Environment, Development and Sustainability
https://doi.org/10.1007/s10668-021-02045-0

A new operational approach for understanding water-related interactions to achieve water sustainability in growing cities

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Received: 14 July 2019 / Accepted: 8 December 2021

Abstract
About 56 percent of the world's population currently lives in cities. Anthropogenic activities have both directly and indirectly modified their environment. Therefore, management actions at the urban level determine whether or not cities are heading toward sustainability. Consequently, water management is in need of a clear insight of the social and ecological water-related interactions. Thus, a new operational approach is proposed for a better understanding of the interactions between the water cycle, cities and the society. In our approach, eleven key issues and their interactions emerge from an analysis of 371 documents published between 2012 and 2018. The interactions between different key issues were examined through four main foci of analysis: water resources, urban throughput, water equity, and water governance and financing. Those main foci help to comprehend water as a holistic element intertwined in urban areas. In addition, our approach provides six challenges to guide the stakeholders in decision-making processes: how to recognize, integrate, and/or restore water-related ecosystem services, how to maintain and improve the supporting green and blue spaces, how to guarantee the quality and quantity of water resources and the water supplied and used, how to ensure public and social health and well-being of the citizens, how to prevent and manage water-related conflicts, and how to make informed and equitable decisions on water management at urban level?

Keywords Water resources · Cities · Urban sustainability · Water management

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Published online: 21 December 2021

1 Introduction

Since 2008, the percentage of urban population exceeded the percentage of rural population worldwide (The World Bank, 2018). According to the World Urbanization Prospects (2018), 55.7 percent of the population lived in urban areas in 2019, for 2030 about 60 percent are predicted. The World's cities are playing an important role in the global change of environment through the interactions of social, economic, and biophysical processes (Bai et al., 2016; Grimm et al., 2008; Phearson et al., 2016; Seto et al., 2012).

Therefore, the dynamics of urban settlements affect the natural environment (Inoguchi et al., 1999). The hydrological cycle of cities changes when buildings, asphalt and concrete replace natural elements such as vegetation and soil (Hough, 1995). In addition, urban activities lead to water withdrawals from surface and groundwater sources, and sometimes even from the rainwater (López et al., 2019). Urban usages influence both, water quantity and water quality. For instance, in many parts of the world, wastewater from domestic uses returns untreated to the environment (UN-WWAP, 2015).

Although urban areas represent about 2.7 percent of the world's land area, cities around the world use roughly 75 percent of total materials/goods and energy produced worldwide (Arto et al., 2016; Strohbach et al., 2009). In the case of water, in 2016, almost 18 percent of the total freshwater withdrawal in the world was used for municipal use or supply (The World Bank, 2016). In 2040, the predicted water demand will be 30 percent higher than it is today (Khan et al., 2017).

Studies of water resources in urban areas have mostly focused on analyzing water supply (e.g., Martos et al., 2016), wastewater management (e.g., Walsh, 2000), lack of water (e.g., Brown & Matlock, 2011), and sustainable water systems (e.g., Ma et al., 2015). Often such issues are addressed in isolation from each other (Ma et al. 2015). However, cities and their immediate physical environment are part of a complex holistic system where multiple sectors interact (Conke & Ferreira, 2015). In such systems, material processes flow in both directions, coming in and going out, between the cities and their areas of influence (Srinivas, 1999).

In this line of thought, the integrated water resources management (IWRM) has become the new paradigm for discussing, legitimizing, and implementing policies related to water resources management (Orlove & Caton, 2010). The IWRM provides the balance of both water supply and water demand by correlating multiple uses of water, stakeholder decisions, and ecosystem needs, which helps to manage water in a holistic manner (Younos & Parece 2016). However, according to Giordano and Shah (2014), the current monopoly of IWRM in the water management discourse is shutting out alternative thoughts on pragmatic solutions for existing water problems. In addition, the implementation of IWRM has proven to be a challenge (Kunz, 2016).

Thus, sustainable water use and water management is in need of an operational understanding of the interactions between the water cycle, the city and its physical environment. Consequently, the aim of this paper is to develop a new operational approach for understanding the water as an intertwined element within the society, the city and the surrounding environment. With this, our article contributes to the water sustainability framework by introducing challenges for urban water management that stakeholders should address to pursue urban sustainability. Our study focuses on growing cities because the interactions between citizens and the surrounding areas have intensified due to the growth in the number of inhabitants, and the increased demand on natural resources.

2 Methods

The procedure for the selection of the literature was conducted in two steps. First, we collected scientific documents published in English from the *ScienceDirect* and *Scopus* databases. The search targeted publications focusing on sustainability, urban contexts as well as water management. Therefore, the search code was: "urban sustainab*" AND water AND grow*. The search was restricted to papers published between 2012 and 2018, thus ensuring novelty but also ample coverage of the available literature. This process yielded 573 documents.

The second step was a data cleaning process, eliminating duplicates (15 items), unrelated papers (23 items) or papers on sustainability that are not focusing on water resources or urban areas (164 items). After this selection, 371 documents remained as relevant for the purpose of this review. Those documents were arranged within a table presented in the supplementary information, stating their references (e.g., authors, journal, title, year), key words and abstracts.

The review of the literature was developed in three stages. Firstly, the abstracts of 324 journal articles, 41 prologues of book chapters, and 6 introductions of conferences were read, identifying and coding the water-related problems addressed by each document. Secondly, the assigned codes were grouped into 11 categories (we called it '*key issues'*), according to their topic. Therefore, a *key issue* is a specific problem that growing cities must address to achieve urban water sustainability. Finally, the 371 documents were re-evaluated and classified into main topic (indicated by number 1) and secondary topics (indicated by number 2); the summary table is presented in the supplementary information.

The results of the literature review were analyzed in three phases. In the first phase, '*key issues'* were further sorted thematically in a list of eight 'key elements.' Those elements were arranged using the four **dimensions** of sustainability, including governance. In this line, a key element is the area of analysis on which each dimension is focused (cf. Table 1). This classification is based on the following points.

Table 1 Key issues and elements related with urban water sustainability. *Source*: Analysis of authors based on the analyzed documents. More details are provided in the supplementary material

Sustainability		Key issues	Number of articles	Average publication year	Most frequent year of publication
Dimensions	Key elements				
Environment	Eco-system	Ecosystem services	21	2015	2016
		Natural water cycle	24	2016	2016
	Water resources	Water quality	36	2015	2015
		Water quantity	33	2015	2015
Social	Well-being	Water supply	53	2016	2018
		Use of water	108	2016	2018
	Public health	Sanitation	37	2016	2014
Economic	Investment water issues		22	2015	2014
	Costs and taxes of services		14	2015	2017
Governance	Management		124	2015	2017
	Water conflicts/disputes		11	2015	2017

In the **environment** dimension, the elements of 'ecosystems' and 'water resources' were investigated. Documents with the main objective of studying the issues of *ecosystem services* and the *water cycle* were classified within the ecosystem element. This classification relies on two considerations. First, the ecosystem services are the benefits that humans obtain from the environment and from the functioning of ecosystems (Keys et al., 2016; TEEB, 2011). Second, the natural cycles could be affected by a change of conditions in the ecosystems (Jiménez-Martínez et al., 2016; Keys et al., 2016). Documents that focus on the issues of *quality* and *quantity of water* were categorized into the element of water resources.

The **social** dimension includes elements of 'well-being' and 'public health'. Documents that focus on studying *water supply* and *water use* were pigeonholed within the element of well-being because they are basic characteristics for a good life of citizens. Documents focusing on *sanitation* were classified within the public health element.

The **economic** dimension includes all documents focused on analyzing *investment* in water issues as well as *costs and taxes* of water services. The **governance** dimension encompasses documents whose main objective is to study the *water management* and *conflicts* related to water. Note that in the dimensions of **economic** and **governance**, the issues cannot be distinguished from elements.

In the second phase, the interactions between different *key issues* were examined. Due to the fact that the analysis of these interactions has been restricted by the dimensions of sustainability, four main foci of study were proposed to explore these interactions in a comprehensive way (cf. Fig. 2). Each focus of analysis manages a specific area related to water resources. Thus, the name assigned to each focus reveals, at a glance, the thematic line studied within them. In the third phase, water-related challenges were proposed as an operational manner to guide stakeholders to achieve urban water sustainability. Those challenges were formulated as questions because, according to Siebert (2007), the easier way to address an issue is to pose the problem as a question.

3 An overview of key issues in urban water sustainability

In Table 1, we present the number of articles of each *key issue* identified in the literature. Which are thematically grouped in eight key elements and sorted into the four **dimensions** of sustainability. Between 2012–2018, the *issues* mostly analyzed in the literature were water *management* (124 documents) and *use of water* (108), followed by *water supply* (53), *sanitation* (37), *water quality* (36), and *water quantity* (33). The least studied issues were *cost and taxes of services* (14 documents) and *water conflicts* (11).

To get an overview of water-related topics addressed in the selected documents, we used word cloud analysis to visualize the keywords covered in the 371 documents. The 50 most frequently used words are presented in Figure 1A in which the font size is proportional to their frequency. Leaving aside the term 'water' itself, the most frequent terms are 'use' and 'management', which indicates that the sustainability concerns are dominated by a utilitarian aim.

The following words are repeated more than 200 times: 'energy', 'resources', 'urban', 'environmental', 'economic', 'development', 'sustainable', 'consumption', 'river', and 'groundwater'. The term 'ecological/ecosystem' appears 167 times. The last three words are 'surface', 'changes', and 'human', which are repeated around 84 times each.

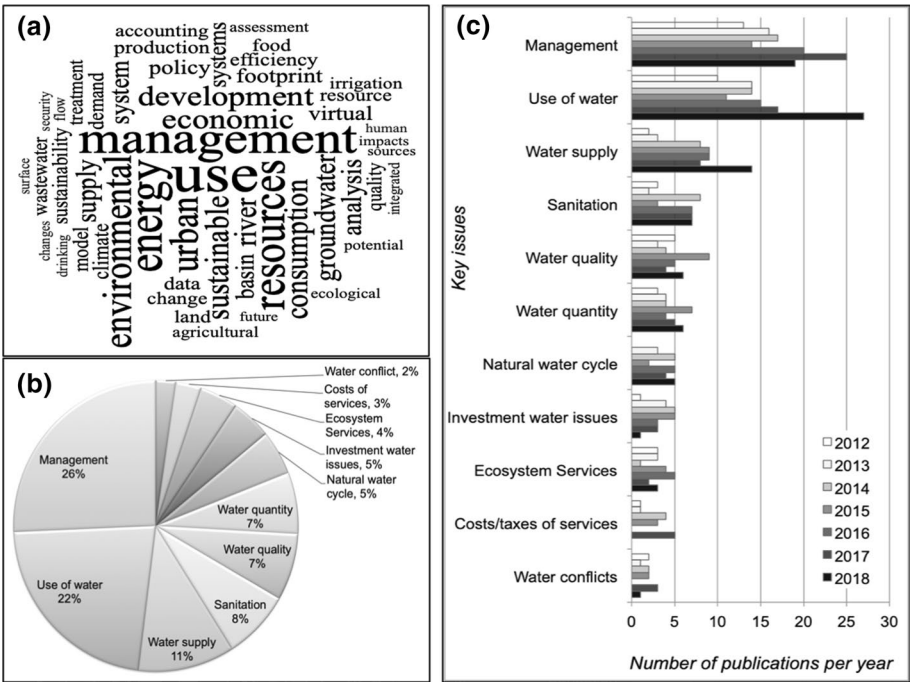

Fig. 1 Analysis of study objectives of the selected literature. **a** the most frequently used words (without 'water'), **b** percentage of documents according to key issues, **c** the most frequent year of documents by key issues. *Source*: Own elaboration based on the analyzed documents.

This result is consistent with a quantitative examination of key issues. Figure 1B shows that 26 percent of the analyzed documents focus on the key issue *water management,* 22 percent on the *use of water*, and 11 percent on *water supply*. Issues of *sanitation*, *water quality,* and *quantity* are comparatively less frequent in the literature. All other issues, including those related to the analysis of *ecosystem services* and the *water cycle*, are addressed in less than 5 percent of the selected documents.

As summarized in Table 1, the average of publications for almost all key issues was in 2015. The analysis of the most frequent year of publications sorted by key issues is presented in Figure 1C. Water in cities has been continuously discussed in academia; however, the different water issues have been addressed separately. Articles that focus on the issues *water supply* and *use of water* have a higher frequency of publication in 2018, while articles that focus on the issues *sanitation* and *investment of the water* have a higher frequency of publication in 2014.

It is noteworthy that 280 documents (75% of all the reviewed papers) focus on just one of the eleven identified key issues. This indicates that only one fourth of the literature on urban water sustainability actually combines more than one key issue.

Geographically, 27 percent of the selected documents investigate cities in Asia, 11 percent each in Europe and in Oceania, 10 percent in Africa, 4 percent in USA/Canada, and 2 percent in Latin America. In addition, 7 percent of the papers report comparative studies investigating several cities in different countries. The remaining 28 percent do not specify the area of study.

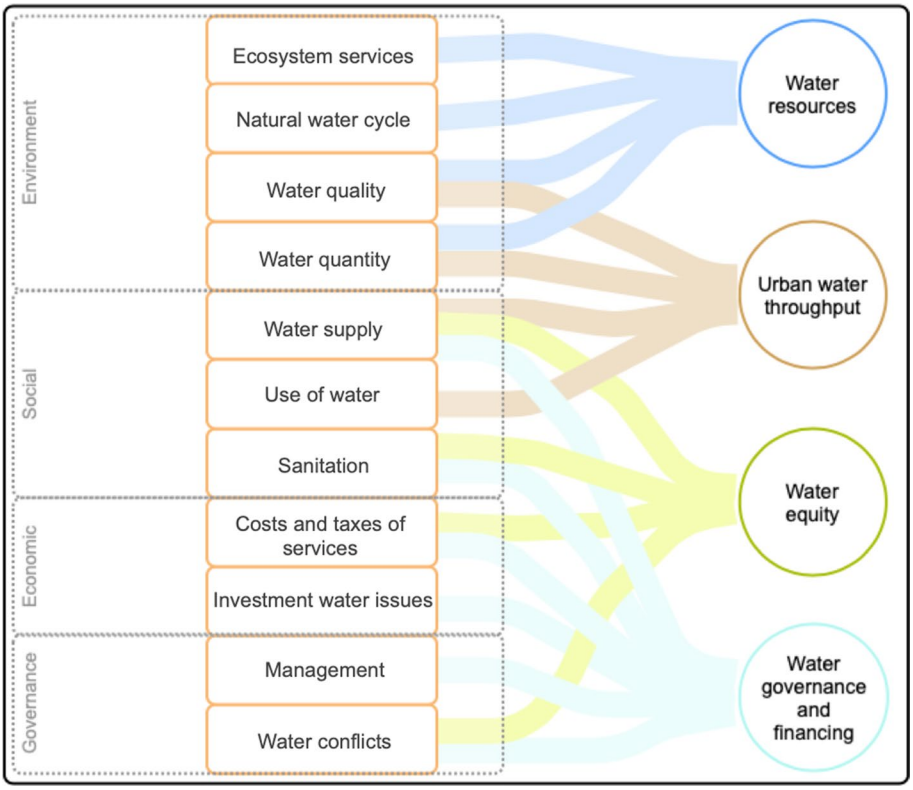

Fig. 2 Holistic framework of urban water management of growing cities. *Source*: Own elaboration based on the analyzed documents.

In order to study the interactions between key issues within each dimension of sustainability, the *eleven key issues* identified were tackled by the four dimensions of sustainability (Fig. 2-left). In this case, the interactions between key issues were limited to each dimension of sustainability. However, the interactions between different key issues (cf. Fig. 3) transcend the boundaries of sustainability dimensions. Consequently, **four main foci** were proposed to explore these interactions in an integrated manner (Fig. 2-right).

The **main foci** group issues according to a specific area of analysis of water resources (Fig. 2). Thus, **water resources** describe the conditions of the water resources and their environment (Sect. 4.1). **Urban water throughput** reveals the pressure on water resources caused by the increasing water demand by all anthropogenic activities (Sect. 4.2). **Water equity** unveils the quality of life of citizens and the surrounding environment (Sect. 4.3). **Water governance and financing** reports all items associated with the actors in charge of water management (Sect. 4.4).

4 An operational approach for understanding water-related interactions between key issues

In this section, we postulate a new operational approach to understand the social and ecological water-related interactions in growing urban areas. Figure 3 depicts the **four main foci** (gray) proposed to explore the interactions between *key issues* (red). In addition, six key water management challenges were identified (blue) to guide decision-making processes. Each challenge comprehensively addresses the connected key issue, operationalizing the urban water sustainability (see discussion section). On this basis, stakeholders and decision makers can address water-related issues to achieve urban water sustainability.

4.1 Water resources

The documents analyzed reveal a close relation between humans and the water cycle, and how water becomes an element of the society (Boelens et al., 2016; Linton & Budds, 2014). Therefore, anthropogenic actions modify directly or indirectly the natural water cycle by generating pressure on the environment and related ecosystems (Jiang et al., 2015). The changes of natural land conditions by paved surfaces (Wu et al., 2015) have an impact on the infiltration of rainwater and run-off, affecting the *natural water cycle* (Hanssen & Viles, 2014; Liu et al., 2019).

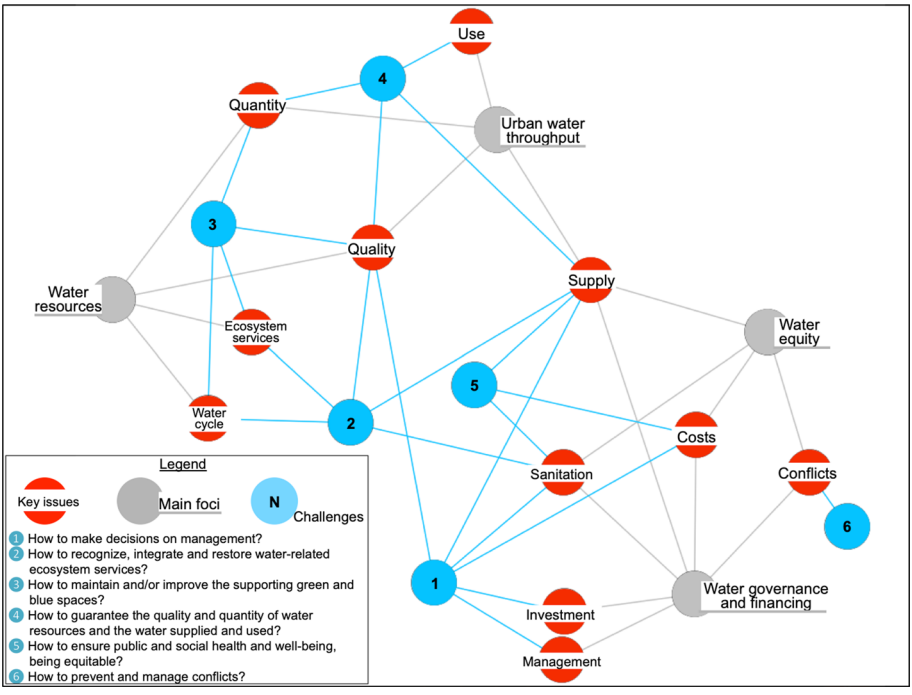

Fig. 3 Operational approach of the interactions of urban water sustainability elements. *Source*: Analysis of authors based on the analyzed documents

The main water stress factors are changes in the *natural water cycle* along with climate changes (Inglezakis et al., 2016). The problem of the water scarcity is connected directly with the *quantity of water* (Vanham et al., 2018). Urbanization processes and anthropogenic activities have exacerbated problems not only in *water quantity*, but also in *water quality* (Xu et al., 2018).

The increase of the population growth rate causes a significant increase in water demand (Chen et al., 2013). As a result an increased *quantity of water* is withdrawn from the environment to satisfy the basic human needs and industries demand (Liu Yating et al., 2018). But at the same time, more industrial and domestic wastewater is returned to the environment, with or without treatment (Shao et al., 2014; Wang et al., 2014). The contamination of the water resources is one of the environmental impacts generated by human activities, affecting its *quality* (Katukiza et al., 2012; Luh & Bartram, 2017).

In addition, anthropogenic actions also generate environmental impacts, that, along with the expansion of urban areas, affect the ecosystems (Elmqvist et al., 2015). Consequently, the capacity of the ecosystems to provide *ecosystem services* has been affected, such as the run-off mitigation, water supply, urban temperature regulation, air purification, and noise reduction, among others (Gómez-Baggethun et al., 2013; Gómez-Baggethun & Barton, 2013).

4.2 Urban water throughput

Although more than 70 percent of planet Earth is covered by water, only 3 percent is freshwater (Fekete, 2013). However, climatic and hydrological conditions, urbanization, population growth, increased per-capita water use, pollution and over-abstraction of groundwater are affecting the water security (Kujinga et al., 2014). For this reason, the interactions between the issues *water supply, use of water* as well as *quality* and *quantity of water* were analyzed (Fig. 3).

Water resources are essential for social and economic development, being used in all anthropogenic activities, e.g., the production of 1 kg beef demands about 15,000 liters of water, to produce a pair of jeans roughly 8,000 liters of water is required (Hoekstra, 2013). However, as mentioned above, freshwater resources face both, *quality* and *quantity* problems (Inglezakis et al., 2016).

In 2016, worldwide almost 60 percent of the total freshwater withdrawal was used for agriculture, 22 percent for industry, and only 18 percent corresponds to municipal use or *supply* (The World Bank, 2016). But, unfortunately more than a billion people still lack access to safe freshwater around the world (Khan et al., 2017). In future, the situation may become even worse if the pressure generated in the environment by all anthropogenic actions continues. According to the Organization for Economic Co-operation and Development, in 2050 the water demand will have increased by 55 percent compared to the reference year 2012 (OECD, 2012).

4.3 Water equity

Safe drinking water and sanitation are essential for a healthy life and human well-being (Naimi-Ait-Aoudia & Berezowska-Azzag, 2014). Globally, in 2015, 91 percent of the households used improved drinking water sources, while 68 percent has improved sanitation (Hutton & Chase, 2016). However, there are still 1.1 billion people without access to

safe drinking water and 2.4 billion lacking proper sanitation (Fekete, 2013; Khan et al., 2017).

Rural populations, slum dwellers, and marginalized groups are lagging behind in accessing these services (Hutton & Chase, 2016). Consequently, in recent years, "equity" has become an objective of water governance (Goff and Crow 2014). In the focus **water equity**, the issues *water supply, sanitation, the cost of the service* and *water-related conflicts* are studied (Fig. 3).

The *water supply* is a key issue to ensure the access to water (Hope & Rouse, 2013). There is a direct link between the access of safe drinking water and life expectancy, healthy life expectancy as well as lower infant (under 5 years) and maternal mortality risks (Mújica et al., 2015). Besides, there is a direct link between poor *sanitation* and increased incidences of diseases as well as the pollution of the environment (Katukiza et al., 2012).

In addition, the lack of access to drinking water and sanitation has an impact on the human well-being, affecting the public health and causing *conflicts* for the citizens (Baino-Salingay et al., 2017). But it also has a significant economic impact. For instance, the cost of deficient sanitary conditions exceeded 4 percent of the total Gross Domestic Product (GDP) in South Africa, while in East Asian, the Pacific and Sub-Saharan African economies, it was 2 percent of the GDP (Hutton & Chase, 2016).

On the other hand, the *cost of the water* used is calculated based on all the costs incurred, including the extraction, treatment, pumping, storage, purification, and disposal. However, the true value of the water is not known (Ogasawara & Matsushita, 2018).

4.4 Water governance and financing

As depicted in Fig. 3, in **water governance and financing**, the issues water management, investment in water, the cost of water services, water-related conflicts, water supply and sanitation are studied.

The key issue of water management is connected to investments in water that are arranged by decisions taken by stakeholders (Chen et al., 2014; Ogasawara & Matsushita, 2018). The literature reveals beneficial effects on investments in water-related issues to achieve cities with improved quality of life standards, and to reduce the pollution of the environment (Francis et al., 2015; Pagsuyoin et al., 2015). For example, the intervention on water supply and sanitation services improves the access to these services or the implementation of new technologies increases their efficiency (Hutton & Chase, 2016; Katukiza et al., 2012).

Nevertheless, power differences between various social classes influence the socio-environmental interactions and decisions taken by stakeholders (Boelens et al., 2016; Linton & Budds, 2014). In addition, the different uses of water have a direct impact on the daily life and human survival, such as access to water, which has the capacity to promote people to either escape from poverty or condemn them (Goff & Crow, 2014).

This confirms the argument made by Gupta and colleagues (2013), who said that the crisis in the governance of the water is caused by problems of ownership and access to water in combination with a growing demand for water resources. But, also the lack of information to support decision-making processes influences the sustainable management of water resources (Obst & Vardon, 2014; Pedro-Monzonís et al., 2016; Vardon et al., 2018).

These decisions also impact the service cost (Adams & Boateng, 2018) and conflicts (Dovie, 2015) related to water, thus connecting these issues with **water governance** as

well as **water equity** (Lankford, 2013). In addition, decisions on water supply are also connected to **urban water throughput**.

5 Discussion

Cities are directly related to their surrounding environment that provides them essential goods, e.g., water, food (Vanham et al., 2017), raw materials, energy (Chen & Chen, 2016), and also spaces for recreation, sports and social interactions. As a result, the quality of life for urban citizens is affected (Rozos et al., 2013). This relationship has both, positive effects (Gómez-Baggethun et al., 2013) and negative impacts (Kiss et al., 2015) on the areas surrounding the cities.

The policy on water resources entails a holistic and integrated understanding, which should transcend disciplinary boundaries and overcome fragmented governance (Bowmer, 2014). In this line, Gupta and colleagues (2013) argued that water governance must be understood as a cross-cutting issue. However, according to Kunz and colleagues (2013), there is a recognized need to move from the theory of water governance (e.g., IWRM) to practice.

Our analysis of the literature has revealed key issues related to the sustainability of water. However, they do not operate in isolation from each other. Consequently, the **four foci** proposed demonstrate the interactions between the *eleven key issues*, but also the main areas of concern for the formulation of policies in urban areas. Thus, it has allowed us to identify six challenges that water management must address to achieve urban water sustainability. Therefore, these key challenges become part of our operational approach to manage water-related issues, realizing that each water policy implemented in growing cities has a direct effect on several key water issues simultaneously.

Each of the six key challenges, proposed as questions, promotes the development of critical and creative thinking by stakeholders and decision makers to solve problems, as was noted by Sternberg (1994). In this way, the challenge how to make decisions on water management at urban level emerges to be the main challenge for decision makers. This challenge also constitutes the main connection of all foci proposed to debate the *key issues'* interactions. In this vein, the decisions on water resources taken by stakeholders have a direct connection with the focus **water governance and financing**, which, as discussed in point 4.4, handles the key issues water *management*, *investment* in water, *cost of service*, and *conflicts* related to water resources.

Besides, they have a direct impact on the key issues water *supply* and *sanitation*, which, in combination with the issues *cost of service* and *water-related conflicts,* are studied in **water equity** (4.3). In addition, the decisions taken are connected with the *quality of water*, which impacts both, the **water resources** (4.1) and the **urban water throughput** (4.2). The latter focus also connects the issue *water supply*. Consequently, to make informed decisions on water resources at urban level, it is necessary to have a holistic view of the real situation of the water in cities.

The foci of water resources, urban water throughput and water equity are connected by three challenges. The ecosystem services in urban areas contribute enhancing the resilience, health and quality of life of citizens (Gómez-Baggethun et al., 2013). Therefore, understanding its importance for the environment contributes to make informed decisions to achieve a sustainable management of water resources and to increase the quality of urban life. On this basis, to recognize and integrate and/or restore water-related ecosystem

services at urban level allows addressing the key issues *natural water cycle*, *ecosystem services,* and the *quality of water*, which were analyzed in **water resources** (4.1). It also faces the key issues *water supply* and *sanitation*, which are studied in **water equity** (4.3). In addition, *water supply* and *quality* of water are analyzed in **urban water throughput** (4.2).

Conserving and restoring ecosystem services in urban areas contribute reducing the ecological footprints and the ecological debts of cities while increasing the quality of life for their inhabitants (Gómez-Baggethun & Barton, 2013). For that reason, to maintain and/or improve the supporting green and blue spaces has a direct impact on the key issues *natural water cycle*, *ecosystem services* and *quality and quantity of water*, which were analyzed in **water resources** (4.1).

The key issues *quality* and *quantity* of water are related not only to water resources, but also to **urban water throughput** (4.2), which in turn is also connected with **water equity** (4.3). This is in agreement with Elmqvist and colleagues (Elmqvist et al., 2015) who show that the restoration of ecosystems such as rivers, lakes, and forests in urban areas can not only be ecologically and socially desirable, but also economically advantageous.

Well-being and the health of citizens are closely related to the level of access to water and sanitation (Hutton & Chase, 2016; Naimi-Ait-Aoudia & Berezowska-Azzag, 2014). Consequently, the decisions taken by stakeholders to guarantee the quality and quantity of water resources, and the water supplied and used have an influence on the key issues *quantity* of water, water *quality*, *use* of water and water *supply*, which are analyzed in **urban water throughput** (4.2), but also in **water equity** (4.3) and **water resources** (4.1).

The foci of water equity, urban water throughput and water governance and financing are connected by the challenge how to ensure public and social health and well-being, being equitable? In this challenge, the key issues *water supply*, *sanitation*, and *cost of service* were considered, which are analyzed in **water equity** (4.3), but also in **urban water throughput** (4.2) and **water governance and financing** (4.4). This contributes addressing the current inequity in decision-making processes related to water supply and sanitation services (Hutton & Chase, 2016).

The foci of water equity and water governance and financing are connected by the challenge how to prevent and manage water-related conflicts? As noted by Dovie (2015), mainstreaming policies and decision-support systems would help reduce water-related conflicts. The decisions taken by stakeholders to address this challenge resolve the key issue *water-related conflicts or disputes*, which is analyzed in **water equity** (4.3), but also in **water governance and financing** (4.4).

All in all, the proposed new operational approach provides a better understanding of the complex social and ecological water-related interactions within growing cities. Additionally, citizens and decision makers can operationally address the key challenges for water management to achieve urban water sustainability.

6 Conclusion

In this article, the main topics discussed in 371 documents on urban water sustainability between 2012 and 2018 were identified and classified in *eleven key issues*. These key issues represent specific problems that growing cities must address to achieve urban water sustainability. Their interactions were explored using **four main foci** of analysis. Thus, the focus **water resources** reveals the interactions between key issues related to the *natural water cycle*, *ecosystem services*, and the *quantity* and *quality* of water. These issues describe the

conditions of the water resources and their environment. **Urban water throughput** shows the interplay between *water supply*, the *use* of water, and *quantity* and *quality* of water. These reveal the pressure on water resources caused by the increasing water demand by all anthropogenic activities. **Water equity** presents the interactions between *water supply*, *sanitation*, *cost* of service, and water-related *conflicts*. These are connected with the quality of life of citizens and the surrounding environment. **Water governance and financing** shows the interplay between water *management*, *investment* in water issues, the *cost* of water services and water-related *conflicts*, and are associated with the actors in charge of water management.

In order to address the eleven identified key issues and their interactions, our work provides a new operational approach for a better understanding of the interlinkages between the water cycle, cities and the society. Thus, our approach contributes to make informed decisions about water resources at urban level by understanding that each decision implemented in cities has a direct impact on multiple water key issues. For this purpose, our new operational approach introduces six challenges for urban water management that stakeholders should handle to pursue urban sustainability: (1) to make informed and equitable decisions on water management at urban level, (2) to recognize and integrate and/or restore water-related ecosystem services at urban level, (3) to guarantee the quality and quantity of water resources and the water supplied and used, (4) to maintain and improve the supporting green and blue spaces, (5) to ensure public and social health and well-being of the citizens, and (6) to prevent and manage conflicts related to water resources.

In addition, based on the geographical location of the studied cities, our work identified a little interest of research in Latin American cities. Only 2 percent of the selected documents focus their studies on cities in Latin America while 27 percent focus on cities in Asia. Consequently, we consider that Latin American cities are an important area of study that should be further explored.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10668-021-02045-0.

Acknowledgements We are grateful to Tapirus Cia. Ltda. (Ecuador) for financing this investigation. We as well thank Kristina Cvetich's assistance with English language editing and proofreading. BRL acknowledges funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie Grant Agreement N◦ 797444 (CLAMOR).

Funding Open Access Funding provided by Universitat Autonoma de Barcelona.

Declarations

Conflict of interest None.

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