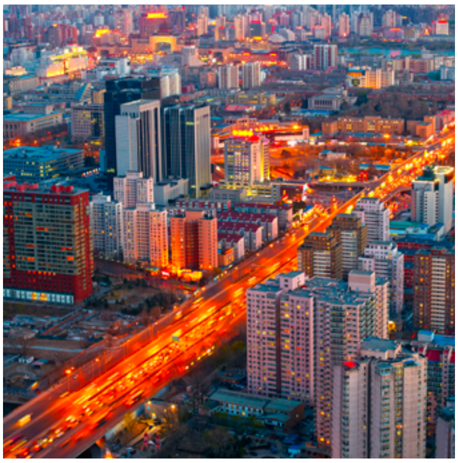
Wastewater
Report 2018

the international
water association

The Reuse Opportunity





Contents

List of acronyms

BOD - Biological Oxygen Demand
BOT - Build-Operate-Transfer
GHG - Greenhouse Gas
MBR - Membrane Reactor
MLD - Million Litre per Day
MWh - Megawatt hour
O&M - Operation and Maintenance
PPP - Public Private Partnership
SDG - Sustainable Development Goals
STP - Sewage Treatment Plant
WWTP - Wastewater Treatment Plants

Acknowledgments

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Infographics data

- The population data was searched on the web from most recent sources available.
- The wastewater sewer and treatment coverage, as well as the water reuse, energy recovery and fertiliser value recovery was provided by local city contacts.
- City wide GHG emissions data was available only for the following cities:
  - Chennai. Source: Powerpoint presentation by Sumana Bhattacharya, ICSD, India, Aug 2014, found on the web.
  - Lima. Source: Carbon Disclosure Project website.
  - Manila. Extrpolated from Source: Greenhouse Gas Emissions in the Philippines Factsheet, USAID
  - Beijing. Source: CO2 emissions inventory of Chinese Cities, Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-176, 2016
  - Durban. Source: Summary Document: eThekwini Greenhouse Gas Emissions Inventory 2015, Energy Office eThekwini Municipality
- GHG emissions from wastewater management was calculated using the ECAM tool, made available by the WaCCliM project.

Cities Seizing the Reuse Opportunity in a Circular Economy

The theme for UN-Water World Water Day in 2017 was Wastewater which has helped to raise awareness of this global problem and create momentum amongst like-minded organisations to drive change. The change required is captured within target 6.3 of the Sustainable Development Goals (SDG), which commits governments to halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse by 2030.

Today, around 80% of all wastewater is discharged into the world's waterways where it creates health, environmental and climate-related hazards. Urbanisation further exacerbates this challenge with increasing wastewater generation, while at the same time using more of Earth's dwindling resources. Recovering the water, energy, nutrients and other precious materials embedded in wastewater is a key opportunity to be seized.

The discharge of untreated effluent in water bodies does not only lead to eutrophication and human health risks, it also contributes significantly to Greenhouse Gas (GHG) emissions in the form of nitrous oxide and methane. Emissions from untreated sewage represents three times the emissions of conventional wastewater treatment. The emissions from untreated sewage can represent a significant percentage of cities' global emissions, even when treatment coverage is still poor as in many emerging cities.

The SDGs demand we halve the amount of untreated wastewater and provide universal access to adequate sanitation. During the same period, the global population is estimated to rise to 8.5 billion people. These pressures will drive cities to address the wastewater challenge and seize the reuse opportunity. Of paramount importance are the dual objectives of safeguarding human health and environmental protection, but beyond this, cities need to identify ways of deriving value from the materials, energy and water that is embedded in wastewater streams.

Decisive, urgent and large-scale action is needed to increase wastewater and fecal sludge treatment, reuse and recycling. Cities should be empowered to take the lead on a resource revolution, with governments and the private sector investing heavily in infrastructure to enable a transition to a circular economy, bringing about significant environmental, economic and social benefits. A portfolio of solutions including centralised and decentralised, natural and built, wet and dry options.

The concept of circular economy, which aims to decouple economic growth and development from the consumption of finite resources, has emerged in response to the drawbacks of the conventional 'take-make-consume and dispose' model of growth. Water, with the energy it consumes and produces, and the materials it contains, has a critical role in transitioning to the circular economy.

Used water is one of the most under-exploited resources we have. Water from industrial or domestic use contains energy, water, organics, phosphates, nitrogen, cellulose, rare earths, and other resources. Technologies are increasingly making resource recovery from wastewater commercially feasible, including bio-gas, fertiliser, paper, metals, plastics and, perhaps most importantly, it is a source of 'new' water.

For the water sector, transitioning to a circular economy presents an opportunity to fast track achieving the SDGs through accelerating and scaling-up recent scientific and technological advances that support greater efficiency in the sector.

This report aims to illustrate the wastewater challenge and reuse opportunity in eight cities across the globe, presenting a reuse roadmap and identifying priorities and benefits to meeting SDG target 6.3. The cities profiled in this report are not the 'usual suspects' of pioneering cities who have been on this trajectory for some time, but rather cities small and large from developing countries where the existing and future challenges are felt more acutely and the need for change is pressing.

Aqaba: A mid-size city turning its “zero discharge” challenge into a good opportunity

Aqaba, the largest city on the Gulf of Aqaba, lies at the crossroads of three continents as a major tourist destination and an attractive business centre. Benefitting from the special economic zone policies, Aqaba pioneered wastewater reuse in industries, boosted tourism and restored the world famous Aqaba Bird Observatory. The challenge to implement a zero sewage discharge policy is addressed by: (1) seizing the opportunity to supplement the city’s water resources with fit for purpose reuse water that is then sold; (2) recovering energy from wastewater to reduce the operating costs; and (3) drawing in private sector financing based on shared interests for an attractive and liveable city.

KEY DRIVERS

WATER SCARCITY

Jordan is one of the most water scarce countries in the world, with a national average water demand of 120 l/c/d. In Aqaba, the water scarce environment is exacerbated by a particularly high water demand (330 l/c/d) due to tourism.

INDUSTRY AND TOURISM

Aqaba provides strategic access to regional and international markets. The city strives to promote business opportunities and a high-quality lifestyle, shapes attractive landscapes and protects seawater quality for tourism. Private sector investment is high in both the industrial zone and in tourism.

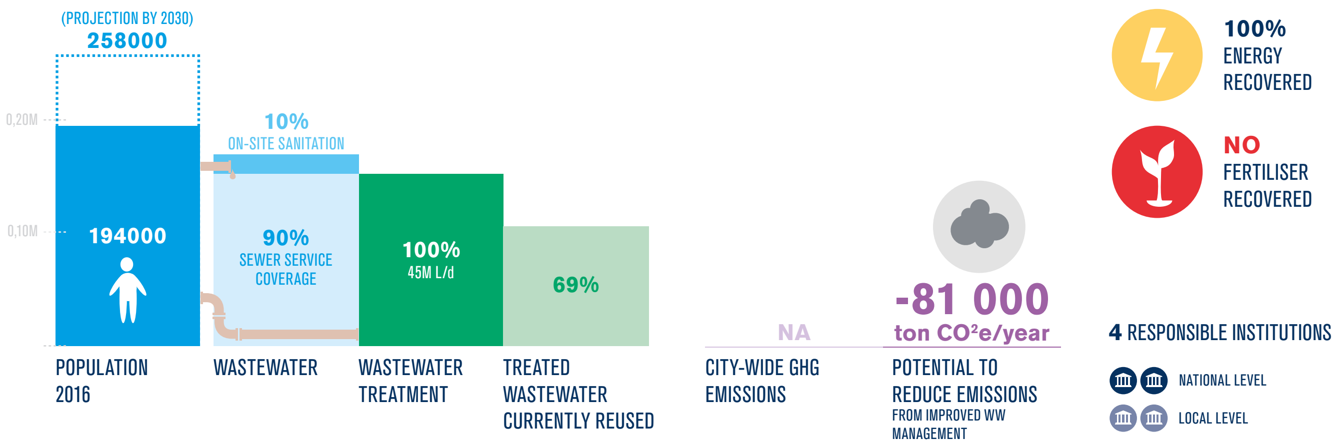
DECENTRALISED MANAGEMENT

Aqaba is regulated under the Aqaba Special Economic Zone Authority (ASEZA), which enables local authorities to adapt regulations to local needs, providing flexibility from the national regulations. ASEZ Law has helped the city to form and initiate laws and management tools that provide the enabling environment for investment in the wastewater reuse sector.

PRIORITIES

ZERO DISCHARGE

The "Zero Discharge" policy is being implemented to protect the quality of the marine environment and preserve the region’s attractiveness for tourism. In compliance with this



policy, the Aqaba Water Company (AWC) has made huge investments available for sewer and wastewater treatment capital costs in the past years. Currently, 90% of the wastewater is collected and treated, equaling 31,000 m^3/d. The treatment streams include a treatment pond of 9,000 m^3/d, the northern treatment plant of 12,000 m^3/d, and the southern plant, currently running at its capacity of 10,000 m^3/d, with plan for expansion to 24,000 m^3/d.

COST RECOVERY

AWC is structured with full operation and maintenance cost recovery. ASEZA's commercial law enables AWC to ensure its financial sustainability through recovering energy and selling reclaimed water. The capital investment is paid off by the tourism sector, under a Public Private Partnership (PPP) contract. Aqaba enjoys low sewer energy costs due to its flat environment, which minimises the pumping costs. Centralised WWTPs were selected as the best option combining the advantages of the economy of scale and the low pumping costs.

WORKING WITH NATURE

The treatment pond covers an area of 0.6km² and lies at the tip of the Gulf of Aqaba along a major migration bottleneck between Eurasia and Africa. Maintaining this quality habitat for migratory birds is a priority, even though the quality of the effluent produced is lower than with mechanical treatments. The treated effluent is directed towards the Agricultural Reclaimed Water network, serving a number of customers for their seasonal irrigation.

BENEFITS

- The investment in infrastructure for wastewater treatment and reuse pays off in terms of tourism, public health and overall well-being of the residents and generates more than **4 Million US $ in income for the AWC.**
- Reuse of reclaimed water covers 30% of the City's water demand. It enables Aqaba to **maintain the green areas and urban landscape**, as well as cover the water demand of development projects and the industrial zone.
- The resource recovery strategy **reduces carbon emissions** through enhanced operation and energy efficiency, as well as through producing carbon neutral power from solar farms and biogas.

WASTEWATER ROADMAP

2021

By 2021:

Infrastructure

- Rehabilitation of sewer networks in the eastern part of the city (Alshabiaha).
- Increase wastewater treatment capacity by upgrading existing WWTPs.

Regulation

- Strengthening the private sector participation office.
- Attract foreign investments in the wastewater sector in Aqaba (industrial reuse).

2030

By 2030:

- The Master Plan (dated July 2010) projects an increase of the wastewater daily flow rate to 61,000 m^3/day by 2030. Tenders to expand the treatment capacity to 70,000 m^3/d have been initiated.

2035

By 2035:

- Increase wastewater treatment capacity by building new wastewater treatment plants in the south.
- Reuse of treated wastewater in tourism (hotels and restoration centers).

Bangkok: Using sludge as a resource and a valuable economic good

Bangkok is a large metropolitan area with a population expected to reach 7 million inhabitants by 2030. Tackling the challenge of pollution is essential under the high rates of urbanisation. In Thailand, sludge is perceived as a valuable resource in the agricultural based economy. Sludge is collected, treated and transformed to be sold for reuse as fertiliser. The production of energy from sludge treatment is under further investigation for complete resource recovery.

KEY DRIVERS

AGRICULTURE

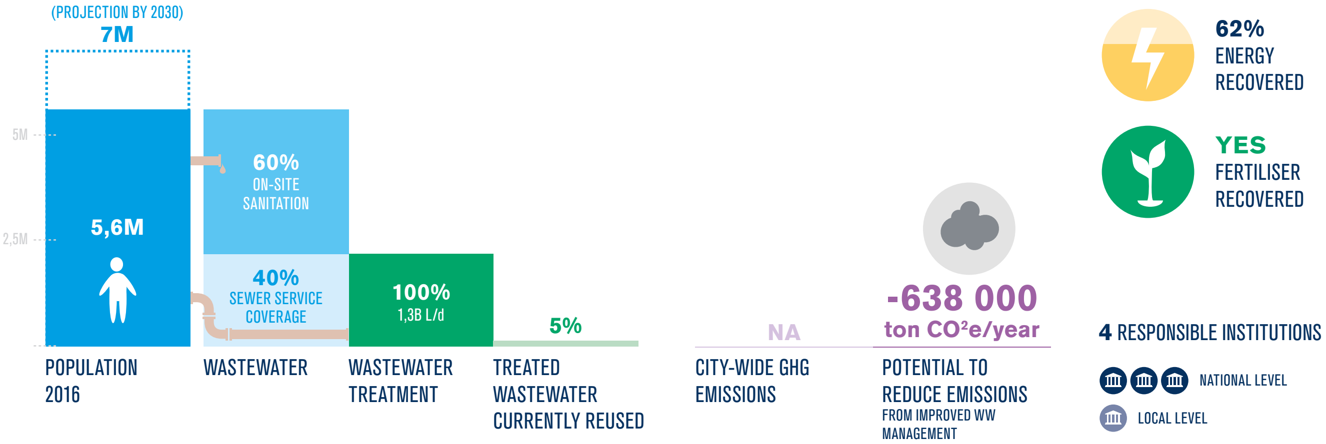
The value of sludge as fertiliser is recognised by farmers, businesses, government and local researchers. More than 60% of the population engages in agriculture, and agricultural export accounts for more than 60% of total exports. Bangkok, though very urbanised, has kept a strong agricultural sector, with a total agricultural area of 21,000 km^2, representing about 14% of the total area of Bangkok Metropolitan region.

POLLUTION

Bangkok has made efforts to reduce pollution through increasing the combined sewage treatment volumes, as well as enforcing stricter requirements on the emptying of domestic septic tanks and fecal sludge treatment. Sewerage infrastructure in Thailand separates black water from grey water at the household level. Black water flows into a septic tank, which is emptied on a regular basis. The grey water flows directly to the combined sewer system, which also collects all rainwater from the urban environment. These are then treated between eight centralised and 12 community WWTPs.

SECTOR REFORM

Sludge reuse activities are shaped by two main national programs: The National Economic and Social Development Five Year Plan and, the National Sewerage Development 32 Year Plan (2010-2041). The Office of Natural Resources and Environmental Policy and Planning (ONEP) establishes the environmental policy and programs, and checks the priority of sewerage projects at the national level.



PRIORITIES

STANDARDS

The Ministry of Public Health released the "Manual on Integrated Septage Management" providing a general framework for designs of septic tanks, anaerobic treatment systems, and standards for health and safety. Bangkok Metropolitan Administration (BMA) by-laws require that a wastewater treatment facility is installed for new housing developments with more than ten detached houses and all industries and businesses.

SLUDGE MANAGEMENT

BMA's strategy is to collect and treat septic sludge to be used as fertiliser in the city's public parks, surrounding green areas and farmland. It also aims to produce compost with a mix of natural rice straw and the dewatered sludge from the 12 WWTPs to be used as manure. Both the use of treated septage and composted sludge are intended to grow to balance out the increase in wastewater treatment coverage and respond to a local demand in fertilisers.

ENERGY RECOVERY

The interest to further valorise the reuse of sludge is high, as it has created new markets and generated income for businesses. Further research is on-going to investigate energy production during treatment, which is challenging due to the high dilution of organics in the combined sewer.

BENEFITS

- There is growing demand for both sewage collection and fertiliser in the area which has resulted in **sewage treatment facilities.**
- The collection of septic sludge and the sales of transformed sludge are **creating new markets and generating income** for businesses.
- **Pollution has been progressively reduced** from untreated combined sewers and poorly managed septic tanks.
- As a result of BMA's by-laws for on-site treatment, urbanisation has not led to increasing pollution.

WASTEWATER ROADMAP

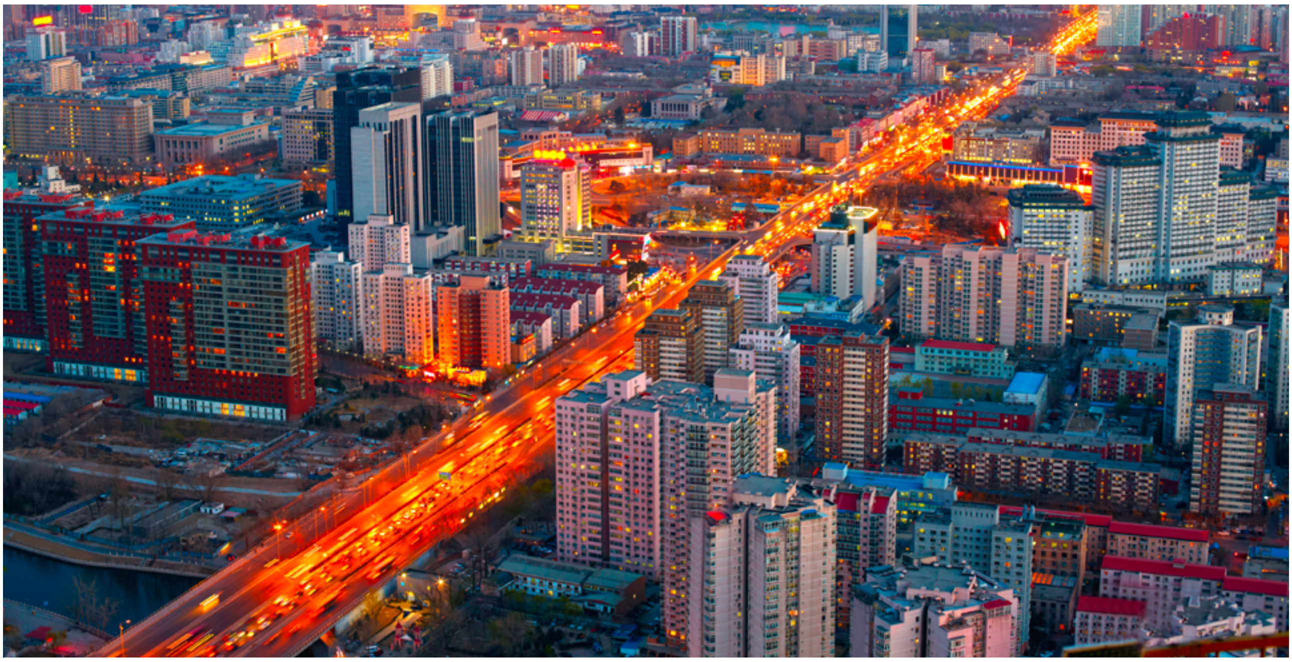
2030

By 2030: There are plans to increase the production capacity of the composting plant to meet the annual demand of fertilisers estimated at 12,000 m³.

BMA has a roadmap to tackle the 11 million m³/day of untreated combined sewer wastewater through increasing treatment capacity. However, much of this volume is composed of rainwater, which could become a benefit to the urban area rather than a nuisance, increasing energy requirements for wastewater conveyance and reducing the energy recovery potential from wastewater due to dilution. A balance between making use of rainwater from sewers and increasing the wastewater treatment capacity will lead Bangkok to become a water-wise city.

2020

By 2020: 60% of domestic wastewater is treated. So far, treated wastewater reuse has been limited to only 5% of total treated wastewater. This has to do with the low water tariffs in the country reducing the incentives for reusing treated wastewater. Building new infrastructure and the development of policies to leverage wastewater reuse will increase overall reuse up to potential to 7% by 2020.



Beijing: Building infrastructure to keep up with an ever expanding mega city

Beijing, the capital of the People's Republic of China, is facing environmental concerns as a result of intense population growth and industrialisation. The city is adopting new business models and investing in 'mega' infrastructure to reduce pollution from increasing wastewater flows. In seeking investment efficiency, the city has adopted different technologies to foster wastewater reuse. With the new infrastructure, the city has recycled a quarter of its domestic wastewater and improved treatment of up to 85% of industrial wastewater discharge.

KEY DRIVERS

POPULATION GROWTH

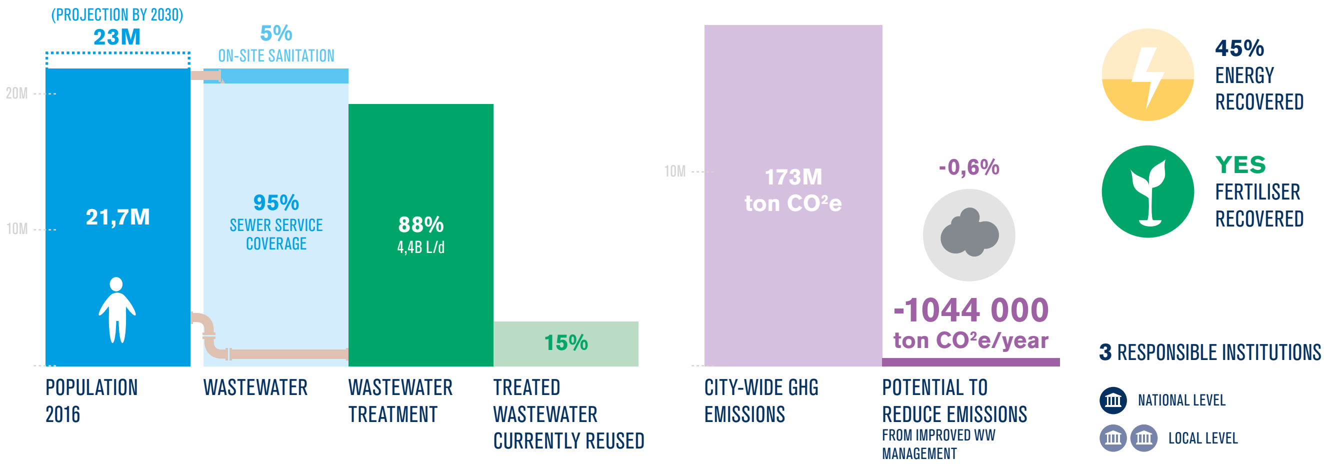
In the 10 years between the 2000 and 2010 censuses, the number of people living in the city grew by 44% - from 13.6 million in 2000 to 19.6 million in 2010. The population continued to grow at a significant speed, and in 2014, the population of Beijing increased by 1.52 million, 53% of which was located in downtown areas. By the end of 2016, the population of Beijing reached 21.7 million. According to the 13th Five-Year Plan (2016-2020), the number of permanent residents should not exceed 23 million.

STANDARDS

Reclaimed and reused water standards are much more stringent than the wastewater discharge standards. The pollution discharge fees are currently too low to create a cost incentive to treat wastewater to reuse standards.

WATER SCARCITY

Beijing is a city where water shortages have become a significant issue impeding social and economic development. The recycling of wastewater provides an effective solution to water scarcity.



PRIORITIES

WASTEWATER TREATMENT CAPACITY

By the end of 2015, there was a sewerage treatment capacity deficit of 500,000 m³/day. In addition, there were about 20 municipal sewage treatment plants and reclaimed water plants with lower effluent quality, which needed to be upgraded urgently. The lagging sewage network construction is one of the main factors that restricts further improvements in sewage treatment efficiency.

FINANCING INFRASTRUCTURE

The local authority revised the public procurement procedures in order to create new business models that encourage private investment and social capital engagement in financing wastewater infrastructure. The wastewater treatment projects are operated now on turnkey models.

INTEGRATED WASTEWATER PROGRAM

The cost of treated wastewater reuse is determined by the technology and the degree of treatment. Beijing's integrated wastewater program is about planning recycled water quality standards for specific applications. Membrane reactor (MBR) technology is widely used in Beijing and has increased cost efficiency in adjusting the treatment level to the reuse application. Although new wastewater infrastructure is built to achieve reuse standards, transporting the final product to the end-users remains complex.

BENEFITS

- **Full coverage of sewage treatment** is possible in the six main urban districts in the short term.
- **The water quality of the Liangshui River has improved** through enforcement of industrial wastewater treatment that reached 85%, and is expected to increase to 100% treatment in 2018.
- Approximately 47% of reused water is used for **agricultural irrigation**, 30% for **environmental reuse** and 20% for **industrial reuse.**

WASTEWATER ROADMAP

2030

By 2030:
Infrastructure: Investment in expanding reclaimed wastewater networks to different users according to the treatment standards.

2020 2021

By 2021:
In terms of regulation:
Reviews of the pollution discharge fees and wastewater reuse tariff will encourage capital investment in wastewater treatment projects. This will also introduce new business models as an alternative to long-term ownership.

Infrastructure:
Investment in wastewater treatment and sewer networks to achieve 100% domestic and industrial wastewater treatment.

Chennai: Addressing water scarcity through accelerated wastewater reuse

Rapid population and economic growth have resulted in increasing water scarcity in Chennai, the capital of the Indian state of Tamil Nadu. The city has therefore established water recycling through strong coordination and good governance. As the first Indian metropolitan area to achieve 100% sewage collection, the Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB), located in Tamil Nadu, formulated a set of service standards setting the scene for accelerated wastewater reuse and the "Zero Water Discharge in Chennai" program. All stakeholders, including government authorities, the private sector and citizens, are mandated by a set of regulations and by-laws to ensure maximum reuse of water and wastewater to safe quality standards.

KEY DRIVERS

WATER SCARCITY

Water stress has become a perennial concern in Chennai with the per capita availability of water dropping from 1,816 cubic meters (CM) in 2001, to 1,545 CM per year today. With a growing population and flourishing economy linked to higher industrial inputs and greater energy demand, there is a domino effect; with water demand from households, industries and power plants growing simultaneously adding to the urban water stress. This has caused a serious strain on the ability of CMWSSB to maintain city water supply to acceptable standards for all users.

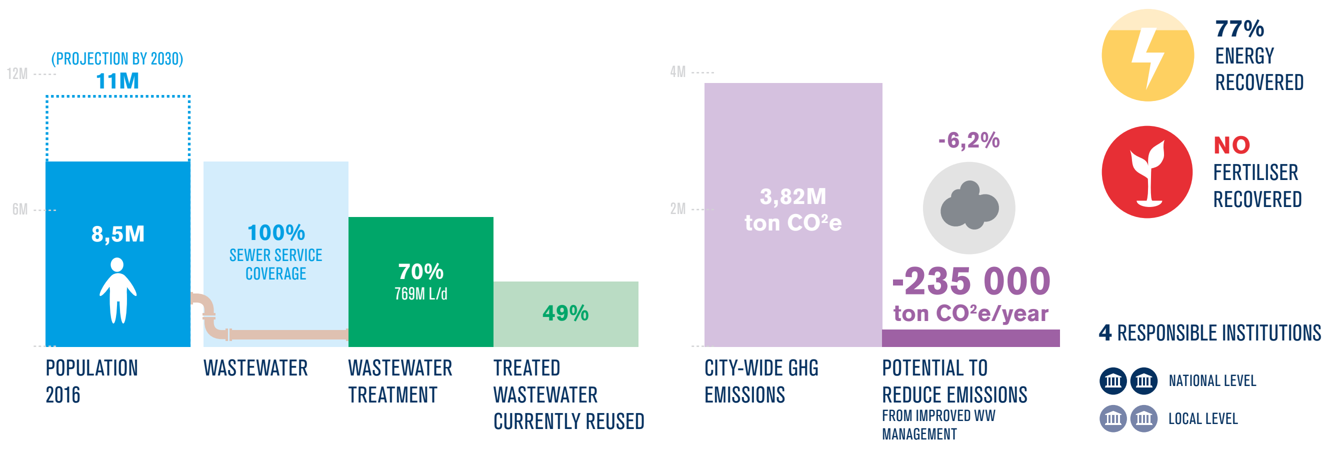
SECTOR REFORM

Over several years, CMWSSB has made serious steps to close the water loop and make the most of available water in Chennai. A bundle of laws and regulations to increase incentives for reusing water been launched. This was followed by strict application of rules and implementing innovations in close partnership with the private sector and inter-governmental agencies.

PRIORITIES

LEGISLATION

In harmony with the CMWSSB water reuse plan, the Greater Chennai Corporation launched a by-law that sets



the rules for mandatory wastewater recycling. Permits for all new developments will only be awarded with wastewater recycling planned into the design. The rules state that only water from toilets are to be connected to the sewerage network, the rest should be used for groundwater recharge after a simple organic filtration. In case of multi-storied apartments, the rules say that the recycled water should be used for toilet flushing. CMWSSB started implementing a rain water harvesting program in 2002. Under this program it is mandated that new or renewed water and sewer connections must include the installation of rain water harvesting systems, to reduce the burden on existing water supply and loading into the combined sewer networks.

ZERO DISCHARGE

In addition to increasing the water tariff for industrial use, it is mandatory for industries and manufacturers to achieve zero liquid discharge in their operations. That means no wastewater is discharged to the environment, and all wastewater is treated to be reused. CMWSSB, through a PPP model, treats wastewater to a standard and sells it to large industries in Chennai that further treat it to tertiary standards.

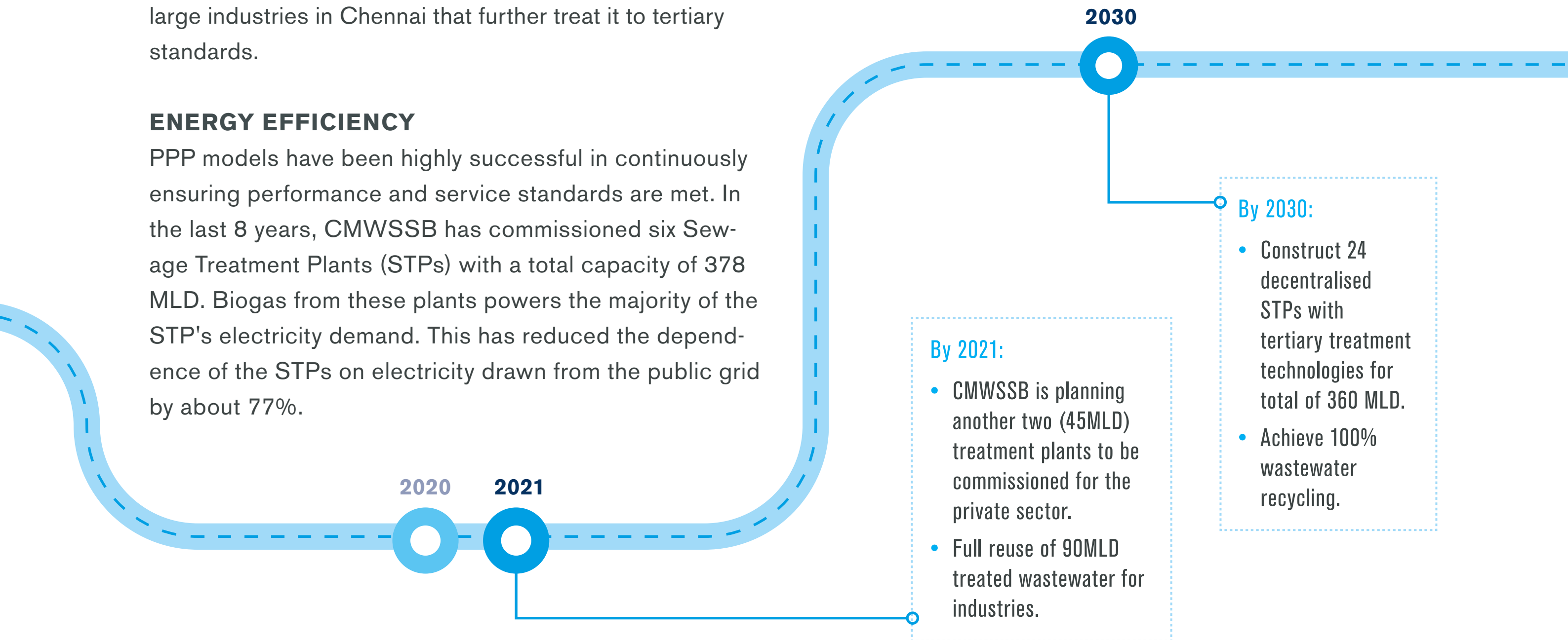
ENERGY EFFICIENCY

PPP models have been highly successful in continuously ensuring performance and service standards are met. In the last 8 years, CMWSSB has commissioned six Sewage Treatment Plants (STPs) with a total capacity of 378 MLD. Biogas from these plants powers the majority of the STP's electricity demand. This has reduced the dependence of the STPs on electricity drawn from the public grid by about 77%.

BENEFITS

- Chennai has achieved around **15% of the city's water demand through water recycling.** Around 8% of the treated wastewater is sold to industries and up to 40.7% of domestic water needs in newly built houses are secured from in-situ wastewater reuse.
- In-situ wastewater reuse in residential areas and rain water harvesting has reduced nearly 60% of water reaching the sewer system that has contributed to **improved operation of sewer networks.**
- The utilisation of biogas for energy production **reduces the GHG emissions and also electricity consumption** from the city grid.
- As demand for onsite wastewater treatment systems increased, **new markets for wastewater treatment manufacturers and businesses** were created.

WASTEWATER ROADMAP



Durban: Wastewater as an economic good

The city of Durban in the eThekwini municipality proved that innovative approaches to water, environmental and institutional management can yield exceptional results. Water scarcity, high tariffs and the increasing cost of discharge have led industries in this South African city to adopt innovative approaches to water recycling. Alternative solutions, such as wastewater reuse, have become more attractive and economically viable.

KEY DRIVERS

URBAN SPRAWL

Projected growth in water demand is based on spatial development plans approved by the eThekwini Municipality. One implication of this planned growth is that a reliance on conventional water resources will be unsustainable in the future; supply through other means must be explored.

INDUSTRY

The eThekwini Municipal region is the economic powerhouse of KwaZulu-Natal, and also contributes significantly to the South African economy. Identified priority sectors for growth include automotive, chemicals, clothing and textiles, food and beverage, furniture, metals, electronics and electrical machinery, and green industries. All of which put increasing demands on water management.

DECENTRALISED MANAGEMENT

The city council enjoys full financial and administrative autonomy, while policies and regulations remain in the hands of the Ministry of Environment and Water Affairs. Since the local government elections in 2000, it has become possible for local governments to assume full responsibility for ensuring water and sanitation services, as provided for in the Constitution.

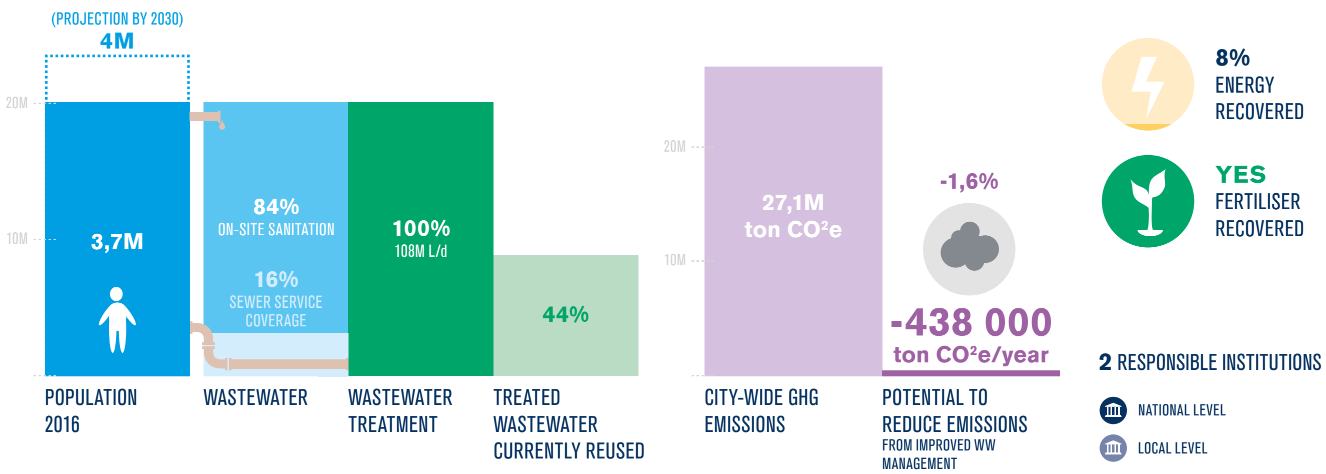
PRIORITIES

INDUSTRIAL REUSE

23% of the city's treated wastewater is reused by local industries in their production processes. Industrial users include companies from the mining and oil and gas industries, reducing their environmental footprint and operating costs.

PRIVATE SECTOR

The first build-operate-transfer (BOT), reducing in Durban was awarded with an overall objective to treat approximately 10% of the city's wastewater to potable standards, and sell the same to industrial customers. Following a



formal tender process, Durban Water Recycling (Pty) Ltd. (DWR), was awarded a 20-year concession contract for the production of high quality reclaimed water.

DECENTRALISED WASTEWATER TREATMENT

The implementation of decentralised solutions are driven by the high demand for housing, services, and land availability for new buildings going beyond the catchment areas. As well as providing basic services, such treatment systems are designed to have minimal impact on the local environment and provide opportunities for potential reuse for agriculture.

BENEFITS

- Recycling effluent has **reduced the demand for potable water by 7% and reduced the quantity of effluent directly discharged into the environment by 10%.**
- The use of recycled water for industries and agriculture in Durban has contributed to an **additional 300,000 people being served with potable water.**
- Industrial users of recycled water **pay 50% less** than the cost of water from the conventional system.

WASTEWATER ROADMAP

The Water Services Development Plan adopted in 2012, includes the council strategic plan for the water supply and sanitation services for the mid- and long-term.

2030

Long-term:

- Upgrade wastewater treatment works (sewer, pump stations and wastewater treatment plants) by 50%.
- Reuse of 96MLD of treated wastewater for drinking purposes.
- Increasing the total capacity of treated sewer effluent from five wastewater catchment areas would equate to 256MLD by 2030.

2020

Mid-term:

Remix water system for reusing wastewater for drinking purposes: A remix water system consists of a combination of desalinated seawater and treated effluent from a wastewater treatment plant. The water is treated through the use of membrane bioreactor technology will provide demand of approximately 65MLD.

Kampala: A growing city dealing with more people and impacts of climate variability

Kampala, the capital of Uganda, has received worldwide recognition as an African pioneer in integrated water management. To address the challenges of growing urbanisation, resource scarcity and climate variability, the National Water and Sewerage Corporation (NWSC) and Kampala Capital City Authority (KCCA) have teamed up to accelerate Kampala's transition towards sustainable wastewater management. These two organisations have actively involved a range of additional city-based stakeholders, including citizens, in delivering solutions. A central pillar of this approach is the establishment of call centers for septic tank emptying and setting up decentralised sanitation systems. Kampala is taking an inclusive, city-wide approach to work towards increased treatment and reuse of wastewater and fecal sludge, on the path towards a circular economy.

KEY DRIVERS

TOPOGRAPHY

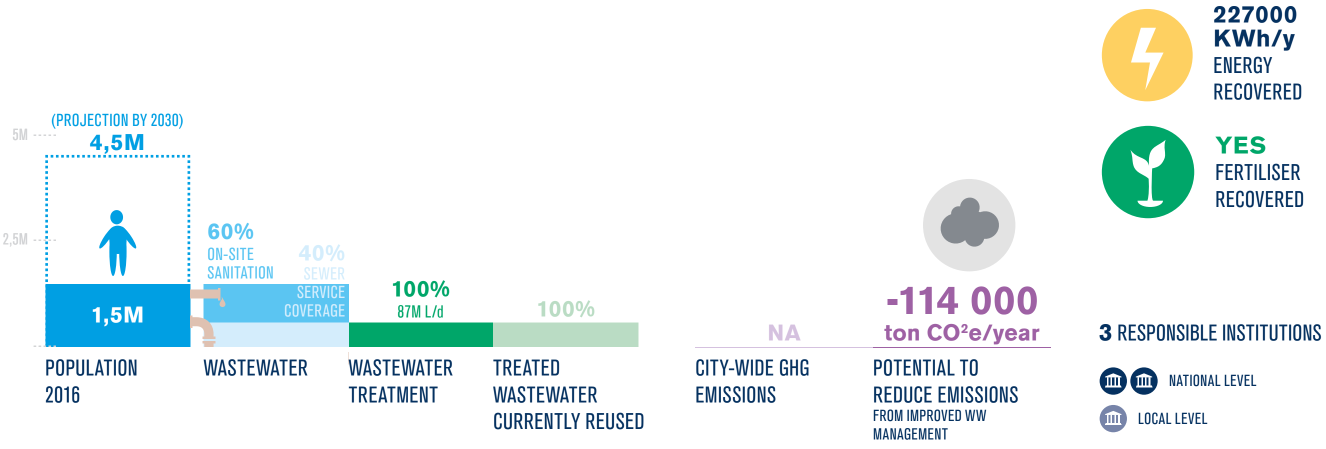
Kampala city originally stretched across seven hills, which has since expanded creating an undulating landscape of peaks and valleys. Currently 10% of the population is served by a sewerage system and 90% by onsite systems; a ratio that may not significantly change in the future due to the nature of the topography. Effluent from such onsite systems often finds its way into the Nakivubo channel and ultimately into the Inner Murchison Bay of Lake Victoria, which is inhabited by a large population of fishermen, and is also the source of abstraction for the drinking water supply of Kampala.

URBANISATION

Kampala has a high urbanisation rate of 5.2% per year, with the population currently around 1.5 million. This population nearly doubles during the day due to the influx of commuters, increasing the burden on public services and systems. Approximately 60% of the population lives in informal settlements, with unplanned infrastructure and high rates of inadequate access to services such as drinking water and sanitation. Urbanised wetlands exposes the population to flood risks and reduces the natural drainage capacity.

POLLUTION

Lake Victoria is also the discharge point of all water draining from the City. Thousands of urban inhabitants live in flood-prone slum areas that are at risk to epidemic diseas-



es related to unsanitary conditions, and send uncontrolled pollution to Lake Victoria. The pollution of Lake Victoria is also correlated with built-up areas in the wetlands, which can no longer play their purifying role. Pollution could reach unacceptable levels and have a significant impact on urban income and food production.

PRIORITIES

RISK MANAGEMENT

Sanitation Safety Plans (SSPs) – a risk management approach that identifies health risks in the sanitation system, are being implemented. As part of this, an improvement plan is being developed and regular monitoring protocols. Both NWSC and KCCA are now working on SSPs and aim to make them city-wide, as the tool offers a way to address the complexity with the sanitation service chain and manage the associated health risks. The SSP implementation has also been part of an important process to engage with all key stakeholders, and to ensure coordination that improves day-to-day operations and service delivery.

EXPANDING SEWER NETWORK AND WASTEWATER TREATMENT CAPACITY

The Kampala Sanitation project of extended infrastructure in the sewer area is a key achievement of NWSC. The project includes implementation of the wastewater treatment plant and expansion and rehabilitation of the sewer network. It includes biogas production, and electricity generation which will be used to power the treatment plant and any surplus will be sent back to the grid.

ENABLING ENVIRONMENT

KCCA has created a legal environment for safe reuse of wastewater products and by-products. This was characterised by a number of polices, reuse guidelines and a wide capacity building campaign for the sector workers and key local community players. The establishment of a call center for septic tanks emptying and sludge treatment and reuse are key outcomes of the enabling environment.

BENEFITS

- NWSC and local small businesses were able to **increase their income,** as now around 15% of NWSC's income is generated from sewerage services and septic tank emptying.
- **The health and safety conditions for pit emptiers and utility workers were improved** through training. This included the level of compliance with hygienic measures during fecal sludge emptying and transport operations, and use of PPE among cesspool emptiers.
- **Alleviation of pollution** in Lake Victoria and restoration of wetlands in its basin by reducing the illegal dumping of fecal sludge.
- **GHG emissions have also been reduced** through the use of energy from biogas.

WASTEWATER ROADMAP

2030

By 2021: To increase sewerage service coverage from 6.4% to at least 30% by 2018 and to increase wastewater treatment quality to comply with national standard will be achieved by:

- The delivery of Kampala Sanitation Program of Bugolobi WWTP and its sewer network.
- Implement packaged waste water treatment.
- Small scale sewage collection and treatment systems for small urban communities.

2021

By 2030:
To increase reuse of resources by:

- Implementation of the new trunk sewer and pump stations to connect new areas to the STPs.
- Generation of power from the STPs.

Lima: Learning by doing under the urgency of shrinking glaciers

Peru, in western South America, is losing its glaciers in the Andean Mountains as natural water sources. This is a result of climate variability and recovering from long periods of drought caused by the La Niña phenomenon. At the same time, intense urbanisation of its capital Lima generates an increasing demand for water, an already scarce resource. Peru has an urgent need to identify and develop adequate and timely solutions given these alarming trends. Peru was forced to act very quickly and "learn by doing" to fight the effects of climate variability. Reusing wastewater proved to be an irresistible choice.

KEY DRIVERS

WATER SCARCITY

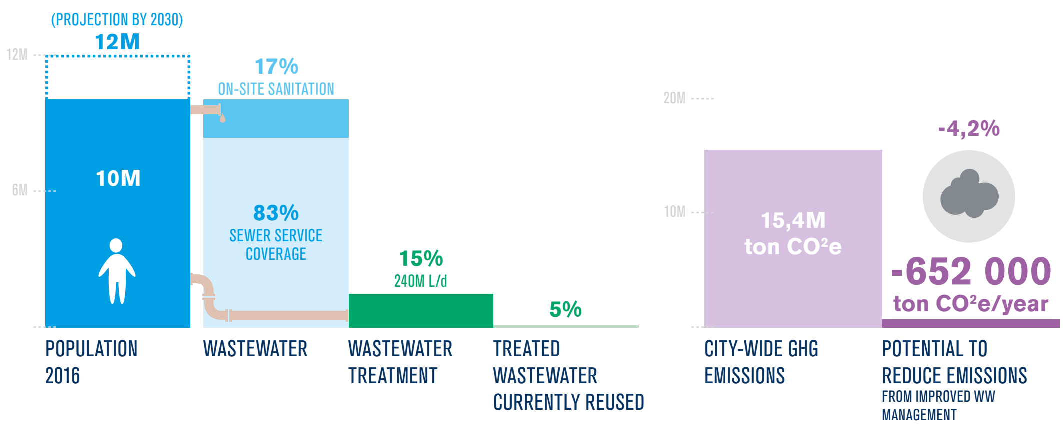
Lima is considered the world's second most extensive city built on a desert after Cairo, and receives hardly any rainfall. Only 2% of Peru's water resources are located in coastal areas such as Lima. Lima abstracts from surface waters and groundwater, with abstraction rates of the latter outstripping resource availability.

CLIMATE VARIABILITY

Lima depends on glaciers in the Andean Mountains (Andes) to provide 60% of its water supply. The glacial melting caused by climate change has pushed Lima to the top of the list of cities on the frontline of combating impacts of climate variability.

DECENTRALISED MANAGEMENT

Despite the centrally planned economy in Peru, especially in public utilities such as water, the Peruvian government has relaxed its control in the Lima region. Lima's Water and Sewer Company SEDAPAL (Servicio de Agua Potable y Alcantarillado de Lima – Sedapal S.A.), has enjoyed relative autonomy in managing water. It promotes a more flexible decision making process to address urgent issues, and opens the door for all stakeholders to participate in delivering solutions to water scarcity.



LOW ENERGY RECOVERED

NO FERTILISER RECOVERED

7 RESPONSIBLE INSTITUTIONS

- NATIONAL LEVEL (4)
- LOCAL LEVEL (2)
- NGO (1)

PRIORITIES

RECYCLING

The growing demand in urban and peri-urban areas for food, energy and water is challenging the traditional distribution of resources, rural-urban resource flows, and nutritional cycles. For this reason, the recovery of water, nutrients and energy from liquid and solid waste generated in urban and peri-urban sanitation systems, becomes an increasing priority for local public authorities.

WASTEWATER TREATMENT CAPACITY

SEDAPAL operates 21 WWTPs with a total capacity of 2.775 m^3/s. That is only 15.3% of the total wastewater generated by the city. The major wastewater flow is directed to water channels or the ocean with only primary treatment.

WASTEWATER REUSE

Lima started using treated wastewater in horticulture and irrigation for green urban spaces. This has paved the way for a wider range of application in industries, agriculture and potentially drinking water.

BENEFITS

- **Increased ownership and responsibility towards reusing wastewater** through building trust between all stakeholders.
- Reuse of 3.5 m^3/s of treated wastewater to **irrigate 3,400 hectares of parks and gardens** managed by Lima's Parks Service (SERPAR).
- **Wastewater reuse is incentivised** through the creation of a legal framework and enabling environment.

WASTEWATER ROADMAP

2021 — 2030 — 2035

By 2021:

Promote consensus agreements to integrate and coordinate city, water and climate risk management.

Increase indirect wastewater reuse by increasing domestic wastewater secondary treatment to 7 m^3/s, and develop 9,000 ha of green areas and 4,000 ha of farming areas in Lima with treated wastewater.

By 2035:

Increase direct reuse of wastewater by implementing proper infrastructure for treated sewer effluent reuse. By 2035, it is expected that 100% of the 24.8 l/s of generated wastewater will be treated to various levels, each adequate with the intended use.

Manila: A mega city regenerating its resources

Manila, the capital of the Philippines, is a rapidly growing mega city. Urbanisation and industrialisation, in combination with low sanitation coverage and poor wastewater management, are key drivers of pollution in Manila Bay and Laguna Lake. A citizen's petition drove to several activities and successful reforms in the sanitation sector where the supreme court ordered key governmental organisations to take action, which paved the way to privatisation. The Manila water sector privatisation story is one of the most successful in the Asia region and continues to strive for excellence.

KEY DRIVERS

POLLUTION

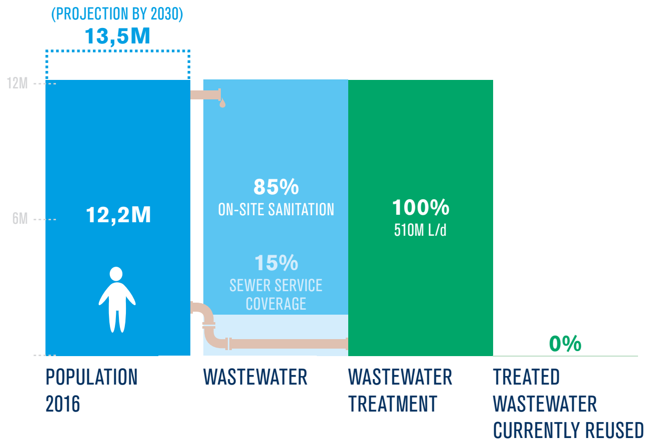
Every year, millions of cubic meters of untreated wastewater are disposed in Manila Bay and Laguna Lake. In 2008, the annual Bilogical Oxygen Demand (BOD) load from the 58 sub-basins at point source in Manila Bay and Laguna Lake was estimated at 232,764 MT/yr. Discharge of untreated domestic wastewater and overflows from septic tanks have been the major source of pollution. Both Manila Bay and Laguna Lake are sources of drinking water and habitat for native fish that people depend on for their livelihood and primary food source.

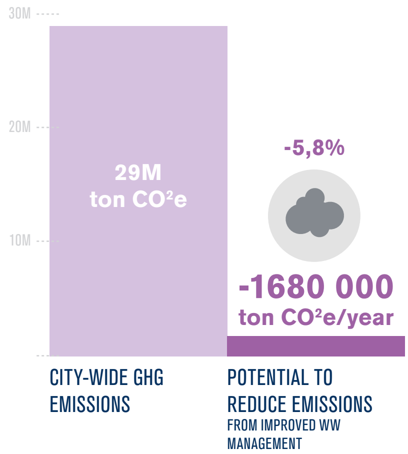
POPULATION GROWTH

Metro Manila has an estimated population of 12.8 million and is predicted to reach 16,7 million by 2030. Connection to sewer networks was only 8% in 2008, due to the lack of financial resources, cumbersome procurement procedures and densely populated areas. These issues resulted in untreated wastewater discharge into the environment, threatening public health and urban liveability.

SECTOR REFORM

In 1995, national executive and legislative actions led to bidding out two concession contracts by the Metropolitan Waterworks and Sewerage System. Under the concession agreements, the operational and financial burden of utility management and investment fell on private companies Maynilad Water Services Inc., for the western side, and Manila Water Company Inc., for the eastern side. Two concession agreements were signed for a 25-year period and have since been extended for an additional 15 years. A regulatory framework and relevant acts were developed and passed to facilitate the planning and implementation





of several programmes to increase sanitation coverage, reduce untreated wastewater discharge, and increase wastewater reuse.

PRIORITIES

EXPANDING THE SEWER NETWORK

15% of the population is connected to sewer networks and 85% have access to onsite sanitation (septic tanks), of which 44% of the fecal sludge and effluent is safely managed. The flexibility of the private sector offers a range of technical solutions to speed up connections to the sewerage network. Existing storm water infrastructure has been used as a temporary solution for a combined sewer system. More than 58 decentralised treatment plants were constructed (in addition to the existing centralised plants), seeking low operation costs and the most potential for energy production while ensuring effluent standards were met.

EXPANDING SANITATION COVERAGE

The private concessionaries and the local government agencies have committed to increase connection to the sewer network by 100% and safely manage 100% of fecal sludge from on-site sanitation systems by 2028.

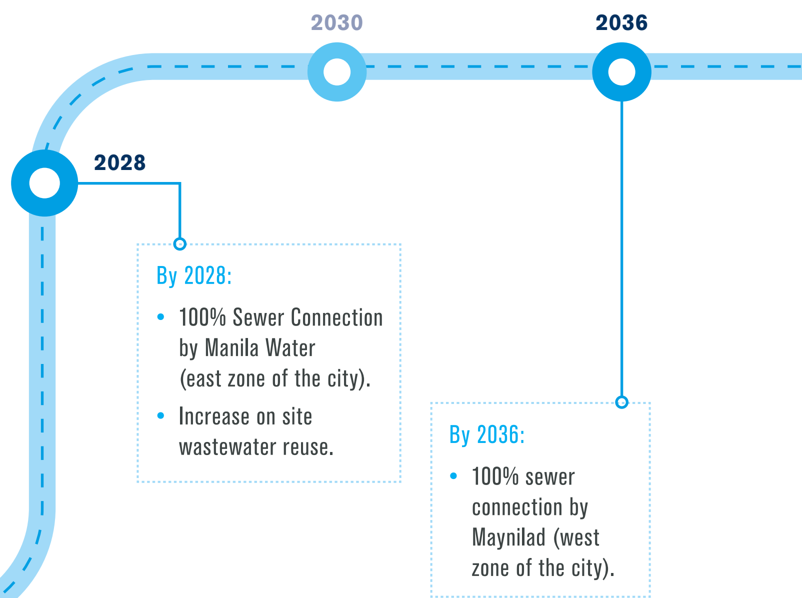
REDUCING POLLUTION

A combined effort from government agencies and private operators to initiate decentralised treatment facilities and reuse of wastewater for flushing toilets, watering of gardens and street cleaning has reduced loading of pollutants and nutrients to Manila Bay and the Laguna Bay tributaries, while reducing pressure on water resources. Further, strict implementation of the polluter pays principle (where a fee is collected for discharge of untreated wastewater) has incentivised industries and "gated" communities to install onsite/decentralised treatment plants. These efforts have led to the restoration the Laguna Lake which is used as a source of drinking water and aquaculture.

BENEFITS

- Sector reform and privatisation has led to strengthened partnerships among inter-governmental agencies and the private sector to **accelerate sanitation coverage** in Metro Manila.
- A regulatory framework and legislation have paved the way to the development and implementation of plans that commit all stakeholders to **100% coverage and safely managed/reuse of wastewater and sludge by 2028.**
- Implementation of the polluter pays approach rather than issuing fines has been a key driver in **incentivising industries and residential compounds to install onsite/decentralised treatment systems.**
- Combined efforts from government agencies, private sector and residents has **reduced pollutant loads** to the environment and regenerated key resources that are key sources of drinking water and food.

WASTEWATER ROADMAP



Summary

It is estimated that current wastewater treatment capacity is 70% of the generated wastewater in high-income countries, and only 8% in low-income countries (Sato et al, 2013[1]). Decisive, urgent and large scale action is needed. Cities should be empowered to take the lead on a resource revolution, with governments and the private sector investing heavily in infrastructure to enable a transition to a circular economy, which in turn will bring significant environmental, economic and social benefits.

There is a well-established suite of technologies that a number of cities and countries have successfully deployed to increase the amount of wastewater that is recycled and reused. The Global market for wastewater recycling and reuse reached nearly $12.2 Billion in 2016 and should reach $22.3 billion by 2021 (BCC Research, 2017[2]). This market expansion is in response to a growing demand from cities and industry for water against a backdrop of increased urbanisation, population growth and climate variability.

The most significant driver for wastewater reuse is water scarcity. Nations and cities are compelled to look beyond their traditional sources of water supply and look at portfolio approaches that include treated wastewater. At the same time, there is a sharper focus on preventing pollution of source waters, reducing the amount of untreated wastewater that is discharged and tapping into the inherent value found in wastewater streams, which is further galvanised by the Sustainable Development Goals (SDGs). Whilst the SDGs set an ambitious target for reuse, it also presents a great opportunity to address water security, public health and socio-economic development.

Whilst the necessity of wastewater reuse in places like Aqaba and Lima, where water scarcity has been the norm for many years, is apparent, cities are increasingly taking proactive actions to improve their water security. Cities recognise water as an essential resource for growth and prosperity. In a number of countries, cities and their institutions are given greater autonomy; decision making is decentralised and systems are being adapted to local drivers and demands.

In megacities such as Beijing, where population growth and urban sprawl will continue, there is a need to build out infrastructure to keep up with demand. This build out needs to happen with less available land, with technologies which are less energy intensive and can cope with increasing nutrient loads and can extract useful materials from wastewater. Cities are looking at social, environmental and health benefits of these approaches and understanding the true value of sustainable water management.

Cities across the globe are establishing ambitious targets, and developing policies to support 'zero discharge' concepts, such as in Aqaba and Chennai for example. Such policies are often targeted towards industry and require meaningful incentives. Partnering with industry, such as in Durban, where 98% of wastewater is treated and used by industry, can have a financial impact on reducing operational costs, for example.

Sector reform, in places like Manila have granted greater autonomy to utilities, sharpened legislation to decrease polluting effluent and created incentives for private sector participation. In combination, these changes are having a positive effect on wastewater management. These combinations are critical, with no silver bullets; cities need to look at integrated approaches that look across sectors and systems. In Kampala, approaching sanitation and wastewater management – onsite and sewered options – is an important step to rethinking urban waste management. With an effective partnership between the National Water and Sewerage Corporation (NWSC) and Kampala Capital City Authority (KCCA), there is a great opportunity to not only provide good public services, but to protect Africa's largest lake for millions of people.

Getting the regulatory and market conditions right for commercialisation of reuse products is important. In Bangkok, with a large agricultural sector there are opportunities to create a market for fertiliser produced from treated sludge for a variety of applications. But they are not stopping there, by exploring opportunities to produce energy from sludge; they are seeking further benefits to incentivise partnerships and action to deal with an increased demand for wastewater treatment.

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[1] Sato, T., Qadir, M., Yamamoto, S., Endo, T. and Zahoor, A. 2013. Global, regional, and country level need for data on wastewater generation, treatment, and use. Agricultural Water Management, Vol. 130, pp. 1–13. dx.doi.org/10.1016/j.agwat.2013.08.007

[2] https://www.bccresearch.com/market-research/environment/water-wastewater-treatment-markets-report-env008d.html

Within the context of the SDGs, countries, cities and industries are committing themselves to a future with universal access to safe water and adequate sanitation and where half of wastewater is reused. Such commitments require new ways of thinking; no longer do we think about removing a problem, but rather how to create opportunities - ones that can be created through incentives and shared for mutual benefits.

Lessons learned

The cities covered in this report were carefully selected to cover a wide range of conditions and most importantly, the governance framework that enable these practices. The lessons learned offer examples to leaders in other cities of how wastewater reuse can be achieved. Each city will be different, but the approaches being pioneered in these cities are applicable and scalable globally. The wide variety of examples covered aims to inspire further research to synthesise and customize solutions for all cities.

1. ESTABLISHING THE RIGHT ENABLING ENVIRONMENT

Improving the enabling environment was the first step in almost all cases. National programs, plans, revision of water rights and laws have been achieved by a strong commitment from the central government in Lima, Durban and Manila. National policies promoted wastewater reuse and river cleaning master plans, and offered the legal framework for local government action and international and public funding. Support from international development cooperation has also significantly contributed to the successful implementation of new regulations.

2. ENGAGE WITH THE PUBLIC

There are many different ways for effective public engagement to take place, where trust is built between the public, institutions and operators to increase the acceptance of wastewater reuse. Awareness raising and promotion of reuse practices, like in Kampala and Durban, or encouraging active participation of NGOs and local communities in the supply chain of wastewater reuse, such as in Lima, demonstrate good examples of trust-building. The bottom up approach in Manila is an example of effective public engagement. The petition that the residents of Manila signed drove the change of laws and regulation enforcement.

3. DECENTRALIZATION CAN IMPROVE DECISION MAKING OUTCOMES

Decentralisation of decision-making seems to be an effective mechanism that increases investor interest, as seen in Durban and Aqaba, and to accelerate progress and reduce bureaucracy like in Lima and Manila. Yet, decentralization takes different forms in each case: complete decentralisation as a free economic zone in Aqaba; municipal autonomy laws in Durban; informal power delegation to the local level in Lima; and empowering local communities and involvement of the public in Kampala. It is crucial to note that the willingness to take responsibilities and leadership at local level is a pre-condition to avoid delegating up responsibilities.

4. REUSE CAN DRIVE INNOVATION

In all eight cities, innovations and tailored made solutions were introduced. In Durban, for example, stakeholders created business opportunities for wastewater reuse as a solution for the high cost of outfall upgrade. In Aqaba, regulators creatively introduced different standards for different reuse options as a starting point for wastewater infrastructure planning. They introduced a new planning path based on first identifying use: the selection of location and design to minimize cost and increase efficiency, compared to the conventional path of identifying the discharge standard, designing the facility and then finding the location.
Financing wastewater infrastructure remains the most challenging part for most governments. Beijing, a mega city, offers a procurement method that brings investor interest and generates new financing mechanisms.

5. TOOLS NEED TO BE CONTEXT SPECIFIC

In Chennai, the effective use of different management tools such as financial incentives, building permits and standardization, enabled greater cooperation for effective wastewater reuse. While the financial incentives for water recycling were missing in Bangkok due to low water tariffs, sludge as a fertilizer was the main product in the supply chain in contrast to other cases where it is only considered a by-product of treatment. In Durban, the financial incentives proved to be effective tools to influence market dynamics and shift from supply to demand management on newly emerging economic goods, including recycled water.
Adaptive management in Lima helped to understand the context and uncertainties involved in finding the most sustainable solution. A continuous learn-by-doing approach was able to respond to the urgency of water supply in the area.

The IWA Principles for Water-Wise Cities

A good plan for wastewater reuse will be embedded within a broader urban planning framework that positions water cycle management as a key connector and enabler for other services, sectors and systems. The IWA Principles for Water-Wise Cities provide 17 principles across four levels of action and five building blocks to support cities in developing and realising a vision for a water-wise future. The eight case studies presented in this report provide useful examples of how cities can take action towards the wastewater reuse opportunity using the five building blocks.

Vision

Recognising the opportunity to close the loop on resources when handling wastewater.

Vision may be driven by national plans like in Bangkok or Beijing or by the local government like in Kampala or Chennai. The development of a local vision can also be enabled by the national policies like in Aqaba, where a special economic zone was created, or in Durban, where the city council was given full autonomy to address the water and sanitation issues. The case of Manila raises awareness on the power of citizens, who initiated the vision with their drive to clean the Manila Bay.

Planning Tools

Enabling the assessment of treatment requirement, costs and co-benefits, as well as the demand for recycled products.

Durban and Aqaba show that planning tools can be used to convey to multiple stakeholders the benefit of investing in reuse infrastructure beyond the mandatory wastewater treatment mandate. The ability to demonstrate the benefit of clean waterways for tourism, or the benefit of ensuring water supply to industries, supports coordinated action and investments by the public and private sector stakeholders.

Knowledge & Capacity

Implementing the vision starts with the existing capacities of urban stakeholders and increasing them step by step.

A great example comes from Lima, where "learning by doing" has become a moto given the urgency of initiating change towards more sustainable resources. It's about starting to take action where staff already have competencies and to build from there. Beijing has built and is still building capacities in energy recovery and treated effluent reuse.

Implementation Tools

Tools such as financing schemes and regulatory or financial incentives are key to drive change.

Tariffs as seen in Durban, or by-laws in Bangkok and Chennai, drive the behavior of urban stakeholders to support the implementation of the vision. Chennai, Aqaba, Durban and Manila, have set successful PPP contracts. Models to sell recycled goods from sludge or treated effluent have been implemented in Bangkok, Durban and Aqaba.

Governance

Providing the framework for urban stakeholders to work together on implementing the vision.

Bringing stakeholders together is exemplified in Kampala, as the city developed an integrated plan to tackle their wastewater challenge while also recovering energy, nutrients and water for industries.

In partnership with

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