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Hong Kong's water security: a governance perspective

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ABSTRACT

Traditional concerns regarding Hong Kong's water security have centred on water quantity, quality and pricing. In contrast, this article embraces an integrative conceptualization of water security from a governance perspective. A technocratic and supply-oriented water system may overlook challenges stemming from scalar mismatches at the territorial, institutional and discursive levels, as well as at the science–policy interface. Resilience thinking could identify new areas of concern and provide contextually sensitive insights into Hong Kong's water security, which will be subject to the restructuring of the water governance system, which concerns changing discourses, power relations and institutional mechanisms.

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Introduction

The notion of water security has traditionally centred on availability, accessibility, affordability and human needs (Cook & Bakker, 2012; Global Water Partnership, 2000). This traditional conceptualization has led to the prevalence of technocratic framing and assessment of water security over the past two decades, which have mainly considered disturbances of external drivers (e.g., climate change and population growth) and infra-structural responses (e.g., reservoirs and water supply technologies). However, a growing number of studies have pointed out that water security should not be approached only through engineering measures; it involves complex and uncertain social-political relationships in which multifarious actors reorganize the way water is distributed, utilized and transformed (Empinotti, Budds, & Aversa, 2019; Jepson et al., 2017; Loftus, 2015; Swyngedouw, 2004). In this sense, water security is not only an issue of scarcity, to be addressed by technocratic advancement in provision, but also a process of contestation and coordination embedded in hydro-political and hydro-social interactions.

The emphasis on the political and social dimensions of hydrological processes suggests that water is not a simple material object that needs to be secured. More importantly, water security can no longer be a static objective, since it is grounded in the political arrangements and social structures through which physical flows are governed. This integrative framing repositions water security as a capacity to support water quantity, quality and services in a way that maintains human well-being and development (Jepson

et al., 2017). From this point of view, approaching water security from a governance perspective echoes with a global paradigm shift in environmental governance towards *resilience*, the ability of a complex social-ecological system to recover, reorganize and adapt to external shocks (Folke, 2003).

This article engages in discussion with the literature on water governance and urban water resilience by examining the empirical case of Hong Kong from a governance perspective. It addresses three research questions: What challenges to Hong Kong's water security can be identified under an integrative conceptualization and analytical framework? What are the main deficiencies of the ongoing reforms in a governance perspective of water security? And how might resilience thinking inform future governance restructuring for Hong Kong's water security? Findings from this article could provide insights into previously underappreciated problems of water security nested in complex hydro-political and hydro-social relationships, offer empirical observations and highlight practical concerns for future water governance restructuring.

The rest of the article is organized as follows. First, we briefly introduce the background of Hong Kong's water supply. Then, we situate Hong Kong's water security assessment in a governance context and reveal the challenges associated with scalar mismatches at various levels. Next, we review recent governance reforms undertaken by the Hong Kong and mainland governments, as well as their deficiencies. Finally, we suggest the way towards restructuring governance for water security based on resilience thinking, as the ongoing reforms fall short of a paradigmatic shift.

Hong Kong's water supply

Hong Kong, with a population of 7.52 million (Census and Statistics Department, 2019), sits east of the Pearl River (Zhujiang) estuary, on the south-east coast of the People's Republic of China. It was formerly a British colony (1842 to June 1997), and is currently (since the handover in July 1997) a Chinese Special Administrative Region, governed under a unique 'one country, two systems' framework, which allows Hong Kong to enjoy its own governmental system as well as judicial and financial autonomy. Despite its sub-tropical climate, Hong Kong has severe water scarcity, mainly owing to considerable variation in seasonal and annual rainfall, limited capacity to harvest precipitation, lack of sizable natural lakes or rivers, and unusable groundwater, as well as rapid population and socio-economic growth (Civic Exchange & ADM Capital Foundation, 2017; Peart, 2004; Yue & Tang, 2011).

Until the early 1960s, the British colonial government's strategy to tackle Hong Kong's water shortages was to develop a self-sufficient water supply system through hydraulic engineering (Wang et al., 2016). For instance, with water supply as the top priority, the government endeavoured to maximize local storage capacity by building as many reservoirs as possible and preserving their associated catchment zones (Liu, 2013). Seawater flushing has been used in government and government-aided high-density development schemes since the late 1950s. Unconventional strategies such as desalination were also used for a short period (Hartley, Tortajada, & Biswas, 2018). These efforts, however, were inadequate to relieve Hong Kong's water shortages. During the drought in 1963, the government had to impose stringent water rationing, limiting water service to four hours every four days (Cheung, 2014).

If water self-sufficiency was no longer a viable option for Hong Kong, the British colonial government had to look into other water sources. An obvious and effective way to meet the increasing local water need was to import freshwater from Mainland China. On 15 November 1960, the Guangdong Provincial Government and the British colonial government reached an agreement to supply 22.7 million m³ of raw water from the Shenzhen Reservoir to Hong Kong every year. In 1963, these two governments held several rounds of discussions and reached a consensus on the implementation of the Dongjiang-Shenzhen Water Supply Project (DSWSP) (Water Supplies Department, 2017a). This large-scale cross-basin project to transfer raw water through an open channel in the lower section of the Dongjiang to Hong Kong was commenced in 1964 and finished in 1965, with a total length of 83 km. The DSWSP has since been expanded three times, raising its annual capacity from 68 million m³ in 1965 to 2.4 billion m³ in 2017 (Guangdong Hydropower Planning & Design Institute, 2013). With the DSWSP, Hong Kong's dependence on Dongjiang water has been continuously increasing, currently accounting for 70–80% of its total freshwater consumption, compared to 20% in 1965 (Civic Exchange & ADM Capital Foundation, 2017). At present, rainwater from local catchments, imported water from the Dongjiang and seawater for toilet flushing account for 26%, 52% and 22%, respectively, of the total water consumption in Hong Kong (Water Supplies Department, 2018). This three-pillar structure has allowed Hong Kong to enjoy a 24-hour continuous water supply for more than three decades (Legislative Council, 2015). In fact, overconsumption has even become a salient problem in Hong Kong, which has one of the highest average daily per capita consumption of potable water in the world (THE FOREST, 2018).

The conceptualization of water security: diversity, practicality and limitations

The conceptualization of water security in Hong Kong

The amelioration of Hong Kong's water supply condition does not necessarily signify a high degree of water security, which according to Cook and Bakker (2012) remains subject to diverse framings. As scholars approach the notion of water security from different disciplinary perspectives, it is imperative to review how water security has been conceptualized and to reevaluate various policies, strategies and actions that have been adopted by decision makers and practitioners under different framings of water security.

In a general sense, water security is 'the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability' (United Nations Water, 2013). This broad and integrative definition conceptualizes water security on four interconnected dimensions. First, sufficient quantity and acceptable quality of water supply for humans is the fundamental element of water security. This also involves temporal and a spatial scales, on which water security may vary across different individuals, sectors, areas and seasons. Second, the boundary of water security is closely associated with how 'human needs' are defined. It could range from basic needs, such as access to safe drinking water, to all development-related concerns pertaining to the use of water. Third, water security is

not only a socio-economic concept but also an ecological one that involves water-related disasters, such as floods and droughts, as well as ecosystem functions and services. Fourth, water security is not just a human-centred term; rather, the sustainability of the natural environment and ecosystem is another important concern in water utilization and management. Water security at any level to ensure a clean, healthy and productive life should not come at the cost of environmental or ecosystem degradation (Global Water Partnership, 2000).

In addition to the various goals of water security, scholars have argued that extra attention should be paid to directions as to how these goals can be achieved (Empinotti et al., 2019). These scholars focus on hydro-social and hydro-political relations through which access to water is navigated and transformed (Jepson et al., 2017; Loftus, 2015). In this sense, water security concerns the engagement of people and organizations, not just as water users but also as political actors in water governance.

The growing significance of water governance in the literature suggests that water security is a contextually sensitive concept in an era of complexity and uncertainty. Instead of universal modalities and principles prescribed without adequate consideration of practicalities and local implementation, the key elements of good governance that supports water security could vary across political, social, economic and ecological settings (Budds, 2009), covering both formal and informal rules and arrangements for interactions between waters and social-political structures at different scales (Linton & Budds, 2014). Therefore, the conceptualization of water security in Hong Kong should concern more than a series of water scarcity problems traditionally tackled by technocratic and supply-oriented approaches; it requires a paradigm shift towards the organizations, spaces, scales, discourses and power relations which shape the status of water security at the operational level.

Challenges to water security and coping strategies

Although the conceptualization of water security has been developing in an integrative, comprehensive and broad way, its operationalization has yet to catch up with theoretical development (Cook & Bakker, 2012). Naturally, conceptual diversity encompasses more variables, multiscale contexts and complex method selections, which are not necessarily compatible with pragmatic concerns. In other words, there is a gap between the integrative framing and the operationalization of water security, as how the concept should be theoretically interpreted may diverge from how it could be practically addressed. To identify and assess specific water security concerns, most decision makers and practitioners understand challenges to water security from an operational perspective in empirical settings. Accordingly, coping strategies are linked to established frameworks and conventional solutions that are within a relatively narrow scope.

The integrative conceptualization and the narrow operationalization of water security are not necessarily mutually exclusive; yet the gap between them may bring limitations to long-term water security, which requires a complementary relationship between vision and practicality. For instance, water managers have often placed policy attention on the most acute water security concerns, such as water availability (quantity) and pollution (quality). In this sense, the operationalization of water security might be reduced to the ability to supply water. The large literature on the pressure on water availability from

economic development, population growth and climate change is a salient example of this simplification. Under this narrow framing, proposed solutions to water security problems normally focus on engineering approaches that aim to relieve water scarcity for specific water users or regions. However, the narrow conceptualization of water security, for operational simplicity, may obscure important factors such as governance capacity, scale, regional inequality, local heterogeneity and geopolitical concerns. Without a broad, integrative and systematic conceptualization, short-sighted and one-sided policies may dominate the discourse on and solutions to water security problems, threatening the long-term sustainability of economy and ecology.

What is missing in Hong Kong's water security assessment?

Hong Kong bears some of the most severe yet inadequately examined implications of the inconsistency between the operationalization and conceptualization of water security. On the one hand, Hong Kong embodies an extremely complex water governance context, where water scarcity, water pollution, regional inequality, transboundary tensions and geopolitical concerns are encapsulated in one of world's most populated and rapidly developing areas. On the other hand, decision makers and practitioners have been addressing these complex water-related problems through a simple yet powerful engineering approach, which seemingly has secured stable water supply for Hong Kong. Under the integrative conceptualization of water security, however, several important issues remain to be analyzed and discussed.

First, governance capacity has yet to be adequately included in the agenda of water security. Although a variety of water infrastructure (e.g., water treatment plants and water diversion projects) provides a relatively sophisticated water supply system for Hong Kong, these heavy engineering approaches involve limited policy reform, institutional collaboration and strategic planning. Second, many water conflicts, which stem from socio-economic inequality and asymmetric rights and responsibilities, both in Hong Kong and in its water supply hinterland, may threaten Hong Kong's long-term water security. These conflicts cannot be resolved by infrastructure or engineering solutions. Third, Hong Kong is not immune to various external disturbances associated with climatic and socio-economic changes, to which engineering projects may be unable to adapt. The 'lock-in' effects of technocracy, therefore, urgently require resilience building, which involves a holistic, dynamic and integrative water governance paradigm. Fourth, the unique 'one country, two systems' framework constitutes a special geopolitical relation where water-related issues are easily politicized. The discourses and images of water supply for Hong Kong are manifestations of complex power struggles, social interactions and historical relations. In this sense, water security for Hong Kong is not only an engineering task but also a political process, in which a broad range of non-technical factors influence its dynamics and outcomes.

The challenges to Hong Kong's water security: scalar mismatches in water governance

Traditional concerns regarding Hong Kong's water security are mostly built upon immediate practical needs, which centre on water issues per se, such as quantity, quality and pricing (Biswas, 2015). Although the DSWSP has to a great extent provided Hong Kong

a sufficient amount of good-quality raw water, these traditional concerns have dominated the mainstream discourse and have been closely associated with conflicts and dissenting voices at the sub-jurisdictional level in both Hong Kong and Mainland China (Hong Kong Economy, 2017; Legislative Council, 2014a, 2014b, 2017). But on top of the traditional concerns, the fundamental challenges to Hong Kong's water security do not solely rest on the DSWSP or the biophysical characteristics of water per se. The overemphasis on obvious water problems may neglect more profound reasons for water conflicts in the unique 'one country, two systems' context. We argue that situating water security in a broader framework of regional political economy and political ecology will reveal understudied scalar mismatches at the territorial, institutional and discursive levels as well as at the policy–science interface, all of which constitute fundamental challenges to Hong Kong's water security.

Territorial mismatch

The DSWSP has provided Hong Kong a relatively reliable water source. But dependence on Dongjiang water exposes Hong Kong to a variety of new risks, situated in a complex catchment. In other words, with the DSWSP, Hong Kong's water security has been closely connected to a large territory and placed in a broad spatial context that does not match Hong Kong's domestic conditions.

The territorial mismatch affects Hong Kong's water security in two ways. For one thing, Hong Kong is not self-sufficient in water supply but is included in a basin-wide competition for water resources. Its main water source, the Dongjiang River, originates in Xunwu County, Jiangxi Province, and flows south-west through Guangdong Province before entering the South China Sea. The main stream is 562 km long and covers a 27,040 km² catchment, where regional economic development and more than 40 million people's livelihoods are closely associated with the Dongjiang's water. At the river basin level, significant challenges have emerged in recent years, including rapid population growth, urbanization, industrial development, reduction of agricultural land use, ecological degradation, and annual fluctuation of river flow due to natural and human-induced factors, including climate change (Yang, Chan, & Scheffran, 2018). Given that Hong Kong's water supply largely depends on the available quantity and quality of the Dongjiang water (Chen, 2001), some believe that the water supply of Hong Kong is being threatened by competition from upstream cities (Sadhvani, Chau, Loh, Kilburn, & Lawson, 2009) and that 'there is no assurance that the Dongjiang will always be able to provide a constant water supply for Hong Kong' (Legislative Council, 2015).

The basin-wide competition for water resources is exacerbated by the strong socio-economic asymmetries that are nested in various riparian jurisdictions. Currently, the Dongjiang water allocation plan sets aside up to 1.1 billion m³ of water from the Dongjiang River for Hong Kong (People's Government of Guangdong Province, 2008), 34% more than the 820 million m³ ceiling of the water supply agreement and 50–60% higher than Hong Kong's actual annual consumption. This allocation signifies Hong Kong's political privilege, in the sense that a sufficient amount of water is reserved for Hong Kong for the foreseeable future. Meanwhile, other jurisdictions in the Dongjiang catchment must address their increasing water demand under strict water constraints (Wang et al., 2017). If severe droughts lead to water stress in Guangdong, cities across the Pearl River basin may need to

ration, while Hong Kong gets full access to the diminished supply (Hartley et al., 2018). Moreover, the asymmetric distribution of the Dongjiang water is guided by a utilitarian principle under which downstream developed areas enjoy more benefits, while the upstream developing areas bear more conservation responsibilities (Wang et al., 2017). This unbalanced approach to water distribution situates Hong Kong in an intense regional competition between upstream and downstream, between urban and rural, and between the coastal and the inland, which might lead to conflicts that challenge Hong Kong's water security.

Institutional mismatch

The large territory with which Hong Kong's water security closely connects inevitably involves a complex matrix of institutional arrangements for transboundary water governance. Yet under the 'one country, two systems' framework, Hong Kong is governed by a political and legal system radically different from that of mainland municipalities. As a result, Hong Kong governmental officials and their mainland counterparts often have different approaches to transboundary externalities, leading to institutional mismatches.

Although integration between Hong Kong and the mainland has long been on the central government's agenda, regional cooperation and coordination have been more difficult than expected (Yang, 2005). For example, the governments of nine provinces and two special administrative regions (Hong Kong and Macao) signed a Pan-Pearl River Delta Regional Co-operation Framework Agreement in 2004. The National Development and Reform Commission, which plays a key role in planning and execution in the mainland, proposed an 'Outline of the Plan for the Reform and Development of the Pearl River Delta Region (2008–2020)' in 2009. The formulation of the Guangdong-Hong Kong-Macao Greater Bay Area Initiative was included in the 13th Five-Year Plan (2016–2020). But these initiatives remain as conceptual tools and are far from politically 'unified' (Bie, Jong, & Derudder, 2015; Cheung, 2010). There is no endeavour towards comprehensive political and administrative unification, essentially because of the different standpoints and interests of different cities involved, and the respective planning and decision making of those cities (Viktor, 2018). The boundary separating Hong Kong and the mainland presents many challenges of institutional integration (Lee & Chu, 2017).

The governance of the Dongjiang River is also politically complicated. Jurisdictions at various administrative levels across the river basin are involved (Yang, Zhang, & Wambui Ngaruiya, 2013); recent research has identified 37 stakeholders who play a part in water governance in the basin (Yang et al., 2018). Although the collaborative dynamics between Hong Kong and mainland cities are based on reciprocity and symbiosis, the DSWSP is regarded as a buy-sell water supply contract, and current collaboration is limited to strategic infrastructure development and data sharing (Hartley, 2017). Mainland cities make decisions on water allocation and other matters collectively, whereas Hong Kong does not have a role in monitoring the quality and conditions of the river in the mainland, nor does it participate in meetings concerning the development decisions that will influence the sustainability of the Dongjiang water (Civic Exchange & ADM Capital Foundation, 2017; Hartley et al., 2018). And the initiatives on water conservation launched by the China's central government, such as the Three Red Lines and Ecological Civilization, are not applicable in Hong Kong.

The institutional mismatch stems not only from the lack of integration between the administrative systems of Hong Kong and the mainland, but also from fragmentation within each administrative system. On the mainland side, water governance is vertically framed by a hierarchy dominated by command-and-control measures, which means that the central government redistributes rights and responsibilities for water governance by authorizing provincial, municipal and county governments, which often compete with each other (Zhao, 2015). Horizontally, at every level of government, water governance inevitably involves a wide range of functional agencies, often with overlapping roles and conflicting interests. Regionally, river basin commissions, which reside under the Ministry of Water Resources and are located in individual river basins, are supposed to override political boundaries (Dai, 2015; Nickum, 2010). Yet many studies have concluded that the lack of coordination among various departments has caused overlaps and loopholes in water governance in the mainland (Dai, 2015). Though the institutional reform initiated by the central level in early 2018 aims to solve this problem, it is still too early to tell about its effectiveness. And on the Hong Kong side, fragmentation is also a problem, which poses a challenge for strategic and operational coordination (Hartley, 2014; Liu, 2013).

Discursive mismatch

In addition to the mismatches at the territorial and institutional levels, a previously understudied challenge to Hong Kong's water security lies in the divergent discourses on Hong Kong's water issues and the DSWSP. These divergent discourses have not only produced different narratives on the nature of the Dongjiang water but also resulted in inconsistent policies and strategies around the future of Hong Kong's water governance system.

The discursive mismatch regarding Hong Kong's water security has two aspects. One is that Hong Kong's water scarcity has not received enough academic and policy attention and the value of water resources has not been fully appreciated, indicating an 'illusion of plenty' in Hong Kong society (Civic Exchange & ADM Capital Foundation, 2017). This is partly due to the lack of public awareness surrounding water issues, which have made water sustainability efforts difficult (Lee, 2017). With Hong Kong's first priority in a political arrangement that guarantees its water supply even in a major drought, the imported water has been the most economical and reliable source of water, allowing the Hong Kong government not to actively join the global push for water conservation. Currently, average domestic daily water consumption in Hong Kong is around 21% higher than the global average, and unlike in other cities, it has increased consistently over the past 15 years (Huang, 2017). In the past two decades the true cost of water has been concealed by heavy government subsidies, and it remains largely unknown to the general public. As a result, public awareness of the importance of water conservation is dismal. Furthermore, climate security consciousness is still in its infancy, and there has not been an integrated climate response policy between urban development, water supply and climate impacts. The public lack deep awareness of the possible water supply risks under climate impacts, and this has allowed the government take few measures to address these risks (Yang et al., 2013).

The other aspect is that the discourses on the DSWSP have been contentious, resulting in geopolitical tensions between stakeholders in Hong Kong and the mainland, which could become political obstacles to effective transboundary water cooperation and coordination.

The mainland stakeholders have adopted a 'reunification' narrative that personifies the Dongjiang water. The DSWSP has become a story of 'compatriots who are nourished by the same water'. These discourses portray an intimate relationship between the mainland and Hong Kong, unifying the people through their commonalities in ethnicity and everyday lives. In contrast, some Hong Kong stakeholders have politicized the nature of water, depicting the DSWSP as an instrument for controlling Hong Kong and seizing extra economic benefits (Cheung, 2014). Although these contentious discourses have mostly appeared in the media and not been reflected in formal political arrangements (Wang, 2017), one cannot neglect their impacts on future arrangements for transboundary water governance between Hong Kong and the mainland.

Science–policy mismatch

The challenges to Hong Kong's water security stem not only from territorial, institutional and discursive mismatches but also from the science–policy interface, where the relationship between the traditional technocratic regime and the development of a holistic and integrative policy is not always well coordinated.

The technocratic mindset, which is manifested by a series of engineering approaches such as the DSWSP, has undoubtedly benefited Hong Kong. In line with this mindset, Hong Kong is currently developing a new desalination plant, which is scheduled for completion in 2020. However, the socio-economic and institutional expertise of the Hong Kong government has not reached the same standard as its engineering ability (Civic Exchange & ADM Capital Foundation, 2017). For example, the government established an Innovation and Technology Commission in 2000 to spearhead Hong Kong's drive to become a world-class, knowledge-based economy (Innovation and Technology Commission, 2005). The Innovation and Technology Fund, administered by the commission, aims to increase the added value, productivity and competitiveness of economic activities in Hong Kong. However, only 2.3% of total funds have been distributed to the environmental sector in the decade since the establishment of the commission (Liu, 2013). More importantly, limited resources have been put into institutional, capacity or awareness building, which are critical for supporting policy reform.

Many non-technocratic options have not been effectively included in the Hong Kong government's agenda, though they are not very hard to adopt. For example, there are a variety of water-saving systems that could be used in building projects, and there are technologies that can make older buildings more sustainable. Smaller examples, such as the very simple technology of faucets and shower heads, have been long available. An effective approach would be to apply regulations that facilitate the installation of water-saving facilities in new buildings. But Hong Kong has not yet done this (Lee, 2017). Most importantly, the dominance of technocracy might hinder decision makers from developing new solutions to more profound challenges that are nested in territorial, institutional and discursive mismatches, which are not easy to address solely through engineering means.

Adaptation: governance reforms to cope with the challenges

The integrative conceptualization of water security incorporates the previously under-examined social and political dimensions of water governance with conventional solutions

centred on water supply infrastructure. More specifically, the integrative conceptualization reveals that more profound and persistent challenges to Hong Kong's water security are nested in a series of scalar mismatches at the territory, institutional and discursive levels. This section summarizes the current water governance reforms undertaken by both Hong Kong and mainland governments and implemented through different projects with different focuses, in response to challenges to water security. Then we consider to what extent these governance reforms address the challenges, highlighting the gaps between operation and conceptualization, between technocratic solutions and hydro-political tensions, and between short-term effects and long-term sustainability.

In 2008, the Hong Kong government introduced its Total Water Management strategy, which was formulated by the Water Supplies Department 'with the intention of diversifying Hong Kong's water portfolio, providing a catch-all solution to water disruption from climate change' (Civic Exchange & ADM Capital Foundation, 2017). Total Water Management focuses on two major areas: water demand management and water supply management (Table 1).

In the mainland, early water conservation approaches were dominated by the 'hard path', characterized by Gleick (2003) as emphasizing the construction of massive infrastructure to increase the water supply. Later, water conservation started to transition towards a 'soft path' approach, which includes economic instruments to curb demand (Wang, Ng, & Qi, 2019),

Table 1. Key initiatives of Total Water Management in Hong Kong (2008).

Initiatives		Purposes/contents	Approaches
Water demand management	Enhancing public education	To encourage the public to actively reduce daily domestic water consumption	Let's Save 10L Water campaign (Water Supplies Department, 2017b); publishing water-saving tips; programmes for school children such as the Water Conservation Ambassador Selection Scheme, School Roadshow, and School Water Audit (Water Supplies Department, 2017c).
	Best practice guidelines	To promote efficient water usage among non-domestic water users	Providing best practice guidelines for the hotel industry and catering industry; recommending a series of water conservation measures (e.g., improve employees' awareness of water conservation, establish a reward scheme for employees, and assigning employee(s) to monitor water use and reviewing the water consumption data)
	Promoting water-saving devices	To enhance water use efficiency	Voluntary Water Efficiency Labelling Scheme (Water Supplies Department, 2017c); Water Intelligent Network and Smart Metering System app
Water supply management	Water leakage control	To reduce water loss due to pipeline leakage	Replacing and rehabilitating 3000 km of aged water mains, reducing leakage from 25%+ in 2000 to about 15% in 2017 (Water Supplies Department, 2019a)
	Desalination plants	To develop new water resources and prepare for uncertainties	Re-opening a plan for a reverse osmosis seawater desalination plant at Tseung Kwan O (Freyberg, 2013); construction is planned to begin in 2019, with an initial production capacity of 50 million m ³ /y (about 5% of Hong Kong's total water consumption)
	Water reclamation	To develop an alternative water source	Pilot schemes involving the use of reclaimed water and preparing legislation for supply of reclaimed water, perhaps starting in 2022 (Water Supplies Department, 2019b)

Table 2. Key initiatives and approaches of reforms related to water security in Mainland China.

Initiatives	Year	Purposes/contents	Approaches
Ecological Civilization	2007	To outline a commitment to innovative, coordinated, green, open and shared development	Incorporated eco-civilization into the “Five-in-One” blueprint of socialism with Chinese characteristics; promulgated an Integrated Reform Plan for Promoting Ecological Civilization, in which objectives, principles, standards and mechanisms are set (Dai, 2018)
Most Stringent Water Management System	2011	Sets three major objectives: total water use, water use efficiency, and water quality	Sets national targets, which are further unpacked through the administrative hierarchy at the sub-national level; sets up working system, strengthening leadership to monitor performance, implement pilot projects, introduce water-saving technologies and enhance public awareness (Global Water Partnership, 2015)
Sponge City Programme	2015	To minimize the influence of urban development on the ecological environment through comprehensive measures to improve water permeation, water retention, water storage, water purification, water drainage, water saving and water reuse	Setting progressive targets, implementing pilot projects, the central government provides initial capital and technical guidelines, applying a top-down supervision system with strict rules and deadlines (Dai, van Rijswijk, Driessen, & Keessen, 2018)
Action Plan for the Prevention and Control of Water Pollution	2015	Sets out 10 general measures and provides an inclusive toolkit for water quality management	Divides the 10 measures into 38 sub-measures with deadlines and responsible departments, including 238 specific actions on surface water, groundwater, urban water, coastal water and ecological environment (China Water Risk, 2015; Dai & Qiu, 2017)
River Chief system	2016	To overcome fragmentation in water management to protect water resources, prevent and control water pollution and improve ecological restoration	Appoints main governmental and party leaders ‘river chiefs’ across all administrative levels, responsible for water resource protection, pollution prevention and control, and ecological restoration in their respective jurisdictions; sets deadlines and assessment criteria for river chiefs (Chien & Hong, 2018; Liu, Chen, Liu, & Lin, 2019)
Natural Resource Balance Sheet	2017	To apply natural resource audits when leading officers leave their positions, thus establishing a lifelong accountability system for ecological and environmental damage	Implementing pilot audit activities and formulating interim regulations (Zhang, 2018)

though the use of hydraulic infrastructure remained prevalent (Liu et al., 2013). Since the 2010s, the Chinese government has put increasing emphasis on economic and institutional measures to manage water resources and improve water use efficiency (Liu et al., 2013). Some key initiatives and approaches are summarized in Table 2.

The practical constraints on water policy makers and resource managers differ between the mainland and Hong Kong. Likewise, one can identify different conservation strategies adopted by the governments in the mainland and Hong Kong.

The Total Water Management strategy sets macro-scale goals for water conservation. But it is rather descriptive, lacking clearly defined targets or regional perspectives, and is implemented on a mostly voluntary basis (Civic Exchange & ADM Capital Foundation, 2017). There

is little evidence of effective programmes or initiatives to meet them, or any progress to date. Critics have complained that the relevant government agencies have ‘no sense of urgency’ when it comes to reducing reliance on mainland water, instead seeing the territory as ‘entitled to the [mainland’s] resources’ (Huang, 2017). One prominent think tank declares that the Water Supplies Department ‘has been underperforming for nearly two decades’, often failing to meet legal requirements, under-staffing key water strategy enforcement departments, and focusing heavily on engineering, with little attention to public awareness (Huang, 2017). For example, the Audit Commission (2015) revealed that some Leisure and Cultural Services Department venues consumed more water after implementing ‘best practice’ guidelines.

In contrast to Hong Kong’s Total Water Management strategy, which is descriptive, voluntary and without clear targets, the mainland government has addressed some of its profound institutional problems for water governance, which are nested in a fragmented, authoritarian political system (Wang, Liu, & Dang, 2018). These reforms target the unclear division of responsibility, failure of coordination, non-compulsory targets and inadequate political will for water conservation, all of which jointly characterize a conventional paradigm that hinders successful water governance. But despite the progress of these governance reforms, one should note that their long-term effectiveness and sustainability have yet to be fully examined.

A major deficiency of these water governance reforms, particularly in Hong Kong, is that their overall design barely touches the scalar mismatches which give rise to the fundamental challenges to Hong Kong’s water security. Most of the ongoing changes have been guided by imminent practical concerns that depend heavily on the traditional path of technocracy and institutional segmentation. The failure to incorporate the integrative water security framing into the reform agenda allows the persistence of some hidden inadequacies in the current water governance paradigm, which may threaten Hong Kong’s long-term water security. In this sense, there is still much information to uncover and many changes to be carried out in order to formulate holistic and systematic solutions to address Hong Kong’s future water security problems.

Resilience thinking: an alternative approach to water security

The resilience approach

Resilience thinking is a global paradigm shift in values, beliefs and actions, and has implications for shaping the human relationship to nature. The resilience of a social-ecological system (SES) is ‘the capacity of a system to absorb disturbance and reorganize while undergoing change, so as to retain essentially the same function, structure, identity, and feedbacks’ (Walker, Hollin, Carpenter, & Kinzig, 2004). The integrative framing and governance perspective on Hong Kong’s water security moves beyond conventionally identified challenges such as increasing demand caused by economic development, population growth and climatic change, or inadequate supply caused by limited infrastructure. It embraces resilience thinking, which accepts unforeseeable and uncontrollable water variability (e.g., hydrological fluctuations and socio-economic transformation) emerging from the interconnections and interdependence of societies, economies, politics and the environment (Folke et al., 2002; Holling, 1978). In this framework, Hong Kong’s water security is not gauged by the government’s technocratic ability to provide and control but by the capacity of a complex SES to cope with, adapt to, and learn to manage uncertainties in

a rapidly changing world (Folke, Hahn, Olsson, & Norberg, 2005; Gunderson & Folke, 2005; Schultz, Folke, Osterblom, & Olsson, 2015; Stone-Jovicich, 2015).

In spite of the mainstreaming of resilience thinking over some 20 years, two salient issues in resilience scholarship remain to be further explored. One is the implementation of resilience approaches and their compatibility with existing practices of governance – to what extent and in what ways resilience thinking may complement or conflict current institutions. The other is a differentiated understanding of resilience, which moves towards flexible institutional solutions that are contextually sensitive to the complexity of heterogeneous local conditions. Both issues involve the interplay among diverse framings, discourses and values in different cultural and political contexts, among the role of individuals, communities, agencies and institutional arrangements, and among dynamics of power, politics, and conflicts which drive change and shape complexity in coupled SES (Armitage, Béné, Charles, Johnson, & Allison, 2012; Brown, 2014; Brown & Westaway, 2011; Davidson, 2010). In this context, a resilience framework that closely examines the combination of miscellaneous characteristics of a broader SES where the issue of Hong Kong's water security is situated might not only provide deeper insights for Hong Kong's water security but also facilitate detailed discussion of the research gaps in resilience thinking.

Incorporating the resilience approach in Hong Kong

Human relations to water systems is an important subject in resilience research (Chelleri, Schuetze, & Salvati, 2015; Folke, 2003). Meeting water security through the resilience approach is particularly significant for Hong Kong for the following reasons.

First, Hong Kong is a water-scarce city facing a variety of water-related challenges originating outside its territory and governed beyond its jurisdiction. The territorial, institutional and discursive mismatches are manifestations of these challenges. Therefore, Hong Kong's water security cannot be isolated from how the freshwater and aquatic environment is managed and altered in a broader SES, where great socio-economic and political complexity influences the city's capacity to absorb water-related disturbance.

Second, the wide range of policy attempts and institutional reforms to address regional water security issues have been carried out under the 'one country, two systems' framework, in which interjurisdictional cooperation is paradoxically challenged by the need to maintain Hong Kong's autonomy. Under this framework, a domestic perspective, either that of the mainland or that of Hong Kong, often brings about institutional divisions, which may obscure the fact that Hong Kong's water security requires transboundary cooperation. A holistic framework such as the resilience approach, which includes a larger governance context, is therefore imperative for in-depth analysis of how to overcome institutional obstacles to integration.

Third, Hong Kong reflects the sharp contrast between a heuristic model of system change and a traditional paradigm dominated by 'prediction' and 'control'. Yet, this contrast does not necessarily remove Hong Kong from the arena of human–nature interactions, or the scope of resilience analysis; rather, it provides an exceptional case through which scholars could probe into the commonalities, differences and variations in associating the resilience approach with local heterogeneities. As the Special Administrative Region of a typically perceived 'authoritarian' China, on the one hand Hong Kong has exclusive administrative power and resources that distinguish it from

other Chinese cities; and on the other hand, it is subject to China's fragmented authoritarian water governance approach, which is simultaneously characterized by state-centrism, technocracy and limited stakeholder participation, as well as institutional reforms (Wang et al., 2017). One can observe mixed policy and governance attempts (e.g., neoliberalization of water supply, structural change of industries, transboundary water diversion and institutional adjustments), which include both command-and-control measures and adaptive management to improve regional water security, albeit without the guidance of systematic resilience principles. In this sense, Hong Kong can serve not only as a bridge between international practices of resilience thinking and Chinese characteristics, but also as a starting point for revisiting urban water supply systems for megacities.

In the resilience perspective, the potential risks and vulnerability of Hong Kong's water security differ from those conventionally identified by policy makers. In this sense, a resilience analytical framework can measure the pressure, policy response and development progress of Hong Kong and its regional neighbours concerning Hong Kong's capacity to absorb and adapt to challenges to sustainable urban water supply. Academics and policy makers could identify new areas of concern and contextually sensitive strategies for improving urban water resilience, which are not being adequately addressed by the current technocratic and state-centric water governance system. From a theoretical point of view, scrutinizing the multifarious local conditions in Hong Kong will enrich the understanding of resilience thinking to better fit local complexities and improve the effectiveness of both conventional engineering projects and the newly formed institutions to improve urban water resilience in the empirical context of China.

The way forward: restructuring governance for water security

Moving beyond traditional concerns with the quantity, quality and financial arrangements associated with water supply infrastructure (i.e., the DSWSP), we have embraced an integrative conceptualization of water security and examined Hong Kong's water security from a governance perspective. This approach reveals the deficiencies of a technocratic and supply-oriented water system although Hong Kong is currently able to quench its thirst through a comprehensive hydraulic system. These deficiencies, we argue, stem from scalar mismatches at the territorial, institutional and discursive levels, as well as at the science-policy interface, which have yet to be adequately included in water governance reforms in either Hong Kong or the mainland. In this context, we suggest that resilience thinking, as an alternative approach to understanding water-related challenges nested in a complex SES, might be conducive to fostering Hong Kong's water security. Moreover, resilience thinking highlights heterogeneous political, socio-economic and ecological settings, where specific rather than universal solutions to water crisis are effective. Therefore, we argue that some commonly held principles of good governance, such as participation, transparency and accountability, are no panacea for water security; rather, the scalings, discourses, power relations and institutional frameworks that reshape the structure of water governance are more pertinent to understanding the dynamics of water security.

We have identified three entry points where governance restructuring is needed for a more resilient and secure water system for Hong Kong. First, a critical factor in

understanding Hong Kong's water security is how contentious discourses on the DSWSP have been constructed among diverse stakeholders, and how technocracy has dominated decision-making processes. With most academic and policy attention on infrastructure, few have explored why the 'hard' approach has gained its legitimacy and how power relations have shaped the technocratic discourse. The persistent undervaluation of water in Hong Kong society, as well as the contest between politicization and depoliticization of water among different powers, have led the Hong Kong and mainland governments to position themselves as 'practical problem solvers' that improve water security through hydraulic infrastructure rather than through discursive campaigns for awareness and consensus, thus reconsolidating the influence of technocracy at the operational level.

Second, sectoral and regional segmentation remain prevalent in the water governance system, particularly under the 'one country, two systems' framework. For example, water agencies in Hong Kong and the mainland are mainly responsible for utilization of specific water bodies, but without mandates for land use planning, civic infrastructure and agriculture that influence water availability and quality. Likewise, territorially based administrative units lack coordination mechanisms to address inequalities in water allocation and water conservation between upstream and downstream, between rural and urban, and between inland and coastal jurisdictions. As Hong Kong's water security is closely tied to a fragmented authoritarian system, which continues to respond to cross-sectoral and interjurisdictional conflicts with top-down measures rather than polycentrism, segmentation again facilitates simple centralized action to ensure water security through hydraulic infrastructure.

Third, the rescaling of policy implementation has been associated with unclear roles for different agencies and stakeholders at the operational level, and thus may give rise to contradictions and incompatibilities between reform goals and their actual impacts. As stated in the section on adaptation, various governance reforms have been conducted by the Hong Kong and mainland governments. Yet the success of these reforms requires capacity, cooperation and enforcement across different scales (different levels of government, different functional organizations and different stakeholders). These requirements may not be effectively translated into working arrangements for governance reforms. For example, the implementation of the central government's 'river chief' system is highly decentralized. This task is rescaled to the county and even the village level, where multifarious stakeholders, both state and non-state, have to make decisions on how to enforce the top-down reform and thus various practices occurring during implementation. In this sense, governance evolution is more complex and dynamic than the formulation of targets, the deliberation of formal rules and the setting up of water institutions. Therefore, more attention should be paid to the dynamics and effectiveness of governance restructuring rather than the governance reform itself.

In sum, Hong Kong's water security is not simply about providing enough water at a low price through water infrastructure; rather, it is characterized by the capacity of an SES that involves complex governance attributes. We argue that the restructuring of the water governance system, which concerns changing discourses, power relations and institutional mechanisms, plays a critical role in determining how water is organized and how secure Hong Kong's future water supply will be.

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