Chapter 2
Key Challenges to Urban Water Management in ASEAN

Water is essential for a country's socio-economic development and a key facet of many of the United Nations Sustainable Development Goals (UN SDGs). Access to safe drinking water is vital for healthy societies, biodiversity, and ecosystems (World Bank 2016). Yet, cities worldwide, including ASEAN cities, are facing increasing challenges to their water security. Urban water challenges have escalated due to multiple factors, in particular, rapid urbanisation and urban population expansion; increase in standard of living that results in higher per capita water consumption; increasing industrialisation; ageing infrastructure and a lack of new infrastructure given the requirements; significant non-revenue water losses; and the impacts of climate change on water supply and availability (Boretti and Rosa 2019; Gain and Wada 2014; Lorenzo and Kinzig 2019; Trias 2021; Wang et al. 2020). Some of these challenges are discussed in more detail below.

2.1 Rapid Urbanisation in Developing Countries

In the ASEAN region, 49.5% of the population or 326.8 million people lived in urban areas in 2019 (World Bank 2020). This number is projected to increase by another 70 million by 2025 (ASEAN 2018). Evidently, most cities in ASEAN are witnessing an explosive growth in their population size (Lorenzo and Kinzig 2019), at an average growth rate of 2.4% between 2010 and 2019 (World Bank 2020).

There is a strong relation among economic activity, population growth, and water resource use. Higher GDP per capita and rapid population growth in ASEAN's

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Table 2.1 Percentage of total annual freshwater withdrawal

Country	Domestic (% of total annual freshwater withdrawal)	Industry (% of total annual freshwater withdrawal)	Domestic and industrial (% of total annual freshwater withdrawal)
Brunei Darussalam	45.0	49.2	94.2
Malaysia	34.9	42.8	77.7
Singapore	45.0	51.0	96

Source ASEAN Secretariat (2017)

urban areas in recent decades have been accompanied by a surge in water demand.[1] Studies project that the average water consumption of ASEAN cities, such as Yangon (Myanmar) and Penang (Malaysia), will double by 2040, reaching 2519 million litres/day and 1696 million litres/day, respectively (ADB 2020; PBA n.d.). This rise in water consumption has incontrovertibly increased the stress on water sources in ASEAN countries. As a result of greater pressure being placed on the region's water resource availability, water resource per capita availability has decreased.

High rates of annual freshwater withdrawals in the domestic and industrial sectors for ASEAN countries contribute strongly to the declining trend of water availability in the region (ASEAN Secretariat 2017). The freshwater withdrawal percentage for the domestic and industrial sectors (combined) in Brunei, Malaysia, and Singapore represented 94.2%, 77.7%, and 96% of the total annual freshwater withdrawal, respectively. This is illustrated in Table 2.1. As of 2014, the total annual water withdrawal for ASEAN countries amounted to 385 billion m^3, representing approximately 20% of water withdrawals in Asia (ASEAN Secretariat 2017).

Estimates show that between 2007 and 2017, the total water resources in the region have decreased on average by 12%, from 11,171 m^3/capita/year to 12,721 m^3/capita/year (The World Bank n.d.) (see Table 2.2). For instance, Singapore's annual per capita water sources dipped by 18.3% over this ten-year period and the Philippines by 15%. Despite its abundant water sources of 20,025 m^3/capita/year in 2017,[2] Brunei Darussalam also experienced a significant decline in its per capita water resources by almost 11.6% (The World Bank n.d.).

In addition, a proportion of ASEAN's population is living in informal urban settlements without safe and sufficient access to water and sanitation. In 2018—with the exception of Singapore, Malaysia, and Brunei Darussalam—nearly 15% of the ASEAN population (amounting to 91.7 million people) lived in informal urban settlements without adequate access to water and sanitation (UN-Habitat 2020). In 2017, 91.4% of ASEAN's 647.5 million inhabitants reportedly had access to basic or safely managed water. However, 84.9% of these inhabitants still required further treatment of this water for safe consumption (JMP n.d.a).

[1] Average water consumption for domestic and industrial use increases with an increase in GDP per capita growth (Koontanakulvong et al. 2014).

[2] Mainly due to its much smaller population size than Singapore and Malaysia and its proximity to the rest of forest-rich Borneo.

Table 2.2 Per capita water resource availability (m^3/capita/year)

ASEAN country	2007	2017	% decline in water source availability
Brunei Darussalam	22,669	20,025	11.6
Cambodia	8816	7533	14.5
Indonesia	8689	7629	12.2
Lao PDR	32,028	27,383	14.5
Malaysia	21,707	18,646	14.1
Myanmar	20,213	18,788	7.1
Philippines	5358	4554	15
Singapore	131	107	18.3
Thailand	3393	3244	4.3
Vietnam	4208	3799	9.7

Source Ritchie and Roser (2017), The World Bank (n.d.)

Meeting the water needs of a rapidly growing population becomes even more challenging in the absence of adequate urban planning and critical infrastructural maintenance (Lorenzo and Kinzig 2019; WHO and UNICEF 2019; World Bank 2019b). In ASEAN cities, increases in the operational costs of water treatment, transportation, and distribution, as well as infrastructure rehabilitation, pose further challenges to water service providers in meeting the water needs of a burgeoning urban population. For example, in Singapore, the operating expenses[3] of its water system increased by USD 615 million (SGD 0.84 billion) over a 15-year period, due to a rise in operating costs from USD 410 million (SGD 0.56 billion) in 2005 to USD 1.03 billion (SGD 1.4 billion) in 2020 (PUB 2013, 2021).

2.2 Non-revenue Water

Non-revenue water (NRW) has been a leading concern for ASEAN countries due to the high rates of water losses in water supply networks (ADB 2010). NRW management allows water service providers to expand and improve services while enhancing its financial performance. The NRW in the water distribution system may include real losses (actual water losses in water distribution network), apparent losses (water consumption that is not billed to end-users), or unbilled authorised consumption (Alegre et al. 2016; EU ERDF n.d.).

High NRW loss prevents water utilities from providing full and reliable coverage at affordable prices (Liemberger and Wyatt 2019). It also leads to a significant increase

[3] Operating expenses primarily comprise of depreciation of property, plant and equipment (PPE), manpower, maintenance, electricity, research and development, administrative, and other miscellaneous expenses incurred for the collection, production, distribution, and reclamation of water in Singapore (PUB 2021).

in the capital that water service providers must expend on operational and maintenance (O&M) costs to guarantee undisrupted water supply to users (Araral and Yahua 2013; Jones et al. 2021). Moreover, water consumers in the domestic and non-domestic sectors often have little incentive to reduce their water consumption or use water more efficiently (Damania et al. 2017).

As of 2019, the global average NRW rate stood at 30% or 126 billion m^3, equating to financial losses of an average of USD 39 billion/year. Recent estimates suggest that the volume of NRW in Southeast Asia is 6.7 billion m^3 a year or 18.4 million m^3 per day, with the cost/value of water lost amounting to USD 2 billion annually (Liemberger and Wyatt 2019). In general, NRW represents between 25 and 50% of the total water supply and, in some developing countries, accounts for up to 75% of the total water supply (IWA 2015).

NRW rates also vary considerably between ASEAN countries. For example, in 2018, NRW rates in Singapore, Malaysia, Vietnam, and Indonesia were 5.6%,[4] 36.5%, 21.5%, and 32.75%, respectively (PUB 2020; BPPSPAM 2019; SPAN 2018; World Bank 2019a). NRW rates may also vary widely between cities in a country. In Malaysia, for instance, cities such as Pulao Pinang and Johor had NRW rates of 21.7% and 24.19%, respectively (PBAHB 2018; Ranhill 2018). In comparison, the NRW rates of Pahang, Kelantan, and Perlis were considerably higher at 47.5%, 49.3%, and 63.1%, respectively (Jones et al. 2021).

The primary reason for high NRW rates in ASEAN countries is leakage from ageing water infrastructure and deteriorating pipelines (Araral and Yahua 2013). These pose challenges to water service providers in supplying reliable and safe drinking water to end-users (ADB 2010; Kristvik et al. 2019). In many ASEAN cities, the age of water distribution networks and infrastructure is associated with high rates of NRW. To reduce high NRW rates caused by ageing infrastructure, various ASEAN cities, such as Jakarta (Indonesia), Petaling Jaya (Malaysia), and Vientiane (Lao PDR), are planning to upgrade or are in the process of upgrading their water distribution networks (Lee 2021). ASEAN cities such as Phnom Penh (Cambodia) have also benefited from pipe rehabilitation programmes that have been implemented and maintained since 1993 (PPWSA n.d.). Despite an expansion of the pipeline distribution network from 2009 to 2011, NRW rates remained below 6% for the period (Biswas et al. 2021).

Given the persistence of NRW in ASEAN cities, WDM measures could play a critical role in reducing the volume of water loss in these cities and improve water-use efficiency.

[4] Unaccounted for water (UFW) (PUB representative in AWGWRM. Email interview, 7 March 2022).

2.3 Climate Change

Climate change plays a key role in influencing the availability, patterns, distribution, and quality of water resources (Florke et al. 2018; Wang et al. 2020; World Bank 2017). It is expected to have persistent impacts on renewable freshwater resources due to changes in temperature, precipitation trends, and annual surface evaporation[5] (Collins et al. 2013; Hejazi et al. 2014; IIASA 2018). With increased humidity, higher and mid-latitude land masses are predicted to experience significantly higher amounts of precipitation.

Changes in climate differ from country to country within ASEAN, with spatial variations linked to the hydrologic cycle. Wet tropical regions such as SEA are likely to encounter extreme and more frequent precipitation events, which increase the incidence of flooding and contamination of water sources (UN-Water n.d.). Higher temperatures increase surface evaporation and heighten precipitation frequency. The temperatures of inland water bodies in SEA are also predicted to rise by 0.5 to 2.0 °C by 2100. Rising water temperatures induce the growth of bacteria and algae, which deteriorates water quality (Lorenzo and Kinzig 2019). In contrast, semi-arid regions are likely to experience less precipitation and severe droughts, which can impair the resilience and reliability of water supplies (Collins et al. 2013; Trias 2021). Sea level rise has also been attributed to increased risks of saltwater intrusion and fluctuations in groundwater availability. Climate-related risks thus have profound impacts on the quality and availability of potable water in cities and represent an emerging challenge that ASEAN's cities will need to adapt to.

Climate change is transforming the water landscape. Changing rainfall patterns and droughts and floods that are more intense and last longer are affecting availability and variability of water resources adding to water stress and requiring that water is used more efficiently. Less availability of water resources requires that stringent WDM strategies are implemented in order to ensure that water is conserved and that supply is maintained even during changing conditions. Additionally, given the region economic and population growth, more assets and people will be exposed to water extremes unless adaptation and mitigation actions are taken. WDM is one of the most important adaptation measures (Biswas and Tortajada 2022).

2.4 The Role of Water Demand Management in ASEAN

In recent years, water resource management in ASEAN countries has been identified as an issue of strategic importance by the ASEAN Cooperation on Water Resources Management (2020). Urban water demand management, in particular, constitutes one of the identified critical measures for water resource management. The consensus among ASEAN leaders on the imperative of protecting and sustaining water resources

[5] Higher temperatures lead to greater surface evaporation (Lorenzo and Kinzig 2020).

led to the establishment of a dedicated working group—the ASEAN Working Group on Water Resources Management (AWGWRM), in the early 2000s. The AWGWRM provides a consultative platform for ASEAN member states to advance the objective of promoting sustainability of water resources to ensure equitable accessibility and sufficient water availability of acceptable quality to meet the needs of the people of ASEAN (2019).

WDM refers to 'the implementation of policies or measures which serve to control or influence the amount of water used' (EEA 1996). Ultimately, WDM aims to increase the efficiency of water consumption by providing water users with efficient, cost-effective, and more sustainable water supplies, along with the enhancement or protection of water quality (Bao et al. 2013; Butler and Memon 2006; Kampragou et al. 2011; Kayaga and Smout 2011; Smith et al. 2015). Water efficiency can be achieved by means of technical measures (e.g. water-efficient fittings, leakage detection technology), process and operational modifications (e.g. customer engagement, billing procedures), economic incentives (e.g. metering, tariff schemes), and consumer education (e.g. water conservation campaigns) (Kayaga and Smout 2011).

WDM is vital not only for water-scarce countries, but also for countries seeking to improve their internal water security in the long run (Hoa et al. 2017; UN-Water 2016). Traditionally, governments have turned to water supply expansion or supply augmentation, from sourcing for new water supplies, increasing treatment capacity, to expanding treatment and distribution facilities (Trowsdale et al. 2017). This approach, however, is costly on several fronts. Firstly, infrastructure development is comparatively more capital intensive than the cost of implementing water demand management or efficiency measures. Secondly, the environmental ramifications of infrastructure development have been well-evidenced: changes in hydrological flows arising from impoundments and mass withdrawal activities have affected local ecosystem health and water quality; man-made reservoirs have been attributed to significant evaporative water losses; and aquifer pumping activities reduce water quality, increase risks of land subsidence, saltwater intrusion, and reduce river flows (Abansi et al. 2018; Arfanuzzaman and Rahman 2017; Bao et al. 2013; Hoa et al. 2017). Thirdly, the energy costs associated with water and wastewater supply treatment and distribution are substantial and translate to compounded economic costs for water service providers and municipalities (EPA 2016; Escriva-Bou et al. 2018; Kayaga and Smout 2011; Trowsdale et al. 2017).

In the light of these considerations, managing existing water resources more efficiently is comparatively more cost-effective and ecologically beneficial than supply augmentation. WDM measures also serve as a potential contingency measure for countries in times of water shortages, where supply augmentation measures cannot be feasibly achieved within a short time frame. A summary of environmental, economic, and social benefits accruing from WDM implementations is listed as follows:

Environmental Benefits

- Improved water quality resulting from reductions of pollutants (e.g. through diversion and treatment of wastewater for recycling) through the introduction of water-

quality standards for both potable and non-potable water supplies (e.g. greywater, reclaimed wastewater, and rainwater).
- Reduced greenhouse gas emissions resulting from a decrease in energy consumed by new water infrastructures (e.g. water supply, treatment, and pumping) as well as from the installation of water-saving appliances (e.g. dual-flush toilets, low-flow taps, etc.), which consume less energy and water.
- Decreased quantity of water consumed and greater water availability in future.
- Less impact on ecosystems and environmental conditions due to fewer withdrawals from water sources (e.g. groundwater, aquifers, and streams).
- Improved water body aesthetics (e.g. through increased flow of water into rivers which can improve river health).

Sources Abansi et al. (2018), Arfanuzzaman and Rahman (2017), Bao et al. (2013), Hoa et al. (2017), Sauri (2013), Zapana-Churata et al. (2021).

Economic Benefits

- Creation of financially sustainable water systems due to reductions in energy demands (e.g. water extraction, treatment, and distribution).
- Cost savings on water bills of water users due to decreased water consumption.
- Reduction and control of water losses in the distribution system (e.g. leakage from distribution pipes) by reducing non-revenue water (e.g. leakage detection programmes), generating additional revenue for the water service providers to achieve long-term financial sustainability.
- Fewer operational, clean-up, and maintenance costs due to reductions in water treatments and water supply charges.
- Reduction in total water demand by curtailing water waste and misuse. Savings in capital expenditure due to avoiding, downsizing, and postponing expensive infrastructure developments and amendments (e.g. treatment capacities, pumping and delivery networks, and new sources of water supply).

Sources EPA (2016), Escriva-Bou et al. (2018), Russell and Fielding (2010), Kayaga and Smout (2011), Mehan and Kline (2012), Smith et al. (2015), Trowsdale et al. (2017).

Social Benefits

- Improved water service coverage and access to water.
- Improved equity of water supply due to reductions in the quantity of water lost in distribution systems.
- Optimising water use and cross-sectoral efficiency by providing water users with a reasonable allocation of water.
- Encouragement of water efficiency and citizen welfare due to more equitable redistribution of wasted water.
- Strengthening of effective public participation and government openness due to greater public awareness of the importance of water through public outreach efforts (public campaigns, school curriculum, detailed billing information, etc.).

- Reduced present and future water scarcity concerns due to greater efficiency in water consumption.
- Job creation and sustainability of services in water-related sectors (e.g. staff for leak repairs and monitoring, pipe replacements, and public campaign creation).

Sources Arfanuzzaman and Rahman (2017), EBA (2018), UNEP (2015), World Bank (2017).

Despite the many benefits of WDM, participation can be limited by a series of barriers that result from expected negative outcomes, disapproving social pressure, and missed opportunities at the personal, societal, and institutional levels. It is these aspects that can hinder water conservation and thus result in water insecurity in several countries of the region (Wehn and Almomani 2019).

2.5 Key Takeaways

1. ASEAN cities face emerging challenges to their water security. These include rapid urbanisation and urban population expansion; higher per capita water consumption amid improvements in living standards in cities; increasing industrialisation; ageing water infrastructures and a lack of new infrastructure to meet increased water demand, significant non-revenue water losses; and climate change risks to water supply and availability.
2. WDM offers an alternative to governments and water service providers for addressing the emerging threats to urban water security in ASEAN.
3. WDM refers to the implementation of policies or measures which serve to control or influence the amount of water used. WDM aims to increase the efficiency of water consumption and can be achieved through technical measures, process and operational modifications, economic incentives, and consumer education.
4. Compared to supply augmentation strategies, WDM is comparatively more cost-effective and less environmentally invasive in implementation and facilitates both energy and water resource conservation. WDM strategies can also be more readily mobilised in times of unexpected water scarcity.
5. Investments in WDM have been found to yield multiple environmental, economic, and social benefits to governments, water service providers, and end-users.

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