Four National Taps

SINGAPORE'S WATER RESILIENCE STORY

As an island-state with few natural water-storage resources, Singapore historically faced challenges in securing its water supply. Chairman of Singapore's national water agency PUB, **Tan Gee Paw**, explains how a strategy of diversification, innovation and investment in technology safeguards this vital resource.

The Challenge

Singapore is a densely populated city-state with over five million people in just 718 square kilometres. Although it receives an average of 2,400 millimetres of rainfall each year, it has limited land to collect and store rainwater. With neither big rivers nor lakes, Singapore was ranked 170th out of 193 countries for availability of natural water resources in the 2006 United Nations World Water Development Report.

During the early days of Singapore's independence in the 1960s and 1970s, it relied mainly on water imported from neighbouring countries to meet its needs. This meant that if a drought affected Singapore and

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its neighbours concurrently, the city would be extremely vulnerable in times of very little rainfall. Singapore would then also be at the mercy of its neighbours for survival.

In 1960 and 1963-4, severe droughts did hit Singapore and water rationing had to be carried out. At that time, the city faced water shortages due to post-war population growth and under-investment in infrastructure. Providing an adequate water supply became a top priority then.

Today, the threat of a prolonged drought remains a cause for concern. In the past decade, Singapore experienced two dry spells — in 2010 and 2014. In fact, February 2014 was the driest month recorded in the last 145 years, with only 0.2 millimetres of rainfall recorded compared with the mean February rainfall of 161 millimetres.

01 Water rationing in the 1960s.

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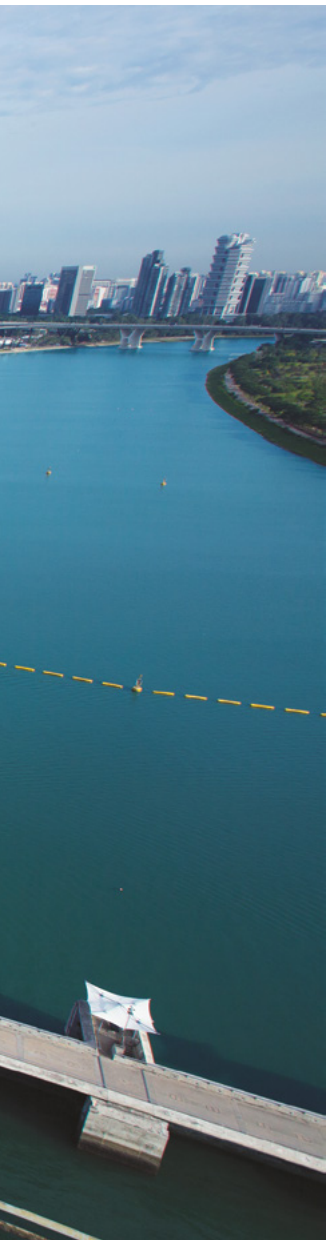

The Solution

Singapore's first significant step towards building a sound water management system for the long term began in 1971 with the formation of the Water Planning Unit under the Prime Minister's Office. The first Water Master Plan in 1972 envisioned a diversified water supply over the next half-century, from what would become known as the Four National Taps: local catchment water, imported water, reclaimed water, and desalinated water.

Maximising Existing Local Supply

PUB's first strategy was to harvest and store as much rain as possible, which required the creation of unprotected, urbanised water catchments. However, many of the rivers that could be dammed for reservoirs had been polluted by economic and residential activities.

Driven to create a clean, liveable environment and expand water supply, the government undertook a massive clean-up effort for the Singapore and Kallang rivers, relocating pollutive activities, resettling squatters into proper housing, and legislating to protect catchments.

Today, two-thirds of Singapore's land area collects rainwater which is then channelled into 17 reservoirs. Reservoirs at Punggol, Serangoon and Marina were created by damming rivers. Marina Reservoir, set in the heart of downtown Singapore, collects rainwater from some of the oldest and most densely built-up areas of Singapore. Singapore is the only city in the world where urban stormwater harvesting is carried out on such a large scale. Notwithstanding, the local catchment supply remained vulnerable to drought. Alternative sources of water that are less rainfall-dependent were required.

01 The Marina Reservoir is fed by five rivers running through the heart of Singapore and can meet about 10% of Singapore's water needs.

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Transitioning to Unconventional Water Sources

Singapore had been exploring water reuse since the 1970s as a means of diversifying its water resources, but had shelved the idea due to high costs and the unproven reliability of membrane technology then. By the 1990s, the performance and cost of membrane technology had improved significantly, and other countries were starting to use it in water treatment and reclamation.

In 1998, a PUB study team tested the latest membrane technology in water reclamation for potable purposes. Two years later, the agency commissioned a full-scale demonstration plant that could produce 10,000 cubic metres of ultra-clean, high-grade reclaimed water a day. In 2003, NEWater was introduced. To ensure that NEWater is of the highest quality, a comprehensive water sampling and analysis programme was implemented, benchmarking the results against World Health Organisation and the United States Environmental Protection Agency's drinking water standards.

Today, NEWater is supplied primarily for non-domestic use in wafer fabrication parks, industrial estates and commercial buildings, and to top up reservoirs during dry months. It allows Singapore to reduce its dependence on rainfall, enabling every drop to be used and reused.

As membrane technology continued to advance, desalination became a natural choice for the island city. In 2005, Singapore opened its first desalination plant which has a capacity to produce 136,000 cubic metres per day. A second plant commissioned in 2013, added another 318,500 cubic metres of capacity per day. To be better prepared against dry spells which may become more prolonged due to climate change, a third desalination plant will be built by 2017.

As rainfall-independent sources, NEWater and desalinated water are key to building up Singapore's drought resilience. By 2060, the two sources will be able to meet up to 80% of Singapore's total water demand.

Managing Demand

Aware that Singapore's water-management success may breed complacency, the PUB relies on a multi-pronged approach to promote conservation: by pricing water correctly, mandating standards for efficiency in water usage, and facilitating programmes to encourage water conservation. Demand management is equally essential to ensure a sustainable water supply.

In the long term, non-domestic use is expected to make up 70% of total water demand. Singapore encourages industries to adopt water-efficient systems and processes, and views this as an opportunity to grow the local water industry by spurring the co-creation, test-bedding and adoption of water-efficient technologies.

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01 The NEWater Visitor Centre offers an educational and interactive multimedia experience on Singapore's water story and water reclamation.

02 NEWater is produced by further purifying treated used water using advanced membrane technologies.

03 Post-treatment facilities at the Tuaspring Desalination Plant. The two desalination plants in Singapore are designed, built, owned and operated by the private sector.

04 Children at primary schools learn about water conservation.

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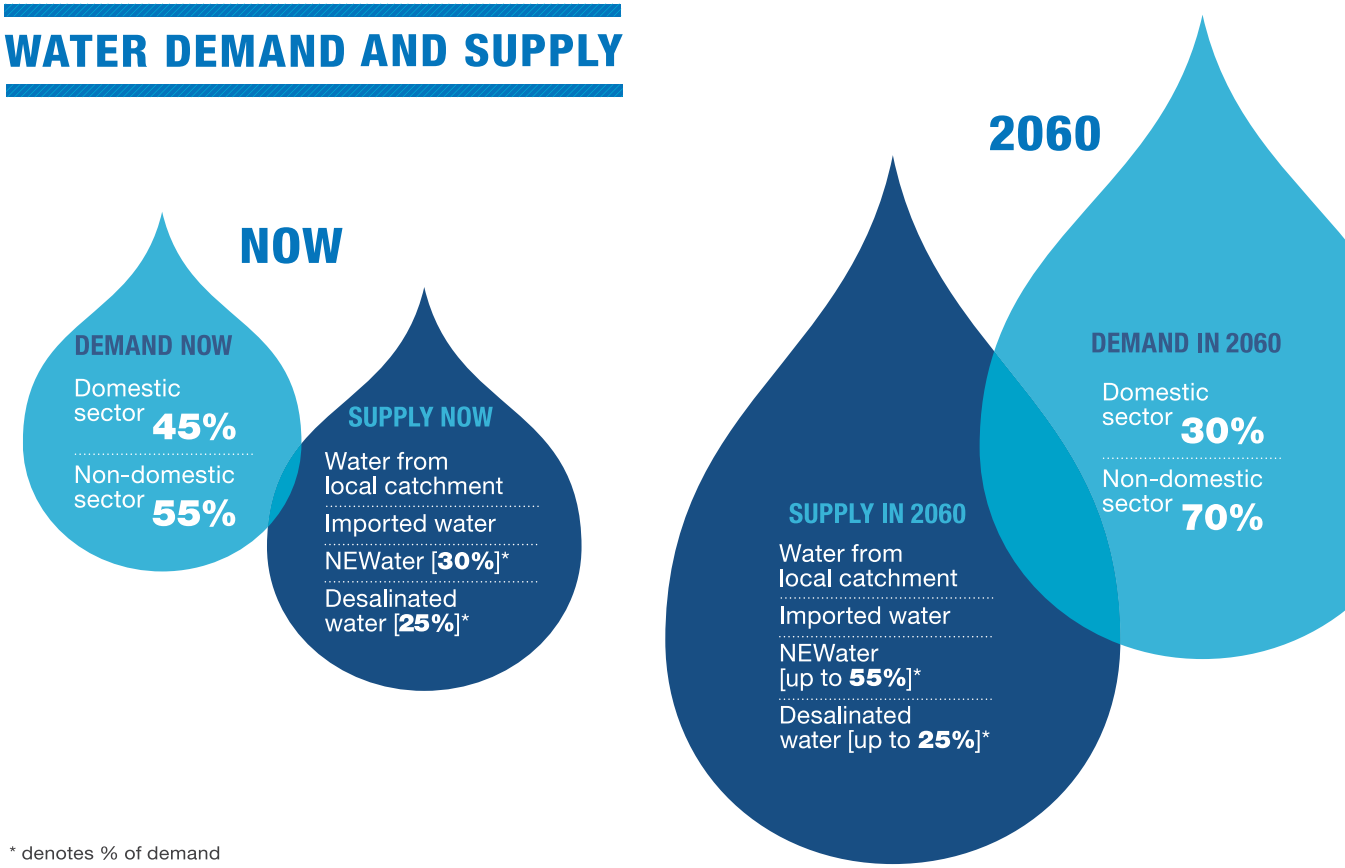
WATER DEMAND AND SUPPLY



* denotes % of demand

01 Sources of water demand and supply in Singapore.

The Outcome

Singapore has come a long way from its water-rationing days. Today, its people enjoy good, clean drinking water at the turn of a tap. The success of Singapore's water resource management was made possible with clear vision, firm political resolve and the integration of urban planning with water resource management. Singapore has also gained global recognition for its water management achievements. The PUB received the Stockholm Industry Water Award in 2007 and the "Water for Life" United Nations Best Practices Award in 2014.

Singapore has lowered its daily per capita domestic water consumption from 165 litres in 2003 to 150.4 litres in 2014, and aims to further reduce this to 140 litres by 2030. Today, it is a global water hub with 150 water companies and 26 research centres actively pursuing a range of water infrastructural and R&D work.

During the dry spell in 2014, Singapore was able to meet its water needs by running desalination and NEWater plants at nearly full capacities. Fortunately, regular rainfall resumed after three dry months. A prolonged drought would have put a strain on the system. The journey towards water sustainability has not ended, and PUB continues to update its water supply strategies, invest in research and innovation, and promote water-consciousness.

Tan Gee Paw was appointed Chairman of PUB, Singapore's national water agency on 1 April 2001. As Chairman, Tan brought about the integration of water, drainage and sewerage services under one agency, enabling Singapore to put in place a robust and sustainable water-supply system. He was also instrumental in overseeing the development of NEWater.

His invaluable contributions over the decades have been recognised through numerous awards which include the Public Administration Medal (Silver) in 1978, a Special Award (Gold Medal) for Clean River Commemoration in 1987, the President's Award for the Environment in 2007 and the Distinguished Service Order in 2010 for his work as Chairman of PUB.