PART 2

GLOBAL STANDARDS, INDICATORS, AND CERTIFICATION SCHEMES

Part 2 of the report examines how global standard indicators and certification schemes operate and details what we can learn from them. Doing so sets the foundation for the development of a future Smart Water City standard and certification scheme in later stages of this project.

This part is divided into two chapters: Chapter 3 defines what global standards indicators and certification schemes are and identifies their characteristics. This chapter helps us to distinguish the different topics that performance indicators can aim to measure and how best to do it. Chapter 4 analyses in detail eight relevant standards and certification schemes measuring sustainable development and/or water resources management in urban settings. Standards elaborated by international organizations are distinguished from those developed by the private sector, non-governmental organizations, and by academia. The chapter explains the indicators and sources of information that each standard employs and, when appropriate, its certification process. The chapter concludes with a comparison of these standards, setting the groundwork for future development of a Smart Water Cities standards and certification scheme.

CHAPTER 3
DEVELOPING STANDARDS: CONCEPT AND MEASUREMENTS

3.1. What are standards and what do they measure?

Measuring performance has been a longstanding aim of human activity. Evidence exists of the attempts to measure workers and employees' performance as far back as the Middle Ages. With the introduction of modern methods of mass production in the 20th century, such as specialization of labor and the introduction of tools and machinery, organizational management became more complex and structured, and with it, the examination of performance became the subject of a robust discipline (See Kuske & Zander, 2005). From this, we have gained substantial knowledge, experience, and best practices for measuring human activity.

Standards serve to measure performance. They define the characteristics of a product, a process, or a service, including its different constitutive elements, its safety aspects, and performance requirements, etc. Standards may apply to the specific and mechanical functioning of new technologies, but they may also apply to more comprehensive products, services, procedures, etc. They are developed to measure a particular product or service and to establish how those services or products meets certain requirements. These requirements may be legal obligations without which a product or service cannot be offered to the public, or voluntary, serving to establish if a certain product meets specific criteria. By doing so, such standards facilitate the evaluation of how different products and processes work and set benchmarks to compare between alternative products and processes.

In certain cases, a product, service, or system that meets the requirements of a standard is given assurance by an independent certification body.

To issue a certification, the certification body examines whether the applicant (usually a manufacturer or a service provider) meets the established criteria, and depending on the results, decides whether to award the certification. Thus, certifications guarantee that a product or service has certain qualities. Frequently, the certified manufacturer or service provider displays the certification symbol on its product as a mark of distinction or as proof of achievement. This provides users and consumers with extra information on the product's characteristics and helps the certified organization to distinguish itself from its competitors.

To develop standards, it is necessary to define what elements of a product or service are worth measuring. Different approaches exist to doing so. The input-

process-output-outcome-impact typology, used by UN bodies, is particularly helpful in defining what different aspects of a program, strategy, or project can be measured (UNISDR, 2015):

INPUT → PROCESS → OUTPUT → OUTCOME → IMPACT

• ***Input indicators*** refer to the resources needed for the implementation of an intervention, a product, or a service. Input indictors measure the quantity, quality, and timeliness of resources employed. Elements such as financial resources, time, staff, expertise, methods employed, materials, etc. are all examples of input indicators.

• ***Process indicators*** measure whether planned activities and milestones have taken place. Examples of process indicators could include scheduled meetings that have taken place, conducting training courses, launching an information campaign, etc. In the context of a smart city, the distribution of smart meters by a certain deadline could be an example of process indicator.

• ***Output indicators*** refer to what the system produces, the activity resulting from a program, a strategy, or a policy. For example, in a smart city, an output indicator would measure the area of isolated roofs in the city, or the number of electric busses in the system, or the volume of recycled water used, etc.

• ***Outcome indicators*** measure intermediate results generated by outputs. Outcome indicators refer more specifically to the objectives of an intervention and concern meaningful changes for the population served, such as anticipated changes in knowledge, skills, attitudes, and behavior. Often, they are coverage

indicators measuring the extent to which the target population has been reached. For instance, volume of water saved resulting from the implementation of certain water saving measures would be an outcome indicator.

• ***Impact indicators*** measure the results that are directly due to the outcomes of a program. They tend to operate on a longer-term basis and often concern the ultimate goals of the policy or program. They are harder to measure; establishing the causal link between the policy outcomes and their impact is not always easy. Indeed, the impact of a policy does not only depend on the measures taken, and the impact might happen or not. For instance, reducing a city's water consumption or increasing water flood protection can be impact indicators of a Smart Water City.

Recognizing the different types of approaches reveals different elements of evaluating the same product, service, or policy. Also, different measures from these different approaches can be used to track performance and have a more rounded account of how a product or service functions. Depending on what is measured, the performance of that product will likely be different in terms of its effectiveness, efficacity, timeliness, etc.

3.2. Characteristics of standards

In addition to deciding what aspect of performance to measure, developing standards involves making decisions on how best to measure performance. This task requires identifying adequate indicators capable of providing information on the performance that we wish to evaluate and monitor.

Understanding the most important characteristics of good indicators and standards can help set adequate, fit-for-purpose standards and certification schemes. These characteristics can work to examine the virtues of existing standards with critical eyes and to propose indicators and measurements that better serve objectives of developing a global standard scheme for Smart Water Cities. A seminal work by George T. Doran (1981) identified the characteristics of successful standards and presented them with the acronym S.M.A.R.T. whereby the letters stand for:

1. Specific. They target a specific and precise area of performance. This implies that standards need to be clear and well-define, and that they effectively measure the factors we want to know about. This feature is closely related to that of validity, i.e. the extent to which a measurement or test accurately quantifies what is intended to be assessed.

2. Measurable. Performance can be examined and accounted for. Standards can employ quantitative or qualitative indicators. Quantitative indicators measure performance in numbers, such as units, prices, proportions, rates of change, and ratios, etc. Qualitative indicators report performance in words: degree of satisfaction or agreement or opinion. Regardless of the type of indicator employed, all indicators should concern aspects of performance that can be effectively assessed.

3. Attainable (also Assignable). The standard measures performance that

can be achieved with a reasonable level of effort under normal operating conditions. A good indicator reports on the activities of a team or cluster of teams that work together. Attainable standards assume the existence of potential accidents and typical losses that can normally happen.

4. Realistic. They state what results can realistically be achieved, given available resources. This principle is often linked to the notions of simplicity and applicability, which are key elements for indicators to be successfully employed. Indeed, on many occasions, performance indicators are administered and measured by personnel dealing with many tasks, have limited time and monetary resources. Standards should provide clear and relevant information without much reference to technical or methodological details.

5. Time-related. Indicators may employ a different timeframe for evaluation: either short-term progress evaluation or long-term impact assessment. It is important to establish a timeframe because depending on the moment when the evaluation occurs, the observations might be different. Certain effects take longer to be detectable, whereas other indicators may bring about meaningful results even at shorter and more frequent intervals.

In addition, other important characteristics of good standard have been highlighted:

6. Relevance. Relevant standards measure performance that matters. Parmenter (2015) distinguishes between simple standard indicators and KPIs. KPIs focus on the "critical performance for the current and future success of the organization". They are measures that link daily activities to the factors that are critical for an organization's success. In this sense, depending on their relevance or centrality, standards employ core indicators, which identify which key elements must be assessed in all cases, supporting indicators, which can be appropriate to measure recommended performance elements, and profile indicators, which provide context for the performance assessment.

7. Orientation. Standards can be further classified into "prescriptive" and "performance oriented". The first type provides guidance on the measures and solutions that can be applied. In doing so, they also limit the scope of the solutions that can be implemented. The second type of standard seeks to provide guidance on the final performance, leaving room for innovative solutions in design (Huovila et al., 2019). It has also been argued that that KPIs should "encourage appropriate action" in that they should ensure that they have a positive impact on performance. The objective is to avoid developing poorly thought through measures that unintentionally lead to dysfunctional behavior within organizations.

8. Revisable. Good standards need to be revisable as progress is made and certain objectives are attained. Equally, they also need to be revisable when circumstances worsen in order to provide appropriate guidance to policy makers and organizations and to aid in the improvement of deteriorated situations. In this sense, standard setting is a process, not an end result: standards help to set more ambitious targets, constantly adopting new circumstances, technologies, actors, and activities.

CHAPTER 4
ANALYSIS OF GLOBAL STANDARDS, INDICATORS, AND CERTIFICATION SCHEMES


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Many standards and certification schemes dealing with urban sustainable growth and local development have been adopted in the last 20 years. The signing of the Local Agenda 21 by the UN in the early 1990s inaugurated a period when monitoring urban activity became a central activity of international agencies and organizations around the world. This chapter examines eight of those global standards and certification schemes. Analyzing the characteristics of these global standards and certification schemes provides frameworks for how the indicators and the procedures are set up, which helps to draw lessons for establishing future global standards and certification schemes for Smart Water Cities.

The eight global standards and certification schemes have been selected for two reasons:

1. The standard's topic, that is, the performance that the standard measures: all the selected standards concern sustainability, smartness, resilience, etc.
2. The standard's unit analysis: all the selected standards concern the local level, mainly understood as the city.

The selected standards have been developed both by international organizations and by non-governmental organizations and the private

sector. Amongst the first are the UN, the International Organization for Standardization (ISO), and the Organization for Economic Co-operation and Development (OECD). UN has led an initiative to evaluate local policies and measures to make cities smarter and more sustainable. This initiative, called the United 4 Smart Sustainable Cities (U4SSC), has been conducted since 2016 with the ITU, United Nations Economic Commission for Europe (UNECE), and UN-Habitat. This instrument focuses on three aspects: the cities' attainment of the SDGs, their degree of smartness, and their sustainability.

ISO brings together 165 national standards official bodies as members. Since its constitution in 1946, ISO has issued over 22,000 standards and currently produces around 100 new standards each month on an array of areas, topics, and technologies. Sustainability and smart development features vary greatly in ISO standards production. ISO 37120 Series on Sustainable Cities and Communities, a set of three standards concerning urban sustainability (ISO 37120), smartness (ISO 37122), and resilience (ISO 37123), is examined.

The OECD is an intergovernmental organization founded in 1961 to stimulate economic progress and world trade. The OECD has undertaken research and analysis for international comparison for its 38 member countries and beyond. Their publications help to define the criteria and indicators used to examine and measure a wide variety of products, services, and policies. The OECD's work on smart cities is examined by focusing on the OECD Smart City Measurement Framework.

Amongst non-governmental organizations and the private sector which has elaborated on standards and certification schemes for smart and sustainable water cities, five standards were selected. The organizations behind the CITYKeys Smart City Index assessment framework and the LEED for Cities and Communities standard have focused on measuring sustainable city practices, including but not limited to water resources management. The other three standards–Arcadis Sustainable Cities Water Index, KWR City Blueprint Approach, and AWS International Water Stewardship Standard–have paid attention to water resources management.

As a research project funded by the European Union's Horizon 2020 program, CITYKeys Smart City Index was developed by a consortium of European universities and research centres. It validated KPIs and data collection procedures for examining and comparing smart city solutions across European cities. Its detailed analysis deserves full attention in this report.

The U.S. Green Building Council (USGBC) and the Green Business Certification, inc. (GBCI) are behind one of the better-known standards and certification schemes for sustainable cities: the LEED for Cities and Communities. The USGBC is a not-for-profit organization advocating for sustainable building practices which has developed the LEED indicators and procedures. The GBCI is an organization that provides third-party credentials and verification for the LEED standard.

Arcadis and the Centre for Economics and Business Research (CEBR) are two private consultancies operating globally from their headquarters in the Netherlands and the UK, respectively. They have developed the Arcadis

Sustainable Cities Water Index, which seeks to assess and rank the urban water management of cities around the world.

KWR City Blueprint Approach is a tool to examine Integrated Water Resources Management (IWRM) in cities. This index has been prepared by KWR Water Research Institute, an independent research center based in the Netherlands. The City Blueprint Approach provides a methodology for diagnosing how cities around the world ensure an integrated management of their urban waters.

The Alliance for Water Stewardship (AWS) is a membership-based association bringing together businesses, NGOs, and the public sector. The AWS seeks to promote local water resources sustainability through the adoption of a standard and certification scheme, the International Water Stewardship Standard, or the AWS Standard.

The following pages examine each of the standards in depth. For each global standard, we analyze its main characteristics, including what they measure and how they do so; and if a certification of the standard exists, we analyze main characteristics and its procedure for certification. In following the Global Standard, the elements analyzed are as follows:

1. **Standard topic** reflects what performance the standard aims to measure, such as sustainability, smartness, resilience, or other, as well as its scope of application–the city, the community, water basins, or other sites.

2. **Standard categories** reflect the subject of a standard, broken down into a series of elements for measuring, which may consider sectoral policies, stages of implementation, or other.

3. **Standard indicators** are the elements that serve to examine and measure performance. They derive from observed facts and phenomena.

4. **Standard metrics** concern the unit of measurement employed by the standards.

When a certification scheme exists to accredit one of the examined standards, four further aspects are analyzed:

1. **Certification organisation** refers to the organizations examine and issues the certification.

2. **Certification applicant** concerns the organization or actor that can apply for the certification. It asks if they are public or private organization, a regional authority, a city, or its neighbourhood.

3. **Certification process** refers to the procedure that the applicants must follow to receive a certification.

4. **Type of certification** concerns to how long the validity period of the certification is. It asks if certifications are graded according to the grade achieved and if there is a minimum mark to be awarded a certification.

4.1. International organizations

4.1.1 United 4 Smart Sustainable Cities

The United 4 Smart Sustainable Cities (U4SSC) is a United Nation initiative coordinated by International Telecommunication Union (ITU), United Nations Economic Commission for Europe (UNECE), and UN-Habitat. Launched in May 2016, this instrument examines the cities' attainment of the Sustainable Development Goals, their degree of smartness, and their sustainability.

1. Standard topic
The U4SSC seeks to provide a methodology to measure the smartness and sustainability of cities around the world. The initiative aims to enable cities to measure their progress over time, compare their performance to other cities and allow for the dissemination of best practices at the city level.

2. Standard categories.
The standard establishes three dimensions – Economy; Environmental; and Society and Culture - and seven subdimensions (ICT; Productivity; Infrastructure; Environment; Energy; Education, Health and Culture; Safety, Housing, and Social Inclusion). Each subdimension is broken down into 28 different categories (See Table 8).

"Water and sanitation" is a category that appears in three subdimensions (ICT; Environment; Infrastructure). In each of these subdimensions, different aspects of water and sanitation performance are measured, such as the characteristics of the infrastructure in the sector and its degree of environmental protection. Thus, for instance, the ICT subdivision, which is in the Economy dimension, breaks down into six categories where a city will examine the presence and use of ICTs in different sectors of the economy. These include water and sanitation, drainage sectors, as well as electricity, transport, and public sector.

Table 8. Dimensions, Subdimensions and Categories of the United 4 Smart Sustainable Cities Standard

Dimension	Subdimension	Category
Economy	ICT	ICT Infrastructure
		Water and Sanitation
		Drainage
		Electricity supply
		Transport
		Public sector
	Productivity	Innovation
		Employment
	Infrastructure	**Water and Sanitation**
		Waste
		Electricity supply
		Transport
		Building
		Urban planning
Environment	Environment	Air quality
		Water and Sanitation
		Waste
		Environmental quality
		Public Spaces and Nature
	Energy	Energy
Social and Culture	Education Health and Culture	Education
		Health
		Culture
	Safety, Housing and Social Inclusion	Housing
		Social inclusion
		Citizen participation
		Safety
		Food security

Water-related categories are shown in bold.

3. Standard Indicators

The U4SSC standard has 91 indicators: 45 in the Economy dimension, 17 in the Environment dimension, and 29 in the Social and Culture dimension. The standard employs output indicators whereby what a city "produces" in terms of economic, social, and environmental "smart" sustainability is measured.

Not all indicators have the same value. Some of them are "core" indicators and others are "advanced" indicators. Core indicators concern the basic elements that a smart and sustainable city should be able to achieve. Advanced indicators provide a more in-depth view of a city and measure progress on more advanced initiatives; however, they may be beyond the current capabilities of some cities to report or implement. 11 indicators are proposed to examine the function of the water and sanitation sector in the economy and the environmental categories. All but one of them are core indicators. They are the following:

Table 9. Water Indicators in the United 4 Smart Sustainable Cities Standard

Dimension (Subdimension)	Indicator	Definition
Economy (Infrastructure)	Basic Water Supply	Percentage of city households with access to a basic water supply
	Potable Water Supply	Percentage of households with a safely managed drinking water service
	Water Supply Loss	Percentage of water loss in the water distribution system
	Wastewater Collection	Percentage of households served by wastewater collection
	Household Sanitation	Percentage of city households with access to basic sanitation facilities
Economy (ICT)	Smart Water Meters	Percentage implementation of smart water meters
	Water Supply ICT Monitoring	Percentage of the water distribution system monitored by ICT (advanced)
Environment (Environment)	Drinking Water Quality	Percentage of households covered by an audited Water Safety Plan
	Water Consumption	Total water consumption per capita
	Fresh Water Consumption	Percentage of water consumed from freshwater sources
	Wastewater Treatment	Percentage of wastewater receiving treatment (Primary, Secondary, Tertiary)

4. Standard metrics.
The metrics employed for the indicators are all quantitative, and refer to either a percentage of the population, or a ratio per capita of the population. By doing so, the indicators allow comparisons among cities. The standard also indicates the most likely data source or relevant database where this information can be collected, which refers mostly to local water service providers but also from the WHO/UNICEF Joint Monitoring Program for Water Supply and Sanitation.

4.1.2 ISO 37120 Series on Sustainable Cities and Communities

The International Organization for Standardization (ISO) is a worldwide federation of national standard bodies dedicated to the preparation and publication of International Standards. ISO technical committees work on developing the standards, with governmental and non-governmental international organizations taking part in the work.
ISO has developed a series on sustainable cities and communities, which includes three ISO standards (ISO 37120, ISO 37122, and ISO 37123) focused on sustainable, smart, and resilient cities. These three ISO standards, known as the ISO 37120 Series on Sustainable Cities and Communities, bring over 276 different indicators to examine local policies and development strategies.

1. Standard topic.
The ISO 37120 Series on Sustainable Cities and Communities (ISO 37120 Series) consists of three ISO standards designed to assist cities in evaluating and monitoring city performance. They are as follows:

• ISO 37120 standard for city services and quality of life examines the degree of sustainability in the provision of urban services, as well as citizen's health and wellbeing.

Once a city has been awarded an ISO 37120, it can opt for ISO 37122 and ISO 37123.

• ISO 37122 standard for smart cities analyses the presence of ICTs in urban life and local services.

• ISO 37123 standard for resilient cities measures examines the extent to which cities can prepare for, recover from, and adapt to various shocks and stresses.

The standards consider sustainability as a general and guiding principle in the development of cities. Therefore, being awarded ISO 37120 standard is a prerequisite for applying to the other two standards, ISO 37122 and ISO 37123. "Smart city" and "resilient city" are considered subsidiary to adhering to the principles of economic efficiency, environmental sustainability, and social equity that ISO 37120 standard measures.

2. Standards categories.

The ISO 37120 Series identifies 19 different categories–referred in the ISO publications as themes–which correspond to services provided and activities organized at the local level (Table 10). Urban water services are present in two different categories: wastewater and water.

Table 10. Categories of ISO 37120 Series on Sustainable Cities and Communities

	Categories
1	Economy
2	Education
3	Energy
4	Environment and climate change
5	Finance
6	Governance
7	Health
8	Housing
9	Population and social conditions
10	Recreation
11	Safety
12	Solid waste
13	Sport and culture
14	Telecommunication
15	Transportation
16	Urban/local agriculture and food security
17	Urban planning
18	**Wastewater**
19	**Water**

Source: ISO 2018; 2019a; 2019b

Water-related categories are shown in bold.

3. Standards indicators

The ISO 37120 Series has developed different sets of indicators depending on the topic that they refer to:

- ISO 37120 standard consists of 104 indicators in 19 categories. Not all indicators are the same: of the 104, 45 are "core" or more relevant indicators, while 59 are "supporting" or recommended indicators; 4 core/supporting indicators belong to the wastewater category, 7 to the water category. They are mainly concerned with coverage of urban water services to the population, volume of water consumed, and supply services (e.g. leakages and interruptions).

- In addition, ISO 37120 standard has developed 24 "profile indicators" which are used for providing information to help compare certified cities. These profile indicators provide basic background information on the cities, such as population, urban density, household income, education, budget, etc., that provide context for assessing urban sustainability.

- ISO 37122 standard has 80 indicators in the 19 categories and is focused on the digitalization of the different local sectors. 4 of those indicators concern the water category and look at the use of digital water quality, water network monitoring, and the use of smart water meters. 5 indicators belong to the wastewater category and examine elements such as percentage of water reused and digital measurements.

- ISO 37123 standard consists of 68 indicators in 19 categories that examine to what extent a city is ready to adjust to multi-hazards and different stressors. The water category includes two indicators: the first concerns the number of different water sources providing at least 5% of the city's total water supply; and second concerns the percentage of city population that can be supplied with drinking water by alternative methods for 72 hours. No indicators have been developed for the wastewater category.

Table 11. Water Categories and Indicators of the ISO 37120 Series on Sustainable Cities and Communities

Category	Standard and Indicator		
	ISO 37120	ISO 37122	ISO 37123
Wastewater	Percentage of city population served by wastewater collection (core)	Percentage of treated wastewater being reused	
	Percentage of city's wastewater receiving centralized treatment (core)	Percentage of biosolids that are reused (dry matter mass)	
	Percentage of population with access to improved sanitation (core)	Energy derived from wastewater as a percentage of total energy consumption of the city	
	Compliance rate of wastewater treatment (supporting)	Percentage of total amount of wastewater in the city that is used to generate energy	
		Percentage of the wastewater pipeline network monitored by a real-time data-tracking sensor system	
Water	Percentage of city population with potable water supply service (core)	Percentage of drinking water tracked by real-time, water quality monitoring station	Number of different sources providing at least 5% of total water supply capacity
	Percentage of city population with sustainable access to an improved water source (core)	Number of real-time environmental water quality monitoring stations per 100,000 population	Percentage of city population that can be supplied with drinking water by alternative methods for 72 hours
	Total domestic water consumption per capita (litres/day) (core)	Percentage of the city's water distribution network monitored by a smart water system	
	Compliance rate of drinking water quality (core indicator)	Percentage of buildings in the city with smart water meters	
	Total water consumption per capita (litres/day) (supporting)		
	Average annual hours of water service interruptions per household (supporting)		
	Percentage of water loss (unaccounted for water) (supporting)		

4. Standard metrics

All indicators in the series use quantitative metrics. Ratios and percentages of population, labour force, customers, city areas, revenue, utility uses, budget, etc., are often employed.

Certification Scheme

1. Certification organization

ISO did not develop the ISO 37120 Series itself. The World Council on City Data (WCCD), based in Canada, led the development of these three series as well as their audit protocol, including a third-party verification and certification scheme. Moreover, ISO does not provide certification for any of its standards. Certification is performed by external accreditation bodies authorized to issue ISO standard certification. Nonetheless, ISO has produced standards related to the certification process, and so it recommends certification applicants to choose certification bodies that follow these standards to ensure that they comply with the necessary quality requirements. There are many different certification organizations: the British Standards Institution (BSI) (UK), the Organisme Français de Certification (OFC) (France), and the ANSI National Accreditation Board (ANAB) (USA) are among the most well-known accreditation bodies worldwide.

2. Certification applicant

ISO 37120 Series targets urban communities, which are defined as cities, municipalities, or local governments defined by a specific administrative district, regardless of their size and location.

3. Certification process

Cities wishing to evaluate their performance with the ISO 37120 Series on Sustainable Cities and Communities need to receive the ISO 37120 standard certification first.

Applicants to this ISO 37120 standard certification can receive five different certification stages:

- Aspiration: a verified score between 30 and 45 core standard indicators.
- Bronze: a verified score between 46 to 59 indicators, including 46 core indicators plus 0 to 13 supporting indicators.
- Silver: a verified score of 60 to 75 indicators, including 46 core indicators plus 14 to 29 supporting indicators.
- Gold: a verified score of 76 to 90 indicators, including 46 core indicators plus 30 to 44 supporting indicators.
- Platinum: a verified score of 91 to 100 indicators, including 46 core indicators plus 45 to 54 supporting indicators.

Unlike other standards, ISO does not request that cities report on all indicators. Instead, depending on their objectives, cities can choose the appropriate set of indicators to examine and report on. Thus, the standard aims to operate as an instrument for local authorities and policy makers to evaluate their performance; they can ultimately decide what aspects to examine.

Certified cities must undergo an annual recertification process. As of July 2021, 92 cities in 28 countries have received ISO 37120 certification.

Once cities have received an ISO 37120 certification, they are then eligible for ISO 37122 and ISO 37123 certifications.

4.1.3 OECD Smart City Measurement Framework

OECD Smart City Measurement Framework assesses the performance of smart cities. This framework seeks to evaluate both the degree and impact of digitalization in cities around the world, as well as the engagement and participation of city actors in developing smart cities.

1. Standard topic

OECD Smart Cities Measurement Framework evaluates and compares cities' policies to introduce digitalization in local services and stakeholders' engagement in developing inclusive, sustainable, and resilient societies.

2. Standards categories.

The framework has three categories, referred to as pillars in the OECD publication:

A. Digitalization, which measures digital innovation at the city level by the use of ICTs;

B. Engagement, which measures the involvement of city stakeholders in building the smart city;

C. Smart city performance, which measures four main elements of urban life: well-being, inclusion, sustainability, and resilience.

Table 12. Categories and Subcategories of the OECD Smart City Measurement Framework

Category	Subcategory
Digitalization	Connectivity
	Mobility
	Jobs and firms
	Housing and built environment
	Health and safety
	Education and skills
	E-government
	Energy, water, and waste
Engagement	Inclusiveness and equity
	Capacity and information
	Efficiency and effectiveness
	Adaptiveness
Smart city performance (Well-being)	Jobs
	Income
	Housing
	Access to services
	Education
	Political participation
	Health
	Environmental quality
	Personal safety
	Community
	Life satisfaction
Smart City performance (Inclusion)	Economic
	Gender and LGBT+
	Migrant and ethnic
	Inter-generational
Smart City performance (Sustainability)	Energy
	Climate
	Biodiversity
	Material footprint
Smart City performance (Resilience)	Health and social
	Institutions

Water-related categories are shown in bold.

3. Standards indicators

The three categories of the OECD Smart City Measurement Framework break down into 32 sub-categories and 93 indicators. These indicators measure input, output, and outcomes. Output indicators are more widely used, which allows evidence of what the city produces in terms of digital services and facilities. These indicators provide information of ICTs equipment in the city, including in the case of water services, the percentage use of water meters. In addition, the framework also measures the expenditure employed in research and development in the city which tells us the financial and capacity building resources that the city allocates for digitalization. Several indicators are also designed to measure

outcomes, and in that, we find several instances where life or city satisfaction and feelings of safety are measured elements. There are two indicators on urban water services.

Table 13. Water Indicators in the OECD Smart City Measurement Framework

Category	Subcategory	Indicator
Digitalisation	Energy, water, and waste	Percentage of households equipped with smart water meters
		Percentage drinking water under water quality monitoring by real-time water quality monitoring stations

4. Standard metrics

To allow for comparison, indicators frequently use percentages and fractions as metrics. Such is the case for all the indicators concerning water resources management and services in the digitalization category. For certain indicators, such as life satisfaction and those in the engagement category, the standard employs the Linkert scale, by which the evaluator evaluates the performance of the city by giving it a value between two values (commonly, between 0 and 10, where 0 corresponds to a bad performance and 10 a good performance). In doing so, the Linkert scale transforms qualitative characteristics into quantitative values, which facilitates cross-city comparisons.

4.2. Non-governmental organizations and the private sector

4.2.1 CITYKeys Smart City Index

CITYKeys was a research project undertaken by a consortium of universities and research centers under the direction of Research Professor, Airaksinen Miimu, at the Technical Research Centre in Finland. As part of this project, the CITYKeys researchers developed the Smart City Index, composed of 76 city indicators measuring technological, economic, and social aspects of cities.

1. Standard topic

The CITYKeys project defined indicators to measure "smart cities", cities that mobilize and use available resources for improving the quality of life for its inhabitants and visitors. These indicators constitute the "Smart City Index" and measure quality of life, resource efficiency, innovation and green economy, and local democracy.

2. Standards categories

The standard has four categories which correspond to the four key areas of smart cities: People, Planet, Prosperity, and Governance. The categories break down into 19 subcategories, as indicated in Table 14. Water is included in the Planet category, in two subcategories (Materials, Water and Land; Ecosystem). The first subcategory examines the uses and the status of urban water, as well as materials and land. The second subcategory looks at the share of green and water spaces in the city.

Table 14. Categories and Subcategories of CITYKeys Smart City Index

Category	Subcategory
People	Health
	Safety
	Access to (other) services
	Education
	Quality of housing and the built environment
Planet	Energy & mitigation
	Materials, water, and land
	Climate resilience
	Pollution and waste
	Ecosystem
Prosperity	Employment
	Equity
	Green economy
	Economic performance
	Innovation
	Attractiveness and competitiveness
Governance	Organization
	Community involvement
	Multi-level governance

Water-related categories are shown in bold.

3. Standards indicators

76 indicators have been established to examine and compare smart cities. 22 indicators are employed in each of the Planet, People, and Prosperity categories, plus 10 indicators serve as measures in the Governance category. They are mostly output indicators, although one input indicator is also included in the multilevel subcategory–expenditure by the local authority for a smart city transition. There are 5 indicators concerning water and they are all output indicators.

Table 15. Water Indicators in CITYKeys Smart City Index

Category	Subcategory	Indicator
Planet	Materials, water, and land	Water consumption
		Grey and rainwater use
		Water Exploitation Index
		Water losses
	Ecosystem	Share of green and water spaces

4. Standard metrics

The quantitative metrics of the indicators facilitate comparison between cases. Percentages and ratios are widely employed in the Prosperity and Planet categories. The standard has also established Linkert scales to measure qualitative variables. The Likert scale evaluates based on a value scale between 0 (not at all) and 5 (excellent). A Likert scale requires some understanding of the city context for an accurate assessment to take place.

4.2.2 Leed for Cities and Communities

The Leadership in Energy and Environmental Design (LEED) for Cities and Communities is a global standard and certification scheme that measures and certifies cities' sustainability performance and quality of life. The standard has been developed by two American organizations, the U.S. Green Building Council (USGBC) and the Green Business Certification Inc. (GBSI). USGBC has developed the LEED standard, while the GBCI issues the LEED certification to third party applicants.

1. Standard topic

The LEED for Cities and Communities standard seeks to evaluate urban sustainability. It looks at cities, understood as places with a governing body (i.e. cities, towns, counties, and other local government jurisdictions), and communities, which refer to "non-city places", including regions, districts, business improvement districts (BIDs), economic development zones, neighborhoods, campuses, and military installations–places that have responsibilities over services provision but no government jurisdiction.

2. Standard categories

The standard is divided into 9 categories and 40 subcategories considered central elements for a sustainable city. One of the categories concerns water access and quality. This category breaks down into 5 subcategories, as presented in Table 16.

Not all subcategories are the same. Amongst all the subcategories, the LEED for Cities and Communities identifies some elements that are more important for a city than others. For instance, in the Water category, guaranteeing adequate access to safe drinking water is considered a fundamental element for a city. In the energy category, having access to a reliable and resilient source of energy is also considered a requirement for a sustainable city.

Table 16. Categories and Subcategories of LEED for Cities and Community Standard

Category	Subcategory
Integrative process	Integrative planning and leadership
	Green building policy and incentives
Natural systems and ecology	Ecosystem assessment (required)
	Green spaces
	Natural resources conservation and restoration
	Light pollution deduction
	Resilience planning
Transport and land use	Transportation performance
	Compact, mixes use and transit-oriented development
	Access to quality transit
	Alternative fuel vehicles
	Smart mobility and transportation policy
	High-priority site
Water access and quality	**Water access and quality (required)**
	Water performance
	Integrated water management
	Storm water management
	Smart water systems
Energy and greenhouse gas emissions	Power access, reliability, and resilience (required)
	Energy and Greenhouse Gas Emissions Performance
	Energy Efficiency
	Renewable Energy
	Low Carbon Economy
	Grid Harmonization
Material and resources	Solid Waste Management (required)
	Waste Performance
	Special Waste Streams Management
	Responsible Sourcing for Infrastructure
	Material Recovery
	Smart Waste Management Systems
Quality of life	Demographic Assessment (required)
	Quality of Life Performance
	Trend Improvements
	Distributional Equity
	Environmental Justice
	Housing and Transportation Affordability
	Civic and Community Engagement
	Civil and Human Rights
Innovation	Innovation
Regional priority	Regional Priority

Water-related categories are shown in bold.

3. Standard indicators

The LEED for Cities and Communities standard has developed indicators for each subcategory. For the Water Access and Quality category, 8 indicators have been adopted, as indicated in Table 17 below. A combination of quantitative and qualitative indicators is employed to measure outcome, processes, and inputs. Outcome indicators measure cities' results, such as access to water and sanitation and quality of infrastructure. Process and input indicators are also employed, such as the adoption of water balance statement or water audits. They are mostly qualitative and measure the actions and resources in place in a city or community.

Table 17. Subcategories and Indicators of the Water Access and Quality Category– LEED for Cities and Community Standard

Category	Subcategory	Indicator
Water access and quality	Water access and quality	Access to water and sanitation
		Quality of drinking water
		Quality of treated wastewater
		Quality of stormwater infrastructure
	Water performance	Water Performance Score
	Integrated water management	Adoption of a water balance statement
	Storm water management	Number of flooding incidents in past 5 years
	Smart water systems	Existence of water audit

4. Standard metrics

The standard uses quantitative metrics–percentages and rates. In the case of water performance, the necessary information can be generally obtained directly from the urban water providers–access to water, water quality, and infrastructure. The standard has also established performance scores. In the case of water, a Water Performance Score has been defined, which is computed by considering the volume of water used.

Certification Scheme

1. Certification organisation

The Green Business Certification Inc. (GBCI) and the U.S. Green Building Council (USGBC) provide the independent oversight and the certification of the LEED standard.

2. Certification applicant

Cities and communities can apply to the LEED for Cities and Communities certification. Examples of actors able to apply for a LEED certification include:

- A city or county manager representing a jurisdiction
- A private sector planner developing a new city or community
- A local developer working on a district or collection of buildings on an urban site/block within a mature city
- A housing authority or local group measuring the sustainability of a neighborhood

In this sense, the LEED certification is not restricted to public or private organizations or areas of a particular size or population; a wider definition of

applicant is provided. In addition, the certification distinguishes between new cities and existing cities. Existing cities can submit to receive a certification resulting from measuring the performance of their present social, economic, and environmental conditions at a citywide scale or at a community level, whereas new cities and communities can apply to obtain a "Plan + Design" certification which estimates their performance in the planning, design, and development stages.

3. Certification process

The process to receive the certification is divided into three stages:

- **Precertification** is an optional stage, whereby the applicant submits an initial document stating the overview, goals, strategies, and roadmap for the sustainability activities by city, with the purpose of having an initial examination of its status before submitting all the certification requirements. The precertification helps the applicant better understand the strength and weaknesses of project circumstances, which might help to put in place remediation measures.
- **Certification** is the main step in the certification process. It consists of the city or community documenting sustainable strategies it has undertaken, according to requirements, and receiving its first certification if it meets the standards.
- **Recertification.** After having received a certification, cities and communities are invited to resubmit performance data in the future to receive an updated score, thus renewing their certification.

In addition, the LEED standard employs an online scoring and benchmarking platform where cities can include their metrics across an array of performance indicators and share the results. The objective of this voluntary measure is to inform others about success stories and promote "healthy competition".

4. Type of certification

The GBCI examines and reviews the submitted data and gives a score to the cities and communities according to the standards established. After successful review, the submissions that meet the minimum requirements receive a minimum score of 40 points and can receive the LEED certification. In addition, cities can also be given one of four levels of certification, which reflects different degrees of achievement. Depending on the value of the indicators, the city or community gets a score. The higher the score, the better the city or community's performance is considered to be. The score that the applicant earns determines the level of LEED certification that cities and communities receive:

- LEED Certified: a verified score of 40-49
- LEED Silver: a verified score of 50-59
- LEED Gold: a verified score of 60-79
- LEED Platinum: a verified score of 80+

By means of recertification, an applicant can improve their score, or equally, lose points if their performance has worsened. The objective of these different scores is to encourage cities and communities to identify ways of improving their scores and performance and for them to understand the reasons why they may have deteriorated. Cities and communities that have received the certification frequently display this achievement in their websites and publications.

4.2.3 Arcadis Sustainable Cities Water Index

This index has been prepared two private organizations: Arcadis, a consultancy firm specialized in natural and built assets, and the Centre for Economics and Business Research (CEBR), an economic consultancy firm. This standard builds on the earlier Arcadis Sustainable Cities Index, which addressed various aspects of urban sustainability, and focuses solely on the water sector. The index has 17 indicators which measure three elements of water resources management in cities: resilience, quality, and efficiency. Within these categories, the indicators create an overall ranking for cities around the world.

1. Standard topic

The Arcadis Sustainable Cities Water Index examines the urban water sustainability. Water sustainability regards three main areas: water resiliency, efficiency, and quality. Cities are ranked according to how sustainably they manage and maintain water, as well as how exposed and vulnerable to natural risks they are.

2. Standard categories

This standard is divided into three categories: water resilience, water efficiency and water quality:

- Water resilience relates to the capacity of adaptation of the city in the face of water challenges, such as too much water (floods) and too little water (droughts).
- Water efficiency deals with how effectively and cost-efficient a city can provide water services.
- Water quality is a category to measure how clean and healthy water supply is in a city.

3. Standard indicators

To measure water resilience, this standard looks at six different indicators: water-related disaster risk, flood risk, water stress, water balance, reserve water, and green space.

To measure water efficiency, the standard looks at the presence of non-revenue water (leakage), water charges, metered water, reused wastewater, service continuity, sanitation, and drinking water.

To measure water quality, the standard looks at sanitation, characteristics of drinking water coverage, extent of water treatment, presence of water-related diseases, protection of threatened species dependent of water resources, and the presence of water pollution.

In total, 19 input indicators enter the water index: 6 in the Resilience category, 7 in the Efficiency category, and 6 in the Quality category. Two of them (drinking water and sanitation) appear in Efficiency and Quality categories, as they define both services.

Not all the indicators are the same; however, they are weighted according to their relative importance to water sustainability and quality of life. Having access to drinking water and to sanitation, two essential elements for public health and life, rank the highest. At the bottom of the table is Reused Wastewater, which helps to put less strain on existing water supplies and can create positive returns on investment. However, it is considered less important to ensure water sustainability and well-being. Information on the rank of each indicator is presented in Table 18.

4. Standard metrics

This standard employs quantitative metrics–percentages, number per capita, average costs, etc. The standard developers have indicated for each indicator where the information can be found which helps to identify adequate, comparable, and reliable sources for the information requested. For instance, it suggests using data made available by WHO/UNICEF Joint Monitoring Program for Water Supply and Sanitation when information on drinking water supply and sanitation is necessary. Data by the World Bank and from the municipal service providers can provide the necessary evidence to measure performance on metered water and leakage.

Table 18. The Arcadis Sustainable Cities Water Index Categories, Indicators and Metrics

Category	Indicator	Rank	Metrics
Resilience	Water-related disaster risk	3	Number of different types of water-related natural disasters a city is exposed to, including floods, storms, droughts and mud flows.
	Flood risk	3	Number of floods experienced between 1985–2011
	Water stress	5	Percentage of freshwater withdrawn/total available locally
	Water balance	6	Monthly deficits and surpluses of rainfall
	Reserve water	8	Reservoir capacity within 100km of city, relative to total city water supply
	Green space	14	Percentage of city area covered with green space
Efficiency	Drinking water*	1	Percentage of households with safe and secure drinking water.
	Sanitation**	2	Percentage of households with access to improved sanitation.
	Service continuity	9	Continuity of service, average hours per day over the whole network.
	Leakage	10	The proportion of water lost in transit. Includes unbilled consumption, apparent losses, and physical leakage.
	Metered water	12	Percentage of households whose water consumption is metered.
	Water charges	13	Average cost per cubic meter of water to consumers, relative to average income in city.
	Reused wastewater	16	Wastewater reuse compared to total wastewater produced.
Quality	Drinking water*	1	Percentage of households using an improved drinking-water source.
	Sanitation**	2	Percentage of households with access to improved sanitation.
	Water-related disease	4	Incidence of water/sanitation related disease per capita.
	Raw water pollution	7	Concentration of phosphorus and sediment yields from source
	Treated wastewater	11	Percentage of wastewater treated.
	Threatened freshwater amphibian species	15	Percentage of freshwater amphibian species classified by the International Union for Conservation of Nature as threatened in an area.

Same indicators on *Drinking water and **Sanitation in Efficiency and Quality categories.

4.2.4 KWR City Blueprint Approach

The City Blueprint Approach is an assessment tool to measure Integrated Water Resources Management (IWRM) in cities. It has been developed by KWR Water Research Institute, a research centre based in the Netherlands. The City Blueprint Approach helps cities identify local strategies towards sustainability.

1. Standard topic

City Blueprint Approach is an assessment tool developed to evaluate the sustainability of urban water resources. It has been established as a response to extreme weather events such as floods and drought to help cities to improve their water resources management and water services performance.

2. Standard categories

The City Blueprint Approach examines three complementary categories:

1. The Trends and Pressures Framework (TPF) examines what urban water challenges cities face and it has three subcategories: social pressures, environmental pressures, and financial pressures.
2. City Blueprint Framework (CBF) assesses how effectively cities manage their urban water cycle from water provision to climate change and governance.
3. Governance Capacity Framework (GCF) examines how cities manage their water resources.

3. Standard indicators

In total, the City Blueprint Approach has 63 indicators in the three framework categories. The TPF and CBF categories tend to measure outputs, as they provide a diagnosis of the current circumstances in the city. The GCF category gathers information on inputs, such as resources, capacities, staff, and expertise, that the cities have put in place to bring about a sustainable and integrated management of water resources in cities.

- **Trends and Pressures Framework (TPF)**

12 indicators measure the social, environmental, and financial trends and pressures faced by the local city. Indicators such as urbanization rate, water scarcity, flood risks, unemployment, etc. provide information on the background and the context of the cities. Each indicator receives a number according to the following scale from 0 to 4 points: 0-0.5 points (no concern), 0.5-1.5 points (little concern), 1.5-2.5 points (medium concern), 2.5-3.5 points (concern), and 3.5-4.0 points (great concern).

- **City Blueprint Framework (CBF)**

24 indicators constitute the CBF category which examines how successfully cities manage different urban service provision and undertake sustainability plans. They measure aspects such as water quality, solid waste treatment, basic water services, wastewater treatment, infrastructure, and more.
With the information collected for each indicator, a score is given from 0 (bad performance) to 10 (excellent performance). The values of each indicator are plotted in a spider diagram which reflects the strengths and weaknesses of their performance. Then, following existing indicator scores, cities are classified into five categories (1) cities lacking basic water services, (2) wasteful cities, (3) water efficient cities, (4) resource efficient and adaptive cities, and (5) water wise cities (Koop & Van Leeuwen, 2015).

• Governance Capacity Framework (GCF)

The GCF category includes 27 indicators in three subcategories: Knowing, Wanting, and Enabling. In the subcategory, Knowing, the indicators assess whether the local government has the appropriate understanding of the urban water challenges of a given city. In the subcategory, Wanting, the indicators measure whether the local level has an adequate mindset to confront these challenges as well as responsible actors with a willingness to do it. In subcategory, Enabling, the indicators examine whether the local government has the financial, administrative, and organizational capacities to adopt the measures needed.

Table 19. Categories, Subcategories, Dimensions, and Indicators of KWR City Blueprint Approach

Category	Subcategory	Dimension	Indicator
Trend and Pressures Framework	Social Pressures	-	Urbanization rate
			Burden of disease
			Education rate
			Political instability
	Environmental Pressures		Flooding
			Water scarcity
			Heat Risk
	Financial Pressures		Economic pressure
			Unemployment rate
			Poverty rate
			Inflation rate
City Blueprint Framework	-	-	Water footprint
			Water scarcity
			Water self-sufficiency
			Surface water quality
			Groundwater quality
			Sufficient to drink
			Water system leakages
			Water efficiency
			Drinking water Consumption
			Drinking water quality
			Safe sanitation
			Sewage sludge recycling
			Energy efficiency
			Energy recovery
			Nutrient recovery
			Average age sewer system
			Infrastructure separation
			Climate commitments
			Adaptation Strategies
			Climate-robust buildings
			Biodiversity
			Attractiveness
			Management and action plans
			Public participation

Category	Subcategory	Dimension	Indicator
Governance Capacity framework	Knowing	Awareness	Community of knowledge
			Sense of urgency
			Behavioural internalization
		Useful knowledge	Information availability
			Information transparency
			Knowledge cohesion
		Continuous learning	Smart monitoring
			Evaluation
			Cross-stakeholder learning
	Wanting	Stakeholder engagement process	Stakeholder inclusiveness
			Protection of core values
			Progress and variety of options
		Management ambition	Ambitious and realistic goals
			Discourse embedding
			Management cohesion
		Agents of change	Entrepreneurial agents
			Collaborative agents
			Visionary agents
	Enabling	Multilevel network potential	Room to manoeuvre
			Clear division of responsibilities
			Authority
		Financial viability	Affordability
			Consumer willingness to pay
			Financial continuation
		Implementing capacity	Policy instruments
			Statutory compliance
			Preparedness

4. Standard metrics

The City Blueprint Approach employs quantitative data on urban water performance and urban characteristics. One of its main characteristics, however, is that it uses Likert scales extensively by grading TPF in a scale from 0 to 4 for the TPF category) and from 0 to 10 for the CBF category. By doing this, the evaluation allows for a comparison between categories and between cases.

5. Certification Scheme

The City Blueprint Approach is not a certification, but an assessment method for identifying cities' strong and weak points in its management of water resources. The City Blueprint Approach method has been employed by analysts and scholars interested in comparative urban sustainability to understand and compare the functioning and activities of cities. It is one of the tools made available by Watershare, a network of water research organizations and utilities dedicated to water research with global and local collaboration. The City Blueprint Approach guidelines highlight the need for assessments to be done in collaboration with local stakeholders, as they have access to expert knowledge and will employ the results quickly.

To assess city's sustainability with the City Blueprint Approach, three main steps are followed:

1. Information collection, which consists of the gathering of relevant information via a literature review on the circumstances that the city faces, a questionnaire issued to the city authorities, and quality control of the data check, which is then shared with city authorities.
2. Information processing, which consists in calculating the score of the City BluePrint Framework category on a scale of 0 to 10. The score on the Trends and Pressures Framework is also calculated.
3. Contextualization, which consists of providing an account of the local urban water resources management performance by drawing from the information collected with the City Blueprint Approach, as well as with the existing literature and other cities' assessments and explanations.

More than 125 cities and regions in more than 40 countries have been examined following the City Blueprint Approach since 2011, such as Ahmedabad (India), Amsterdam (Netherlands), Bandung (Indonesia), Cape Town (South Africa), Dar es Salaam (Tanzania), Hamburg (Germany), Ho Chi Minh City (Viet Nam), Istanbul (Turkey), Melbourne (Australia), Quito (Ecuador), Rotterdam (Netherlands), and Seoul (Republic of Korea). City Blueprint Approach offers an online platform providing information to cities for knowledge exchange. By using this platform, cities can learn practical lessons from other cities that have already implemented certain measures and learn from their example.

4.2.5 AWS International Water Stewardship Standard

The International Water Stewardship Standard was developed by the Alliance for Water Stewardship (AWS) to examine how water is protected at a site and catchment level according to environmental, social, and economical criteria. It serves as guidance for the adoption of protective measures. The standard has 98 indicators.

1. Standard topic

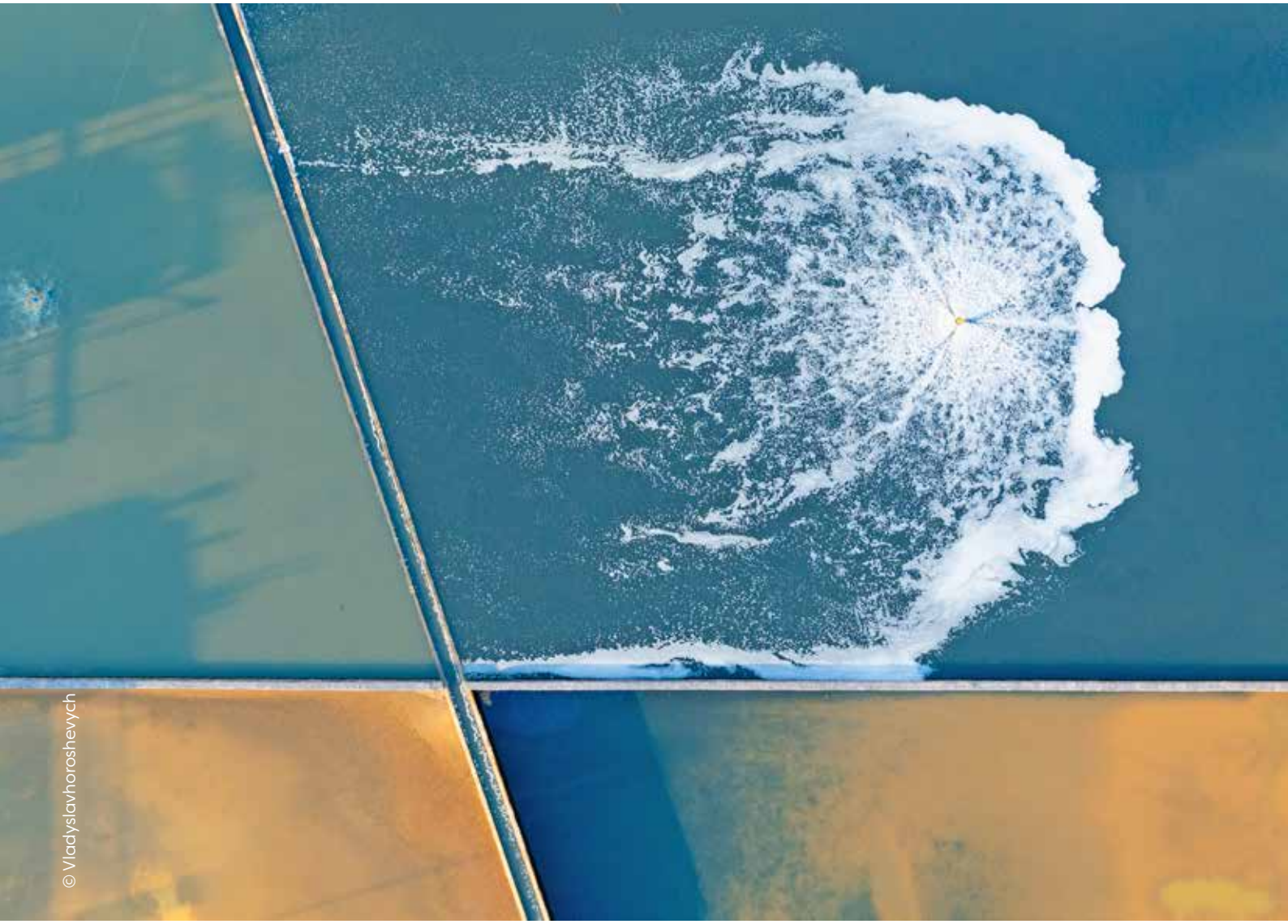
The International Water Stewardship Standard seeks to evaluate water resources sustainability in sites and river catchments.

2. Standards categories

To examine the degree of sustainability of sites and catchments, the standard is divided into five categories of analysis (Gather and understand; Commit and plan; Implement; Evaluate; and Communicate and disclose). Each category corresponds to different steps of the policy-making cycle. Each of the 5 main categories are further divided into subcategories which provide further specification of the areas considered. In total, there are 30 subcategories in the standard. The "Gather and understand" category seeks to provide guidance of the information that policymakers need to collect to ensure that the sustainability standards are met. The "Commit and plan" category is about deciding and planning the measures that are going to be put in place. The "Implement" category is the phase when different measures for protecting water resources of sites and river catchments are established. The "Evaluate" category provides guidance to assess what needs to be made for evaluating the measures implemented to protect water bodies. Finally, the "Communicate and disclose" category establishes the guidance for how best to communicate information to the public about water status in sites and river catchment areas.

Table 20. Categories and Subcategories of AWS International Water Stewardship Standard

Category	Subcategory
Gather and understand	Gather information to define the site's physical scope for water stewardship purposes.
	Understand relevant stakeholders, their water related challenges, and the site's ability to influence beyond its boundaries.
	Gather water-related data for the site, including: water balance, water quality, Important Water-Related Areas, water governance, WASH, water-related costs, revenues, and shared value creation.
	Gather data on the site's indirect water use.
	Gather water-related data for the catchment.
	Understand current and future shared water challenges in the catchment by linking the water challenges identified by stakeholders with the site's water challenges.
	Understand the site's water risks and opportunities.
	Understand best practice towards achieving AWS outcomes.
Commit and plan	Commit to water stewardship by having a senior manager in charge.
	Develop and document a process to achieve and maintain legal and regulatory compliance.
	Create a water stewardship strategy.
	Demonstrate the site's responsiveness and resilience to responding to water risks.
Implement	Implement a plan to participate positively in catchment governance.
	Implement a system to comply with water-related legal and regulatory requirements and respect water rights.
	Implement a plan to achieve site water quality targets.
	Implement a plan to achieve site water balance targets.
	Implement a plan to maintain or improve the site's and/or catchment's Important Water-Related Areas.
	Implement a plan to provide access to safe drinking water, effective sanitation, and protective hygiene (WASH) for all workers at all premises under the site's control.
	Implement a plan to maintain or improve indirect water use within the catchment.
	Implement a plan to engage with and notify the owners of any shared water-related infrastructure of any concerns the site may have.
	Implement actions to achieve best practice towards AWS outcomes.
Evaluate	Evaluate the site's performance, considering its actions and targets from its water stewardship.
	Evaluate the impacts of water-related emergency incidents (including extreme events); if any have occurred, determine the effectiveness of corrective and preventative measures.
	Evaluate stakeholders' consultation feedback regarding the site's water stewardship performance.
	Evaluate and update the site's water stewardship plan.
Communicate and disclose	Disclose water-related internal governance of the site's management.
	Communicate the water stewardship plan with relevant stakeholders.
	Disclose annual site water stewardship summary.
	Disclose efforts to collectively address shared water challenges.
	Communicate transparency in water-related compliance.



3. Standards indicators.
98 indicators have been developed for the International Water Stewardship Standard to measure different aspects of the management of water bodies: 34 indicators in the "Gather and understand" category; 10 in the "Commit and plan" category; 36 in the "Implement" category; 8 in the "Evaluate" category; and 10 in the "Communicate and disclose" category (see Table 21).

All indicators are not the same. Out of the 98 indicators, 68 are core indicators, while 30 are advanced indicators. Core indicators concern primary objectives, more relevant and important for the management of water sites. Advanced indicators, while relevant, are secondary.

The indicators are "process indicators," establishing the actions needed to achieve the sustainability of sites and catchments. The indicators are not measured quantitatively, but qualitatively. They have a wide field of application, as they are not dependent on requisites on input or outputs. Not all indicators have the same value: there are core criteria, which must be met as a minimum requirement for certification, and also advanced criteria, which can award additional points.

Table 21. Categories and Indicators of AWS International Water Stewardship Standard

Category	Subcategory
Gather and understand	Gather information to define the site's physical scope for water stewardship purposes.
	Understand relevant stakeholders, their water related challenges, and the site's ability to influence beyond its boundaries.
	Gather water-related data for the site, including: water balance, water quality, Important Water-Related Areas, water governance, WASH, water-related costs, revenues, and shared value creation.
	Gather data on the site's indirect water use.
	Gather water-related data for the catchment.
	Understand current and future shared water challenges in the catchment by linking the water challenges identified by stakeholders with the site's water challenges.
	Understand the site's water risks and opportunities.
	Understand best practice towards achieving AWS outcomes.
Commit and plan	Commit to water stewardship by having a senior manager in charge.
	Develop and document a process to achieve and maintain legal and regulatory compliance.
	Create a water stewardship strategy.
	Demonstrate the site's responsiveness and resilience to responding to water risks.
Implement	Implement a plan to participate positively in catchment governance.
	Implement a system to comply with water-related legal and regulatory requirements and respect water rights.
	Implement a plan to achieve site water quality targets.
	Implement a plan to achieve site water balance targets.
	Implement a plan to maintain or improve the site's and/or catchment's Important Water-Related Areas.
	Implement a plan to provide access to safe drinking water, effective sanitation, and protective hygiene (WASH) for all workers at all premises under the site's control.
	Implement a plan to maintain or improve indirect water use within the catchment.
	Implement a plan to engage with and notify the owners of any shared water-related infrastructure of any concerns the site may have.
	Implement actions to achieve best practice towards AWS outcomes.
Evaluate	Evaluate the site's performance, considering its actions and targets from its water stewardship.
	Evaluate the impacts of water-related emergency incidents (including extreme events); if any have occurred, determine the effectiveness of corrective and preventative measures.
	Evaluate stakeholders' consultation feedback regarding the site's water stewardship performance.
	Evaluate and update the site's water stewardship plan.
Communicate and disclose	Disclose water-related internal governance of the site's management.
	Communicate the water stewardship plan with relevant stakeholders.
	Disclose annual site water stewardship summary.
	Disclose efforts to collectively address shared water challenges.
	Communicate transparency in water-related compliance.

4. Standard metrics.
The measurement in this standard is not quantitative, but qualitative. The standard's applicants and auditors must assess the situation, grading it according to their observations.

Certification Scheme

1. Certification organisation
The AWS does not provide a certification to the applicants, but accredits three types of service providers: Consultancies, Conformity Assessment Bodies (CABs), and individuals that have received training to become certification suppliers. AWS publishes organizations that can deliver accreditation. The AWS strongly recommends that implementers of the AWS Standard work with the AWS accredited service providers and professionally credentialed organizations to receive certification.

2. Certification applicant
The certification scheme is applicable globally to all organizations and industrial sectors, independently of their size and operational complexity. This includes including agriculture, and non-profit sectors.

3. Certification process
The AWS has established a five-step procedure for applicants to get certifications:

- **Phase 1: Familiarization:** applicants are asked to find about the AWS Standard and reflect on how their site or catchment area meets the indicators.
- **Phase 2: AWS Standard System Training:** applicants participate in a training session that provides key information on the standard, the indicators, and the certification process.
- **Phase 3: Completion and Submission of Certification Applications:** applicants submit their online request to receive a certification for their sites or catchment area.
- **Phase 4: Implementation:** once the information for the AWS Standard is collected, all actions necessary for the certification are adopted.
- **Phase 5: Audit:** the site is audited and any gaps with meeting the standards are highlighted. Once audited and found to be in compliance with the AWS Standard, the sites are awarded AWS Certification.

4. Type of certification
There are three levels of AWS Standard certification that a site may achieve: Core, gold and platinum. All core criteria must be met as a minimum requirement for certification. Additional points are awarded for performance against the advanced criteria. The points required for each certification level are as follows:

- Core: all core standards, plus 0 to 39 points in advanced indicators.
- Gold: all core standards, plus 40 to 79 points in advanced indicators.
- Platinum: all core standards, plus 80 or more points in advanced indicators.

The greater the number of points achieved the higher the level of water stewardship performance and AWS certification. The maximum value of each advanced indicator is established in the accreditation guidelines.

A site's certificate is valid for three years, subject to successful annual surveillance audits. It is expected that over time, applicants will search to adopt more advanced actions in the spirit of improving their performance.

4.3. Comparison of global standards and certification schemes

Several aspects stand out from the comparison of these eight well-established instruments to analyze and evaluate cities from around the world:

1. Variation in the standard topic
The standards vary in their topic subject. Four of the standards analyzed make water sustainability the key topic of the standard (Arcadis Sustainable Cities Water Index, KWR City Blueprint Approach, and AWS International Water Stewardship Standard). Their objective is to measure the environmental protection of water bodies and citizens' access to water resources.

The other four standards make specific references to "smartness" as a central topic (United 4 Smart Sustainable Cities, ISO 37120 series on sustainable cities and communities, OECD Smart City Measurement Framework, and CITYKeys Smart City Index). They are interested in measuring the presence of digital technologies in the provision of urban services. Smart development is, nonetheless, understood as heavily interconnected to sustainability, and so, these standards also refer to the protection of the environment and social inclusion.

In addition, quality of life–understood as citizens' wellbeing–is also an important concern, and thus smart sustainable development is also put in connection to indicators such as access to health and education, safety, food security, etc., in several cases, such as LEED for Cities and Communities, CITYKeys Smart City Index, OECD Smart City Measurement Framework, ISO 37120 Series, etc.

2. Cities as unit of analysis
The city–taken to be the space inhabited by many people living in proximity, and under one administration–is the preferred unit to examine urban sustainable and smart development in most of the examined standards. One standard (AWS International Water Stewardship Standard) uses the term "site" instead, which refers to areas within a river basin. In addition, two standards can be applied to cities and to "communities", understood as smaller urban units such as neighborhoods or city districts. All standards are designed to examine urban areas with different features, irrespective of their size, economic development, governance arrangements, etc.

3. Governance of urban water resources
Six standards except the Arcadis Sustainable Cities Water Index and the United 4 Smart Sustainable Cities do include some indicators on urban governance. Elements such as the existence of coordination between departments, citizen's participation, or mechanisms for monitoring and evaluation are measured. However, the variation in the indicators on governance is large, so no set of the most crucial elements at the city level has been established.

4. Water has a key role in smart sustainable cities

Water plays a key role in all the standards dealing with smart, urban sustainability. Water is key for socio-economic development and life, and thus all standards seek to grasp the extent to which cities provide for a safe and secure access to this finite resource.

However, several of the examined standards only take a partial view of the different functions of water in cities. The United 4 Smart Sustainable Cities, ISO 37120 Series, OECD Smart City Measurement Framework, CITYKeys Smart City Index, and LEED for Cities and Communities standard have a larger scope of analysis than water and include other sectoral policies and dimensions. Thus, the functions of water as a resource and an urban service are only considered with a reduced number of indicators (see Table 22).

Arcadis Sustainable Cities Water Index, KWR City Blueprint Approach, and AWS International Water Stewardship Standard are much more comprehensive in the analysis of the water sector and can be of great help in the design of a future Smart Water City standard scheme. Yet, some limitations concur:

- Arcadis Sustainable Cities Water Index includes 17 indicators to measure and evaluate the functioning of urban water services provision. Some gaps are still present regarding water quality and wastewater collection. Aspects concerning urban governance are not taken into consideration.
- KWR City Blueprint Approach successfully measures characteristics of the city and also pays dedicated attention to the governance of the water sector. However, the standard is concerned with measuring the existing urban water status and not the functioning of water services provision in the city.
- AWS International Water Stewardship Standard takes the river basin and water sites as units of analysis. Therefore, the focus is not on the functions of water in the city, which have particularities that need to be specifically examined (such as, the operation of water services infrastructures, for instance).

5. Characteristics of the indicators: number, hierarchized, quantitative and output measures

With regards to the characteristics of the indicators of the standards examined, various elements need to be highlighted:

- The range of indicators from 19 of Arcadis Sustainable Cities Water Index to 276 of ISO 37120 Series that the standards propose is large. The other six standards have more than 40 indicators. Decisions on the number of indicators have large implications: the more data that the standard collects, the fuller their diagnosis. However, greater data requirements may also make it difficult to collect information in certain city cases and lead to incomplete data gathering exercises. A trade-off between data comparability and exhaustiveness exists.

- Some standards have established a hierarchy of indicators. This means that the collection of certain information is deemed essential, whereas other indicators may help to complement the data gathering exercise.

- Most standards indicators collect quantitative data, gathered in percentages and rates. Doing so facilitates comparisons across city and country cases. In some cases, such as KWR City Blueprint Approach and the CITYKeys Smart

City Index, the information requested is of a qualitative nature and requires an evaluation. In these cases, the information is collected with a Linkert scale where the evaluator grades the circumstances and the status of water in the city. The LEED for Cites and Communities standard employs a scoreboard. In these cases, it necessary to establish a set of guidelines to ensure the information collected by different researchers/evaluators is reliable and comparable.

• Most of the standards have preferred indicators that account for city outputs, that is, the measure of sustainability or smartness that the city displays. Indicators on the resources employed to achieve such smart and sustainable results (input indicators) are employed less. Process indicators are heavily employed only in the AWS International Water Stewardship Standard, as it accounts in detail the mechanisms and the measures put in place, irrespective of their results or the resources employed.

6. Certification types

In three out of the eight examined standards, a certification can be granted to accredit that a city authority or local organization meets a standard's requirements. This is the case of the ISO 37120 standard as well as the LEED and AWS standards. The three certifications propose different levels of certification depending on what degree of requirement the standard has met:

- Five levels in the case of the ISO 37120 standard;
- Four levels in the case of the LEED standard; and
- Three levels in the case of the AWS standard.

The different types of certifications are used as evidence for grading the performance of cities.

Table 22. Comparison of the Subject, Structure, and Indicators of Eight Global Standards on Smart and Sustainable Water Urban Management

Standard	Subject	Structure	Water-related indicator
United 4 Smart Sustainable Cities	Smart Sustainable Cities	• 3 dimensions (Economy; Environment; Society and Culture) • 7 sub-dimensions (ICT; Productivity; Infrastructure; Environment; Energy; Education, Health and Culture; Safety, Housing and Social Inclusion) • 28 categories • 91 indicators (quantitative)	11 indicators • 2 in water distribution (supply) 1 measuring smart technology • 1 in water distribution (loss) • 2 in consumption • 1 in drinking water (supply) • 1 in drinking water (quality) • 1 in wastewater (collection) • 1 in wastewater (treatment) • 1 in sanitation • 1 in water source (quantity)
ISO 37120 Series (Sustainable Cities and Communities) *	Smart and sustainable cities and communities	• 19 themes • 104 indicators (ISO 37120 standard); 80 indicators (ISO 37122 standard); 68 indicators (ISO 37123 standard), all quantitative	11 indicators (ISO 37120 standard) • 1 in water distribution (supply) • 1 in water distribution (loss) • 2 in consumption • 1 in drinking water (supply) • 1 in drinking water (quality) • 1 in wastewater (collection) • 2 in wastewater (treatment) • 1 in sanitation • 1 in water source (quantity)
			9 indicators (ISO 37122 standard) • 1 in water distribution (supply), measuring smart technology • 1 in consumption, measuring smart technology • 1 in drinking water (quality), measuring smart technology • 1 in wastewater (collection), measuring smart technology • 1 in wastewater (reuse) • 3 in wastewater (resource recovery) • 1 in water source (quality), measuring smart technology
			2 indicators (ISO 37123 standard) • 1 in drinking water (supply) • 1 in water source (quantity)
OECD Smart City Measurement Framework	Smart cities	• 3 pillars (Digitalization; Engagement; Smart City Performance) • 32 sub-categories • 93 indicators (quantitative)	2 indicators • 1 in consumption, measuring smart technology • 1 in drinking water (quality), measuring smart technology

Standard	Subject	Structure	Water-related indicator
CITYKeys Smart City Index	Smart cities	• 4 categories (People; Planet; Prosperity; Governance) • 19 sub-categories • 76 indicators (quantitative – with Likert scale)	5 indicators • 1 in water distribution (loss) • 1 in consumption • 2 in water source (quantity) • 1 in ecosystem
LEED for Cities and Communities*	Cities and communities' sustainability	• 9 categories (Energy; Water; Waste; Transportation; Quality of Life) • 40 indicators (quantitative and qualitative – scoreboard)	8 indicators • 1 Access to water and sanitation • 1 Quality of drinking water • 1 Quality of treated wastewater • 1 Quality of stormwater • infrastructure • 1 on Water consumption per capita (water performance) • 1 on water balance • 1 on flooding • 1 on Water audit
Arcadis Sustainable Cities Water Index	Sustainable water cities	• 3 categories (Resilience; Efficiency; Quality) • 18 indicators (quantitative)	All • 1 in water distribution (supply) • 1 in water distribution (loss) • 2 in consumption • 1 in drinking water (supply) • 1 in wastewater (treatment) • 1 in wastewater (reuse) • 2 in sanitation • 3 in water source (quantity) • 1 in water source (quality) • 2 in ecosystem • 2 in disaster risk
KWR City Blueprint Approach	Cities' Integrated water resources management	• 3 frameworks (Trends and Pressures; City Blueprint; Governance Capacity) • 64 indicators (quantitative – with Likert scale)	All • 1 in water distribution (loss) • 3 in consumption • 2 in drinking water (supply) • 1 in drinking water (quality) • 2 in wastewater (collection) • 4 in wastewater (resource recovery) • 1 in sanitation • 1 in water source (quantity) • 2 in water source (quality) • 1 in ecosystem • 3 in climate change • 3 in social factor • 12 in trends and pressures • 27 in governance capacity
AWS International Water Stewardship Standard*	Water resources sustainability in sites and river catchments	• 5 categories (Gather and Understand; Commit and Plan; Implement; Evaluate; Communicate and Disclose) • 30 sub-categories • 98 indicators	All • 34 indicators in gather and understand • 10 in commit and plan • 36 in implement • 8 in evaluate • 10 in communicate and disclose

* Certification schemes present

4.4. Key findings for the development of a Smart Water Cities global standard and certification scheme

Above all, from the comparison of eight global standards and certification schemes, a paradox emerges: while water is a key element for urban growth and development, we currently lack an instrument to measure and benchmark Smart Water Cities comprehensively. In particular, the comparison shows the existence of two main gaps:

1. The existing standards focus almost exclusively on conventional urban water management. Thus, while some data is collected on the characteristics of the urban service provision such as drinking water and sanitation, we have scarce measurements of other key functions such as reuse and resource recovery, disaster risks, or ecosystem functions which are central to the sustainability of the water urban system.

2. The existing standards pay only reduced attention to the use of smart water technologies, even when they refer to smart development as a standard topic. Tables 23 to Table 31 divide, for each standard, the indicators that measure conventional technologies from smart technologies. It shows the limited number of water indicators that have examined the presence of smart technologies.

As smart technologies become widespread in the water sector, developing an instrument that allows for the examination and the comparison of the urban water system in a comprehensive manner throughout the urban water cycle is becoming more and more necessary. Such an instrument can be helpful in establishing an initial baseline of key elements that cities need to concentrate and deliver on, which can be helpful for policymakers and water providers in identifying and defining urban water management priorities. In addition, such an instrument can be helpful in examining the evolution of a single city, to track its progress (or lack thereof), and point at future measures that cities can take to continue improving their performance. Finally, such a tool can be also employed to compare and benchmark different cities at a moment in time, to identify with greater clarity what measures operate in a more effective and efficient manner in different contexts, and to learn from these experiences with more comprehensive and precise data.

Table 23. Water-Related Indicators in the Examined Standards: U4SSC

Degree of smartness		Basic	Smart technology
Water distribution	Supply	Basic water supply (Percentage of city households with access to a basic water supply)	Water supply ICT monitoring (Percentage of the water distribution system monitored by ICT (advanced))
	Loss	Water supply loss (Percentage of water loss in the water distribution system)	
Consumption		Water consumption (Total water consumption per capita)	Smart water meters (Percentage implementation of smart water meters)
Drinking water	Supply	Portable water supply (Percentage of households with a safely managed drinking water service)	
	Quality	Drinking water quality (Percentage of households covered by an audited Water Safety Plan)	
Wastewater	Collection	Wastewater collection (Percentage of households served by wastewater collection)	
	Treatment	Wastewater treatment (Percentage of wastewater receiving treatment (Primary, Secondary, Tertiary))	
	Reuse		
	Resource recovery		
Sanitation		Household sanitation (Percentage of the city households with access to basic sanitation facilities)	
Water source	Quantity	Fresh water consumption (Percentage of water consumed from freshwater sources)	
	Quality		
Ecosystem			
Disaster risk			
Climate change			
Social factor			

Table 24. Water-Related Indicators in the Examined Standards: ISO 37120 Standard in ISO 37120 Series

Degree of smartness		Basic	Smart technology
Water distribution	Supply	Average annual hours of water service interruptions per household (supporting)	
	Loss	Percentage of water loss (unaccounted for water) (supporting)	
Consumption		• Total domestic water consumption per capita (litres/day) (core) • Total water consumption per capita (litres/day) (supporting)	
Drinking water	Supply	Percentage of city population with potable water supply service (core)	
	Quality	Compliance rate of drinking water quality (core)	
Wastewater	Collection	Percentage of city population served by wastewater collection (core)	
	Treatment	• Percentage of city's wastewater receiving centralized treatment (core) • Compliance rate of wastewater treatment (supporting)	
	Reuse		
	Resource recovery		
Sanitation		Percentage of population with access to improved sanitation (core)	
Water source	Quantity	Percentage of city population with sustainable access to an improved water source (core)	
	Quality		
Ecosystem			
Disaster risk			
Climate change			
Social factor			

Table 25. Water-Related Indicators in the Examined Standards: ISO 37122 Standard in ISO 37120 Series

Degree of smartness		Basic	Smart technology
Water distribution	Supply		Percentage of the city's water distribution network monitored by a smart water system
	Loss		
Consumption			Percentage of buildings in the city with smart water meters
Drinking water	Supply		
	Quality		Percentage of drinking water tracked by real-time, water quality monitoring station
Wastewater	Collection		Percentage of the wastewater pipeline network monitored by a real-time data-tracking sensor system
	Treatment		
	Reuse	Percentage of treated wastewater being reused	
	Resource recovery	• Percentage of biosolids that are reused (dry matter mass) • Energy derived from wastewater as a percentage of total energy consumption of the city • Percentage of total amount of wastewater in the city that is used to generate energy	
Sanitation			
Water source	Quantity		
	Quality		Number of real-time environmental water quality monitoring stations per 100,000 population
Ecosystem			
Disaster risk			
Climate change			
Social factor			

Table 26. Water-Related Indicators in the Examined Standards: ISO 37123 Standard in ISO 37120 Series

Degree of smartness		Basic	Smart technology
Water distribution	Supply		
	Loss		
Consumption			
Drinking water	Supply	Percentage of city population that can be supplied with drinking water by alternative methods for 72 hours	
	Quality		
Wastewater	Collection		
	Treatment		
	Reuse		
	Resource recovery		
Sanitation			
Water source	Quantity	Number of different sources providing at least 5% of total water supply capacity	
	Quality		
Ecosystem			
Disaster risk			
Climate change			
Social factor			

Table 27. Water-Related Indicators in the Examined Standards: OECD Smart City Measurement Framework

Degree of smartness		Basic	Smart technology
Water distribution	Supply		
	Loss		
Consumption			Percentage of households equipped with smart water meters
Drinking water	Supply		
	Quality		Percentage drinking water under water quality monitoring by real-time water quality monitoring station
Wastewater	Collection		
	Treatment		
	Reuse		
	Resource recovery		
Sanitation			
Water source	Quantity		
	Quality		
Ecosystem			
Disaster risk			
Climate change			
Social factor			

Table 28. Water-Related Indicators in the Examined Standards: CITYKeys Smart City Index

Degree of smartness		Basic	Smart technology
Water distribution	Supply		
	Loss		Water losses
Consumption		Water consumption	
Drinking water	Supply		
	Quality		
Wastewater	Collection		
	Treatment		
	Reuse		
	Resource recovery		
Sanitation			
Water source	Quantity	Grey and rainwater use	Water Exploitation Index
	Quality		
Ecosystem		Share of green and water spaces	
Disaster risk			
Climate change			
Social factor			

Table 29. Water-Related Indicators in the Examined Standards: LEED for Cities and Communities

Degree of smartness		Basic	Smart technology
Water distribution	Supply		
	Loss		
Consumption		Water Performance Score	
Drinking water	Supply		
	Quality	Quality of drinking water	
Wastewater	Collection	Stormwater collection infrastructure	
	Treatment	Quality of treated wastewater	
	Reuse		
	Resource recovery		
Sanitation			
Water source	Quantity		
	Quality		
Ecosystem			
Disaster risk		Flooding incidents	
Climate change			
Social factor		Water Balance and audit	

Table 30. Water-Related Indicators in the Examined Standards: Arcadis Sustainable Cities Water Index

Degree of smartness		Basic	Smart technology
Water distribution	Supply	Service continuity (Continuity of service, average hours per day over the whole network)	
	Loss		
Consumption		Leakage (The proportion of water lost in transit. Includes unbilled consumption, apparent losses, and physical leakage)	
Drinking water	Supply	• Metered water (Percentage of households whose water consumption is metered) • Water charges (Average cost per cubic meter of water to consumers, relative to average income in city)	
	Quality	Drinking water (Percentage of households with safe and secure drinking water)	
Wastewater	Collection		
	Treatment		
	Reuse	Treated wastewater (Percentage of wastewater treated)	
	Resource recovery	Reused wastewater (Wastewater reuse compared to total wastewater produced)	
Sanitation			
Water source	Quantity	• Sanitation (Percentage of households with access to improved sanitation) • Water-related disease (Incidence of water/ sanitation related disease per capita)	
	Quality	• Water stress (Percentage of freshwater withdrawn/total available locally) • Water balance (Monthly deficits and surpluses of rainfall) • Reserve water (Reservoir capacity within 100km of city, relative to total city water supply)	
Ecosystem		• Raw water pollution (Concentration of phosphorus and sediment yields from source) • Threatened freshwater amphibian species (Percentage of freshwater amphibian species classified by the International Union for Conservation of Nature as threatened in an area	
Disaster risk		• Water-related disaster risk (Number of different types of water-related natural disasters a city is exposed to, including floods, storms, droughts and mud flows.) • Flood risk (Number of floods experienced between 1985-2011)	
Climate change			
Social factor			

Table 31. Water-Related Indicators in the Examined Standards: KWR City Blueprint Approach

Degree of smartness		Basic	Smart technology
Water distribution	Supply		
	Loss	Water system leakages	
Consumption		• Water footprint • Water self-sufficiency • Water efficiency	
Drinking water	Supply	• Sufficient to drink • Drinking water consumption	
	Quality	Drinking water quality	
Wastewater	Collection	• Average age sewer system • Infrastructure separation	
	Treatment		
	Reuse		
	Resource recovery	• Sewage sludge recycling • Energy efficiency • Energy recovery • Nutrient recovery	
Sanitation		Safe sanitation	
Water source	Quantity	Water scarcity	
	Quality	• Surface water quality • Groundwater quality	
Ecosystem		Biodiversity	
Disaster risk			
Climate change		• Climate commitments • Adaptation strategies • Climate-robust buildings	
Social factor		• Attractiveness • Management and action plans • Public participation	

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