In collaboration with the Swiss Agency for Development and Cooperation

WORLD ECONOMIC FORUM

THE **IMAGINE IF** WATER SERIES

Circular Cities:
A circular water economy for cleaner, greener, healthier, more prosperous cities

BRIEFING PAPER

JULY 2021

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The **Imagine If** Water Series

This is the first in a series of papers that highlight new ways of thinking about global water resources. This **Imagine If** Water Series aims to inspire, provoke and invite new ideas. The world's water resources are a system already pushed to the edge. At the same time, water is connected to a diverse set of burning economic, social and environmental issues. In today's context, where the world strives to restart its engines while addressing multiple economic and social priorities, it is necessary to see water as a catalyst and as a key to unlocking multiple wins spanning these pressing issues to achieve a more equitable and sustainable global economy.

Imagine if...

Imagine if cities of the future could enhance humanity's quality of life, becoming healthier places to live, more resilient to climate-related shocks, more sustainable, supporting vibrant hubs of economic activity, innovation and job opportunities.

Imagine if cities were recognized as global climate champions in the "race to net-zero" carbon economy. Circular cities, where the use and reuse of water and wastewater resources are optimized, can unlock the true value and potential of urban areas and propel the world towards achieving this vision.

1

The challenges that cities face

Urban areas around the globe are becoming less liveable due to water stress, exacerbated by climate change. This needs to change right now.

Over the next three decades, the world's population living in urban areas is projected to swell to nearly 7 billion people, which will be more than two thirds of all humanity.[1] Yet in this time cities will be less liveable due to climate change, unstable weather patterns and extreme meteorological events.

Cities face a real challenge with increasing water stress, as some are already running out of water. In 2018, Cape Town was poised to become the first major global city to hit "Day Zero", the day when the taps would be turned off due to drought, high demand and inadequate supply. The metropolis came close. It isn't alone – Istanbul, Mexico City and Chennai have all faced water crises recently.

One in four cities – representing over $4 trillion in economic activity – are already water stressed.[2] This is also true of 70% of the world's megacities.[3] If the world continues with business as usual,[4] 45 cities, each with over 3 million residents, will face extremely high-water stress by 2030; and by 2050, the number of urban dwellers facing acute water shortages could climb to over 1 billion.[5]

Water problems are not limited to droughts; the number of extreme rainfall events is also growing due to more energy in the atmosphere. These produce intense precipitation, resulting in increased urban flooding.[6] Extensive cityscapes consisting of concrete, tarmac and buildings create higher flood flows within metropolitan areas.[7] In 2020, Jakarta saw the highest daily rainfall since records began in 1866: floods killed 19 people and 62,000 people were evacuated.[8]

At the same time, cities are becoming hotter. Nine of the planet's 10 warmest years have taken place since 2005, with the five warmest all occurring since 2015.[9] By 2050, more than 970 cities will experience average summer temperature highs of 35˚C. Right now, only 354 cities are this hot.[10] By 2050, heat waves will affect more than 1.6 billion people in urban centres.[11] Towards the end of the century, cities could warm by as much as 4.4˚C on average.[12] Builders predominantly construct cities using concrete, which traps this warmth and creates an urban heat island effect, increasing temperatures.

Climate change is exacerbating these impacts, making them more frequent and intense. Adding to this, rapid urbanization is escalating demand for and pressure on city resources. Every month, 5 million people migrate to urban centres around the globe, much of this in the developing world.[13] This means increasing demand for water and energy, as well as more human waste and water pollution. This puts increasing strain on wastewater treatment plants and utilities, and the riverine systems into which water is often discharged.

Water pollution is making waterways sick and deteriorating the environment, potentially having adverse effects on human health. Over 80% of the world's wastewater is still released into the environment without treatment:[14] roughly 30% in high-income countries; 62% in upper middle-income countries; 72% in lower middle-income nations; and a staggering 92% in low-income countries.[15]

This level of pressure on urban ecosystems is not sustainable.

Over 80%

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2

The design of cities is the issue

When it comes to urban areas, water is used in a linear way. It is captured, used and disposed of – a system that must change rapidly in a climate-conscious world.

In the 21st century, the design, development and building of cities is not fit for purpose. Grey infrastructure is predominantly used to capture rainfall and runoff to channel water from upstream dams, distant watersheds or groundwater extraction and pipe it into cities. It is then shifted out using drainage systems and channelled waterways built using concrete and human engineering.

Therefore, most city water follows a linear path: cities capture it, use it and then dispose of it, treated or untreated, into waterways that eventually flow into the ocean. This approach to water infrastructure in urban areas is not sustainable in the long-term because it does not value water as a finite resource that is unpredictable in its supply. Without changes in design, cities will become less liveable in the second half of this century.

By 2050, the world will add 1 million square kilometres of urban space,[16] stretching across tens of thousands of cities globally – a surface area larger than Egypt. The current urban development model means this expansion is likely to be concrete and grey infrastructure.

This business-as-usual approach has other consequences. Reducing heat in ever expanding concrete jungles is a challenge. Cooling as an industry consumes up to 30% of global electricity and generates 8% of greenhouse gas emissions worldwide. By 2030, the number of air conditioners will increase by two-thirds from the 2 billion units currently installed.[17] Electricity demand for cooling in buildings could also rise by as much as 50% globally.[18] The strain on cities will be palpable.

Hotter cities also impact economic activity. The costs of lower labour productivity worldwide due to rising temperatures is expected to hit humanity hard, with an accumulated financial loss due to heat stress amounting to $2.4 trillion by 2030.[19]

3 The circular water economy within cities

Closing the loop on water use will insulate cities from future climate-related shocks.

In a post-COVID-19 world, it is necessary to redesign cities: building back better and greener should be the new imperative. The world's 50 largest economies have pledged $14.6 trillion to long-term recovery measures, with $341 billion earmarked for green initiatives.[20] At the same time, green finance is reaching new heights, with traded green bonds now valued at over $2.3 trillion.[21]

Rethinking water infrastructure must be at the forefront of this agenda. It plays an incredibly vital role in creating a more sustainable cityscape. The quality and amount of water an urban area uses, reuses and exchanges with the wider watershed is intrinsically linked to the health of the local environment.

Circular cities with water at the core – where they manage water in cycles and maintain it at its highest possible intrinsic value within the urban environment – should be a fundamental aim. This puts less stress on natural ecosystems. It also insulates cities from external environmental stresses. Cities need to adapt and become resilient to the impacts of climate change already manifesting themselves today and projected to become worse – namely heatwaves, flooding, unpredictable rainfall and imminent Day Zeros.

The main goal needs to be closing the loop on water use. Cities must look to reuse *all* materials in water and water itself, minimizing waste from drinking, sanitation, irrigation, heating and cooling. In a circular city there is no such thing as wastewater. Each metropolis would tap this resource fully, as a rich source of energy and nutrients – including carbon, nitrogen, phosphorus, heat, organic waste and biosolids – as many are crucial to urban living.

Managing water efficiently in cycles within an urban area will insulate a city from climate change, decoupling a city's economic growth from water use, allowing cities to grow significantly without consuming more water. By the middle of this century, the circular economy has the potential to reduce water consumption from primary resources by 53%.[22]

Cities would also benefit from using water to enhance natural capital throughout urban spaces. Ponds, bioswales, creeks and lakes, which also boost biodiversity, are more desirable places to live and work next to, enhancing the quality of life and mental well-being of city dwellers.

Investments in better water management can drive operational savings. They are value-creating investments with short payback periods; they also have environmental benefits. This money could be used to reinvest in new water infrastructure that is more geared towards the circular economy.

For instance, research on the opportunities associated with efficient wastewater management found that by deploying readily available technologies, $40 billion in savings could be made across the US, Europe and China, and that nearly 50% of electricity-related emissions from the global wastewater sector could also be abated.[23]

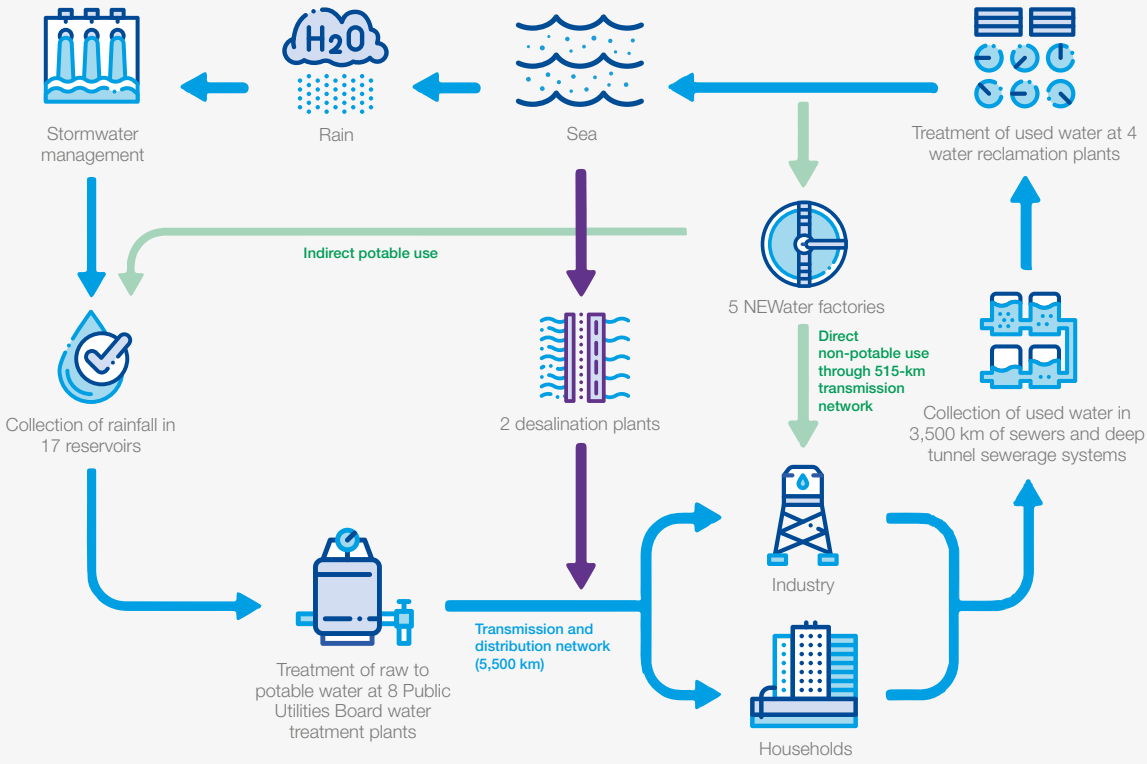
Cities with ambitions to become more circular could additionally unlock significant amounts of green and climate finance to build new water infrastructure that is not an environmental, social and governance (ESG) risk, but an asset. This will also future-proof urban growth in a more sustainable world.

Such water investments would also create jobs in a circular economy. The recycling industry employs more than 1.5 million people worldwide.[24] New jobs will be in blue-green industries and reworking city water ecosystems. New job titles that will emerge include "green rooftop water manager", "city wetland executive", "urban cooling supervisor", and "circular water director".

Cities cannot achieve full-blown circularity overnight. It involves replumbing entire neighbourhoods and cities, even watersheds. But some urban areas are starting to make progress through their circular water initiatives. It will be vital to increasingly bring these together in one place: much greater value is generated when one district's waste is another's resource and vice versa.

BOX 1 Learning from Singapore and its circular water economy

Singapore, a city-state with no natural aquifers, is at the forefront of the circular water economy. Reclaimed water satisfies 40% of current water demand.[25] Called NEWater, it is projected to expand to 55% by 2060. Public acceptance of drinking recycled water is a challenge that the country has overcome through widespread education. It has even produced a beer from recycled water.[26] Water reuse is one of the most important pillars for Singapore to provide safe and reliable water sources in the future.[27] The city collects stormwater in reservoirs within city boundaries; it is also rolling out 300,000 smart water meters by 2023.[28] Singapore has become a global hydro-hub, pioneering new water technologies and jobs.[29]



Adapted from: *Public Utilities Board, Singapore*

BOX 2 The 50L Home Coalition

As more cities face the risk and uncertainty of severe water shortages and potential Day Zero scenarios, a group of private sector leaders has come together with the 2030 Water Resources Group, World Business Council for Sustainable Development and World Economic Forum to form the 50L Home Coalition – an initiative that aims to reinvent the future of water by reimagining city infrastructure and changing the narrative on domestic water consumption. As part of its efforts, The 50L Home Coalition is generating new ideas and opportunities to accelerate innovations in homes and across urban infrastructure and ecosystems to enhance water circularity and water reuse.

4

A portfolio of circular water solutions

Many innovations already exist around the world. Cities must deploy these at scale and interconnect them to achieve a circular water economy.

Water capture and storage

Sponge cities will act as a water buffer
Shanghai's mission to improve the city's resilience to climate change prompted the Chinese megacity to rewrite its urban-drainage strategy, putting nature-based solutions first. It has deployed sponge city districts, which store vast amounts of stormwater until needed. This type of blue-green infrastructure was tens of billions of US dollars cheaper than the grey solutions initially proposed.[30]

Cities must use captured rainwater for cooling
Blue-green infrastructure can offset urban heat islands. For instance, Potsdamer Platz in Berlin, with its green roofs, buffer ponds and stormwater cisterns, reduces summer temperatures by 2°C.[31] The evapotranspiration of planted trees in Mexico City can reduce urban air temperatures by 1°C.[32]

City water sources will save energy on cooling
Toronto and Paris have deployed free cooling from urban water sources to cool buildings. Climespace takes 50% of its cooling needs from the River Seine, meaning 35% less electricity, 50% less CO_2 emissions and 65% less water consumption than traditional air conditioning.[33]

Wastewater

Wastewater use is key to circular city movement
Wastewater is the largest untapped city waste category – as big as all solid waste types combined.[34] It has up to 14 times more embedded chemical and thermal energy within it compared to tap water.[35] For a city of 4 million people, the value of the carbon, ammonia and phosphorus recovered from wastewater could be worth $300 million a year.[36] However, the adoption of circular water infrastructure requires up-front investments and legislation.

Reward dry factories that are less water-intense
The circular water economy is progressing well at city factories. There is a strong trend towards dry factories, where they recycle and reuse a significant portion of the water used for industrial purposes in a closed loop, reducing external demand for water.

Use circular sanitation centres
The Suvidha programme in India deploys urban sanitation community centres in low-income neighbourhoods. The programme designs them with a circular economy approach to water using rainwater and recycled water from showers, handwashing and laundry facilities for flushing toilets. This saves 21 million litres of water across four centres, serving 12,000 people in Mumbai.[37]

Invest in industrial symbiosis
Grouped industrial factories can exchange wastewater and resource streams in a symbiotic manner. Wastewater from one can be treated and reused as a resource and input for another. Kalundborg, Denmark, has popularized this system, sharing water, energy and resources between 14 different factory units.[38] It has a cost-benefit ratio of between 32:1 and 53:1,[39] saving millions of euros, as well as 635,000 tonnes of CO_2-equivalent emissions and 2.9 million m^3 of water a year.[40]

BOX 3 | **Pinpointing circular water solutions**

New office blocks with rain capture and stormwater cisterns can minimize piped-in water use and be self-sufficient in water.

Rainwater stored via permeable concrete in storm swales and via rooftops can be used to water community gardens or for sanitation in apartment blocks.

Warm wastewater from industry or data centres can be a resource for district heating and energy savings.

Wastewater treatment plants can be reengineered to operate as net energy producers. Biogas from wastewater can also be harnessed to generate electricity.

If all resources are extracted from a city's wastewater, urban areas can be a net generator of fertiliser and organic matter to be used for profit on peri-urban farms.

Creating a platform for buying, selling or sharing wastewater would provide opportunities to reuse and monetize water, its energy and bioresources across sectors.

5 Getting started

It is vital to support a concerted global push for circular water city initiatives. This creates demand and provides impetus for innovation and investment.

Support a leader group of cities committed to a percentage of circular water infrastructure by 2030
It has already started: over the next three decades, China has said that 80% of urban areas should absorb and reuse at least 70% of rainwater; 30 pilot metropolises are involved as part of its Sponge City project.[41] The 17 countries that are home to a quarter of the world's population and face extreme water stress should be a priority.[42]

Form a network of "100 Circular Cities" modelled after the 100 Resilient Cities or C40 Network
Candidate cities would be those that are already circular economy hotspots, including Amsterdam, Rotterdam, Malmo and Brussels. Combining these with potentially at-risk cities that may be close to Day Zero scenarios in terms of water scarcity, including London, Tokyo, Mexico City and Istanbul, would form an inspiring peer-to-peer learning and best-practice adoption network.[43]

Set up "blue" circular economic zones, with tax breaks and lower tariffs like free trade zones
Industrial parks and new integrated city districts are a good place for circular economics with water at the core to start, since new clusters of businesses and housing would use each other's resources and waste streams, realizing savings and monitoring systems. These zones would encourage experimentation in the best circular economic models for water and attract green finance.

Escalate consumer education and awareness globally on water and circularity
Education on how important toilet-to-tap water is for city dwellers will be crucial if circular city initiatives are to evolve. Trust, information and social norms are important when it comes to using recycled drinking water. Food and beverage companies continue to avoid using reclaimed treated water as a product ingredient because of consumer attitudes. This has to change.

Fund circular city water outcomes
Blue bonds are already looking at outcomes for the ocean and circular economy investment funds. Blue-green bonds and other financial incentives must look at aligning environmental, social and governance (ESG) and water goals, and real estate investors must encourage cities to adopt circular approaches. Many environmental and social wins can also be water wins. Pension funds and institutional investors would look more favourably on new city and water infrastructure if they were circular.

BOX 4 **Priority areas for action and impact**

- **Commit cities now to further action on circular water initiatives**
- **Show that a new economic model works at scale for circular water initiatives for cities**
- **Invest in pilot projects and new neighbourhoods that use circular water principles**

6 A circular water approach for cities: An evolution in thinking

Water is the ultimate circular resource because it can be processed relatively cheaply, unlike clothes, electronics or plastic. Water can also be used productively again and again, thereby creating further value. With the high concentration of people in cities, significant energy potential and bioresources are embedded in the water used. This is a hugely underused and undervalued resource.

With further urbanization expected in the 21st century, this will continue. Worldwide, cities have massive water footprints. Cities occupy less than 3% of the land on Earth, yet the catchment areas that provide them with water cover roughly 41%.[44] This is not sustainable. The way humans use water must change right now.

A circular water approach represents an incredible opportunity to reduce cities' water footprints and unlock a virtuous cycle of resiliency, economic growth, and sustainability, while achieving gains in health, climate and nature. Urban areas will become more resilient – particularly to climate change – more sustainable, and healthier environments for their inhabitants. They will also be kinder to the watersheds and the natural environments they reside in. Above all, it will ensure water security for the future of cities.

Doing nothing is not an option. Now is the best time to rethink and redesign the role of water in urban areas for cities to thrive.

Acknowledgements

The World Economic Forum would like to acknowledge the valuable contributions of the following people in the development of this briefing paper.

Anna Huber, World Economic Forum
Alex Mung, World Economic Forum

Nick Easen, Consultant

Andre Fourie, Anheuser-Busch InBev
Mark Fletcher, ARUP
Steven Lloyd, ARUP
Fredrik Hellman, AstraZeneca
Jason Snape, AstraZeneca
Murray Birt, DWS
Francesco Curto, DWS
Michael Lewis, DWS
Jonas Fredsted Villadsen, Grundfos
Asger Narud, Grundfos
Adam Hosking, Jacobs
Roberta Barbieri, PepsiCo
David Grant, PepsiCo
Maeve Hall, Unilever
Hanh Nguyen, Unilever
Houston Spencer, Xylem
Randolf Waters, Xylem

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World Economic Forum
91–93 route de la Capite
CH-1223 Cologny/Geneva
Switzerland

Tel.: +41 (0) 22 869 1212
Fax: +41 (0) 22 786 2744
contact@weforum.org
www.weforum.org