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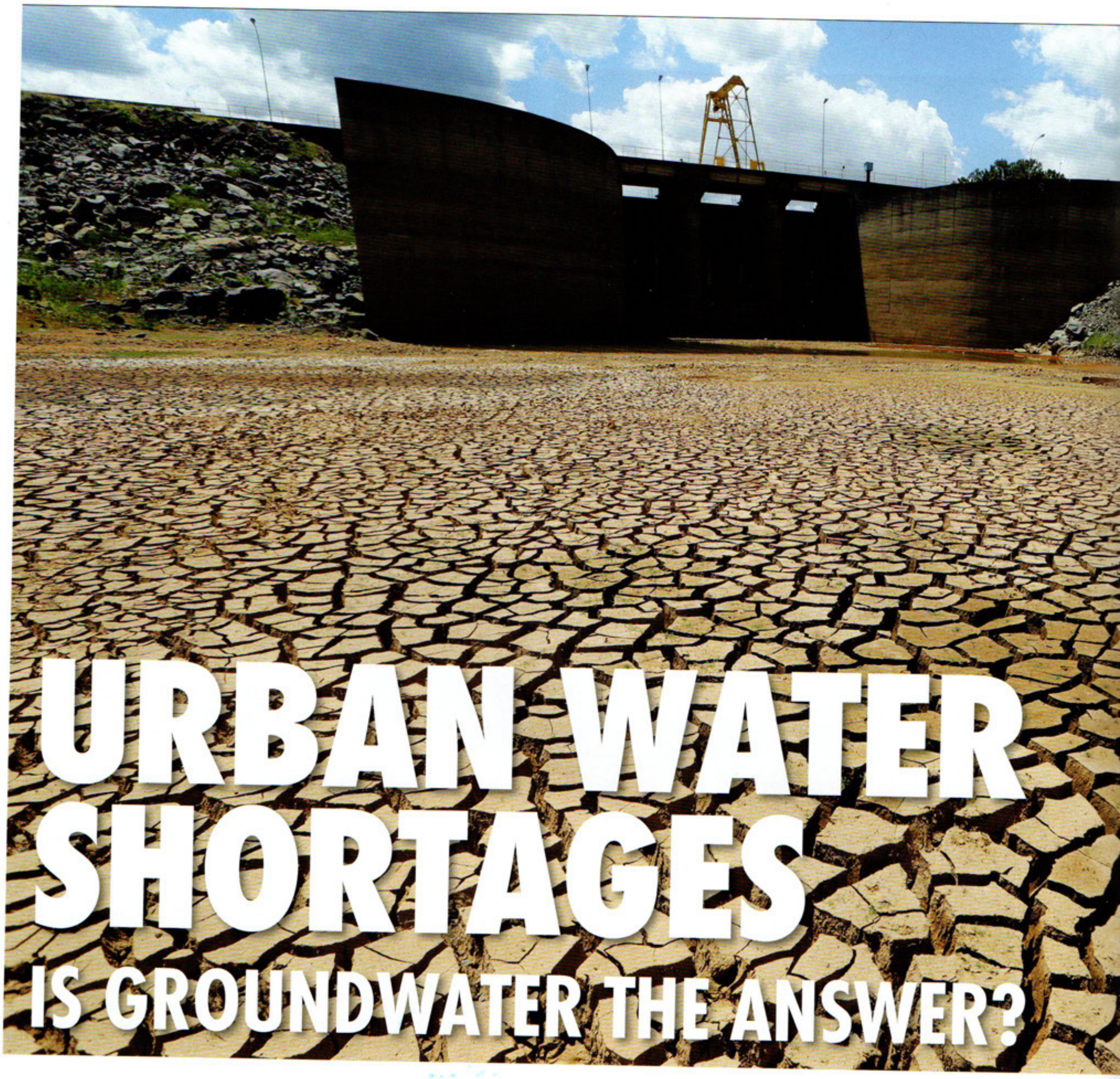


URBAN WATER SHORTAGES

IS GROUNDWATER THE ANSWER?

As more of our cities face critical water shortages, the pressure is on urban water utilities and other authorities to rethink their drought resilience. **Stephen Foster**, **Michael Eichholz**, **Ricardo Hirata** and **Mohammad Faiz Alam** report

RECENT water-supply crises in Cape Town, Chennai and Sao Paulo are increasing pressure on urban water utilities and other stakeholders to interrogate their supply's resilience to drought.

Climate change will bring more frequent droughts, increase evaporation from surface waterbodies, and create more intense rainfall that causes flooding and flashy streamflow, especially in semi-arid climatic zones. Better water storage will be critical for the future security of water supply – and having a major aquifer near the urban area in question will enhance supply resilience. Groundwater offers sustainable, decentralised, cost-effective solutions for climate-change adaptation. Aquifers are a natural buffer against variable river flow, storing large volumes of groundwater, protected from evapotranspiration and less vulnerable to pollution than surface water. Aquifers are an important indicator of physical water-resource security for a given city and its catchment area.

Four criteria assess what role a groundwater system can play, alongside local surface water, in climate-change adaptation, and how much management it requires to fulfill this role; storage availability, supply productivity, natural quality and pollution vulnerability.

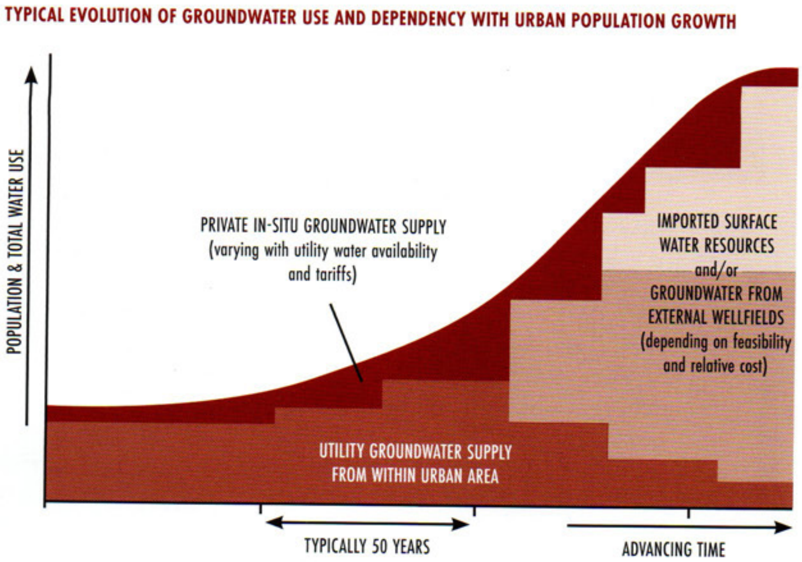
In some hydrogeologic settings local aquifers do not have large enough storage or sufficient production potential to support water-utility water wells. However, they often support large numbers of private self-supply water wells.

There are questions, too, about the natural resilience to climate change of groundwater reserves in shallow aquifers, where soil compaction from global warming may reduce recharge from rainfall, although other factors may counterbalance this effect.

MANAGEMENT MEASURES

To support climate-change adaptation, groundwater systems need proper management and protection:

The Cantareira reservoir during a severe drought in the state of Sao Paulo



- **Demand-side management** to ensure that groundwater withdrawals align with realistic assessments of average renewable resources of the local aquifer, conserving some environmental discharge supported by groundwater
- **Supply-side management**, promoting recharge-enhancement such as roof and road drainage soakaways and permeable pavements, that factor in changes in rainfall patterns and protect water quality
- **Protection against pollution**, building sound waterwells, declaring protection zones around important groundwater sources and noting that anthropogenic pressures on groundwater quality may intensify under climate change.

We must also establish, maintain and improve groundwater levels and quality-monitoring networks to generate data that will guide the adaptation of water-resource policy and land-use management for groundwater sustainability.

That requires significant financial investment and stakeholder contributions; the funding allocated to manage natural infrastructure is almost always inadequate. Urban water utilities must participate as the major stakeholder in groundwater as a drinking-water source.

So far, few cities have implemented conjunctive and adaptive groundwater management in any practical sense and the result is numerous recent urban water-supply crises. We must foster a resource culture within developing cities' water utilities to promote a more balanced approach on long-term water-supply security.

COMPLICATIONS

Growing numbers of private urban water wells only complicate matters. Globally, the urban population is growing at a rate without precedent. But in many developing cities, the coverage and reliability of utility water supplies is inadequate.

That leads people to find other ways to meet their water needs. Private self-supply, using in-situ water wells – which includes all types of bore hole, bore well, tube well and dug well – is booming, especially in cities in south Asia, tropical Africa and Brazil. Sinking urban self-supply water wells begins as a coping strategy on the part of those who can afford it – and it typically costs anything between US$2,000-US$20,000 according to hydrogeologic setting. But all too often, it continues in perpetuity as a cost-reduction strategy, as the operating costs are lower than full-rate water-utility tariff charges and as users see these wells as more reliable.

Off-grid supply from urban water wells is poorly documented; in many cities, it is not considered in public-policy terms. It can contribute to water contamination and it greatly reduces much-needed water-utility revenue – even though it also relieves resource pressure on water-utility supplies.

Public policy urgently needs water-utility planning and operation to reflect the economic and technical impacts of private self-supply water wells, to be able to regulate to cut public health risks and to optimise private investment against that of urban utility water and wastewater services.

It will take effective public communication programmes to alert private groundwater users to their obligation to regularise their wells, along with a regulatory regime that offers advantages – an element of resource conservation and quality evaluation – rather than simply issue penalties.

Government departments require user collaboration and enhanced investment in improved GPS and inspection capacity to better integrate private investment in urban water-supply provision.

BARRIERS

Water utilities' response and contribution to sustainable groundwater management has been patchy, with a few notable exceptions. The impediments to a more proactive position appear to be:

- The water-utility functioning under a time-limited, action-specific concession within a public body such as a municipal department or national ministry, in which development and protection of new groundwater sources falls outside their remit as their actions are limited to mains leakage and wastage reduction
- The water utility's operations must conform with defined local geo-political boundaries, as prescribed under its municipal concession, which constrains its ability to manage groundwater
- The water utility and the area it covers are too small to protect and manage groundwater resources.

Sometimes, the utility assumes that another national or local organisation – such as the environment agency, the ministry for water resources or the basin authority – is responsible for managing groundwater resources. It may assume that the prevailing regulatory regime requires it to provide a wholesome, safe drinking-water supply – which it can only guarantee through advanced water treatment, passing the cost on to the water user.

Misunderstandings like these demand an urgent institutional diagnostic, looking at whether:

- Do governance factors, such as variable water-utility remit and regulation, and access to financial investment, constrain these organisations' groundwater management?
- Do water utilities have adequate professional awareness of and training that covers the role of groundwater resources and what it takes to manage and protect them?

Often, urban water-utilities that are responsible for water supply and for sewerage and drainage services can act more effectively to promote groundwater management and protection. They do this by prioritising:

- Installing mains sewerage and eliminating high-density, in-situ sanitation to protect areas that have good quality, shallow groundwater
- Enhancing aquifer recharge, using drainage soakaways from roofs and paved areas, and using permeable pavement to reduce land-surface impermeabilisation
- Enhancing urban aquifer recharge with appropriately treated wastewater, paying careful attention to its chemical and biological quality.

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WATER SCARCITY: A TALE OF THREE CITIES

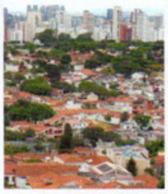
CHENNAI, INDIA

CHENNAI IS THE fourth-largest metropolitan area in India. Its 8.6 million people faced an acute water crisis last year. Its four main reservoirs and lakes almost dried up due to persistent drought. By June, their combined surface-water reserves had shrunk to 0.1 per cent of total storage capacity and the water utility could supply only 525 Ml/d of the city's 830 Ml/d demand. Parts of the city came to depend on groundwater, abstracted within and outside the city limits.

Chennai has more than 420,000 private wells, but the water table has fallen, due to long-term overexploitation and limited recharge during recent poor monsoons. As a result, many wells have dried up and contamination from seawater has reduced groundwater quality.

These pressures forced Chennai to deploy more than 5,000 tankers able to carry up to 9,000 litres of water, making five or six trips, to supply groundwater from the surrounding rural areas for the water utility and private operators at a total rate of 200-300 Ml/d. Chennai's history of poor groundwater management has fuelled conflict over access to water between city dwellers and villagers.

SAO PAULO, BRAZIL



SÃO PAULO IS South America's largest metropolitan region, home to 21.5 million people. Its 39 municipalities cover 7,946 km2 and have a combined annual GDP of US$237 billion.

Some 95 per cent of the population sources its water from public supply, mainly by a complex surface-water system that produces 5,270 Ml/d, 1 per cent of it from groundwater. More than 13,000 private water wells extract 950 Ml/d – or 18 per cent of the public supply, at a cost five to eight times lower.

Private wells' contribution increased to 25 per cent during the last major water crisis of 2013-2015. Although private self-supply increased water-supply security, large-scale uncontrolled water-well drilling has caused problems, lowering water-table levels, creating conflict between users and increasing the risk of pollution. Few private sources undergo regular chemical analysis.

Studies attribute Sao Paulo's failure to manage groundwater resources to a failure to understand how important this is for water-supply security or to understand conflicts between users. Because the water-management agencies face little pressure to improve matters, there is no incentive to regulate the city's thousands of private water wells.

CAPE TOWN, SOUTH AFRICA

CAPE TOWN HAS a population of about 3.8 million that requires the public water authorities to supply about 900 Ml/d. Cape Town faced an extreme water crisis in 2017-2018, that prompted the city's Water and Sanitation Department to impose severe water-supply restrictions – even though it had cut its distribution-system leakage losses to just 14 per cent.

The crisis stemmed from the 2015-2017 drought, when total annual rainfall fell to less than 250mm, compared to a long-term average of more than 600mm. In June 2017, when storage in Cape Town's largest surface-water reservoirs fell to below 15 per cent, piped per capita supply fell to 100 lpd, then to 80 lpd, then to 50 lpd. Soon scientists were predicting Day Zero. The crisis saw people forced to queue to collect a daily ration of 25 lpd per head from 150 collection points. But thanks to heavy rain that month, Cape Town narrowly averted a crisis.

Western Cape Province's public water supply relies almost exclusively on surface-water reservoirs that hold a maximum 900 million sq m a year, of which 70 per cent is held in Theewaterskloof and Voelviel dams. The province made a serious policy error in not diversifying its water sources, particularly given that Western Cape groundwater systems – the Cape Flats, Table Mountain and Atlantis aquifers – have significant yield potential. These sources urgently need to be assessed and better managed. In theory, at least, they could provide Cape Town with a public water supply reserve for drought of more than 200 Ml/d.