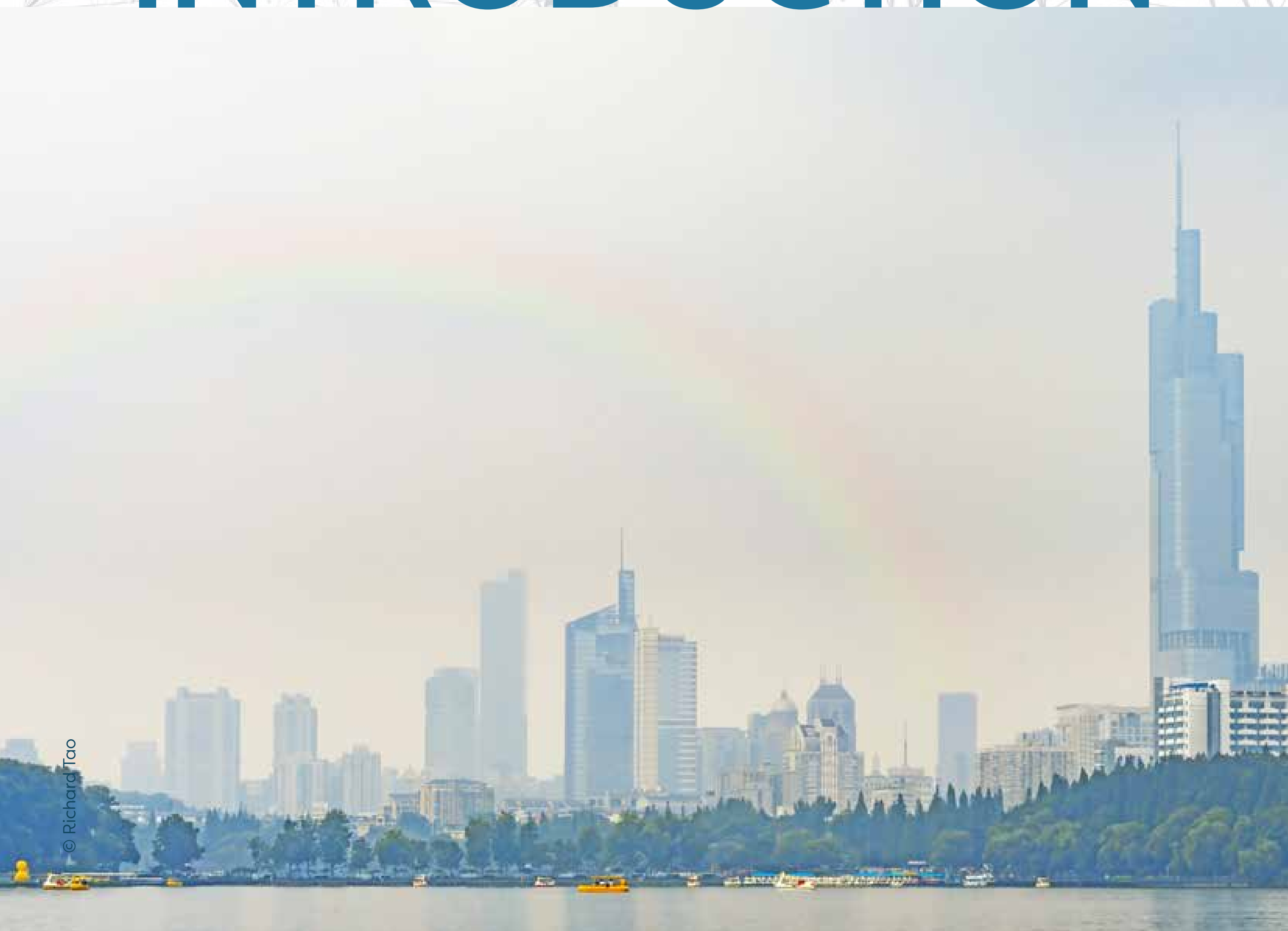
INTRODUCTION



The world population today is predominantly urban. The number of people living in cities has more than doubled over the last 45 years, going from 1.5 billion in 1975, to 4.3 billion in 2020. In relative terms, the proportion of people living in cities has also increased: while in 1975, 37% of the total world population lived in cities, this share grew to 56% in 2020 (OECD, 2020a). Cities are central elements in the development of human geographies. They are spaces where peoples, goods, and capital meet. City life is linked to many positive traits: cities symbolize modernization and cultural heterogeneity; they bring together diverse people with different sets of beliefs, customs, and traditions; and they spearhead countries' economic growth, technological innovation, and greater societal freedoms (Paunov, et al., 2019). Highly urbanised countries are generally associated with higher incomes, lower poverty rates, stronger and more resilient institutions, enhanced democratic accountability, and higher levels of gender equality.

These benefits aside, cities are currently facing large challenges. Urban life has been thoroughly impacted by climate change. The rise of the average temperature of the earth is one of the key drivers behind the increase of the frequency and intensity of extreme weather events, such as floods and droughts, which is directly affecting the life and wellbeing of millions of people and the environment (Rentschler & Salhab, 2020). Simultaneously, cities are key contributors to climate change. Although they occupy only about 3% of the world's land surface, estimates suggest that cities are responsible for 75% of global CO_2 emissions, with transport and buildings being among the largest contributors. They are also large energy consumers, representing almost two-thirds of total global energy consumption, and producing up to 50% of the world's solid waste (OECD, 2019). In addition, cities are growing at a great rate, taking up the land and the water of the surrounding urban areas, often prime agricultural land. Many cities around the world suffer from inadequate infrastructure and uneven access to basic services which have a particularly harmful impact on vulnerable groups (FAO, 2018). Indeed, city growth has made the provision of adequate housing and essential resources more challenging, and because of mass relocation of people from rural to urban areas, city slums have formed. In addition, social problems, such as unemployment and urban poverty have increased. Cities have thus become highly inequal: individuals who grew up in the poorest neighbourhoods earn 5-6% less than those who grew up in the most affluent, while life expectancy can vary by 20 years from one neighbourhood to another within cities such as Baltimore (USA) or London (UK) (OECD, 2019). These inequalities are posing questions as to how better prepare our societies for providing the necessary protections, healthcare, and welfare needed for a larger, aging, and more complex urban population.

The management of water resources and the provision of water services in urban areas have also posed serious challenges. The World Meteorological Organization (WMO) reports that water-related hazards have dominated disasters over the past 50 years, causing severe damage to cities (WMO, 2021). Disasters, such as storms and floods, have resulted in some of the largest human and economic loss. Between 1970 and 2019, storms and floods caused 635,932 deaths and brought about 636 billion USD in losses. Due to urbanization and increasing populations in cities, this water-related damage has a greater impact on city life. Urbanization impacts the water cycle. Urban surfaces are often covered by buildings, asphalt, and other materials. This prevents rainwater from being absorbed into the soil, thus interrupting the natural water cycle. Rainwater in cities can thus easily become contaminated when it encounters pollutants such as metals, litter, or oil. Polluted water then flows directly into the rivers.

Significant progress has been made in access to water services in the last 20 years, and thus over 1 billion people have gained access to piped water supplies between 2000 and 2015 alone. Improvements have been seen in Latin America and the Caribbean, Eastern Asia, and South-Eastern Asia. These regions are on track to achieve universal access by 2030. However, significant water, sanitation, and hygiene (WASH) challenges continue to exist. 844 million people still lack a service to secure basic drinking water, having to either use sources with water collection times exceeding 30 minutes, unprotected wells and springs, or to take water directly from surface water sources. These come with severe health risks. Basic sanitation is also largely inaccessible for a large proportion of the world population, particularly in the sub-Saharan Africa and Central and Southern Asia. While improvements have been reported, 2.3 billion people in the world still lack basic sanitation (UNICEF & WHO, 2019). Adequate surface water drainage continues to be problematic in both rural and urban areas.

Water service provisions tend to be better in cities than in rural areas across all world regions due to "economies of agglomeration", i.e., the fewer costs/per person of providing services in highly dense area (OECD, 2020a), but ensuring an adequate management of water resources and providing urban water services in larger cities are difficult tasks. Aging infrastructure is largely responsible for water leakage in cities. According to a study conducted by the World Bank, the world's annual volume of water loss is about 32 billion cubic meters. Developing countries, many of which are undergoing rapid urbanization, are responsible for approximately half this loss. Water leakage is detrimental to cities, as it leads to the waste and overconsumption of valuable resources. Water treatment facilities, which consume a lot of energy and water, must compensate for these losses. However, laying down new water mains, retrofitting water infrastructure, planning, and building adequate water treatment in urban areas are all technically complex and financially demanding measures. Besides, urban water measures are closely intertwined with other policies such as land use and spatial design, public services provision (electricity, gas, and transport), and social inclusion, etc. These measures involve actors with likely different and often conflicting interests. Under these circumstances, long-term planning and a comprehensive, inclusive, and robust approach to water governance framework is necessary.

Information and Communication Technologies (ICTs) have been called to play a key role as facilitators of change and progress for cities. Set against a background of large global trends, the use of ICTs is frequently presented as a powerful strategy for "smart" development, i.e., economic development that encompasses the use of ICTs and environmental sustainability. From this perspective, ICTs facilitate and make possible clean development in infrastructure and service provision in sectors as diverse as energy, buildings, transportation, waste, safety and security, health care, and education (ITU, 2016). The ultimate effects of these technologies cannot be predetermined, particularly in a changing international context of climate change, population growth, and pandemics. However, evidence of their positive impact has been documented (ITU, 2020).

The role of ICTs in urban water management, though relevant, poses challenges that require attention. Cities have thoroughly transformed natural water habitats: pavements and buildings have reduced water infiltration, increased water run-off, and pollution, as well as limited the recharge of groundwater supplies, amongst other steps. In addition, as centres for research and innovation, cities have been at the forefront of a fast-tracked trend to use intelligent technologies to provide solutions and improved services to existing and upcoming urban challenges. The number of local smart initiatives that carry the "Smart City" name has increased at great speed in the last two decades worldwide, showing a growing interest in how technologies can influence and change city life. These initiatives adjust to the local circumstances and have different features, but they all share the adoption of ICTs in local sectors and services as a desirable objective (OECD, 2020a).

In the urban water sector, the adoption of smart technologies has been growing steadily over the past decade – although at a slower pace than other sectors such as energy, transport, agriculture, and communication. Today we have examples of the use of smart water technologies in many different urban settings, and yet, despite the importance of water for the development of cities and of the increasing use of ICTs in the sector, we lack an adequate instrument to examine and compare urban water management in different cities, and the impact that ICTs may have in urban water systems.

The Smart Water Cities Project – Stage 1 Identifying Smart Water Cities

The present report is the first output of a three-year research project entitled "Smart Water Cities Project". The project, conducted collaboratively between K-water, AWC, and IWRA, aims to contribute to the knowledge sharing of smart water technologies in urban environments around the world and to promote their implementation (see Box 1).

The Smart Water Cities project's main objective is to develop an instrument for measuring and evaluating smart urban water management in cities around the world to form a global standard and certification scheme for Smart Water Cities. This instrument will serve to examine and compare the management of urban water resources both in existing cities (e.g., developing/developed cities; growing/shrinking cities) and in future cities being planned. This global standard and certification scheme will provide integrated and comprehensive information on the urban water status, and will offer advice and guidance to cities and communities for becoming smart(er) (e.g., what are the strengths of a city in water resources management? What should be improved in the city? How? In which area? With what kind of solutions/institutional frameworks/ resources would it help? etc.) The global standard and certification scheme will contribute to the development of capacities and decision-making functions of local water providers and communities as well as for authorities, in both a qualitative and quantitative manner.

Box 1. Smart Water Cities Project Organizations

K-water is a government-owned corporation for comprehensive water resource development, providing both public and industrial water in the Republic of Korea, established in 1987. K-water has a large pool of practical engineering expertise regarding water resources and has championed Smart Water technologies for several years.

The AWC is a non-profit, non-governmental organization established in 2015. The AWC is a new innovative regional cooperation body that sets solving the water issues faced by Asia as a core value, and aims to seek scientific and technological solutions and suggest concrete implementation plans.

The IWRA is a non-profit, non-governmental organization established in 1971. It is a cross-disciplinary, membership-focused, international association that uses events, projects, publications and research to facilitate and inspire dialogue, knowledge sharing, and science-based solutions for the sustainable management of water resources across all sectors, scales and communities at the interface between science and policy.

With this overall goal, the Smart Water Cities project is divided into three phases, each with their own objectives and tasks. The first phase, to which this report belongs, is called "Identifying Smart Water Cities". It contains two objectives:

- First, to examine the water urban challenges that cities face around the world, the global agenda on Smart Water Cities, the national/local policies and strategies on smart cities and water resources management, and the main features of a Smart Water City;
- Second, to analyze existing standards and certification schemes dedicated to urban sustainability and to learn from their examples.

This background work is fundamental. Identifying the water challenges that cities confront daily, as well as surveying the concepts, existing practices, and the debate on smart urban development, are necessary feats for developing an effective methodology for examining, comparing, and benchmarking Smart Water Cities around the world.

The other two stages of the project are entitled "Developing Standards" and "Certification". These phases will develop new standards framework and Key Performance Indicators (KPIs) for Smart Water Cities, respectively, as well as propose a new internationally recognised certification scheme for Smart Water Cities in the coming years (see Box 2).

Box 2. The Smart Water Cities Project

	PHASE 1 Identifying Smart Water Cities	PHASE 2 Developing standards	PHASE 3 Certification
Period	01.2021~12.2021	01.2022~12.2022	01.2023~12.2023
Goal	Analysis of Smart Water Cities, global agenda, regional/ national policies and strategies, global standards frameworks and certification schemes and case studies	Development of KPIs for Smart Water City and certification protocols	Pilot testing of the certification scheme and guidelines

Following the objectives of phase 1 of the project, the present report is divided into two main parts:

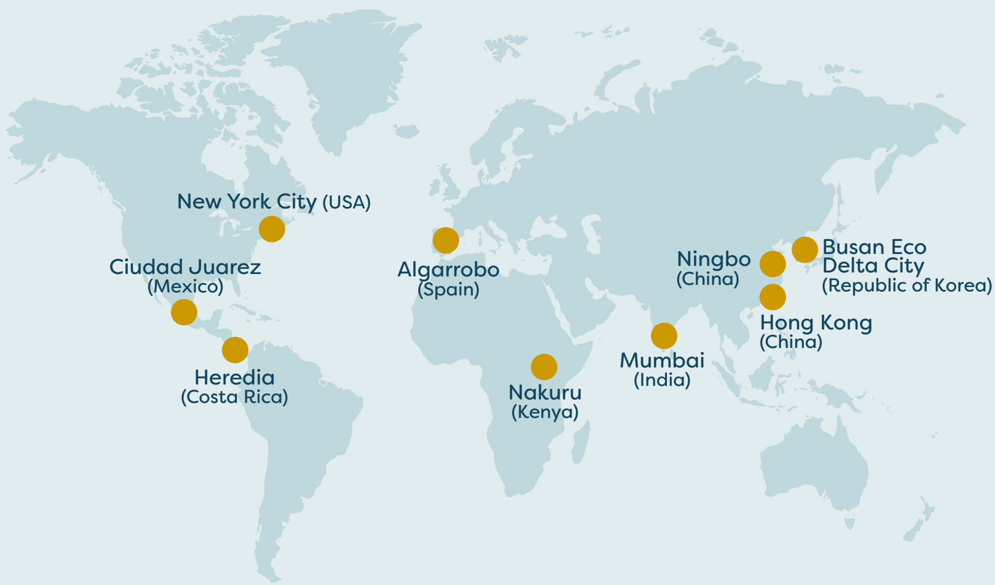
Part 1 defines what a Smart Water City is. To do this, it examines the main features of cities, the different functions that water fulfils in the urban environment and the water challenges that world cities are facing. From this examination, a Smart Water City is defined not just as a city that implements ICTs to provide water services, but one that improves urban sustainability and, ultimately, the quality of life of its citizen. This is in thanks to the adoption of these technologies in different stages of the urban water cycle, as well as to the adoption of sound policies and government strategies in close collaboration with relevant companies/agencies.

In addition, Part 1 provides illustrations of how cities around the world have dealt with current water challenges. Figure 1 presents 9 comparative case studies to show the variety of measures adopted in different contexts, their impact on people, communities, and the environment, and the barriers and enablers to their implementation. The cases have been written by scholars and practitioners that have submitted their case studies proposals in an open call issued by IWRA, K-Water and AWC. Their proposals were selected for development into case studies as part of this report. The full version by the authors can be found in the annex.

To ensure a diverse range of case studies for the report, various selection criteria have been employed. These include: the geographical location and type of city; respective water challenge; and national/local policies and strategies. As a result of this criteria, cases are diverse. Some concern small municipalities, such as Algarrobo in the south of Spain, whereas others, such as New York City (USA), represent larger and more complex cities. Some, such as Mumbai (India), are considered ancient cities, whereas others, such as the Busan Eco Delta City (BEDC), in Busan (Republic of Korea), have not yet been built. The challenges faced across these case studies are also diverse: water scarcity, flooding, water pollution, and infrastructure aging–to name a few. Some chapters, such as Heredia (Costa Rica) present a single urban challenge and a small-scale solution, whereas others, such as BEDC, take a larger viewpoint to consider various urban water challenges simultaneously and to present the urban solutions that authorities have adopted. Finally, the report presents examples of how a similar initiative has been implemented under different circumstances and with very distinct implications. Such is the case of Ciudad Juarez (Mexico), Hong Kong (China) and Mumbai (India) with the implementation of smart meters.

These cases do not seek to provide a prescriptive list of interventions that cities ought to put in place, or an exhaustive account of all smart solutions. Rather, they illustrate the status of urban smart practices in world cities today, as well as the successes, and occasionally also the failures, of urban smart water measures. All in all, these examples show how a multitude of institutions, technologies and practices have emerged and implemented with the aim to manage urban water resources more efficiently and to create more liveable cities. They present real-life evidence of the elements that a future global certification scheme for Smart Water Cities needs to be aware of and to take into consideration.

Figure 1. City Cases in the Smart Water Cities Project



Part 2 of the report examines and compares eight global standard indicators and certification schemes developed by different public and private organizations. The objective of this part of the report is to learn from these standards and to draw lessons applicable to the development of future certification schemes for Smart Water Cities.

Mumbay, India

These standards and certification schemes are well-known initiatives. They concern the local level, or city level, and deal with either of the three elements interlinked in the definition of Smart Water City: ICTs, water, and/or integrated management. They are the following:

- United 4 Smart Sustainable Cities
- ISO 37120 Series on Sustainable Cities and Communities
- OECD Smart City Measurement Framework
- CITYKeys Smart City Index
- LEED for Cities and Communities
- Arcadis Sustainable Cities Water Index
- KWR City Blueprint Approach
- AWS International Water Stewardship Standard

For each global standard scheme, Part 2 of this project examines the categories, the indicators, and the metrics that they employ. It also compares their general features, highlighting the strengths and weaknesses. When relevant, this section explains the procedures that potential certification applicants need to follow to receive both international certification and recognition from an international certification organization.

Gathering information about how other certifications and global standard frameworks operate is very helpful for identifying common practices and procedures. Standards and certification schemes have contributed to an understanding of what makes cities smarter, more liveable, and sustainable, and they have provided guidance on how to improve their performance. The analysis has also helped to detect the deficits in the existing approaches and to define the scope for a future Smart Water City certification scheme. Overall, the analysis provides a robust framework for later stages of the Smart Water Cities project and shows that developing indicators on urban water sustainability and smartness is a process: standards help to set more ambitious targets, constantly adopting new global agenda, policy, and strategies, as well as new technologies.

Finally, the conclusions summarize the main findings of the report and present the next steps of the project, outlining the roadmap for Stage 2 and Stage 3 of the project.