What is water-smartness and how to assess it?

Deliverable 6.1

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D6.1: What is water-smartness and how to assess it?

Summary

Deliverable 6.1 – What is water-smartness and how to assess it? - aims at presenting the work fulfilled under Task 6.1 in WP6 towards the development of the B-WaterSmart Framework. Precondition to develop the framework is to understand what water-smartness is. Through an extensive literature review and inputs form the six Living Labs of the project, the multi-sectoral, multi-actor and multi-objective dimensions characterizing "water-smartness" have been emphasized, bringing the authors to conclude that more than "water-smartness", it was necessary to define what a water-smart society is. Having an agreed definition allows to move to the next step: its operationalization into an applicable water smartness assessment framework, the B-WaterSmart Framework. The report defines the methodology followed during the framework design and conception, it includes the key features of the B-WaterSmart framework and its high-level architecture. The main design driving factors have been identified based on feedbacks gathered from the LL owners. The report has been structured by first presenting the approach adopted to arrive to the definition endorsed (Chapters 2-4) and then, by using the definition, the preliminary theoretical concept and design of the framework are presented (Chapters 5 and 6). The deliverable also gives an overview of the next steps planned for the framework co-creation, so to further guide design and development.

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List of Acronyms and Abbreviations

BCI: Blue City Index

CBF: City Blueprint Framework

CE: Circular Economy

D: Deliverable

DESSIN: Demonstrating EcoSystem Services enabling INnovation in the Water Sector (project)

EC: European Commission

ESS: Ecosystem Services

EU: European Union

GCF: Governance Capacity Framework

IAM: Infrastructure Asset Management

ICLEI: International Council for Local Environmental Initiatives

IT: Information Technology

IWA: International Water Association

IWRM: Integrated Water Resources Management

LL: Living Lab

M: Month

MS: MileStone

OECD: Organisation for Economic Co-operation and Development

PI: Performance Indicator

PDCA: Plan-Do-Check-Act

RAF: Resilience Assessment Framework

RESCCUE: RESilience to cope with Climate Change in Urban arEas

SA: Sustainability Assessment

SD: Sustainable Development

SDG: Sustainable Development Goals

SES: Socio-ecological Systems

SME: Small-medium enterprise

SNM: Strategic Niche Management

STI: Science, Technology and Innovation system

SuDs: Sustainable Drainage Systems

SWITCH: Software Workbench for Interactive, Time Critical and Highly self-adaptive Cloud applications (project)

T: Task

TIS: Technological Innovation Systems

TM: Transition Management

TPF: Trends and Pressures Framework

TRUST: TRansition to sustainable Urban Systems of Tomorrow (project)

UN: United Nations

UNDP: United Nations Development Programme

UNEP: United Nations Environment Programme

UNISDR: United Nations Office for Disaster Risk Reduction

UK: United Kindom

UWCS: Urban Water Cycle Services

UWOT: Urban Water Optioneering Tool

WEF nexus: Water-Energy-Food nexus

WP: Work Package

Executive summary

The ultimate goal of the B-WaterSmart project is to accelerate the transformation to water-smart economies and societies. To achieve the goal, eight specific objectives have to be accomplished, as described in the description of action of the project:

- Objective 1: enable systemic innovation;
- Objective 2: create water-smart coastal regions;
- Objective 3: exploit the potential of smart resource allocation;
- Objective 4: foster resource recovery, circular economy, and ecosystem regeneration;
- Objective 5: facilitate a water-smart culture;
- Objective 6: demonstrate the gain in water-smartness as a novel and holistic concept;
- Objective 7: stimulate new business opportunities for European water solution providers;
- Objective 8: boost European and international accessibility and replication, exchange and uptake of innovations in water management.

WP6 provides the means to achieve objective 6. No harmonized and established approaches on how to assess the 'water-smartness' status or gains of a system, or society exist; therefore, the mission of WP6 is to fill this gap by providing the definition of a water-smart society to be operationalized into an applicable evaluation framework, which will be converted into an online dashboard (by Task 3.9) after testing it in Task 1.4 across the six LLs.

WP6 is structured into three tasks: Task 6.1 covers the groundwork, including an extensive literature review and the gathering of preliminary user-requirements for the intended framework; Task 6.2 will develop the framework and Task 6.3 will further refine it after a period of testing performed by the LLs.

This deliverable presents the work fulfilled under Task 6.1 and therefore it aims at providing the readers with a picture of the methodology followed to come up with the definition of water-smart society adopted and to provide the framework design and conception.

The report also serves to define the scope of the framework so to guide further design and development and to set the objectives of the framework, which are:

- support LL problem owners in their objective-oriented strategic planning process;
- assist LL owners and practitioners to assess gains in the process of achieving long-term strategic objectives in a non-prescriptive, transparent, consistent, credible, stakeholder-based and easy-to-use way;
- help policy-makers and decision-makers overcome existing barriers and implement their strategic agendas towards a water-smart society in support of development priorities in a sustainable way; and
- enable benchmarking by providing a minimum set of metrics that can be used for comparisons in relation to set objectives, in time and with other LLs.

Using an integrated approach, proposed as an iterative six-step process, the framework aspires to constitute an assessment tool to be applied at the strategic level of decision-making to continuously improve the transition process to a water-smart society.

Furthermore, D6.1 outlines the key features of the B-WaterSmart framework and explains each of them based on both practical considerations provided by the LL owners through seminars, and lessons from other framework development trajectories. The following features are addressed:

1. High level architecture
2. Main users
3. Main functionalities
4. Frameworks’ structure size
5. Performance display & time frame
6. Frameworks' deployment

Additional information is provided in the ANNEX part which includes a glossary of the terminology applied, in order to ensure a common understanding and facilitate the process of co-creation of the Framework and its future use.

1 Introduction

1.1 Motivation, goals and structure of D6.1

The World Water Day 2021 drew attention to the different values that water holds in daily life, culture and in the connections with the environment and within communities.

Alongside the positive values that water has, there are also many critical issues: water is threatened by the growth in demand for agriculture and industry, by the worsening of the impacts of climate change, by the deterioration of infrastructures. How water is evaluated determines how water is managed and shared and if we neglect its value, we risk mismanaging this finite and irreplaceable resource.

The United Nations World Water Development Report 2021 "Valuing Water" (UN, 2021) highlights that "*the different values of water need to be reconciled, and the trade-offs between them resolved and incorporated into systematic and inclusive planning and decision-making processes*".

Understanding and assessing the value of water and incorporating it into decision-making are fundamental to achieving sustainable and equitable water resources management and the Sustainable Development Goals (SDGs) of the United Nations' 2030 Agenda for Sustainable Development.

The UN report groups current methodologies and approaches to the valuation of water into five interrelated perspectives: valuing water sources, in situ water resources and ecosystems; valuing water infrastructure for water storage, use, reuse or supply augmentation; valuing water services, mainly drinking water, sanitation and related human health aspects; valuing water as an input to production and socio-economic activity, such as food and agriculture, energy and industry, business and employment; and other sociocultural values of water, including recreational, cultural and spiritual attributes.

According to the UN report, the way forward is to develop common approaches, but also to prioritize improved approaches to compare, contrast and merge different values, and to incorporate fair and equitable conclusions into improved policy and planning.

In this direction, the B-WaterSmart project, and specifically through WP6, aims at providing an assessment framework to support multi-stakeholder and strategic decision-making towards the transition to a water-smart society that recognizes multiple values and facilitates the active participation of a varied set of actors.

However, the first step prior to the development of the framework is to define the concept of "being a water-smart society".

Water Europe has defined a long-term vision for a "European Water-Smart Society", where "the true value of water is recognised and realised, and where all available water sources are managed in such a way that water scarcity and the pollution of water are avoided, water and resource loops are largely closed to foster a circular economy and optimal resource efficiency, and the water system is made resilient against the impact of climate change events".

The definition comes with four key impact challenges:

- Reducing the impact of society on the natural water resources by 50%, through increases in efficiency and in alternative water sources

- Realising the true value of water for society, the economy, and the environment in order to increase the rational use and re-use of water

- Boosting the European water market and competitiveness of European water industries through ambitious investment and innovation programmes, as well as Living Lab experiments

- Securing the long-term resilience, stability, sustainability, and security of society with regards to water through the achievement of a circular water economy

However, what this is taken to mean and what it implies in practice remains to be seen. The concept of a water-smart society is rather new and has not been much elaborated in water governance research, nor among practitioners.

Therefore, to achieve the vision of being a water-smart society, in which the values of water are recognized and reconciled, requires a definition and the operationalization into an applicable water smartness assessment framework.

D6.1 serves two objectives: the first being to provide the project definition of being a "water-smart society" not yet present in literature and the other to outline the theoretical foundation of the water-smartness assessment framework.

In fulfilling these objectives, Section 2 highlights the features that should characterize a water-smart society providing a preliminary definition based on a comprehensive literature review of key concepts and frameworks related to sustainable water management, integrated water management, circular economy, smart cities, sociology of water, water governance, and sustainability transitions as sociotechnical system change. In order to ensure that the framework will be applicable for practitioners, feedback from the LLs on a preliminary definition is outlined in Section 3. Section 4 builds on the insights from literature and on the feedback from the practitioners to come up to the project's adopted definition. In Section 5 lessons are drawn from leading frameworks that are most related to the envisioned aims, scope and objectives of the B-WaterSmart framework. Section 6 delineates key design features of the framework and provides a preliminary overview of the theoretical foundation of the water-smartness assessment framework. Finally, Section 7 presents key conclusions and next steps.

1.2 Relevance of D6.1 within the B-WaterSmart project and the WP6 interaction with the other WPs

The work performed in Task 6.1, and in WP6 in general, is not isolated, but requires a close dialogue with WP2-5 and it has to be grounded in an active collaboration with the LLs to contribute to the "water-smart society" definition, to set requirements for the framework and to contribute to its creation through a well-structured plan of interactions along the project, as described in the B-WaterSmart description of work and graphically depicted in Figure 1.

D6.1 makes use of the preliminary LLs requirements for the framework provided through consultation of the problem-owners (facilitated by Task 1.5 as indicated by the arrow from Task 1.5 to Task 6.1 in Figure 1). D6.1 will feed Task 6.2 where the actual framework will be developed as a holistic and strategic framework that links qualitative and quantitative metrics to assess water-smartness, including technical (WP2), circular economy (WP4) and governance and social aspects (WP5). The inputs from WP2, 4 and 5 will be provided to Task 6.2 in the form of metrics by the same WPs by M15 (MS13). To support this exercise, D6.1 also includes guiding information to be used by WP2, 4 and 5 on how to select and define metrics that are relevant for the scope of application of the framework. This interaction between WP2, 4 and 5 and Task 6.2 is highlighted by the orange circle in the Figure 1.

At M19, Task 6.2 will provide Task 1.4 (red circle on the interaction between Task 6.1 and Task 1.4 in the figure below) with the preliminary version of the framework (Prototype V_0) (MS16) to be tested until M24; during M19-24, Task 6.2 will continue to develop the prototype in iteration with Task 1.4 and set the architectural requirements for Task 3.9, which after M30 will convert the assessment framework into a dashboard version (yellow circle in the figure above). Task 6.2 ends with the prototype version V_1, which will be refined in Task 6.3, as version V_2, and then converted into the dashboard by Task 3.9 (green circle in the figure below).

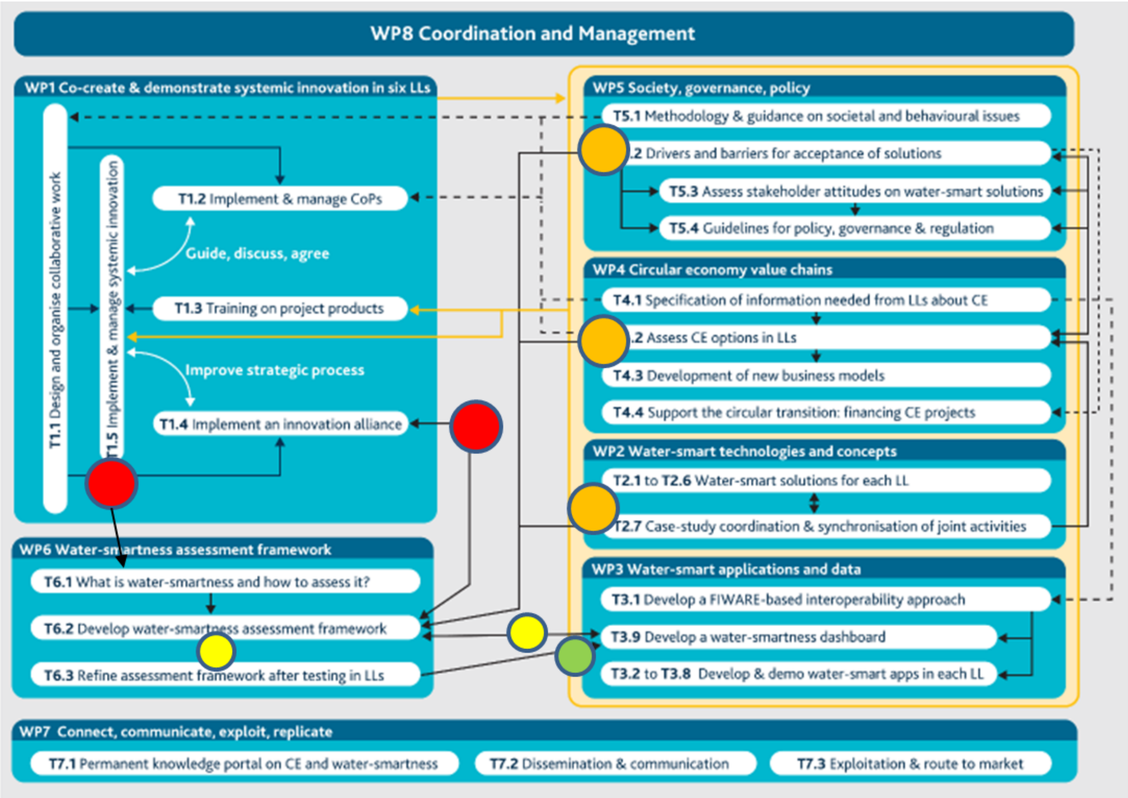


Figure 1: The relevance of D6.1 within B-WaterSmart and interaction of WP6 with the other WPs

2 Towards a definition of water-smart society

A consistent, pre-established definition of a water-smart society has not been found in the exploratory literature review carried out by the B-WaterSmart WP6 team, but the review allowed collecting relevant insights from previous research. A co-learning and development process with the B-WaterSmart LL owners was also conducted, to discuss preliminary understandings of the concept and identify the overarching strategic objectives the assessment framework must address. For both activities, a common working definition, provided by WP6, based on past research experience, and brainstorming within the research team was used as starting point:

"Societies and economies are water-smart when they succeed at generating value from and through water and to extract value from water in a context of circular economy. In a water-smart society, societal well-being and value through water is generated. In a water-smart economy, business around water is created. In a water-smart society and economy governance models centred on the water value boost the efficient, effective, and safe circular use of resources, while boosting economic activities around water and ensuring a sustainable service."

These initial formulations have since been revised, based on recent literature and the co-developed insights. This chapter presents the findings from the literature review, identifying aspects to consider and discussing how a definition could be tailored to help realise visions for more water-smart societies in the project LLs and beyond. Section 2.1. provides an overview of the studied literature and key insights therefrom. Section 2.2. is a brief discussion of how these insights could or should inform the definition of water-smart societies. The results and process of co-learning and development with the LL owners are presented in Chapter 3.

2.1 Perspectives from literature

The notion of 'water-smartness' and or 'water-smart' is often used with reference to both economy and society, *e.g.* the EU programme funding B-WaterSmart envisions *"a 'water-smart' economy and society in which all available water resources, including surface, groundwater, wastewater, and process water, are managed in such a way as to avoid water scarcity and pollution, increase resilience to climate change, appropriately manage water-related risks, and ensure that all valuable substances that could be obtained from wastewater treatment processes, or are embedded in used water streams, are recovered."* It is, however, important to be clear on which level is in focus. Economy is normally considered as one out of several social domains, relating more specifically to the production, use, and management of resources. Society refers, more broadly, to a group of individuals involved in persistent social interaction, or sharing the same territory, subject to the same political authority and dominant cultural expectations. This includes the connection between economy and other domains, such as politics, education, and values, attitudes, and practices in private life, *etc.*

The literature review focused on the notion of a water-smart society. It was carried out in Web of Science, and as noted exploratory, with the aim to shed more light on the perspectives and processes to consider in defining a water-smart society. Since research-based literature on water-smart society is virtually non-existing, several search strings were applied, as shown below:

Searches (November 2020)	Relevant titles	Relevant abstracts	Marked list
Water_smart_society	0	0	0
Water_smartness_society	1	0	0
Smart_city_water	812	324	41
Circular_society_water (2019-2020)	2296 (906)	159	+5
Water_sustainable_society (2019-2020)	3028 (782)	284	+26

Table 1: Overview of the search strings used to support the literature review.

To maintain an open, interdisciplinary perspective, specific journals were not selected, but rather limit the search to the last five years, and further down to 2019-2020, as indicated in the table above. Titles and abstracts considered less relevant were on very specific technologies, processes and/or methods, without addressing aspects or strategies relating (directly or indirectly) to water-smartness at a societal level. Many articles appeared in several of the searches, but the process ended with a total of 73, which was cut down to 35, again based on scope/extent to which they relate to water-smart society. Careful reading of this list confirmed the initial impression, that there has been little research on water-smart society as such. While some of the reviewed articles provide interesting perspectives and address central topics, others are less useful for the purposes. On this background, it was decided to also draw on more general insights from previous research relating to water and sustainable society (Figure 2).

Figure 2: Strands of research drawn upon for insights related to water-smart society.

As Figure 2 illustrates, there are several strands of research that shed light on different aspects and together may contribute to a fuller picture of a water-smart society than they do individually. Sustainable water management carries a more or less direct link with the SDGs, while integrated water resource management tends to focus on the coordinated development and management of water, land and related resources. The concept of circular economy is central, and the research on smart cities and water solutions draws attention to the potential and challenges associated with improved information and communication, often but not always and only linked with digitalization. Recent research on water governance increasingly takes a multi-level and multi-actor approach, with emphasis on learning and co-development.

2.1.1 Sustainable water management

Sustainability has become an established concept and amid its plethora of existing working definitions, there seems to be an unwritten agreement between practitioners and academia alike to use a set of common characteristics that define and are used to measure sustainability. These characteristics incorporate the three dimensions of sustainability: the environmental, the economic and the social dimension, and some specialists also include additional dimensions such as governance and asset management. These dimensions include several objectives *e.g*., conservation of the natural environment and reduction of the use of non-renewable resources, economic viability and value creation, intergenerational equity (social, geographical, and governance equity), and diversity, autonomy in communities, citizen well-being, and gratification of fundamental human needs. Such objectives are then translated into different criteria and indicators that enable the assessment of sustainability.

In our view, implementation of water-smartness in society should be oriented to sustainability, *i.e.* sustainability should be the ultimate goal for the society and being water-smart can provide better ways to achieve and/or to maintain sustainability. Sustainability is commonly associated with purposive change or transitions towards sustainability goals, linked to the above-mentioned dimensions. This may in some cases involve fundamental transformation processes, where not only technology but also societal structures are changed (Grin *et al.* 2010). At the same time, water-smartness must incorporate resilience, defined as *"the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks"* (Folke 2016), *e.g.* in the face of adverse developments, natural hazards or economic shocks against scenarios of change. The concept of resilience, as the framework of sustainability, has been included in policy rhetoric in water sectors during recent times. Both resilience and sustainability follow a similar trajectory in their rise of application and popularity among academia and practitioners. However, the relationship between resilience and sustainability has been a subject of criticisms. Although resilience and sustainability are undoubtedly highly interrelated concepts, it is considered important to note that in some cases the objectives of resilience may conflict with those of sustainability (Leigh and Lee 2019). One may encounter situations where interventions that aim to achieve resilience at one temporal or spatial scale may negatively impact or affect sustainability goals, *vice versa*. For example, rainwater harvesting is an appealing sustainability practice, but is vulnerable to droughts. It is therefore important to envisage that all potential resilience-based interventions and actions must also be viewed in the context of sustainability (Lawson *et al.* 2020).

As a point of departure, the sustainable water management concept developed in FP7 TRUST project (TRansition to sustainable Urban Systems of Tomorrow) that focuses on opportunities for strategic long-term transitions towards sustainability in urban water services will be applied and further evolved in B-WaterSmart. TRUST provides a holistic perspective with a focus on measuring water cycle services performance according to the five dimensions (*i.e*., social, environmental, economic, governance and asset management). However, there is less emphasis on system interactions and the interplay between UWCS and other sectors and urban services.

According to Brattebø *et al*. (2013), “Sustainability in urban water cycle services (UWCS) is met when the quality of assets and governance of the systems is sufficient to actively secure the water sector’s necessary contributions to social, environmental and economic sustainability in the urban system as a whole”. In Alegre (2012) the needed contributions are linked to urban social, environmental, and economic development, in "a way that meets the needs of the present without compromising the ability of future generations to meet their own needs" thus replicating the Brundtland Commission. Sustainability assessment of UWCS should be transparent, valid, and holistic, and must include the dimensions of social, environmental, economic, asset and governance sustainability.

The socio-ecological systems (SES) concept has become increasingly important in sustainability science (Folke, 2006, Ostrom, 2009). This concept is used to describe, analyse, and model human-nature relationships, in terms of resource systems and -units, governance systems and actors, and how their focal interactions, such as chosen water management solutions, influence the overall resilience or robustness of the system. Some studies aim to link SES and the concept of Ecosystem Services (ESS) (Maes *et al*. 2013, Bouwma *et al*. 2017)). Such a perspective enables more holistic evaluation of the economic, environmental, and social impacts resulting from new interventions. It has amongst other been applied in the DESSIN project, which developed an ESS evaluation framework to enable sustainable innovation in urban water management, also including a multi-criteria component based on TRUST (Anzaldua *et al*., 2018). While SES and ESS approaches may be challenging in terms of complexity and data requirements, they bring wider system interactions into the perspective on sustainability. As noted by Liehr *et al*. (2017), the various types of services within the ESS concept may also interlink critical areas of human-nature interactions, such as water, food and energy.

At the same time, it has been noted that a so-called "indicator approach" is associated with a tendency to present sustainability as a codified 'entity' (Hallin *et al*. 2020). Hallin *et al*. (2020) argue that more attention should be paid to how sustainability is performed, situated in a particular space and time context, and expressive of specific values and perspectives. This underscores the need to consider the strategic objectives and sustainability perspectives in the given case or city context, and to address the process as well as measured distance and progress towards predefined sustainable development goals. The importance of considering the overarching SDGs as well as local perspectives and sustainability objectives is also highlighted in an integrated assessment framework for sustainable water management which has been developed by Helness *et al*. (2017) and adapted for use in different local contexts.

2.1.2 Integrated water resource management

Uncertainties arising from climate and environmental crisis in cities require new approaches towards efficient and resilient management of the urban water cycle. These must respond to challenges resulting from the combination of population growth and aged water infrastructures, shifts in social priorities and public policies, a new demand on governance and emerging technologies, including natural systems, information technology (IT), and small-scale modular units. Adapting to these dynamic settings implies the need for an integrated and integrative perspective. This is amongst other highlighted in the new Adaptation Strategy from the European Union, which acknowledges that sustainable water management requires closer cooperation between adaptation action and water management authorities, and transformational changes across all sectors (European Commission, 2021).

The water-sensitive city provides a unifying vision of urban water management processes and interactions. This concept integrates political decisions, social and institutional investment, technological advances, and individual attitudes and responsibilities. Beyond just seeking to meet the city's water demand, a transition strategy towards a water-sensitive city offers multiple benefits. These range from economic prosperity, with the efficient use of different water sources, to increased resilience to climate change impacts that ultimately promotes the city's environmental health and inhabitants' well-being (Rodrigues and Antunes, 2021).

Urban water cycle management approaches should not only emphasise sustainable water use, but also protect the environment and enhance biodiversity. The water sensitive urban design approach describes the process that promotes a greater sensitivity to water in the urban water cycle as an alternative to traditional water management approaches (Artioli *et al.*, 2017). By promoting harmony between natural and urban processes, it seeks to restore the natural water cycle in the urban context, give access to different water sources, protect water bodies, and reduce the risks associated with extreme weather events. Water is recognised as an essential asset that must be valued and integrated not only into the urban scale but also at the watershed landscape scale.

This integrated approach is also valid when upscaling to the global level. Instead of focusing only on Objective 6 (Ensure availability and sustainable management of water and sanitation for all), it is necessary to take into account other SDGs such as those for ending poverty, providing clean and affordable energy, achieving gender equality, protecting terrestrial ecosystems, promoting sustainable cities, combatting hunger and climate change, and strengthening the Global Partnership for Sustainable Development. (Benson *et al*., 2020)

The water-energy-food nexus has achieved prominence as one the possible frameworks to assess this integrated model to investigate urban complexity. The nexus sets an imperative for integrated management and policymaking, centring on the potential trade-offs and complementarities between interdependent water, energy, and food systems (MacGrane *et al*.,2019). Its operationalisation seeks to integrate across systems through technological and institutional change (Artioli *et al*., 2017). In this respect water-smartness implies a significant shift of public policies configurations on matters such as the water supply, food security and energy efficiency to city dwellers and users. On the one hand, cities are sites of water, food and energy distribution, consumption and to a lesser extent, production, and reuse.

Taking this nexus narrative seriously also means that water-smartness implies a broader perspective where new flows of capital and other economic drivers need to be defined concerning the location of farming, industrial areas, water sources and power stations, according to new patterns of spatial planning and development. For instance, short supply chains must be strengthened to align with principles of circular economy, environmental health and human wellbeing. It is also important to link natural, social, economic, and environmental systems to assure that resources and services are managed according to principles of human dignity and human equality (MacGrane *et al*.,2019).

Adopting the water-energy-food nexus implies the capacity of identifying clear interlinks between water and land-use functionalities mostly explicit through the spatial planning policy design. At the same time, water, land and energy are crucial resources that should be at the forefront of the transition to circularity and further efforts should be made to ensure their embeddedness. As it often requires a fit-for-purpose approach, this transition requires policymaking and governance solutions to better relate the synergies between urban and rural borders in terms of administrative jurisdiction assumed by new actors, new responsibilities, and new environmental and health risks. Water resources are not circumscribed to the area where they are consumed. They spread across territories, through river basin hydrographic networks and ecosystems, including rivers, lakes, water reservoirs, and aquifers. Water ecosystem services associated with the hydrological cycle, and affected by the climate, land cover and management should be considered part of the circular economy concept with an integrated view across the entire water cycle (Fidelis *et al.,* 2021).

2.1.3 Circular economy and society

Transformation towards a circular economy (CE) has become an important issue in environmental management and it is crucial in the European Green Deal. In general terms, CE can be defined as "*a system where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste is minimised."* (EC, 2015). The New Circular Economy Action Plan emphasizes that this requires radical rethinking and exploring new ways of ensuring long-term wellbeing for all, where cities, as engines for economic development, can drive the agenda forward (Eurocities 2020). Moreover, the EU taxonomy for sustainable activities that was officially launched in June 2020, emphasizing "*The transition to a circular economy*" as one of six environmental objectives towards 2030 (EU 2020).

The influential Water and Circular Economy white paper by the Ellen MacArthur Foundation emphasizes the need to optimize design of waste externalities, resource yields and resource extraction from the water system, while maximizing regeneration of natural capital by reducing consumption and non-consuming use of water (EMF 2018). Some methods to prevent waste are already applied, summarized as the so-called 2Rs: reduction — prevent wastewater generation in the first place by the reduction of water usage and pollution reduction at source and reuse — reuse of wastewater as an alternative source of water supply; 3Rs: including recovery or reclamation of water from wastewater for potable or non-potable usage; and 4Rs: adding recovery of resources as nutrients and energy from water-based waste (Smol *et al*., 2020). However, to really transform the sector from a linear to a CE model, there is the need for more profound changes, in terms of a) integrated urban resource management, connecting to stakeholders beyond traditional boundaries (urban and basin), b) leadership innovation, and c) new business models, creating connections and synergies within the water cycle and across to other sectors (IWA, 2016). On this basis, amongst other, Smol *et al.* (2020) propose a new CE framework for the water and wastewater sector, supplementing the 4Rs with two additional strategies: *reclamation (removal)*—focused on highly effective removal of pollutants, and *rethink*— seen as the basis for introducing systematic changes in the whole value chain surrounding water and water-based resources.

At the same time, a more definite conceptualization of CE is called for, especially concerning its relation and contribution to sustainable development (SD) (Kirchherr *et al.*, 2017). Geissdorfer *et al.* (2017), found three main conceptualisations of the relation; as either a) conditional (CE is a condition for SD), b) beneficial (CE benefits SD), or c) as a trade-off (CE comes with costs and benefits regarding SD). Millar *et al.* (2019) note how CE shall promote economic growth while both protecting the environment and ensuring social equity remains unclear.

According to Kalmykova *et al.* (2018) CE is rather more focused on eco-efficiency than on eco-effectiveness, while amongst other Korhonen *et al.* (2018a) highlight limitations for environmental sustainability in CE, including lock-in and rebound effects. Schöggl *et al.* (2020) argue that both concerning the beginning and end-of-life phase, CE is still dominated by a corporate perspective, whereas higher value retention options involving consumers and citizens need more attention. They also call for reflection upon tools or models that are needed to promote circular transitions and sustainability outcomes, and how barriers to upscaling may be handled. These challenges are also highlighted by stakeholders in the water and wastewater sector. Laitinen *et al.* (2020), found that Finnish stakeholders saw issues such as leakage and fee reductions as less significant, but rather emphasized the need for capacity building, sufficient legislation, digitalisation, and new business models.

Paiho *et al.* (2020), emphasize that city-level actions are essential to encourage businesses and consumers to adopt circular modes of thinking and doing, as stated in the Urban Agenda for the EU (2018). Based upon an extensive literature review as well as dedicated stakeholder workshops, they define a circular city as*, "...based on closing, slowing and narrowing the resource loops as far as possible after the potential for conservation, efficiency improvements, resource sharing, servitization and virtualization has been exhausted, with remaining needs for fresh material and energy being covered as far as possible based on local production using renewable natural resources"* (Paiho *et al*., 2020). The consulted stakeholders also emphasized that the circular city must be inclusive for its citizens, self-sufficient to an optimal local level, and responsible in its actions.

According to Paiho *et al*. (2020), key enablers of CE in cities can be categorized as follows:

Business: • Using circular criteria in public procurement • Facilitating spaces and funding for innovation • Identifying external sources of funding • Data economy	Policy: • Developing a long-term, holistic vision • Recognizing barriers to circularity and addressing them • Involving non-municipal stakeholders and encouraging collaboration between them • Promoting coordination across municipal departments • Networking and lobbying with other cities
Technical: • Applying circular principles in urban planning • Supporting ICT solutions	Knowledge: • Analyzing the local conditions as a basis for strategy development • Monitoring and evaluating circular projects continuously. • Educating stakeholders about CE

Based on the three generic CE business models of closing, slowing and narrowing loops, Paiho *et al.* (2020) outline four scenarios for circular city development:

- Circular city as a collective action
- Circular city build on city offering (municipality providing infrastructure, organizing)
- Circular city as a part of international networks
- Circular city as a place for local competing services

These imply different roles for different stakeholders (*e.g.* municipality as mainly enabler, provider or user). According to those consulted, the indicators for circular city should give an inclusive and holistic view of the status of circularity, taking into account sustainability, responsibility and in overall the attitude “towards zero”. Finally, the authors note that although lack of data may pose a challenge, there are benefits to be gained from harmonizing goal setting and indicators on a scientific basis (Paiho *et al.*, 2020).

Williams (2019) suggests that not only looping, but also regenerating and adapting are fundamental to the delivery of the circular processes in cities. Regeneration refers to preservation of natural capital and essential ecosystem services, *e.g.,* through incorporation of green and blue infrastructure. Adaptation involves planning and design to enable the adaptation and renewal of existing infrastructure with minimal resource wastage, *e.g.,* through flexible, modular systems and meanwhile spaces. Four further supporting actions – optimisation, sharing, substitution and localisation – can be used to reinforce these circular actions. The latter is especially important, to reduce and localise impacts and encourage pro-environmental behaviour (Williams, 2019).

2.1.4 Smart cities and water-smartness

The smart city concept contains the notion of cities testing and implementing innovative, sustainable and integrated solutions to become greener, more efficient and better places (EUROCITY, Smart cities & digital transformation – Eurocities). It is a multifaceted construct, far from having a consensual definition. Perspectives can be quite comprehensive or narrower. However, a 'smart city' is often seen to use digital technologies to engage more effectively and actively with its citizens, enhance the city performance and wellbeing of the citizens, reduce operational costs and the city resource consumption, generate new business opportunities and increase the attractiveness of the city (https://www.etsi.org/technologies/smart-cities). Hence, digital transformation plays a key role in many definitions.

However, the common association with technologic aspects is also viewed as limiting by many opting for the inclusion of multiple elements to characterise the smart city. Ramaprasad *et al.* (2017), emphasizes the concept as multidimensional, embodying desirable outcomes including sustainability, quality of live, equity, liveability and resilience and involving multiple stakeholders namely citizens, professionals, communities, institutions, businesses, and governments. These authors consider the concept of smart city as a combination of elements of complementary classes (see Figure 3) and water can be represented in all components of this definition.

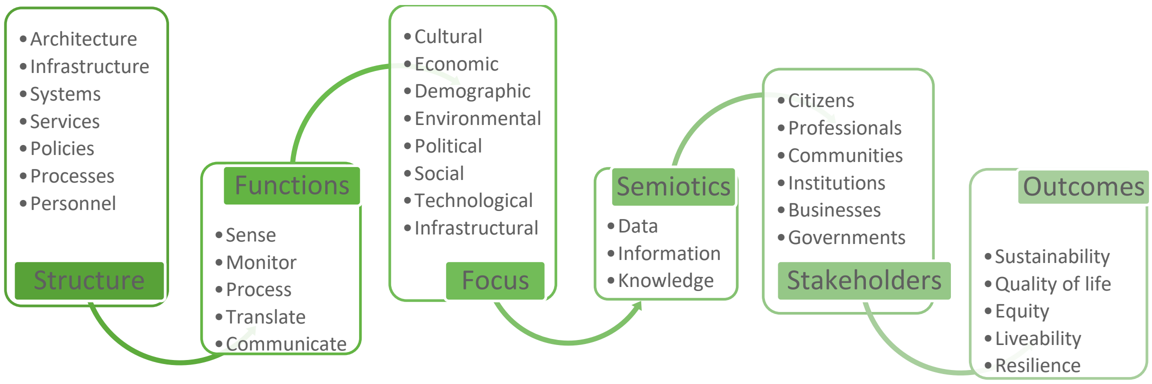


Figure 3: Definition of smart city by Ramaprasad *et al.* (2017)

This comprehensive approach is in alignment with Meijer and Bolívar (2016) who concluded, from an investigation in academic publications, about the need for smart cities to embody the dimensions of i) smartness (smart technology, smart people, or smart collaborations) together with ii) a transformative or incremental perspective on changes in urban governance and iii) better outcomes or a more open process as the legitimacy claim for smart city governance. Other authors follow this comprehensive view, such as Dameri (2013), that proposes a smart city as "a well-defined geographical area, in which (…) technologies (…), cooperate to create benefits for citizens in terms of well-being, inclusion and participation, environmental quality, intelligent development; it is governed by a well-defined pool of subjects, able to state the rules and policy for the city government and development".

Buck and While (2015) explore the "opportunities and tensions" in the practical side of transforming this imaginary in a reality, in a discussion where water has a relatively low rank in the key strategic themes for city smartness, with an *"overestimation of the transformative power of technology and underestimation of the importance of the 'soft' human infrastructures underpinning urban decision-making and governance".* A bias towards technology is also found by Ahvenniemi *et al* (2017), who recommend a stronger emphasis on ultimate goals such as environment, economy or social sustainability in frameworks aiming at evaluating city smartness. Anthopoulos (2017) investigated 10 cities around the world and conclude about the risk of a narrow view of the 'smart reality' consisting of a "wedding" of vendors and local governments as the main drive while not addressing the real community problems. Technology is another important set of assets to enable cities to build smartness together with other dimensions of smart cities that should contain a set of features to be considered smart such as the existence of a corresponding, agenda, strategic or master plan that defines the smart city vision and mission (Anthopoulos, 2017).

Wilson (2019) highlights the potential connection between smart solutions, multi-sector governance and citizen involvement. Smart cities may be perceived as the original platform economies that can now (with the foundation blocks of ICT, connectivity and data) benefit from copying models used by digital platform businesses to bring actors together in new ways (Wilson, 2019). However, when smart cities become too smart, it might lead to public choice constraints, *i.e.,* no alternatives to smart solutions. Other problems include security issues due to cyber-attacks on critical infrastructures and problems with deployment (Singh *et al.,* 2020), as well as issues with data availability, enabling policy and cost of investment (Cleevly 2020).

Discrepancies between smart and sustainable cities are described by Bibri *et al* (2017) together with existing gaps in the research within the field of smart sustainable cities, recognising the way technology plays an essential role to foster sustainable, equitable, liveable, resilient cities providing quality of live to citizens. The two main streams of approaches to smart city, technology, and ICT–oriented and people–oriented approaches need to converge into a common approach.

Water, or more specifically, the water cycle, is part of the urban concept and functions in many ways, and a basic element of liveability and quality of life. However, Ahvenniemi *et al* (2017) found that generally, water management has little consideration in smart city frameworks while has more weight in sustainability frameworks. 'Bristol is open' is one example of smart city project including the water sector, demonstrating the potential to use digitalisation to improve water quality monitoring through real-time high-frequency water quality data (Chen and Han, 2018). During the project, IoT was used to collect multi-parameter water quality monitoring data of the Bristol Floating Harbour and display it online. This formed part of the world's first city- scale demonstration of a programmable city using software defined networking to connect different facets of the city (Wilson, 2019). Big data science and analytics may also promote a paradigm shift (Bibri 2019). Bibri (2019) introduces the concept of smart sustainable / sustainable smart urbanism, which may benefit from the use of big data science and analytics. With the help of advanced analytics, data gaps, *e.g.,* in energy consumption, may be closed, and big data and advanced analytics may be used as a tool to predict irrigation water demand.

Furthermore, Widener *et al.* (2017) suggest that digitizing information to understand and visualise the linkages between drivers of innovativeness, the state of water infrastructure and regional planning contexts can help to spatialize data and thus showcase water governance and sustainability in place specific contexts and contribute to efficient policies (Widener *et al.,* 2017).

A comprehensive understanding of the smart city integrates the water cycle intrinsically and explicitly, as a resource, as potentiator of quality of life and as a potential risk source that needs to be managed (Ahvenniemi *et al.* 2017, Allam and Newman, 2018; Anthopoulos, 2017; Bibri *et al* 2017; Buck and While, 2017; Colding, 2017, among others). Water-smartness needs to be aligned with the comprehensive smart city concept and water management needs to foster multisector approaches to gain visibility to other city stakeholders thus raising opportunities for common actions with common benefits.

2.1.5 Sociology of water and "sociohydrology"

Several articles emphasizing social aspects were brought up in the literature search. While these apply to different analytical frameworks and address different contexts and scales, many of them may be grouped as contributions on social interactions in water management.

Watson (2017, 2019) examines smart water projects in the UK that demonstrate a shifting of responsibility of water management from the state and water companies to individual households through smart meters, timers and other devices that monitor and reduce consumption. She highlights the need for such projects to attend to factors of gender, religious affiliation, age, immigrant background and social class, as different social groups harbour differing moral and social attitudes to water. Smart water meters are differently effective in challenging existing habits, also since they disrupt private-public boundaries and meanings of the home. At a different level, water in cities may connect people, *e.g.,* by assembling us for relaxation, work, and exercise, but also constitute multiple differences which are themselves not fixed but shift and change across time and place. Watson's work underscores that 'smartness' must consider culture and social dynamics, citizen perceptions and practices, not only when it comes to governance but also when designing and implementing specific water management solutions.

Olsson *et al*. (2020), highlight the importance of environmental justice. In a study on urban nature-based solutions in Sweden, they show how distributive (*e.g.,* in terms of access to ecosystem services), recognition (*e.g.,* public *perception* of the distributed access to the services) as well as procedural (*e.g.,* perceived possibility to influence its distribution) justice are closely interwoven and interacting with other issues of concern for local stakeholders. They argue that broad stakeholder involvement, as well as recognition of existing built-in power structures, are keys to sustainable urban development.

Ramirez *et al.* (2020), from a science, technology and innovation system (STI) perspective, underscore the need to involve social movements, which can bring changing priorities and agendas to the surface. Citizen science alliances can be fruitful not only for consultation and/or field assistance, but as a source of action learning, where *"knowledge production evolves in a dynamic tension between new meanings, changing events, practices and materialities"* (Ramirez *et al.,* 2020). Sañudo-Fontaneda and Robina-Ramírez (2019), writing on Sustainable Drainage Systems (SuDS) emphasize the three pillars of urban water-sensitive design: cities as water supply catchments, cities providing ecosystem services and cities comprising water sensitive communities. They found that SuDS designed with community self-organisation based on the UNESCO (2011) water-related ethics principles (human dignity and the right to water, equity, vicinity, frugality, transaction, multiple and beneficial use of water, mandatory application of water quality and quantity measures, compensation and user pays, polluter pays, participation, and equitable and reasonable utilization) helped communities discover and explore further options to look after the environment, beyond merely complying with requirements.

In recent years, there have also been efforts to launch "sociohydrology" as a system perspective on human-water interactions with a focus on the specifics of the hydrologic cycle in space and time, including the role of water infrastructure (Di Baldassare *et al.,* 2019). It posits to bridge the gap between the SDGs and integrated water resources management, with a holistic approach that considers both short-term and long-term consequences of shifts in water governance. Different types of feedback mechanisms are defined to shed light on intended and unintended impacts of water management decisions on a wider set of sustainability objectives (Di Baldassare *et al*., 2019). One example is supply-demand cycles, *e.g.,* as in the case where a new dam, managed aquifer recharge or other technology is applied for adaptation to increasing water scarcity and may appear quite sustainable in itself but enable continuation of farming practices that will be unsustainable in the longer run, due to long-term impacts of climate change. In a system perspective it might be more sustainable (both environmentally, economically and socially) to change to a different type of farming or land use right away. Another example is so-called rebound effects, or unintended consequences from the push toward technological solutions without consideration of broader sociocultural behaviours and their consequences. On the background of such mechanisms, a "sociohydrology" perspective would imply that water-smartness should include consideration of temporal dynamics, spatial processes, and so-called legacy risks, or the expected cost of decisions made today carried over a very long-time frame.

While some of the studies mentioned in this section deal with perceptions and processes at community level and "sociohydrology" emphasizes broader and long-term impacts, all underscore the need to consider social dynamics and pre-existing practices in water-smartness, to maximise co-benefits and learning effects and minimise the risk of unforeseen negative impacts of smart water solutions.

2.1.6 Recent perspectives on water governance

Water governance can be defined as "*the range of political, institutional and administrative rules, practices and processes (formal and informal) through which decisions are taken and implemented, stakeholders can articulate their interests and have their concerns considered, and decision makers are held accountable for water management*" (OECD 2011. It is also seen as a *"[…] social function that regulates development and management of water resources and provisions of water services at different levels of society and guides the resource towards a desirable state and away from an undesirable state" (Pahl-Wostl 2015).* This includes both state and non-state actors and provides a perspective that goes way beyond the functional exercise of water management. As noted by Jimenez *et al.* (2020), this and other 'new governance' models tend to shift towards a society-centric, multilevel, collaborative and more market-based view. They also draw attention to how resilience scholars define adaptive governance, as the ability to evolve, adapt or transform in a situation of change, through a range of interaction and actions that occurs between different actors in a social-ecological system (Chaffin *et al.* 2014).

The concept of water wisdom builds on existing governance paradigms such as adaptive governance, anticipatory governance, and resilience. The IWA's principles of water-wise cities consists of four levels of action: i. regenerative water services which is focused on circular water systems, ii. water sensitive urban design focused on water as nature-based solution in cities, iii. basin connected cities which entails that urban development accounts for its environmental conditions such as avoiding urban development in a flood plain, and iv. water sensitive communities which emphasize the importance of human capital for achieving water wisdom. These action levels are to be achieved through five building blocks, vision, governance, knowledge and capacity, planning tools and implementation tools (IWA 2021).

Beyond conceptual water-wise actions and building blocks, Koop (2019) provided an empirical understanding of what water-wisdom may entail, which steps cities across the globe may take to achieve water-wisdom and which governance conditions account for water-wise management.

Through the assessment of 24 water-related indicators (covering basic water services, water quality, wastewater treatment, water infrastructure, solid waste, climate adaptation and plans and action) and a hierarchical clustering of 125 city assessments, an empirically based classification of urban transformation levels towards water-wise management was developed. The classification ranges from cities lacking basic water services, to wasteful, water efficient, resource efficient and adaptive, and ultimately, water-wise cities (Koop and van Leeuwen 2015b).

Water-wise city was defined as a city having a maximum score for all the 24 indicators, as depicted below (Figure 4).

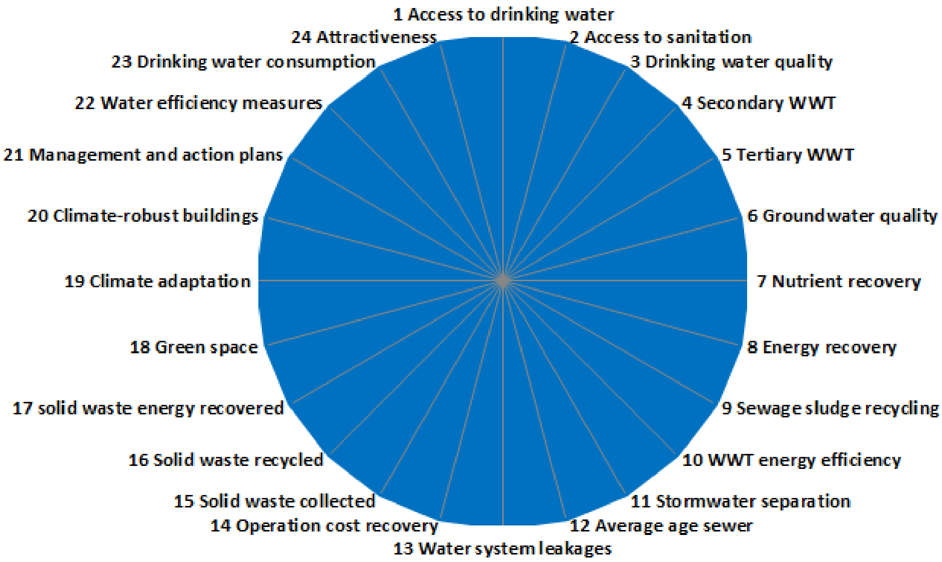


Figure 4: City Blueprint assessment of integrated water management. The message is the bluer, the better. A city with maximum scores for all the indicators – being entirely blue – is defined as being water-wise. Of the 125 cities assessed, no city has yet achieved water-wisdom.

Of the cities assessed, no city was able to achieve water wisdom. However, by combining the best scores of these cities, you may get a water-wise city. What no single city has achieved so far can thus be achieved by city-to-city learning, exchange of existing policies, experiences, and practices.

In this perspective, water wisdom is closely linked with governance capacity (Koop *et al*. 2017; Section 5.2.6). Governance capacity includes institutional capacity, defined in terms of how institutional setting, rules, and regulations enable actors to collaborate and address common problems (UNDP 2008), as well as resources and discourses (*e.g.* Engle and Lemos 2010; Pahl-Wostl 2009). Governance capacity is therefore intrinsically context dependent. Koop *et al*. 2017 take the position that governance capacity is about enabling effective change. The kind of change that is needed depends on the context. For instance, integration is required if scopes are fragmented, adaptive capacity is needed to address inflexibility, and anticipatory approaches are called for when responses are reactive (Segrave *et al*. 2016). Nevertheless, a few commonalities regarding governance capacity can be identified. Governance capacity is:

- the ability of actors to identify and jointly act on shared problems (Dang *et al.* 2016).
- determined by actors' interactions formed by social-institutional settings and allocation of resources (Pahl-Wostl 2009).
- Shaped by actors' frame of reference that includes stakeholder's interests, values, and culture. Actors' frame of reference in turn shapes interactions and influence collective problem-solving (Adger *et al.* 2009).

Because the nature of actors' interactions often tends to be complex, unpredictable, and susceptible to external developments, governance capacity in itself does not guarantee efficacious change. It rather can be considered as a precondition or enabler for effective change. Koop *et al*. (2019) found that cities with high water management performance i) tend to be well prepared for both gradual and sudden events through the existence of policy and action plans, ii) allocation of resources and responsibilities is clear and enables iii) a high statutory compliance with policy and management ambitions. In addition, smart monitoring ensures that compliance gaps are identified and can be addressed through a continuous evaluation and optimal use of policy instruments. Hence, the interaction between implementing capacity and the ability of local authorities to continuously monitor, evaluate and learn seems to be essential for high water management performance.

2.1.7 Sociotechnical research on sustainability transitions

Socio-technical research on sustainability transitions, grounded in evolutionary economics, geography, sociology and innovation studies, argue that the large-scale sustainability challenges related to water and other critical resources require radical changes in production and consumption patterns (Köhler *et al*. 2019). The complex interactions between technology, power, politics, markets, institutions *etc.* must be better understood, and the underlying dynamics of structural change have to be addressed (Geels 2011). Most studies in this field consider transitions as multi-directional processes spanning across three levels 1) niches, which are the locus for radical innovations; 2) socio-technical regimes, consisting of the institutions, practices and technologies maintaining existing systems; and 3) exogenous societal developments. "Lock-in mechanisms" linked to existing systems are associated with path-dependency favouring incremental change (Klitkou *et al*. 2015). For example, Fuenfschilling and Truffer (2016) show how different institutional logics (a traditional hydraulic perspective versus a more market-oriented and a water sensitive logic) compete in the water sector. In a case study from Australia, they found that desalinization technologies gained an upper hand against recycling in response to drought, being framed as a better fit with the existing regime, still dominated by the hydraulic logic and related system values, such as safety and quality in water supply.

How to work around such mechanisms and facilitate radical innovation is a crucial question. *Strategic Niche Management* is promoted as an approach to a) articulate the needed changes in technological and institutional framework conditions, b) learn about the feasibility and gains of radical technologies, c) stimulate further technological development, and d) build network of actors committed to the transition (Schot and Geels 2008). In line with Koop (2017) this perspective suggests that enabling effective change may be an important element of water-smart societies but draws particular attention to the role city authorities and water utilities can take as facilitators and actors in innovation. Furthermore, the importance of *Technological Innovation Systems (TIS),* and their interaction with broader context systems (Bergek *et al*., 2015) and technology dynamics (for example biogas from wastewater as both complementary and competing with other alternative fuels) is highlighted (Magnusson and Berggren, 2018).

Finally, *Transition Management (TM)* is promoted as a distinct governance approach, with four steps (Loorbach, 2010): 1) vision development and identification of potential transition pathways, 2) tactical activities to develop more specific plans for concrete routes, 3) operational activities, including innovation, demonstration, and implementation of new solutions, 4) reflexive activities, including project evaluations and monitoring of progress). The EU project SWITCH provided a TM framework for urban water cycle services (Jefferies and Duffy 2011) (Figure 5).

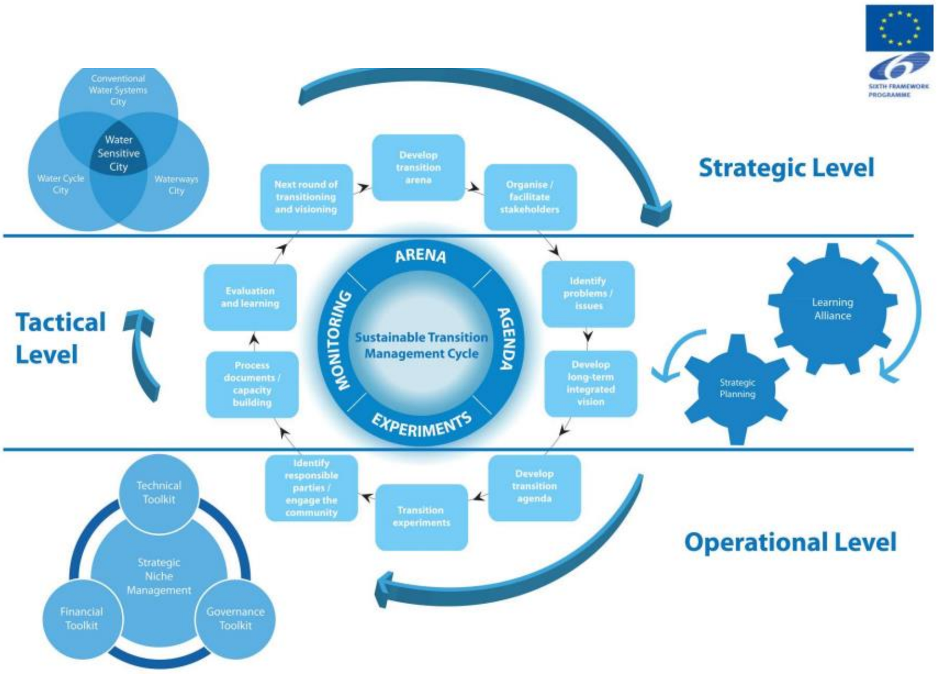


Figure 5. SWITCH Transition Framework (Jefferies and Duffy 2011)

The framework highlights the need for facilitation and development at multiple levels, including long-term visioning and city-to-city learning at strategic level, capacity building and experiments at tactical level, and active engagement with niches for radical innovations at operational level.

Key features of TM may be listed as follows (Pisano, 2014):

- system-thinking, considering multi-sector, multi-actor and multi-level interactions
- long-term thinking (at least 25 years) as a framework for shaping short-term policy
- back-casting and forecasting: setting goals based on long-term sustainability visions, scenario studies, trend analysis and short-term possibilities
- focus on learning (*i.e.,* learning-by-doing, doing-by-learning, through experiments)
- an orientation towards system innovation and experimentation;

- learning about a variety of options;
- participation by and interaction with stakeholders

Following this line of thinking, water-smartness may be considered as an adverb, relating to strategic orientation and effort, as much as a characteristic or quality of a society or utility. This would imply that progress in terms of adaptability, flexibility, ability to include multiple perspectives and facilitate change, should be considered in an assessment framework.

2.2 Towards a definition of water-smart society

The literature review, presented in Section 2.1, was conducted to identify the aspects that should characterize a water-smart society and therefore help derive a definition of "water-smart society" to be adopted in the B-WaterSmart project.

In the following, key elements emerging from the scientific community are summarized per topic addressed. At the end of this chapter a suggestion of definition capturing the most relevant listed features is proposed. The literature-based definition will then be compared with the one created in collaboration with the LL owners to finally come up with the project adopted definition, presented in Chapter 4.

The studied literature provides valuable insights on objectives, aspects and activities relating to water smartness and the emerging notion of a water-smart society. However, not all of these may necessarily be covered in a formal definition or considered in a user-friendly assessment framework for strategic planning purposes.

In the literature on sustainable water management, the broadly accepted integrated approach to sustainability, including social and economic, as well as environmental aspects, is well established. Moreover, TRUST highlights the importance of asset management and governance, at the interface between the social, economic and environmental dimensions. More recently, perspectives combining SES and ESS draw attention to wider system interactions that may result from specific water management measures, especially through their ecological impacts. An approach applied by Helness *et al.* (2017), amongst other building on TRUST, relates sustainability directly to the global SDGs, while emphasizing the need to link them to context-specific development objectives. A more recent perspective from the sustainability literature warns against 'entification' and suggests sustainability is performative, thus a moving and not steady target.

From the literature on IWRM and the WEF-nexus, insights are gained into the interaction and need to coordinate water management across different levels and scales, and also, increasingly, across sectors. Synergies, trade-offs and co-benefits must be considered and optimised in a water-smart society.

The concept of CE brings a focus on strategies to close, slow down and narrow resource loops. While material flows within and between corporations have been most in focus, recent work on circular cities draws more attention to the value retention to be gained from more customer and citizen involvement. It argues that regeneration, localization and adaptation of existing infrastructure are crucial elements, and emphasizes the need for institutional change and new business models.

Smart cities are also increasingly considered as a multidimensional concept, embodying desirable outcomes including sustainability, quality of life, equity, liveability and resilience and involving multiple stakeholders. Still, two of the main topics considered are how digital technologies can enable system integration and stakeholder involvement in new ways, and how improved information and communication management can increase knowledge and wisdom, considered as ability to make projections, scenarios, and 'prescriptions' based on critical judgement.

The articles on sociology of water and 'sociohydrology' that came up in the search suggest that a water-smart society must be sensitive to human-water interactions, both as to how social perceptions, practices, norms and values influence the impact and ability of different water management measures, how social movements may be engaged for action learning and how long-term feedback mechanisms between water resource systems and human production and consumption patterns may be associated with wider risks and un-anticipated developments.

Recent work on water governance, highlight a shift towards a society-centric, multilevel, collaborative and market-based view, with more focus on knowledge development, learning and flexible intermittent targets to anticipate changing situations. The latter is in line with the emphasis in socio-technical transition studies, which draw attention to the need for institutional as well as technological change to facilitate sustainability transitions. In light of the path-dependency associated with established systems, efforts to nurture innovation niches, experimentation, and technological variation may be crucial in a water-smart society. Likewise, long-term thinking, involving multiple actors and perspectives are considered important.

The key insights extracted from the literature are summarised below (Table 2).

Table 2: Key topics to consider for defining water-smart society.

Strands of literature	**Key topics guiding the water-smart society definition**
Sustainable water management	Environmental, economic and social sustainability, with governance and asset management as distinct dimensions
	Socio-ecological interactions, ESS
	SDGs and local development objectives
	Sustainability as performative vs. coded entity
IWRM and FWE	Coordination across levels and scales
	Multi-sector interactions
	Synergies and trade-offs
Circular Economy	Closing, slowing and narrowing loops
	Regeneration
	Localisation
	Adaptation of existing infrastructure

Smart cities	Use of smart technologies
	System integration
	Involving multiple stakeholders, citizens
	Data for knowledge development
Sociology of water and 'sociohydrology'	Sensitive to human-water interactions
	Social perceptions, practices, norms, values
	Engage with social movements, action learning
	Societal feedback mechanisms
Water governance	Towards a more collaborative and market-based view
	Learning and knowledge development
	Capacity-building
	Anticipate change
Transition studies	Multi-level and multi-actor governance
	Be aware of and address lock-ins
	Nurture niches, experimentation, variation
	Long-term thinking, flexibility

The table may not do justice to the respective strands of literature. The distinctions between them are not clean-cut. There are overlaps between the issues highlighted, and each field of research does of course contribute with broader and more detailed insights than shown here. However, the table provides an overview of aspects to consider, for defining a water-smart society.

With these aspects in mind, the initial working definition may be adjusted as follows:

A water-smart society is generating societal well-being and economic value via sustainable management of water resources. It enables citizens and actors to engage in continuous co-learning and innovation to boost efficient, effective, and safe circular use of resources. This is done in a long-term perspective focused on guaranteeing the conservation of ecosystems and maximising their services to society, while anticipating changing conditions and adapting existing infrastructure.

This definition puts the three dimensions of sustainability to the fore, while stating that sustainability is generated and always in the making. The emphasis on enabling citizens and actors to engage in continuous co-learning and innovation highlights the importance of involvement across levels and sectors. It places co-learning and innovation centrally in the definition, seeing these as crucial to achieve the radical system change required to transition from a linear to a circular economy.

Innovation is seen to include both technical and social innovations and enabling entails new governance models as well as innovative tools (where digital technologies may hold a huge potential, but not be prerequisite for water-smartness). Boosting efficient, effective, and safe circular use of resources refers to "safe water for all", as well as resource efficiency and green business development. The long-term perspective and focus on conserving ecosystems as well as their wider benefits to society is emphasized, together with the ability to manage complex and uncertain conditions, while adapting and renewing existing infrastructure in a flexible way.

The next chapter presents what aspects the LL owners consider should be emphasized according to their vision of a water-smart society.

The feedback from the LL owners complements the findings from literature, leading up to a definition of how water-smart society can be addressed and operationalised for use in the assessment framework presented from Chapter 6.

3 Living Lab owners' feedback on the preliminary water-smart society definition

3.1 Introduction

In order to ensure that the framework, which will build on the definition of "water-smart societies" will be applicable for practitioners, a preliminary definition was presented to the LL owners during structured interviews in January 2021 within a Task 1.5 activity (refer to MS02 and MS06).

The preliminary definition, drafted by WP6 as a working base from which the final definition can emerge, was presented to the LL owners. The definition adopted is proposed here again to support the reader:

"Societies and economies are water-smart when they succeed at conserving water and at generating value from and through water in a context of circular economy. In a water-smart society, societal well-being and value through water is generated. In a water-smart economy, business around water is created. In a water-smart society and economy governance models centred on the water value boost the efficient, effective and safe circular use of resources, while boosting economic activities around water and ensuring a sustainable service."

Looking at the proposed definition the LL owners were asked: does the definition reflect your understanding of a water-smart society? What are the key dimensions that should be contained in the definition? Are there any keyword that should be included in the definition?

The following sections present the relevant and constructive feedback received by the LL owners on the preliminary definition and a revised version of it is presented at the end of the chapter; with the aim of capturing the key features included in the LL-based and literature based definitions, the B-WaterSmart project adopted definition of a "water-smart society" is finally provided in Chapter 4.

3.2 Received feedback from the LL owners

3.2.1 Alicante

3.2.1.1 Understanding / Dimensions / Emphasis

Topics suggested to complement the preliminary definition:

- Digital dimension: there is no reference to the digital dimension. It is understood that digital dimension is a tool and not a goal of “water-smartness”, but “making use of edge technologies and digital solutions” might fit into the definition;
- Positive impact on environment: overall it seems that environmental impacts or the importance of water for the environment is not of major importance. In this line, something related to “environmental restorations” could be included;
- Promotion of “awareness” / “sensibilization”/ “knowledge”, “transparency” to the society: it could be summarized with “citizenship implication”;
- Risk management related to climate change (flood prevention) could be included.

3.2.1.2 Keywords to be considered

Suggested keywords to be possibly included in the definition:

- Digital solutions
- Risk management
- Citizen implication

3.2.2 Bodø

3.2.2.1 Understanding / Dimensions / Emphasis

Topics suggested to complement the preliminary definition:

Bodø emphasised the environmental perspective of a water-smart society, with specific attention at optimising the use of resources (*e.g.,* avoiding to use more resources than needed) and at preserving at best the natural cycle of the water.

3.2.3 East Frisia

3.2.3.1 Understanding / Dimensions / Emphasis

Topics suggested to complement the preliminary definition:

- The ecological/environmental dimension is missing;
- Accessibility and affordability of water (SDG 6) are missing.

3.2.3.2 Keywords to be considered

Suggested keywords to be possibly included in the definition:

- Affordability
- Adaptability, flexibility
- Innovative technologies
- Digital solutions

3.2.4 Flanders

3.2.4.1 Understanding / Dimensions / Emphasis

Topics suggested to complement the preliminary definition:

- Aspects around data driven services are considered important aspects;
- The definition is perceived as business focused. The value through water is less relevant for the city, though it is important for water utilities. However, encouraging innovative business is important for the city. Particularly with regards to agriculture, the value of water is seen as indirect in preserving and replenishing groundwater resources, which provides value to society and nature, and is difficult to assign an economical value;
- There are initiatives for governance models, but not on how water can be sufficiently valued. Starting from the idea of water-smart societies may help develop governance models;
- The description of value seems very broad in comparison to the mention of societal well being;
- Environmental sustainability should be more clearly included.

3.2.4.2 Keywords to be considered

Suggested keywords to be possibly included in the definition:

- Aspects around data driven services
- Support base among stakeholders and citizens
- Explicit mention the value of water beyond economical value (*e.g.,* ecological, ...)
- Sustainability and protection of the environment
- Optimal / efficient water use and water management

3.2.4.3 Optional modification of the definition

The phrase 'sustainable service' seems too focused on industry and production aspects. A better phrasing may be 'ensuring a sustainable society'.

3.2.5 Lisbon

3.2.5.1 Understanding / Dimensions / Emphasis

Topics suggested to complement the preliminary definition:

- Ensure water for all (everyone and every relevant use) with quality and affordability. "All" means all people and all relevant uses (urban, industrial, agricultural), and water is made available efficiently and at an affordable cost for people, economy; therefore, "water for all" refers to both physical and economic accessibility to water.
- Make water management more transparent, providing full information to citizens and organizations and promoting education and debate around issues regarding smart water management.

3.2.5.2 Keywords

Suggested keywords to be possibly included in the definition:

- Transparency/Information, to be reflects for instance by "well-informed society"
- Education/Debate, to be reflected for instance by "engaged and active citizens"

3.2.5.3 Optional modification of the definition

"Societies and economies are water-smart when they succeed at efficiently ensuring water for all relevant uses, at conserving water and at generating value from and through water in a context of circular economy. In a water-smart society, well-informed and engaged citizens pursue societal well-being underpinned by water's intrinsic environmental and value through water is generated. In a water-smart economy, business around water is created. In a water-smart society and economy governance models centred on the water value boost the efficient, effective and safe circular use of resources, while boosting economic activities around water and ensuring a sustainable service."

3.2.6 Venice

3.2.6.1 Understanding / Dimensions / Emphasis

Topics suggested to complement the preliminary definition:

- The proposed preliminary definition reflects the VERITAS understanding of water-smart society;

- The key dimensions that should be contained in the definition are governance, social, economic and environmental;
- The LL owner emphasised the relevance of the governance and social dimension.

3.2.6.2 Keywords

Suggested keywords to be possibly included in the definition: "social empowerment."

3.2.6.3 Optional modification of the definition

Societies and economies are water-smart when they succeed at conserving water and at generating value from and through water in a context of circular economy. In a water-smart society, value through water is generated through social empowerment (*e.g.,* awareness). In a water-smart economy, business around water is created. In a water-smart society and economy governance models centred on the water value boost the effective and efficient circular use of resources. A water-smart society and economy exploits water resources in a smart way while boosting economic activities around water and ensuring a safe and sustainable service.

3.3 The revised definition addressing the LL's feedbacks

Taking into account the valuable reflections and suggestions provided by the interviewed Partners a revised definition was created.

Although using different terminology, the Partners invited to try to include the following concepts:

- to establish a water-smart society the engagement and empowerment (*e.g.*, awareness) of society is crucial, as well as the need of enabling governance;
- a water-smart society has to take advantage from digital technologies;
- a water-smart society has to preserve the environment;
- a water-smart society builds on empowered and motivated citizens;
- a water-smart society has to be resilient (flexible, adaptive);
- in a water-smart society water has to be physically and affordably available;
- a water-smart society has to ensure safety;
- a society is water-smart under possible alternative scenarios of challenges (risk, climate, demographic, *etc.*).

Based on the above list of inputs, an exercise to try to fit the suggestions into a revised definition was performed, to anchor the features to be considered in the final step: the adopted definition presented in Chapter 4. In Table 3, the first column depicts the preliminary definition, the second column presents the concepts missing, as for feedback of the interviewed partners, and the third column presents the updated definition; the same colour code is used in columns two and three to highlight the words and / or sentences introduced in the attempt to cover the missing concepts.

Preliminary working definition	Identified missing concepts	Revised definition
"Societies and economies are water-smart when they succeed at conserving water and at generating value from and through water in a context of circular economy. In a water-smart society, societal well-being and value through water is generated. In a water-smart economy, business around water is created. In a water-smart society and economy governance models centred on the water value boost the efficient, effective and safe circular use of resources, while boosting economic activities around water and ensuring a sustainable service."	- Digital dimension - Environmental dimension - *Societal empowerment* - Resilience (flexibility, adaptability) - Affordability - Safety / Risk - Challenges (risk, climate, demographic, …)	"Societies and economies are water-smart when they succeed at safely and **efficiently ensuring water for all relevant uses**, at preserving the environment and at generating value from and through water in a context of circular economy, regardless the present and the future challenges. In a water-smart society, *well-informed and engaged citizens pursue* societal well-being *underpinned by water's intrinsic environmental* and value through water is generated. In a water-smart economy, business around water is created. In a water-smart society and economy, governance models centred on the water value boost the efficient, effective, resilient, and safe circular use of resources, making use of edge technologies and digital solutions, while boosting economic activities around water and ensuring a sustainable service."

Table 3: Preliminary definition proposed to the LL owners, initial feedback and revised version.

As shown in Table 3 all suggestions have been included in a sort of "patchwork" exercise. Relevant to note the good alignment between the vision of the LL owners and the literature-based features characterizing a water-smart society.

Next step is to combine the literature and the practitioners' inputs into a concise and comprehensive definition, which is provided in the next chapter as a dedicated chapter, so to facilitate the reader in finding the project's adopted definition and avoiding having it hidden in between the deliverable pages.

4 B-WaterSmart definition of water-smart society

The literature investigation of Chapter 2 and the vision shared by the LL owners presented in Chapter 3 bring to the conclusion that becoming a water-smart society is a transition process and it has to be grounded on clear long term strategic objectives, multi-domain and multi-actor system - thinking and with an orientation towards system innovation, resilience and sustainable service.

On this basis, the following B-WaterSmart definition of water-smart society is proposed:

Societies are water-smart when they generate societal well-being via sustainable management of water resources. In water-smart societies, well-informed citizens and actors across sectors engage in continuous co-learning and innovation to develop an efficient, effective, equitable and safe circular use of water and the related resources. This is achieved by adopting a long-term perspective to ensure water for all relevant uses, to safeguard ecosystems and their services to society, to boost value creation around water, while anticipating change towards resilient infrastructure.

Table 4 analyses each sentence of the proposed definition and explains how it reflects the aspects characterizing a water-smart society and fits the literature findings and the LL owners' vision.

Definition	Analysis and Remarks
Societies are water-smart when they generate societal well-being via sustainable management of water resources.	The first sentence wants to highlight "water-smart" as a quality of society striving for sustainability as main objective to generate societal value from water. By stating "*sustainable* management of water resources" as the starting point, intrinsically the definition reflects that a water-smart society succeeds to balance the three sustainability dimensions: social, economic, environmental, through the instrumental support of reliable infrastructure and good governance.
In water-smart societies, well-informed citizens and actors across sectors engage in continuous co-learning and innovation to develop an efficient, effective, equitable and safe circular use of water and the related resources.	Although the word governance is not explicitly mentioned, the second sentence is dedicated to the role of new governance models, emphasizing multi-level, multi-actor, multi-sector involvement and learning, as enablers to create water-smart societies. Governance is related to the rules of the game, the respect for those rules by the stakeholders, the transparency of information, the knowledge creation, the participation in the decision-making process, particularly of the citizens, the effectiveness and efficiency of the measures taken and the quality of the accountability and adjustment mechanisms. Innovation is seen to include both technical and social innovations; "*engage… to develop*" entails governance models as well as innovative tools, where digital technologies may hold a huge potential, but not be prerequisite for water smartness. Specifically on digitalization, it was decided to refer to it behind the word

Definition	Analysis and Remarks
	"*innovation*" and to avoid a direct reference to technologies; although digital technologies can support and enable the implementation of a strategic plan towards a water-smarter society, "digital" is not an adjective that characterizes the vision of being a water smart-er society. Developing *"an efficient, effective, equitable and safe circular use of water and the related resources"* refers to ensuring equitable and safe water for all uses and creating value from resource efficiency, circularity, and green business development. This sentence also addressed the requirement of reflecting risk/safety through the term "safe".
This is achieved by adopting a long-term perspective to ensure water for all relevant uses, to safeguard ecosystems and their services to society, to boost value creation around water, while anticipating change towards resilient infrastructure.	The third sentence emphasize the long-term oriented aspect of the water-smart transition process which has to be planned with clear definition of strategic objectives (covering the social, economic, environmental, governance and technical dimensions). The long-term perspective also includes the ability to anticipate and adapt to change towards resilient infrastructure, therefore reflecting *resilience* as characteristic of the strategic planning of water-smart societies. This last sentence also paves the way to the development of the B-WaterSmart framework, by stating part of its scope: it must address long - term strategic changes and sustainability qualities, in contrast to a focus to more short-term operational and/or tactical interests of other modelling solutions developed in the project.

Table 4: How does the proposed definition fit the literature findings and the LL owners' vision?

5 Towards the B-WaterSmart Framework

5.1 Introduction

Developing frameworks is a delicate balance between various aspects such as measurability, scale, applications, user-friendliness, comprehensiveness, and focus. In this chapter, lessons will be drawn from six leading frameworks that are most related to the envisioned aims, scope and objectives of the B-WaterSmart framework. Hence, these lessons and experiences may form valuable input for the B-WaterSmart framework.

The six frameworks vary in scope. The "Transitions to the Urban Water Services of Tomorrow" (TRUST) framework focusses on sustainable and low-carbon water cycle services and assets for strategic, tactic and operational processes (see Section 5.2.1). Whereas the AWARE-P framework applies a more focused niche since it aims to provide an objective- and metric-driven organized framework for evaluating and comparing planning alternatives or competing infrastructure asset management solutions (see Section 5.2.2). While the niche is more confined to asset management, the user-interface and optioneering features are sophisticated in supporting strategic-tactical asset management decisions-making and management. The City Blueprint® framework on the other hand is a snapshot of integrated urban water management and aims to facilitate strategic decision-makers in envisioning, developing and implementing stepwise measures to transform towards water-wise or water sensitive cities (see Section 5.2.3). Where TRUST, AWARE-P and the City Blueprint frameworks primarily focus on water cycle services and assets that are intrinsically interrelated with other urban services, the RESCCUE framework (see Section 5.2.4) takes the concept of resilience as the point of departure. The framework focuses primarily on strategic integration of urban dimension to enhance the capability of cities to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage. Beyond cities, the DESSIN ESS Evaluation Framework (see Section 5.2.5) takes surface or groundwater body, sub-catchment or catchment ecosystems as the primary scope for facilitating decision-making. The aim is to enhance the appraisal of the effects of innovative solutions on freshwater ecosystems and their services. Finally, the governance capacity framework (see Section 5.2.6) assesses the capacity of local stakeholders to collaborate and address a common water-related or environmental challenges. Since, the framework primarily focusses on the problem-solving capacity, the type of problem that is assessed can vary in scale and focus. As such urban and regional challenges of water, waste and climate change are typically being assessed.

Since each of these frameworks differ in scope and objective, the extensive experience with developing and applying each framework provides some key lessons listed for each framework in Section 0. Next, Section 5.3 provides a synthesis with concluding lessons to be incorporated in the development of the B-WaterSmart framework.

5.2 Literature review on existing frameworks

5.2.1 TRUST framework

Scope

The "Transitions to the Urban Water Services of Tomorrow" (TRUST) project aimed at providing knowledge and guidance to enable communities to achieve sustainable, low-carbon water futures without compromising service quality. The project included a WP dedicated to the development of an Urban Water Cycle System (UWCS) performance assessment framework, meant to support water utilities in assessing the level of sustainability of the service provided. The design of the framework was based on the UWCS sustainability definition formulated by TRUST, already discussed in Section 2.1.1:

“Sustainability in Urban Water Cycle Services (UWCS) is met when the quality of assets and governance of the systems is sufficient to actively secure the water sector’s needed contributions to social, environmental and economic sustainability in the urban system as a whole” (Alegre *et al.* 2012).

Building from the definition, the TRUST project provided a sustainability assessment framework which includes three main dimensions, *i.e.,* social, environmental, economic and two supporting dimensions, *i.e.,* assets and governance. The scope of performing the assessment is to provide insights on how to improve the management and development of UWCS assets and governance, as part of a strategic transition process towards 2040, in order to positively influence the end dimensions of social, environmental and economic sustainability.

The assessment is made operational by critically and carefully examining a chosen set of performance metrics/indicators and how they comply with a predefined set of sustainability objectives and criteria.

Framework, definitions & data population

In the TRUST assessment framework, the five sustainability dimensions are linked to 13 sustainability objectives, and 23 performance criteria (Alegre *et al.* 2012), see Figure 6. Once the user selects the list of relevant objectives and corresponding criteria, the next step should be the selection of metrics to be computed to assess the distance from the sustainability objectives.

As a result, the performance assessment system comprises a set of performance assessment metrics and related data elements that represent real instances of the undertaking context. The project also provided a list of metrics for inspiration from which the user could choose from or create new ones.

In the context of TRUST, the main goal was to provide the theoretical framework. However, the methodology and the assessment approach were also operationalised in the so called "Sustainability Self-Assessment Tool", where results are shown aggregated at criteria level first and at objective level then, with a final score at dimension level (Alegre *et al.*, 2012).

DIMENSION	OBJECTIVES	ASSESSMENT CRITERIA
Social	S1) Access to urban water services S2) Effectively satisfy the current users' needs and expectations S3) Acceptance and awareness of UWCS	S11) Service coverage S21) Quality of service S22) Safety and health S31) Affordability
Environment	En1) Efficient use of water, energy and materials En2) Minimisation of other environmental impacts	En11) Efficiency in the use of water (including final uses) En12) Efficiency in the use of energy En13) Efficiency in the use of materials En21) Environmental efficiency (resource exploitation and life cycle emissions to water, air and soil)
Economic	Ec1) Ensure economic sustainability of the UWCS	Ec11) Cost recovery and reinvestment in UWCS (incl. cost financing) Ec12) Economic efficiency Ec13) Leverage (degree of indebtedness) Ec14) Willingness to pay
Governance	G1) Public participation G2) Transparency and accountability G3) Clearness, steadiness and measurability of the UWCS policies G4) Alignment of city, corporate and water resources planning	G11) Participation initiatives G21) Availability of information and public disclosure G22) Availability of mechanisms of accountability G31) Clearness, steadiness, ambitiousness and measurability of policies G41) Degree of alignment of city, corporate and water resources planning
Assets	A1) Infrastructure reliability, adequacy and resilience A2) Human capital A3) Information and knowledge management	A11) Adequacy of the rehabilitation rate A12) Reliability and failures A13) Adequate infrastructural capacity A14) Adaptability to changes (e.g. climate change Adaptation) A21) Adequacy of training, capacity building and knowledge transfer A31) Quality of the information and of the knowledge management system

Figure 6: The strategic objectives and assessment criteria adopted in the TRUST sustainability framework (Alegre *et al.* 2012).

Key lessons for B-WaterSmart Framework

1. The TRUST sustainability framework provides a structured and applicable framework to guide decision-makers in setting long-term strategic objectives and measure progress in providing a more sustainable service through the library of assessment criteria and metrics suggested. Objectives, criteria and metrics are categorized in five sustainability dimensions.
2. The TRUST framework included a large number of objectives, criteria and metrics resulting in a complex and demanding process of deployment. The B-WaterSmart framework needs to propose a better balance in terms of resources and data requirements versus the level of detail of the results. In order to get a better focus, the B-WaterSmart framework will have to primarily target the strategic level of the decision-making process, and to some extent address the tactical level. However, purely operational assessments may be better served with another decision-supported tool tailored on these types of decisions and considerations.

3. The method has been implemented in a software with interesting visualization features and options to compare alternatives and scenarios which should be taken into consideration, at least for inspiration, when developing the B-WaterSmart dashboard in Task 3.9.

5.2.2 AWARE-P framework

Scope

A large proportion of the world's built urban water infrastructures have, over the past decades, accumulated alarming levels of deferred maintenance and rehabilitation. The combined replacement value of such infrastructures can be overwhelming, demanding efficient planning and the capability to pace spending and maximize its impact over the long term (Alegre and Coelho, 2012).

The AWARE-P methodology and associated tools incorporate the principles generally recommended and adopted in infrastructure asset management (IAM) by leading-edge research, consultant and utility organizations and it approaches IAM as a management process, based on Plan-Do-Check-Act (PDCA) principles and requiring full alignment between the strategic objectives and targets, and the actual priorities and actions implemented (Alegre at al., 2012). The methodology allows for the assessment and comparison of intervention alternatives from the performance, cost and risk perspectives over the analysis horizon(s), taking into account the objectives and targets defined.

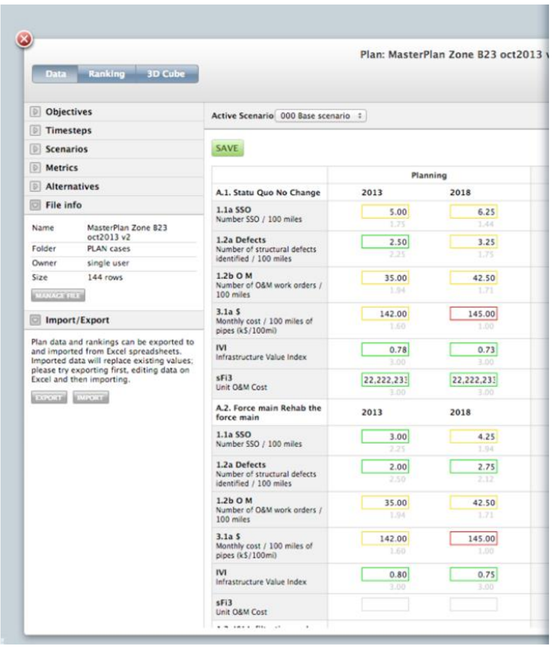
Framework, definitions & data population

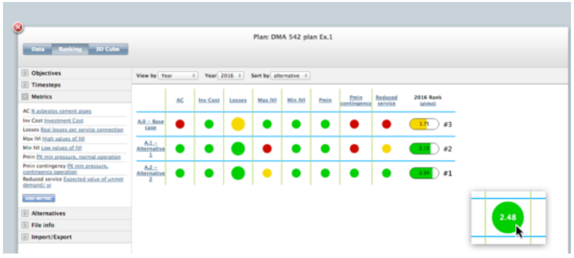
The AWARE-P IAM planning software was designed as a non-intrusive, web-based, collaborative environment to integrate data, processes, objectives, metrics and decisions, with the capability to assess and account for individual as well as system behavior. It offers the ability to collect available data and information from a large variety of sources and processes that may be relevant to the IAM decision-making process, including maps, GIS layers (shapefiles) and geodatabases; inventory records; work orders, maintenance, inspections/CCTV records; network models, performance indicators, asset valuation records, among others (Coelho and Vitorino, 2013).

In the PLAN decision-making environment, the software provides an objective- and metric-driven organized framework for evaluating and comparing planning alternatives or competing IAM solutions, through assessment metrics (Figure 7). It comprises a growing, modular portfolio of system metrics and network analysis tools that may equally be used individually for diagnosis and sensitivity gain. The approach corresponds to a vision of IAM that seeks to align and integrate all efforts that may reflect on the infrastructure itself and on the data and information available about it, striving for measurable long-term infrastructural sustainability — be it on the financial, environmental or quality of service dimensions (Coelho and Vitorino, 2013).

PLAN embodies the central planning framework, where planning alternatives or competing solutions are measured up and compared through selected metrics, through interactive numerical 2D/3D graphical information display (Figure 8). The tool is based on the three main axes that characterize the assessment and comparison exercise: a set of alternatives, a set of standardized metrics and a given time frame. The latter comprehends a number of user-specified time steps and may include both a planning horizon (*i.e.*, the time frame of the intervention) and an analysis horizon (a longer time frame for impact assessment). The 3D Cube facilitates negotiation and communication of complex decision-making problems.

The metrics selected by the user, which may come from the performance, risk and cost assessment tools present in the AWARE-P portfolio or from external evaluations as selected by the user, are standardized as numerical indices and then categorized as color-coded levels, with an emphasis on coherent definition by the user of the reference category values. It allows to consider different scenarios that translate potential external contexts that may impact the system(s) or alternatives under consideration over the horizon concerned.





b) Alternatives ranking

a) Metrics and classification for the alternatives

Figure 7: AWARE-P: example of assessment and visualisation of alternatives. (a) metrics and classification; (b) ranking (AWARE-P, 2014)

Key lessons for B-WaterSmart Framework

1. AWARE-P software provides a tool to support an assessment structured by objectives, criteria and metrics, allows to include reference values applicable to the metrics and to analyse, compare and rank alternatives and scenarios.
2. It could provide a tool to facilitate and support the application of the prototype V0 version of the B-WaterSmart assessment framework by the six LL6 living labs, while the dashboard is not yet operational to be used. Therefore, it could facilitate the provision of recommendations for the framework refinement and transformation into a software tool.

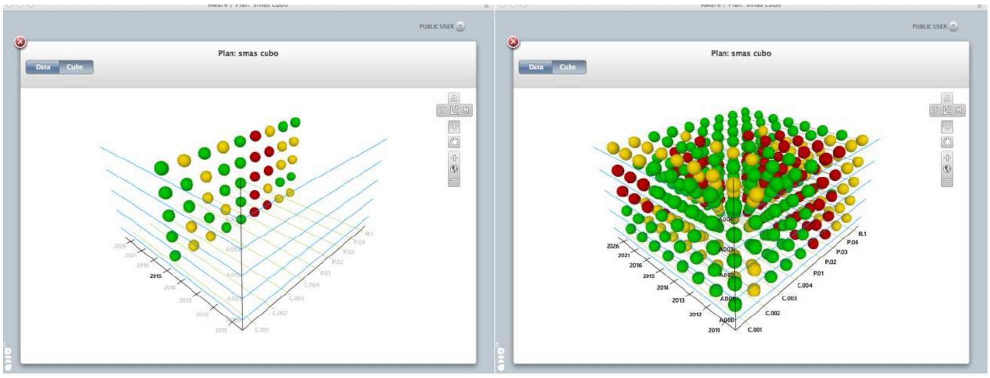


Figure 8: AWARE-P: example of alternatives results and comparison, 2D/3D visualisation (Coelho and Vitorino, 2013); http://aware-p.org/.

5.2.3 City Blueprint & SUPERLOCAL framework

Scope

Rapid urbanization and climate change pose increasing pressures on water management, particularly in cities (OECD 2015). In 2014, about 4 billion people lived in urban areas, in many cases situated along major rivers, deltas and coasts (Koop and Van Leeuwen 2017). By 2050, the global urban population is estimated to increase with 2.5 billion (UN 2014). Moreover, cities account for approximately 80% of the world's GDP and 75% of energy and materials are consumed in urban areas (UNEP 2013). As a result, cities may hold the key to reduce environmental pressures. Urban water management is pivotal for infrastructure planning and the adoption of flexible and resilient technologies and approaches such as fit-for-purpose water use, resource recovery from wastewater, and blue-green infrastructures (Brown *et al*. 2011). Accordingly, the main objective of the City Blueprint® action is to create awareness among decision-makers of strategic integrated water management priorities. It may help them envisioning, developing and implementing stepwise measures to transform towards water-wise or water sensitive cities (Koop 2019). The first step in the strategic planning process is that stakeholders are identified, and information is provided for a baseline assessment. Hereafter, long-term goals, and priorities are set resulting in follow-up actions leading to measures that promote sustainable IWRM (Philip *et al*. 2011). The City Blueprint Framework (CBF) aims to be the first step in this strategic planning (Figure 9). Such a baseline also provides a frame of reference to improve the implementation capacities of cities by sharing information, experiences and practices which can be described as city–to-city learning (Koop and Van Leeuwen 2015a, b).

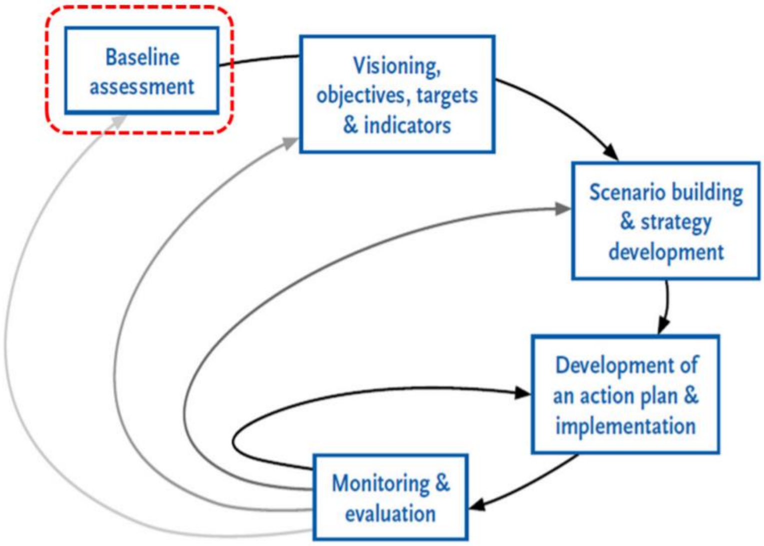


Figure 9: Positioning of the City Blueprint framework in the strategic planning process for urban water management (figure according to Philip *et al.* 2011).

Framework, definitions & data population

The City Blueprint consists of two complementary frameworks: the Trends and Pressures Framework (TPF) and the City Blueprint performance Framework (CBF). The TPF provides an overview of the key social, environmental, financial and governance challenges that cities may face. The framework consists of 24 indicators that are scored from 0 (no concern) to 10 (great concern). The CBF consists also of 24 indicators and provides a comprehensive overview of integrated urban water management. The CBF consists of seven broad categories: I basic water services, II water quality, III wastewater treatment, IV water infrastructure, V solid waste, VI climate adaptation and VII management and action plans. The indicators are scored from 0 (poor performance) to 10 (high performance) through the use of publicly available data and information validated and acquired with local authorities including water utilities, municipalities, flood risk authorities, waste companies and others. The geometric mean of the indicators is the Blue City Index (BCI). The indicators are scored in a transparent, simple and intelligible fashion through an online available questionnaire: https://library.kwrwater.nl/publication/61397318/. At present, 125 cities have been assessed with the City Blueprint methodology (Figure 10 and Figure 11).

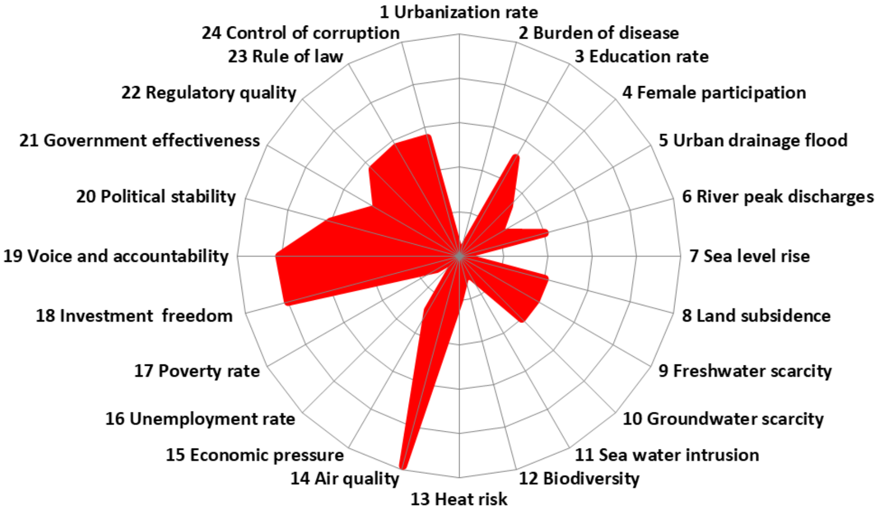


Figure 10: City Blueprint Trends and Pressures assessment of Beijing, China. The key message is 'the more red, the more concern'. Indicators score from 0 (no concern) to 10 (great concern). Data from Chang *et al*. 2020.

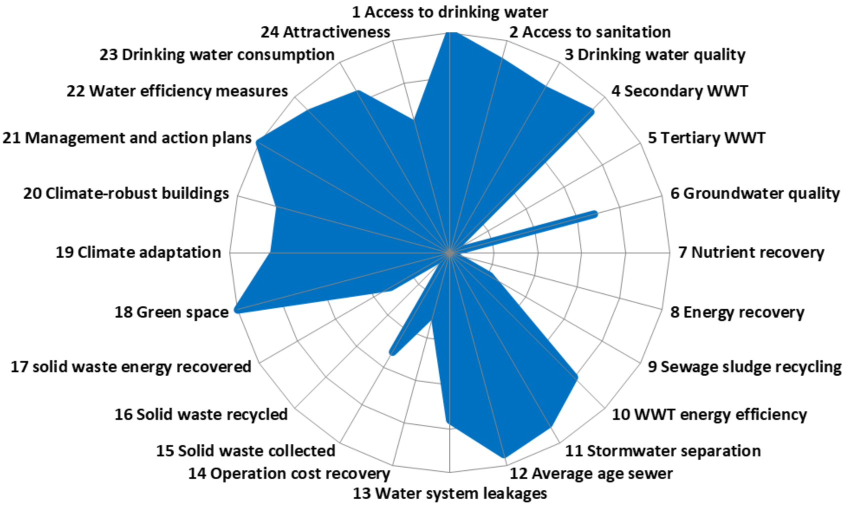


Figure 11: City Blueprint of Beijing, China. The key message is 'the bluer, the better'. Indicators score 0 (poor performance) to 10 (high performance). Data from Chang *et al*. 2020.

Supplementary to the semi-qualitative, baseline assessments of the City Blueprint framework that target the city level, KWR has developed a model-based framework to quantify circularity in neighbourhood systems (Bouziotas *et al.* 2019). This framework, which is based on the UWOT water cycle model to assess technological performance for both baseline and future scenarios, has been applied in the neighbourhood of SUPERLOCAL (in the Province of Limburg, the Netherlands) and has been used for the ex-ante evaluation of different technology options in a newly redesigned area. Like the City Blueprint, assessment results are communicated using a spider chart (larger area coverage means better, see lower panel of Figure 12), but the relevant metrics now are fewer, focused solely on urban water flows and are generated based on the output of the model, addressing different parts of the urban water cycle (such as the reduction in central wastewater, reduction in central potable water demands, amount of rainwater able to be stored locally, *etc*.). As this is a model-based assessment, the output is also given in much more detailed formats, such as time series or aggregated response metrics (*e.g.*, volumes), and comes in the form of a dashboard (Figure 12). This planning tool for water circular neighbourhoods enables careful considerations of various future developments, design choices and policies. These two assessment frameworks can be used in a supplementary manner, for instance to (a.) perform a comprehensive quick-scan to identify city strategic management issues (using the City Blueprint), but also to (b.) support interventions in specific areas and explore future scenarios, by employing the SUPERLOCAL framework.

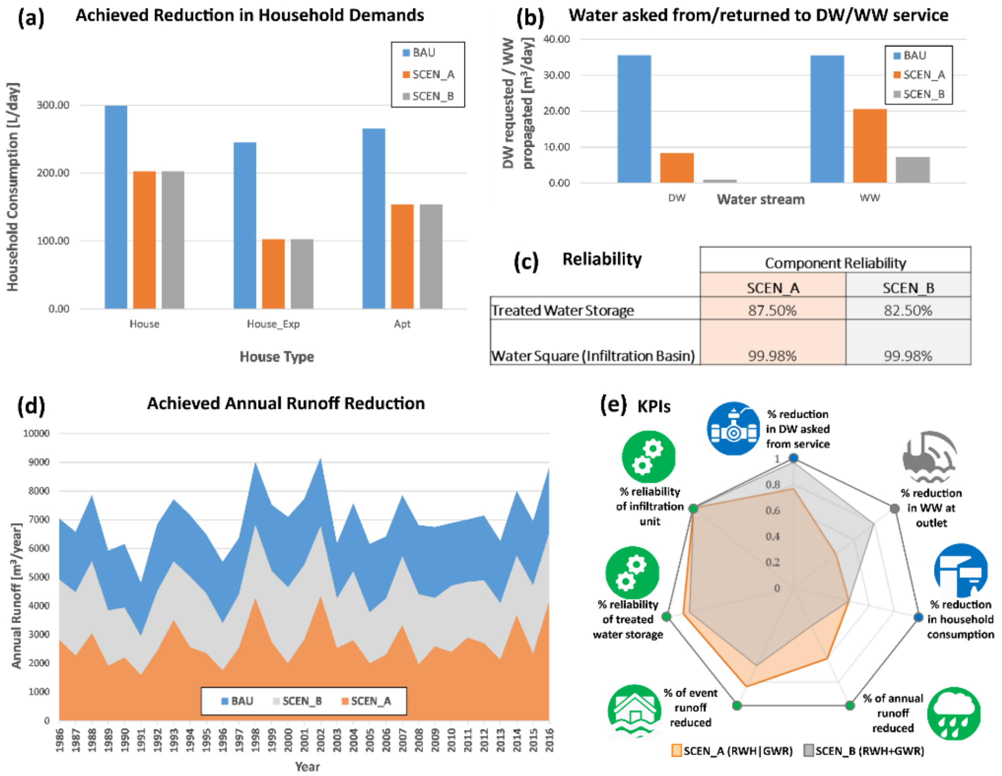


Figure 12 The SUPERLOCAL assessment framework (upper panel), as well as the dashboard of results (lower panel).

Key lessons for B-WaterSmart Framework

1. Through a publicly available questionnaire, indicators are scored using desk study but always in close collaboration with local stakeholders and water authorities. In this way, the results are by definition a co-production and therefore more likely to support decision-making.
2. The frameworks are standardised, simple, and comprehensive by focussing on many relevant aspects of integrated urban water management. It therefore appeals to a broad audience with varying backgrounds and expertise's. It supports strategic urban decision-making which by definition is a result of different sectorial interests and priorities.
3. The methodology can be described as a quick-scan. It takes about the week to assess an average city (depending on data availability). With minimal time and resources, a large pool of cities can be ‘seduced’ to participate in such an assessment.

4. The SUPERLOCAL assessment framework is based on model simulation and it can communicate more detailed information regarding urban water flows in neighbourhoods for both for baseline and future scenarios. Such a to-the-point approach might be applicable in the context of B-WaterSmart.

5.2.4 RESCCUE framework

Scope

Urban areas are dynamic, facing evolving hazards, having interacting strategic services and assets. Their management involves multiple stakeholders resulting in even more complexity. Potential impacts of climate dynamics, such as intense precipitation events, tidal effects, droughts or heat waves, may aggravate current conditions and appearance of new hazards. These challenges require an integrated and forward-looking approach to resilient and sustainable urban development, being essential to identify the real needs for its achievement.

Several tools and frameworks for assessing resilience have been developed in different fields, such as those created by ICLEI 2010, UN-Habitat CRPT 2013, Rockefeller & Arup 2014, World Bank 2015, UNISDR 2015, EPA 2017, among others (Patel and Nosal, 2016; UNISDR, 2017a,b; Summers *et al*., 2017; EPA, 2017). However, considering the focus on climate change and urban services, specific needs were identified, particularly in assessing strategic urban sectors and their interactions with others and with the wider urban system. Therefore, a resilience assessment framework (RESCCUE RAF) was developed directing and facilitating an objective-driven resilience diagnosis of urban cities and services, providing a freely available web-based tool – RAF App – to support its usage (Cardoso *et al*., 2020a). This framework supports the decision on selection of resilience measures and the development of strategies to enhance resilience, outlining a path to co-build resilience action plans, and to track resilience progress in the city or service over time. The framework has been applied to assess resilience to climate change with a focus on the urban water cycle in order to support the development of cities' resilience action plans for Barcelona (Spain), Lisbon (Portugal) and Bristol (UK) (Cardoso *et al*., 2020a,b, Velasco *et al*., 2020).

Framework, definitions & data population

The RESCCUE RAF considers the city, services and infrastructure resilience. The services within this framework scope are those comprised in the urban water cycle, *i.e*., water supply, wastewater, and stormwater, and those having interconnections and interdependencies closely related with the water services, *i.e.*, waste management, electrical energy supply and mobility. The external context of the city and services is considered by a standard characterization profile of the city and of the services.

The framework considers four resilience dimensions: organisational (top-down governance relations and urban population involvement, at the city level), spatial (urban space and environment), functional (resilience of strategic services) and physical (resilience of services infrastructure). Time dimension is implicitly part of the analysis.

The RESCCUE RAF has a hierarchical tree structure: for each dimension, resilience objectives are defined, representing the ambitions to be achieved in the medium-long term by the city and services. Dimensions related to the urban services, firstly unfold into sub-dimensions, representing each service to be assessed. Each objective is described by a set of criteria translating different points of view. Each criterion assembles the respective set of assessment metrics, through which it is possible to classify the resilience development level, by comparison with reference values, reflecting the resilience maturity of the city or of the service under assessment. Metrics are defined consisting in questions, parameters or functions used to assess the criteria. Providing the possibility of a staged assessment according to the city or service resilience maturity, a relevance degree is assigned to each metric namely: essential, including all metrics with higher relevance, required to integrate the resilience assessment of any city or service; complementary, additional metrics to be considered whenever integration of a city or service specific aspects' is sought, corresponding to a more detailed resilience assessment; comprehensive, additional metrics recommended whenever a more in-depth assessment is aimed, for a city or service with a higher maturity in its resilience path. It also incorporates strategic and tactical levels.

In total RESCCUE RAF includes 719 metrics, from which 433 are essential, 202 are complementary and 84 are comprehensive. For each dimension, the objectives and assessment criteria are presented in Table 5, indicating the respective number of metrics, and these are described in detail in Cardoso *et al*. (2020a).

ORGANISATIONAL		
OBJECTIVE Criterion	No. total metrics	No. essential metrics
COLLECTIVE ENGAGEMENT AND AWARENESS		
Citizens and communities engagement	5	3
Citizens and communities awareness and training	5	3
LEADERSHIP AND MANAGEMENT		
Government decision-making and finance	4	3
Coordination and communication with stakeholders	4	2
Resilience engaged city	19	13
CITY PREPAREDNESS		
City preparedness for disaster response	13	8
City preparedness for CC	7	6
City preparedness for recovery and build back	7	5
Availability and access to basic services	10	7
TOTAL	74	50

SPATIAL		
OBJECTIVE Criterion	No. total metrics	No. essential metrics
SPATIAL RISK MANAGEMENT		
General hazard and exposure mapping	5	5
Hazard and exposure for CC	3	3
Resilient urban development	7	4
Impacts of climate-related event	2	2
PROVISION OF PROTECTIVE INFRASTRUCTURES AND ECOSYSTEMS		
Protective infrastructures and ecosystems services	9	6
Dependence and autonomy regarding other services considering CC	3	2
TOTAL	29	22

FUNCTIONAL		
OBJECTIVE Criterion	No. total metrics	No. essential metrics
SERVICE PLANNING AND RISK MANAGEMENT		
Strategic planning	5	5
Resilience engaged service	5-6	4-5
Risk management	7-12	2-7
Reliable service	6-11	1-5
Flexible service	4-6	1-4
AUTONOMOUS SERVICE		
Service importance to the city	2	1
Service inter-dependency with other services considering CC	2	0
SERVICE PREPAREDNESS		
Service preparedness for disaster response	0-4	0-4
Service preparedness for CC	6-8	4
Service preparedness for recovery and build back	0-15	0-8
TOTAL	37-71	18-43

PHYSICAL		
OBJECTIVE Criterion	No. total metrics	No. essential metrics
SAFE INFRASTRUCTURE		
Infrastructure assets criticality and protection	5	5
Infrastructure assets robustness	10-14	4-6
AUTONOMOUS AND FLEXIBLE INFRASTRUCTURE		
Infrastructure assets importance to and dependency on other services	3-4	3
Infrastructure assets autonomy	1-6	0-4
Infrastructure assets redundancy	1-3	0-3
INFRASTRUCTURE PREPAREDNESS		
Contribution to city resilience	3-4	2-3
Infrastructure assets exposure to CC	3	0-3
Preparedness for CC	2	1
Preparedness for recovery and build back	7-9	2-4
TOTAL	35-50	17-32

Table 5: The RESCCUE Resilience Assessment Framework: overview of the dimensions.

The RESCCUE RAF App (https://toolkit.resccue.eu/all-tools/) is a web-based tool that supports the application of the framework, facilitating the visualisation of assessment results, from the overall, by dimension, by service, by criteria and by metric (Figure 13).

Key lessons for B-WaterSmart Framework

1. Considering the due alignment or adaptation for an application to circular systems, governance is widely regarded as an essential dimension to be considered. Accordingly, the LLs have expressed the relevance of the topic in the workshop about formulating strategic objectives. The RESCCUE RAF framework considers the governance dimension, providing the relevant objectives for resilience, and how they can be assessed

and evaluated through criteria and metrics, in a structured and standardised way. Therefore, it can inform and support the B-WaterSmart framework development, in what may be applicable.

2. The same also applies to the functional and physical dimensions of the RAF framework, regarding water, wastewater and stormwater services and infrastructures, informing and supporting the B-WaterSmart framework development, in what may be applicable.
3. The RAF framework considers a relevance degree to each metric (essential, complementary, and comprehensive) in order to be applicable to any city or service despite its maturity. In order to control the data points, this concept could be used in the B-WaterSmart framework, regarding those metrics to be applied in the six LLs (*e.g.* essential), those metrics that are supplementary for specific contexts, applicable only in a part of the LLs (*e.g.* complementary) or those that provide a more in-depth assessment (*e.g.*, comprehensive). The same applies for the strategic and tactical decision levels.
4. The method is standardised and reproducible and it is based on independent research through a co-production process that involved and incorporated the concerns of a wide diversity of stakeholders (Cardoso *et al*., 2020c).

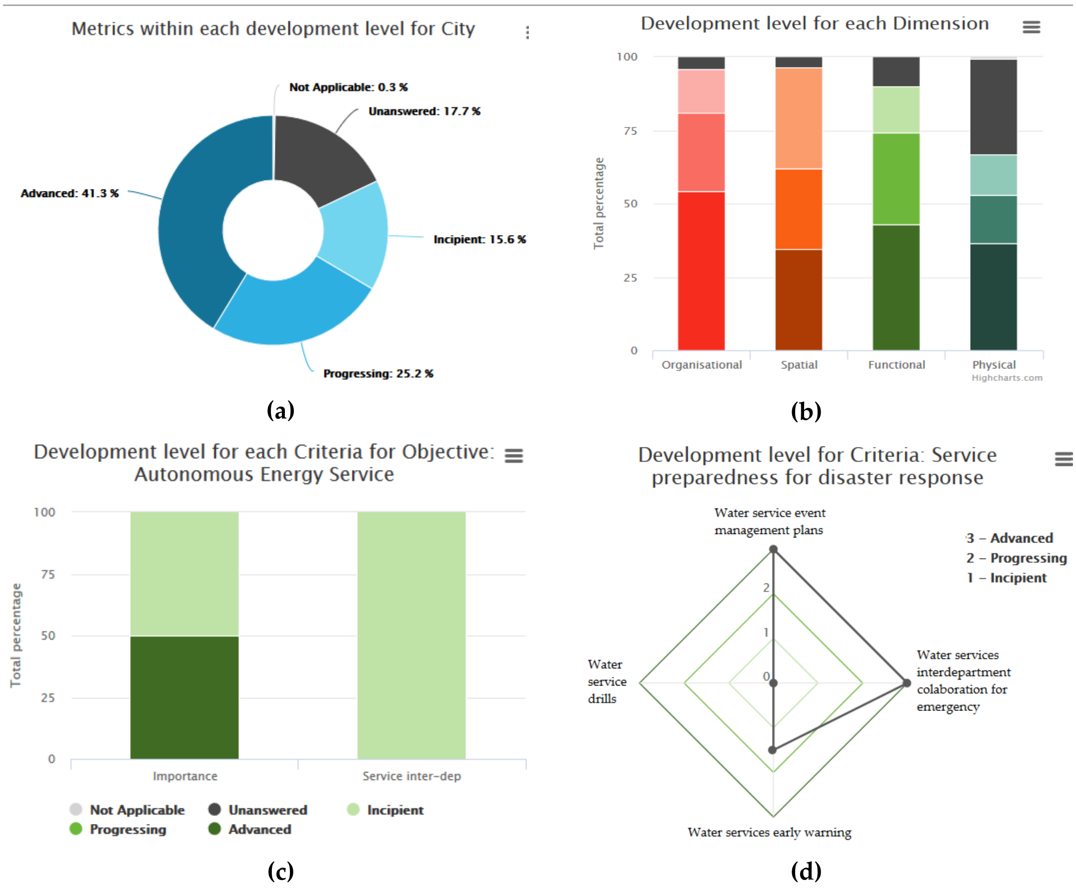


Figure 13: Example of assessment results visualisation. (a) Overall; (b) Overall per dimension; (c) Objective: autonomous electrical energy service; (d) Criterion water service preparedness for disaster response, by metric (Cardoso *et al.,* 2020a)

5.2.5 DESSIN framework

Scope

Water managers need to incorporate their interlinkages with freshwater ecosystems. Service delivery to customers relies on a sustainable management at the link between water infrastructure and natural water bodies. Therefore, it is important to incorporate the view on ecosystem services in water infrastructure management and investment decisions.

The DESSIN ESS Evaluation Framework is a structured approach for measuring change in ecosystem services (ESS). The main purpose of running an evaluation using this framework is to facilitate the application of the ESS approach in the appraisal of the effects of innovative solutions on freshwater ecosystems and their services. This can be beneficial to make 'water-smarter' decisions by incorporating the view on freshwater ecosystems.

The framework consists of the DESSIN Cookbook the Companion Document: https://dessin-project.eu/?wpdmpro=dessin-cookbook-companion-document-draft-d11-2b. The DESSIN Cookbook presents the practical steps that the user should follow to apply the DESSIN ESS Evaluation Framework. It is intended as a practical guidance for running the evaluations and thus does not include elaborate descriptions of the concepts used (these are found in the Companion Document). The cookbook guides the user through the five parts of the evaluation framework, detailing and exemplifying the practical steps to follow in the application of the framework (Anzaldua *et al*. 2016a).

Framework, definitions and data population

Definitions

For the use of the framework an ecosystem, ecosystem services and sustainability of technologies can be defined as follows (Anzaldua *et al.* 2016b):

- Ecosystem: the environmental system of interest within a project (*e.g*., a surface or groundwater body, sub-catchment or catchment).
- Ecosystem services (ESS): the contributions that ecosystems make to human well-being. They are seen as arising from the interaction of biotic and abiotic processes and refer specifically to the 'final' outputs or products from ecological systems (Haines-Young 2011).
- Sustainability of technological solutions: a given technology or solution implemented to mitigate water scarcity or water quality issues is sustainable when it can actively support the supply of ESS demand while contributing to social, environmental, and financial development in a way that meets the needs of the present without compromising the ability of future generations to meet their own needs and contributing to good governance.

The overall framework

According to Anzaldua *et al*. (2016a) the DESSIN framework consists of five parts and its practical application can be broken down into eight steps. This is depicted in Figure 14 and briefly summarized in the following paragraphs.

In Part I of the evaluation, the environmental system of interest (*e.g.,* a surface or groundwater body, sub-catchment or catchment), *i.e.,* the ecosystem, must be defined and described and the local stakeholders must be identified. Furthermore, administrative details and objectives of the assessment must be declared (see Part I of Figure 14 below).

In the following steps of the process a general overview of the Drivers found in the area of study must be gathered and the Pressures resulting from them must be identified (Part II). Once these first two elements of the DPSIR scheme have been characterized, the claimed/expected capabilities of the proposed measures (*i.e.,* of the Responses) must be examined to determine if their effect would be on Drivers, Pressures, State or a combination of these. This can be used to develop a list of case relevant ESS. Subsequently, and on the basis of the potential beneficiaries found in the area, case relevant ESS are further categorized into final ESS and intermediate ESS (Part III).

After the important Drivers, Pressures, claimed/expected capabilities, case relevant ESS and beneficiaries have been identified in Parts II and III, changes in ESS resulting from the proposed measures should be estimated. This is carried out in Part IV. Here, parameters and indicators used to estimate changes are selected and the changes are quantified. It must be noted that when the framework is used to evaluate a proposed measure (as opposed to an already implemented measure), it is necessary to estimate the impacts of these innovative solutions as real-world evidence is not yet available.

A detailed application example for Part I until Part IV can be found in Gerner *et al.* (2018). In this paper results of the evaluation of a major river restoration project (River Emscher in Germany) and its effects on ecosystems and resulting ESS beneficiary for inhabitants can be found.

Finally, the sustainability assessment (SA) in Part V supplements the ESS evaluation.

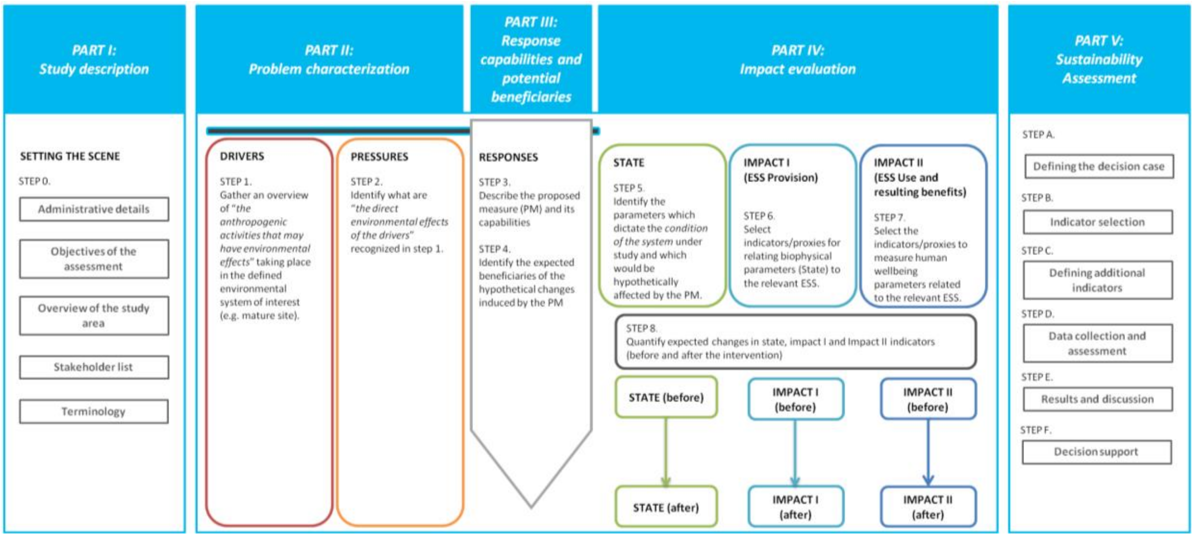


Figure 14: Practical steps for the application of the DESSIN ESS Evaluation Framework (Anzaldua *et al.* 2016a).

The SA allows the user of the DESSIN ESS Evaluation Framework to widen the analysis, putting the evaluated changes in ESS into perspective by considering multiple dimensions. These multiple dimensions include wider social, environmental, financial, governmental, and asset performance aspects of the examined solution. This allows for the consideration of potential disadvantages like costs and environmental effects (*e.g.,* additional greenhouse gas emissions) and their comparison with the advantages in terms of benefits expected from implementing the solution. The approach can be used to evaluate the effects of a single solution by assessing the baseline scenario and the after - implementation scenario. Another application can be to use the SA to compare alternative solutions and identify the one that seems most promising, taking a broad set of perspectives into account (Anzaldua *et al.* 2016a). In order to choose fitting metrics, indicators and units for assessing the effects of a technology there is a DESSIN Sustainability Indicator List available. It offers a consistent set of Dimensions, Objectives, Criteria and Metrics for sustainability assessments to choose from for a case specific assessment. The figure below shows how the indicators can be used to illustrate the use of a technology under different sustainability indicators. It shows how a system improvement in the water management system of Aarhus (Denmark) has been improved after new technology (after) incorporations compared to the baseline (before). The numbers in brackets refer to specific IDs for metrics from the DESSIN Sustainability Indicator List.

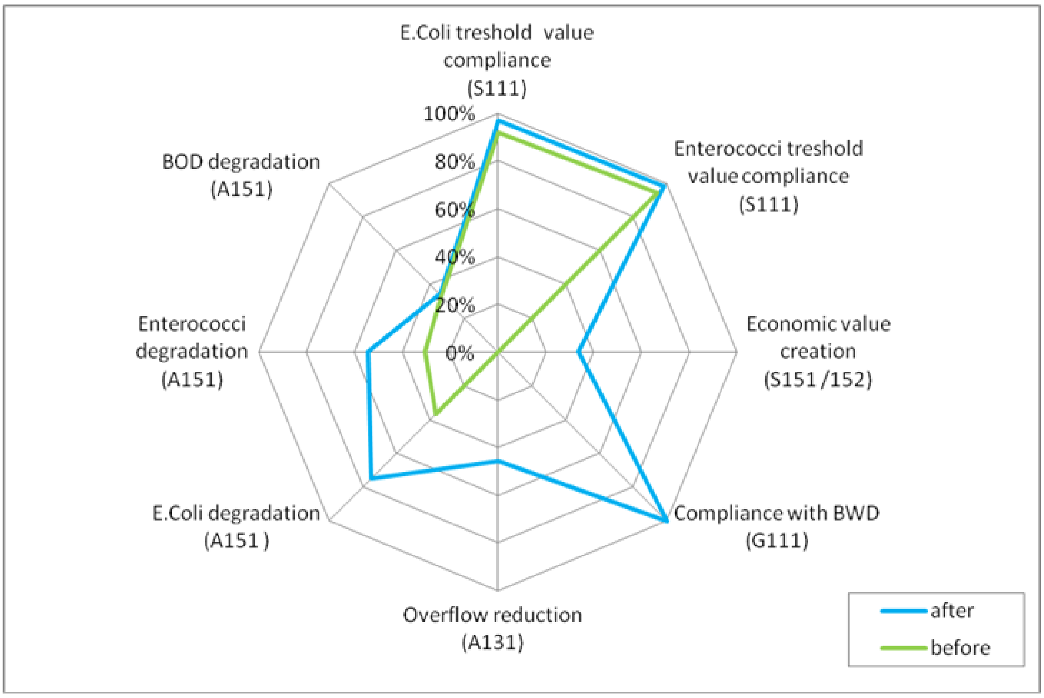


Figure 15: Spider plot for comparison of performance per indicator for the baseline scenario and the after-implementation scenario. Example based on Aarhus mature case study (Anzaldua *et al.* 2016a)

Key lessons for B-WaterSmart framework

1. For a water circular and water-smart system the freshwater ecosystems need to be incorporated in any operational or investment related decision; DESSIN offers tools for this aim.
2. The use of either the ESS-evaluation part from the DESSIN frame or of the SA-frame proved to be illustrative and applicable to inform water management decisions.
3. The framework offers the potential to include the environmental-economic perspective in the B-WaterSmart framework.

4. The framework offers the potential to include the sustainability perspective in the B-WaterSmart framework.

5.2.6 Governance Capacity Framework

Scope

Despite numerous potential solutions – available from existing scientific knowledge and practical experiences – many regions, cities and organisations have yet to find adequate responses to their water and circular economy challenges. Part of the problem is that most of these challenges transcend administrative boundaries and challenge us to go beyond traditional short-term and sectorial ways of governing, which have given little consideration to the long-term impacts on the entire hydrological and material flow cycle and the redistribution of risks, costs and responsibilities associated with circular solutions. In order to understand how we can better address these types of multifaceted challenges, a plethora of social factors and conditions have been identified that either impede or enhance our ability to act proactively. However, most of these studies focus on specific case studies or have a conceptual nature, which limits their usefulness and learning value beyond the individual context or scientific discipline. Hence, a diagnostic framework is required that integrates existing knowledge to facilitate the accumulation of coherent and empirical research that can enable the comparison among cases and provide conceptual clarity and coherence necessary to support circular solutions in practice. Water and circular economy challenges often transcend administrative boundaries and include many different organizations each with different responsibilities and interests. Therefore, the governance capacity framework is problem oriented instead of focusing on a single institution.

The framework measures 'governance capacity' by analysing how well organisations, multi-level governments and stakeholders collaborate in solving a common water-related challenge. By assessing specifically defined challenges, the framework supports specific, concrete, and applicable outcomes to and through experts and practitioners in the field. Accordingly, the framework has been applied to assess multiple water, climate and circular economy challenges at the city and regional level across the globe. More specifically detailed assessments have been published with respect to the Circular Economy (*e.g.,* Ddiba *et al*. 2020; Steflova *et al*. 2019,2021), water scarcity (*e.g.,* Madonsela 2019; Schreurs *et al*. 2018), wastewater treatment (*e.g.,* Kim *et al*. 2018; Aartsen *et al*. 2018; Rahmasary *et al*. 2019, 2021), flood risk (*e.g.,* Koop *et al*. 2018; Brockhoff *et al*. 2019).

Framework, definitions & data population

Governance capacity is defined as "the key set of governance conditions that should be developed to enable change that will be effective in finding dynamic solutions for governance challenges of water, waste, and climate change in cities" (Koop *et al.* 2017). The framework consists of three dimensions, nine conditions and 27 indicators (Table 6). For each of the 27 indicators, a Likert-type scoring scale has been developed, which ranges from very encouraging (++) to very limiting (−−) to the governance capacity: https://library.kwrwater.nl/publication/61397218/. Each indicator has a pre-defined question that has to be answered by the researcher based on policy analysis, literature review, expert interviews and their feedback. The answer consists of a score and more importantly a substantiation of the score by providing arguments supported by existing plans, policies and expert input.

Dimensions	Conditions	Indicators
Knowing	1 Awareness	1.1 Community knowledge
		1.2 Local sense of urgency
		1.3 Behavioral internalization
	2 Useful knowledge	2.1 Information availability
		2.2 Information transparency
		2.3 Knowledge cohesion
	3 Continuous learning	3.1 Smart monitoring
		3.2 Evaluation
		3.3 Cross-stakeholder learning
Wanting	4 Stakeholder engagement . process	4.1 Stakeholder inclusiveness
		4.2 Protection of core values
		4.3 Progress and variety of options
	5 Management ambition	5.1 Ambitious and realistic management
		5.2 Discourse embedding
		5.3 Management cohesion
	6 Agents of change	6.1 Entrepreneurial agents
		6.2 Collaborative agents
		6.3 Visionary agents
Enabling	7 Multi-level network. . potential	7.1 Room to manoeuvre
		7.2 Clear division of responsibilities
		7.3 Authority
	8 Financial viability	8.1 Affordability
		8.2 Consumer willingness to pay
		8.3 Financial continuation
	9 Implementing capacity	9.1 Policy instruments
		9.2 Statutory compliance
		9.3 Preparedness

Table 6: The water Governance Capacity Framework (GCF). The GCF consists of nine conditions, each defined by three indicators.

The actual assessment of the framework consists of three steps:

1. A preliminary score of each indicator based on a written substation from a desk study of policy documents, plans, reports, and scientific literature.
2. Based on a standardised stakeholder analysis, interviews with key experts are conducted. At least 3 to 5 experts per indicator have to be interviewed. Their input is (anonymously) incorporated in the score substantiation.
3. The experts are given the opportunity to provide feedback on the preliminary scores and substantiations of these scores. The final score is determined by the independent researcher and is based on arguments and scoring criteria.

The standardised methodology and scoring system and assessment steps are operationalised in a software that allows maximum transparency and protection of personal data simultaneously. In this way, interview recordings a safely stored in a database and different tiers of access allows for different users to enter the data. The final scores of the indicators are ranked clockwise from most limiting (--) to most encouraging (++) the overall capacity to address a water or circular economy challenge. Figure 16 and Figure 17 provide an example for the city of Amsterdam, the Netherlands.

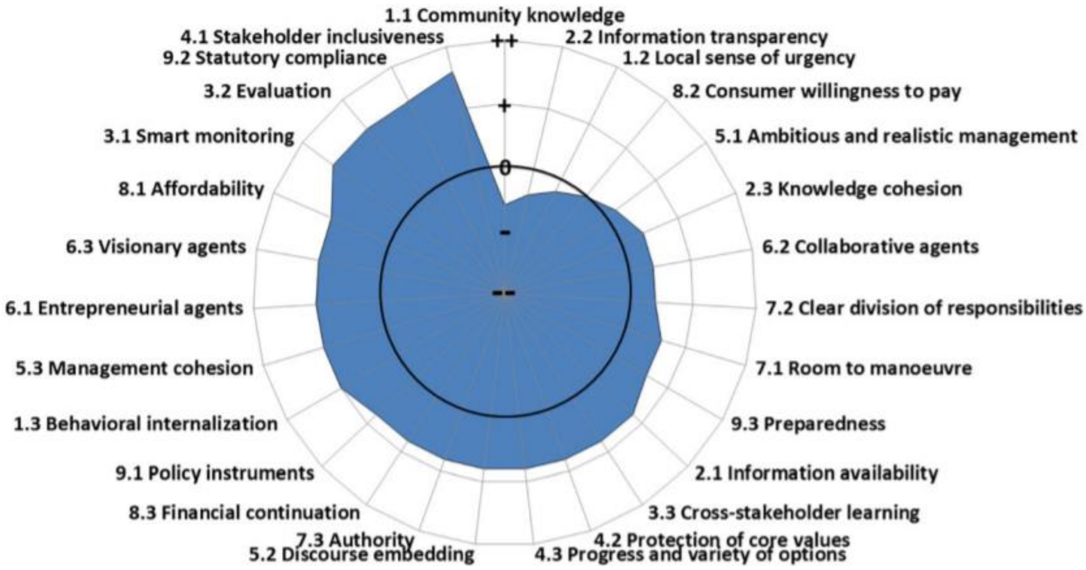


Figure 16: Overview of the governance capacity of the city of Amsterdam. The 27 indicators scores are ranked clockwise from low to high. Scores range from very encouraging (++) to very limiting (–) to the governance capacity that is a prerequisite for finding dynamic solutions to address the identified governance challenges (Koop *et al.* 2017).

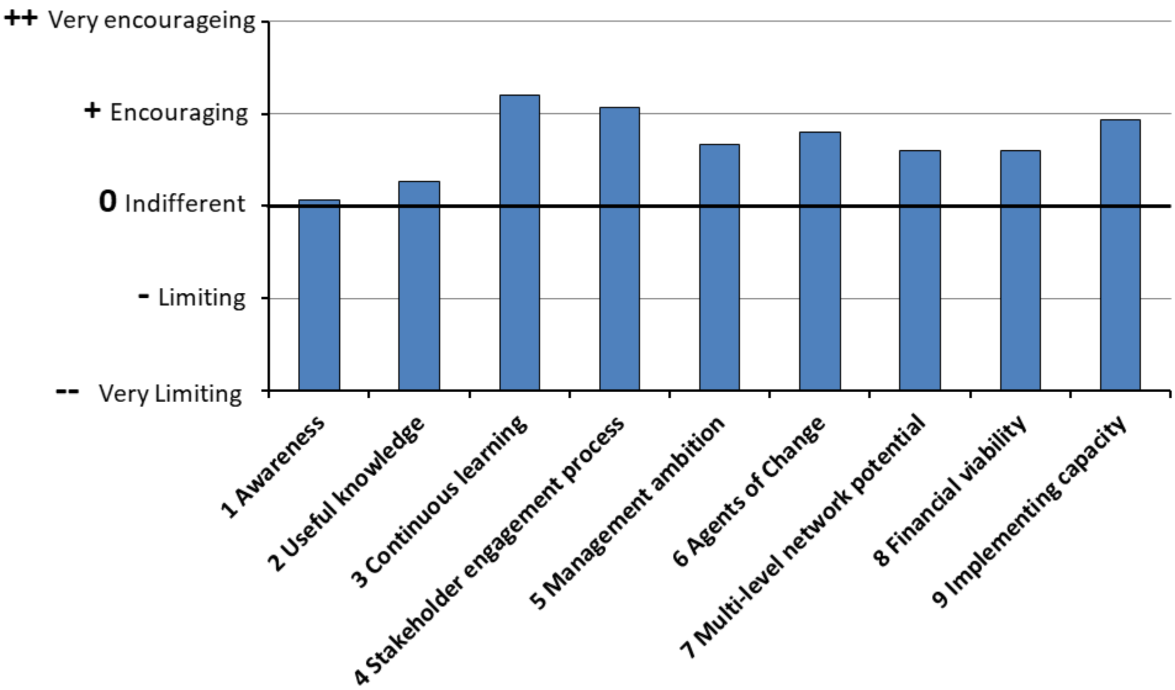


Figure 17: Overview of the governance capacity of the city of Amsterdam. Each of the nine conditions is an average of three indicators showed in Figure 16. Scores range from very encouraging (++) to very limiting (–) to the governance capacity that is a prerequisite for finding dynamic solutions to address the identified governance challenges (Koop *et al.* 2017).

Key lessons for B-WaterSmart Framework

1. Beyond the obvious challenges of applying circular systems in a technical and operational fashion, governance is widely regarded as an essential enabler. Accordingly, the LLs have expressed the relevance of the topic in the workshop about formulating strategic objectives. The governance capacity framework provides a standardised and applicable framework that provide structured and specific discussion of governance challenges and solution pathways. Due to the experience of applying the framework in over 40 cases across many contexts, it can provide key benefits for B-WaterSmart LLs.
2. The framework is applicable in terms of required resources and data demand. Since the assessment can vary from 1 month for an in-depth analysis or alternatively a shorter more pragmatic application in about a week. In particular, yearly assessments enable quicker application of the framework is particularly able to show the particular that has been made in terms of collaboration and governance of the CE challenge.
3. The method is standardised and reproducible and is based on independent research through a co-production process with local experts. Key benefit is that the results are therefore more incorporated action points while remaining rather unbiased through the independent research that performs the assessment in this transparent and reproducible fashion.

5.3 Synthesis

Based on these six frameworks, common denominators or overall lessons that serves as points of references in the development and application of the B-WaterSmart framework can be identified. These points of reference can be summarised as:

1. Parsimony, structure & simplicity

Focus on a specific end-user is essential to reduce complexity, data demand and support decision-making processes. Particularly for supporting strategic decisions, parsimony, structure and simplicity is called for. A distinction between *i.* essential or core metrics and *ii.* complementary metrics, supports these principles of structure and parsimony but also maintains options for more in-depth analysis to serve individual demands.

2. Governance is key

There is large recognition for the importance of 'good governance' for achieving objectives like sustainable water services, infrastructure assets management, ecosystem services and urban resilience. This is often addressed by a separate, supportive category or dimension in the frameworks. The governance capacity framework is an exception, this framework is solely focused on assessing governance capacity.

3. Ensure reproducible knowledge co-production

Clear standardized guidelines in data collection and score calculation are essential to ensure reproducibility. Most frameworks require an independent researcher(s) that coordinate a knowledge co-production process including a wide diversity of stakeholders as well as data-quality assurance. It improves data accuracy but also enhances recognition and eligibility of the results. In short, it is much more likely that the end-user will use the framework to make decisions if the results are obtained through a standardized knowledge co-production process.

4. It is all about visualisation

All frameworks feature advanced visualisation support. Visualisation is essential for both tactic-strategic optioneering as well as for strategic prioritization and balancing of interests and values. Visualisation is particularly powerful if visualisation features correspond with the frameworks structure.

5. The power of goal-oriented communication

All the six frameworks report their metrics, criteria and objectives in a goal-oriented manner, and this is for good reasons. It enables quick and correct interpretation, aligns with the end-users' motivation to use the framework, it allows for tailored assessment outputs, enhances accountability and priorities are more easily recognized. Often reference values as well as various targets are used for goal-oriented communication of the framework's results.

6. Enhance adaptive & anticipatory capacity

Most frameworks enable a performance assessment of different long-term scenarios or fundamental system designs as well as the implications of various decisions and management approaches. In short, a framework is better able to support decision-making if it can anticipate future scenario's and enhances the capacity adapt to more unexpected events by accounting for risks, costs and benefits of water-smart systems.

6 The B-WaterSmart Framework scope, concept and design

6.1 Scope of the Framework

Based on the lessons and experiences from related frameworks (Chapter 5) and careful consideration of user needs as expressed by the LL (Chapter 3) on both the definition and envisioned added value, the objectives of the framework are to:

1. support LL problem owners in their objective-oriented strategic planning process;
2. assist LL owners and practitioners to assess gains in the process of achieving long-term strategic objectives in a non-prescriptive, transparent, consistent, credible, stakeholder-based and easy-to-use way;
3. help policy-makers and decision-makers overcome existing barriers and implement their strategic agendas towards a water-smart society in support of development priorities in a sustainable way; and
4. enable benchmarking by providing a minimum set of metrics that can be used for comparisons in relation to one's own objectives, in time and with other LLs.

Using an integrated approach, the framework aspires to constitute an assessment tool to be applied at the strategic level of decision-making.

6.2 Framework development - a process outline

The methodology followed in this deliverable to design the B-WaterSmart framework combines a literature review of assessment tools, presented in Chapter 5, with LL owners inputs collected through a series of interviews and workshops. The consultations were used to understand the needs, requirements and expectations of the B-WaterSmart practitioners, while the literature review was conducted to highlight good practice and lessons learnt using different types of tools.

The outcomes of the literature review, LL owners' interviews and consultations have been integral in developing the suggested concept and design of the framework outlined in this report.

The work performed in WP6 to create the B-WaterSmart Framework follows two parallel paths (Figure 18): defining the deployment "Methodology" (Part A), guiding the user on how to apply the framework in order to assess the performance against set objectives, and building the "Content" (Part B), consisting of structured libraries of strategic objectives, assessment criteria and metrics to be selected when applying the framework. As such, part B, the "Content" of the Framework, is under creation in a collaborative environment with the LL owners and in collaboration with WP1. Both Parts, A and B, will be further detailed, developed (Tasks 6.2), refined and tested (Task 6.3), through dedicated workshops. The basis for this interactive process with the LL owners has already started and a preliminary list of strategic objectives, contributing to Part B, have been drafted as presented in the following sections. In due time, the Innovation Alliance (InAll), will also contribute significantly for both Parts, A and B (Task 1.4).

Once the final version of the B-WaterSmart Framework (V_2) will be finalized by WP6 at M30 (D6.3), Part A and Part B will be implemented in the dashboard by Task 3.9 (as described in Section 6.5).

Therefore, the description provided in this deliverable is intended as initial proposal to start the development interactive co-production process to arrive to a final framework to assess water smartness: The B-WaterSmart Framework.

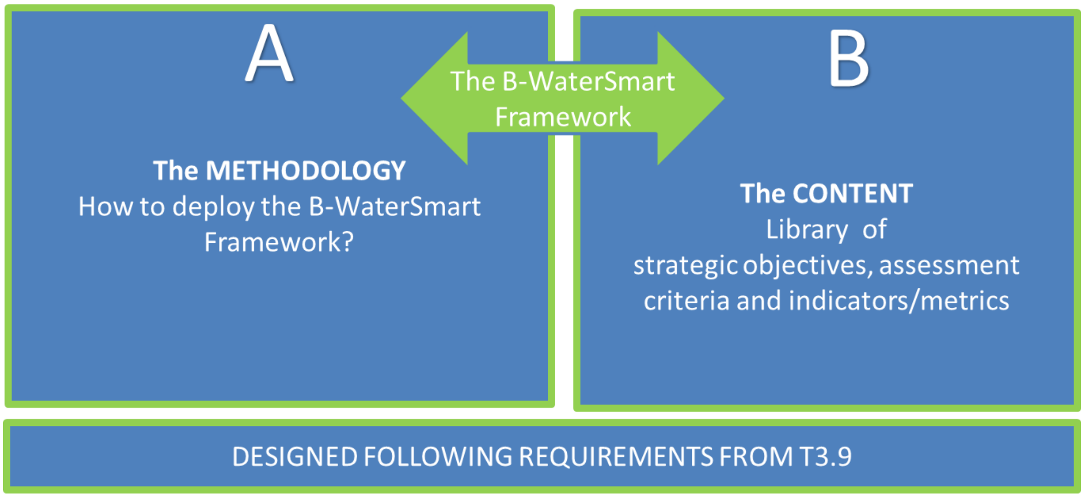


Figure 18: The complementary elements of the B-WaterSmart Framework creation

Next, the Section 6.3 provides a first outline of the B-WaterSmart Framework content (Part B in Figure 18), while the methodological process to be followed by a user in deploying the framework (Part A in Figure 18) is described in Section 6.4.

6.3 The B-WaterSmart Framework – A first outline

To facilitate the collaboration in developing the content of the Framework and its future use, a set of key definitions has been developed to ensure a common understanding of the terminology that is applied. For instance, definitions and interrelations between the Framework's dimension, strategic objective, assessment criteria and metrics are provided. A full glossary of reference is provided in the APPENDIX.

The B-WaterSmart assessment taxonomy has five dimensions, reflecting the dimensions of sustainability transitions: *i.* social, *ii.* environmental, *iii.* economic, *iv.* technical and *v.* governance. Each dimension is characterized with a list of selected strategic objectives. Each objective is specified by assessment criteria as points of view that allow for the assessment of the objectives. Each criterion in turn is described with a set of indicators or metrics which will serve to assess the distance from a set target (Table 7).

Dimension	Strategic objectives	Assessment criteria	Metrics

Table 7: The back-bone structure of the B-WaterSmart Framework

6.3.1 The five dimensions

"Dimensions" describe the value-components within the concept of "water-smart society". The B-WaterSmart Framework adopts five dimensions, as in TRUST, which reflect the relevant aspects characterizing a water-smart society. The strategic objectives and criteria apply to all LLs, for the metrics some level of tailoring is permitted resulting is a maximum of about 25% of the metrics being site specific. The dimensions are i. social, ii. environmental, iii. economic, iv. technical and v. governance. The social, environmental, and economic dimensions are "core dimensions" reflecting the 3Ps of sustainability, where Ps refer to People, Planet, and Profit, also often referred to as the triple bottom line, while the last two dimensions are considered as preconditions for water-smart societies.

The **social dimension** is reflecting the ambition of a water-smart society in contributing to life-enhancing relations within the affected communities. It includes the enhancement of quality of life, in terms of health and safety, socioeconomic impact creation, employment, equitable distribution among users and realization of cultural values, but also the active engagement of citizens as fundamental actors in the transition process. Assessment criteria and metrics related to the strategic objectives under the social dimension will be aligned with the work performed under WP5.

The **environmental dimension** includes all direct impacts of solutions implementation on the environment as well as preservation and protection of the environment under different scenarios of change (including climate changes). Environment can refer to urban environment, natural environment, ecosystems: the different characterizations will be expressed through the adoption of adequate assessment criteria. The main objectives in the environmental dimension are to ensure an efficient use of resources and avoid undesirable environmental impacts. Assessment criteria and metrics related to the strategic objectives under the environmental dimension will be aligned with the impact that activities performed in the LLs might have to the environment and it is expected to be related with the work performed mainly in WP2, WP3 and in part inspired by WP4.

The **economic dimension** checks the affordability, the ability to promote circular business models and develop new markets around the value of water. Economic strategic objectives, assessment criteria and metrics will be aligned with the work performed under WP4 to ensure the B-WaterSmart Framework can assist in measuring the level of circular economy opportunities implementation and feasibility.

The **technical dimension** reflects the level of performance of a given innovative solution in providing expected functions, to be defined in the context of the project objectives and which will characterize the list of selected assessment criteria and metrics. The criteria and the metrics will have to facilitate the assessment of level of progress in achieving technical strategic objectives, which, at this stage are identified as the ability to transform water systems from being passive to being pro-active and adaptive and the ability to shorten the water distribution and use chains. Assessment criteria and metrics related to the strategic objectives under the technical dimension will be aligned with the work performed under WP2 and partially 3.

The **governance dimension** reflects the fundamental role of good governance to enable the transition process towards water-smart societies, by way of reliable management, stakeholder's engagement, cohesive policies and processes, as well as sufficient awareness, statutory compliance, coordination and financial viability. Assessment criteria and metrics related to the strategic objectives under the governance dimension will be aligned with the work performed under WP4 and WP5.

6.3.2 Methodology towards the preliminary list of strategic objectives

A clear definition of strategic objectives is core to the development of the Framework content, and it is often one of the most challenging steps for the development of a successful strategic plan. Therefore, much time was dedicated by Task 6.1 to come up with a list of strategic objectives in close collaboration with the LL owners. The current agreed list, depicted in Table 8, has not to be considered as final, since further refinement will surely become necessary along the progress of developing the LL's strategic agendas (WP1).

Up to now, two types of interactions with the LLs, a LL specific workshop (only LL mentor and LL owner) and a joint workshop with all LLs, were performed under the coordination of WP1 with material and information provided by WP6. With regards to the expected inputs to this deliverable, the goals of the interviews were to generate in-depth knowledge on the LL specific long-term strategic objectives, to define intermediate goals/targets and to gather feedback from the LL owners on a first version of water-smart society definition provided by WP6.

To facilitate the discussion on formulating strategic objectives, each LL owner was asked to prioritise 10 preliminary strategic objectives with a ranking. The results of this exercise formed a point of departure for the discussion. The LL owners had the option to prioritise any of the preliminary strategic objectives defined by WP6 but was also explicitly provided with the opportunity to change and add strategic objectives according to their user needs and vision of a water-smart society. The only requirements of the long-term strategic objectives were that they are mindful of the overall B-WaterSmart project objectives, and that ideally the long-term strategic objectives should reflect the perspectives of the strategic decision-making level of the LL owner's organisations.

The methodology adopted in planning and running the interviews, as well as the questions posed and the LL owners' feedback, are presented in the B-Water Smart milestone 6 (MS06). For the purpose of this deliverable, the table reflecting the questions guiding the interviews is extracted from MS06 as Figure 19.

The answers provided to the questions related to the level 3 "Preliminary water smartness definition" served the co-development of the definition of "water-smart society" to be adopted by the project, as presented in Chapters 3 and 4.

The answers to the level 1 of questions "Long-term strategic objectives" have been the foundation for the identification of the preliminary list of strategic objectives to be included in the Framework.

The answers to the level 2 of questions "Intermediate goals/targets" have more direct relevance for the formulation of the strategic agendas in WP1, but the information obtained will be also used in Task 6.2 as starting points to identify the "points of views" for the assessment of the objectives. More specifically, the answers will be used to develop assessment criteria that better reflect the LLs' challenges and the barriers responsible for the current distance from the set objectives. Some "Intermediate goals/targets" formulated by the LL owners in MS06 could also be interpreted as "milestones" (see Section 6.4), *i.e.,* a list of intermediate actions which might need to be accomplished at a given time in the process of achieving the strategic objectives. Either way, the information provided are valuable and will be used also in WP6, besides WP1, to inform the definition of the assessment criteria or the identification of actions to be accomplished along the process of becoming water-smart.

Present the ranking of strategic objectives	On this basis are there any strategic objectives not represented here? If so, what is missing?
1) Long-term strategic objectives (Repeat this block of questions for all identified objectives)	Why is the objective important? (What is emphasised by the LL owner?)
	What concerns them and/or do they aspire to?
	How far are they from the objective? What intermediate goals can be set?
	What are the drivers, barriers, challenges to reach the objective with respect to technical, economic, social, policy, regulatory (reuse water, waste, energy) terms?
	Is the objective already being measured? How could it be measured? Are there any assessment tools that might be promising?
2) Intermediate goals/targets	Are there any steps already implemented or planned to reach these goals? If not, what would be the intermediate steps to take?
	What would be the drivers, barriers, challenges (technical, economic, social, policy, regulatory (reuse water, waste, energy)) for the implementation or planning of those goals/targets?
Do your answers to the above questions reflect the position of your organisation's top decision-makers? What would be different and why? How can we incorporate this difference in the objectives to be defined now?	
Do you think that the above questions reflect a consensus for the region? If these questions were discussed at the CoP, do you expect the results to be similar or very different? What would be the major difference?	
3) Preliminary water smartness definition	Does the definition reflect your understanding on water smartness? What are the key dimensions that should be contained in the definition?
	Are there any keyword that should be included in the definition? What is missing? What are other dimensions and criteria to be considered?

Figure 19: Screenshot of Table 1 in MS06 presenting the list of questions posed to the LL owners to define a preliminary list of strategic objectives.

Based on the specific answers per LL, the task of WP6 has been to extrapolate the formulation of strategic objectives per dimension reflecting the requirements of each LL; in some cases, strategic objectives were formulated with different wording, but aiming at the same content, therefore only one formulation was selected. The resulting current list is depicted in Table 8. Populating the table with the rest of the content reflecting the water-smart society vision of the LLs is part of the future work of WP6, Task 6.2.

Dimension (Selected dimensions)	Strategic objectives (Preliminary list)	Assessment criteria	Metrics						
				Living Labs					
				1	2	3	4	5	6
SOCIAL	1. Ensuring water for all	1.1…	1.1.1…						
			1.1.2…						
		1.2…	1.2.1…						
SOCIAL	2. Safeguarding health								
SOCIAL	3. Achieving social acceptance								
ENVIRONMENTAL	4. Becoming a low emission society and a sustainable city								
ENVIRONMENTAL	5. Conserving the environment								
ENVIRONMENTAL	6. Becoming resilient to climate change especially to floods/droughts								
ECONOMIC	7. Identifying business models to promote the extraction of value from water (circular economy) and fostering/sustaining policies revision								
ECONOMIC	8. Promoting sustainable and circular business models related to water smartness								
TECHNICAL	9. Extracting value from water by transforming water systems from passive to active, adaptive								
TECHNICAL	10. Shortening the distribution and use chains								
GOVERNANCE	11. Raising and creating awareness among stakeholders on water smartness opportunities in a circular context								
GOVERNANCE	12. Developing innovative governance systems centered on the water value								

Table 8: Current list of dimensions and strategic objectives of the B-WaterSmart framework, with an overview of the complete matrix to be further developed.

From the LL interviews the relevant role of governance in achieving a water-smart society was emphasized, particularly through raising awareness among stakeholders on opportunities in circular context and the development of innovative governance systems centred on the value of water, as reflected by the strategic objectives 11 and 12 in Table 8. However, governance typically tends to be an intangible and ambiguous concept. Therefore, in preparation to the next step of populating the framework with assessment criteria and metrics, an illustrative draft proposal is provided of how to move from the strategic objectives to the metrics, starting from this most ranked and relevant dimension: "Governance". The objectives, assessment criteria and metrics presented in the example are still work in progress but are used here just for illustrative purposes. The illustration explains and anticipates the work that will be performed in close collaboration with relevant WPs within Task 6.2 from M10 for all the dimensions and all the strategic objectives.

The next steps in the development of Part B will be to finalize the list of objectives, provide for each objective a set of criteria and for each criterion there must be corresponding metrics, following, for each dimension, the approach presented below for the Governance dimension. Instructions on how to define the assessment criteria and the metrics (and by whom and when within the project) are provided respectively in Sections 6.6 and 6.7.

6.3.3 From strategic objectives to assessment criteria and metrics: The Governance dimension as use case

In this section, the approach that will be followed by Task 6.2 in further revising the strategic objectives and identifying meaningful assessment criteria and metrics supporting the process of transition of the LL towards a water-smart society is illustrated with the governance dimension as example to be also further consolidated.

As anticipated above, the LLs explicitly emphasized the role of governance in achieving water-smartness. Particularly through raising awareness among stakeholders on water smartness opportunities in circular context and the development of innovative governance systems centred on the value of water. Their observation was that governance is not necessary an objective in itself, but a means to reach an end. Although good governance is often considered a cornerstone in achieving objectives such as water-smartness and CE solutions, governance typically tends to be an intangible and ambiguous concept. The very principle is that most challenge cannot be addressed by a single organisation or a single policy. It rather is a joint outcome of various public and private stakeholders at various levels (*e.g.,* regional, national or European). The capacity of these stakeholders to work together and address these common challenges is often considered to be the essence of good governance.

Water-smart approaches often benefit from (temporary) adjustments of regulations through pilots or experiments that - if they proof to be successful - require upscaling. This upscaling typically requires policy adjustment. Simultaneously, responsibilities, costs and risks are deliberately or implicitly redistributed. Hence, such upscaling is an impeccable example of how good governance is essential for mainstreaming water-smart solutions. In recent decades, this more horizontal type of decision-making has replaced the more traditional hierarchical command-and-control approach that used to reside with public authorities. Nowadays, this more horizontal public-private effort to jointly account for risks, costs and revenues associated with innovation and policy development is commonly described as ‘governance’ (Kettl 2000; Stoker 2000; Swyngedouw 2006). Accordingly, the ability of all relevant public and private stakeholders to address a common challenge can be described as ‘governance capacity’.

Governance capacity to address a water challenge can be considered as a balanced set of conditions that need to be well developed. In order to monitor, evaluate and improve governance processes that attempt to address circularity challenges, it is necessary to break-down this complex and often ambiguous notion of governance into measurable units that can be assessed on a regular basis. In order to provide such an assessment, the strategic objectives, criteria and metrics related to governance need to be specific and obtained through a standardised data collection process.

Therefore, an existing framework – the governance capacity framework - is assimilated into the B-WaterSmart framework (Section 6.5). Accordingly, the proposed metrics will be scored through a standardised knowledge co-production approach software consisting of i. literature studies, ii. stakeholder interviews and iii. stakeholder feedback on preliminary results that are determined through (an update of) a standardized scoring scale method: https://library.kwrwater.nl/publication/61397218/. The time required for a full assessment of the proposed metrics for the governance category is moderate ranging from one week to one month.

The identified strategic objective 11, in Table 8*, to raise and create awareness among stakeholders on water smartness opportunities in a circular context* is supported by three assessment criteria acquired from the Governance Capacity Framework. These assessment criteria are i. the level of awareness, ii. the accessibility to useful knowledge and iii. the capacity to learn continuously (Table 9). Each assessment criterion has three metrics. The level of community knowledge, sense of urgency and behavioural internalisation are metrics (11.1.1 to 11.1.3) for *awareness* of water-smart opportunities. Similarly, the availability, transparency, and level of cohesion of knowledge are the metrics (11.2.1 to 11.2.3) for *useful knowledge* about water-smart systems. Finally, the ability to monitor, evaluate and have cross-stakeholder learning form the metrics (11.3.1 to 11.3.3) for the assessment criteria *continuous learning* about solution pathways to achieve water-smartness.

Strategic objective	Assessment criteria	Metrics
11. Raising and creating awareness among stakeholders on water smartness opportunities in a circular context	11.1 Awareness	11.1.1 Community knowledge
		11.1.2 Local sense of urgency
		11.1.3 Behavioural internalisation
	11.2 Useful knowledge	11.2.1 Information availability
		11.2.2 Information transparency
		11.2.3 Knowledge cohesion
	11.3 Continuous learning	11.3.1 Smart monitoring
		11.3.2 Evaluation
		11.3.3 Cross-stakeholder learning

Table 9: The assessment criteria and the metrics related to the strategic objective 11 (in Governance)

In order to *develop innovative governance systems centred on the value of water* (strategic objective 12 identified by the LLs in Table 8), there needs to be a *level of ambition* propagated through inclusive decision-making, goals and by individuals as well as an *enabling environment* to coordinate, fund and implement governance systems centred on the value of water (splitting the objective 12 in two more specific ones). Therefore, in further interaction with the LL owners the option of breaking down the strategic objective will be discussed; for convenience those 2 objectives are here denoted with 12a and 12b, to not change the current numbering of the objectives. As said, the preliminary list of agreed objectives will be revised by the LL owners, in line with the progress of WP1 activities and therefore a revised list is expected as final one adopted in the project. This section also serves to explains the dynamic of the interactions between the LL owners and the WP6 team and give perspective on the actual future steps to be undertaken (*i.e.,* revising the governance objectives proposed by the LL based on literature insights).

The *establishing a common level of ambition* (strategic objective 12a) to account for the value of water (Table 10) consists of three assessment criteria: i. stakeholder engagement process, ii, management ambition and iii. agents of change. *Stakeholder engagement process* accounts for inclusiveness (metric 12a.1.1), integrity (metric 12a.1.2) and smooth process (metric 12a.1.3) of jointly accounting for the value of water. *Management ambition* is featured by assessing whether goals are ambition and yet also realistic, if the ambitions are also embedded in the existing management discourse and if the ambition is also supported by a cohesive management structure (metrics 12a.2.1 to 12a.2.3). Finally, individuals that mobilize the required local resources (metric 12a.3.1), bring stakeholders together (metric 12a.3.2) and provide a long-term vision that accounts for the value of water (metric 12a.3.3) are included in the assessment criteria *agents of change*.

Strategic objective	Assessment criteria	Metrics
12a. Establishing a common level of ambition to account for the value of water	12a.1 Stakeholder engagement process	12a.1.1 Stakeholder inclusiveness
		12a.1.2 Protection of core values
		12a.1.3 Progress and variety of options
	12a.2 Management ambition	12a.2.1 Ambitious and realistic goals
		12a.2.2 Discourse embedding
		12a.2.3 Management cohesion
	12a.3 Agents of change	12a.3.1 Entrepreneurial agents
		12a.3.2 Collaborative agents
		12a.3.3 Visionary agents

Table 10: The assessment criteria and the metrics related to the strategic objective 12a (in Governance)

Finally, the *enabling environment to implement water-smart solutions* (Table 11) consists of three assessment criteria: i. multi-level network potential, ii. financial viability and iii. implementing capacity. The assessment criteria *multi-level network potential* assesses the freedom and opportunity of stakeholders to develop a variety of solutions (metric 12b.1.1), if the division of responsibilities is clear (metric 12b.1.2) and to what extend the value of water is embedded in formal forms of authority (metric 12b.1.3). *Financial viability* is an important enabler of water-smart solutions and is featured into affordability and willingness to pay for water-smart solutions as well the financial continuation of schemes and processes (metric 12b.2.1 to 12b.2.3). Finally, *implementing capacity* is assessed through how well policy instruments are used to enhance water-smartness (metric 12b.3.1), the extent of statutory compliance (metric 12b.3.2) and preparedness for issues like water and resource scarcity.

Strategic objective	**Assessment criteria**	**Metrics**
12b. Enabling environment to implement water-smart solutions	*12b*.1 Multi-level network potential	12b.1.1 Room to manoeuvre
		12b.1.2 Clear division of responsibilities
		12b.1.3 Authority
	12b.2 Financial viability	12b.2.1 Affordability
		12b.2.2 Consumer willingness to pay
		12b.2.3 Financial continuation
	12b.3 Implementing capacity	12b.3.1 Policy instruments
		12b.3.2 Statutory compliance
		12b.3.3 Preparedness

Table 11: The assessment criteria and the metrics related to the strategic objective 12b (in Governance)

6.4 How to use the B-WaterSmart framework

This section presents the proposed deployment "Methodology", Part A. The definitions of the terms applied ("reference value", "target", "milestone", "scenario" and "alternative") are provided in the APPENDIX of this document. Furthermore, instructions on how to set reference values and targets, mentioned in the description below, are provided in Section 6.8.

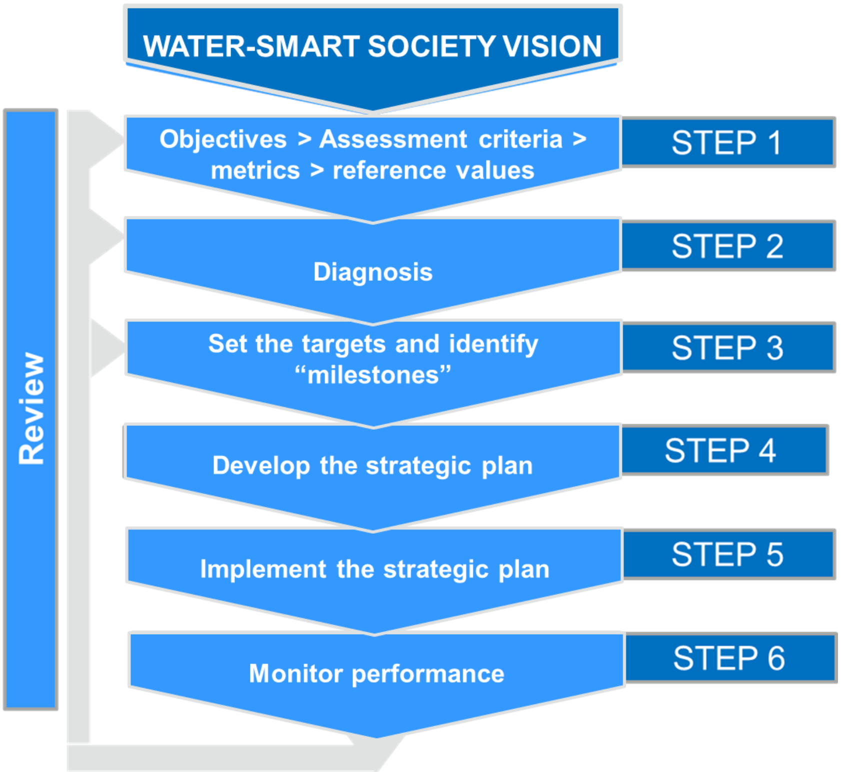


Figure 20: The iterative six-step process to meet the water-smart vision proposed for the deployment of the B-WaterSmart framework.

As depicted in Figure 20, an iterative six-step process for continuously improving the transition process to a water - smart society is proposed as deployment methodology, and it comprises, at the current stage of development, the following steps:

- **STEP1 – Selection of strategic objectives, assessment criteria, metrics and reference values**

  Step 1 is a crucial stage to set up clear directions of action, as well as accountability of results through timely review. It consists of the definition, by the strategic management decision level, of clear objectives, assessment criteria, metrics to assess them, and finally, reference values for every metric. The strategic objectives are grounded on the water-smart society vision and their definition requires proficient knowledge of the context.

  - Once the metrics have been selected, it is important to identify their measurement details, such as definitions, measurement units, who collects the data and the frequency of data collection. It is important to check for metrics that are already being monitored for other purposes and to include these in the metrics sets. It is also important to narrow the selection of the relevant metrics instead of using an overly large set. Guidelines on data collection, also to ensure reproducibility, will be provided within Task 6.2, by M24.

- **STEP 2 - Diagnosis**

  In order to decide how to act, it is essential to carry out a sound diagnosis to assess the reference situation using the established metrics. This step usually includes the collection and evaluation of relevant information (on the external context - global and stakeholder-specific - and on the internal context) and the assessment of the performance against the selected objectives. Assessing the reference situation allows to check progress over time by comparison with the results of assessments performed over time (*e.g.,* on regular yearly basis) or to assess the effectiveness of alternative solutions (see step 4). The diagnosis should also include scenarios (see the APPENDIX for further explanation about the scenarios) to enhance anticipatory capacity (see Section 6.5.2); scenarios are due to factors (isolated and/or combined) that may influence the analysis and should therefore be considered (*e.g.*, demographic trends, regulatory changes).

- **STEP 3 - Set the targets and identify "milestones"**

  The diagnosis allows to identify the performance against the set objectives; therefore, the user is now ready to set targets for each metric selected at STEP 1 to express the desired level of performance to be achieved for short, medium and long terms. To achieve the targets for each metric, a list of intermediate actions, "milestones", might need to be accomplished at a given time. At this step, the milestones[1] have to be defined as well as the time at which the action has to be completed.

- **STEP 4 – Develop the strategic plan**

  Following the diagnosis, alternative solutions (*i.e*., strategies, interventions, or actions, see more about alternatives in the APPENDIX) can be identified, assessed based on the same metrics, targets and scenarios previously considered, and compared between each other and with the reference situation, to select those resulting in a higher global value for organisation/city/region. The results should be expressed in a document, the strategic plan, that should be synthetic, clear, and effectively disseminated to all relevant internal and external stakeholders. The plan should contain a summary of the diagnosis and of the selected alternative solutions. The alternative solutions are not limited to alternative technological solutions, but to any change of practice related to the multiple dimensions of the framework (*e.g.,* alternative solutions to achieve set targets in awareness creation, under the Governance dimension).

- **STEP 5 - Implement the strategic plan**

  It consists of the actual implementation of the plan produced. The implementation involves executing the selected alternatives in the timeframe defined in the plan. Being outside the scope of the framework to guide the user on how to implement the plan, which has to be tailored on each specific case, it is encouraged to include in the plan the period in time at which the effects of the alternatives should be perceived so to schedule when to monitor the effectiveness of the plan, leading to the next step.

- **STEP 6 - Monitor performance**

[1] The milestones have been introduced to align with the concept of "Intermediate goals/targets" provided in the strategic agendas developed under WP1 (see MS06). In MS06, "Intermediate goals/targets" reflect actions to be accomplished, more than goals or targets to be achieved (*e.g.*, Stakeholders mapping completed). The terminology adopted by WP1 at that time led to be potentially misleading, having had different interpretations by the LLs. WP6 uses "milestones" to avoid confusion with the term "target" as desired level of performance and "objectives". The need to include the identification of milestones in STEPs 3 is not fully clear at this stage and it will require further interaction, along the activities of Task 6.2, with WP1 at later stage of maturity of the strategic agendas' development.

Monitoring and reviewing are critical for the continuous improvement process. To perform this step, users should develop a monitoring plan for monitoring and reporting metrics during the plan implementation – by whom, how often, quality assurance methods, and format for reporting.

The iterative six-step process here proposed, and the description of each STEP, will be further revised and detailed as part of the process of co-creation with the LL owners along the work to be performed in Task 6.2.

6.5 The B-WaterSmart Framework set up

This paragraph outlines a proposal for the key features of the B-WaterSmart framework and explains each of them based on both practical considerations provided by the LL owners through seminars performed in fall 2020 (see MS02) and lessons from other framework development trajectories as discussed in Section 5.3. Accordingly, the following aspects are addressed:

- Main users
- Main functionalities
- Frameworks' structure size
- Performance display & time frame
- Frameworks' deployment

It is expected that the B-WaterSmart framework will be made available to the LL owners as MS Excel spreadsheet to facilitate the feedback loop interactions.

The actual demonstration of the Framework will be performed with the use of the dashboard to be developed in WP3, Task 3.9. The dashboard will allow for visualization of the B-WaterSmart framework concept and provide the environment for the user to interact with the Framework. It can be seen as final module of the Framework, that allows users to get hands-on experience with the water-smartness concept. The dashboard will embrace novel approach to the data visualization by encompassing circular economy and social aspect, together with technical parameters in one dashboard. To accomplish this, advanced visualization techniques will be used.

The dashboard will be powered by FIWARE (https://www.fiware.org/). FIWARE is an open-source platform providing a set of standards which enable development of smart solutions. FIWARE is commonly used in diverse sectors to support the technology behind Smart Cities, Smart Farming, Smart Industry, *etc*.

Different FIWARE tools (https://www.fiware.org/developers/catalogue/) like *WireCloud, Knowage, Kurento* will be assessed for the suitability for the water sector. Furthermore, visualization tools including *Tableau* and *Infogram* might be used for better effect. The use of those tools will help understand and analyse the data as well as present them in a visually attractive way. Additionally, gamification, an approach of using elements of game-design in non-gaming environment might be applied. This is expected to attract the users and increase their engagement.

Firstly, V_2 of the B-WaterSmart framework will be developed into early prototype dashboard by Task 3.9 (M36), which will be available for testing. The final prototype of the dashboard fully deployed online will be developed after receiving feedback from the LLs.

6.5.1 Main Users

To ensure that the B-WaterSmart framework can support water-smart decision-making through a practice-oriented framework, the first question that needs to be answered is ‘who is going to use the framework and in what way?’. Lessons from other frameworks indicate that frameworks can be used for multiple purposes by different end-users. Examples include, policymaking, management evaluation, public awareness and engagement, benchmarking to attract funding or showcase and exchange good practices or as a tool to communicate with different stakeholders. In the design of a framework, the identification of the primary end-users and of the primary objectives of these end-users form the point of departure. The B-WaterSmart LLs have a broad coverage and complementarity of scales, users, sectors, challenges, and geographical spread across Europe. Moreover, the six LLs share a high ambition by local end-users/problem-owner towards water-smartness. Finally, LLs have their potential for interoperability, replicability, transferability, and market uptake. Their geographical scope ranges an urban to regional context. However, the application of water-smart solutions in their city or region may depend on multi-level governance ranging from European and national regulation to collaboration with local stakeholders, SMEs, and citizens. In this context, the LLs are considered the protagonists for water-smart solutions to achieve a circular economy and therefore will be considered the main user and focal point of the framework. Each LLs comprise of a variety of public and private stakeholders each with slightly different stakes and interests. By selecting LLs as main user, the framework will have to support local and regional decision-makers primarily. These typically include strategic decisions by public authorities such as water utilities, municipalities, and regional water managers. They are faced with complex strategic questions such as: Are our ambitions of achieving a circular economy sufficiently ambitious and realistic? What are the key barriers, enablers and opportunities to enhance water-smart solutions and how can we support this further? Their decision-making accounts for a range of affected or collaborating private stakeholders such as industry, technology providers, SMEs and interest groups such as environmental groups, recreational associations, various grassroots and (in many cases) their electorate. With the framework supporting the LLs in their role as protagonists of water-smart solutions, the framework’s results are envisioned to also be used as a means of dialogue, cross-fertilisation, and leverage between the LLs’ strategic decision-makers with national and European policy-circles. A third likely user of the framework are consultants and researchers that may use the framework to formulate advice or knowledge development to support water-smart and sustainable solutions at local, regional, national, or transnational level.

Main users:

1. **Living Labs’ local and regional strategic decision-makers** - such as water utilities, municipalities, regional water managers – are envisioned to use the framework for the strategic decision-making and communication to various local stakeholders. They provide a framework to take accountability.
2. Through the LLs’ local and regional strategic decision-makers the framework may also be as a means of dialogue, cross-fertilisation and leverage with national and European policy-circles. Vice versa, **European and national authorities** may benefit from the ambitions, barriers and opportunities that the framework aims to exemplify.
3. **Consultants and researchers** that may use the framework to formulate advice or knowledge development to support water-smart and sustainable solutions at local, regional, national or transnational level.

6.5.2 Frameworks' main functionality

Functionality is simply the quality of being suited to serve a purpose well in a practical manner. Accordingly, for the framework to be suitable for supporting strategical decision-makers in enhancing water-smart solutions, three key functionalities are identified that are fundamental for the frameworks' design:

1. The framework needs to provide a minimum set of metrics that is able to compare (i) the current state in relations to the LLs own objectives, (ii) developments over time and (iii) between cases. The minimum set of metrics has to be selected so to reflect a baseline that can support strategic decision-making process. Iterative monitoring, evaluation and cross-stakeholder learning is at the core learning and progress towards policy objectives (Koop *et al.* 2017). A baseline for integrated monitoring of water-smart ambitions is operational for such learning cycles. Since LLs within and beyond the B-WaterSmart project face similar challenge in becoming water-smart, exchange of knowledge, policy experiences and success stories may have a substantial and so far untapped potential. Since LLs all have to adhere to European legislation, share similar social environmental and financial constraints and opportunities there is ample of opportunity for mutual learning amongst the LLs. A common list of metrics with commonly defined reference values could facilitate this process.

2. The framework aims to enhance adaptive management. Contrary to the assumptions that ecosystem management is linear, predictable and controllable, adaptive management embraces the fact that authorities have to make decisions while facing inevitable uncertainties, complexities and risks (*e.g.,* Gunderson and Holling 2001; Folke *et al.* 2002; Berkes 2009). The ability to adapt to and cope with unexpected and complicated circumstances is the essence of adaptive management (Den Uyl 2014). Monitoring, evaluation, pursuing promising opportunities through experimentation and adjusting the management approach accordingly can be facilitated by regular and timely framework scoring. A yearly update of the framework seems to be compatible with decision-making processes, technological developments and policy and political cycles while maintaining data requirements at manageable levels.

3. The framework aims to enhance anticipatory governance. Anticipatory governance is defined as the process of governing in the present to adapt to or shape uncertain futures (Muiderman *et al.* 2019). For anticipatory governance, the use of scenarios is pivotal. Scenarios can explore the impact of various potential developments ranging from impacts of climate change (e.g. extreme rainfall, heat waves, sea level rise), social-geographic changes (*e.g.*, aging populations, land-use changes or level of (cyber) security), changing regulations (*e.g.,* Green Deal), technical developments (*e.g.,* artificial intelligence, energy storage or upcycling technologies) to economic changes (*e.g.,* investment climate, level of wealth or transition to a service economy). Metrics of the framework need to be responsive to different scenario simulations in order to support decision-making that is able to anticipate these developments by adopting and improving current water-smart solutions.

As such, the following are the resulting main functionalities of the proposed framework:

1. Provide a minimum set of metrics that is able to compare (i) the current state in relations to the LLs own objectives, (ii) developments over time and (iii) between cases.
2. Enhance adaptive management through yearly data-update of the framework to enhance flexibility, experimentation, and learning.
3. Enhance anticipatory capacity by allowing scenarios assessment to enable informed decision-making in adapting the current system to future challenges.

6.5.3 Frameworks' structure & size

Four complementary levels form the backbone of framework (Table 7, Table 8 and Table 12):

1. Dimensions describe the value-components within the concept and definition of water-smart society.
2. Strategic objectives are the end goals that the LLs aim to achieve. Objectives have to be clear and concise, as well as ambitious, feasible and compatible, and take into account the ultimate goal for of achieving the "water smart society" vision. The set of strategic objectives is both comprehensive (incorporating all relevant aspects of a water-smart society) and long term (*i.e.,* 10, 20 or 50 years).
3. Criteria are points of view that allow for the assessment of the objectives. For each criterion, metrics must be selected for targets to be set, and for further monitoring of the results.
4. Metrics are the specific parameters or functions used to quantitatively or qualitatively assess criteria; metrics can be indicators, indices or levels.

The full list of definitions adopted is provided in the APPENDIX of this document. Beyond metrics, there are supportive elements that are also summarised in the APPENDIX.

Dimension (Selected dimensions)	**Strategic objectives (Preliminary list)**	**Assessment criteria**	**Metrics**						
				Living Labs					
				1	2	3	4	5	6
ENVIRONMENTAL	5. Conserving the environment	5.1 Eutrophication	5.1.1 Nutrient emission/day	x	x	x	x	x	
			5.1.2 ….		x	x	x	x	x
			5.1.3 ….	x					x
		5.2 Water shortages	1.2.1 ….	x	x		x	x	x
			1.2.2 ….		x	x	x	x	x
			1.2.3 ….	x			x		x

Table 12: Proposed levels that form the frameworks' backbone structure. Strategic objectives and criteria are ought to be similar across the LLs. The indicators may differ although a 75% overlap in indicators is aimed at. The example provided is only for illustrative purposes.

The selection of metrics is largely dependent on data availability whereas strategic objectives have a more normative and qualitative character. Accordingly, the criteria form a linking pin between the two. The relation between the three levels should be compatible. Hence, the choice of performance metrics is a balance between on the one hand strategic objectives and criteria, and on the other hand data availability. As a result, some performance metrics may turn out to be site-specific while other metrics are generic. The balance here is about 75% generic and 25% site-specific performance metrics. The strategic objectives and criteria require a generic framework to enhance comparison between them and to boost the wider application of the framework in other regions across Europe.

The size of the framework has to be balanced. Too large frameworks may lead to high data demand for populating the metrics. As a consequence, data-demanding frameworks risk long-term discontinuity because the data-population requires too much time and resources. Large frameworks may also risk data fatigues of its main users. Some estimates claim that 90% of all the data ever created was generated in the last five years (Marr *et al*. 2018). In theory, this explosion data availability would mean that decision-makers are enabled to make more informed and better goal-based decisions. However, the human capacity to comprehend multiple things at the same time – the mental storage capacity - remains limited (Cowan 2001). On the other hand, too small frameworks tend to neglect important aspects and dynamics for supporting goal-directed decisions. The over simplicity may provide a false representation of often complex systems and considerations.

Overall, about 5 to 10 strategic objectives would be recommended (currently 12 have been identified by the LL owners). For each strategic objective, two to three criteria are aimed at. In the same vein, for each criterion, two to three metrics, with at least one metric measured in all LLs. The latter guidelines imply that the number of data points (*i.e.,* the total number metrics measured at the LLs) for each assessment cycle may range from:

- 10 strategic objectives * 3 criteria * 3 metrics = 90 metrics per LL
- 5 strategic objectives * 2 criteria * 2 metrics = 20 metrics per LL

Note that such number of metrics would be the minimum baseline. Beyond these essential metrics, complementary metrics, criteria and strategic objectives can be included by individual LLs; however, the maximum number of metrics has to be limited and it will be a requirement set by Task 3.9 for the feasibility of use of the end product, the dashboard.

6.5.4 Performance display & time frame

Inherent to metrics are reference values. Reference values are the judgement of what good, fair and poor is for each metric for the stakeholders across LLs. This judgement shall be established independently from the specific cases and be as stable as possible over time. Moreover, a metric can have multiple targets. Targets are the actual proposed values to be achieved for each metric and specific case within a given time frame (short-, medium- or long-term). Finally, a metric can have milestones. Milestones are significant intermediate actions to be accomplished at a given time in the process of achieving the strategic objectives. The milestones reflect what the LL owners have described as "intermediate goals" during the interviews presented in MS06. The timeline of the framework for the short-medium- long term will have to be aligned with the timeline set by the LLs in the strategic agendas (*e.g.*, 2025 / 2030 / 2050). Figure 21 provides an example of a hypothetical case for material reuse.

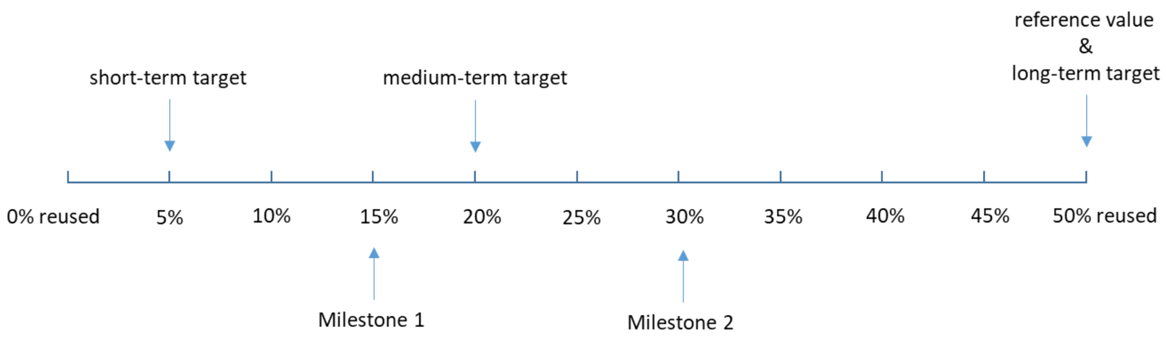


Figure 21: Hypothetical example of material reuse exemplifying the interconnection between targets and reference values.

The performance display of these targets is proposed to be expressed as a distance to target on a scale of 0 points (long road ahead) to 100 points (mission completed). The performance display of cross-comparison between LLs is proposed to be expressed as a distance to reference value. Suppose that in the hypothetical example in Figure 21, a site has 25% of its materials being reused. In that case, the short-term target scores 100 points, the medium-term target scores 80 points (*i.e.*

(20/25)*100). The long-term target and reference value are both 50%. Hence, the long-term target and cross-comparison performance display becomes 50 points (*i.e.* (25/50)*100).

This type of performance display has some key advantages:

- A variety of units can be relatively easy be converted to a scale from 0 to 100 points without too much loss of accuracy.
- As a communication strategy, a distance to a target or reference is a continuous evaluation of a commitment that is already made. This is very effective from a behaviour science and particularly for commitment-making experiment perspective (Jeager and Schultz 2017).
- Unit is intelligible for non-experts. The performance display enables everyone who takes an interest to play around with the framework by setting its own objectives and for example explore how they can be achieved under different scenarios.
- It allows not only use by local/regional decision-makers (*i.e.,* the LL) but also by for example legislators (*e.g.*) to understand the impact of draft policies by inserting certain objectives. This would enable them to test, evaluate and improve the draft policy (potentially in LL) before initiating it into practice.

Important implication of distance to target or distance to reference performance display is that the output is sensitive to a rather arbitrary setting of targets and reference values.

6.5.5 Frameworks' deployment

Once the framework has been developed, it is important to outline who is going to do the regular assessments. Principally, there are three options:

1. Independent organisation in charge of data collection and scoring
2. Independent organisation in charge of data quality assurance and scoring
3. Self-assessment by LL.

It is projected that data collection for the framework's metrics may be most efficiently performed by the LLs themselves. The data quality assurance might be most reliable if it is performed by an independent organisation that performs a routine of quality assurances for each LL.

6.6 Guidance on how to define assessment criteria

Relevant for: WP6 team and the LLs (owner, CoP and mentor).

Assessment criteria represent all the key aspects or viewpoints that need to be addressed to assess the compliance of the strategic objectives. For each objective, the relevant criteria from the portfolio offered by the B-WaterSmart framework should be selected. This means the assessment criteria will be the common ground for the B-WaterSmart LLs.

To create the portfolio, the assessment criteria will be defined by the WP6 team in close collaboration with the LLs (owners, related CoPs and mentors), to ensure alignment with the local barriers to be overcome and the actions to be taken to realise the water-smart vision of each LL at strategic level. The assessment criteria will be also formulated trying to align to and reflect the UN SGDs and relevant EU taxonomies (*e.g.,* the EU taxonomy for sustainable activities), so to make the framework also a useful tool to evaluate the progress towards meeting the SDGs in Europe. A consolidated list of assessment criteria has to be available by M24 (V_1 of the assessment framework). As stated in 6.5.3, for each strategic objective two to three criteria are aimed at.

The first workshop with the LL owners and mentors focusing on assessment criteria will be organized by WP6 at the end of June 2021 (M10).

The following process shall be adopted for the definition of the B-WaterSmart assessment criteria:

1. Start from the B-WaterSmart suggested strategic objectives;
2. Identify, for each objective, two or three essential viewpoints that express the overall intent behind the objective. For instance, for the objective "Water for all", meaning water for all persons and all uses, criteria need to address all the potential uses and users (*e.g.,* water service coverage in urban areas; water coverage for irrigation usage; water coverage for industrial usage; *etc*.)
3. Cross-check with the information provided by each LL and complete, if needed, with other key assessment criteria.
4. Analyse the global listing of criteria and eliminate overlaps.

Globally, the assessment criteria shall:

- be relevant for the strategic objectives;
- be formulated in a clear and concise description;
- be as universal as possible (*i.e.,* not case-dependent);
- be assessable via metrics;
- be simple and easy to understand.

6.7 Guidance on how to define metrics

Relevant for: WP2, 4, 5, the LLs (owner, CoP and mentor) and the WP6 team.

The first step towards the definition of the framework assessment metrics will be performed by M15 by the WP2, 4 and 5 teams (MS13), respectively in relation to the technical, economic and social-governance dimensions. The metrics will have to reflect the specifics of the work performed in each LL within the individual WPs, be relevant at strategic level and fit in the predefined assessment criteria list. Therefore, short-term operational and/or tactical metrics will be out of the scope of the Framework. For instance, WP4 will provide in D4.2. circular economy indicators to be applied by the LLs. D4.2 will include indicators related to the economic dimensions specifically tailored to the circular economy (*e.g*., business of investments, Savings, Productivity, Added value, Economic efficiency, Gains and revenues, Economic structure, Affordability). However, not all the indicators included in D4.2 will be relevant for the Framework scope: some of the indicators will support specific detailed assessment of circular efficiency, and therefore more pertinent at operational level, while others will be more strategic and of interest of decision makers to monitor the achievement of set long term strategic objectives. Those indicators should give an inclusive and holistic view of the status of circularity, taking into account sustainability, responsibility and in overall the attitude "towards zero". Only this type of indicators and metrics will be applicable for the B-WaterSmart framework.

In order to achieve MS13, WP2, 4 and 5, based on the activities performed in collaboration with the LLs, will be invited to:

- Identify the strategic objectives that the WP supports to achieve;
- Based on the activities performed (and goals to be achieved) in collaboration with the LLs and on the level of maturity of the work performed by M15, either propose categories of metrics

(*e.g.,* job creation; efficiency), or, preferably, propose specific metrics (*e.g.,* number of jobs, amount of employment derived from given activity; recycle rate).

A dedicated workshop to guide WP2, 4, 5 further on achieving MS13 will be organized by WP6 and WP1 (Task 1.3) in June 2021 (M10).

The list of metrics suggested by the said WPs will be then revised to identify gaps by the LL owners, and related CoPs on need, under the coordination of WP6 and the support of the LL mentors. The choice of metrics will be a balance between on the one hand strategic objectives and criteria, and on the other hand data availability. As a result, some performance metrics may turn out to be site-specific while other metrics are generic. The balance proposed is about 75% generic and 25% site-specific performance metrics. For each criterion, two to three metrics per LL, with at least one metric that is measured in all LL, are aimed at.

The final, consistent and agreed list of metrics will have to be available by M30 and achieved through the three versions of the framework made available for the LLs' feedbacks (V_0 at M19 (preliminary list), V_1 at M24 (almost final list) and V_2 at M30 (final list, only minor revision allowed to facilitate the work of Task 3.9)).

The definition of the metrics to be included in the B-WaterSmart framework shall comply with the requirements listed below (adapted from Alegre *et al*, 2016).

Individually, each metric shall:

- be relevant for the strategic objectives of the LL;
- fit in the predefined assessment criteria;
- be clearly defined, with a concise meaning;
- be reasonably achievable (which mainly depends on the related variables);
- be auditable;
- be as universal as possible and provide a measure which is independent from the particular conditions of the LL;
- be simple and easy to understand;
- be quantifiable so as to provide an objective measurement of the service, avoiding any personal or subjective appraisal (best use of already collected data should be made);
- include information on the data quality of the variables.

Collectively, it shall be ensured that:

- every assessment metric provides information significantly different from the other metrics in the framework;
- definitions of the assessment metrics are unequivocal (this requirement is made extensive to its variables);
- only metrics which are deemed essential for effective performance evaluation are established.

Before looking at specific metrics, it is important to assess what are the key strategic objectives that it would be important to measure the distance from.

6.8 Instructions on how to set reference values and targets

Relevant for: LL owners and B-WaterSmart users in general.

While targets are simply the necessary or wanted values for the defined metrics, reference values are the judgement of what good, fair and poor is for each metric and for the stakeholders across the board. A reference value can be considered a joint performance ambition. A target can be an individual LL performance ambition for a given time.

The reference values are aimed to allow for comparisons between cases or alternative solutions, and monitor evolution in becoming water-smart over time. For this reason, this judgement shall be established independently from the specific cases and be as stable as possible over time.

Reference values may be established based on (sorted by preference):

1) Theoretical concepts behind the metrics;
2) European legislation or regulation or standardization;
3) Literature reviews on best practices;
4) Statistical analysis of the metrics values associated to expert assessment of the cases;
5) Proposal for an easy, moderate and ambitious joint reference value based on expert judgment of researchers and LL experts for each metric;
6) Joint choice for easy, moderate or ambitious reference value for each metric by strategic level representatives of the LLs.

A target is the value or the level that the organization intends to meet at a given time for each metric. Therefore, targets depend on specific cases and often evolve with time. Especially when the current values are below the long-term organizational objectives, it is recommended to set up different short, medium and long-term targets in order to allow for an adequate transition.

Target should be feasible and take into account the following main factors:

- baseline – the values or levels resulting from the application of the B-WaterSmart framework to the current situation provide a baseline (reference situation) that allows to know how far the organization is from its long-term objectives;
- context and priorities – the external and internal organizational context and drivers should be taken into account since they may slow down or speed up the transition path;
- resources – before setting up a target, the human, technological and financial resources required to achieve it should be estimated and the feasibility to mobilize these resources should be assessed.

The reference values and the long-term target values may not necessarily coincide, depending on the main factors described above.

7 Key conclusions and next steps

D6.1 is the first deliverable of WP6 and it has two specific goals:

1) to provide the definition of "water-smart society" to be adopted by the entire B-WaterSmart project;
2) to provide the preliminary theoretical concept and design of the B-WaterSmart framework, which reflects the formulated definition, and it supports the creation and implementation of strategic plans to achieve the water-smart society vision.

Based on an extensive literature review and insights form the LLs, the following definition of water-smart society is endorsed:

Societies are water-smart when they generate societal well-being via sustainable management of water resources. In water-smart societies, well-informed citizens and actors across sectors engage in continuous co-learning and innovation to develop an efficient, effective, equitable and safe circular use of water and the related resources. This is achieved by adopting a long-term perspective to ensure water for all relevant uses, to safeguard ecosystems and their services to society, to boost value creation around water, while anticipating change towards resilient infrastructure.

Next, a preliminary list of 12 strategic objectives has been proposed that adheres to and further specifies this definition of water-smart society.

To achieve the two goals of this deliverable the same methodological approach was followed: the literature review findings have been combined with LL owners' inputs and feedback collected through a series of interviews and workshops.

For the conceptualization of the framework, the WP6 team has reviewed tools and approaches for assessments that are relevant to the development of the B-WaterSmart framework and conducted a preliminary study of the LL owners' perspectives on the needs for and expectations of the B-WaterSmart framework. Analysis of how existing tools meet the needs of stakeholders has informed the development of the preliminary concept and design of the framework presented in this deliverable, which overall outlines the framework key features, the user requirements and the proposed iterative six-step process for its deployment.

The B-WaterSmart framework key features are grounded on an assessment taxonomy with five dimensions, reflecting the dimensions of sustainability transitions: i. social, ii. environmental, iii. economic, iv. technical and v. governance. Each dimension is characterized with a list of selected strategic objectives. Each objective is specified by assessment criteria as points of view that allow for the assessment of the objectives. Each criterion in turn is described with a set of metrics which will serve to assess the distance from a set target.

In accordance with the B-WaterSmart project description of work, the framework will be further detailed, developed, validated, and aligned with the project overall aim along Task 6.2 and Task 6.3. Therefore, the framework description provided in this deliverable represents the initial proposal for a common approach to the water-smartness assessment.

Next steps for Task 6.2 will include:

By M19 (Prototype V_0, MS16):

- Finalization of the strategic objectives list through interaction with the LL owners;
- Preliminary list of the assessment criteria, to be identified by the LL owners and mentors under the WP6 guidance, as viewpoints that overall express the intent behind the objective;
- Review, gaps identification and implementation of the list of metrics, relevant for the strategic level of application of the framework, proposed by the WP2, 4 and 5 teams at M15;

By M24 (Prototype V_1, D6.1):

- Consolidation of the list of assessment criteria, involving the CoPs;
- Progress on the definition and selection of the metrics up to a mature level to be finalized, with minor revisions, by M30 through iteration with the LLs;
- Provide guidelines in data collection to ensure reproducibility, as for instance instructions on standardised reporting of metadata (*e.g.,* reporting of data source, explanation of how data is obtained), on data collection schedule, on quality assurance and definition of roles.
- Define a preliminary list of architectural requirements through collaboration with Task 3.9, allowing Task 3.9 to start working on the online dashboard, including how to implement the deployment methodology (Part A of the framework development) and the selection of effective visualization tools.

Besides the specific WP6 tasks listed above, recommendations from LL owners will be adopted through continuous collaboration under the WP1 umbrella (Task 1.4), so to revise the list of the strategic objectives, of the assessment criteria and of the metrics on need and to include relevant new requirements that might arise while the project develops with further involvement of the LLs' CoPs; the iteration with the LL owners will also be facilitated by dedicated training activities (organized by Task 1.3) where, possibly, small pilots exercises with defined use-cases, and based on real data, could be included to test the framework. The process of refinement of the framework (Task 6.3) will continue from M25 until M30 (Prototype V_2) when its transformation into a software tool by Task 3.9 will start.

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APPENDIX

Key definitions adopted in the Part B ("Content") of the B-WaterSmart Framework

Strategic Objectives are the goals that the organization aims to achieve. Objectives have to be clear and concise, as well as ambitious, feasible and compatible, and take into account the ultimate goal for the utility of achieving the "water-smart" vision. The strategic objectives must reflect the transition features of how becoming a water-smart society. For each objective, it is recommended that key assessment criteria are specified.

Criteria are points of view that allow for the assessment of the objectives. For each criterion, metrics must be selected in order for targets to be set, and for further monitoring of the results.

Metrics are the specific parameters or functions used to quantitatively or qualitatively assess criteria; metrics can be indicators, indices or levels:

> *Performance indicators* are metrics of efficiency or effectiveness and consist of a value expressed in specific units. Performance Indicators are typically expressed as ratios between variables; these may be commensurate (*e.g.,* %) or non-commensurate (*e.g.*, \$/m^3). Performance indicators should be characterized with a confidence grade which indicates the quality of the data represented by the indicator.
>
> *Performance indices* are quantitative, commensurate metrics incorporating an intrinsic judgment of performance in their formulation. They may result for instance from the combination of more disaggregated performance measures (*e.g.,* weighted average of performance indicators), from analysis tools (*e.g.*, simulation models, statistical tools, cost efficiency methods) or from scoring systems.
>
> *Performance levels*, which are performance metrics of a qualitative nature, expressed in discrete categories (*e.g.,* excellent, good, fair, poor).

Complementary definitions

A performance assessment system comprises a set of performance assessment metrics and related data elements that represent real instances of the undertaking context. The classification of these data elements depends on the active role they play:

Data elements: A basic datum from the system that can either be measured from the field or is easily obtainable. Depending on their nature and role within the system, data elements can be considered variables, context information or simply explanatory factors.

Variables: A variable is a data element from the system that can be combined into processing rules in order to define the performance assessment metric. The complete variable consists of a value (resulting from a measurement or a record) expressed in a specific unit, and its reliability level that indicates the quality of the data represented by the variable.

Context information: Context information are data elements that provide information on the inherent characteristics of an undertaking and account for differences between systems. There are two possible types of context information:

- Information describing pure context and external factors to the management of the system. These data elements remain relatively constant through time (demographics, geography, *etc*.) and in any case are not affected by management decisions.
- Some data elements on the other hand are not modifiable by management decisions in the short or medium term, but the management policies can influence them in the long term (for instance the state of the infrastructure of the utility).

Context information is especially useful when comparing indicators from different systems.

Explanatory factors: An explanatory factor is any element of the system of performance indicators (PI) that can be used to explain PI values, *i.e*., the level of performance at the analysis stage. This includes PI, variables, context information and other data elements not playing an active role before the analysis stage.

Key definitions adopted in the Part A ("Methodology") of the B-WaterSmart Framework

Reference values are the judgement of what good, fair and poor is for each metric for the stakeholders across the board. This judgement shall be established independently from the specific cases and be as stable as possible over time.

Targets are the actual proposed values to be achieved for each metric and specific case within a given time frame (short, medium or long term).

Milestones are significant intermediate actions to be accomplished at a given time in the process of achieving the strategic objectives.

Scenarios are defined by factors (isolated and/or combined) not controlled by the decision maker, but which may influence the analysis and should therefore be considered (*e.g.,* demographic trends, regulatory changes, climate projections). It is not recommended to select more than two scenarios to avoid increasing the decision problem complexity. The scenarios are used to deal with uncertainties about the future; although they do not represent a complete description of the future, they can help to highlight central factors to be considered in the decision-making process. The factors come into the decision process since the "Water Domain" is not “standalone”, but it interacts with other domains (government, regulators, users and communities, environment,…) that can impose factors influencing the water domain performances; this implies that decisions made in and about the other domains will also have impacts on the water domain and should be taken into consideration, *e.g.,* decision taken in other domains can impact the achievement of the LL strategic objectives.

Alternatives relate to the candidate decisions the organization/decision maker may take to achieve the strategic objectives and of which it has control upon. Alternatives can refer to alternative technological solutions, but also management practices, awareness campaigns, communication, policies influence, *etc*.

B-WaterSmart

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