



Editorial

Toward addressing urban water security: Searching for practicability



1. Introduction

The emergence of global water quality and quantity concerns has necessitated immediate attention to the concept of water security. This has particular importance in urban regions due to direct impacts of water-related threats on human livelihood and economy, making urban water management even politically-sensitive. Despite urgent needs, addressing “urban water security” is not trivial due to extremely complex interactions within and between human and water systems in urban regions. These interactions substantially change in time and space, depending on the details within climate, geography, urban development, demography, socio-economy and governance (see e.g., Breyer, Chang, & Parandvash, 2012; Chang, Praskievicz, & Parandvash, 2014; Franczyk and Chang, 2009; House-Peters and Chang, 2011) and can have extend impacts even beyond urban territories (see e.g., Bain et al., 2014; Cheung, Poon, Lan, & Wong, 2003; Van der Perk, 2013).

Despite being a new concept, scientific contributions around urban water security are rapidly emerging. The SCS's special issue on *Towards Sustainable Cities and Society: Addressing the Water Security Challenge* aims at providing a forum for studies that shed light on complexities in addressing urban water security, seek innovative tools, methodologies and technologies to overcome urban water security challenges, and promote operational and social practicability in science and management solutions. To the best of our knowledge, this is the first attempt of its kind, dedicated exclusively to water security challenges and solutions in urban settings. The twenty three featured articles in this special issue can be divided into four categories: (1) modeling approaches to urban water security – 7 articles; (2) new insights to urban water security – 5 articles; (3) technological and regulative solutions to urban water security – 4 articles; and (4) social dimension of urban water security – 6 articles. We note that the majority of these contributions are developed around specific case studies; nonetheless, the findings can be relevant to other urban regions – and in some cases to other application domains – as long as general principles are adapted. Below, we briefly introduce contributions featured in this special issue, with a greater goal of portraying the current state-of-the-art, gaps and understandings.

2. Modeling approaches to urban water security

Quantitative assessment of urban water security issue often include numerical modeling tools, which are essential for a number of reasons ranging from better understanding of the coupled interactions between and within human- and natural-water systems, to assessing the potential risks and vulnerabilities to urban water security, to finding practicable management solutions under changing and uncertain conditions. As water demands in urban regions are high, one important focus of the modeling studies has been on describing the dynamics of water demand and use. Eslamian, Li, and Haghighat (2016) provided a generic modeling approach to prediction of urban water use, considering meteorological and socio-economic factors. Application of the method in the city of Brossard, Quebec, Canada has shown that the dynamics of urban water use may be due to complex interactions between involving variables across various scales, which should be separated into distinct components in a way that can be explicitly handled through management options. Another important focus of numerical modeling is on representing the dynamics within urban water supply systems. Ali, Shafiee, and Berglund, (2017) described the complex dynamic within urban water supply systems using an agent-based modeling framework, coupling models of consumers and utility managers with models of water availability. Modeling agents were designed to describe the interactions between households, water managers, water availability and climate. The practical utility of the suggested model in evaluating the conservation programs and drought restriction in the city of Raleigh, North Carolina, USA, shows that such approaches can effectively describe the dynamics of water supply in cities around the world. Within the context of supply-demand management, efforts are also made on providing modeling tools for system upgrade. Fraga, Medellín-Azuara, and Marques, (2017), for instance, provided an integrated optimization framework to combine short and long term water supply expansion scenarios in a set of practicable decision portfolios. By considering a case study in southern Brazil, they showed that loss reduction can provide a strong alternative to capacity expansion. Such findings are quite relevant to developing countries and/or those with limited water resources, in which system upgrade may not be practical option due to limited financial and water resources.

Another important focus of urban water security is on disaster management. Depending on the form of natural disaster, the approaches to modeling can be different although the virtue of vulnerability assessment stays the same. In that regard, current approaches mainly implement a stress test-based procedure to assess the vulnerability of the system to a set of historical or synthetic extreme events. In the context of sudden disasters such as earthquakes, Pagano, Pluchinotta, Giordano, and Vurro (2017) studied the evolution of resilience in drinking water supply system during 2009 L'Aquila earthquake in Italy with particular attention to the role of structural and non-structural variables for managing the disaster.

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They built a System Dynamics model, representing the interactions between technical, organizational and socio-economic dimensions during disaster outbreak and evaluate the sensitivity of management options against infrastructure vulnerability, hazard intensity and organizational preparedness. Their study highlights the utility of decision support systems in representing the dynamic evolution of different elements within a broader coupled natural-human systems that influence resilience of a particular water supply system. In the case of a creeping disaster like droughts, [Gober, Sampson, Quay, White, and Chow \(2016\)](#) explored the vulnerability of Phoenix, Arizona, USA to a 12th century drought condition across a range of policies for population and water management using a water system simulation model. Their findings show that business-as-usual management options can be quite vulnerable to increasing population even without considering drought conditions. Gober and colleagues' work demonstrates how modeling tools can be instrumental in evidence-based discussions of climate adaptation and ultimately facilitate more anticipatory management strategies.

With the unfolding effects of climate change, an important focus of urban water security is on addressing the climate change impacts on the interactions within the human-water systems. This can have a range of applications, relevant to analyzing the balance between water supply and demand and/or the vulnerability of urban infrastructure to climate-induced extreme conditions (see e.g. [Hassanzadeh, Nazemi, & Elshorbagy, 2013](#)). The main approach is based on general top-down procedure to climate change impact assessment, considering impact models being fed by available downscaled climate projections. [Tavakol-Davani et al. \(2016\)](#) used this procedure to address the additional stress on combined sewer systems due to climate change. Considering the existing sewerage system in the City of Toledo in Ohio, USA, they showed that climate change can result into nearly 20% increase in the occurrence, volume and duration of overflow in the system. To address management needs, they evaluated the benefits of rainwater harvesting in controlling overflows in combined sewerage systems. They showed that implementing only 200-gallon retention tanks in half of the buildings in vulnerable neighbourhoods can significantly improve the performance of the drainage system in controlling the overflow during peak flow periods. Such solutions are quite applicable and appealing to stakeholders as they reduce the vulnerability of the system with additional benefits (e.g., the harvested water can be used as a source of grey water supply for domestic uses etc.).

There is a growing literature on using modeling approaches to shed light on the impacts of management decisions on the evolution of water-related threats. [Kingsborough, Borgomeo, and Hall \(2016\)](#) combined the risk-based decision making framework with the development of long-term adaptation pathways. Using this approach, they highlighted how the risk of water shortage in the City of London, UK, can vary dynamically throughout the 21st century depending on both transient climate and anthropogenic adaptation pathways. Apart from providing a systematic approach for mapping the performance of adaptation options with respect to multiple decision timescales, the concept of adaptation pathways provides a practicable tool for demonstrating the value of long-term adaptation planning to stakeholders and can be tailored to other application domains.

3. New insights to urban water security

The appearance of new data and conceptual views has led to the recognition of challenges (and new frontiers) that needs exploration within the broader context of urban water security. [Nazemi and Madani \(2017\)](#) briefly overviewed the emergence of urban water security as a scientific discourse and highlighted key challenges along with science and technological needs for better understanding and managing massively coupled human-water systems in urban regions. [Noiva, Fernández, & Wescoat \(2016\)](#) noted that the majority of current contributions are developed around specific case studies, and therefore, there is a gap in understanding large-scale patterns of demand-supply (in)balance in urban areas. They used a clustering scheme to categorize the demand-supply patterns within 142 cities worldwide based on their similarities and differences in terms of annual per capita water use, population and hydroclimatic water supply. They highlighted a particular category of cities at the global scale in which water use is in greater rates than water supply. As these cities should seek water from greater depths and/or distances, costs of water supply and wastewater treatment are comparatively large to other cities. To reduce such costs, misbalance between water supply and demand should be managed using water conservation practices. Such management practices can be further fine-tuned based on socio-economic indices in individual cities to provide locally relevant solutions through a global perspective. The study of Novia and colleagues is a vivid example of how including real-world data can provide large-scale insights on the dynamics of water supply and demand interactions and support the decision making process. Exploring data can also highlight previously unrecognized interactions between various elements of water security and their nexus with other systems such as energy and food. [Hardin et al. \(2017\)](#) compared CO₂ footprint of energy production in California drought during and before the recent drought. They showed that drought conditions can increase the CO₂ footprint of energy production by one-third due to the decline in hydropower production, and argued that additional water conservation cannot fully mitigate this loss. Their study is a clear example that in places like California, where hydropower is an important source of energy and water availability is limited developing management plans that consider the interaction between energy and water systems are essential.

As noted above, when addressing water security under changing climate conditions is concerned, downscaled climate simulations are often used within the impact assessment framework. Although top-down approaches are intuitively appealing, uncertainties from climate projections can directly propagate into the impact assessment ([Nazemi and Wheeler, 2014](#)). This issue necessitates deeper look at the needs of the impact assessment in urban areas and whether currently available downscaled climate simulations can maintain such needs. [Jaramillo and Nazemi \(2017\)](#) compared a downscaled climate product with climate observations in the city of Montreal in Quebec, Canada over a common spatial scale. They noted a considerable spatial variability in long-term observed climate over the Greater Montreal area, and showed that downscaled simulations are unable to fully capture such spatial variabilities. They argued that given the level of details required, the downscaling products might not be readily useable in urban environment. This necessitates further localization of downscaled simulations, however major challenges still remain due to the uncertainty in future climate projections. As a result, adapting bottom-up vulnerability assessment approaches can be more suitable given the fact that the results of analysis is not dependent on the particular climate model and/or concentration pathway. Such bottom-up approaches can provide legitimate and practicable solutions to urban water managers (see [Hassanzadeh, Elshorbagy, Wheeler, & Gober, 2016](#)) and can be further combined with the results obtained from top-down assessments (see [Wheeler and Gober, 2013](#)).

From a broader perspective, it should be noted that even if we fully overcome current limitations in climate modeling technology and are given perfect climate projections at the appropriate scale, addressing vulnerability and coming up with applicable management strategies is not trivial. In many cases this is due to unclear definition of water security, which can mislead the scope of water management. To overcome these, [Leong \(2016\)](#) introduced a new definition for resilience, which can provide greater precision and practical guidance for management and policy communities. They looked at the case of extreme drought in Singapore, and noted that the terms “adaptation” and “mitigation” often used interchangeably or in conjunction, although they are antithetical in nature. In their opinion, such conceptual confusions can create enormous management and policy obstacles.

4. Technological and regulative solutions to urban water security

Apart from modeling approaches, achieving water security in urban environments requires implementing effective and practicable technologies. Such technologies do not necessarily need to be high-tech but should be applicable worldwide and be appealing to both managers and public. (Nachshon, Netzer, and Livshitz (2016) looked at rainwater harvesting as an old and inexpensive method for water conservation and demonstrated its practical utility in the City of Tel-Aviv, Israel. They argued that rainwater harvesting in urban areas can be an effective technology for recharging groundwater aquifers that have become hydrologically disconnected from surface due to increasing impervious areas and built environments. Another simple technology for water conservation is water reuse. By focusing on London, UK, (Wilcox, Nasiri, Bell, and Rahaman (2016) reviewed different dimensions of water reuse in urban environments and showed that water reuse can provide a sustainable supply solution in water scarce regions and can maintain service reliability particularly under climatic changes.

Technologies are required for maintaining water quality in urban regions despite all the remaining challenges. In the case of stormwater regulation, Bichai and Ashbolt (2017) provided a review of current practices globally. They noticed that nebulous guidelines along with lack of recognizing potential public health concerns of stormwater management are the main reasons hindering their uptake. Using the principles of Water Safety Plans combined with monitoring and auditing protocols, they propose a performance-based scheme for the development of site-specific plans. The common water storm management schemes do not normally address the issues related to exotic contaminants emitted from urban environments. Such chemicals can include pharmaceutical or endocrine compounds and can be highly toxic to the ecosystem and human. Mirzaei et al. (2016) introduced zinc oxide catalyst as a promising treatment scheme to deal with exotic contaminants and discussed parameters that affect the performance of the catalyst. They also investigated methods for modifying zinc oxide structure to enhance the performance of this specific water quality solution.

Having effective technologies are also necessary to reduce flooding hazards particularly under the increased frequency of extreme weather events as a result of climate change. Ossa-Moreno, Smith, and Mijic (2017) discussed the role of Sustainable Urban Drainage Systems (SuDS) in managing flood risk with a particular focus on wider benefits such as such as air quality enhancement, ecology and health improvements amongst others. Using a case study in London, UK, they highlighted the values of SuDS in reducing the flood risk as well as their wider benefits. They showed that when with consideration of wider benefits, SuDS become economically feasible to stakeholders, noting rigid financial ground as a key driver for making a technology appealing to water managers and utilities in practice.

5. The social dimension of urban water security

In addition to economic feasibility, management decisions should be also feasible to citizens and have a strong community support. Dean, Fielding, Lindsay, Newton, and Ross (2016) discussed the importance of “social capital” on acceptability of alternative water conservation schemes. They showed that the social capital can be largely influenced by geographic, demographic and cultural attributes. (Rice, Wutich, White, and Westerhoff (2016) also emphasized on the role of education and the specific knowledge on water reuse technologies as important factors in the social acceptability of wastewater reuse. The importance of knowledge is also highlighted in a contribution by (Persaud et al., 2016), who showed that the knowledge of best management practices can be an important factor in managing fertilizers and pesticide transports at household level. With this context, broader environmental goals can have an important role in implementing water security solutions. Skambraks et al. (2017) hinted that environmental actions taken by local governments can promote transformation in water and wastewater management in municipalities, which can be further supported by water utilities.

Needless to say, knowledge delivery needs communication at different levels. At the public level, Bradford et al. (2017) emphasized on the need for having many pathways for receiving the information and noted the importance of communication through the word of mouth, in person and/or through social media. At the organizational level, the means of communication can vary from stakeholder engagements to collaborative management to formal partnership. Crow-Miller, Chang, Stoker, and Wentz (2016) looked at the challenges and opportunities in making collaborative urban water management through university-utility cooperation. Regardless of broader shared goals in the two institutions, they noted challenges in bringing out the potential of such collaborative frameworks due to lack of transparent communication and trust, mismatch between the scopes of utilities and universities as well as misaligned institutional expectations. They argued that there is need for developing a shared culture at the boundary of science and decision making, which goes beyond one-way interaction and pushes the boundary of both science and decision-making processes.

6. Conclusion

The context of “urban water security” is currently in its infancy, however, a rigid body of literature is forming around (1) modeling approaches to urban water security; (2) new insight to specific needs in urban water security; (3) technological and regulative frameworks to urban water security; as well as (4) social dimensions of urban water security. Having said that, the specific nature and forms of interactions between human and water systems in urban areas requires pushing the traditional boundaries of water security both in science and management spheres. Such extensions are needed to provide a collaborative two-way interaction between science and management that can ultimately respond to real-world urban water security threats in an applicable fashion.

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