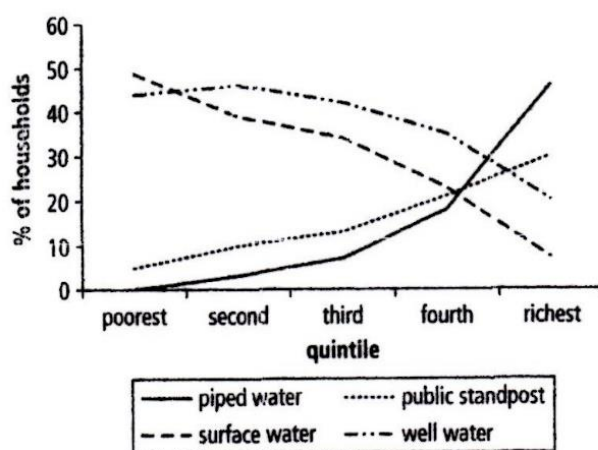
** countries with 'tradition' of groundwater use for urban water-supply

An up-dated AICD survey (Banerjee et al, 2017) suggests that in recent years urban water-services have declined with respect to proportion served, but with notable differences between the middle- and low-income countries, and with mains water-supply access universally confined to the 'upper income quintiles.

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

According to the latest AICD analysis most households can afford to spend US\$ 2/month on water-supply (equivalent to a subsistence household being charged US\$ 0.4/m³ for 5 m³ to cover operational cost recovery). But when costs exceed US\$5/month non-payment of bills becomes an acute problem, and excludes the poorer quintiles (Table 4) – but in South Africa most households can afford at least US\$10/month (for example, if capital-cost recovery is also included a charge of US\$8/month or US\$0.8/m³ for 10 m³ is needed). At regional level this results in a sharp contrast between the water-service access between richer and poorer urban households (Figure 1).

Figure 1: Regional average variation of African water-service provision according to household income in 2009 (Foster & Briceño-Garmendia, 2010)



A key question for African governments is whether they can afford to finance the shortfall on water-service affordability, especially in respect of capital-cost recovery – underwriting this from national taxation in countries like Senegal & Cote d'Ivoire resulted in an economic burden equivalent to around 0.8% GDP in 2009 (Foster & Briceño-Garmendia, 2010).

Table 4: Affordability of improved urban water-supply in selected countries (after Banerjee et al, 2017)

COUNTRY	PROPn with IMPROVED SUPPLY		AFFORDABILITY of IMPROVED SUPPLY		AFFORDABILITY of PIPED SUPPLY	
	AICD	JMP	Propn	Quintile	Propn	quintile
Ghana	92%	88%	72%	2 nd -5 th	34%	3 rd -5 th
Tanzania	98%	85%	67%	1 st -5 th	22%	4 th -5 th
Zambia	62%	86%	83%	3 rd -5 th	46%	4 th -5 th

It is also clear that classical block tariff structures (with cross-subsidy of the basic level of social provision) are not adequately targeted to help the poor, since in the end they underwrite the cost of service provision to all households.

Urban dwellers have to get their basic water-supply requirement from somewhere, and the key question is how suitable are the alternatives from the perspective of the individual householder and of the community as a whole. Improved alternative sources are principally the following:

- collection from utility or community water-supply boreholes, which is a major source reaching 35% of the total urban supply in some countries
- collection from utility water stand-posts and kiosks served from the mains, also of major importance reaching 35% of the total in many countries
- purchase from licensed private water vendors, which has grown dramatically in some countries of West Africa in recent years to exceed 10% of the total urban water-supply.

The case of Nigeria (Table 2) is particularly significant in view of its very large and rapidly growing urban population. Here the level of dependency on unreticulated waterwells had increased from about 38 to 43 million of the total urban population (75-80 million) by 2008-09, despite the fact that the coverage of public mains water-supply had also expanded.

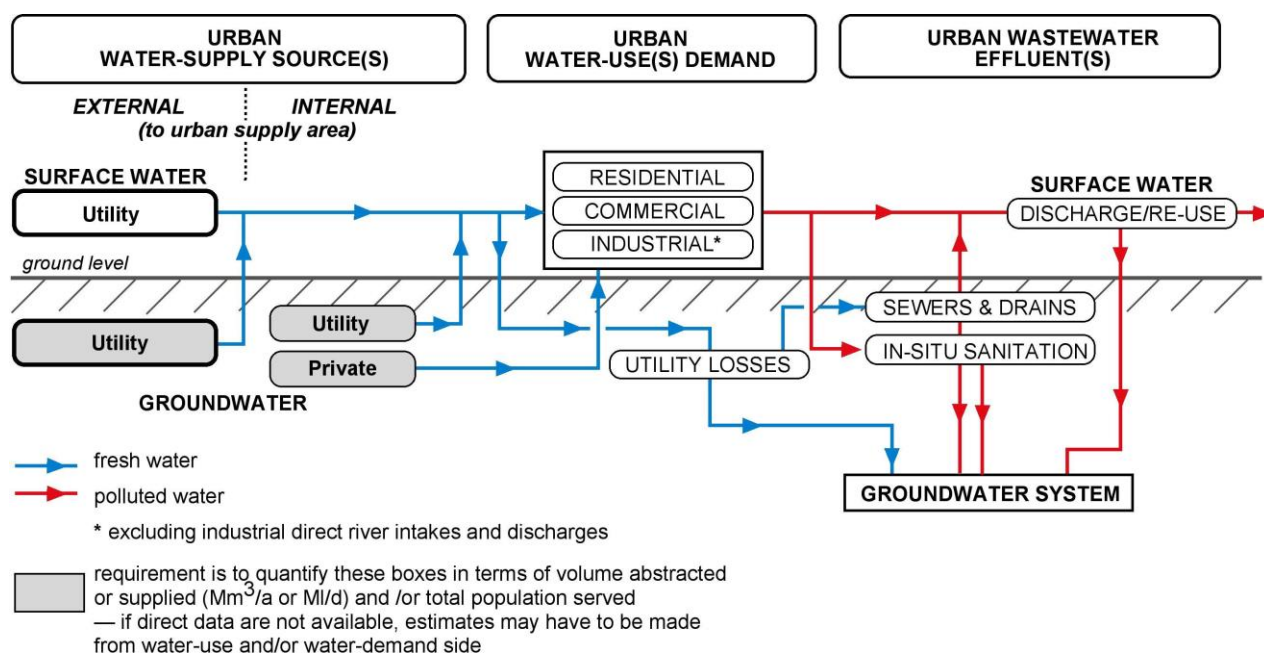
3.2 Modes of Urban Groundwater Use

Groundwater has been a vital source of water-supply since the very first urban settlements of human history – when it was captured at springheads and by shallow manually-excavated waterwells. And the world has witnessed a major growth of groundwater use for urban supply in many industrialised nations since the 1950s and in the developing world since the 1980s.

The principal modes of use of groundwater in urban areas are summarised in Figure 2. To understand the dynamics of urban water-supply development and water-resource accounting it is important:

- not to overlook the potential significance of private self-supply from groundwater, not just for industrial purposes (which is more traditional) but also by residential and commercial users
- to appreciate that urban water utilities in the developing world (and some in the industrialised nations) have high levels of 'unaccounted for' water (often > 30% and up to 50% of the original supply), which comprise both (a) illegal or unauthorised connections and (b) physical losses from the distribution system to the ground.

Figure 2: Schematic overview of the sources and uses of urban water-supply

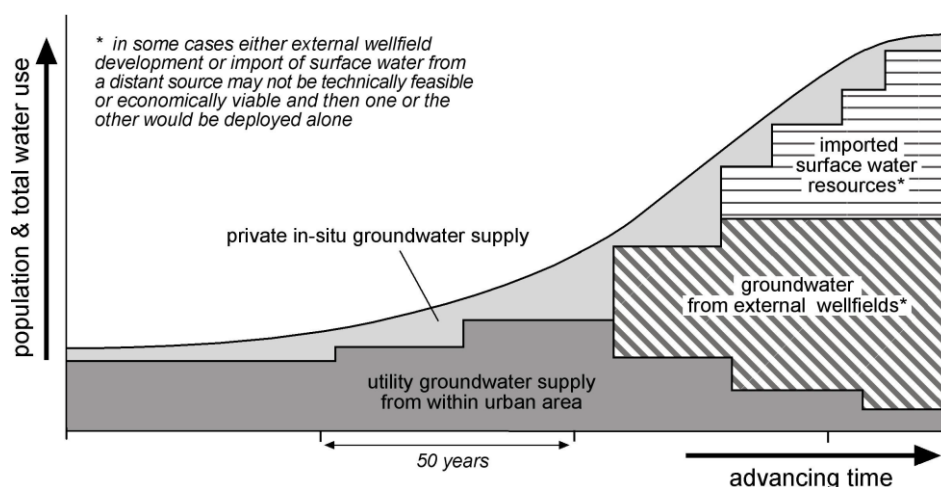


- to distinguish within utility groundwater use between (a) waterwells constructed within the urbanised area often on a piecemeal basis in response to urban growth and (b) imported from designed and protected 'external wellfields or springheads' as part of a long-term strategy for water-supply development – the former tends to be the norm in developing nations, whilst most developed countries moved progressively towards the latter condition some decades ago in efforts to improve water-supply security and to reduce greatly the risk of serious groundwater source pollution.

When attempting to take stock of urban groundwater use and dependency, it is also important to recognise that the situation in any given urban area is in a continuous state of evolution on a time-scale of decades (Foster, 2009).

3.3 Drivers & Constraints on Groundwater Exploitation

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 at modest distribution and treatment cost in response to rising demand (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 (Figure 3).

Figure 3: Typical evolution of groundwater use and dependency with population of urban area

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.

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 water-demand in larger cities, and resource sustainability has often become an issue. Serious localised aquifer depletion (especially in semi-confined aquifer systems) results, 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 (a) import of additional surface water-supplies from distant sources, usually at high associated capital and revenue cost and (b) establishment of municipal wellfields outside cities (with capture areas being declared drinking-water protection zones), which requires a lot of coordination between the water-sector and agencies controlling land-use. But in the developing world the introduction of such major new schemes often encounters impediments when it comes to raising financial investments and to overcoming institutional impediments.

Urban groundwater use includes not only utility withdrawals, but also private in-situ self-supply from groundwater for residential, commercial and industrial uses. In-situ residential self-supply is a major and growing phenomena in developing nations where 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.

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. The growth in private urban groundwater use is not restricted just to cities with ready access to high-yielding aquifers, but is often even more pronounced where only minor shallow aquifers occur (Tuinhof et al, 2011; Foster et al, 2012).

In the developing world it is important that groundwater resources be used more widely on an efficient and sustainable basis for urban water-supply, since as such they can often play a key role in water-utility adaptation strategies to climate change. In this context it will be vital that:

- effective demand management measures are introduced to constrain inefficient and unnecessary use and reduce 'unaccounted for' water
- 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.

3.4 Quantifying Urban Groundwater Use & Dependency

The term 'groundwater supply' is usually taken to include water pumped or overflowing from all types of waterwell or borehole (irrespective of their depth and construction), together with all water captured by springheads or galleries. However, it should be recognised that in periods of extended dry weather the baseflow of rivers (or at least those not regulated by surface-water empoundments or transfers) is also groundwater-derived. To provide an indication of the level of dependency, the population of areas supplied by groundwater sources alone is quoted as the 'groundwater-dependent population', but there is usually also a substantial proportion of the population receiving their water-supply from both groundwater and surface-water sources (depending on the time of year and other factors), and this can thus be misleading. However, for Tropical Africa the current study concludes that data collection and compilation by urban water-service utilities on water source types, abstraction and status (as opposed to water distribution and users) is at best patchy and at worst deficient – with many utilities apparently demonstrating a degree of apparent 'water resource illiteracy'.

Clearly, quantification of private groundwater use and dependency has to use a different approach – because of the often very large numbers of individually small waterwells involved and the fact that they are pumped intermittently (and sometimes seasonally) for few hours per day. Representative household surveys are required to make estimates of use, and these can be grossed-up to urban areas of similar properties.

4. ANALYSIS OF DATA FOR SELECTED CITIES

In attempting to establish an inventory of groundwater dependency, both of the water utility and of private users, it was necessary to work on a city-by-city basis, recognizing the inherent limitations and potential errors in the corresponding databases (Box 1).

Box 1: Potential Sources of Inconsistency and Error in Urban Groundwater Data

A: Definition of Urban Boundaries

The IUSS, who promote periodic country DHS surveys, do not attempt to standardise the term 'urban', but simply note that (a) 'large or mega-cities' usually include all continuous urban areas with a population of 1,000,000 and above, whilst 'small cities' usually include all population centres in the range 100,000 to 1,000,000 and (b) in some cases towns with populations in the range 10,000 to 100,000 are also included. Another common difficulty when trying to account systematically for urban groundwater use is that national records and local computations are not explicit or consistent about boundaries used, with potential confusion in larger cities over whether the stocktaking refers to:

- the main urban municipality concerned
- the metropolitan area of the same name, comprising an agglomeration of various municipalities
- the area currently served (or potentially served) by the corresponding water- service utility.

B: Household Surveys & Utility Records

The statistical basis on which DHS household surveys are founded only allows estimation of the proportion of user groups obtaining their domestic water-supply from a given type of source, and there is no indication of the volumetric use or the purpose(s) for which the water is used, nor is their clarity about whether some source categories are groundwater or surface water.

Utility groundwater use is usually reported in one of two ways:

- aggregate annual abstraction (usually metered and expressed as Mm³/a), which is the most balanced statistic
- maximum production capacity (usually estimated from waterwell yield potential and expressed in l/s or Ml/d), which may be a better indication of the potential role of groundwater in meeting drought demand.

But these volumes are not those actually received by the users, because of elevated physical distribution losses, which are often not recorded or 'lost' somewhere in 'unaccounted-for' water.

The preliminary summary data in Table 5 are the best available for the selected cities (which are discussed in more detail below).

Table 5: Summary of groundwater use and dependency in selected cities

CITY (population)	LUSAKA (1.94 million)	KABWE (0.22 million)	DAR-ES-SALAAM (3.80 million)	ARUSHA (0.42 million)	ACCRA (3.90 million)	KUMASI (2.40 million)
Year	2011	2015	2013	2012	2015	2007
Water Utility	LWSC	LGWSC	DAWASA(CO)	AUWSA	GWCL	GWCL
Utility Water Supply	270 MI/d	~ 50 MI/d	290 MI/d	175 MI/d	360 MI/d	90 MI/d
Utility GW Propn	45%	100%	10%	80%	<5%	0%
Private Supply	100-300 MI/d	? 10 MI/d	110 MI/d	?? MI/d	? 15MI/d	? 25 MI/d
Overall GW Propn	60-75%	100%	35%	? 85+%	? <5%	? >20%
Comments		LGWSC water-production includes other smaller towns	major new ground-water prospect under development		Greater Accra MA much larger population	high excess demand compared to GWCL production

4.1 Zambia

Zambia comprises 9 provinces and each is serviced by a commercial water-service utility (except for Copperbelt Province which has 3 utilities). All but one of these utilities extracts its water-supply from both surface water and groundwater sources – and for the majority of utilities groundwater plays a major role (Table 6).

Table 6: Zambia – estimated groundwater use by some urban water utilities

(based on Zambia National Water Supply & Sanitation Council–Urban Sector Report 2010-11, with much additional information through personal communication with utility operational staff)

UTILITY (with no. towns/ municipalities served)	TOTAL POPLN (million)	UTILITY		WATER-SUPPLY Overall Unaccounted -For	#	
		Total Rate of Supply (M m ³ /a)	Propn of Groundwater		Total Popln Served (million)	Service Level (hr/d)
Lusaka (4)	1.94	98.6	60%	43%	1.46	18
Kafubu (3)	0.65	55.5	55%	49%	0.57	15
Mulonga (3)	0.45	60.0	60%	40%	0.40	17
Lukanga (6)	0.38	24.8	60%	58%	0.25	21
North-Western (7)	0.24	3.9	50%	34%	0.17	23

in most of the urban municipalities and towns listed there are also a large number of private residential and commercial water boreholes and dugwells

The information provided does not include estimates of private in-situ self-supply from groundwater – yet thousands of people (both rich and poor) obtain or supplement their water-supply from shallow waterwells and deeper boreholes. For example, it is estimated that 80-350 MI/d of groundwater is pumped by private users in Lusaka alone, compared to the 220 MI/d provided by the water-service utility (according to the Environmental Council of Zambia). The Department of Water Affairs has records for 1,900 private water

boreholes, and there are 1,000s more drilled by unregistered drilling contractors. Many households do not reveal that they have a private waterwell, because they fear action by the authorities on grounds of health concern.

The most recent DHS exercises from Zambia (at about 5-year intervals during 1992–2007) provide some examples of the difficulties that can be encountered – for example, standard survey proforma did not explicitly include all water-supply sources used by urban dwellers and categories changed somewhat in successive surveys. In the DHS 2007 exercise, 77% of urban water users responded that they (mainly) obtained their water-supply from a ‘piped source’ and only 18% were directly dependent upon groundwater (from stand-alone open or protected wells). However, in Lusaka about 55% of the ‘piped water’ distributed by the public utility is drawn from boreholes (indirect use of groundwater) and that reticulated to ‘communal taps’ comes partly from groundwater. Also the DHS 2007 exercise did not explicitly include the option for respondents to answer that they purchase water-supply from a ‘water-kiosk’ – yet this has become commonplace among more than 65% of the population of the city’s various low income areas.

4.1.1 Lusaka

- Lusaka, the Zambian capital, grew in population from about 0.5 million in 1978 to 1.7 million in 2009, and now has about 70% of its population in slum settlements (‘compounds’ with 30-year land tenure). The Lusaka Water & Sanitation Company (LWSC) managed to increase water-supply coverage from 34% to 50% between 2003 and 2007 (with about 70,000 new connections), and also introduced satellite systems from stand-alone boreholes in some peri-urban areas.
- It currently obtains 70–90 MI/d from a Kafue River intake/treatment plant and 130 MI/d from 72 deep boreholes into the major karstic limestone aquifer which underlies of the southern part the city. A further 80–350 MI/d of the total urban water-supply are estimated to be drawn from some 1900 registered private boreholes (and there are also a large number of shallow dugwells without register or monitor in areas where the water-table is at less than 3m depth). Thus overall groundwater provides about 70% of total supply, with the maximum demand put at about 400 MI/d. There are significant and widespread groundwater fecal contamination problems derived from in-situ sanitation (including periodic cholera outbreaks), together with slightly-elevated geogenic fluoride and locally excessive heavy metal and trace synthetic organic pollution.
- LWSC have some 50–60% water ‘unaccounted for’ and poor revenue collection (<70%). Those households connected to mains network are metered or charged by housing rateable value. An important initiative of LWSC was the creation of a ‘Pro-Poor Unit’, which reviews affordability of water-supply and has put in place water-kiosks with subsidised tariffs (US\$ 2.10/month or US\$ 0.25/m³ compared to dwelling tap at US\$0.34–0.59/m³ according to consumption), and taken other social action to facilitate low-cost water-supply. Nevertheless a large number of poor households still rely on unimproved shallow dugwells for much of their water-supply.
- Other household water sources include (a) communal taps, whose access is to a defined user group paying US\$ 1.70 per month flat rate (b) community-based schemes based on boreholes at settlement level, provided by NGOs under approval of the municipal council and guidance of NWASCO and (c) private boreholes, which have increased amongst the upper income quintiles to overcome discontinuity of LWSC supply.

4.1.2 Kabwe

- The city of Kabwe, a long-standing centre of lead, zinc and other heavy metal mining, has grown from 0.17 million in 1990, to 0.20 million in 2010 and 0.22 million in 2016, with a major slum settlement (Makululu) now being home to around 50,000. The Lukanga Water & Sewerage Co. (LGWSC) provides the public water-supply (Table 6) and produced some 26 Mm³/a for an urban mains coverage of about 70% in 2010. Its dwelling tap tariff ranges from US\$ 0.26-43/m³ according to consumption.
- In the case of Kabwe the supply is wholly from groundwater obtained from deep boreholes into a karstic dolomitic limestone (with a shallow water table at 5-10 m depth and covered by some 5-20 m of saprolitic weathering deposits) in the vicinity of the city.
- The main modes of urban water-supply are 'piped to dwelling' and 'collected from stand-post or water-kiosk', but there is also a fairly elevated level of self-supply from dugwells and from private boreholes in affluent neighbourhoods.
- Overall the service provision level is relatively high, but there are concerns about faecal pollution of groundwater from shallow dugwells in particular, given the high vulnerability of the aquifer system and the predominant (~90%) dependence on pit latrines for urban sanitation. There have been various programmes for improving the surface completion of communal and domestic dugwells, provision of hand-pumps rather than bucket access, supplementary domestic water disinfection in household and awareness campaigns on use precautions of dugwell water-supply.

4.2 Tanzania

4.2.1 Dar-es-Salaam

- Dar-es-Salaam recorded a population of 2.5 million in the 2002 census, but since then it has been growing at a rate of 4.3% pa and reached 4.0 million in 2013, with perhaps 70% being concentrated in slum settlements. The water-service utility DAWASA (and DAWASCO operating company) have two intakes on the Ruvu River providing 65 & 75 Ml/d and the Mtoni river source which is rated at 110 Ml/d, providing total surface-water sources of 260 Ml/d, together with various boreholes in the urban area rated at 30 Ml/d for emergency use. DAWASA domestic tariffs are US\$ 0.50/m³ for piped service to dwelling to US\$ 0.30/m³ for collection at water-kiosks.
- Current demand is put at about 310 Mm³/a compared to the utility production potential of 200 Mm³/a and distribution losses of 95 Mm³/a (about 50%). Thus many people rely on community and private unreticulated borehole sources, which are estimated to produce about 110 Ml/d. DAWASA is developing a new major groundwater wellfield some 25-40 km south of the city with the prospect of producing 260 Ml/d (Tuinhof et al, 2011).
- Access to an improved water-supply is put at between 50-65%, with major problems arising in the slum settlements. The lower-incomes quintiles rely mainly on communal stand-posts and water-kiosks for their supply, but purchase of small volumes from informal water vendors and collection from unimproved waterwells are on the increase (Mushi, 2013). Thus DAWASA is endeavouring to increase the number of stand-alone boreholes – these are then handed over to community cooperatives for operational management, although problems often arise with pump maintenance and long-term operational support agreements are needed.

4.2.2 Arusha

- Arusha in northern Tanzania (2012 population of 0.42 million) has arguably one of the best water-supply services in East Africa. The AUWSA (the Arusha Water & Sewerage Authority) has about 45% urban coverage and achieves a 24 hours/day service for most of the year except in the rainy season. The maximum demand is put at 93 MI/d. In 2017 the AUWSA operated 16 deep waterwells (each mainly yielding 10-40 l/s and providing 32% of the total supply), 3 springhead captures (providing 48% of the total supply) and a river intake/treatment works (usually providing some 35-45 MI/d of about 20% of the total supply). The groundwater sources experience some problems with elevated geogenic fluoride contamination.
- The domestic water-supply tariff for those receiving piped supply to dwelling is from US\$ 0.39/m³ to US\$ 0.53/m³ for higher consumption plus a service fee of US\$0.98/month/ connection – while collection from water-kiosks is charged at US\$ 0.30/m³ plus a one-off registration charge of US\$ 5.82.

4.3 Ghana

4.3.1 Accra

- Accra, the capital of Ghana, has grown rapidly in population in recent decades in excess of 3.5% pa – from around 1.0 million in 1985, to 1.7 million in 2000, and approaching 4.0 million in 2015. If the entire Greater Accra Metropolitan Area, including all the outlying townships such as Ashiaman, Teshia, Dodowa, Tema, Mendir, Nungua, Lashibi, Doma & Taifa is considered (many of which are slum settlements) then the population is much higher and the total demand is estimated to be around 450-500 MI/d.
- The Ghana Water Co Ltd (GWCL) has intake and treatment plants on the Weija Lake & Volta River producing around 165 & 190 MI/d respectively, together with deep boreholes in Dodowa producing 2 MI/d, and about 20% of the population have household connections (although only a part of these have a continuous service).
- Groundwater resources in the weathered crystalline basement aquifer are limited, and the aquifer tends to yield saline groundwater in the southern part of the city – thus the proportion of the population using boreholes and dugwells is limited. With the unreliability of the GWCL supplies at stand-posts and water-kiosks in many districts, an increasing number are dependent on private water sales from tankers, at kiosks and in sachets (Table 7). Whilst GWCL supplies remain the cheapest available with the 'social tariff' set at US\$ 0.44/m³ (US\$ 0.70/m³ for large volumes), many have to resort to purchase from water vendors in various forms charging US\$ 1.50 to 6.50/m³ (Nyanko et al, 2008).
- No comprehensive data on Accra water-supply arrangements are available from the Ghana Water Co Ltd (GWCL), but a highly relevant study of water-supply in one township, Dodowa of about 50,000 population and an average household income of US\$ 265/month, has been recently made (Grönwall, 2016). Since the 1960s, and until fairly recently, Dodowa was self-sufficient as regards water-supply utilising boreholes drilled to 15-80 m depth in the weathered crystalline basement – the larger yielding of which were normally used after Fe/Mn removal to feed community stand-posts. In addition there were a number of WRC licensed boreholes supplying commercial premises and water-bottling companies, together with around 45 private dugwells (where these yield < 5 l/s no abstraction license is required).

Table 7: Modes of water delivery in Greater Accra Metropolitan Area (from Adank et al, 2011)

SERVICE TYPE & PROVIDER	PROP. OF POPULATION ESTIMATED	
	drinking water	general domestic
<i>GWCL or community household connection</i>	51%	56%
<i>GWCL stand-post/kiosk</i>	35%	31%
<i>private vendors kiosk/tanker</i>	4%	9%
<i>private sachet-water purchase</i>	9%	1%
<i>boreholes and dugwells</i>	1%	2%
<i>other polluted</i>	0%	1%

- In 2015 GWCL completed the Kpong water-supply expansion scheme, providing 300 Ml/d for Greater Accra and enabling a piped supply to be offered to Dodowa households, although connection charges were considered prohibitive by most. A survey in 2015 suggested that householders obtained their water-supply from various sources (Table 8), with a (superficially) surprising recent trend being prefer vendor 'sachet water' on grounds of quality or taste.

Table 8: Household sources of domestic water-supply in Dodowa, Greater Accra-Ghana

WATER-SUPPLY SOURCES (household utilization)	MAIN PROVIDER & GOVERNANCE
<p>pipd-supply from Kpong surface water (15% to dwelling; 56% at stand-posts)</p> <p>bottled or sachet water (96%)</p> <p>borehole with motor- or hand-pump (20%)</p> <p>dugwell with buckets(38%)</p> <p>water-tanker (<5%)</p> <p>rainwater harvesting (<5%)</p>	<p>GWCL – in most cases re-sold by neighbour and/or purchased at public stand-post</p> <p>private vendor (usually registered)</p> <p>community or self-supply</p> <p>self-supply or community</p> <p>unregistered private vendor</p> <p>self-supply</p>

4.3.2 Kumasi

- Kumasi, the second largest city of Ghana, reached a population of around 2.5 million by 2007, including 33 suburbs which were mainly slum settlements. In 2000 the GWCL (Ghana Water Co Ltd) operated a supply of 32 Mm³/a with 40-60% system losses, from two main surface-water sources – the Barekese & Owabi reservoirs and treatment plants rated at 80 Ml/d and 15 Ml/d respectively, but current total production is put at 73 Ml/d.
- By 2008 the urban demand was estimated to be 76 Mm³/a, only about 40% of which can be met by the existing GWCL production capacity (Akumiah, 2007). In the areas of wealthy houses and government buildings (30%) the population uses piped utility water to premises and water-supply boreholes (with a capital cost of about US\$ 2,000 for 8 m depth including hand-pump). Whereas in the slum settlements (70%) the population depend mainly on unimproved sources, such as dugwells of 3m depth and rainwater harvesting (Kuma et al, 2010). There would appear to be scope for the water-utility to develop local groundwater resources of modest yield in the very deeply-weathered crystalline basement rocks of the area to support water stand-posts and local reticulation systems in outlying suburbs. There has also recently been a major growth of water vendors, who still operate without clear regulatory control as regards acceptable sources, containers and prices.

5. GROUNDWATER USE – A ‘PRO-POOR PHENOMENON’ ?

5.1 Water Utilities & Groundwater Resources

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 currently escalating rates of urbanisation, urban water service systems will probably need to be both more decentralised and planned as ‘closed-loop’ operational cells. This is particularly relevant for servicing new suburbs with population in the range 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. They can also promote energy and nutrient recovery by converting current liabilities, such as energy required for wastewater treatment, into assets, such as energy recovery from wastewater treatment, and facilitating local wastewater reuse. A decentralised urban water-service paradigm will also increase adaptive potential if clusters are added in stages to meet growing demand. The natural drought resilience and quality protection of many aquifers and deep waterwells means that they are well suited to be the water-supply source for such systems, and since these systems will treat wastewater nutrient content as a resource by separating urine from faeces and recovering it for sale as fertiliser, their installation should substantially reduce the urban subsurface contaminant load for in-situ sanitation (and thus one major groundwater pollution threat). Nevertheless, it will also be necessary to put a special effort into on-the-ground inspection and control of other forms of urban land and groundwater contamination, such as gasoline stations, small-scale motor shops, dry-cleaning laundries, etc., to prevent the loss of important waterwell sources.

However, to make best use of such opportunities will require more water-resource awareness in water utilities, and closer partnership with groundwater resource regulator and knowledge centres. Some major African cities (eg. Dar-es-Salaam and Addis Ababa) have embarked on this course in recent years to explore the development of major new groundwater resources. 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 connected to the mains distribution system) for communal use by low income households in particular.

There are also strong arguments for national governments to utilize the organizational 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. This includes effects on the distribution and trends in water-demand, the opportunities and impediments to revenue collection and influence of sewer flows and treatment plant. There is also considerable scope for utilizing water utility laboratory capacity to provide a ‘water-quality monitoring and advisory service’ private waterwell users and water vendors.

5.2 Self-Supply from Groundwater

A very important question in relation to urban private domestic self-supply from groundwater is – whether it is essentially a ‘pro-poor phenomenon’ or favours more rich 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 is still usually beyond the reach of individual poor households (Box 2), and they are thus totally dependent on 'communal NGO action' and/or 'neighbour agreement' to gain access to the resource.

Box 2: Trends in the Cost of Urban Waterwell Construction

The relatively high-cost of private waterwell drilling (compared to that in South Asia) has been identified as a critical factor constraining domestic groundwater use in African cities (Table 5). In more recent years there have been some significant reductions in some cities and increases in others.

Table 9: Waterwell construction costs in Sub-Saharan Africa (Tuinhof et al, 2011)

TYPE OF WATERWELL	DEPTH, DIAMETER & YIELD RANGE	CONSTRUCTION DETAIL	TOTAL COST (US \$)
shallow tubewells/borewells for domestic and village water-supply	20 - 50 m depth 100 - 150 diameter 0.1 - 0.5l/s yield	<ul style="list-style-type: none"> plastic lining & part unlined hand pump 	3,000 -5,000
deeper tubewells for village and small-town water-supply or minor irrigation	50 - 150 m depth 100 - 250 diameter 1 - 10l/s yield	<ul style="list-style-type: none"> pvc or steel lining electric or diesel-engined pump 	15,000 - 25,000
deep tubewells for urban water utilities, industrial use or large-scale irrigation	150 - 250 m depth 200 - 400 diameter 20 - 100l/s yield	<ul style="list-style-type: none"> purpose-designed high capacity submersible pump 	25,000 - 100,000 (or sometimes more)

For example in Lusaka there are now about 150 waterwell drilling companies, operated by experienced India personnel but using mainly relatively old equipment. This has lowered waterwell costs to between (the equivalent of) US\$ 1,500 for a 50m borehole installed with a low-cost electric pump to US\$ 3,500 for a deeper borehole with a more reliable electric submersible pump. Shallow dugwells equipped with a hand-pump usually around US \$500.

By way of contrast in Nairobi, where groundwater levels fell notably between 1970 and 2010, much deeper water boreholes are required. A typical borehole yielding 1-2 l/s would now be some 200 m in depth and cost US\$ 12-15,000 with submersible pump installed. Nevertheless, large numbers of water boreholes are being drilled by medium-sized industries, apartment blocks and commercial premises because of the inadequate service levels of the water utility (which is faced with a lack of major capital investment to cope with rapid urban expansion and escalating demand). There is significant uncertainty about the overall current rate of groundwater abstraction in Greater Nairobi, but some put it in the range 30-50 Ml/d, and it is believed to have peaked at around 85 Ml/d in the water crisis of 2002.

In West African cities a high level of private water-borehole drilling is also reported. Despite unfavourable hydrogeologic conditions in Accra, with saline groundwater in the southern part of the city, costs for an equipped system are said to be mainly in the range US\$ 7-12,000. Nigeria has a very large and rapidly growing urban population, and by 2010 was reporting that more than 40 million urban dwellers were dependent upon unreticulated waterwells, although no systematic data is available on more recent trends and current costs.

Moreover, detailed surveys reveal that:

- large numbers of households in affluent urban areas are resorting to in-situ self-supply from groundwater (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 high consumption – and these affluent households are more likely to construct better-protected deeper boreholes
- 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 fecal pollution from on-site sanitation systems and surface drainage.

When large numbers of more affluent dwellers opt for in-situ self-supply in urban areas the knock-on effects are complex. On the one hand it ‘frees-up’ utility water-production capacity to meet the needs of more marginal low-income neighbourhoods – but on the other hand the same phenomena ‘reduces utility revenue collection’ and makes it more difficult for them to make new infrastructure investments and to maintain highly-subsidised social tariffs for minimal use.

5.3 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%) that live 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%) that live 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 is so poor that they have to make regular recourse to alternative solutions.

Since the urban poor cannot readily afford the cost of either borewell/dugwell 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 500m of a reliable utility stand-post or water-kiosk
- live within 500m of a community borewell provided by the municipality or a NGO
- a regulated water-vendor is offering a reliable local service

and all of these options require quality control procedures and an affordable tariff.

The ‘traditional’ inverted tariff for water-supply services – with a cross-subsidy between the ‘social tariff’ and standard high-use tariffs – has not been a major help as regards water-supply affordability for poor households, since it is poorly targeted and has the effect of providing an element of subsidy over a wide range of income quintiles. Access to utility piped water-supply to dwelling is entirely confined to the upper income quintiles – given that for example the current limits on household water-service expenditure in Tanzania, Ghana & Zambia are US\$ 1, 2 & 3/month respectively. All other households have to depend on

alternative water-supply sources, such as utility stand-posts or water-kiosks, community borewells and water vendors. In reality most urban consumers depend on combinations of all these sources according to availability, season and price.

5.4 Consequence of 'Open Access' to Groundwater

In the most situations, the main beneficiaries of 'open access' to groundwater are high-income water-users, who benefit from being able to invest in private boreholes to increase supply reliability and reduce cost for large-volume use compared to standard utility tariff. A loss of 'high-tariff revenue' by the water utility and thus no 'economy of scale' in urban water-services investments is an inevitable consequence, and 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). However, large-scale private self-supply from groundwater can have the indirect effect of relieving demand pressures on the water utility, especially in critical districts and where large point demands exist from industrial, commercial and recreational users. There is also a public-health hazard where groundwater quality is seriously compromised, which impacts more on poorer households because of their dependence on shallow dugwells. This needs to be carefully managed, with recommendations that waterwell supplies only be used for non-sensitive purposes.

6. OUTLINE PROPOSALS FOR FOLLOW-UP ACTION

The rapid growth of urban population in Tropical Africa, and its increasing dependence on groundwater for domestic water-supply security, make the topics discussed in this report of critical importance for the future.

It will be evident that water utilities in Tropical Africa face a major challenge in trying to cope with rapid population growth, urban-area expansion and escalating water demand. They thus merit every possible support in strengthening their capacity, broadening their remit and improving their operations. UN-Habitat/GWOPA, who work in close alliance with the African Water Association (AFWA), recognise this and have identified the following priority topics for applied research and practical development:

- **engineering water-source climate resilience**
- **water source protection and quality management**
- amplification and diversification of sanitation services
- wastewater collection, treatment and reuse
- improving energy efficiency
- reducing non-revenue water
- streamlining client billing and charging
- **consolidating and refining governance provisions**
- **expanding pro-poor water services**
- **human resource development.**

The topics in **bold** are those recommended as appropriate for future beneficial collaboration between UPGro and GWOPA, and are grouped below into ‘two interrelated sets’ requiring more detailed attention at the interdisciplinary research and policy level.

6.1 Expansion of Water-Utility Pro-Poor Operations

A structured dialogue needs to be facilitated on approaches to the expansion of water-utility operations so as to include a wider range of ‘pro-poor’ technical and policy interventions.

This could comprise a focused workshop to explore water-utility training needs in relation to a range of potential pro-poor facets of their operations, including all or some of the following:

- reviewing mandates to evaluate the constraints and potential of current governance provisions for utilities to assume a broader role in urban water resources
- developing approaches to structuring connection charges and consumption tariffs to favour supply of low-income households
- assessing ‘unaccounted-for’ water, and especially physical system leakage, and approaches to recovery
- potential utility services to monitor and manage direct self-supply from groundwater (including use metrics, sewer discharges, quality hazards/use suitability).

A suitable venue for the workshop could be Lusaka or Dar-es-Salaam, since in both instances the local utility has already taken some significant initiatives of this type. The following are identified as lead collaborating

organisations with UPGro for workshop promotion and design of the emerging training programme: Global Water Operators Partnership Alliance (GWOPA of UN-Habitat), African Water Association (AFWA via GWOPA), WaterAid-UK, Skat/Rural Water Supply Network and International Water Association (IWA). The workshop should also be of interest to various IDBs. Resource persons familiar with the topic are Anne Bousquet (GWOPA), Jenny Grönwall (SIWI), Aditi Chandak (Water Aid) and Stephen Foster (for UPGro). The nomination of utilities (probably six in the first instance), and process of selecting participants would be coordinated by GWOPA.

6.2 Water-Utility Groundwater Management & Protection Needs

In close coordination with the above initiatives, it is equally strongly recommended to promote a technical workshop on water-utility needs in relation groundwater development, management and protection which would cover the following topics:

- assessment of groundwater pollution vulnerability and protection of drinking- water quality
- rational development and management of groundwater resources for utility water-supply (so as to improve drought security and minimise quality hazard)
- technical and economic evaluation of direct private self-supply from groundwater, and how it can be better harmonized with the water and sanitation services offered by urban utilities
- fostering an integrated approach to urban water-services including prioritisation and zoning of sanitation/sewerage and urban drainage.

There may be benefit from organising this workshop back-to-back with that described at 6.1 – using the same venue and host utility, and with some overlapping participants. The following are identified as lead collaborating organisations with UPGro for the promotion of the workshop and design of the emerging training programme: Global Water Operators Partnership Alliance (GWOPA of UN-Habitat), African Water Association (AFWA via GWOPA), Skat/RWSN, AfGW-Net (African Groundwater Net) and International Association of Hydrogeologists (IAH). Technical staff of the following water utilities could be invited to contribute case profiles – Abidjan, Dakar, Mombasa, Lusaka, Kabwe, Dodoma & Arusha, The workshop should also be on interest to various IDBs. Resource persons with close familiarity with this topic are Stephen Foster (for UPGro), Jenny Grönwall (SIWI) and Jose-Luis Martin-Bordes (GWOPA).

6.3 Longer-Term Follow-Up Actions

It is expected that the above workshops would lead to the design and provision of training modules for water utilities from the region.

It is also hoped that they will be followed by some systematic technical and socioeconomic assessment of domestic water-supply sources in selected cities, including consideration of drought security and quality hazards, coupled with an economic appraisal of the trends in public and private investment on domestic water-supply provision in those cities. This should be undertaken by a consortium of local consultants and international advisors, working in close liaison with the local water utility, during a 12-month period.

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