Building Water Resilience in Sustainable Neighbourhoods: A Progressive Shift in Hong Kong

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ABSTRACT

Hong Kong lacks fresh water resources. In the past, the government coped with the increasing water demand due to population and economic growth by a 3-pronged water supply, viz. local yield, seawater for flushing and imported raw water from Dongjiang in Mainland China. In the face of climate change challenges in the city and Pearl River Delta region in southern Mainland China, a progressive shift on the water resources management has been underway in the city since the promulgation of Total Water Management Strategy for Hong Kong in 2008. A number of initiatives are being implemented at both the city and neighbourhood scales to strike an optimal balance between the demand and supply of water resources.

This paper introduces the holistic approach and adaptive actions taken in Hong Kong in driving for sustainable use of water resources against the vulnerabilities under the climate change. The paper focuses on the inter-connected initiatives and opportunities at the neighbourhood level in Hong Kong which help strengthen resilience by transforming the water-related infrastructures into beneficial assets for sustainable built environment and a better living. Examples on water reclamation, greywater recycling and the smart water supplies network management system at a district level will be discussed with highlights on their roles, synergies and co-benefits towards sustainable neighbourhoods. The paper indicates that the water management measures at the neighbourhood level will continue to be crucial elements for integration into the overall water management strategy in building towards resilience to accommodate the densely populated metropolitan city as a sustainable habitat for generations to come.

Keywords: *sustainable neighbourhood, climate change, total water management strategy, water reuse, water loss management*

1. INTRODUCTION

Hong Kong is one of the world's metropolis, with a total area of about 1,100 km^2 and over 7 million population.

Providing an adequate water supply for Hong Kong has always been a challenge because there are no natural lakes, rivers or substantial groundwater resources. Our rainfall is abundant with an average of about 2,400 mm each year but it fluctuates from heavy rainfall up to 400 mm per month during the summer to minimal rainfall during the dry winter months. Although about one-third of Hong Kong's land has been gazetted as water gathering grounds where surface runoff is collected for potable use, local yield is insufficient to meet the increasing demand of potable water to support the economic and population growth, which amounts to 973 million m^3 (mcm) in 2015. Besides, the yield is unstable varying from 103 to 336 mcm/ year in the past 20 years.

Despite the inadequate natural water resources, Hong Kong has been enjoying reliable round-the-clock supply in the last thirty years. Over the years, Hong Kong has attained water security through innovative solutions including, (i) using seawater for flushing since 1957, (ii) importing freshwater from Dongjiang (DJ) in Guangdong province since 1965, and (iii) building impounding reservoirs including the two reservoirs built in the sea namely the Plover Cove and High Island Reservoirs in the 1960s and 1970s. At present, DJ water caters for 70 to 80% of the freshwater consumption in Hong Kong. There has been no water rationing since 1982. Yet, Hong Kong is facing challenges in the years ahead.

2. TOTAL WATER MANAGEMENT STRATEGY

Uncertainties due to climate change increase the risk of drought, not only in Hong Kong but also the Pearl River Delta (PRD) region. Although Hong Kong has adequate supply of DJ water even in drought condition, as a good partner to other PRD municipalities, we play a part in tackling this global challenge, and have developed and

implemented the Total Water Management (TWM) strategy for sustainable use of water resources since 2008. The strategy was initially formulated up to 2030 and is currently under review for period beyond 2030 in adapting to climate changes impacts.

The TWM strategy adopts a holistic and forward looking approach at both the city and neighbourhood scales emphasizing on an optimal balance by curbing water demand growth through conservation while strengthening water supplies management. On the demand side, the multi-pronged, community-wide water conservation measures in collaboration with stakeholders and the public and territory-wide water loss management programmes are being implemented. As for supply management, Hong Kong has been expanding its seawater flushing system and has increased its coverage from 80% to 85% of the population to save freshwater. Apart from the existing 3 water sources, viz. local yield, seawater for flushing and imported DJ water, Hong Kong has been actively exploiting 3 additional sources, viz. reclaimed water, recycled grey water/ rainwater harvesting and desalinated water, thus enhancing the supply from 3 to 6 prongs in the 2020s. Further, the TWM strategy achieves water conservation via multi-faceted soft and hard measures by encouraging active participation, commitment and cross-sectoral collaboration from government, stakeholders and the public. These include establishment of a "Water Resources Education Centre", launching of the "Cherish Water Campus" for primary school students, and "Let's Save 10L Water" campaign as well as a 5-day Water Conservation Week held in November 2016 where government, green groups, schools, trades and the public join hands to promote water conservation.

3. BUILDING WATER RESILIENCE AT NEIGHBOURHOOD LEVEL

Under the TWM strategy, opportunities have been identified from the demand and supply perspectives for implementation of inter-connected initiatives at the neighbourhood level for the quest of sustainable use of water resources in Hong Kong. It is achieved by the transformation of water-related infrastructures into beneficial assets to build and strengthen water resilience for sustainable built environment and a better living. The success of the transformation requires the timely planning and implementation of the relevant schemes under the respective initiatives, viz. (a) water reclamation in north-eastern part of the New Territories (NENT), (b) pilot scheme for greywater recycling at Anderson Quarry Development (AQR) development, and (c) smart water supplies network.

3.1. Water reclamation in north-eastern part of New Territories

In Hong Kong, the use of seawater for flushing has been a cost-effective solution to save precious fresh water resources. However, for those areas that are far from the sea, such as North-eastern part of the New Territories including Sheung Shui and Fanling (SSF), the cost of installing seawater supply networks for toilet flushing is high. With a view to supporting the development of NENT New Development areas (NDA), the government needs to expand Shek Wu Hui Sewage Treatment Works and upgrade its treatment technology to tertiary level to ensure that the additional effluent from the sewage treatment works will not increase the loading to the Deep Bay.

The government makes use of this opportunity to produce reclaimed water that could be used for toilet flushing and other non-potable uses as appropriate by further upgrading the quality of the tertiary treated effluent from the Shek Wu Hui Sewage Treatment Works to an acceptable water quality standard. The upgrading of the water quality could be achieved by an additional simple process of chlorination with sodium hypochlorite solution. The reclaimed water would then be pumped to the reclaimed water service reservoir for distribution to customers.

The use of reclaimed water in NENT, for the replacement of freshwater for toilet flushing and other non-potable uses, can save precious freshwater resources and alleviate the loading of existing water treatment works and fresh water supplies system. It also helps minimize the discharge of treated sewage effluent, and the associated stress and impact to the environment. It can also save the substantial capital investment for the infrastructures for sewage effluent discharge.

The government is currently taking forward the initiative to supply reclaimed water for toilet flushing and other non-potable use in NENT starting with SSF in phases from 2022 onwards. Planning and design of the different phases of the associated infrastructures are in progress and the construction works will commence in stages from 2017. In addition, the study on the financial and legal framework for supply of reclaimed water is also being undertaken.

At the ultimate stage, the reclaimed water supply will serve about half a million of population in the NENT, and by then the seawater and reclaimed water networks in the city will altogether provide flushing water to about 90% of

the population. The use of reclaimed water in the neighbourhood level in NENT will save a corresponding amount of fresh water consumption. The government will continue to study the feasibility of supplying reclaimed water in other areas without seawater for flushing at neighbourhood scale.

All in all, the water reclamation initiative at the neighbourhood level brings synergies and environmental benefits, in terms of reduced water pollution loading as well as achieving water conservation. It enhances the overall water security and hence the adaptation to the challenge of climate change.

3.2. Pilot scheme of greywater recycling at Anderson Road Quarry project

The exploration of grey water recycling (and rainwater harvesting) as an alternative water resource is another initiative under TWM. The government has begun planning a pilot scheme to supply recycled grey water for flushing purposes in the Anderson Road Quarry (ARQ) development project. The 40-hectare ARQ site used to be a quarry for the supply of aggregate, asphalt and concrete in supporting the construction works in Hong Kong since 1950s, and has been planned for residential development with 25,000 target population.

The grey water recycling facilities to be operated by the government centrally in the development, alongside with other planned smart water initiatives such as an artificial flood attenuation lake cum park, an underground stormwater storage tank, rainwater harvesting system, bioretention system, and porous pavement, are being explored and proposed in the ARQ development site. These green initiatives aim to facilitate sustainable use of water resources, and alleviate flooding with benefits of creating a healthy and harmonious environment in the ARQ development which also have beneficial effects to the revitalisation of Tsui Ping River downstream and its neighbour areas.

The geographical location of ARQ at the elevated platform of approximately +200mPD provides an invaluable opportunity to launch the pilot scheme of the public grey water recycling system for toilet flushing as an alternative to the conventional flushing supply of seawater. Grey water from wash basins, baths, showers, dishwashers, laundry machines and kitchen sinks etc. in blocks of residential buildings at the neighbourhood scale, in the ARQ development, would be collected via a separate collection pipework system for treatment in the grey water recycling plant in the development. Membrane BioReactors (MBRs) plus disinfection could be adopted for treatment of the collected grey water for flushing purpose. The recycled grey water, will be pumped to the recycled grey water service reservoir before distributing to the customers for toilet flushing in the ARQ development.

The grey water recycling system helps manage the water entering and leaving the AQR development at the neighbourhood level. It provides an efficient short circuit between disposal of the greywater and supply of flushing water via interflows which would otherwise need to be dealt with in the water loop at the territory level. Such territory-wide water loop would entail (i) the transport of the concerned grey water with other sewage via the sewerage system to the Stonecutters Island Sewage Treatment Works, at more than 10 km from the AQR development site, for further treatment before disposing of to the sea, and (ii) the intake of seawater via a pumping system for the provision of flushing water to the ARQ development which is about 3 km from the sea.

The grey water recycling does not only save the pumping energy required to lift the seawater for flushing to the elevated platform at 200m height but also reduces the overall lengths and hence the maintenance/ repair costs of the flushing water supply lines as well as the social disruption and complaints that may arise from leaks and bursts of the watermains operating at high pressure. Last but not least, the grey water recycling system reduces the impacts to the water quality of the receiving water body through reduction of effluent discharge.

The government will continue to work on the scheme layout for the grey water recycling system in the AQR development and will take it forward to the investigation and detailed design stage as well as resolving issues related to the grey water recycling such as amendment of existing legislation, incorporation of new land lease conditions and implementation of separate grey water collection systems both within the buildings and in the development.

Separately, the government is also taking the lead in implementing grey water reuse and rainwater harvesting in government projects through the promulgation of the joint technical circular of the Development Bureau and Environment Bureau. The government has been working with the Hong Kong Green Building Council to promote wider adoption of water recycling in private buildings through the Building Environmental Assessment Method

(BEAM) Plus scheme. Water recycling proposals adopted in the design of a building will be eligible for credits under BEAM. In so doing private developers are encouraged to implement water recycling systems both in new developments and renovation projects as well as in existing buildings.

3.3. Smart water supplies network for water loss management

With the substantial completion of the 15-year territory-wide replacement and rehabilitation programme of about 3,000km of aged water mains in end 2015, the condition of the water distribution network in Hong Kong has been returned to a healthy state. Both the number of bursts and leakage rate have been significantly improved.

Water loss management has been one of the key elements under the TWM. With the significant improvement in the healthiness of the water supplies network, the government switches the strategy from large-scale replacement and rehabilitation programme to a smart network management for maintaining the healthiness of the network in a cost effective way. Riding on the development of the advanced technology and with reference to overseas experience, the government plans to establish progressively the Water Intelligence Network (WIN), through the division of the water distribution network in the territory into some 2,000 District Metering Areas (DMAs)/ pressure Management Areas (PMAs) at the neighbourhood scale.

The DMA is defined as a discrete area of water distribution network established by the closure of boundary valve(s), and the water supply into the area is metered and monitored. The DMA can also be established as PMA to reduce the excessive pressure in the watermains within the area whilst adequate supply pressure to customers is maintained. DMAs and PMAs are equipped with monitoring and sensing equipment to collect network operation data, such as time-series flow into the area in particular the night flow, pressure data and other associated network data, for analysis of the water loss of the area.

The set-up of DMAs/ PMAs in a water distribution network at the neighbourhood level for water loss management, has a number of advantages. It has been very difficult to locate problematic locations in a large distribution network. Active leakage control as well as detection of unauthorized consumption in the smaller DMAs are more efficient, and leaks in the underground watermains could be identified by means of minimum night flow monitoring. Furthermore, pressure optimization can be implemented in the DMA to make it a PMA as well.

The set-up of DMAs under WIN at neighbourhood/ district levels help monitor the conditions of the water supply networks in individual DMAs continuously. Real-time monitoring can also be carried out when necessary. WIN will enable the determination of the most cost-effective network management measures or a combination of measures for the individual DMAs from the 4 pillars of actions, viz. (i) active leakage detection and control, (ii) pressure management, (iii) speedy and quality repair, and (iv) asset management by rehabilitation/ replacement of aged watermains which are beyond economic repair. In gist, it will enable timely preventive actions to be taken to ensure network healthiness, and thereby minimises water main bursts, leakage and inconvenience to the public and associated complaints in individual neighbourhoods. WIN can also prioritise the DMAs for action.

WIN strengthens the water loss management of the water distribution network at the neighbourhood level and enhances the water demand management contributing to the water resilience of the city.

4. CONCLUSION

The government has been planning for implementing various total water management initiatives at the neighbourhood level, including water reclamation at NENT, pilot scheme for grey water recycling at AQR development and smart water supplies network for water loss management. These initiatives are crucial elements for the individual neighbourhoods and also for integration into the overall TWM strategy. They will contribute and showcase the creation of efficient, integrated and resilient neighbourhood water infrastructures. The water resilience built by these infrastructures is of paramount importance to the growth of this metropolitan city.

It is expected that more sustainable water management developments would be continuously planned and built at both the neighbourhood and city scales to make Hong Kong a sustainable habitat for generations to come.

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