URBAN WATER SUPPLY

Post Day Zero – Lessons in resilience from São Paulo

With burgeoning populations coupled with extreme weather conditions driven by climate change, cities around the world are grappling with maintaining adequate water supply to their millions of residents. Just like Cape Town, the Brazilian city of São Paulo has come precariously close to running out of water. Petro Kotzé reports.

The term Day Zero has for most South Africans (and many beyond the country's borders) become synonymous with Cape Town. Already restricting residents to a daily limit of 50 litres of water per person since February, Day Zero is when dam levels reach 13.5% and city management will turn the taps off. Residents must then queue for 25 litres each at approximately 200 sites across the peninsula. At the time of writing this article, this date was indefinitely staved off due to the combined result of reduced consumption, management of water releases by the Department of Water and Sanitation, water donation from the farmers in the Palmiet River basin and the implementation of tariff management measures by the City.

The crisis seems unprecedented, but Cape Town is not the only major city that has come precariously close to running out of water. In 2015, São Paulo, one of the 10 largest metropolitan areas in the world, had less than 20 days of water left for its near-22 million population. The city has since emerged more resilient to drought, but in the words of Jerson Kelman, CEO of São Paulo's water and sewage supplier, Companhia de Saneamento Básico do Estado de São Paulo **(SABESP),** "we should strive for the best but be prepared for the worst."

The sentiment has resonance far beyond Brazil. A projected 6.4 billion people will live in cities by 2050, with a projected

estimate of 55% increase in water demand. Simultaneously, water will become increasingly scarce and the playing field more uncertain. Urban water managers are set to face unprecedented challenges in future, and the lessons learned from cities like São Paulo can offer valuable knowledge to those that are responsible for keeping the taps running elsewhere.

An unprecedented drought

São Paulo is the industrial centre of Latin America. The city, capital of São Paulo state is in south-eastern Brazil, 350 km southwest of Rio de Janeiro. It is located on a plateau of the Brazilian Highlands, extending inland from the Serra do Mar, which rises as part of the Great Escarpment. Located 820 m above sea level, the city sits in a shallow basin surrounded by valleys and foothills now blanketed with vast industrial suburbs. Preferred residential areas are on the high terrain, while working class residences and commercial properties are on the lower alluvial land along the banks of the Tietê, the Pinheiros, and the Tamanduateí rivers. The population of **São Paulo's urban agglomeration is a staggering** 21 730 000, a figure that expanded with 664 000 since 2015.

Though 12-16% of the freshwater on the planet is in Brazil, the majority of this is in the Amazon River and northern rainforests, mostly beyond the reach of São Paulo. Instead, the city is serviced by six separate dam systems. The largest of these is the Cantareira, responsible for supplying nearly 10 million of the population.

Hydrological data dating back 84 years shows that the average water flow has been roughly 40 million L/s. The worst year on record was 1953, when annual average output dwindled to 20 million L/s. In water years 2014-2015 (running from October to September), this trickled to 10 million L/s. "What we had in 2014 was only half of the worst we had had before in almost a century," says Kelman, when interviewed by the World Bank. "We were not prepared."

Some of the first measures that were implemented aimed at curbing water use. In February 2014, SABESP launched a Water Consumption Reduction Incentive Programme, awarding those who decreased their use sufficiently. "Demand management played a very important role in drought management in São Paulo, and the tariff bonus programme encouraged the population to change their habits, adopting actions that reduced the consumption of water," says Thadeu Abicalil, Senior Water and Sanitation Specialist at the World Bank. The programme aimed to reduce consumption by 20% compared to the average recorded in the months between February 2013 and January 2014. In case of success, the customer would get a 30% bonus, even if it is within the minimum consumption range.

In November 2014, SABESP announced that the programme awarded bonuses to 53% of users and stimulated another 23% to reduce consumption without right to discount. However, 24% of users increased their consumption and exceeded the average prior to the implementation of the programme, despite public appeals by means of advertising campaigns for rational use of water amidst the notorious water scarcity.

Hydraulic scheme of the Cantareira water supply system

SABESP then introduced a contingency fee. Customers whose monthly consumption exceeded the average with up to 20% were charged 40% of the water tariff; those who consumed more than 20% were charged 100% more of the water tariff. "The contingency tariff was applied even for clients with a firm demand contract, mostly industry and commerce," says Abicalil. Per capita consumption in the RMSP decreased from 155 liters/person/day in February 2014 to 118 in March 2015. By July 2015, 83% of customers in the RMSP (Região Metropolitana São Paulo or, the São Paulo metropolitan area) reduced consumption, and 73% received the bonus while the remaining 10% reduced consumption without reaching the target to receive the discount. Of the mentioned 73%, 63% reduced their consumption by more than 20%, 5% reduced consumption between 15% and 20% (bonus range of 20%) and other 5% reduced between 10% and 15% and received a bonus of 10%.

SABESP also reduced volumes of non-revenue water by replacing old pipes, altering water pressure and providing guidance on the use of water meters. This led to an estimated 23% reduce in water use, amounting to 330 000 000 m^3, while the discount incentive scheme achieved a further 19% reduction in domestic use (330 000 000 m^3 per annum).

Still, as water levels dwindled, panic ensued. Decreased agricultural and industrial output threatened and ailing economy, and the hoarding of rainwater in canisters spurred an outbreak of mosquito-borne dengue. Eventually, the Cantareira system drained out, leaving the city on the brink of running empty. "I don't know what would have happened if we lost control of the water supply for 22 million people," says Kelman, who joined SABESP in January 2015, when their water stock was down to 5%. "It was only enough water for 40 days, a little more than a month. In that situation, really, tension was high."

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São Paulo's near-miraculous turnabout was thanks to a combination of initiatives – including large infrastructure projects, an intense programme to reduce water losses, and eventually, rain. SABESP footed majority of the bills, with some loan financing by the Federal Government and the International Bank for Reconstruction and Development (IBRD). Projects that were prioritised included connecting systems that still had capacity (the Billings reservoir, the Rio Pequeno, and the Rio Grande) with pipelines to treatment stations (the Taiacupeba water treatment station). The treatment capacity of another, the Guarapiranga system, was expanded from 14 to 16 million L/s within a couple of months with the use of ultrafiltration membranes.

Then, it started to rain. Ironically, downpours in February 2015 wreaked havoc, causing widespread flooding across the city, but falling beyond the reach of the main reservoir 60 km away. Still, at the end of the rainy season in March 2015, storage capacity was at 15%, and by February 2016, water levels at the main reservoir have more than doubled.

The megacity of São Paulo, in Brazil, had less than 20 days of water left for the near-22 million population during the height of drought in 2015.

The Pinheiros River is one of the rivers feeding the city.

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Building a more resilient future

Many measures adopted during and after the crisis, on both demand and supply side management, increased the water reliability of the metro area, says Abicalil. "The São Paulo metropolitan area is now a more resilient city for droughts."

On the supply side, three large structural projects are set to add a further 13 million L/s to SABESP's drinking water production capacity for the Metropolitan region. The Sao Lourenco public-private partnership (already underway when the crisis hit) will deliver treated water to the western Metropolitan Region. The almost R2 billion Jaguari-Atibainha project will connect the Paraiba do Sul basin to the Piracicaba, home of the Cantareira system. The third will divert water from the Itapanhau River, which flows into the Atlantic.

Still, SABESP (literally) paid a high price for their success. In addition to the funding of large-scale infrastructure investments, the company's financial stability was severely impacted by the reduced water use of domestic customers. Net profit fell by almost two thirds from 2014 to 2015 and water and sewerage tariffs were increased with 15.2% to recover some of the investment made thereafter.

Tough questions remain regards the payment scheme for bulk water, the bonus and contingency fee scheme demonstrated the importance of demand management and the elasticity of price, says Abicalil. Questions include whether water rights and bulk water charges should be implemented for all users (urban, industrial, agriculture, energy, transport) as a comprehensive instrument for water management; if in case of scarcity, a compensation scheme should be designed to upstream water users by downstream water users; or, if high-value and priority users such as urban residents should compensate for non-priority uses, such as agriculture.

Abicalil points out that although São Paulo is more resilient to drought, water security also relates to other extreme climatic events that the city is vulnerable to, such as floods in the summer season. A third dimension of water security that SABESP is working hard to improve relates to water quality of rivers and in reservoirs.

In sum, a water secure future for São Paulo lies in an integrated approach to urban water, says Abicalil - one that goes beyond merely looking at the resilience to drought, and the reliability of water supply.

20 lessons from São Paulo

(supplied by Thadeu Abicalil, Senior Water and Sanitation Specialist at the World Bank, Prof Francisco da Assis Souza from the Federal University of Ceará and Carmen Molejon Quintana, Water Resources Specialist of the World Bank)

1. **Drought is a socio-natural phenomenon and management requires action in different arenas:** Actions in the arenas of public opinion, political-institutional and judicial, as well as technical solutions should aim to mitigate conflict and work towards sustainable decisions from technical, social, political and institutional points of view.
2. **Rules for allocation and rationing should be decided on before the drought,** together with social parties involved.
3. **Set rules for public participation before the onset of drought:** Public participation is important for legitimacy and social integration but defining the rules and framework for this process during the crisis is not sustainable, and arbitration of conflicts during the crisis without pre-defined rules can be extremely challenging.
4. **Drought management requires different expertise for sustainable solutions:** Water resources systems are complex socio-natural systems, and decisions must be supported by legitimate and relevant knowledge across social, economic, political, climatic, ecosystem, and engineering dimensions.
5. **Water systems are complex and should be analysed as an integrated whole:** All role-players must recognise that there are competing uses and benefits involved. Modelling must be applied to analyse the system and incorporate future uncertainties.
6. **The operational management of drought requires agile and continuous decision-making processes:** Response time to changes is a decisive factor in the quality of drought mitigation response.
7. **Technical expertise is essential:** The technical quality of the organizations that manage and operate the system is a decisive factor in the management of droughts.
8. **Water systems' vulnerabilities to droughts can be mitigated by relatively small interventions in hydraulic structures:** Actions such as the adjustment of water intake characteristics to ensure submergence level for pumps can significantly relax the operation of hydro-systems.
9. **The actions of drought management should incorporate actions of supply management, demand management and conflict management.** For supply management, operational flexibility of the system is the golden rule (ranges of pressure variation; sectorization of the supply network; redundancy with possible supply by different sources). Economic incentives (tariff or bonus) should be analysed in conjunction with other behavioural change strategies in demand management. The legal-institutional framework for conflict management during drought must be built with a view to mitigation.
10. **The public prosecution process should be institutionally centralised:** Individual public prosecutions impose high costs – both to the organisation, and on a personal level to responsible technicians. A strategy that enables the continuous and centralized monitoring of the decision-making process by the control bodies, especially the Public Prosecutor, could be useful to produce a better environment for this process.
11. **Drought monitoring is essential:** São Paulo has a significant hydrometeorological and fluviometric measurement network but not drought monitoring. As the crisis developed the drought was evaluated empirically. Identifying the onset, severity and purpose of drought is essential, as early warning can go a long way towards mitigating the impacts of droughts.
12. **Establish a drought management plan before the onset of drought:** Supported by an early warning system, this will result in reduced impact of drought by identifying necessary measures in advance for each stage of the drought, and necessary conditions for their implementation. During crises, previously viable resources might become unavailable, and their cost can increase significantly due to their necessity at short notice.
13. **Coordinate and integrate water management institutions for successful drought management:** An institutional framework for the physical, political, institutional and social spheres should be built to coordinate actions. Planning and definition of roles should be completed before the drought.
14. **The definition of permissible risk is a fundamental criterion for projects that promote water security and must be established with social legitimacy:** Water resources systems are designed to provide a guaranteed supply of water. The risk of shortage is defined by the likelihood of the occurrence of events more severe than those of the project value. Usually, a 90% guarantee of supply is used as reference, with a 10% probability of failure. This definition of hydrological risk does not explicitly consider damage. Systems for human supply should provide for the lowest probability of failure, though this implies higher deployment and operating costs.
15. **Political disputes between regional interests and world views must find institutional shelter for their arbitration in the water management process:** For Sao Paulo, space for mediation is made possible by the SIGERH (sistema integrado de gestão de recursos hídricos) with support from the Law of the Waters.
16. **A communication plan to inform public opinion is of great importance:** Conditions for transparent communication should be defined by institutions, to prevent opportunistic individuals or entities from gaining recognition and social standing through the creation of noise and using half-truths. Though multiple interpretations of events are legitimate, and inherent to democracy, these must occur within the stipulated public participation space.
17. **Drought planning must include financial mechanisms for reduced income:** During the crisis, the amount of water distributed and billed for by companies reduces significantly, with a concurrent impact on the sustainability of integral organisations such as sanitation delivery companies.
18. **The role of the water grant should be defined:** Is this an administrative instrument for authorizing water use, or does it play a role in defining broader public policies? The role of water policy must also be understood – whether it guides the water sector, guides other public policies, defines only the role of agencies in the water sector or further beyond.
19. **Consumption patterns and beliefs are forever changed:** The period of water scarcity impacts the water conservation habits, but the social fabric of the city was distorted during the drought, and there is no return to pre-drought conditions. This is a positive result, but temptation to return to pre-drought levels of consumption must be tackled.
20. **A drought governance system is key:** Drought management must take place in different arenas (technical, political, public opinion, legal) and requires technical expertise to deal with inherent complexity and uncertainty, institutional mechanisms for conflict arbitration, supply management that promotes efficiency, and efficient and equitable demand.