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# Climate change: the **utility groundwater role** in supply security

A changing climate means groundwater is vital to water supply security. **Stephen Foster**, **Julia Gathu**, **Michael Eicholz** and **Ricardo Hirata** report on progress with a survey into the contribution of water utilities to its management.

Climate change is widely predicted to impact water resources, including through more frequent and protracted droughts. Making better use of water storage (in one form or another) will be critical for water supply security. Aquifers, with their large natural groundwater storage, offer a potentially sustainable cost-effective option to improve urban water supply resilience. But to perform this function sustainably, groundwater (like any other form of natural capital) requires improved management and protection to avoid resource degradation through depletion and pollution.

Globally, water utilities represent the major stakeholder of groundwater as the primary source of low-cost, high-quality drinking water, and they widely need to promote a more balanced approach to achieving long-term water supply security. However, as yet, few urban water utilities (and hardly any in the developing world) have embraced adaptive groundwater management at the practical operational level. As a result, there have been numerous examples of urban water supply crises (for example, São Paulo, Cape Town, Bangalore and Chennai).

Given this background, the IWA Groundwater Management Specialist Group decided (in March 2019) to embark on a systematic survey of groundwater use by water utilities and the factors encouraging or impeding their proactive engagement in groundwater management and protection. This article provides an update of the interim findings, in advance of a fuller report to coincide with the IWA World Water Congress & Exhibition in Copenhagen in October 2020.

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## Sustainable use for climate change adaptation

Aquifers provide a natural buffer against the variability of river flow, because of the extremely large volume of groundwater they hold in storage (more than 95% of our liquid freshwater stocks). Thus, their presence is a key indicator of physical water security at the scale of a specific city and its hinterland. Most aquifers have water retention times ranging from decades to centuries and millennia, and normally at least a few hundred years even for shallow groundwater systems (with the sole exception of karstic limestones). Moreover, their stored water is naturally protected from evapotranspiration losses and is less vulnerable to pollution than surface water. Four criteria are key to assessing the role a given groundwater system can play in climate change adaptation and the level of management required to fulfill this role: storage availability, supply productivity, natural quality, and pollution vulnerability.

There are, however, some hydrogeologic settings (for example, much of Peninsular India and parts of the Sub-Saharan African Shield) where the local aquifers do not have sufficient production potential to support major utility wells. Their urban use will be restricted to limited

**“It will be essential for urban water utilities to participate proactively in protection of their groundwater sources**

piped supplies in suburban areas and/ or private non-piped self-supply. Additionally, there is some concern about possible reductions in groundwater recharge rates, and the reserves of low-storage shallow aquifers, given that current rates of anthropogenic change are about 10 times faster than natural rates of climate variation over the past 200,000 years.

Higher ambient temperatures will inevitably lead to increased groundwater demand, and potential growth in well abstraction could accelerate the rate of depletion of aquifer reserves. Intensive well abstraction is a relatively recent global phenomenon, and the development of effective governance provisions and management measures for groundwater regulation is still in its infancy. But if groundwater systems are to perform their potentially critical role in climate change adaptation they will require proper management and protection.

The action required must embrace a range of measures:

- Demand-side management to ensure that groundwater withdrawals are revised in alignment with realistic assessments of average recharge rates, after taking into account the need for some environmental discharge →

Palace of the Waters - São José do Rio Preto

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## São José do Rio Preto, São Paulo, Brazil

São José do Rio Preto is a city of about 500,000 inhabitants, located in the interior of São Paulo state, whose water services are supplied by municipally owned company SEMAE. The urban water supply of about 50 $Mm^3$/year is provided by the Preto River (17%), public wells in the unconfined Bauru Aquifer (27%) and the deep confined Guarani Aquifer (22%), and some 1,700 private wells in the Bauru Aquifer (33%), of which 80% are not yet licensed.

Although there is intense competition between the water-utility and private wells, private abstractions cannot be closed without causing serious problems for the public supply. Thus, SEMAE has taken various measures to impose some order on private groundwater use, which is mainly by residential condominiums and industrial premises.

First, it has mapped and metered all private wells (licensed or otherwise), as the basis for charging for sewerage discharge. Second, it commissioned a study of all private wells to improve the management of the Bauru Aquifer, based on the identification of areas of intense exploitation.

The technique consisted of dividing the urbanised area into 500m x 500m squares, mapping all known wells, and classifying them according to well density (4-10, 11-30 and >30) and total groundwater abstraction (<0.36 $Mm^3$/year, 0.36-0.72 $Mm^3$/year, >0.72$Mm^3$/year) compared with the estimated aquifer rainfall recharge.

The result provided a classification on three levels, and in each cell, action has been strongly recommended to the regulatory agency (GSP-DAEE) to limit groundwater use through closure of existing private wells, non-renewal of abstraction licences, and prohibition of new well construction.

Groundwater quality investigations have revealed that the upper 30-40 metres of the Bauru Aquifer (which exceeds 150 metres in total thickness) have significant nitrate contamination, from both sewerage losses and in-situ sanitation, and this is now having to be confronted.

| Facet | Specific questions |
|---|---|
| Resource use – levels and modes | What is your groundwater abstraction (annual total and/or dry season rate) and what proportion of overall water supply does this represent? |
| | How would you describe the mode of groundwater use (conjunctive with surface water, base-load supply, or just supplying 'difficult areas')? |
| | Have you developed external wellfields in rural areas to improve water supply security, and are there any conflicts with intensive agriculture? |
| Management and protection | Are you involved in groundwater management and protection initiatives alone and/or in cooperation with national or regional authorities? |
| | Are private waterwells intensively used for self-supply in your city, and are you actively involved in managing its impacts? |
| | Do you operate a groundwater monitoring programme on a stand-alone basis or in cooperation with regional agencies or basin organisations? |
| | Is there scope to enhance your water-supply security through improved management and protection of groundwater resources? |
| Capacity and governance | Do you have adequate professional training on the role of groundwater, and what is involved in resource management and protection? |
| | Do governance factors (such as operational remit and regulatory regime) and/or access to finance, constrain your approach? |

**Table A.** Water utility questionnaire on groundwater dependency, management and protection

- Policy formulation on intensive private urban well use, so as to harmonise this with utility water and wastewater services, and to reduce its health risk, given that off-grid solutions to urban water supply are often problematic
- Supply-side management by promotion of appropriate recharge enhancement (such as routing roof and road drainage to soakaways), taking into account the need to ensure adequate water quality
- Effective protection against groundwater pollution (especially by nitrates, pathogens, hydrocarbon fuels, solvents, pesticides, and so on), by declaring protection zones around well and spring sources of public supplies.

It will also be important to establish, maintain and improve groundwater level and quality monitoring networks, since the information they provide is essential for making adaptive adjustments to water resource policy and land use management to ensure groundwater sustainability. All of these measures will require significant financial investment and stakeholder contribution since, at present, the level of funding allocated for managing natural infrastructure remains inadequate in most cases.

## Assessing utility engagement

The structure of the questionnaire being used in the survey of present groundwater dependence of water utilities, and their experience in facing the challenges of resource management and quality protection is given in Table A. It is hoped eventually to get detailed and reliable returns from at least 100 urban water utilities worldwide.

It is already evident, from the first 20 returns, that to date the contribution of urban water utilities to sustainable groundwater management has been rather limited. There are however some notable exceptions, two of which are outlined here in the accompanying boxes.

More generally it would appear that water utility managers and engineers are too often beset by day-to-day problems, and thus tend to look for operationally simple water supply arrangements (such as a single major source and a large treatment works), rather than to more secure and robust conjunctive solutions. An institutional diagnostic is beginning to provide indications of a number of potential reasons for this (Table B). These clearly range from fundamental misconceptions to real impediments imposed by the conditions of the operating concession and/or structural deficiencies in the water sector as a whole.

In future, it will be essential for urban water utilities to participate proactively in protection of their groundwater sources, since they are the major stakeholder of groundwater as a drinking water

| Factor | Outcome |
|---|---|
| **Utility assumption (sometimes reinforced by legislation) that groundwater resource management and protection are the sole responsibility of another organisation** | Responsibility falls entirely to environment agency, water resources ministry or basin authority |
| **Utility perception that safe drinking water quality cannot be achieved by groundwater protection measures** | Presumption that required quality can only be guaranteed by advanced water treatment (with cost charged to water-users) |
| **Utility is operating under a time-limited, action-specific concession to a public body (such as municipal department or national ministry) requiring action only on mains leakage and unaccounted-for water** | Development of new groundwater sources and their protection through land husbandry agreements is outside utility remit |
| **Utility is too small and/or has to conform with pre-defined local geopolitical boundaries in its operations as prescribed under municipal concession** | Insufficient authority over required land area to be effective, which constrains approach taken to wellfield construction, aquifer management and protection |

**Table B.** Factors impeding water utility involvement with sustainable groundwater management

source, and their formal participation in various roles at different scales in close cooperation with other agencies (Table C) is considered a very high priority. Political stakeholders and water regulators alike are thus called upon to promote enabling conditions for much enhanced water utility involvement in groundwater management, for example by amplifying possibilities to engage in source protection measures, and introducing financial and legal mechanisms that promote this.

It is also evident that urban water utilities that have responsibility for both water supply and mains sewerage/drainage services are more able to act effectively to protect and enhance potable groundwater by prioritising: (a) the installation of mains sewerage and elimination of high-density in-situ sanitation in areas with good quality shallow groundwater; (b) the use of drainage soakaways for stormwater runoff from roofs →

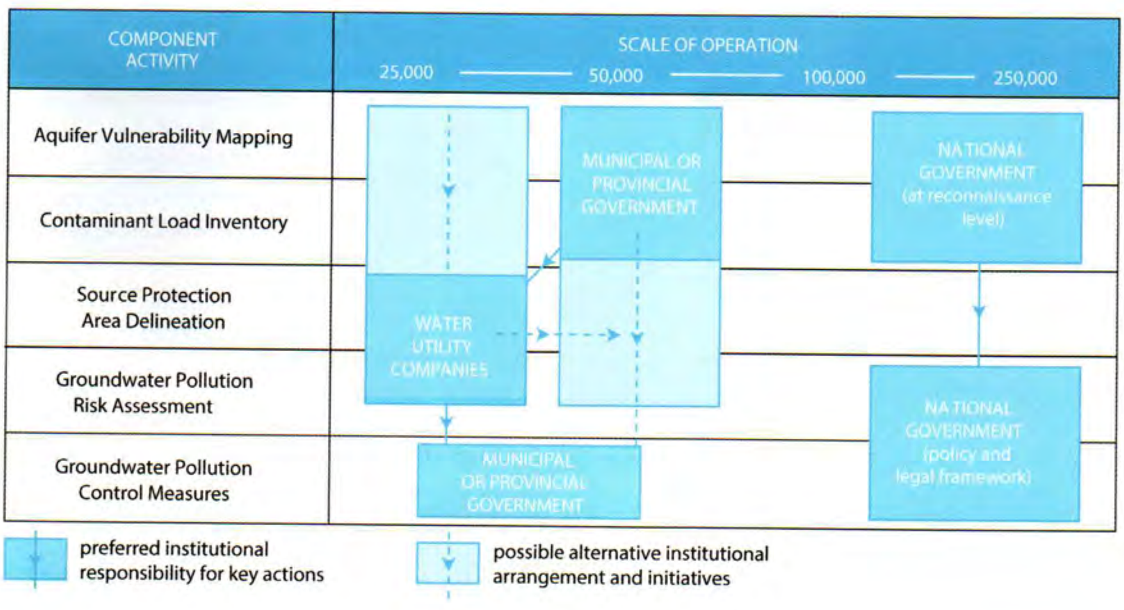
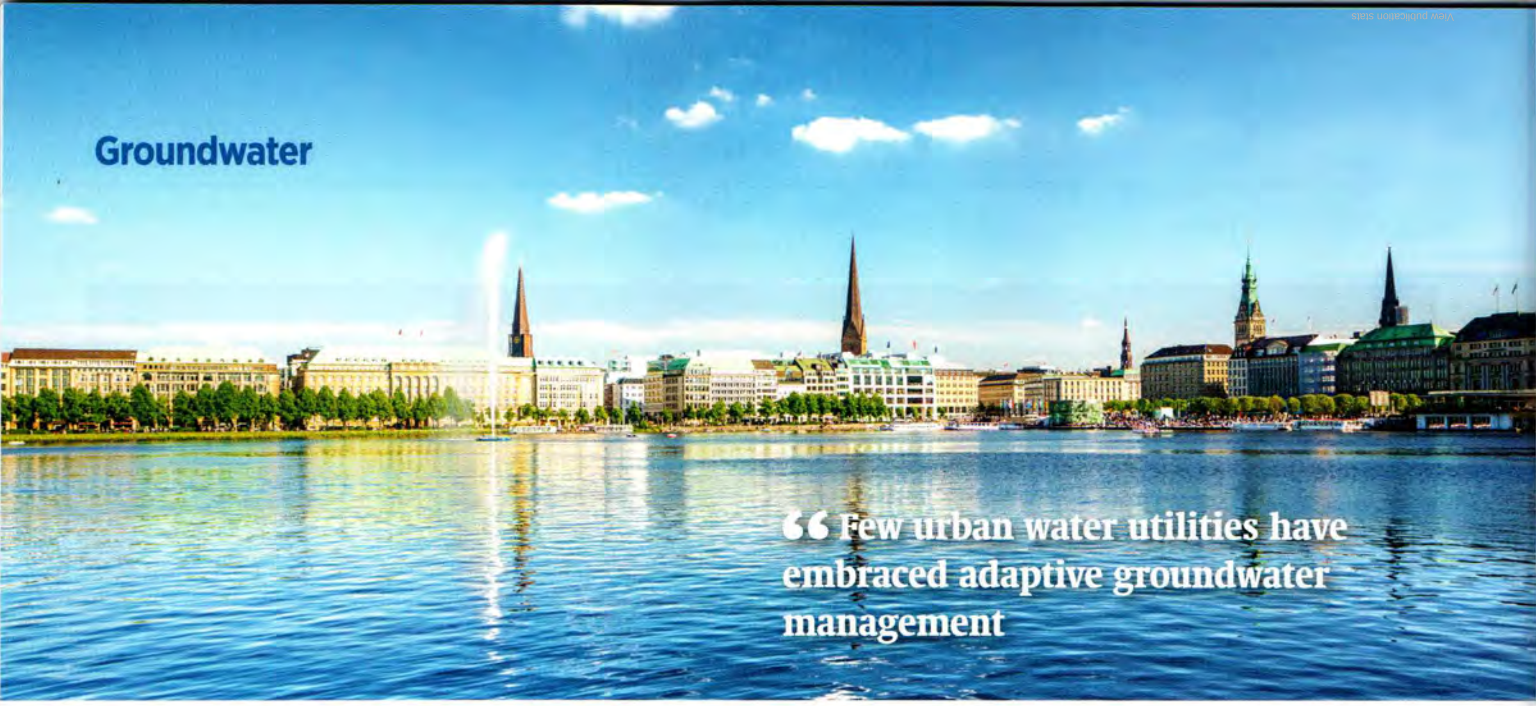



**Table C.** Recommended roles of water utilities in general scheme of groundwater quality protection




Alster lake, Hamburg
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## Hamburg, Germany

Hamburg Wasser is a fully municipally owned water and sewerage company, serving 2,150,000 inhabitants. In 1964, after a long transition period, its water supply switched completely from filtered river water to groundwater. Today, it operates about 470 wells tapping shallow Quaternary and deeper Tertiary aquifers and pumping about 120 $Mm^3/a$, which is treated at 16 plants.

Nine of the corresponding catchment areas have legal status as groundwater protection zones, and three are located outside Hamburg's boundaries (which in this case are also state boundaries). Because of the German federal structure, Hamburg Wasser has to comply with the legal regulations of three different federal states and maintain constructive dialogue with several regional and local water authorities.

In some cases conflicts arise since, depending on local hydrogeological and land-use conditions, shallow aquifers can be threatened by industrial or agricultural pollution, while deeper aquifers are vulnerable to salinisation from adjacent salt domes and require carefully designed abstraction schemes.

Hamburg Wasser maintains its own network of about 1400 monitoring wells, and is fully aware of the specific vulnerabilities of the aquifer systems its exploits. After many years of experience, annual groundwater sampling for chemical analysis in the catchment areas has been reduced to 350, excluding special programmes. The data are stored in a digital information system, which also contains geological information and groundwater level data, and allows the production of hydrogeological data in the form of cross-sections, contour mapping and time-series data.

Finally, in cooperation with governmental geological surveys, a 3D numerical groundwater model has been elaborated on a regional scale, which covers an area of 4500 $km^2$ and includes 3000 production and 7500 monitoring wells. This is used constantly for several purposes, such as wellfield management, water rights applications, detection and remediation of pollution, interactive management with industrial groundwater abstractions, and design of groundwater protection programmes.

and paved areas (and the use of permeable pavement to reduce the extent of impermeable sufaces) so as to enhance aquifer recharge; and (c) the promotion of urban wastewater use for managed aquifer recharge, with careful attention being paid to its chemical and biological quality.

Urgent action also needs to be taken to foster a resource culture within water utilities, so that they are better equipped to confront the major challenge of improving water supply resilience for climate change adaptation. And it is clear that, in many instances, this will require some modification to their governance regime and/or concession agreements to allow this to happen. ●

**Further reading**

**Alam M F & Foster S, 2019. Policy priorities for the boom in urban private wells. IWA, *The Source*, October: 54-57.**

**FAO-UN, 2016. Global Framework for Action to achieve the Vision on Groundwater Governance. UN Food & Agricultural Organisation (for GEF, IAH, UNESCO & World Bank) Publication (Rome).**

**Foster S et al, 2006. Groundwater quality protection – a guide for water utilities, municipal authorities and environment agencies. World Bank publication 114pp (www.un-igrac.org).**

**Foster S & MacDonald A, 2014. The 'water security' dialogue: why it needs to be better informed about groundwater. *Hydrogeology Journal* 22: 1489-1492.**

**Foster et al, 2019. Urban groundwater – mobilising stakeholders to improve monitoring. IWA, *The Source*, March: 58-62.**