EXECUTIVE SUMMARY

Water under Severe Stress Worldwide

Climate Change: A Global Threat to Water Security

Only 2% of the world's water is freshwater - a fundamental resource needed for growing food, producing energy, and our very survival. Water availability per capita is decreasing internationally, and today 25-39% of the world's population is estimated to live in watersheds exposed to scarcity. By 2050, over half of the world's population could be subject to water stress.

Climate change has exacerbated this situation and today is one of the biggest challenges humanity faces globally. The Intergovernmental Panel on Climate Change (IPCC) indicated, in its Fifth Assessment Report, that for every 1°C increase in global temperature, a further 7% of the Earth's population would face decreases in freshwater availability. Experts predict that temperatures could climb by as much as 7.4°C above pre-industrial levels by the end of the century, under a business-as-usual scenario.

Rising temperatures impact variables throughout the atmospheric and oceanic systems meaning water availability (including quantity, quality and seasonality) will change. This, in turn, could exacerbate droughts and floods. At the same time, the frequency and intensity of precipitation will increasingly vary and rain, rather than snow, will fall more frequently. In response, soil moisture and groundwater levels will change. More intense typhoons, sea level rise and migrating rainfall patterns are only a few of the most imminent and expected consequences.

Projected Population Growth Makes the Situation Even More Challenging

Compounding the disruptions brought by climate change, growing populations are putting water resources under more stress. It is projected that the world's population will reach 7.71 billion by 2020 and 9.55 billion by 2050. The intensity of consumption will be especially striking in Africa, Asia and South America where the majority of population growth will occur. The projected increase in population will inevitably lead to an increase in water, food and energy consumption, thus further increasing water demand in the future.

Additionally, factors such as migration, technological advancement, infrastructure and shifting land use patterns will affect water availability in the future. Water security is, therefore, high on the political agendas of many countries, jurisdictions and cities.

Pressure Mounting in the Pearl River Delta

In the Pearl River Delta (PRD), which includes parts of Guangdong Province, Hong Kong and Macau, the consequence of disrupted climate regimes has become a major concern, leading to uncertainty around long term water availability. Indeed, some researchers believe that river flows in the PRD, could decline by as much as 24% by the 2070s. However, observations on the PRD's second largest river, the Dongjiang, which supplies water to seven of China's major cities as well as the majority of Hong Kong's freshwater, indicate that the system remains relatively stable and resilient. Vast engineering works, such as the Xinfengjiang Reservoir in Guangdong Province, have reportedly bolstered the capacity of the basin, with sufficient stores to offset all but the most infrequent and extreme multi-year droughts.

The Dongjiang has, however, been beleaguered by pollution from aggressive industrial expansion and rapid urbanisation throughout Guangdong and the surrounding regions. The economy of the province now accounts for 10% of China's GDP. Population in the PRD has also boomed to the extent that more than 20,000 diversion projects now syphon water from the Dongjiang, sustaining more than 40 million people.

In order to supplement growing demands, authorities throughout China are continually seeking to improve their water management strategies. The Xijiang is the western tributary of the Pearl River, and southern cities have turned to this watercourse to make up for deficits elsewhere. However, this so-called 'Golden Waterway' has experienced significant shortages of its own, notably stranding 900 shipping vessels in 2011 as runoff declined by 30%.

In spite of the prevailing uncertainty as to the sufficiency of long-term water supplies from the Dongjiang, it is clear that water scarcity and drought are risks that need to be recognised by Hong Kong's government as well as its public.

Hong Kong's Water Security Challenges

Despite abundant rainfall, seasonal typhoons, large impounding reservoirs and a water supply from China that has remained largely uninterrupted for over 30 years, Hong Kong itself is more naturally water scarce than parts of the Middle East and Africa. Defying this stark reality, water security is worryingly low on the Hong Kong government's agenda. Yet, with the mounting pressures of population growth, thirsty businesses, changing land uses and climate change, it has never been more important to consider the future of Hong Kong's water security.

The Historical Context: A Legacy of Inertia

In 1965, the Hong Kong government negotiated a deal with the Guangdong authority to supply Hong Kong with freshwater, and in doing so, established a connection with the Dongjiang. This supply first exceeded the yield from Hong Kong's local catchments in the mid-1980s and Hong Kong has not rationed its water since May 1982.

This agreement has been maintained for over five decades, with Hong Kong receiving up to 80% of its supply from China in recent years. The security provided by the Dongjiang has been invaluable, and yet it has also hindered local innovation and attempts to diversify the system for more than half a century.

Hong Kong imports hundreds of millions of cubic metres (m^3) of raw water from China every year, and the regional demand placed on the Dongjiang surged past the level deemed "ecologically safe" in 2004. In response, China ushered in an era of strict allocation policies, and in 2008 Hong Kong's introduced its 'Total Water Management' (TWM) Strategy. The TWM Strategy was formulated by the Water Supplies Department (WSD) with the intention of diversifying Hong Kong's water portfolio, providing a catch-all solution to water disruption from climate change and as a strategy to "enhance Hong Kong's role as a good partner" in the PRD.

Despite the TWM Strategy, at the broadest scale no water policy has been advocated or established and little progress has been made in addressing long-term water security. Nevertheless, the Strategy is a necessary part of any plan to enhance Hong Kong's resilience and reduce Hong Kong's demand on the natural systems of the PRD. The rationale and motivation for such a transition is pragmatic and should be centred on Hong Kong's desire to be a good neighbour. As a major city and economic power within the PRD, the effects of Hong Kong's decisions on water ripple across the region, with consequences for all.

Hong Kong has the capacity and resources to become a regional leader in water management and resilience, and it is vital that the city harmonises water usage with its neighbours by contributing to the sustainable development of the Delta and aligning Hong Kong with the progressive water policies championed by China.

Supplying Hong Kong: Reliance on the Pearl River Delta

Today, the majority of Hong Kong's water continues to flow from Guangdong Province. Hong Kong has exclusive rights via the so-called 'DongShen Agreement' to as much as 820 million m^3 of this raw freshwater each year. This comprises the bulk of the 1.25 billion m^3 of fresh and seawater consumed by the city's population annually.

Negotiated every three years between the governments of Guangdong Province and Hong Kong, the Agreement is overseen by Guangdong Investment Limited (GI), in which the provincial government has a majority stake. The deal is lucrative and directly benefits GI's shareholders, with the water it supplied to Hong Kong providing approximately 46% of GI's revenue in 2015.

Under the administration of GI, the unit cost of Dongjiang water has been steadily increasing with the annual payment rising from HK$2.43 billion in 2001 to HK$4.22 billion in 2015. Hong Kong now pays 3.3 times more than neighbouring Shenzhen and Dongguan, despite demanding 34% less water. Whilst this appears imbalanced at first, the reality is that Hong Kong should be paying a high price for a guaranteed supply of this valuable resource. Indeed, contentious though it would be, it would be reasonable to expect Hong Kong to pay an even higher price for this water, with the aim of contributing financially, through 'water resource fees' and eco-compensation schemes, to ensure high water quality and conservation efforts in upland areas.

The major weakness of the current 'Package Lump Sum Deal,' the payment mechanism of the DongShen Agreement, is that Hong Kong must pay for all of its agreed allocation, regardless of how much water it actually imports. The approach has contributed to disincentivising conservation, whilst annual withdrawals have remained under the 820 million m^3 ceiling.

Hong Kong Government Performance: Uninspiring Over Two Decades

The WSD is the sole water authority managing water supply and regulating potable and flushing water quality in Hong Kong. Ensuring an uninterrupted supply of good quality drinking water to Hong Kong residents is the department's primary focus. The engineering mind-set that has allowed WSD to achieve this has undoubtedly benefited Hong Kong. However, neither the WSD nor its policy bureau – the Development Bureau – have cultivated the important socio-economic or environmental expertise that would enable a comprehensive policy and strategic approach to ensuring Hong Kong's long-term water security.

Part of the challenge for the WSD in implementing a robust, accountable series of policies and initiatives, is the way in which the government operates. According to investigations conducted by independent government agencies, the Department has been underperforming for nearly two decades in multiple areas.

Due to the traditional vertical structure of government, inter-departmental operations and collaboration are necessities that can rapidly become complicated. Work as basic as maintenance can require coordination and collaboration between numerous government departments and bureaux, each of which operate in compliance with different ordinances and objectives. Insufficient co-ordination and poorly defined responsibilities contribute to the lack of a coherent water policy .

Management of the water system has been further complicated by the shortcomings in the WSD's existing protocols and remit, which does not ensure the integrity and safety of water to the point of delivery, but only to the point of connection.

Wasting a Valuable Resource: Non-Revenue Water

The WSD manages a distribution network of pipes extending around 8,075 km (81% freshwater; 19% seawater) – a distance equivalent to a flight from Hong Kong to Cairo. The network has, however, been challenged for decades. By 2000, it was clear that a quarter of Hong Kong's water was lost from government-maintained pipes before it could reach its intended destination.

Poor, often retroactive management of the distribution network has been an ongoing issue. From 2000 to 2015, the government mains network has been vastly improved, through the WSD's 'Replacement and Rehabilitation' (R&R) programme, with leakage reduced by 10%. Nevertheless, it remains considerably higher than the rates observed in similarly wealthy and developed world cities.

In 2013 (the most recent year disaggregated leakage data was available), 17% of freshwater was still being squandered as it flowed through government mains. A further 15% was lost through a combination of leakage from private mains (inside services), illegal extraction, as well as inaccurate metering – all considered 'non-revenue water'. Whilst it is unclear precisely how much of Hong Kong's freshwater is lost to each of these mechanisms, it is estimated that as much as 11% could be due to leakage from private premises.

Overall, the 31.6% of freshwater unaccounted for in 2013 potentially representing HK$1.35 billion in lost revenue. By 2015, this figure had risen to 33%. Between 2004 and 2015, the WSD may have lost as much as HK$17 billion of potential revenue from its unmetered freshwater alone.

Reckless Overconsumption

Despite the inadequacies of the network, the WSD has successfully met local demand for over three decades thanks to supply from the Dongjiang. Unfortunately, this impressive record has fostered a false sense of security and an illusion of plenty among Hong Kong's consumers. A study of 48 major international cities found that Hong Kong is one of the highest per capita water users globally and has experienced an exceptional rise in domestic water demand since 1990. This has been fostered in part by the perception of unlimited supplies.

While over half of Hong Kong's freshwater is consumed by the domestic sector, poorly-directed and seemingly ineffective attempts have been made by the WSD to rein in domestic consumption. Campaigns have been well-intended, yet largely

uninspired and, ironically, have been accompanied by rising demand. In 2011, the government's 'Domestic Water Consumption Survey,' which aimed to glean a holistic impression of how water is used, was half-hearted, with the department failing to design a robust study methodology. Furthermore, the WSD has neither repeated nor appeared to have advanced its investigations on this front over the subsequent six years.

Beyond water for domestic use, the remainder of Hong Kong's water supply is dedicated to non-domestic users: largely commercial consumers and the government. A quarter is used by service trades (e.g. catering, hotel sector), and the remainder by industry (6.2%), construction and shipping (2.4%), government establishments (4.4%) and as flushing water (7.9%). Combined, these consumed 423 million m^3 of freshwater in 2015. Government establishments used 10% of this.

Operating in the Dark

One of the greatest barriers to addressing overconsumption, and thereby Hong Kong's water security, is the opacity of domestic and non-domestic consumption patterns, and user behaviour. To this end, the WSD is operating in the dark, striving to manage a "precious resource" without a full picture of its use and loss. For example, water consumption of the highly varied enterprises and activities incorporated within the 'non-domestic sectors' is rarely disaggregated, examined, or explained.

Many major water users in Hong Kong depend on the extraction of a publically subsidised resource, but are not obliged to disclose consumption figures. This situation has resulted in large voids in public knowledge and complicated attempts to improve the efficiency of water allocations and consumption. For example, Ocean Park and Watsons Water are known to consume large quantities of water, yet their usage has never been publically disclosed. They are unlisted and therefore not bound by disclosure requirements, such as the recent 'Environmental, Social and Governance' (ESG) requirements of the Hong Kong Exchange. As long as heavy users are permitted to extract with no accountability, reform will be problematic.

Whilst gaps remain in the WSD's database, it will remain challenging to create targeted policies and initiatives to address consumption. In 2015, the WSD piloted its 'Smart Metering System' smartphone app, providing near real-time data and a record of recent consumption. Under its broad scheme of developing a 'Water Intelligent Network,' a component of the government's plans to transition Hong Kong into a 'smart city,' the department aims to install smart water meters across Hong Kong. Among other strategies, this innovation could play a major role in reining in consumption, and should be adopted sooner rather than later.

Lack of Rational Water Pricing

Water is arguably the world's most underappreciated and undervalued resource. In Hong Kong, this view has been reinforced by a low pricing structure facilitating increasing overconsumption. Hong Kong's waters tariffs are tiered, based on the volume of water consumed in blocks (Tier 1 to 4). Since 1995, every household account has received a free allotment of 12m^3 (12,000 litres) of potable water (Tier 1) to use over a four-month period. Consumption beyond this free allocation is priced at some of the lowest rates in the world, such that the most expensive Tier 4 tariff (HK$9.05 per m^3) levied for consumption in excess of 62m^3 of water every 4 months, covers less than 60% of the cost of production, based on 2015 figures. Perversely, the government refers to this low price as its "punitive rate".

The current tariff system has resulted in 70% of domestic water being purchased at a government-subsidised price. This has bred complacency as well as hostility towards any suggestion of reform. The Chinese government recommends pricing water at 2.5% to 3% of household income, which is ten times more than Hong Kong's current ratio.

Lack of a rational pricing policy has also contributed to a recurring annual deficit in the WSD's budget, which, in 2015, was over HK$1 billion. The WSD has sought to reform its tariffs in the past, but this has been opposed persistently by the Legislative Council (LegCo). The main argument championed by LegCo is based on sparing the city's poor from any additional hardship. As of 2015, there were nearly one million people in Hong Kong living below the poverty line, even as the government's budgetary surplus grew to HK$860 billion.

The answer, however, is not to reject reform but develop practical solutions that protect the financially disadvantaged.

Striving toward a Water Secure Future

Hong Kong is intrinsically bound to China, not only through economy, politics, history and geography, but also, critically, through water. As part of the PRD, and being reliant on its water resources, Hong Kong has a responsibility to manage its water supply effectively and with foresight. The Administration has the opportunity and a moral, social and financial obligation to lead Hong Kong towards a future in which the PRD's water supply is secure.

More importantly, Hong Kong has sufficient means, capability and reason to tackle the innumerable challenges plaguing its water system. Taking prompt, efficient and impactful actions on charting a water policy for Hong Kong, reducing the city's demand for water, and diversifying and optimising water supply should be a priority.

Detailing its "Hong Kong 2030+" vision, the government cited the existing TWM Strategy as a component of its plans to develop an integrated smart, green and resilient infrastructure system. However, in order to achieve this, Hong Kong must review, develop and implement a strategy that is truly capable of adapting to changing circumstances. It should take a holistic approach that addresses climate risk and energy as part of its water management and encompasses plans to deploy innovative and creative solutions.

Establish a Comprehensive Water Policy, Strategy and Targets

The time has come for well-coordinated, ambitious and concerted efforts to deliver a policy and supporting strategy that will clarify commitments, establish clear goals and key performance indicators, as well as ambitious timeframes relative to our water security. This should incentivise expeditious and innovative solutions, clarify the ramifications for its own and others' failure and non-compliance, and be subject to regular review.

If the Hong Kong government is to continue promoting local freshwater as "one of the safest water supplies in the world", it must also change its current source to connection point policy. This means taking steps to honour the WSD's 2006 pledge stating its commitment to implementing "measures and practices to ensure the quality and safety of drinking water to consumer beyond the connection points." This is an important step in enhancing the integrity of the entire water system, especially with a view to minimising potential losses from private premises.

Improving Governance and Management

Governance reform is essential to ensuring that management of Hong Kong's water resources is unified under a policymaking body that has the broader skills, expertise and authority to develop and implement a comprehensive water policy and strategy. Such a strategy should encompass sustainability, including both social and development goals. Hong Kong clearly needs to redefine the importance of water, which is still perceived as an abundant resource by the community at large. Hong Kong's long-term water sustainability should then be given a higher policy priority. Effective governance of the water sector, as one integrated policy area, needs substantial reform, not improvements at the margin.

In terms of management, the government should, in parallel, clarify the multiple and seemingly overlapping responsibilities across numerous departments on different aspects of water supply, including safety, quality and disposal, while moving towards an integrated approach. The various departments should strive to introduce incentives for staff for proactivity and creativity, and promote transparency within both the private sector and the government itself.

Until water security is explicitly considered in policy and relevant departments held to account, Hong Kong will continue to struggle to manage its water sustainably.

Plug Gaps in the System

Tackling leakage and losses throughout the entire water supply network must be a core component of any strategy for bolstering Hong Kong's long-term water security. A third of our valuable freshwater should not be, literally, slipping through the cracks. Accordingly, a combination of strengthening the prosecutorial powers of the WSD, expansion of repair and maintenance efforts, and enhanced monitoring should all help to address this multi-faceted issue.

Diversifying Water Supply

In addition to conservation, Hong Kong must also explore and expand local water sources to diversify and optimise supply.

In seeking to develop a future water management system that offers resilience and sustainability, Hong Kong should consider moving towards a circular water system. This means maximising the reclamation, treatment and reuse of the one billion m^3 of wastewater generated each year. In addition to significantly developing such local capacity, decentralised and district-wide rainwater harvesting should be expanded.

Desalination has been persistently championed by the government and a facility is scheduled for construction at Tseung Kwan O, commencing in 2018. This is despite ongoing concerns of LegCo members about the costs and the benefits. Before this HK$9.3 billion project begins, more than HK$118 million will have been spent, over just five years, on consultants, design and planning works. Combined with the plant's promise of meeting just 5% of daily demand with its first phase and operating only during drought conditions, the facility at Tsueng Kwan O as it stands, is at risk of being an expensive project with little overall impact on Hong Kong's long-term water security.

Another long-term consideration, which remains costly and potentially divisive, is the deepening or expansion of Hong Kong reservoirs, thereby increasing local storage capacity. The WSD has considered these options, particularly for small and medium-sized reservoirs subject to more frequent overflows from heavy rain. However, these strategies have long been considered prohibitively expensive, technically challenging, environmentally unfriendly and ultimately "undesirable."

Go Smart and Encourage Innovation

For Hong Kong to move towards becoming a smart city, the WSD should be encouraged to embrace new technologies, as well as learn from and employ best practices from around the world. The department has been stagnant for too long, overly cautious, and often held to account by LegCo. Smart metering, smartphone applications and the home-grown 'Water Intelligent Network' have all passed

through varying stages of trial and assessment. Hong Kong can no longer afford to dedicate decades and hundreds of millions of dollars to insufficient and protracted research, which is in danger of delivering expensive, cumbersome and rapidly outmoded products.

To promote conservation and enhance both demand- and supply-side management, the WSD also needs to accelerate its switch to smart meters. Such a move could markedly improve public awareness, potentially encourage better engagement with the WSD and the broader government on water issues, as well as encourage heavy users to either defend their demand or reform. In the era of big data, transparency is key. Relevant data generated or collected should be publicly released.

Embark on Stakeholder Engagement with Consumers

The WSD must consider embarking on a comprehensive public engagement programme to raise the awareness of its consumers on water conservation and issues of public concern. There have been water conservation programmes, but their effectiveness is in doubt as the water use per capita in Hong Kong is still high and knowledge of water stress appears largely absent. The current rhetoric around water resources as "precious" is insufficient and has not been reinforced by actions demonstrating the value of water or the severity of Hong Kong's situation. The potential threats to Hong Kong's supply must be highlighted and government initiatives addressing them must be promoted. Targets should be set to facilitate water conservation accompanied by robust mechanisms for measuring and reviewing progress.

Implement Much-Needed and Long-Awaited Tariff Reform

Raising tariffs strategically, and so that they do not harm the poorer members of society, would allow the WSD to recoup a greater share of its operational overheads and, at best, would promote water conservation. For Hong Kong residents living below the poverty line, however, it is imperative that access to clean water is not compromised. There is, nevertheless, scope for those who earn more to pay more, without disadvantaging those with lower incomes.

Act with Urgency

On many environmental and sustainability issues, Hong Kong lags behind neighbouring cities and, more broadly, those of China. Water supply and management issues have been inadequately addressed for over two decades despite outstanding recommendations from the government's own Audit Commission (AC). As cities throughout the PRD respond quickly to urban and environmental change, Hong Kong must also respond with the same sense of urgency.

Prioritising the Options

For Hong Kong to ensure a water secure future, it must clearly continue to address non-revenue water challenges and develop water management strategies in harmony with the PRD. Naturally, the optimal strategy must balance and prioritise alternatives based on cost, environmental impact, feasibility and volume of water saved or produced, as well as public concerns.

Under its TWM Strategy, the WSD has pledged to expand and diversify local taps and significantly improve conservation. The combination of approaches identified in the TWM Strategy aims to save 236 million m^3 of water per year by 2030.

Informed by the findings of this report, an alternate approach that illustrates the inadequacy of the TWM Strategy is highlighted, focusing on addressing areas where government performance has been lacklustre and where renewed action could result in significant water savings. Measures are suggested which, if realised by 2030, would potentially save a volume equivalent to 24% of Hong Kong's projected annual freshwater demand, more than doubling the savings proposed by the TWM Strategy. In doing so, it is estimated that the Dongjiang's contribution to Hong Kong's freshwater supply could be reduced from the 60-80% at present, to 40-60% by 2030.

However, this remains a purely academic exercise. Without strategic debate of some of the key issues raised in this report, including identification of social goals and values of water resource management to inform a sustainable water strategy; adoption of a new approach will remain out of reach.