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Political dynamics and water supply in Hong Kong

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ABSTRACT

Management of environmental resources presents challenges across jurisdictional boundaries. In the case of river basins, multiple localities must coordinate water allocation, often across social, economic, and political contexts. As such, the scale of governance systems often fails to match that of environmental challenges or the reach of their impacts. This study analyses Hong Kong's water supply management in the context of political tensions between Hong Kong and mainland China, a transboundary dynamic offering broader lessons for improving regional water management. Hong Kong imports a majority of its water from neighboring Guangdong province, historically shaping a pattern of dependency and complacency. This study finds that chronic underinvestment in alternative sources of water exposes Hong Kong to potential instability in water supply from up-stream areas in mainland China. The study's examination of institutional conditions and political dynamics add complexity to the largely technical and scientific research about water governance in Hong Kong.

1. Introduction

Water governance often concerns multiple stakeholders across political boundaries. In such settings, the absence of a central authority subordinates the interests of individual jurisdictions to a collective interest through coordination and negotiation. In diverse institutional settings, supply management of a fundamental resource such as water necessitates mediation of various social, political, and economic interests, testing the efficacy of collaborative models. As the practice of collaborative management for natural resources continues to evolve, particularly amidst the exacerbating forces of demand growth and extreme weather events, the academic literature has addressed the issue from a variety of perspectives. These include not only the broad theoretical and empirical foundations offered by new institutional economics (Ostrom, 2011) and social-ecological systems (Folke, 2006), but also more narrow topics such as user-activity domains (Wiek and Larson, 2012), scalar mismatch in multi-level settings (Moss and Newig, 2010), the renegotiation of shared environmental challenges across boundaries (Lidskog et al., 2011), the institutional dimensions of adapting water management to climate change (Azhoni et al., 2017), and the application of cultural theory to social network analysis to water management (Ruzol et al., 2017). This article explores water governance through the analytical lens of regional governance and political dynamics, seeking to understand how the practical demands of allocative coordination fit within broader socio-political settings. The case, management of water supply in Hong Kong, illustrates these issues by examining the history of the city's water supply systems in reference to the city's relationship with mainland China.

Longstanding contracts for water delivery from mainland China account for nearly 80% of Hong Kong's water supply. After

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initially investing in unconventional sources of water such as desalination, Hong Kong eventually settled for the security and affordability of imported water. This arrangement places the quality and consistency of Hong Kong's water supply at the mercy of cities in the Pearl River delta (PRD), now the world's largest urban mega-region at 42 million inhabitants (Deuskar et al., 2015). This study examines the durability of the current arrangement and argues that continued reliance on imported water, given the possibility of increasingly extreme weather events (e.g. droughts) and its effects on up-stream supply regions in mainland China, compromises Hong Kong's water security.

At the same time, the post-handover relationship between Hong Kong and China's central government, intensifying with the recent rise of pro-democracy movements in Hong Kong, provides a complex political backdrop for the city's dependence on imported water. In the past decade, aberrant weather patterns have led to severe droughts, such as those in California (Griffin and Anchukaitis, 2014; Tortajada et al., 2017) and Australia (Kirby et al., 2014). If similar conditions lead to water stress in Guangdong province, from which Hong Kong's water supply is drawn, cities across the PRD may need to ration while Hong Kong enjoys full access to a contracted supply of water. This may lead to political tension, which now appears to be intensifying between Hong Kong and mainland China but may become a domestic trend if mainland cities sacrifice to honor supply contracts.

Examining the policy implications of such a scenario adds conceptual richness to ideas about regional governance for environmental resources. The proposition is that local intergovernmental collaboration on operational matters solidifies working interdependencies that endure despite external pressures such as national-level political tensions. For example, Hong Kong's Advisory Committee on Water Supplies, a panel of representatives from the government, academia, and the private sector, conducts yearly site visits to infrastructure facilities in Guangdong Province, where discussions are held with mainland officials and other authorities (WSD, 2017a). Aside from a study by Yang et al. (2013), the impact of regional politics on Hong Kong's supply security is a topic that has not received systematic scholarly attention, and this is the gap addressed by this article.

This article continues with a literature review that addresses the current state of research on water management in Hong Kong and on regional political dynamics. The first part of the review covers research about the operational mechanics of water management in Hong Kong, focusing on the challenges inherent in relying on imported water. The second part of the review examines the brief history of post-handover political dynamics in Hong Kong, focusing on public sentiment about integration with mainland China and the rise of localism. This literature supports this article's case that coordination between Hong Kong and mainland China on water issues necessitates consideration of rising political tensions.

Following the literature review, the remainder of the article explores regional collaboration for water management through an analysis of historical trends in operational coordination, institutional relationships, and political dynamics in Hong Kong and the PRD. The article utilizes a case-study method in which government documents and scholarly research are reviewed. A case description of Hong Kong's water management outlines how water has been one defining factor of the city's operational relationship with the mainland. A scenario analysis of how this relationship could be impacted by current political dynamics, along with a proposal for how to improve regional governance of water resources, conclude the article. The argument is that establishment of stronger and more institutionalized regional water governance, based on efficiency, trust, and reciprocity, is needed to moderate rising tensions and better manage supply risks. The contribution of this article is the conceptual integration of environmental and political dynamics to explain how intergovernmental collaboration impacts, and is impacted by, external factors in regional environmental resource management.

2. Literature review

This review explores literature about Hong Kong's water management, with a focus on environmental conditions affecting water supply and the governance of water supply in the region. It concludes with a brief review of literature about political dynamics between Hong Kong and mainland China. After droughts and subsequent rationing in the 1960s, Hong Kong's colonial government adopted a water management approach that Wang et al. (2016) describe as engineering infrastructure and Man et al. (2011) as an ageing development approach. This involved a conventional strategy emphasizing catchment, piping, storage, and purification systems, as well as an unconventional strategy that included desalination for short time. While this approach was adequate given the situation at the time, demand growth and uncertainty about weather patterns are now testing the adaptive capacity of existing systems. Indicators of climate change in the PRD in recent decades, according to Yang et al. (2015), include warmer city centers, an increase in the number of days per year considered hot, higher overall temperatures, extreme precipitation, and inter-annual variability of precipitation. The authors also cite urban development encroachment and population growth as factors contributing to land subsidence, which worsens the severity of floods.

Identifying similar risk factors associated with climate change, Welford (2011) recommends that the Hong Kong government make climate change adaptation a strategic priority, institute community-based adaptation programs, and incentivize the private sector to become involved. Yang et al. (2013) provide a useful overview regarding threats to Hong Kong's water supply, including drought in water source regions, flooding, sea-level rise, and water pollution. Additionally, the authors cite "low-level social tensions" (p. 14) and a lack of concern about water-related self-sufficiency and climate change impacts in Hong Kong policymaking as further threats. According to Man et al. (2011), Hong Kong's current situation calls for a new generation water management model emphasizing approaches such as conservation, demand-side management, and sustainability.

Hong Kong's dependence on imported water now exposes the city to hydrological variations in up-stream Guangdong province's Dongjiang River basin. According to Yang et al. (2016), regional water governance breeds a dynamic in which water and political-economic power are interwoven; Hong Kong is reliant on the mainland for a crucial resource while in turn serving as one anchor for the region's economy. Cities in up-stream areas, including Anyuan, Dingnan, Heyuan, and Xunwu, are compensated for conservation

efforts that ensure water quality and supply consistency for more populous cities down-stream, including those in the mainland (Yang et al., 2016). This regional balancing mechanism is managed in part by the Dongjiang River Basin Administration, which manages the Dongjiang River Basin Water Quantity and Quality Monitoring and Control Centre (WSD, 2016a), oversees the supply and quality of river water, and provides advisory consultation about pollution control and construction projects within protected areas of the basin (WSD, 2017b). Regional allocation is often executed through inter-basin transfers (Zhuang, 2016), in which water sourced from lower-demand areas is transported for use in higher-demand areas; this often involves transfer across ecological basin boundaries.

The Dongjiang River is important for a variety of reasons. In addition to supplying water for much of the PRD region, maintenance of the river's quality and flow, along with effective water allocation and management systems, is crucial for hydropower generation, trade, aquaculture, tourism, and management of saltwater intrusion at the mouth of the river (Chen, 2001). One challenge in managing such issues is the mismatch between the scale of the problem and the institutional apparatus to address it; while Hong Kong is part of the regional water system as a consumer, its involvement in up-stream water management is limited.

A significant omission in literature about Hong Kong's water supply sustainability has been a consideration of the increasingly complex political relationship between Hong Kong and mainland China. In a review of political science frameworks, Orach and Schlüter (2016) explicitly acknowledge the need to consider political dynamics in complex social-ecological systems, as have others (Duit, 2016; Robards et al., 2011). The remainder of this review explores the recent and limited literature about this widening cleft, to establish the context for this article's case study. Hong Kong's current political environment can be analyzed through issues such as election sovereignty, legislative independence, patriotic education, and core-periphery power dynamics, and also through popular concerns such as property values, public behavior among mainland visitors, and online comments by mainland citizens. The literature has addressed many of these issues, but this review focuses specifically on the emergence of localism: the notion that Hong Kong should maintain a distinct identity that is only partly, or not at all, Chinese. This is relevant to the study of water because such tensions can impact Hong Kong's willingness to collaborate with the mainland in ways that go beyond supply contracts.

On July 1, 2003, a march in Hong Kong drew the largest crowd (500,000) for such a gathering since the 1997 handover and is seen as the turning point at which Beijing began to exert more political control and influence over debates about democratization and nationalism (Fong, 2017). The elimination by the Chinese government of universal suffrage in elections for Chief Executive, Hong Kong's highest government post, epitomized for many an insidious and unwarranted intervention (Wang, K.J. et al., 2017; Wang, R. et al., 2017; Kaeding, 2017). The 2014 *Umbrella Movement*, during which major thoroughfares in the city's financial district were occupied by encamped protestors, was indicative of rising Sino-scepticism and an emerging social and political consciousness focused on Hong Kong identity (Chan, 2016). Such events, embodying Fong's concept of *peripheral nationalism*, are reminiscent of China's 1919 *May Fourth* movement, the 1989 Tiananmen Square incident, and Taiwan's 2014 *Sunflower Movement* (Partaken, 2017). In their disruptive tone, Hong Kong's localism events reflect broader tensions in state-society relations, as increased state control (by mainland China) correlates with civil disobedience and as society's quest for autonomy in general progresses from basic social welfare to political autonomy (Wong and Chan, 2017). The June 2017 commemoration of the 20th anniversary of Hong Kong's handover from the UK to mainland China drew more rounds of public protests from the pro-democracy movement. For an overview of the forces behind localism in Hong Kong, including socio-economic conditions and demographic changes, see Cheng (2014) and Chan (2015).

Beyond signs of stronger central government intervention, anti-mainland protests have germinated from a confluence of factors including the influx of mainlanders as tourists and immigrants, the widening wealth gap between Hong Kong's rich and poor, election setbacks for the localist movement, and the reification of localism itself as a movement with its own coherent discourse, dedicated organizations, and high-visibility events (So, 2017). The movement has attracted Hong Kong's youth (Lincey and LIM, 2017), including politically active university students. The underlying motive appears to be the assertion of a unique Hong Kong identity in reaction to the largely unsuccessful inculcation of patriotic pan-Chinese identity by Beijing elites (Lowe and Tsang, 2017; Yew and Kwong, 2014). According to Lowe and Tsang (2017), Hong Kong's geohistorical, socio-political, and cultural distinctions, forged during the British colonial period, are the basis on which citizens collectively distinguish themselves from the mainland. At the same time, localists are resisting what they call Beijing's authoritarian rule and are seeking to assert a unique cultural identity that includes so-called universal values and cosmopolitanism (Chen and Szeto, 2015). According to Yew and Kwong (2014), Hong Kong previously distinguished itself from mainland China using the narrative that Hong Kong was wealthy and mainland China was not. Now that the wealth gap between Hong Kong and mainland China is closing, Hong Kong must find other distinguishing factors, which increasingly reflect a political values-based identity such as respect for freedom and democracy. Even the Hong Kong government has appealed to localism, nationalism, and globalism (Ku, 2016), aiming to solidify political legitimacy while concurrently invoking elements of *Chineseness*. The academic literature has often cast the localist movement as a reaction to threatened identities, with Hong Kong, in ethnic and cultural terms, moving progressively away from what China's government promotes as a unitary national identity (Veg, 2017).

While the focus of Hong Kong localism has evolved from social welfare and rights to a *new preservation movement* focused on diversity, progressive values, political participation by the marginalized, and repudiation of ethno-nationalism (Chen and Szeto, 2015), a "racialized" civic identity has also emerged in some localist circles, countervailing societal principles like quality and freedom (Jackson, 2017: p. 1). Kwong (2016) provides a useful background on the rise of this offshoot of localism, which according to the author expresses dissatisfaction with reform-minded pan-democratic parties that have historically embraced Chinese identity. While both sides favor democratic reforms, they are on opposite sides of Beijing's threshold of tolerance for dissent. The offshoot movement's racialization of civic and national identity has been cast more broadly as exclusionary and regressive (Chen and Szeto, 2015), and has been argued to erode social cohesion (Jackson, 2017), damage the partnership between government and civil society (Chan and Chan, 2017), and create a platform for political tension that the Hong Kong government is doing little to resolve (Sautman

and Yan, 2015).

Hong Kong's political activism has drawn negative reactions from the mainland populace. After protesters harassed Chinese bulk-consumers (informally labelled “parallel traders”) for entering Hong Kong to purchase large quantities of goods not available in the mainland (Ip, 2015), some angry Chinese netizens called for the suspension of water supply to Hong Kong. Cross-border contempt, often evident only for high-profile events and increasingly common with the influx of mainland residents in Hong Kong (Li, 2016), can be described as a two-way street with tensions on both sides. This is one reflection of the continuing complexity of Hong Kong's relationship with mainland China as exhibited in the public sphere. Originating under Deng Xiaoping, the *one country-two systems* principle regards Hong Kong as part of mainland China but originally allowed the city to maintain its long-standing capitalist and democratic institutions. Given the resistance documented above and rapid pace at which Beijing appears to favor integration, there now appears to be concern about the durability of this governance arrangement.

3. Case description

This case description, together with the content of the first part of the literature review, provides the context for this study's analysis and policy implications. The case focuses largely on Hong Kong's water supply regime and its relation to Guangdong province, and describes relevant historical and institutional factors. Southern China is flush with water compared to northern China, and there is little overlap between source regions and populous areas; consequently, China has invested in infrastructure to transfer water to regions where water scarcity could be an economic risk (Zhang, 2009; Pohlner, 2016). In the south, many eastern Guangdong province cities – including Hong Kong – rely primarily on a single source. As an eastern tributary of the Pearl River originating in Jiangxi province, the Dongjiang River flows into one of China's most densely urbanized regions, accounting for a majority of supply in cities such as Dongguan and Heyuan, and 70–80% in Hong Kong (Chen, 2001). Guangdong province produces over 10% of China's GDP (NBS, 2017); China's 1978 market reforms prompted unprecedented industrialization in the province, closed its development gap with Hong Kong, and raised commercial and residential demand for water.

In Hong Kong, water has been sourced from the Dongjiang River since the 1960s, when two severe droughts forced the city to ration water (restricted to four hours per day once every four days, at the most severe stage). This ultimately prompted the pursuit of external sourcing, and long-term supply contracts drafted at that time apply through the mid-21st century. Through this arrangement, Hong Kong receives a vast majority of its water from the mainland, extracted nearly 80 km north of the city in Guangdong province and conveyed through a network of channels, canals, and pumping stations. Known as the Dongjiang-Shenzhen Water Supply Project, the near totality of this infrastructure exists in mainland territory (Fig. 1). The project includes inter-basin transfer of Dongjiang River water for use by Hong Kong and the Guangdong cities of Shenzhen and Dongguan. Project infrastructure underwent large-scale reconstruction between 2000 and 2003, targeting a water supply reliability rate of 90% (GPDI, 2013).

Despite having already agreed to a supply contract with mainland China, Hong Kong's colonial government in the 1970s embarked on an ambitious and innovative plan to supplement imported supply with a pioneering saltwater flushing system and two freshwater reservoirs fashioned from dammed sea inlets – at that time the largest of their type in the world. Hong Kong's venture into desalination ended in 1981 when a newly constructed plant was decommissioned after only six years due to rising energy costs. Dependence by Hong Kong on a single source has since delimited the city's water supply strategies (CWR, 2012), with chronic underinvestment in alternative sources yielding little redundant capacity to buffer against possible Dongjiang River supply fluctuations.

Since the 1980s, Hong Kong has not prioritized alternative sources with the aggression and pragmatism of peer city Singapore, where innovative water purification programs and catchment infrastructure support ambitions to reduce reliance on water imported from neighboring Malaysia (Tortajada et al., 2013). Singapore's motivation to reduce dependence on imported water extends from a history of tenuous trans-boundary cooperation punctuated by episodes of diplomatic tension. In a widely referenced anecdote, Singaporean Prime Minister Lee Kuan Yew resolved to pursue water self-sufficiency for the new country after a single comment from the Malaysian Prime Minister that Malaysia might engage in punitive politics using water supply. Further, Hong Kong's household conservation has been modest, due in part to low consumer water prices that have not been increased for more than two decades. While Hong Kong's per capita water consumption, at an annual 172 m³, is lower than that of mainland China's major cities, it exceeds that of peer cities like Singapore, London, Melbourne, and Paris (CWR, 2012).

It appears that Hong Kong now acknowledges these shortcomings, recently integrating a broader mix of supply sources into its infrastructure plans. The Total Water Management strategy, prepared by the Water Supplies Department in 2008, maps out strategies for planning and managing water resources, including aspects related to supply and demand (WSD, 2008). The 2017 review of the Hong Kong government's Total Water Management strategy is expected to prioritize diminishing reliance on imports, particularly as greywater recycling and desalination are implemented (WSD, 2017c). In 2015, the government announced that a new desalination plant would be operating by 2020. However, cost per unit is expected to be higher than that of imported water, and the plant will account initially for only 5% of supply (with possible expansion to 10%). This commitment to alternative supply has been interpreted as a once latent but now emerging concern about the risks of relying principally on Dongjiang River transfers (Yue and Tang, 2011).

Hong Kong's recent diversification efforts are already a global trend; urban and national governments have embraced climate change preparedness in long-range planning (Araos et al., 2016), including in vulnerable coastal areas (Ives, 2016). Given their low elevations and the intensity of riparian development, Hong Kong and Guangdong province are not immune either to sea-level rise (Huang et al., 2004) or to water scarcity arising from extreme weather patterns (Zhang et al., 2012, 2009). The region has a history of water scarcity, once prompting planners to adopt immediate engineering solutions. Given that the Dongjiang supply system is designed to provide 1.1 billion cubic metres of transferred water per year (WSD, 2016b) to Hong Kong, an amount that was



Fig. 1. Map of water Dongjiang River Basin and Dongjiang-Shenzhen Water Supply Project.
Wang, R. et al., 2017

contractually guaranteed in a 2011 agreement (Civic Exchange, 2010), severe and extended scarcity could force mainland cities to ration water so that Hong Kong's contract is honored. Such a scenario could have repercussions for domestic political dynamics beyond the exhaustively discussed relationship between Hong Kong and mainland China.

4. Analysis of water management dynamics in Hong Kong

This analysis focuses on four interrelated trends that exemplify Hong Kong’s water supply challenges: supply management, alternative sourcing, demand management, and water quality. First, given the post-drought self-sufficiency efforts of the 1970s and 1980s, Hong Kong once enjoyed short-lived status as a water supply innovator. The 2008 Total Water Management strategy pledged to revive this spirit of innovation, advocating for a more diverse source portfolio including desalination, reclaimed water, greywater reuse, and rainwater harvesting. The strategy also promoted demand management programs such as a water efficiency labelling scheme for use at residential and commercial points of consumption, an integrated citywide water usage monitoring network, and investment in the replacement and rehabilitation of delivery and storage infrastructure. Although innovative and widely heralded, Hong Kong’s dual supply system (freshwater and saltwater) is redundant and costly, requiring dedicated infrastructure parallel to that for freshwater and accounting for total fixed assets of HK\$6.5 billion (US\$831 million) as of 2014. The seawater flushing program also requires frequent maintenance due to the corrosion of pipes by salt (HKLC, 2015), and treating wastewater having high organic and saline content (Lefebvre and Moletta, 2006) and seawater contaminated with wastewater (Petrik et al., 2017) is a complicated and costly process. It is unclear how Hong Kong manages and treats contaminated seawater, and financial information about this process is unavailable.

Despite its recent push for innovation, Hong Kong still lags other cities in development of alternative supplies. For example, Singapore’s innovative NEWater program, which purifies wastewater into high-grade reclaimed water for potable and non-potable uses while exceeding the World Health Organization’s potability standards, provides a reliable, long-term, climate-adaptable source and serves a political imperative for self-sufficiency (Tortajada, 2006). Hong Kong’s water supply regime did not similarly incentivize self-sufficiency, as imported water remained cheap and seemingly reliable. In particular, after Hong Kong’s handover from the UK to mainland China was announced in 1984, the colonial government had no political imperative to become self-sufficient in water resourcing, in part because there was no need to expend capital for maintaining political legitimacy. The handover announcement came after alternative supply initiatives were implemented, and from 1984 onward innovations failed to materialize at any significant scale. The differing water management paths between Singapore and Hong Kong reflect the contrasting histories of these otherwise similarly situated cities (for a deep comparison, see Liu and Williams, 2014). These differences also place Hong Kong’s political situation in stark relief; Singapore’s water history reflects the country’s political divergence from its neighbour (Malaysia), while Hong Kong’s reflects imminent political convergence with its neighbour (mainland China).

Second, while most discussions about Hong Kong water have focused on supply-side dynamics, demand management is a largely overlooked factor – both as an analytical issue and policy tool. The city’s domestic per capita consumption of water is higher than that of its peers and has failed to decline over time (Fig. 2). Additionally, systemic water losses (i.e. “non-revenue water”) were estimated to be nearly one third of total production – far higher than Singapore’s roughly 5% (Civic Exchange, 2017). Hong Kong’s unit price of water has not risen since 1995 (HKLC, 2015). As such, pricing is not used as a demand management mechanism, and total charges for water consumption in Hong Kong lag those of many global peers (Fig. 3). Hong Kong also has among the lowest drinking water charges of high-income cities (Fig. 4). Moreover, given that the average annual rate of inflation for the Hong Kong dollar between 1995 and 2017 is 2.21%, based on IMF (2018) data, the current price of water may effectively be far less than the 1995 price. The assessment of cost-recovery rates, applied at levels of consumption currently subsidized or unassessed, could incentivize additional conservation. Depending on demand elasticities, pricing reforms can also generate additional revenue.

Third, recent safety concerns may be contributing to a crisis of public confidence about the quality of Hong Kong’s water. The discovery of high lead content in 2015 water samples from local housing estates elicited public scrutiny and concern (CHP, 2016). Media and opposition politicians argued that these breaches were representative of a broader monitoring failure and management



Fig. 2. Daily per capita domestic water consumption.HKU, n.d

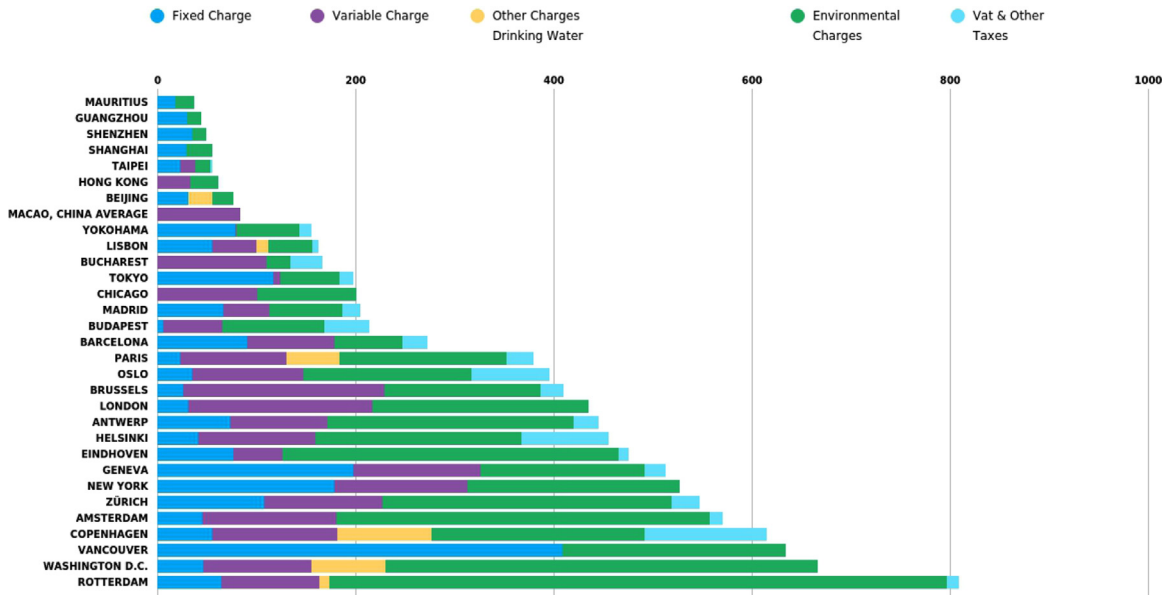


Fig. 3. Charges for consumption of 100 m³ of water in 2015 (data from IWA, 2016).

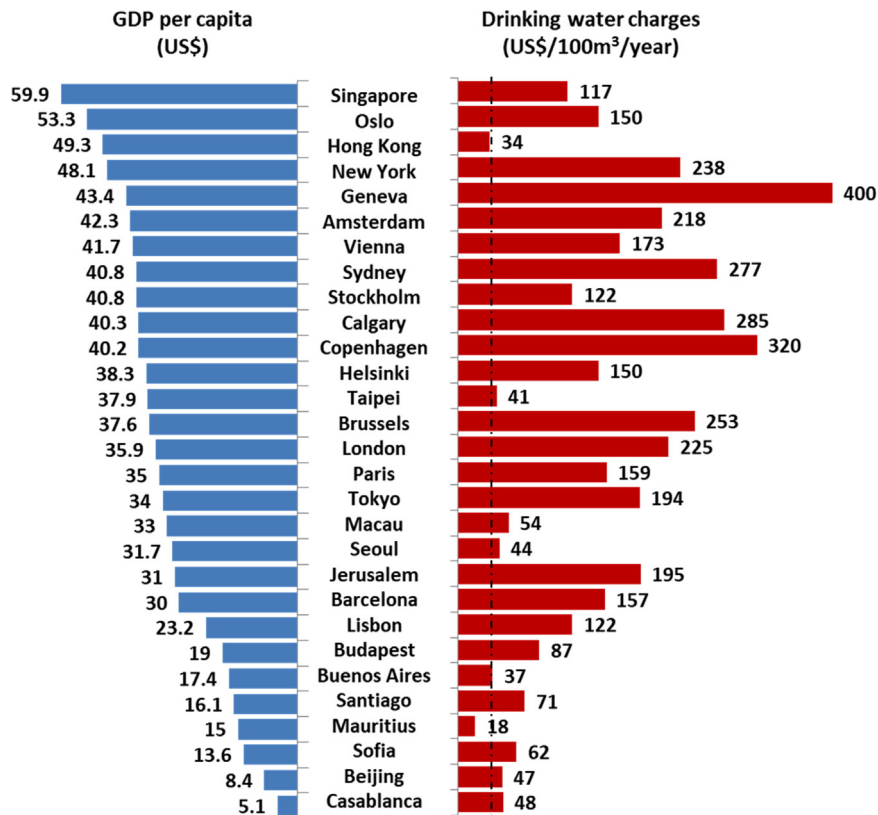


Fig. 4. Comparison of GDP per capita and drinking water charges (adapted from Lee, 2013).

crisis. The government blamed construction companies and inadequate legislation, while other critics argued for heightened accountability from all parties. Purity standards – based on a minimum number of lead parts (typically micrograms) per litre – tend to be cautious overall. The universally accepted threshold is 10 µg (micrograms) per litre, established by the World Health Organization (WHO, 2011) and used now by Hong Kong. However, some countries tolerate higher levels (e.g. 15 in the US and 50 in mainland

China). Even in Hong Kong, measurement levels can far exceed maximum standards; other 2015 samples revealed lead levels ranging from 14 to 41 μg . Recent cases of lead contamination, along with the discovery in one case of legionella bacteria, have eroded public trust in the quality of the system. More information is needed about how long lead levels have been elevated, as this would have implications for infrastructure planning and management.

Finally, improved supply management, in terms of planning for and responding to supply and quality risks, would help ensure that Hong Kong maximizes the potential for efficiency gains. According to an Auditor General's report, planners once so poorly estimated the city's water requirements during the drafting of a supply contract that there was an overflow of 716 million cubic metres of water from 1994 to 1998, costing taxpayers HK\$1.7 billion (WSD, 1999). Further, the supply agreement, in effect since 2006, requires Hong Kong to pay a lump-sum for 820 million cubic metres each year, regardless of how much is supplied (HKLC, 2015). This agreement was made under the guise of flexibility (i.e. the prerogative to adjust supply in response to fluctuating demand). Under a 2017 agreement between Hong Kong and the Guangdong Department of Water Resources, from 2018 to 2020 Hong Kong will pay yearly fixed lump sums for the same volume (HKSAR, 2017); this price is a 6.7% increase from prior years (Ng and Kao, 2017). Such agreements are accompanied by little material incentive (beyond efficiency labelling schemes) for consumers to reduce usage, given the low fixed price per unit consumed. The adoption of water conservation as part of a broader environmental narrative, a strategy Singapore has utilized to notable effect in developing water-themed recreational and educational spaces and creatively branding NEWater, would be a strategic approach to complement supply improvement efforts. Findings are that Hong Kong has lacked targeted policies, operational efficiency, and the will to change consumption behaviors.

Despite these shortcomings, the seemingly mundane challenges of practical governance – which have placed Hong Kong and neighboring Guangdong province into collaborative stead – have created a regional setting defined by operational interdependence (Hartley, 2017). It is this paradoxical setting, namely broader socio-political tension amidst the minute exigencies of practical collaboration, that can provide lessons for regional management of natural resources. The challenges of regional collaboration in this and other cases assume further complexity amidst the threats of extreme weather events, natural resource depletion, and contested allocative mechanisms.

5. Political implications

Political implications are explored through the interactions between Hong Kong and mainland China. Hong Kong's imbalanced supply portfolio favouring imported water is the result of a moral hazard. In this context, the term "moral hazard" refers to the influence of perverse incentives on resource planning that is rational within narrow engineering and short-term parameters but technically and politically unsustainable in the long-run given evolving conditions. In practical terms, comfortable reliance on the cheap and seemingly secure supply of imported water has undermined political urgency to develop alternative sources. Over many decades, this has engendered an infrastructure gap between Hong Kong and peer cities like Singapore, and has arguably compromised the city's resilience to supply shocks. Understanding this techno-political dynamic is difficult given limited access to information. Furthermore, the literature provides only scant guidance, with few recent studies focusing thoroughly and exclusively on the political dynamics of water management between Hong Kong and mainland China. A deeper understanding of the complex political dynamics between Hong Kong and the mainland is needed to fully understand threats to water security.

In Guangdong province and Hong Kong, the political ecology of water supply is regional in scale. The multi-jurisdictional setting is characterized by interdependencies among cities in multiple aspects of water supply management; these include institutional arrangements and shared infrastructure to facilitate allocation. The challenges of operational coordination prompted the creation of basin management committees to address flood control, watershed conservation, and riparian development along the Pearl River and its tributaries (the East River/Dongjiang, North River/Beijiang, and West River/Xijiang). However, regional collaboration in water allocation, after the 1960s, may not have been a concern in Hong Kong because no drought has posed a significant threat and supply is contractually guaranteed. On the mainland side, China's central government's *three red lines* policy establishes targets for total water use, water use efficiency, and control of water pollution for a number of benchmark years to 2030 (Nickum et al., 2017), and also stipulates a fixed water concession per province to be divided among sub-provincial units (e.g. cities). The policy is a response to what the central government sees as excessive demand growth, inefficient use of water, and worsening pollution (MWR, 2012).

The administrative systems of Hong Kong and mainland China remain largely unintegrated, presenting challenges to collaboration on more strategic matters beyond water transfer. Hong Kong's executive and common law-based system is distinct from the top-down and politicized bureaucracy of mainland China's central and local governments. Nevertheless, overtures to collaboration have been made on several issue-specific fronts. According to the Hong Kong Legislative Council (HKLC, 2010), water quality has already been addressed within a regional cooperative framework, specifically regarding monitoring and management schemes. Inter-urban cooperation already exists for regional projects like education, cultural exchange, and industrial development. For example, Hong Kong is collaborating with Guangdong's city governments on transportation infrastructure, namely the Hong Kong-Zhuhai-Macau Bridge and the Guangzhou-Shenzhen-Hong Kong express rail link. As such, the collaborative relationship between Hong Kong and Guangdong cities is driven in part by the practical necessities of urban management, particularly as decades of rapid industrialization have transformed the highly urbanized region's built and natural environments.

Collaboration among the utilities agencies of regional cities focuses on practical issues of water allocation and is largely apolitical, despite tensions between politically active civic groups in Hong Kong and China's central government. While collaborations continue for specific purposes, higher-level political tensions linger. For example, Hong Kong's localist-aligned political parties leveraged their visibility into modest but notable support in the city's 2016 Legislative Council election, winning nearly 20% of the vote amidst record turnout. It is evident that discontent has not dissipated, a notable issue given China's post-2047 plans for Hong Kong (at which

time the governance systems of both are planned to be fully integrated). Aside from Hong Kong's relationship with central government, water scarcity of the sort experienced in the 1960s has the potential to generate tensions between Hong Kong and its regional urban neighbours. If water supply is secure and abundant, allocation is a matter of contractual negotiation, as it has been for the duration of the water contract era. Hong Kong often imports less than the amount to which it is entitled, while supply in Guangdong cities is restricted according to the *three red lines* policy (MWR, 2012). Therefore, allocation could be a contentious issue in scarcity scenarios.

In a research brief (WSD, 2015), the Hong Kong Water Supplies Department indicates that the allocated annual quantity of water would, in drought conditions, fall by an average of 4.7% (5.1% adjusted for population size) in the four mainland cities relying principally on the Dongjiang River (7.2% in Dongguan, 3.3% in Shenzhen, 3.2% in Heyuan, and 5% in Huizhou). There is no similar restriction for Hong Kong. The question then arises whether China's central government would place pressure on Hong Kong to renegotiate contracts to avert mainland-side political pushback resulting from rationing if and when necessary. Arguably, any sacrifice by Chinese cities could be seen by mainland residents (including the netizens that criticized Hong Kong violence against parallel traders) as favouritism towards Hong Kong, a strategy that had less visible opposition in the 1960s than it likely would today.

6. Conclusion

Regional governance of water resources in the Hong Kong-Guangdong region is defined by a history of operational collaboration bounded largely by water supply contracts. Given the growing political tensions between Hong Kong and mainland China, the institutional dynamics of water governance between Hong Kong and other cities in the PRD region deserve more scholarly and practical attention. The twin forces of extreme weather events and growing water demand could lead to water shortages in the longer-term, testing intergovernmental relationships as Hong Kong's contracts continue to be honored. The solution to such challenges, from a regional governance perspective, lies not only in securing supply for all cities through improved technologies but also in cultivating a common understanding of shared responsibility and vulnerability. The latter could compel Hong Kong's leaders to look beyond contracts and regard the city as an equal contributor to the PRD region's water management efforts. Operationalizing this philosophy requires a collaborative approach to managing region-wide demand, improving allocative efficiency, strengthening and legitimizing institutions, and developing infrastructures to manage the impacts of extreme weather events. Furthermore, regional cities can benefit from sharing best practices for water demand management, each making a commitment to lowering their individual water footprints.

Hong Kong has experienced two "watershed" moments that have defined its current water supply system: the droughts of the 1960s and the handover to mainland China in 1997. Recent political tension between the localist movement and China's central government could be seen as a third watershed moment. These three moments and their impact on Hong Kong's water supply reveal four lessons. First, operational challenges and engineering solutions, along with the contracts addressing them, are fundamentally apolitical; this partly explains the currently minimal tension around water supply in Hong Kong. A deeper understanding of and commitment to regional water management can be sold to Hong Kong residents as a practical solution rather than a political compromise with mainland China. Self-sufficiency can thereby be prioritized by the government not as a defence mechanism (as in Singapore), but as a contribution to a region that shares Hong Kong's water source.

Second, when allocative dilemmas inevitably emerge, domestic political pushback in the mainland may arise from perceptions of favouritism towards Hong Kong, particularly during emergency rationing events. This scenario, faced during the 1960s droughts, underscores the need to plan for scarcity by mutually agreeing to allocative measures that balance sacrifice across all PRD cities, including Hong Kong. Third, given mainland China's top-down allocative stipulations as earlier referenced, central government may be forced to choose political stability in one arena versus the other, potentially shifting the source of tension from Hong Kong to mainland cities if animus arises in the latter over perceptions of favouritism. Institutionalized regional collaboration and a commitment to shared sacrifice could countervail arguments that water rationing is political and biased. Finally, regional collaboration relies on the development of cross-jurisdictional trust and reciprocity. While contracts and agreements provide structure to collaboration, all parties can advance regional resilience by signalling individual efforts to manage local demand, pool risk, and contribute to broader conservation efforts. Such mechanisms are currently lacking, as the mechanics of water transfer are the principal topic of coordination. A longer-term perspective is needed that incentivizes participation from individual jurisdictions through accountability mechanisms for demand management and usage efficiency.

In a study of science-policy processes in transboundary water-governance settings, Armitage et al. (2015) call for new forms of collaboration that involve not only science and policy actors, but also non-state actors in a process of building knowledge networks. The incorporation of science and best practices is also contingent on proper measurement of environmental conditions, necessitating transparency and accessibility (Hsu et al., 2012). Water management in Hong Kong and the PRD region could benefit from this model. Full integration between Hong Kong and mainland China will not occur until the mid-21st century, but extreme weather events have the potential to impact supply in the intervening period. Regional governance relationships will likely become increasingly interconnected, and their effectiveness depends on the commitment of all parties, including Hong Kong.

Efforts to understand these shifting dynamics and build institutional durability deserve further attention, both in the literature and among policymakers. Being among the first studies to explore the intersection of these issues in the Hong Kong context, this article calls for further research to determine whether and how Hong Kong would sacrifice in the form of water rationing or supply contract renegotiations to lessen hardships faced by mainland cities under scarcity scenarios. This is among the many issues policymakers must contemplate amidst resource interdependency and increasingly unpredictable weather threats.

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