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Towards a water-smart society: Progress in linking theory and practice

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ABSTRACT

Few scientific publications discuss the vision of the water-smart society. Our paper addresses this gap, outlining key principles of urban water–smartness and translating them into five strategic objectives to support decision-making at the local government level. Based on recent literature and dialogue with six European water Living Labs, we argue that the water-smart society must highlight societal well-being and co-development across sectors. Furthermore, we emphasize the need for a long-term perspective, conserving nature, and maximising ecosystem services, while anticipating change. Finally, we discuss how a more grounded conceptualisation of the water-smart society can guide utilities and urban policy design.

1. Introduction

Climate change, urbanization and changing land-use practices together with increasing consumption are associated with unprecedented water management challenges. These are linked with other challenges, such as global inequalities (Chen et al., 2022) and conflicts (Darbandsari et al., 2020). The role of water governance in sustainable development is therefore highlighted (OECD, 2015). The European Commission's multi-stakeholder platform on water - Water Europe - calls for change towards a water-smart society. Their recently revised vision reads as follows: *"A Water-Smart Society is one in which the value of water is recognised and realised to ensure water security, sustainability, and resilience; all available water sources are managed so that water scarcity and pollution are avoided; water and resource loops are largely closed to foster a circular economy and optimal resource efficiency; the water system is resilient against the impact of climate and demographic change; and all relevant stakeholders are engaged in guaranteeing sustainable water governance. "* (Water Europe, 2023: 4).

Water Europe (2019) associates the water-smart society with a model for system innovation with four components: 1) recognition of the value of water, to increase rational use and reuse of all water resources, 2) new digital and water technologies, 3) a hybrid grey and green water infrastructure, and 4) inclusive multi-stakeholder governance. UN Water highlights the need to reconcile the different values of water and incorporate them into systematic and inclusive planning and decision-making processes (UN, 2021). Still, despite notable efforts (Koop et al., 2022), there remains limited research on what transformative change towards a water-smart society entails and how it can be stimulated. Our paper addresses this gap, by operationalising the vision of a water-smart society into a workable concept and set of strategic objectives, while outlining key implications of the concept for municipalities, water utilities, urban policy design, and future water governance research. The discussion builds on results of the project B-WaterSmart[1 and 2] and is guided by two research questions: What are the key dimensions of urban water smartness? How can the concept be operationalised to accelerate transformative change towards a water-smart society particularly with respect to European regions and cities? In terms of structure, the following section provides the

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[1] https://b-watersmart.eu/.

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conceptual background of the paper. Next, we present the six water Living Labs that were engaged in this research and the suite of methods applied. The subsequent section presents our findings regarding key dimensions of water smartness. Based on the identified dimensions, we propose a refined concept of the water-smart society and show how it can be operationalised in terms of strategic objectives for decision-makers. Finally, we discuss the results and their implications considering the reviewed research.

2. Conceptual background

Arguably, a certain logic of water management has been institutionalised over the past centuries, where safety of supply through technological efficiency, national welfare, and social equity are the most influential values. The dominant technology consists of hydraulic systems with reservoirs, pipes, and pumps, and in most cases, the most influential decision-making actors are the state and water utilities (Fuenfschilling and Truffer, 2016). While this paradigm has been resistant to change, it is increasingly challenged by perspectives and technologies from other fields (Fuenfschilling and Truffer, 2016; Torres et al., 2020).

One such influence is the smart city concept (Bibri and Krogstie, 2017; Golubchikov and Thornbush, 2020). A growing body of research argues that traditional water management techniques are incapable of addressing current water management challenges. Upgrading the existing water distribution network is time-consuming and costly, and adding smart components to achieve real-time monitoring and control may often be more sustainable and feasible (Sonaje and Joshi, 2015; Li et al., 2020). Still, there is no consensus on how a smart water system is defined (Li et al., 2020).

At the same time, there is increasing focus on Circular Economy (CE). While CE has multiple definitions, most of the current conceptualisations focus on materials and energy, paying little attention to water and water-related ecosystems (Salminen et al., 2022). However, strategies such as reduction, reclamation, reuse, recycling, and resource recovery are already being recommended and implemented as transition pathways for the water sector (Smol et al., 2020; Guerra-RodriguezOulego et al., 2020). Thus, Salminen et al. (2022) define water-smart CE as an economic concept whereby water is abstracted within the ecological boundaries of surface and groundwater bodies and used efficiently with a focus on reducing losses and recovering energy and other resources, without significant risks to ecosystems and human health (Salminen et al., 2022: 4). Salminen et al. (2022) do not explicitly discuss nature-based solutions. However, these are also an important part of the picture (Wilcox et al., 2016; Oral et al., 2021).

The smart city is characterised by a great presence of information and communication technology (ICT) applied to critical infrastructure and services, e.g., for water system monitoring, flood preparedness, and mitigation. However, the concept is also used to designate an "instrumented, interconnected and intelligent city" where complex analytics makes for better decisions (Harrison et al., 2010). In urban planning, the smart city tends to imply strategic directions, such as economic growth and better quality of life. There is also a trend towards more holistic notions (Albino et al., 2015; Obringer and Nateghi, 2021), seeing cities as combinations of spatial and socio-economic elements (Duygan et al., 2022), including a diversity of stakeholders, with different competencies, values, and needs that must be taken more into account (Siokas et al., 2022).

A shift towards "smart, sustainable cities" is also observed (Bibri and Krogstie, 2017; Obringer and Nateghi, 2021; Blasi et al., 2022). This is partly related to the "eco-city" and "compact-city" models. However, combining sustainability and "smart" perspectives may be even more fruitful for connecting urban systems, and identifying which elements to coordinate and integrate for increased sustainability (Bibri and Krogstie, 2017). This links well with the Water-Energy-Food (WEF) nexus (Salam et al., 2017), with its goals to reduce trade-offs resulting from policy development in institutional "silos" and develop more integrated approaches.

Moreover, city planners, urban innovators and researchers increasingly work on joint initiatives where the urban water cycle is addressed in "future city" concepts. Visioning is used to define shared agendas across technical and social spectrums (Bricker et al., 2017). However, "future city" visions tend to focus on the built environment, paying less attention to the natural environment (ibid.). While citizen participation (Jang and Gim, 2022), social learning and reflexivity are seen as key elements of urban transformative capacities (Shelton and Lodato, 2019; Docí et al., 2022), few studies focus on governance, policies, performance assessment, and standards to monitor, evaluate and learn from place-based solutions (Sharif and Pokharel, 2020).

Even fewer studies on smart cities explicitly address the SDGs (Blasi et al., 2022). The UN 2030 Agenda does not specify *how* water governance models should include the SDGs, and there is a lack of knowledge on how they best can be adopted in operational contexts (Di Vaio et al., 2021). Horne et al. (2018) call for a stronger sense of urgency and active management of risk events, especially by national governments. Delany-Crowe et al. (2019), in their study of Australian water management policies and the SDGs, argue that cross-jurisdiction policy coherence and national coordination must be improved. While Morgan et al. (2020) highlights the opportunities associated with metropolitan governance, Homsy and Warner (2020) argue that local governments are crucial, having the aptitude to develop sustainability policies that adhere to community values and can mitigate the flaws in local systems. Thus, it is essential to identify how the SDGs can be translated into practice to enhance water resource management and enable coordination of local decisions with global policies (Di Vaio et al., 2021). Recent studies (e.g., Samarakkody et al., 2022), also call for better integration of the resilience concept in smart city criteria, based on the contextual challenges, resources and priorities in each city. These perspectives underpin the importance of defining the water-smart society in relation to the perspectives and needs of practitioners. The next section provides an overview of the materials and methods applied in this study, to address some of these gaps and challenges.

3. Research design and methods

To ensure practical relevance, practitioners of six cities and regions were engaged in this research, as Living Labs (LLs) (EnoLL, 2019). The LLs were formed under the B-WaterSmart project, with the aim to enable systemic innovation and transformation to water-smart societies in coastal Europe. The locations of the LLs are shown in Fig. 1.

The LLs were selected to account for a variety of European regions, in terms of geography and climatic conditions, population and economic activities, and water-related challenges, e.g., impending water scarcity and/or stormwater management and water quality issues. Each LL was built around a set of practice partners, i.e., a water utility and/or municipality and technology providers. These were supported by various knowledge- and market-uptake partners, but did not include wider stakeholders, such as non-governmental organisations (NGOs), who rather were engaged through efforts to develop Communities of Practice (Wenger, 1998) associated with the LLs. Our work on the concept of a water-smart society was a process with five steps, as illustrated in Fig. 2.

Step 1. Initially, the research team provided a preliminary working definition (version 0), as follows: *"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 water."*

Step 2. The working definition was applied in two workshops to co-develop a concept of the water-smart society that reflects the visions

Fig. 1. Names and locations of the LLs engaged in the study.

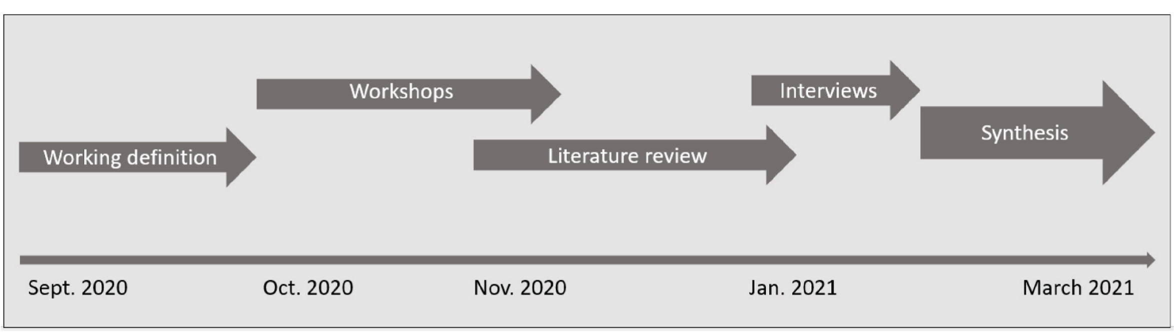

Fig. 2. Research process, with timeline.

and experiences of the practice partners in the LLs. The workshops were conducted to enable direct exchange across and with the cases but had to be online due to COVID-19 restrictions. As shown in Table 1, the participants were evenly distributed across organisation types, and all six LL were represented in both workshops.

Step 3. As a third step, an exploratory literature review was conducted. The search was made in Web of Science, using several search strings (Table 2).

To maintain an open, interdisciplinary perspective, the search was not limited to specific journals, but to the period 2016–2020, and further down to 2019–2020 for two strings, due to a high number of initial hits. Titles and abstracts on specific technologies, processes and/or methods, without relating (directly or indirectly) to water smartness at a societal level were excluded. This left a total of 73 studies, which was reduced to 35 following more detailed examination. The selected articles were assessed in terms of analytical perspective and focus, geography and level of analysis, as well as the dimensions, criteria and/or definition water smartness (or related concept) they discussed.

Careful reading confirmed that there was little research on water-smart society as such. Therefore, we decided to also draw on leading articles on smart cities, sustainable water management, CE, the WEF

Table 1
Workshop attendance.

	Participants in total	Researchers (in total)	Practice partners			
			In total	*Water utility*	*Municipality*	*Technology provider*
Workshop 1	36	23	13	*4*	*6*	*3*
Workshop 2	30	16	14	*4*	*6*	*4*

The first workshop gathered the participants' understanding of "water smartness" through two polls (Mentimeter, 5–12 words per participant). In between the workshops the practice partners were asked the same questions in an online survey; Q1) *Please provide what you think are the most important keywords (max. 12) that should be addressed in a framework to assess "water smartness"?* and Q2) *Please provide what you think are the most important keywords (max 12) that should be addressed in a framework to assess "Water smartness in the context of society and circular economy?"*. This was to eliminate potential bias, since the workshop polls were open to all participants, not only the practitioners. At the second workshop, the results of the previous iterations were presented for discussion (for further detail on the workshops, please see the Appendix).

Table 2
Search strings for the literature review (for the publication years 2016–2020, narrowed down to 2019–2020 for two strings, as indicated by figures in brackets).

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

Nexus, Integrated Water Resources Management (IWRM), water governance, hydro-sociology and sustainability transition studies, which the authors had prior knowledge of. As shown in section 2, some more recently published articles are also highly relevant and therefore included in the discussion.

Step 4. In January 2021, we conducted six structured interviews with the core partner organisation in each LL, involving a total of 28 interviewees. The aim of the interviews was to receive more detailed feedback on the working definition from the level of strategic management of each organisation (for details on the selection process please refer to the Appendix). The partners were asked: Does the working definition reflect your understanding of a water-smart society? What are key dimensions that should be contained in the definition? Are there any keywords that should be added to the definition? They were also given opportunity to modify the initial working definition. The data from the interviews was structured according to the five dimensions of sustainability (i.e., economic, environmental, social, governance, and technical/asset management) emphasised by (Alegre et al., 2012).

Step 5. Lastly, the identified topics, input from the workshops and review findings were used to enhance the preliminary definition to a final co-produced concept of the water-smart society and operationalise it in a cohesive set of strategic objectives.

The following sections present the main results of our study. First, in section 4, we present the input from the workshops with the LLs, the key findings from the literature review and feedback from the interviews with the core partners in the LLs. Then, in section 5, we provide the resulting definition of the water-smart society, highlighting five strategic objectives that can be outlined from it.

4. Results of LL interaction and literature review

4.1. Input from the initial workshops

During the initial workshops, some of the keywords proposed as most essential by the LLs were sustainability (considering environmental and social, as well as economic impacts), efficiency (economic and/or in terms of energy), fit-for-purpose (water for different uses), innovation and wisdom (applying all useful experience and knowledge), followed by water safety (quantity and quality), circular (e.g. reuse and resource recovery), long-term, shorter supply chains and environment (conservation). When asked to propose topics for a framework to assess water smartness in a societal context, the perspective changed slightly. Sustainability, cooperation, and efficiency remained central, but awareness, justice and involving stakeholders also came in strongly, underscoring that water smartness is about people and relations, as much as technology and system performance. Since the purpose was to gain input on the various aspects that should be considered, the keywords were brought up and discussed, but not further defined during the workshops.

Based on these insights, the preliminary working definition was adapted, as follows: *"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."*** Newly added concepts, based on the feedback from the workshops, are highlighted in bold. This definition (version 1) was subsequenlty used as a starting point for the literature review and the interviews.

4.2. Dimensions highlighted in the literature

The key insights extracted from the reviewed literature are summarised in Table 3 and subsequently explained in this section, with reference to specific authors and publications.

As indicated in Table 3, the reviewed literature can be categorised into seven research strands, based on different core concepts that may be associated with the transition towards a water-smart society. First, the literature on ***Sustainable water management*** includes a range of indicator-based studies, underscoring the need to work towards multiple dimensions of sustainability. The considered sustainability objectives vary slightly, but commonly include conservation of nature and reduced use of non-renewable resources, economic viability and value creation, intergenerational equity, diversity, autonomy in communities, citizen well-being, and fulfilment of fundamental human needs. Resilience is central, but can sometimes conflict with sustainability, e.g., building more redundancy in infrastructure systems is more resource-demanding (Leigh and Lee, 2019). Therefore, it is recommended that all potential resilience-based interventions also are viewed in the context of sustainability, and vice versa (Lawson et al., 2020). On this background, the DESSIN (Demonstrating EcoSystem Services enabling INovation in the water sector) project combined ecosystem services (ES) and sustainability assessment in a broad, holistic evaluation framework (Anzaldua et al., 2016a). Such holism is needed to transition towards a water-smart society. However, many of the existing frameworks are complex and demanding in terms of data requirements. It has also been argued that more attention should be paid to how sustainability is situated in particular space and time contexts (Hallin et al., 2021). This is in line

Table 3
Key topics in the reviewed literature, related to the water-smart society.

Strands of literature	Key topics guiding the water-smart society definition
Sustainable water management	Environmental, economic and social sustainability Socio-ecological interactions and ecosystem services SDGs and local development objectives
IWRM and WEF nexus	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 and citizens Data for knowledge development
Sociology of water and 'sociohydrology'	Social perceptions, practices, norms and values Engage with social movements and action learning Societal feedback mechanisms
Water governance	Towards a more collaborative and market-based view Learning and knowledge development Capacity-strengthening Anticipate change Multi-level and multi-actor governance
Socio-technical transition studies	Be aware of and address lock-ins Nurture niches, experimentation and variation Long-term thinking and flexibility

with Helness et al. (2017), who emphasize the importance of considering the overarching SDGs as well as local objectives in sustainability assessment, as well as with the findings from Di Vaio et al.'s (2022) above-mentioned review.

Integrated Water Resources Management (IWRM) is a widely used concept. As a managerial solution that refers mainly to operational activities, it has been criticised for not taking sufficient account of politics, being top-down, too broad, and too narrow, since it ignores important linkages between land and water management (Batchelor and Butterworth, 2014). However, recent studies aim to integrate political decisions, social investment, technological advances, and individual responsibilities, to reduce risks and restore the natural water cycle (Rodrigues and Antunes, 2021). As noted by Furlong et al. (2016), IWRM is also associated with related ideologies centred on urban contexts, such as Integrated Urban Water Management (IUWM), emphasizing integration with urban planning and avoidance of infrastructure lock-in, and Water Sensitive Urban Design (WSUD), which is widely used in Australia, with a special focus on green infrastructure and reuse schemes, associated with improved liveability outcomes. The water-smart city may also draw upon the WEF nexus (Artioli et al., 2017; McGrane et al., 2019): considering cities as sites of water, food and energy distribution, and consumption implies a stronger focus on users. Furthermore, it has implications for the location of farming, industry, water sources, and power stations. Short supply chains must be strengthened to align with CE principles, environmental health, and human well-being (McGrane et al., 2019). An integrated approach building on these insights may be key to urban water smartness.

Circular Economy (CE) is already highlighted by Water Europe, and the "4 Rs" (reduce, reuse, recycle and remove) are on the agenda in the water and waste sectors. However, CE also underscores the need for more profound changes. Smol et al. (2020) suggest two additional strategies for the water sector: reclamation, in the sense of highly effective removal of pollutants, and rethink — introducing systematic changes in the entire value chain. Generally, a more definite conceptualisation of CE is called for, especially concerning sustainable development (Millar et al., 2019), and ecosystem interactions (Fidelis et al., 2021). Korhonen et al. (2018) highlight limitations for environmental sustainability in CE, including lock-in and rebound effects. Thus, there is the need to look beyond resource efficiency and value chain development, and consider long-term socio-ecological interactions. Furthermore, higher value retention options involving consumers need more attention (Schöggl et al., 2020). This requires capacity building and new digital tools, as well as new business models and conducive legislation (Laitinen et al., 2020). Seeing city-level actions as essential to encourage circular behaviours, Paiho et al. (2020) outline four scenarios: Circular city as 1) a collective action, 2) built on city offering (municipality providing infrastructure, organising), 3) part of international CE networks and, 4) as a place for local competing services. These imply different roles for different stakeholders (e.g., municipality as main enabler, provider, or user). Williams (2019) argues that in addition to looping, regenerating (preserving natural capital and ecosystem services) and adapting (e.g., through flexible, modular systems) are fundamental for CE in cities. Four further supporting actions – optimisation, sharing, substitution and, especially, localisation – are recommended (Williams, 2019). Thus, recent CE literature suggests that circularity strategies may apply differently in different cities, depending on their resource pool and pre-existing infrastructure. In any case, city-level action, with relations and roles transgressing current sector boundaries, is foreseen.

Studies of the ***smart city*** highlight various ways in which ICT may provide data to make more efficient use of infrastructure and improve operations across the city, but as noted above there is increasing focus on citizen participation and institutional aspects. Ramaprasad et al. (2017) consider the smart city as a combination of structural elements (infrastructure, systems, and policies), functions (monitoring, process and communication), foci (cultural, environmental and technological), semiotics (data, information and knowledge), stakeholders, and desirable outcomes. The water sector has seen a strong focus on particular technologies, such as sensors and smart meters, providing more efficient operation, enhanced early warnings and faster responses to potential failures (see e.g., Amankwaa et al., 2023). However, digitization may also help visualise the linkages between drivers of innovativeness, the state of infrastructure, and regional planning, and showcase sustainability in place-specific contexts (Widener et al., 2017). Embracing digital transformation can unlock new levels of performance, improve workforce enablement, and spark new business models. At the same time, it brings a host of challenges, such as data privacy, security, and bias. While useable, timely information is critical to achieve SDG 6 (sustainable management of water and sanitation for all) and SDG 11 (inclusive, safe, resilient and sustainable cities and settlements) (Horne et al., 2018), we are warned that information is not merely processed, but made, commodified, accessed, secreted, politicised, and operationalised through smart technologies (Mattern, 2017), and untransparent or unilateral ICT decisions might lead to public choice constraints (Singh et al., 2020). A stronger emphasis on ultimate goals, agendas and strategic plans is therefore recommended (Ahvenniemi et al., 2017; Anthopoulos, 2017). In light of this, a water-smart society must attend to the multiplicity of urban information resources and make sure that ownership and management of data are clearly defined, based on inclusive decision-making.

Recent studies on the ***sociology of water*** suggest that as responsibility is shifted from the state and water utilities to individual households, 'smartness' must pay more attention to culture and social dynamics, also when designing solutions (Watson, 2019). Ramirez et al. (2020) underscore the need to involve citizen science alliances as a source of action learning. Olsson et al. (2020) highlight the importance of environmental justice, arguing that broad stakeholder involvement and recognition of existing built-in power structures are keys to sustainable urban development. This is in line with Sañudo-Fontaneda and Robina-Ramírez (2019), who found that sustainable drainage systems designed with community self-organisation inspired further communal efforts to protect the environment, as well as Scoggins et al. (2022), who provide an approach for community-powered urban stream restoration. "Socio-hydrology" provides a system perspective on human-water interactions, focusing on the hydrologic cycle (Di Baldassarre et al., 2019). Different types of feedback mechanisms are defined to shed light on intended and unintended long-term sustainability impacts of water management decisions (Di Baldassarre et al., 2019). According to these perspectives, water-smartness includes accounting for the role of citizens in water management, with consideration of temporal dynamics, spatial processes, and legacy risks.

Water governance can be defined 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: 26). This includes both state and non-state actors and goes beyond the functional exercise of water management. As noted by Jimenez et al. (2020), such "new governance" perspectives tend to shift towards a society-centric, multilevel, collaborative and more market-based view. "Water-wise cities" are associated with four levels of action: i. regenerative water services focused on CE, ii. water sensitive urban design, ii. basin connected cities, and iv. water sensitive communities (IWA, 2021). Koop (2019) provide a five-step classification, based on problem shifting, from water-secured cities (with supply & sanitation as main challenges), sewered cities (focused on pollution & health risks), climate resilient cities (refurbishing aging infrastructure and enlarging green space), circular (triggered by resource scarcity) and water-wise cities, which are open to new opportunities, tend to score high on preparedness, and have a clear allocation of resources and responsibilities. Moreover, high compliance with policy and management ambitions and ability to continuously monitor, evaluate and learn are essential (Koop, 2019). Recent studies from Australia (e.g., Morgan et al., 2020; Furlong et al., 2016) discuss the interaction between urban water management and water governance at higher levels. In South-East Queensland, metropolitan governance has been associated with fragmentation, but is getting increasingly integrated and considered to create better long-term planning and opportunity to realise broader sustainability outcomes (Morgan et al., 2020). In Melbourne, the creation of an over-arching urban water governance body, later absorbed back into state government, created more collaboration between utilities and led to potentially positive reforms, but did not have any significant impact in terms of implementing IUWM solutions (Furlong et al., 2016). The latter study emphasizes that what are deemed as the most sustainable solutions, planning and governance arrangements is quite situational and context-dependent.

Within **socio-technical transitions studies** (Köhler et al., 2019) complex system interactions, path dependency and lock-ins have been in focus. For instance, Ampe et al. (2020), in a discussion of the transition of the Dutch wastewater system, find that a "market-pull" discourse suggesting incremental change is dominant, as it draws on the existing infrastructure and politico-economic institutions. Furthermore, Transition Management (TM) is promoted as a distinct governance approach. The SWITCH project on water management for the city of the future was an early case, highlighting the need for facilitation and development at multiple levels, including long-term visioning and city-to-city learning, capacity building and experiments, and active engagement with niches for radical innovations (Jefferies and Duffey, 2011). More specifically, TM emphasizes system- and long-term thinking (at least 25 years), radical change, learning, system innovation and experiments, and considering a wide variety of options and scenarios, with participation by stakeholders (Pisano, 2014). One important takeaway from this is that flexibility, ability to include multiple perspectives and facilitate innovative change, should be emphasised in the water-smart society.

Overall, it may be argued that a water-smart society is about enabling social well-being. While environmental, economic, and social sustainability ensuring social well-being often are implicitly underpinned in the literature, the SDGs recognize that development must balance the three aspects of sustainability and aim to ensure peace and prosperity for all by 2030. In the present water governance context, economic valuation is key, to enable CE and ensure water for all relevant uses. Moreover, there seems to be a broad consensus that engaging citizens and other actors is central. Learning through experimentation, system change and long-term thinking is essential, and continuous adaptation is required. For these processes, careful development and use of digital technologies may be invaluable. Based on these insights, the following concept was formulated, as a supplement (version 2) to the initial working definition: *"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."* In the next section, we look into the feedback from the LLs, on topics of importance and how the definition could be adjusted, to match the priorities and concerns of utilities and municipalities.

4.3. Objectives highlighted in the interviews with practitioners

The feedback provided during the interviews, regarding aspects that were missing or should be further highlighted in the preliminary working definition is summarised in Table 4.

Most of the practice partners highlighted the social dimension. However, what they emphasised thereunder varied, linked to the specific water challenges and solutions in focus for each LL, as well as to the categories of personnel that were interviewed. (i.e., municipality and water utility). For the practice partners in Alicante and Venice the social dimension stood out as important, since their demonstration activities include the use of treated wastewater and resource recovery from sewage sludge, where limited social acceptance is a barrier. Other partners (East Frisia, Flanders) emphasised the social dimension in relation to the service mandate of water utilities, i.e., to provide safe and secure water for all. The partners from the LLs in Bodø and Lisbon, although different in terms of setting and scale, identified as a major challenge growing resident populations and industrial development, which increases the demand for water cycle services and potential for pollution. These partners linked the social dimension mainly to quality of life for citizens and the sustainability of urban development. They suggested including concepts such as "water for all", "accessibility and affordability of water (SDG 6)", and the social value in preserving and replenishing groundwater resources for agriculture. Additional keywords proposed were social empowerment, citizenship involvement, affordability, well-informed society, and active and engaged citizens. This is in line with the increasing focus on local development objectives in sustainable water management literature, as well as the reviewed studies on social dynamics, environmental justice and the role of citizens in water management (e.g., Watson, 2019; Ramirez et al., 2020; Olsson et al., 2020).

Furthermore, five of the LLs found the environmental dimension missing. Most of the LLs highlighted the environmental challenges in their city or region. Suggestions for how to address this dimension better were a) adding positive impact on the environment, e.g., through environmental restoration or nature-based solutions, and b) adding optimised use of resources and best possible preservation of the natural water cycle. Proposed keywords were the "ecological value of water"", sustainability", and "protection of the environment". As we have seen, this reflects a concern in some CE studies, that ecology needs more attention (Fidelis et al., 2021, Korhonen et al., 2018a), as well as the recent research on resilience and ES in sustainable water management.

Topics clustered around digital technology were mentioned by half of the LLs. Generally, these were linked to solutions for monitoring, control and optimisation of processes being co-developed in the

Table 4
Feedback from LLs (aspects to highlight or add to initial working definition).

LL	Dimensions				
	Economic	Environmental	Governance	Social	Technical
Alicante		- Positive impact on environment, e.g., “environmental restorations”		- Promotion of awareness, sensibilization, knowledge, transparency, “citizenship implication“	- Digital dimension: “making use of edge technologies and digital solutions” - “Risk management” related to climate change
Bodø		- Environmental perspective - Optimising use of resources (e.g., demand-oriented use) - Preserving the natural water cycle			- Optimising use of resources
East Frisia		- Ecological/environmental dimension		- “Accessibility and affordability” of water (SDG 6)	- “Adaptability, flexibility “ - “Innovative technologies” - “Digital solutions”
Flanders	- Definition is business centred - Economic value of water differs, e.g., value for water utilities compared to value for cities through innovative businesses; - Different perspectives of water value (beyond economic value)	- Ecological value - Indirect value (i.e., agriculture) in preserving and replenishing groundwater resources - “Environmental sustainability” and “protection of the environment”	- Develop new governance models (initiatives exist, but not on how water can be sufficiently valued) - “Optimal/efficient water management“	- Indirect value of water - Imbalance of description of value (very broad) and societal well-being - “Support base among stakeholders and citizens” - “Optimal/efficient water use”	- “Data driven services”
Lisbon	- Affordable cost for economy - “Water for all” refers to both physical and economic accessibility to water		- Make water management more transparent - Smart water management	- Ensure water for all (users and uses) with affordable cost for people - Provide full information to citizens and organisations and promote education and debate - “Well-informed society” - “Engaged and active citizens”	- Ensure water for all (everyone and every relevant use) with sufficient quality
Venice	- Key dimension: economic	- Key dimension: environmental	- Emphasis on governance dimension	- Emphasis on social dimension - “Social empowerment”	

respective cases. This could suggest that such solutions are considered more mature and relevant, and/or that the practice partners were less informed about the opportunities for e.g., visualisation, communication and citizen involvement highlighted in the literature (e.g., Widener et al., 2017).

The governance dimension was also upheld as important. Lisbon LL, especially, promoted transparency and “education and debate around issues regarding smart water management”. While there are new initiatives, the LL of Flanders felt there is a lack of governance models that allow sufficient valuation of water, including non-economic values. New models addressing this gap could be developed through the idea of a water-smart society. “Optimal/efficient water management” was suggested as additional keyword. This resonates with some of the reviewed articles on water governance and sustainability transitions, where multi-actor collaboration, learning and experimentation with new models is emphasised (e.g., Koop et al., 2022, Jefferies and Duffey, 2011).

The working definition was already perceived as “rather business focused” and thus covering the economic dimension sufficiently. Encouraging innovative business was identified as relevant, especially for cities. Other aspects highlighted were “resilience” (flexibility and adaptability), especially linked to alternative scenarios as regards climate change or demographic development, and safety/risk. This, we have seen, reflects recent research on the links between resilience, sustainability, and the smart city (Samarakkody et al., 2022). Overall, the interviews highlighted the following messages:

– Engagement and empowerment of citizens and enabling governance are prerequisites for the water-smart society.
– A water-smart society takes advantage of digital technologies, to conserve the environment and empower and motivate citizens.
– A water-smart society must be resilient (flexible/adaptive) and ensure safety in the face of future challenges and risks, e.g., linked to climate, demography, emergency/disaster management.
– In a water-smart society, water must be physically and affordably available.

Together with the results from the workshops and literature review, these form the basis for our definition of the water-smart society, which is elaborated in the following section.

5. Defining the water-smart society

The input from the practitioners provided valuable supplements to the literature-based definition of section 4.2. On this basis, the research team proposed the following definition of a water-smart society:

"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, safeguard ecosystems and their services to society, boost value creation around water, while anticipating change towards resilient infrastructure."

This definition (version 3) was discussed with the LLs and elaborated as follows: The first sentence highlights the objective of generate societal value. Taking "sustainable management of water resources" as a starting point emphasizes the need to balance the social, economic, and environmental dimensions of sustainability, through the instrumental support of reliable infrastructure and good governance. The second sentence is dedicated to the role of new governance models. Innovation is seen to include both technical and social innovations, where digital technologies may hold an immense potential, but not be a prerequisite for water smartness. 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, while addressing the risk/safety aspect. The last sentence emphasizes the long-term orientation of the water-smart transition process which must be planned with clear strategic objectives. This also includes the ability to anticipate and adapt to change, reflecting the objective of resilience.

Based on the dialogue with the LLs and insights from the literature review, the three sentences in the definition were transposed into a set of five strategic objectives, listed below (Table 5).

The strategic objectives are the overarching goals that municipalities or utilities aim to realise towards their "water-smart" vision. Thus, they reflect the transformative features of the water-smart society.

Strategic objective A, related to SDG 6, aims to ensure that all sectors have access to enough water in terms of quantity, and safe water in terms of quality now and in the future. This links up with SDG 12, responsible consumption and production, in providing water for both domestic and industrial uses, while ensuring health and safety; SDG 10, reduced inequalities, in terms of availability and accessibility; and SDG 11, on sustainable cities and communities.

Strategic objective B, safeguarding ecosystems and their services to society, links SDG 6 to SDG 14 and 15, protecting life below water and life on land, as well as SDG 11, on sustainable cities and societies. The objective describes the ability to prevent deterioration and ensure the protection of water-related ecosystems, enhance ecosystem services, strive towards carbon neutrality and promote resource efficiency. This will also contribute towards SDG 12, responsible consumption and production, and SDG 13, on climate action. Thus, we heed the literature on socio-ecological systems and ES and follow the LLs in emphasizing the environmental dimension strongly.

Strategic objective C refers to generating economic value from synergies in the water-energy-resources-waste nexus through the implementation of circular economy policies and business models. This dimension is well aligned with Water Europe's vision, and specifically addresses SDG 12, responsible consumption and production, ultimately linked to the need for sustainable food (SDG 2) and energy production (SDG 7), as well as SDG 11, sustainable cities and communities, and SDG 8, on decent work and economic growth.

Strategic objective D, promoting adaptive change toward resilient infrastructure, is about the establishment of planning procedures, their successful implementation, as well as financial and decision-making conditions promoting adaptive change towards resilient infrastructure. This relates directly to SDG 9, which aims to build resilient infrastructure, promote sustainable industrialization, and foster innovation, as well as SDG 3, good health and well-being, SDG 11 and SDG 13, on climate action.

Strategic objective E refers to the broad, iterative process of monitoring, evaluating, and learning water-smart practices amongst all relevant sectors by engaging citizens in planning, decision-making and implementation. This is linked to SDG 16, in striving for inclusiveness, as well as life-long learning (SDG 4) and sustainable cities and communities (SDG 11).

Table 5
Strategic objectives outlined from the definition.

Strategic objectives
A. Ensuring water for all relevant uses
B. Safeguarding ecosystems and their services to society
C. Boosting value creation around water
D. Promoting adaptive change towards resilient infrastructure
E. Engaging citizens and actors across sectors in continuous co-learning and innovation

The meaning of each strategic objective must be elaborated in relation to the societal context in question (e.g., city or region), and evaluated against clear assessment criteria. Within the B-WaterSmart project, the LLs are currently in the process of doing this. The ambition in Alicante is to apply water-smart allocation and negotiation to boost reuse and turn a wastewater treatment plant into a biofactory, recovering minerals, nutrients, salts, and energy. In Bodø, relocation of the airport enables new sustainable city development. The LL is working towards small-scale biogas production, using heat from biogas and seawater for urban surface de-icing, and smart leakage & infiltration control. In East Frisia, a sectoral and decentralized water supply strategy is under development considering hitherto unused local water resources. The objective in the Flanders is to establish regional circularity, by exploiting alternative water resources, improving the existing drinking water production, and securing irrigation by interaction with the urban reuse cycle. The focus in Lisbon is on tools & processes for safe water reuse; improved water-energy-phosphorous efficiency in non-potable water uses; and improving households and buildings' climate readiness regarding water and energy. Lastly, the mission in Venice is to enable and complete the water reuse (industrial, agricultural, and urban) goal of a regional/national plan for lagoon protection.

Through further co-creation, testing and validation with the LLs, the project has developed a detailed framework for the establishment of a tailored assessment system with quantified targets and metrics, which will be the subject of a separate paper.

6. Discussion

6.1. Broadening the perspective on urban water smartness

The applied co-development approach helps ground the vision of a water-smart society in recent research. As noted, there is no established definition of water smartness, but a tendency to link it to the benefits of advanced ICT in water management (Li et al., 2020). The recent definition provided by Salminen et al. (2022) takes a systemic perspective but is limited to water-smart CE, encompassing water that has been abstracted from the environment for various economic purposes, circular solutions that are directly connected to water and water-related ecosystems, and the risks posed by CE to these ecosystems. The authors discuss a range of drivers and barriers but do not include social institutions or citizens in their concept. Smol et al. (2020) argue that "rethink", both in technological, organizational, societal, and financial terms, is essential, but do not elaborate on this.

Our study adds a broader perspective, highlighting certain objectives and characteristics that must be sought after in a water-smart society. The LLs were positive about Water Europe, 2020 vision and found that business and value creation are sufficiently covered. However, sustainability is not explicitly mentioned, presumably because it is a rather abstract concept. According to the LLs, as well as the reviewed literature, it is crucial to consider the ability of future generations to meet their needs, not only in terms of resilience, resource efficiency and avoiding pollution but also taking into account wider societal and socio-ecological interactions (Anzaldua et al., 2016a; Lawson et al., 2020). This includes multi-sector interactions and in particular the trade-offs and complementarities between water, energy, and food systems (Artioli et al., 2017; McGrane et al., 2019).

CE is already central in Water Europe's vision. Here, too, the literature emphasizes the need to look beyond specific circularities and consider long-term system interactions (Korhonen et al., 2018a; Fidelis et al., 2021). Regeneration and localisation (Williams, 2019), as well as higher value retention options, including consumers (Laitinen et al.,

2020) are recommended. Nature-based solutions and environmental restoration were also proposed by the LLs, as key elements of the water-smart society. This is in line with the IUWM and WSUD approaches increasingly applied in Australia and the US (Furlong et al., 2016, Livesley et al., 2021; Scoggins et al., 2022).

In accordance with the studies addressing social and cultural interactions in water management, the practice partners emphasised the social dimension. As the specific issues of concern may vary, the proposed definition highlights societal well-being as an overarching aim, linked to ensuring water for all relevant uses in a manner that is not only efficient and effective, but also equitable and safe. Lastly, the LLs highlighted the need for transparency, education, and debate, resonating with the calls for change in "new governance" (Koop et al., 2022; Jimenez et al., 2020) and socio-technical transition studies (Jefferies and Duffey, 2011; Ampe et al., 2020), and the insight that planning is and always will be influenced by subjectivity and political struggles (Furlong et al., 2016). On this background, our definition highlights the need for citizen engagement, co-learning, and innovation, taking a long-term perspective while acknowledging uncertainty and the need for adaptive change.

6.2. Accelerating water-smart transformation in cities

While the literature on smart cities has seen a shift towards sustainability (Bricker et al., 2017; Obringer and Nateghi, 2021; Blasi et al., 2022), we found only a few papers addressing 'smart' cities and the SDGs. As shown above, we sorted and specified the aspects of urban water smartness highlighted by the LLs according to five dimensions of sustainability (Alegre et al., 2012). Finally, the definition was transposed into a set of strategic objectives linked to the SDGs. Thus, our definition brings different aspects of sustainability into one holistic concept, with water as the unifying factor.

The interconnections between the SDGs underscore the need for an integrated nexus approach (Salam et al., 2017) where multi-sector and multi-actor collaboration is prioritised. The dialogue with the LLs shows that this is where many of the most important opportunities and challenges are found, e.g., in aligning policies and regulations, building social acceptance and developing new business models enabling reuse of wastewater and resource recovery for agriculture, industry, energy and transport.

The need for coordination across levels and scales is also highlighted in the literature (Rodrigues and Antunes, 2021; Artioli et al., 2017; McGrane et al., 2019; Delany-Crowe, et al., 2019). While this paper focuses on European cities and regions, other studies show that metropolitan governance and new, higher-level governance bodies can lead to fragmentation as well as more integrated water management, depending on time and context (Morgan et al., 2020; Furlong et al., 2016). In line with studies highlighting complexity and the variety of stakeholder positions to consider (Gilbert and Campbell, 2015; Duygan et al., 2022; Siokas et al., 2022), we also found different perspectives on water smartness across the LLs. This underscores that local contexts and objectives (Helness et al., 2017; Hallin et al., 2021) as well as wider, long-term human-water interactions (Di Baldassarre et al., 2019) must be addressed. Meeting SDG 6 and 11 will require a bundled response to multiple water-related challenges, and priorities will differ from urban area to urban area, especially between cities where water service standards currently are met, and cities with huge inadequacies today, e.g., in developing countries (Horne et al., 2018).

For many water utilities, the perspective on water smartness is related to their inherent task of providing water to their customers, which is of sufficient quality, quantity, and affordable, presently and in the future. In integrated water management, safeguarding water quality and quantity through water resource protection and novel forms of water governance are key issues, while for regional and national authorities, operationalization through water-smart policies may be the most central aspect. Continuous co-learning and innovation are important to align these goals and efforts. While digitalisation is not a goal in itself, it may increase knowledge and wisdom through improved ability to make projections, scenarios, and 'prescriptions' based on critical judgement (Ahvenniemi et al., 2017; Anthopoulos, 2017; Widener et al., 2017).

More explicit inclusion of diverse citizen interests may also help address the critique against collaborative and market-based water governance (Jimenez et al., 2020), that agreements between public and private actors may work against the democratic power balance. Increased focus on knowledge development, learning and experimentation is also recommended in the literature (Koop et al., 2022; Pisano, 2014; Köhler et al., 2019). The need for novel forms of stakeholder involvement was emphasised by the LLs and resonates with recent work on the "future city" (Jang and Gim, 2022; Shelton and Lodato, 2019; Docí et al., 2022). Our definition of the water-smart society meets the call for visions that emphasize sustainability principles, governance and learning from place-based solutions (Sharif and Pokharel, 2020). The link to a set of strategic objectives contributes towards operationalization of the SDGs at the local government level (Di Vaio et al., 2021), as a first step towards defining policies, performance indicators, and standards for water-smart cities and regions.[2]

For water utilities, the concept of the water-smart society may provide direction and help integrate their strategic efforts, both in a longer-term and in a shorter-term perspective. Besides implementing smart technologies to ensure efficient, safe, and affordable services, they need to consider more radical innovations, such as treated wastewater use and resource recovery, which require new value chains. This has implications in terms of capabilities such as organizational culture, leadership, and competence. Increased focus on industrial networks and innovation and knowledge about environmental management, digitalisation and social change is important. Moreover, there is a need for new tools and concepts that can help address the complexity of water-smart societies.

In terms of urban water policy design, Salminen et al. (2022) suggest that joint, coordinated use of economic, regulatory, and informative instruments is needed. They focus especially on economic instruments, discussing legislation for pricing and use of water and costs and investments related to wastewater treatment. Our findings indicate that awareness and knowledge building also will be highly important for the uptake of water-smart solutions. Since this needs to cut across sectors, provision of arenas and forums for multi-stakeholder dialogue and citizen engagement is essential. This may be seen as a shared responsibility – of the relevant authorities, but also of involved research institutions, sector organisations and NGOs. Support for intermediaries, such as cluster organisations and innovation agencies may help accelerate the transition. Innovative green public procurement, e.g., in form of competitions or partnering contracts, is also recommended. System innovation and experiments involving public, private and third sector actors can both generate important knowledge, aid the development of industrial networks and rally support for specific solutions. For this, e.g., the EU Water-Oriented Living Labs (WOLLs) may be important, and similar platforms could be encouraged in other parts of the world. For transfer to actors and cities in developing countries, developing a strong water information base is a crucial step (Horne et al., 2018). Moreover, capabilities and the quality of water governance arrangements, addressed by e.g., the OECD (2015) and the World Bank (2017), are critical factors. Network governance and collective action, e.g., through the United Nations Development Programme (UNDP), is therefore crucial (Horne et al., 2018; Kapuchu and Baudet, 2020).

A key challenge for the research community is to work across disciplines and provide perspectives and tools that are able to address the complexity of the water-smart society, yet focused and simple enough to

[2] Building on the present study, B-WaterSmart is developing an assessment framework for strategic planning towards a water-smart society.

meet the requirements of practitioners and make a difference in the real world. While this paper provides an overarching definition and outlines a set of strategic objectives for transition towards a water-smart society, the next step in to present a tailored system whereby strategic agendas for specific municipalities and utilities can be developed and assessed. This system, including a set of 15 assessment criteria and 60 metrics, will be embedded into a dashboard tool to guide the user in developing strategic plans.

The combination of different methods and co-production with six LLs across Europe provide a solid foundation for the proposed definition, objectives, and recommendations. However, the perspectives of a wider range of stakeholders, and of practitioners in other parts of the world, have not been in focus, and should be addressed in future research.

7. Conclusion

This study aimed to define the "water-smart society", linking the vision to relevant research literature and the perspectives of practitioners in European cities and regions. A review of recent articles on sustainable water management, IWRM, CE, smart cities, human-water interactions, water governance and sustainability transitions found support for the core tenets of the vision. Particularly, development and deployment of digital enablers and inclusive multi-stakeholder governance stand out as crucial for the transition towards a water-smart society. In addition, we found certain perspectives and issues that should be brought more to the fore, namely:

- Focus on societal well-being and long-term sustainability
- Conserving wider ecosystems and their services to society
- Adaptation of existing infrastructure
- Multi-sector (water-energy-food) interactions
- Nurture experimentation, variation and flexibility

The workshops and interviews with practitioners underscored these points. However, some issues were emphasised more strongly:

- Empowerment and enabling governance
- Safety and resilience under alternative risk scenarios (not merely environmental)
- Water has to be both physically available and affordable

The proposed definition takes these aspects into account. The definition suggests that to be transformative, the concept of "water-smart society" should include societal well-being and co-development involving citizens and actors across different disciplines and sectors. Moreover, it emphasizes the need for a long-term perspective, conserving ecosystems and maximising their services to society, while anticipating change and adapting existing infrastructure. By transposing the definition into five strategic objectives, a first step has been made towards operationalising it into an objective-driven assessment framework able to assist decision makers and practitioners in their strategic planning process towards the realization of their water-smart society vision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix

Supplementing information on methodology.

A.1 Detailed description of workshops (Step 2)

To arrive at the definition of the water-smart society presented in this paper a co-development approach was applied, which included close collaboration between researchers and practitioners. The practice partners involved in the co-development were the water boards, municipalities and technology providers associated with the different LLs of the B-WaterSmart project. Following the formulation of a preliminary working definition, a series of workshops (n = 2) was organised to gather the visions and experiences of the practice partners in the LLs. Due to COVID-19 restrictions the workshops had to be online (October/November 2020). Each workshop lasted 3 h and consisted of a mixture of presentations, participant engagement, and discussions.

The workshop participants were a balanced number of researchers (of various disciplines) and practice partners. The latter were a mixture of LL members, from participating water boards, water utilities, municipalities, and technology providers. All practice partners took part in both workshops, while the number of researchers changed slightly from workshop 1 to workshop 2 (see Table 1, main text).

Workshop 1 was used to set the scene. The participants were reminded of the goal of the project and the two workshops, e.g., the development of a collective understanding of a water-smart society, and the exploration of water smartness visions. The participants' understanding of "water smartness" was gathered through two polls (Mentimeter, 5–12 words per participant). The questions asked in the polls were:

I) Please provide what you think are the most important keywords that should be addressed in a framework to assess "Water smartness". Name at least five keywords.
II) Please provide what you think are the most important keywords that should be addressed in a framework to assess "Water smartness in the context of society and circular economy". Name at least five keywords.

Following the polls, the participants were invited to explain some of the most counted keywords provided in poll 1, e.g., sustainability, fit for purpose, innovation, wisdom, shorter supply chains, and poll 2, e.g., cooperation, sustainability, efficiency, stakeholder, awareness. The keyword clouds were further used as point of discussion to explore the understanding of the participants visions of water smartness.

The received feedback from the polls during workshop 1 was provided by all participants. Since these were a balanced number of researcher and practice partners, the received feedback was potentially biased by the researchers' perspective. To account for this bias, the practice partners (only) were asked to provide at least five keywords for the above questions through an Excel survey in between workshop 1 and workshop 2. This filtered feedback was presented to all workshop participants during workshop 2.

Workshop 2 was used to continue the development of the water smartness concept. It included comparison of the different feedbacks of the polls (workshop 1 and Excel survey). The received keywords of the first questions were rather similar across participants, e.g., optimisation, sustainability, stakeholders, water distribution system, while the answers to the second question included more technical requirements, e.g., energy consumption, water distribution, and water reuse. The results of both workshops were used to refine the preliminary definition of water smartness (version 0) with the insights from the practice partners (version 1):

> "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 water." (Preliminary working definition prior to workshops, version 0).
>
> "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.**" (Preliminary working definition post workshop, version 1).

A.2. Detailed description of interviews (Step 4)

Step 4 in defining the concept of water-smart society was a series of interviews with the strategic management level of the main LL organisations, e.g., water utilities and municipalities. The goals of the interviews (n = 6) were to generate in-depth knowledge on LL specific long-term strategic objectives, and to gather feedback from the LL owners on the draft (version 1) definition of the water-smart society. The interviews were held in the second half of January 2021, mostly in person but in some cases online, each scheduled for 3 h.

a. Methodology

The interviews were led by members of the research team, who served as LL mentors and spoke the local language, to avoid potential language barriers. Further, a semi-structured format was chosen to find a balance between flexibility of knowledge exchange and comparability of interview results. The interview guide explained the goals and objectives of the interviews, relevant background information of each LL, and contained a definition of relevant keyword related to water smartness as well as the questions used for the interviews (see table A1).

During the interviews, the interviewees were guided through three blocks of questions: 1) their long-term strategic objectives, 2) the milestones, e.g., intermediate goals/targets, and 3) feedback on a preliminary water smartness definition (Table A1).

Table A1
Interview guide for the January 2021 interviews with the LL owners.

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) Milestones, i.e., intermediate steps to reach strategic objectives	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?

The goal of block 1 was to define at least three long-term strategic objectives for each LL. To facilitate the discussion, each LL owner was presented with the ranking of 10 strategic objectives specific to their LL as a point of departure for the discussion. The LL owners were free to choose any of the strategic objectives defined by the project, but also to change the strategic objectives according to their needs, or to define their own strategic objectives as long as they were in line with the overall project objectives. The long-term strategic objectives should reflect the perspectives of the top decision-making level of the LL owner's organisation.

The same approach was followed for the definition of milestones (block 2). For each long-term strategic objective at least one milestone had to be defined and described including any pathways already implemented or identified to reach the targets. The goal of the last block (block 3) was to advance the preliminary definition of water smartness (version 1) with the practice-oriented perspective of the LL organisations. For this purpose, the preliminary definition of the water-smart society was presented to the participants of the interviews, and relevant keywords were explained based on the shared terminology of the project participants.

Afterwards the participants were invited to provide their feedback on how to improve on the definition. In case dimensions or keywords were added, the participants were asked to provide a definition and explanation of the added content.

The results of each interview were summarised and translated by the respective interviewers and shared with the research team in a joint feedback session after the interviews, which also served as a quality control in terms of provided content and its comparability across LLs.

b. Participants

While the structure of the interviews was identical, the number and background of the participants differed. The common participants were LL mentor and LL owner, but each LL was requested to choose additional participants, i.e., representatives of the decision-making level of their organisation, in case the strategic management was not already represented through the LL owner. This was to ensure that the concept of water smartness and the implementation of a strategic agenda to reach water smartness are endorsed by those with power to implement them.

Where the additional participants had not been involved with the project before, the LL mentors and owners were briefed to provide sufficient introduction to the project and the discussed concepts to ensure alignment between the LLs. Since this divergence in numbers and background of participants naturally influenced the outcomes of the interviews, each LL mentor was asked to provide details on the participants of the interview (e.g., name, organisation, position).

In total, 28 people participated in the interviews, of whom 19 were additional participants. Of these, 14 and 5 were associated with water utilities and municipalities, respectively. The divergence in participant numbers reflect the tendency that participating municipalities were already represented through the strategic management, whereas participating water utilities needed to involve additional members of their organisation to reflect the strategic management level.

c. Results

The answers to the first block of questions "Long-term strategic objectives" have been used as foundation for the identification of a preliminary list of strategic objectives to be included in a framework for water smartness assessment, tailored to the context of specific regions and cities (to be published in a separate paper).

The answers to the second block of questions "Milestones" have more direct relevance for the formulation of strategic agendas for the LLs. The strategic agendas are confidential at this stage, but they will be published as a final deliverable at the end of the B-WaterSmart project in 2024. The information obtained was also used as starting points for the development of assessment criteria that reflect the LLs' challenges and the barriers responsible for the current distance from the set objectives.

The answers to the third block of questions have direct relevance for the formulation of the final version of the water smartness definition presented in this paper. The summarised results can be found in Table 4 of the main text.

The results of the interviews were presented during an online workshop joined by all LLs (LL mentor and LL owner). During the workshop each LL presented the results of the interview followed by a round of feedback and a general discussion. Any outstanding issues regarding the strategic objectives or the water smartness definition were addressed. In general, the participants gave positive feedback on the method of work (interview/workshop) and the information generated.

When comparing the results of the LLs, it could be deduced that the presented long-term visions of water smartness are consistent, and that the singularities reflect the 'profile' of the LL owner, e.g., municipalities have a stronger focus on social aspects such as water for all, while water boards place more emphasis on technical and economic aspects such as resource recovery. The different water smartness 'profiles' will be assessed and presented in subsequent publications by making use of the Water Smartness Assessment Framework. The demonstrated consistency of the long-term visions, and hence the common aspects found in the diverse LLs suggest a strong replicability potential in Europe and beyond.

Table A2 provides a summary description of the LLs and interview participants. LLs are characterised as water board (W) or municipality (M) owned. The listed key challenges, opportunities and special focus of the LLs were adapted from https://b-watersmart.eu.

Table A2

Detailed description of LLs and interview participants. LLs are characterised as water board (W) or municipality (M). Description of key challenges and special focus of LLs adapted from https://b-watersmart.eu.

LL	Participants: Total # and description	Format	Key challenges	Special focus
Alicante (W)	2 – LL mentor and LL owner	Online	Water scarcity; limitations to water reuse due to high salinity/nitrates and low acceptance	Improve water-smartness in the municipality of Alicante by incrementing water reuse and boosting circular economy opportunities
Flanders (W)	8 – LL mentor and LL owner (2); Case study organisations' strategic management (6)	Online	High drinking water demand due to dense population; high water demand for agriculture; groundwater overexploitation; water quality deterioration; water scarcity due to droughts, climate change and urbanization	Development of regional concepts for improving and monitoring water-smartness and a more robust water system with a focus on safe water reuse
East Frisia (W)	5 – LL mentor and LL owner (3); strategic management of LL organisation (2)	Online	Increasing water demand in supply area by growing sectors; limited groundwater resources; locally untapped water reuse potential	Increasing the carrying capacity of water supply: identification of alternative resources; intelligent protection strategies for groundwater bodies; improved treatment of process water for reuse in milk production
Venice (W)	5 – LL mentor and LL owner	Hybrid	Need for reuse and recovery schemes for wastewater & sludge; limitations to reuse and recovery due to low acceptance; water scarcity; untapped efficiency potential (water and resource valorisation)	Enable and complete the water reuse goal of a regional/national plan for lagoon protection; apply nutrient recovery technologies to WWTP; develop shared evaluation model tools for the sustainability of WWTPs effluents and sludge valorisation

(continued on next page)

Table A2 (*continued*)

LL	Participants: Total # and description	Format	Key challenges	Special focus
Bodø (M)	4 – LL mentor and LL owner	Hybrid	Growing residence population and economy; increased pollution; untapped efficiency potential	Sustainable zero-emission urban development; find cost effective way to realise energy potential in wastewater; develop smart leak detection and control system in water supplies; make blue-green infrastructure a part of the solution to handling climate change
Lisbon (M)	4 – LL mentor and LL owner (2); strategic management of LL organisation (2)	In person	The estimated increase in resident population and a growing economy depend on distant freshwater resources with increasing climate challenge; balance water demand with need to increase urban green areas to ensure citizens' quality of life and sustainability of urban life	Development of tools and process to facilitate safe water reuse; improve water-energy-phosphorous efficiency in municipal non-potable water uses; contribute to improving households and buildings' climate readiness regarding water and energy with an assessment/ certification tool

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