From resource to asset: Building a water-resilient Singapore

The country's long-term vision, use of innovative technologies, and stakeholder engagement efforts have been critical to its success.

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For decades, Singapore has struggled to secure an adequate supply of drinking water. Rainfall isn't the problem: its tropical climate produces an average annual amount of 240 centimeters (95 inches). Instead, the challenges lie in a shortage of freshwater sources (such as ground water and aquifers) and the lack of sufficient space to capture and store rainwater. Despite these obstacles, Singapore has managed to meet the full demand for fresh water since 1979, though with significant effort.

Singapore's journey from scarcity to sufficiency highlights the importance of an integrated urban systems approach, with public–private partnerships and stakeholder engagement. These factors have enabled the water-stressed city to manage its challenges in an integrated and holistic manner. One key shift is that the city has begun to approach water as an environmental asset to enhance the livability of the urban environment. Structural challenges remain: a 2015 report from the World Resources Institute estimated that Singapore would be one of the most water-stressed countries by 2040. However, the country's planning and development approach alongside dynamic urban governance has ensured that Singapore is able to adapt and thrive. Its experience offers lessons to other global cities facing water scarcity in the coming years.

A brief history of water management

Since Singapore's independence in 1965, the country has faced two primary water management challenges—an exploding population and flood risk. First, from 1990 to 2018 the population nearly doubled, reaching 5.8 million. Without natural sources to draw on, Singapore's primary option was to contract with Malaysia to provide drinking water. Second, as a low-lying country, Singapore faced the threat of inland flooding, an issue that was exacerbated as development geared up in the post-independence years. Recurring droughts and floods further heightened the risk to property and residents and complicated the management of scarce water resources.

Singapore's initial solution—building reservoirs and drainage networks—was necessary to provide a domestic source of water and mitigate flood risk. As the country grew, officials recognized they must develop and implement a strategy to increase Singapore's water resilience. Under the country's 1972 Water Master Plan, officials designed a policy that called for the construction of catchment areas and reservoirs to collect rainwater to boost local water supply.[1] However, the implementation of an island-wide drainage network, a critical feature, would inevitably compete with rapid urbanization and economic development for scarce land. Balancing these priorities required close coordination between government officials and land use planning agencies.

In the 1990s, Singapore's National Water Agency, PUB, was able to apply breakthroughs in water recycling and desalination technologies to close the water loop. This effort included integrating the water catchment networks, drainage and sewerage systems, water treatment and distribution, and the production of NEWater into one ecosystem.

Integrating multiple objectives

Singapore's current water infrastructure has enabled the country to manage its resources more effectively. Yet elected officials recognized that waterways also needed to be multifunctional assets integrated with residential, commercial, and recreational spaces to make the best use of land. To do so, the public needed to be part of the dialogue on the management of water resources. Such shifts in thinking enabled the government to further unlock the potential of waterways as environmental assets that contribute to urban areas and enhance livability.

The Active, Beautiful, Clean (ABC) Waters program, for example, demonstrates how Singapore has incorporated sustainable city planning with stormwater management. The program was launched in 2006 with the goal of creating community spaces around reservoirs and canals, giving these assets a recreational function by combining "green space" with "blue space." Collaboration played a key role. PUB coordinated with housing, transportation, and other agencies; the private sector; and the public to facilitate the implementation of ABC Waters projects and integrate water-sensitive principles into new development. For example, the Waterway Ridges housing project features ABC Waters design and green waterways to promote the use of natural systems to manage stormwater flows.

The ABC Waters Program also provided an opportunity to develop an integrated urban landscape. Since the nature of the program blurred the boundaries between planning and administration, cooperation between agencies was of utmost importance. One means of encouraging this integration was to maintain open lines of communication to facilitate knowledge sharing.

Case study: The Marina Barrage

The Marina Barrage showcases various ways Singapore has reaped the benefits of integrated development. The project was conceived in the late 1980s, shortly after the cleanup of the Singapore River. Then–Prime Minister Lee Kuan Yew envisioned a barrage at the mouth of the Marina, creating a lake that would serve as a freshwater reserve and support flood control. The idea was put on the backburner until advancements in membrane technology, a vital component of water treatment facilities, made the project viable. The decreased cost of operation and maintenance meant that raw water from urbanized catchments could be treated cost effectively to produce potable water.

Construction on the Marina Barrage began in 2005 at a cost of $165 million.[2] Upon its completion in 2008, it provided three benefits. First, it boosted the country's water supply by creating the island's largest catchment at 10,000 hectares (the barrage now provides enough water to meet 10 percent of Singapore's needs). Second, it alleviated flooding in low-lying areas. Third, it was available to the public. In the past, reservoirs were restricted areas. Opening the Marina Barrage gave people access to the waterfront. Over the past decade, close to 15 million people have visited the barrage for tourism, picnics, water sports, and other activities.[3]

Other cities or countries getting ready to embark on similarly ambitious infrastructure projects should note three factors that enabled Singapore to achieve its goals.

1. **Clear vision and dedicated leadership.** The country's progress was the product of far-sighted plans. In the 1980s, the Singapore river was polluted, so officials set a long-term goal of creating a reservoir and remediating the river so it could serve as a space for the public. The cabinet and ministry reviewed its plans every five years and committed the time and resources necessary to make projects a reality. Some elements of the plan had to be put on hold until technology made projects feasible, but the overarching plan remained consistent.

2. **An imperative to act.** Government leaders prioritized water because it was critical to Singapore's survival and they lacked alternatives. Recent history and long-term trends indicated that Singapore needed to devise effective water management solutions for the country to support economic development and ensure national security.

3. **Flexibility and innovation.** Singapore's leaders were open to new ideas. The ABC Waters program, for example, initially struggled to secure the buy-in of engineers, who were baffled that the government wanted to redesign canals that were already effective and integrate them into the urban surroundings. Government leaders educated stakeholders to persuade them to embrace new approaches such as water-sensitive design that could alleviate flooding.

Much remains to be done

Amid climate change, Singapore will experience increasingly extreme and unpredictable weather, resulting in more frequent and intense storms. To build resilience to the current flood protection scheme, PUB has adopted a "Source-Pathway-Receptor" strategy, which seeks to develop catchment-wide solutions. This holistic approach introduces flexibility and adaptability to the entire system, addressing not just the stormwater drains and canals (the pathways for water) but also areas that generate stormwater runoff (source) and where floods may occur (receptor).

Singapore has continued to adapt its approach to manage scarce water resources. Its leaders intend to strike a balance between urban development and other national needs. By making the management of water infrastructure part of the conversation, its leaders have managed inland flooding while providing sufficient space to capture rainwater to augment the drinking supply.

Singapore reinforces the necessity of continuous innovation. The country is still far from unlocking the full potential of water as an environmental asset. It needs to scale, further develop, and institutionalize the ABC Waters Program to spur the adoption of water-sensitive design into urban-planning efforts. But its efforts to date have built a solid foundation and offer a valuable example to other countries. ■

[1] Tan, Y. S., Jean, L. T. and Tan, K. (2009). *Clean, Green and Blue: Singapore's Journey Towards Environmental and Water Sustainability*. ISEAS Publishing, Singapore

[2] Silvia Schmid, "Catching rainfall in Marina Bay: Water necessity, policy, and innovation in Singapore," Wharton School of the University of Pennsylvania, IGEL, September 2012, igel.wharton.edu.

[3] Siau Ming En, "The big read: A decade on, Marina Barrage is now key to S'pore's water management," *Today*, September 18, 2018, todayonline.com.

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