Hong Kong 2030+:

A Smart, Green and Resilient City Strategy

Planning Department

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Source: HK Tourism Board

Preface

One of the major building blocks for achieving the vision and planning goal proposed under Hong Kong 2030+ is "creating capacity for sustainable growth", and a key to it is to formulate a "smart, green and resilient city strategy" that permeates all aspects of the built environment, from land use planning to transport infrastructure and buildings, for achieving a sustainable and future-proofing city. In particular, it has been widely recognised that the Earth is getting warmer due to greenhouse gas emission and climate change is a global challenge facing everyone, everywhere. Hong Kong is subject to the challenges of limited land and resources, ageing building stock and infrastructure, environmental pollution and urban resilience issues such as climate change and hazards. Under Hong Kong 2030+, we should formulate a smart, green and resilient (SGR) city strategy which aims to minimise demand for and use of resources, reduce carbon emission, increase climatic resilience, and enhance the quality and convenience of living and business. It is noted that currently there is a host of initiatives undertaken/ being implemented in Hong Kong and this paper serves to highlight some of the key concepts that are being developed in Hong Kong, particularly those relevant to land use planning, transport, infrastructure and building development.

This topical paper constitutes part of the research series under “Hong Kong 2030+: Towards a Planning Vision and Strategy Transcending 2030” (Hong Kong 2030+). The findings and proposals of the paper form the basis of the draft updated territorial development strategy which is set out in the Public Engagement Booklet of Hong Kong 2030+.

1 SIGNIFICANCE OF A SMART, GREEN AND RESILIENT CITY

1.1 Scarcity of resources and climate change are global challenges. There are opportunities for a high density city like Hong Kong to pursue a resource efficient, a low-carbon and climatic resilient approach for achieving a sustainable future-proofing city.

1.2 With an aim to promoting low-carbon living and businesses, we should explore ways to capitalise on the technological advancement, urban innovations and strategic planning opportunities to promote smart city development. The smart city strategy is more than a mere application of Information and Communication Technology (ICT), it also calls for smart and efficient management of resources to promote a sustainable development and quality of life of the people. In line with the global trend, instead of submitting to a “take-make-dispose” linear economy, Hong Kong is aspiring to create a circular economy whereby resources could become restorative and regenerative for beneficial uses to promote smart use of resources and to minimise waste. This is also conducive to branding Hong Kong as a sustainable global city.

1.3 As a city, Hong Kong should also be environmentally responsible. Noting that buildings and vehicles are the main sources of greenhouse gas (GHG) emissions, we should strive to be a green city in stewardship of sustainable development.

1.4 Furthermore, with high concentration of people, buildings and infrastructure, urban areas are more susceptible to the adverse impacts of climate change and hazards. Hence, a planning strategy for building a resilient city should be developed to ensure that Hong Kong will be more well-prepared and will remain functional with minimal disturbance in any natural or manmade disasters that may occur.

2 SMART, GREEN AND RESILIENT CONCEPTS

2.1 Contemporary paradigms of urban development to address the inter-relationship among people, environment and nature have been established and a plethora of terms have been developed around the concepts of SGR city. These different terminologies represent variation in the conceptual understanding of different stakeholders and interest groups spanning across different sectors in pursuing the future development of our city. Many of these terms are not mutually exclusive and most often overlapping and complementary with each other. Above all, to better understand the relevancy of these concepts to our city, it is important to understand and take into account the existing context, both at global and local levels.

2.2 The following section aims to provide a brief overview of the SGR concepts that are commonly cited though they are not exhaustive.

SMART CITY

2.3 Conventionally, a “smart city” refers to a city that utilises ICT to make its components, infrastructure, utilities and services more efficient and interactive with the people.

2.4 A wider definition of “Smart City” extends from a purely technocentric concept to a concept that underpins urban performance in economic and social development. Caragliu et al. (2011) suggested that a city is smart *“when investments in human and social capital and traditional and* modern *communication infrastructure fuel sustainable economic growth and a high quality life, with wise management of natural resources; through participatory governance”* [1].

2.5 Boyd Cohen, a smart city expert, has developed a holistic framework viz. Smart City Wheel to further delineate the components of a Smart City. A total of six components for Smart City can be found in the Smart City Wheel, viz. Smart Economy, Smart Environment, Smart Government, Smart Living, Smart Mobility and Smart People [2].

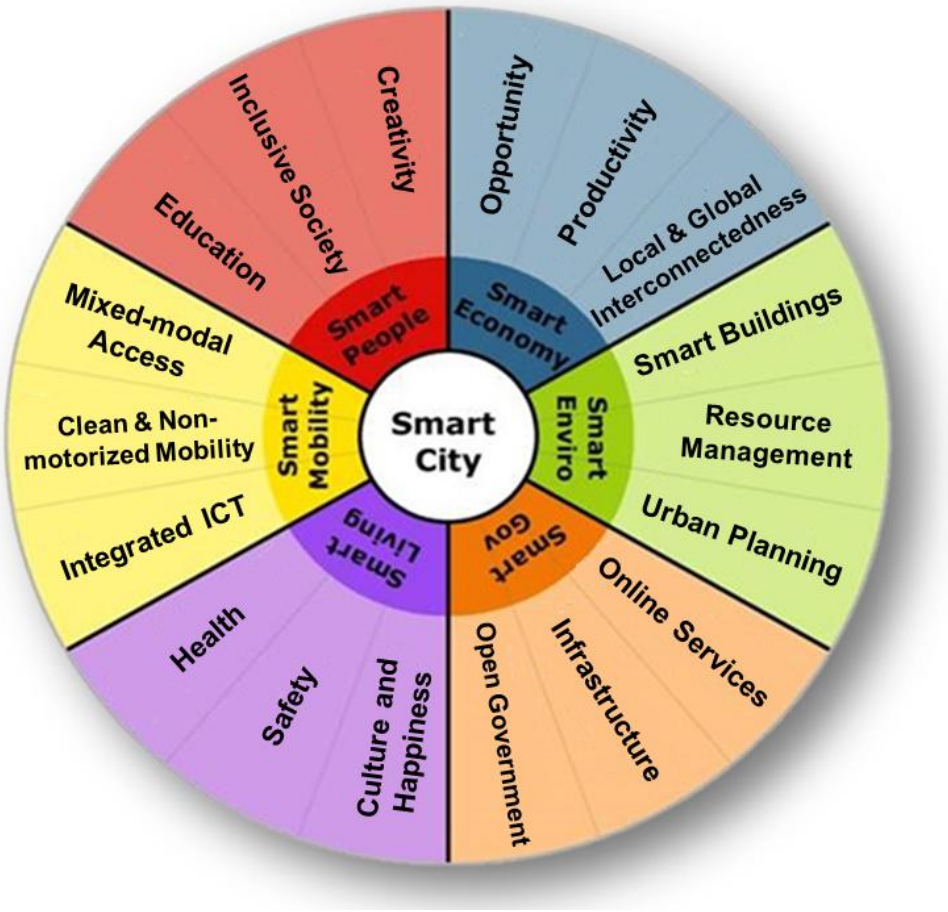


Figure 1 Boyd Cohen’s Smart City Wheel (Adapted) [2]

GREEN CITY

2.6 A “green city” refers to a city that is environmentally friendly and “*strives to lessen its environmental impact by reducing waste, tumbling emissions, fostering recycling, expediting the use of renewable energy and boosting housing density while expanding open space and encouraging the development of sustainable local business”*[3]. The term “Green City” also embraces the essence of other similar concepts, namely “Eco-City” and “Low-Carbon City”, which aim to reduce carbon footprint whilst not compromising development potential.

RESILIENT CITY

2.7 A “resilient city” refers to a city that can reduce the damage and risk incurred from disasters, accompanied with the ability to bounce back to the stable state (The United Nations) [4]. The Rockerfeller Foundation, an organisation pioneering work on climatic resilience, defines seven qualities of which a resilient city should possess [5]:

Reflective: the system should recognise and accept the ever-changing circumstances, and have mechanism for continuous evolution.

Robust: the system should be well-constructed to withstand a hazard event without significant damage.

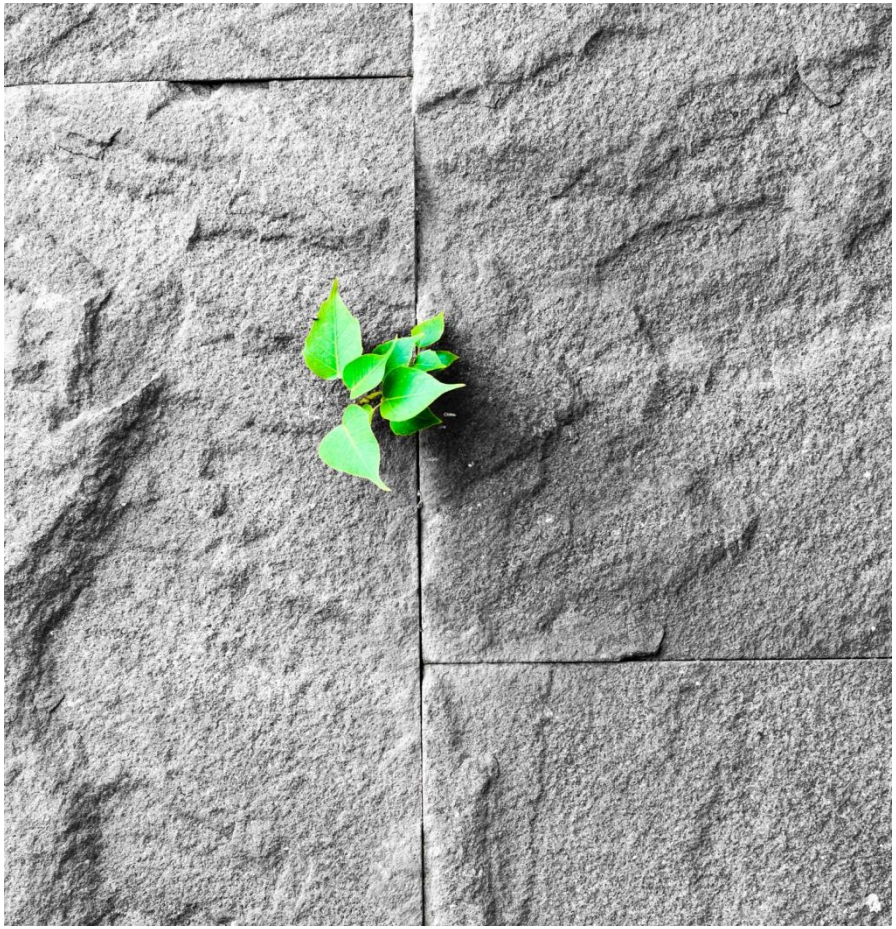
Redundant: the spare capacity within a system for accommodation of pressures or disruption when necessary.

Flexible: the ability to evolve and adapt in response to the changing circumstances.

Resourceful: people and institutions are aware of the various ways to meet their needs during a hazardous event.

Inclusive: ensures the most vulnerable groups are included by virtues of broad consultation and engagement.

Integrated: various systems within a city should be consistent in decision making and are mutually supportive to each other.



2.8 Our major goal in developing a SGR city framework for Hong Kong is to create capacity in terms of developable land, transport and infrastructure provision and the environment, and make available this capacity in a sustainable manner. To achieve sustainable and future-proofing, we need to take care of the needs of people, environment and nature. Such strategy should permeate all levels of development, and our focus will be on a smart, green and resilient built environment.

2.9 As Hong Kong is moving towards a knowledge-based economy with innovation and technology envisaged to be the key drivers in the global economic development, it is important to provide a conducive environment to promote close collaboration among the government, private sectors and industries, academia, research institutions and the public to foster the innovative capacity of our city.

3 CURRENT MAJOR SMART, GREEN AND RESILIENT INITIATIVES IN HONG KONG

3.1 **Government's Policies and Initiatives:** From a policy and territorial level, the Government has been taking proactive steps in promoting SGR city development in Hong Kong. For example, the Central Policy Unit (CPU) [6] has conducted a research on smart city. The Environment Bureau (ENB) (in collaboration with other bureaux) has published various plans including "A Clean Air Plan for Hong Kong" [7], "Hong Kong Blueprint for Sustainable Use of Resources 2013-2022" [8], "A Food Waste and Yard Waste Plan for Hong Kong 2014-2022" [9], and "Energy Saving Plan for Hong Kong's Built Environment 2015~2025+" [10], and "Climate Change Report" [11]. The Government will also issue the "Biodiversity Strategy and Action Plan" and "Climate Action Plan" in due course. As for this topical paper, the focus is on those aspects relating to land use planning, mobility and infrastructure in the built environment.

3.2 The 2016 Policy Address re-affirmed the Government's commitment to building Hong Kong as a smart city and the Innovation and Technology Bureau (ITB) will, in collaboration with research institutions and public and private organisations, study the development of a smart city and formulate the related digital framework and standards. Our objectives for developing Hong Kong into a smart city are to:

- make use of innovation and technology to address urban challenges to enhance city planning, operation and management to improve quality of life, and to improve sustainability, efficiency and safety of our city;
- enhance city attractiveness to global business and talents; and
- inspire continuous city innovation and sustainable economic development.

3.3 **Smart City Blueprint:** To map out a territory-wide blueprint for building Hong Kong into a smart city, the Office of the Government Chief Information Officer (OGCIO) has commissioned a consultancy to formulate a Smart City Blueprint for Hong Kong in mid-2017.

3.4 Our robust ICT infrastructure, coupled with Hong Kong people's readiness to use technology, provides a favourable environment for Hong Kong to take further strides as a smart city. The Planning Department also uses ICT when carrying out planning tasks, including data collection and analysis, information sharing, as well as providing a platform for engaging the community interactively and effectively in various stages of the planning process. Moreover, the territory-wide survey for broad land use classification and update of Land Utilisation Map in Hong Kong, using satellite images and GIS, provides an annual update on the land use situation in Hong Kong. The Geoinfo One Stop 2 (GOS2) helps disseminate information and planning proposals, and the Public Participation GIS (PPGIS) facilitates public engagement on planning and development proposals.

3.5 ICT has also been used in promoting smart mobility and providing environmental information. For example, the Transport Department (TD) has been implementing the Intelligent Transport Systems (including "Hong Kong eTransport", "Hong Kong eRouting" and "eTraffic News", etc) under two major areas, namely "Smart Way to Travel" and "Smart Way for Safety and Efficiency" [6]. Moreover, to cater for the needs of ageing population, TD is currently investigating the feasibility of installing smart devices at signalised crossings for extending the pedestrian crossing time for the elderly. The Housing Department has also utilised ICT, for instance in tree management.

3.6 Moreover, the Environmental Protection Department (EPD) has been launching different Mobile Apps, including "Waste Less", which provides information on the locations of the recyclable collection points in public places all over the territory [12] and "Hong Kong Air Quality Health Index".

3.7 **Green and Low Carbon Initiatives:** Energy generation accounts for around 68% of our total carbon emission. In order to promote the use of clean energy in a more comprehensive manner, ENB is planning to:

- increase the percentage of local gas generation to around 50% of the total fuel mix in 2020 and subject to a reasonable import price, maintain the current interim measure to import 80% of the nuclear output from the Daya Bay Nuclear Power Station, such that nuclear import would account for around 25% of the total fuel mix in 2020;
- include distributed renewable energy subject to public views on the tariff implications, develop more renewable energy;
- enhance our efforts in promoting energy saving in the community and adopting more demand-side management measures to reduce the overall demand; and
- meet the remaining demand for electricity by coal-fired generation.

3.8 Apart from promoting the use of clean energy sources, EPD is endeavouring to promote green living as part of everyday life. By setting up community green stations in each of the Hong Kong's 18 districts, EPD is working towards nurturing a "Use Less, Waste Less" culture in Hong Kong through promoting the waste reduction at source and the collection of recyclables within the community [13].

Figure 2 Shatin Community Green Station

Source: http://www.news.gov.hk/en/categories/environment/html/2015/05/20150511_140256.shtml

3.9 Moreover, the “Food Wise Hong Kong Campaign”, a territory-wide food waste reduction campaign, was launched by the Government in May 2013 to help address the imminent waste problem in Hong Kong. The campaign aims to promote public awareness of food waste problems in Hong Kong and instill behavioural changes in various sectors of the community (including commercial and industrial establishments) and at the individual and household levels, with a view to reducing food waste generation. As of October 2016, over 620 organisations have signed the Food Wise Charter and joined hands to reduce food waste for the community. The Government also launched the “Food Wise Eateries Scheme” in November 2015 and will continue to promote “Food Wise Eateries” to encourage the catering industry to provide portioned food menu to reduce food waste. The Government has also strengthened the support to the NGOs in collecting edible surplus or close-to-expire foods from the commercial sectors like supermarkets, wet markets, restaurants, clubs and hotels for donation to the needy in the community. Since July 2014, the Environment and Conservation Fund (ECF) has been funding non-profit making organisations in carrying out projects to recover surplus food for distribution in the community. As of October 2016, a total of 20 such projects were approved with funding support of about $32 million for the collection of around 2,300 tonnes of surplus food in two years, and donation to 1.9 million headcounts. ECF will continue support suitable surplus food recovery projects.

3.10 The transport sector is another sector which contributes significantly to carbon emission and it accounts for about 17% of our total GHG emissions. In promoting green transport in new development areas (NDAs), the notion of transit-oriented development, complemented by walking and cycling, has been underscored in planning the Kwu Tung North (KTN) and Hung Shui Kiu (HSK) NDAs. Over 80% of the new population in the KTN NDA will reside within 500m of the proposed railway station/public transport interchange [14]. For HSK NDA, a Green Transit Corridor encompassing a rail-based or road-based environmentally-friendly transport services, pedestrian walkways and cycle tracks connecting the residential clusters with employment nodes, railway stations and key community facilities are proposed. Within the NDA, the majority of the new population and employment will be within walking distance of a public transport node [15].

3.11 Moreover, under the current policy, for new towns in the New Territories or NDAs, where traffic density is relatively low, there is more scope to accommodate cycle tracks and ancillary facilities to enable the public to cycle safely for recreational purposes and short distance travels [i]. In this connection, the Government has embarked on a series of improvement packages to further enhance cycling safety and a cycle-friendly environment in the New Territories, including replacing the metal speed reduction bollards by collapsible plastic bollards, providing warning traffic signs and road markings ahead of cycle down-ramps, pedestrian crossing points, etc.

3.12 To promote a low carbon and bicycle friendly environment in the rural areas, new towns and NDAs, the Government has been developing new cycle track network, improving existing cycle tracks and bicycle parking facilities and strengthening publicity and education on cycling safety. TD had launched a pilot scheme in Tai Po to identify and try new improvement measures for cycle tracks and bicycle parking facilities. Subsequently, TD has commissioned a consultancy study to implement the new improvement measures identified under the Tai Po pilot scheme in the nine new towns (including Tsuen Wan, Sha Tin, Tuen Mun, Tai Po, Fanling/Sheung Shui, Yuen Long, Tin Shui Wai, Tseung Kwan O and Tung Chung). The study will also review a list of bicycle prohibition zones on public roads to assess whether they can be lifted or should be maintained. The study is expected to be completed in 2017.

[i] In urban areas where road traffic is heavy and roads and footpaths are congested, it is generally difficult and impracticable to provide extra space as segregated lanes for cycling. Hence, bicycle use as a means of transport in the urban areas is not encouraged under the prevailing policy.

3.13 **City Resilience Initiatives:** In “Hong Kong in a Warming World (2016)” published by Hong Kong Observatory (HKO)[16], climate change in Hong Kong has been comprehensively analysed. In terms of enhancing the resilience of the city against extreme weather conditions, different bureaux/ departments have carried out various initiatives and policies, as highlighted below:

3.14 About 15% of Hong Kong’s total land area is below mean sea level, and parts of these areas are paved and densely populated. Coastal flooding may occur during severe rainstorms, storm surges and certain high tide conditions. Coastal flooding may also arise because of ground settlement and subsidence. Under the influence of climate change and rise in sea level, the frequency of occurrence of extreme sea level events and coastal flooding will likely increase. To understand the potential implications of climate change on coastal structure in Hong Kong and to ascertain necessary updating of the current design standards, the HKO completed the projection of the mean sea level in Hong Kong in the 21st century [17] based on the “Fifth Assessment Report” (AR5) of the Intergovernmental Panel on Climate Change (IPCC) and the Civil Engineering and Development Department (CEDD) completed a study on Review of Studies on Climate Change and its Implications on the Design of Coastal Structures in June 2013 for updating of the “Port Works Design Manual”. Subsequently, another review to update the findings of IPCC’s AR5 has been undertaken and will soon be completed by CEDD.

Figure 3 Flooding Problems Previously Experienced in Hong Kong

Source: DSD (Flooding Problem in Northern Hong Kong Island)

http://www.dsd.gov.hk/others/HKWDT/eng/background.html

3.15 Moreover, the Drainage Services Department (DSD) has progressively completed “Drainage Master Plan” (DMP) studies covering all the flood prone areas in the whole territory. As a result of the drainage improvement works derived from DMP as well as improving flood control management, DSD has brought the number of flooding blackspots from 90 nos. in 1995 to 10 nos. in 2015 [18]. DSD is also utilising real-time sensor to facilitate drainage operations. For instance, real-time water level sensors are installed at the Happy Valley Underground Stormwater Storage Scheme which helps to control the weir crest level to ensure that the filling of the storage tank would start at the most optimal time to prevent premature or late overspill of stormwater into the storage tank. Under this arrangement, the design capacity of the storage tank can be reduced by as much as 30% and ultimately helps achieve sustainable development by minimising the amount of excavation for construction and thus the total construction time [19]. For implementing the flood preventive measures, the Government is also taking active steps in promoting revitalisation of water bodies, such as the Kai Tak River improvement works. The project not only upgrades the drainage capacity of the river but also revitalises the river channel to integrate with redevelopment landscape to provide a leisure environment for public enjoyment.

Figure 4 Happy Valley Underground Stormwater Storage Scheme

Source: DSD (HVUSS) - http://hvusss.eksx.com/index.php

3.16 In addition, DSD, HKO and Home Affairs Department (HAD) have jointly established early storm surge alert systems for some low-lying areas prone to sea flooding. HKO will issue storm surge alert message to DSD and HAD and other relevant government departments when the sea levels are forecast to reach the trigger levels at respective locations. Upon receipt of the alert, DSD will arrange mitigation measures, if necessary, based on the local need to alleviate the impact of flooding to the local residents, and HAD will inform relevant representatives so that residents can take proper preventive measures [11].

3.17 With over 60% of Hong Kong being hilly terrain and summer monsoon /tropical cyclones bringing intensive and prolonged rainfall, Hong Kong is also susceptible to landslip hazards. In this regard, CEDD has been developing a new strategy for managing landslide emergency, in partnership with other government departments. Part of the strategy is to set up public education and communication to enhance community resilience against extreme hazards [20]. The Landslip Warning System that combines rainfall forecast from HKO and instant prediction of landslide occurrence by means of computer algorithm helps enable continuous surveillance for timely issue of warning to the public. The Government has also taken active measures to minimise landslip risk. The Geotechnical Engineering Office of CEDD has improved more than 11,000 high risk slopes within the territory since its establishment in the 1970s [21].

3.18 To safeguard water security in Hong Kong, we need to develop the resilient water resource by seawater desalination which is not susceptible to climate change. The Water Supplies Department (WSD) is implementing the proposed seawater desalination plant using reverse osmosis technology in Tseung Kwan O. The first stage of the desalination plant will have a water production capacity of 135 000 m^3 per day with provision for future expansion to the ultimate capacity up to 270 000 m^3 per day to meet about 5% (10% if expanded) of Hong Kong's fresh water demand.

3.19 The promulgation of “Sustainable Building Design Guidelines” and efforts to promote greening or skyrise greenery by various bureaux / departments are also some of the government actions to promote sustainable environment and help ameliorate urban heat island effect. In addition, to combat “urban heat island” effect and enhance the sustainability of our built environment, the “Hong Kong Planning Standards and Guidelines” (HKPSG) help promote good urban design practices by providing guidelines on massing, height profile, street orientation, etc. Moreover, since 2006, all major Government projects need to carry out air ventilation assessments so that the impact of the proposed developments on the pedestrian wind environment can be mitigated and improved. Moving a step further, Urban Climatic Map and other associated recommended measures could provide strategic and broad practical guidelines to improve the urban thermal comfort and wind environment through optimising the planning and design of our city as well as identifying urban climatically valuable areas and problematic areas. In planning for NDAs, air ventilation in addition to other planning and engineering considerations are reflected in the conscious planning decision for low-carbon developments including the initiatives and measures to maintain and create wind corridors or breezeways, promote tree planting and greening, and adopt environmentally friendly transportation and integrated green infrastructure systems.

PILOT PROJECT IN KOWLOON EAST

Energizing Kowloon East Office (EKEO) is currently tasked to undertake a study entitled “Developing Kowloon East into a Smart City District – Feasibility Study”. It aims to review and evaluate existing and planned smart city initiatives and explore ways in consolidating various initiatives in a coordinated manner for Kowloon East. The Stage 1 public engagement activities are to be launched in November 2016.

Under one of the focuses of the latest Conceptual Master Plan 4.0 - the Walkable Kowloon East initiative, proposals are progressively implemented to improve connectivity and enhance the pedestrian environment. Kai Tak Office is also studying better connection between major spots in the districts by means of an Environmentally Friendly Linkage System.

EKEO’s Conceptual Master Plan 4.0
Source: Energizing Kowloon East Office, Development Bureau

SGR MEASURES UNDERTAKEN AT THE ANDERSON ROAD QUARRY REDEVELOPMENT

Infiltration Channel (Bio-retention Swales)

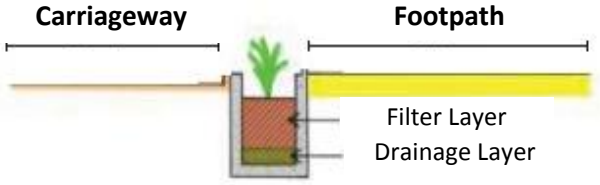
Infiltration channels are proposed to be built on some pedestrian footways at the Anderson Road Quarry Redevelopment. These channels can remove pollutants and separate harmful petrochemicals and sediments from the surface runoff, hence improving the quality of the collected stormwater to be discharged.

Porous Pavement

Permeable surface design will be adopted for the footway pavement. This type of footway surface could avoid ponding of surface water and prevent pedestrians from slipping. In addition, the design of permeable footway surface can also help reduce ground surface temperature.

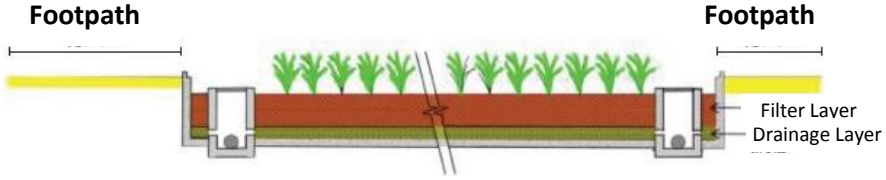
Anderson Road Quarry

Source: ARQ's Public Engagement Digest (September 2011)



Typical Cross Section of Roadside Infiltration Channel

Source: Civil Engineering and Development Department



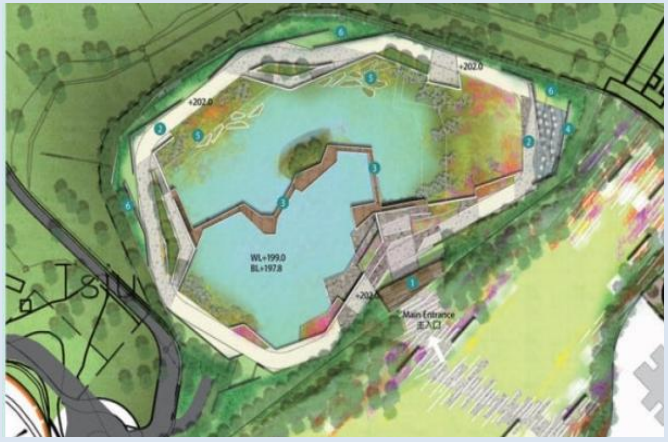
Typical Longitudinal Section of Roadside Infiltration Channel

Source: Civil Engineering and Development Department

SGR MEASURES UNDERTAKEN AT THE ANDERSON ROAD QUARRY DEVELOPMENT

Artificial Flood Lake

The design concept of the flood attenuation lake is to revitalise water bodies in planning drainage networks so as to build a better environment for the public. The flood lake itself is purposely designed for public enjoyment during fine weather days, but would function as a flood attenuation facility for temporary storage of stormwater during extreme weather days to minimise the risk of downstream flooding. Apart from the beautiful scenery and fully utilised water resources, the central artificial island of the artificial flood lake may provide potential habitats for waterbirds.



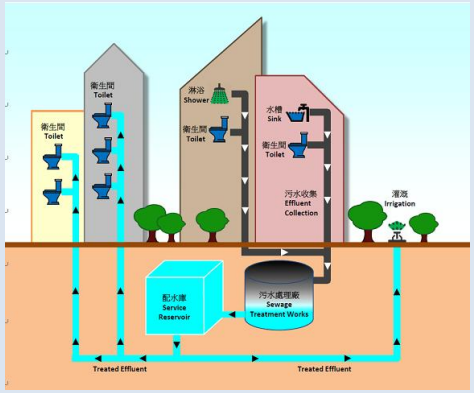
Artificial Flood Lake

Source: Civil Engineering and Development Department

SGR MEASURES UNDERTAKEN AT THE FANLING NORTH AND KWU TUNG NORTH NDAs

Treated Sewage Effluent Reuse System

To cope with the needs of the NDAs, the treatment capacity of the existing sewage treatment works will be increased. The sewage treatment standard will also be upgraded to tertiary level and the tertiary treated sewage effluent after an additional simple process of chlorination can be reused for non-portable purposes, including toilet flushing. This helps conserve water and reduce the amount of treated sewage effluent as well as pollutant load to be discharged into the Deep Bay.



Treated Sewage Effluent Reuse System

Source: Civil Engineering and Development Department

3.20 **Other Initiatives:** Other semi-public and private sector have also played a part in promoting a smart, green and resilient city. The following are some examples:

Mobility and Transport

3.21 The Mass Transit Railway Corporation Limited (MTRCL) has launched the MTR Mobile Application (app) to provide updates of its train schedule. This app facilitates train users to plan their journeys in advance, and simply by choosing the departing station. It also provides arrival time information for the next four trains [22]. Similar applications are also developed by other transport operators or app providers, such as the Kowloon Motor Bus, which provides real-time bus arrival information at bus stops [23]. The potential of car sharing platforms and apps to facilitate drivers in finding their best driving routes and parking spaces are also being explored by companies in Hong Kong [24].

Sustainable Buildings

3.22 To promote sustainable living, Zero Carbon Building (ZCB) was jointly developed by the Construction Industry Council and the Government to showcase state-of-the-art green designs and technologies in the construction industry both internationally and locally. ZCB is designed to use renewable energy sources, including bio-diesel for tri-generation and solar panels, to achieve beyond zero net carbon emission and demonstrates the concept of "positive-energy building" in Hong Kong [25].

Figure 5 Zero Carbon Building

3.23 For the high-tech research and development sector, the Hong Kong Science and Technology Park Corporation (HKSTPC) is also making its mark on Hong Kong's construction industry. HKSTPC is helping to cultivate a green culture shift amongst its Phase 3 tenants via its "Green Lease". Tenants in Phase 3 authorise HKSTPC to connect a smart-meter to monitor their energy consumption via the centralised building management system which will create a detailed profile of each tenants' energy consumption. Real time building performance will be displayed, via an Energy Performance Monitoring System to the public in each building's foyer. This allows tenants to make informed decision on their energy consumptions and achieve saving from their own utility bills.

3.24 Hong Kong Green Building Council (HKGBC) also strives to promote sustainable buildings in Hong Kong through promulgating industry standards and best practices as well as initiating research in green buildings [26]. With a view to reducing environmental impact of buildings while maintaining and improving the quality of the built environment and users' satisfaction, BEAM Plus [ii] has been adopted as an assessment tool for green buildings [27].

HKGBC has recently launched the HK3030 Campaign, an initiative to curb electricity consumption of buildings in Hong Kong by 30% by 2030 [28].

Figure 6 Hong Kong Science Park

[ii] HKGBC has also commissioned a feasibility study on BEAM Plus Neighborhood Development with a view to developing a rating tool for assessing sustainable neighborhood development which is currently under pilot testing.

Sustainable Use of Food Resources

3.25 In advocating the concept of green living, social enterprises and non-government organisations in Hong Kong, such as the Friends of the Earth (FOE), Greeners Action and the World Green Organisation (WGO), have played active roles in promoting sustainable use of food resources. The "Waste No Food" campaign initiated by FOE aims to deepen people's understandings on the environmental consequences of food wastage and encourages people to take action to treasure food in everyday's life [29]. Over 50 organisations have joined the Food Donation Alliance initiated by FOE. To promote similar objective, the food donation scheme initiated by the WGO hopes to encourage sustainable use of food resources by collecting food surplus from local fresh food markets distributes to those in need [30].

Smart Metering

3.26 To promote smart metering development, the two power companies in Hong Kong have started to study and test smart meters for general customers. In this regard, the CLP Power Hong Kong Limited has launched a pilot scheme in 2013 involving 3,000 residential customers and 1,400 small and medium-sized business customers. The use of advanced metering infrastructures enables consumption data collection and helps reduce demand peak [31].

Smart Use of Technology in Logistics

3.27 For the logistics sector, the Modern Terminal Limited, a company which handles 5.4 million Twenty Foot Equivalent Units in 2014, has also made substantial investments to reduce carbon emission by converting to hybrid and electric cranes, which emits 60% less carbon dioxide than conventional diesel-powered cranes [32].

3.28 Examples quoted above are not meant to be exhaustive. They illustrate the numerous efforts and initiatives made by various parties in pursuit of a smart, green and resilient Hong Kong.

4 INTERNATIONAL BENCHMARKING

4.1 Hong Kong's efforts in promoting smart, green and resilient initiatives are recognised elsewhere in the world, as reflected in a number of international benchmarking indexes. Noting that benchmarking should not be taken in earnest as different indicators may have different assumptions, which cannot be compared directly and the quality of data adopted may vary. International benchmarking indexes, nonetheless, are useful as they provide a bird's eye view of the global positioning of Hong Kong and serve as reference to gauge the realms requiring further improvement.

4.2 The following section provides a brief overview of Hong Kong's positioning in the three aspects of smart, green and resilient city in the global context.

Smart City

4.3 In addition to deriving a "Smart City Wheel" as mentioned in section 2.5, Boyd Cohen has once published "The 10 Smartest Cities in Asia-Pacific" in 2013 [33]. Hong Kong was ranked fourth and he remarked that Hong Kong scored the highest in its ranking for smart mobility because of the wide use of Octopus in public transport and other business sectors. Nevertheless, it was noted that the benchmarking exercise was discontinued in the following year as only limited cities were able to participate due to the complexity and time required to collect the relevant data [2].

Green City

4.4 Green City Index was developed by the Economist Intelligence Unit in collaboration with Siemens to assess and compare cities in terms of their environmental performance. Indexes for various continents are provided and the Asian Green City Index (AGCI) measures the environmental performance of 22 major Asian cities across a range of criteria, including energy and carbon emission, transport, water, land use and buildings, waste, sanitation, air quality and environmental governance. Hong Kong was ranked "above average" in the AGCI in year 2011. In particular, Hong Kong consistently ranked "above average' in six out of the eight criteria and excelled in land use and building category, boosted by having one of the largest amounts of green spaces in the Index achieved by proactive policies towards conservation. Hong Kong's performance in the water category was given an average ranking mainly because its water consumption and water

leakage level were relatively high [34].

Resilient City

4.5 By looking into the dimensions of vulnerability and adaptive capacity, the Grosvenor Research Report quantified the resilience performance of 50 cities in the world [35].

4.6 According to the Grosvenor Report [35], the three most resilient cities in the world were in Canada, namely Toronto, Vancouver and Calgary. Amongst the 50 cities, Hong Kong had an overall ranking of 30. Comparing to other Asian countries/cities, Hong Kong came after Tokyo and Osaka but ranked before Singapore. Having said that, Hong Kong was slightly behind Singapore in terms of vulnerability. The Grosvenor Report suggested that Hong Kong was more vulnerable to and threatened by physical events, such as sea level change and typhoon.

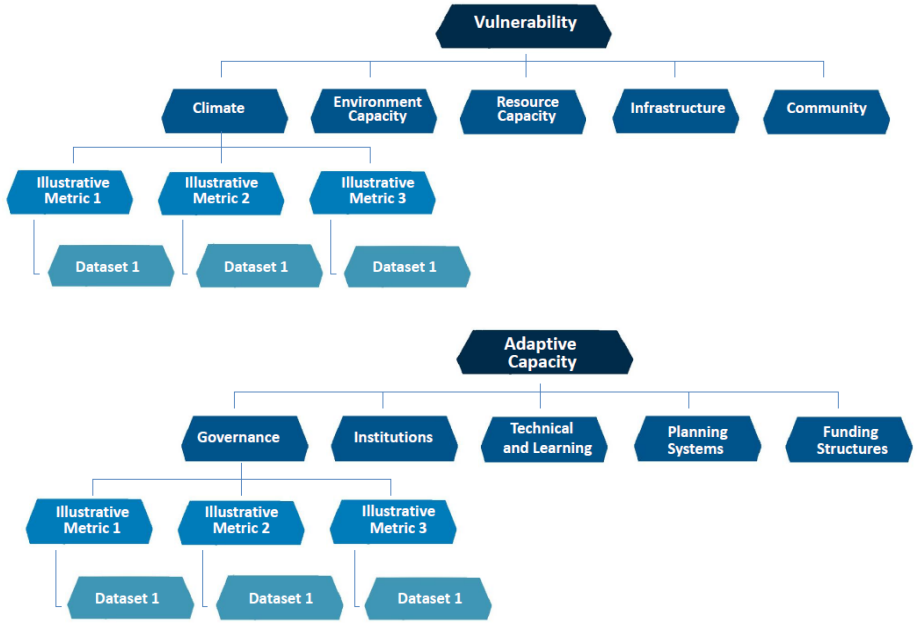


Figure 7 Different Categories under the Vulnerability and Adaptive Capacity

Source: Grosvenor Resilient Cities Research Report (2014) [35]

5 KEY ISSUES FOR PROMOTING SMART, GREEN AND RESILIENT CITY DEVELOPMENT

In the pursuit of SGR city development, various factors will need to be taken into account:

Scarcity of Resources

5.1 Resources have limits and must be cherished. Land, nature, water, energy and other infrastructures, etc are precious resources for Hong Kong. Land is scarce and land development takes time, hence we should use them in an optimal manner and minimise its demand. Likewise, we should find ways to protect nature and the environment, and promote water and energy saving, reduce travel needs, adopt a low-carbon and sustainable lifestyle, and create a conductive environment for circular economy.

Ageing Population and Infrastructure

5.2 According to the latest projections of the Census and Statistics Department, Hong Kong's population will continue to grow in the next 30 years (albeit at a slower rate). Our population will increase by 0.98 million from 7.24 million in 2014 to a peak of 8.22 million in 2043. At the same time, our population is ageing rapidly. Old aged population (i.e. aged 65 or above) will rise significantly from 15% in 2014 to 33% in 2044, while the age cohort of 85 or above will increase more significantly by approximately three folds from around 2.2% to 7.9% over the same period [36]. As such, planning for the built environment should place more emphasis on diverse age-friendly neighbourhoods. In more specific terms, an ageing population will entail the provision of more community, medical and residential care facilities and adjustments to the urban and building design to create an elderly-friendly built environment, such as barrier-free

urban infrastructure, suitably designed and equipped housing for the elderly, recreational facilities for more leisure pursuits, etc. Some of these issues are dealt with separately in other relevant topical papers of the Hong Kong 2030+ Study. Smart city initiatives such as the use of ICT can also help the elderly to age more independently and safely.

5.3 Apart from ageing population, our city is also facing with the issue of ageing building stock and infrastructure. It is estimated that about 326,000 private housing units will be aged 70 or above by 2046, which is nearly 300 times of that in 2015. While building age is certainly not a conclusive factor for redevelopment, older buildings are more prone to building maintenance problems. Buildings in Hong Kong are mainly constructed using reinforced concrete with a general design life span of 50 years. There is a general design working life of 120 years for infrastructures such as highways and railway bridges. Hence, it is important that the conditions of these buildings and infrastructure are properly maintained to ensure public safety.

5.4 As Hong Kong is now facing more frequent severe weather conditions, the physical stability of these older buildings against extreme weather events should not be neglected. In this regard, the Code of Practice on Wind Effects in Hong Kong published in 2004 is now being reviewed by the Buildings Department to update the wind data and information taking into account new circumstances, such as advancements in technological and engineering in the collection of meteorological data, methods of directional wind analysis, etc to make it cope with the current practices adopted overseas. To further promote sustainable development, there might be a need to review the regulatory and maintenance regime of buildings in Hong Kong with a view to extending the life span of building and infrastructure, and resilience to strong winds, extreme weather and seismic activities, etc.

Climate Change and Hazards

5.5 The United Nation's IPCC has found that the Earth's atmospheric carbon dioxide concentration, the main driver of global climate change in the last century, has increased by over 40% since pre-industrial times. The effects of climate change have already emerged with Hong Kong experiencing higher temperatures, more frequent extreme rainfall and increasing number of annual very hot days. Promoting low-carbon living and businesses and reducing emission of greenhouse gas are becoming obligatory rather than a matter of choice. In this regard, the Paris Agreement reached in December 2015 is a crucial step in forging global efforts in combating climate change and signifies the collaborative international commitment to control global warming and reduce greenhouse gas emission. The Paris Agreement proposed to hold the increase in the global average temperate to well below 2°C above the pre-industrial levels [37].

5.6 Like many other cities in the world that have high development densities, Hong Kong suffers from urban heat island (UHI) effect, where temperatures are intensified at the dense urban core because heat is trapped by buildings. Increasing development pressure to meet housing and other needs may further increase development densities and building volume, thereby worsening the UHI effect. Hence, continuous efforts should be made to adopt appropriate measures to improve urban climate and air ventilation in the long run.

5.7 Moreover, Hong Kong is subject to the hazard of rising sea levels with an average increase in sea level in Victoria Harbour of 30mm per decade during 1954-2015 [38]. There is an increasing risk of sea flooding associated with storm surges caused by tropical cyclones. With the rise in mean sea level, the effect of storm surges brought by typhoon will be exacerbated [38]. Extreme sea levels higher than 3.5mPD can cause serious flooding in some of the low-lying areas along the coastlines of Hong Kong. For instance, Typhoon Hagupit caused serious flooding in Tai O in 2008 (reported to be the most serious in the past 60 to 70 years) [39]. This kind of event may become a recurrent event by the end of this century.

5.8 Hong Kong is also subject to extreme weather events, e.g. extreme rainfall and high temperatures [40]. The main climate change threats to hardware infrastructure are damage and destruction associated with extreme weather

events, such as landslides, erosion, landscape degradation, loss of habitats, tree failures, flooding and storm surges. To increase Hong Kong's response capability in disasters and emergencies and to help adsorb climate change-related stresses, it is important to determine the type of defensive infrastructures that our city would need, whether and where the existing infrastructure would need to be relocated and in particular how to deal with the more vulnerable parts of our city (such as the coastal and low-lying areas) [11]. Shared action and cooperation at multiple levels engaging both public and private sectors would help ensure the climate readiness of Hong Kong in face of climate change. Hong Kong has made significant investment in the past two decades to cope with extreme weather events but further investment will be necessary in the coming decades.

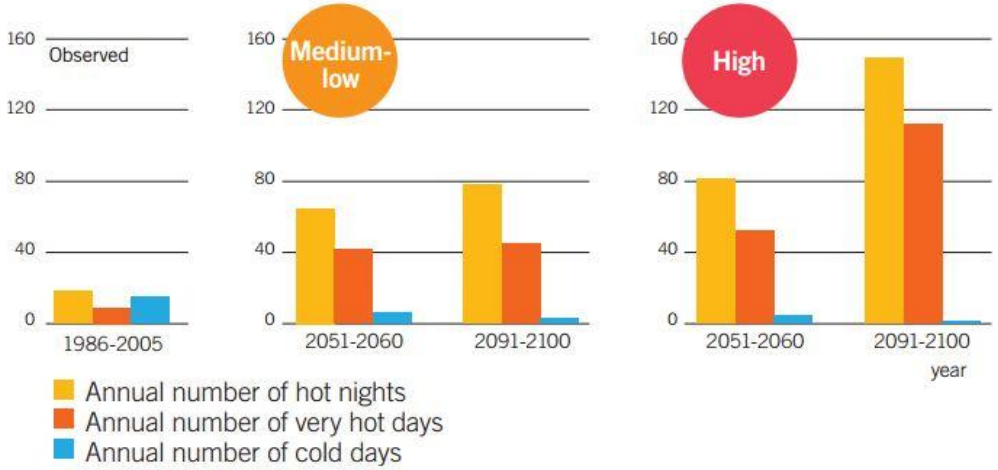


Figure 8 Projected Annual Number of Hot Nights, Very Hot Days and Cold Days in Hong Kong Under the Medium-Low and High Greenhouse Gas Concentration Scenarios

Source: Hong Kong Observatory – (Hong Kong in a Warming World) - http://www.hko.gov.hk/climate_change/climate_change_e.pdf

Balancing Costs and Benefits

5.9 No doubt technology plays a key role in enabling cities to become more liveable, sustainable, and capable of responding to hazards. In fact, technology is advancing very rapidly but technology alone will not make Hong Kong become a smart, green and resilient city. A conducive environment for investments in both hardware and software, supported by clear policies and better institutional mechanisms to bring different sectors together through greater coordination and communication, is crucial.

5.10 This is particularly true when pursuing smart, green and resilient city development which involves substantial investment. It is sometimes difficult to raise financial resources to fund the start-ups and continuous development of new projects. Hence, fiscal policy should enable a variety of different financing mechanisms, and investments should be appraised against longer timescale to match the lifecycle of most infrastructures. Moreover, in balancing the cost and benefits for a specific smart, green and resilient measure, various factors including its potential to save cost over a long period of time should be taken into account. This would ensure that the full scope of both the short-term costs and long-term environmental and social benefits (including more efficient transport system, reduced medical expenses due to improvement in overall environmental conditions) which might not be easy to quantify are taken into account in investment decisions. The traditional financial or economic assessments and financing mechanisms may not be adequate. Innovative financial assessments and alternative financing mechanisms which combine both public and private funds for the smart, green and resilient infrastructures should be explored.


BENEFIT
COST

Environmental Concerns and Health Issues

5.11 Human activities are often blamed for aggravating air pollution that has in turn caused ill health and premature death. Air pollution is defined as "*the contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere*" [41]. Hong Kong, being a high density city, is particularly susceptible to the impact of pollution, especially air pollution. Apart from general air quality, the localised air condition in Hong Kong will also have substantial impact on health. While the Government has been making discernible improvement to the air quality, a smart, green and resilient city strategy for promoting air ventilation in our built environment, and reducing road transportation demand, etc can further improve the air quality. In order to strengthen our abilities to reduce air pollution which can save billions of dollars in future public health care spending, reduce missed work days and school days, and minimise the discomfort and suffering from preventable illness and premature death, it is important to formulate an evidence-based approach to understand the complexity between our built environment and health so as to systematically address such issues.

5.12 Other environmental and health related issues, such as the availability of clean water and food security also affect the well-being of each and every individual of our city. For instance, change in rainfall pattern and possibly in the wider geographical area in Mainland China may affect both local and regional water resources availability. Higher temperature may affect water demand. Extreme weather conditions may lead to loss of production and lower availability of local or imported food products. Moreover, high temperatures and more frequent and prolonged hot days due to climate change and urbanisation could also increase the number of heat-related illness, such as heatstroke and heat exhaustion.

6 KEY COMPONENTS OF A SMART, GREEN AND RESILIENT CITY

The concepts of SGR city embrace many interrelated aspects. Together, they seek to provide sustainable living through technological and innovative application, smart use of resources, robust city planning and low-carbon living and businesses . Those aspects which have greater relevance to strategic planning and the built environment can be broadly grouped under three components, viz. (i) **sustainable land use planning and urban design**, (ii) **smart mobility**, and (iii) **integrated smart and green infrastructure system**. They are illustrated with reference to a number of overseas examples as food for thought.

SUSTAINABLE LAND USE PLANNING AND URBAN DESIGN

Minimise Demand for and Use of Land Resources

6.1 Land, as the main production factor of cities, is limited [42]. In major cities with high population densities, there are practical limits to further increasing urban density. The need to accommodate future development is a key driver for cities to come up with creative and sustainable approaches to development. The smart use of land resources in Hong Kong has been supported by compact high-density development. Apart from clustering developments around the mass transit railway system, some measures are already in place or being considered, such as vertical integration of different facilities/mixed use developments to reduce land take; better use of steeper sloping grounds to increase developable area; better use of brownfield sites to optimise existing land utilisation pattern; building up land reserve to meet future demand in a timely manner; urban renewal; and land use review to promote land use optimisation.

6.2 Underground and cavern development, in particular, is a key way of intensifying land uses in a three dimensional manner (*See case studies - Singapore's Common Services Tunnel at the Marina Bay and Montreal's Underground City*). It has become an increasingly important and strategic land source for Hong Kong. Numerous local and overseas examples demonstrate that underground space/rock cavern development can be a viable alternative, while yielding additional safety, environmental and security benefits for many

applications[43]. By going underground, we can release surface land for alternative beneficial use and at the same time preserve the surface landscape, vegetation and biodiversity by avoiding an "open-cut" option. It can also mitigate surface constraints on land acquisition and is a more effective mitigation measures against the possible adverse impacts of unwelcome but essential public facilities[44].

6.3 There are a variety of uses that have been developed in rock caverns which are mostly NIMBY (Not-In-My-Back-Yard) type facilities. Many are confined to public facilities as the cavern options can usually serve dual purposes: to overcome the overriding circumstances that suitable surface sites are not available, and to "hide" essential NIMBY uses such as sewage treatment works and refuse transfer stations. With technological advancement, it has become evident that caverns can be utilised for other applications, including data centres and indoor games or sport halls.

6.4 Hong Kong has many drivers for cavern/underground space development, including limited surface land for development and for caverns in particular, hilly, steep terrain and strong granitic and volcanic rocks which provide excellent conditions to cavern development. Indeed, Hong Kong has the potential as well as the need for developing underground space. Having said that, while the use of underground space is quite common in relation to mass transit railway and associated underground retail complexes, its application has largely been developed on a project-by-project basis and not yet been applied to the formation of underground space as large scale as was already common in some parts of the world[45].

6.5 To fully capitalise on the merits in each unique circumstances, cavern/ underground space developments should not simply be taken as an individual isolated engineering project. It should also pay regard to the land use and urban design consideration in an integrated planning process. The shared use/ leasing model of cavern/ underground space for private sector usage could also be explored. Moreover, public perception on the type of cavern/ underground space uses should be considered. For example, cavern/ underground spaces might better be used to accommodate those unwelcome but essential public facilities, such as columbarium or sewage treatment services, which might be easier to earn public support.

Moreover, the high construction cost and future maintenance of these cavern/ underground spaces, such as the need for mechanical ventilation, lighting, etc as well as the risk of flooding due to extreme rainfall and storm surges, particularly in coastal regions, should not be overlooked. More importantly, a clear policy is needed to guide underground space development and administrative guidelines to deal with the technical and institutional issues are necessary to make cavern/ underground space developments possible. In this regard, further application on the potential integration of multiple functions into a facility could be explored.

6.6 Moreover, in conducting a land use review and formulating preferred development options, consideration should be given to reshaping travel patterns in a bid to minimise vehicle-based commuting needs. Creation of more employment nodes in NDAs should be pursued to attain a more balanced distribution of population and employment. Such a spatial planning mindset can help rectify the current imbalance between home and job distributions, thereby bringing jobs closer to homes to reduce cross-district trips and relieving traffic congestion in key commuting transport corridors during peak periods. This can in turn alleviate the requirement of substantial land take for the construction of new transport infrastructure. Opportunity for creating pleasant walking and cycling environment should also be considered to help promote a sustainable lifestyle.

6.7 Other issues such as urban farming, particularly recreational and community farming which are conducive to the concepts of sustainability and green living in the urban context should be further explored. This issue will be dealt with separately in another topical paper for the Hong Kong 2030+ Study.

Smart and Green Planning and Design at Different Scales

6.8 In planning future new towns and districts, smart and green planning and design should permeate different scales of development, ranging from homes, buildings, communities and district levels. It should permeate different types of premises such as smart homes and smart offices. Optimising opportunities for low-carbon living and businesses at an early planning stage is an important consideration.

6.9 Opportunities for incorporating green and smart measures should also be explored in retrofitting the existing buildings. The needs of an impending ageing society should also be addressed.

Promote Smart and Low Carbon Economy

6.10 Hong Kong is moving towards a knowledge economy. Opportunities should be explored to capitalise on innovation, technological advancement, and ICT development to promote a smart and low carbon economy including smart production [iii] , smart products and smart services.

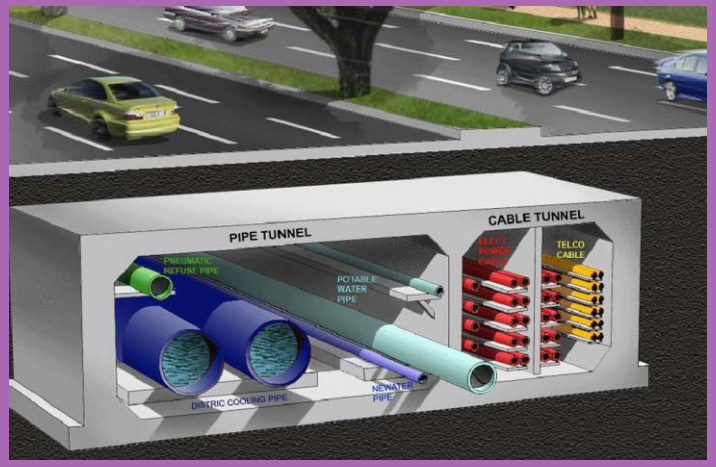
[iii] Industry 4.0 promotes smart manufacturing through the integration of a software-intensive manufacturing system and process, big data and the Internet of Things to form an intelligent and highly efficient network. To facilitate the upgrading and transformation of Hong Kong industries to smart production, the Government hopes to capitalise on the opportunities brought by technology development which will not only increase labour productivity, lower production costs and raise our global competitiveness, but create more quality and diversified employment for our young people.

COMMON SERVICES TUNNEL (CST) (MARINA BAY, SINGAPORE)

CST is an extensive custom-built underground network. CST not only allows easier maintenance and upgrading with minimal disruptive and pollutive road excavation, it also requires a smaller combined area, thereby allowing more systematic and organised planning of the underground space [46].

The Singapore Government first announced its intention to build a CST for Marina Bay Area in 1998. Subsequently, two phases with a total contract sum of about SGD$200 million covering a total length of 3km underground tunnel constructed.

The tunnel caters for both commercial and residential buildings within Marina Bay Financial Centre and One Raffles Quay as well as Marina Bay Sands Integrated Resort [47].



Cross Section of CST

Source: CEDD (Territory-wide Study on Underground Space Development in the Urban Areas of Hong Kong)- http://www.undergroundspace.gov.hk/singapore.htm

Interior of CST

Source: CEDD (Territory-wide Study on Underground Space Development in the Urban Areas of Hong Kong)- http://www.undergroundspace.gov.hk/singapore.htm

MONTREAL UNDERGROUND CITY (MONTREAL, CANADA)

Montreal's Underground City is an indoor pedestrian networks extending for more than 32 km and covering an area of 12 square km in the city's downtown. It began beneath the Central Station complex, took off during the 1960s when Place Ville-Marie, the city's first modern skyscraper, was built. It grew organically over a period of more than 50 years. The underground network consists of tunnels, corridors and atriums linking 66 real estate complexes, approximately 80 percent of downtown office space, 35 percent of retail space and 1,600 housing units.

The extreme summer and winter weather in Montreal is a prime motivation for the development. The indoor walkways create a climate-controlled space that is capable of overcoming local temperatures. The underground city is more than a shopping mall as it is filled with permanent artworks. Every year and during the Nuit blanche festival's Art Souterrain event, these spaces are turned into temporary art galleries.

Eaton Centre, Montreal

Expo in places des arts station, Montreal

Montreal Underground City

Source: CEDD (Territory-wide Study on Underground Space Development in the Urban Areas of Hong Kong) - http://www.undergroundspace.gov.hk/montreal.htm

Climatic Resilient Planning

6.11 In terms of climate resilient planning, the Urban Climatic Map Study has recommended some planning and design measures to improve urban climate. They are considered effective ways to promote sustainability and green living in the urban context. These measures include (i) increasing greenery in the urban area by e.g. extensive road side tree planting, green podium, low-level green roofs and green walls, creating/preserving urban green oases and establishing networks of connected green corridors; (ii) reducing ground coverage through minimising podium, setbacks along narrow streets, arrangement of building layouts to increase permeability; (iii) preserving/ creating breezeways/ air paths to promote air ventilation; (iv) regulating building volume; (v) increasing building permeability by promoting building gaps and separations; and (vi) careful control of building height e.g. adopt building height variation across districts and decrease building height towards prevailing wind direction to promote air movements.

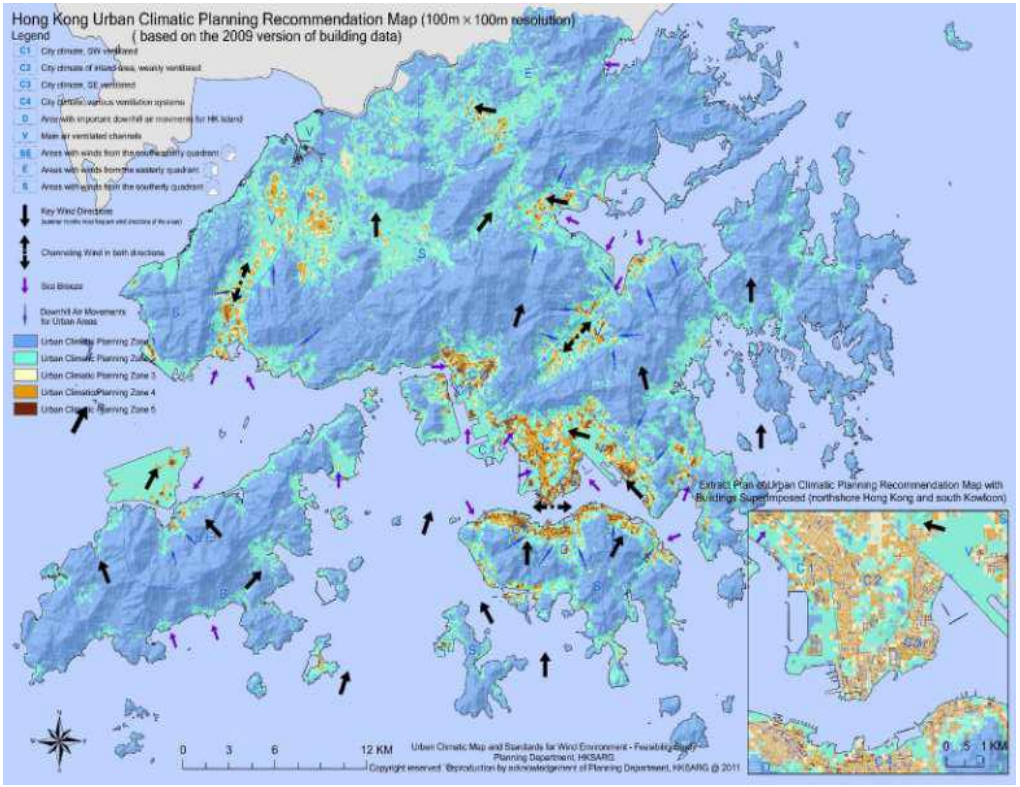


Figure 9 Urban Climatic Map

SMART MOBILITY

6.12 Hong Kong is a compact high-density city. The built-up areas make up only 24% of the total land area and accommodate 7.32 million population. The built-up area density of about 27,000 persons/km^2 is one of the highest in the world. Good mobility is essential to support the social, economic and land development in Hong Kong, and ensuring good mobility in our compact high-density city is a major challenge:

- for instance, we have to keep 12.6 million passengers moving on the public transport system every day, including about 5 millions on MTR;
- as a major regional transport and logistics hub, Hong Kong handled 325.7 million tonnes of inward and outward cargoes last year. We have to ensure smooth movement of the cargo freight in the city; and
- the population living in new towns has increased from 0.6 million in 1973 to 3.4 millions, supported by efficient external road and rail links.

6.13 To promote smart mobility, we need to provide smart transport infrastructure and undertake traffic management and operation. The application of appropriate ICT and other technologies could help further promote smart city.

Transport Infrastructure

6.14 Hong Kong has been successful in adopting an integrated land use-transport-environment planning framework in land development, with developments clustering around railway stations. We will continue to adopt this successful compact rail-based development model. With the 6 railway lines targeted for completion by 2031 under the “Railway Development Strategy 2014”, the total length of railways will increase to 300km. About 75% of the population and 85% of the employment will be within the railway catchment, enabling us to maintain 90% of the passenger trips made by public transport. We will also need to provide new highways to support new development primarily in the northern New Territories and Lantau. The focus will be on enhancing the regional transport connectivity. The use of ICT can also help the planning, operation, management and maintenance of the new/ improved infrastructure assets.

6.15 Providing transport infrastructure also encompasses the promotion of multi-modal public transport and low carbon options, walking and cycling, smart travel information for better choice, an integrated intelligent transport system, and the expansion of the rail network to a rail-based/ transit oriented development mode that is supported by other modes of public transport services, pedestrian networks and/ or cycle tracks. In other words, we propose to underscore railway transportation as the backbone of public transport.

6.16 Underground parking spaces for both cars and bicycles (including automated ones) can help achieve the aim of freeing up space at-grade, promote the concept of "door–to-door parking" by locating the functional activities below ground and increase the efficiency of parking. (*See case study* - Tokyo's *ECO-Cycle and ECO-Park*). With ICT, availability of parking spaces, their locations and shortest route to the spaces can be centralised and easily shown, either on a signage or via mobile devices (e.g. mobile phones). Also, they enable parking location recording or licence plate number searching, thereby expediting the car-finding process. These can significantly reduce the time and distance travelled for searching parking space. Moreover, recognising the licence plates of parked vehicles can facilitate enforcement action against expired parking or automatic triggering of actions against those who occupy parking spaces in excess of a specified duration, thereby deterring prolonged occupation of parking spaces. When applied on the district level, the benefits can be further exemplified. Moreover, transport infrastructure for facilitating universal accessibility (e.g. lifts and escalators) should also be considered to promote smart mobility.

Traffic Management and Operation

6.17 The average of annual growth rate of about 3% public vehicle growth from 1995 to 2015, against about 0.8% population growth and 1.7% domestic household growth, will not be sustainable in terms of road space, car parks, journey time and environmental footprint. Effective traffic management measures, particularly in managing private car growth and use are vital. We also need to reshape the travel pattern and redeem the spatial distribution of homes and jobs.

6.18 ICT could help integrate and upgrade the software of traffic management system to help further promote smart mobility. Below are some examples:

- an integrated intelligent transport system helps provide automatic traffic information and traffic control for managing real time traffic flow, pedestrian flow and cargo flow. In terms of public transport, it provides real-time service information of multiple modes of public transport, such as real-time crowdedness of transport mean, in a single platform. The information includes arrival time of selected public transport system at a particular location, allowing travellers to determine the preferred mode and route of public transport (*See case studies - Strasbourg's StrasMap and Traffic Information and Control System*). Additional functions encompass calculation of the shortest walking distance between the origins/destinations and public transport stations, choosing suitable routes for wheelchair users and for people with walking difficulty such as avoidance of stairs on choosing the walking route, and locating and reserving shared cars and electric vehicles (including reserving charging spots). All these features can allow users to make informed decision and hence reducing the time spent on commuting trips. Dissemination of real-time traffic information through the use of ICT and sensors should be promoted. The implementation of the integrated intelligent public transport system will depend on the availability of real-time service data of different public transport modes and walking path data, which will require efforts from the Government as well as public transport operators.

- A traffic adaptive control system can coordinate traffic signals of several junctions in response to the traffic conditions so as to minimise the number of stops experienced by vehicles and the queue length as well as to reduce journey time. By means of closed circuit television sets installed at the junctions, operators may centrally adjust the traffic signals to cater for any special circumstances. In addition, the operating conditions of the traffic signals can be monitored remotely such that faulty traffic signals can be repaired as soon as possible.

Other Considerations on Smart Mobility

6.19 Other considerations of smart mobility such as walking, cycling, car sharing, park-and-ride as well as means of green mobility are complementary to the rail-based public transport system.

6.20 Improving walkability is a key element for sustainable cities. A comprehensive development of an integrated walkway system can help reducing reliance of the public on road-based transport, which in turn alleviates the demands put on the transport system and lessens the impact on the environment. Providing meticulously planned integrated walkway systems, particularly in NDAs, can reduce the number of short motorised trips and the conflict between pedestrians and vehicles. This will increase mobility, enhance road safety and improve local air quality, contributing positively to smart city development.

6.21 The use of ICT with real-time travel and parking infrastructure will promote the convenience and attractiveness of the first-and-last-mile travel. Its use will also enable inclusive mobility to facilitate mobility of the disadvantaged and the aged (e.g. elderly pedestrian accentuated signal crossing facilities).

STRASMAP (STRASBOURG, FRANCE)

The StrasMap is an interactive map available online or as downloadable smart phone application. It enables people to access up-to-the-minute travel news and information covering areas, including: (i) location finder and journey planners; (ii) traffic information (congestion, accidents, construction, temporary closure, etc); (iii) locations of bus stops, car sharing platforms, bike parks and cycling networks and car parks; (iv) air quality; (v) emergency contact, and (vi) social media sharing platform.

StrasMap
Source: strasmap.eu

ECO-CYCLE and ECO-PARK (TOKYO, JAPAN)

With an aim to reducing the amount of land used for above-ground parking for both cars and bicycles, underground storage facilities, ECO-Cycle and ECO-Park, are developed. The facilities satisfy the concept of “door to door parking” by providing parking space very close to destination, such as train stations and offices. The press-in construction method saves construction time and can be removed and reused for other purposes when they are no longer needed.

ECO-Cycle near Tokyo’s Shinagawa station

TRAFFIC INFORMATION AND CONTROL SYSTEM (STRASBOURG, FRANCE)

Strasbourg is a good example to illustrate the trend towards smart mobility solutions by combining its traffic control operations with an urban video-surveillance centre. It illustrates how separate transport information are coordinated to increase operational efficiency and make cities more convenient and attractive.

The automatic traffic information and control system, called SIRAC, provides 24-hour, all year traffic and transport management and overseas a range of services, including:

(i) real-time display of the system status and traffic situation;
(ii) real-time control of ground equipment;
(iii) traffic flow measurement and analysis;
(iv) access control to pedestrian areas;
(v) tram and bus priority; and
(vi) car park information and guidance, etc.

Under the city's transport management control system, tramway is given first priority and commuting by tramway will not be interrupted by traffic lights as they will be given priority to pass through. Further priority will be given to bus, pedestrians and then car users.

The city-wide surveillance system also performs pedestrian flow control function. Retractable bollards are situated in various locations where pedestrian control is needed. In case of festive events, the bollards will protrude from the ground for blocking vehicles for driving into the controlled areas.

Trams at Strasbourg are given priority

Smart Use of Resources and Resilient Infrastructure Considerations

6.22 A holistic framework is needed for integrating considerations in planning for various infrastructure and resources utilisation in pursuit of a smart, green and resilient city development.

Water Resources

6.23 Given the imminent crisis of water shortage, coupled with the surging level of uncertainty on freshwater supply associated with climate change, it is of utmost importance to conserve water resources. A total water management strategy with an integrated, multi-sectoral approach built on good water demand and supply initiatives is crucial to help promote sustainable use of water resources.

6.24 Apart from broadening the sources for freshwater supply through latest desalination technology, such as reverse osmosis [iv], conservation of the freshwater resources through demand side management tools such as the installation of monitoring and sensing equipment to collect network operation data, maintain the healthiness of the water distribution network, and monitor water consumption (e.g. smart meters) also plays a significant role in optimising the use of water resources and enhancing the security of freshwater supply.

[iv] The process of reverse osmosis enables extraction of potable water from seawater with the use of membrane technology. It has become a mature technology and is used in most of overseas desalination plants in recent years. According to the International Desalination Association, there are over 18,000 desalination plants worldwide with a total water production capacity of more than 86,800,000m^3 per day [48] and reverse osmosis accounts for approximately 60 per cent of installed capacity [49].

Drainage

6.25 The traditional drainage methods including building interception tunnels, upgrading rivers, installing storage tanks and upgrading pipe networks will continue to be utilised to maintain the flood resistance of the drainage system. With a plausible increase in the frequency and severity of extreme rainfall events due to climate change, our infrastructures (in particular drainage facilities) will need to be flexible and responsive to these changing environmental situations. These can be materialised simultaneously by the utilisation of landscape and more blue-green infrastructure as a means for reduction of surface runoffs, recharging of groundwater resources as well as filtration of pollutants and slowing down the flow of runoffs. Techniques available for deployment include green channels, retention basins, constructed wetlands and permeable surfaces. These can also serve as public open space for leisure purpose in dry seasons. (*See case study – Denmark's Musicon Stormwater Management Basin and Skate Park at Roskilde*)

6.26 Moreover, these can provide significant opportunities for rainwater harvesting for non-potable use and creation of wetland habitats, thereby enhancing the landscape and ecological value of an area as well as developing flood resilience and contributing to micro-climatic cooling. (*See case study –Hung Shui Kiu New Development Area's Revitalising River Channel*)

6.27 To promote an integrated green infrastructure, the concept of "Low Impact Development" or "SuDS" could be explored for urban development. It strives to minimise urban runoff in development by utilising the green features in cities. It emphasises maintaining infiltration, local water storage and local use of rainwater. Such green features include porous pavements, green roofs, bioswales, rain gardens, etc.

MUSICON STORMWATER MANAGEMENT BASIN AND SKATE PARK (ROSKILDE, DENMARK)

Denmark is repeatedly hit by heavy rainstorms. To prevent flooded roads and houses, drainage system at Musicon in the Roskilde district of Denmark is one of the large scale drainage projects initiated by the Danish local governments. Unlike other projects, the new development is not only a stormwater drainage system, but also a recreational skate park [50]. One of the project's targets is to handle all stormwater on the surface and utilise the facilities for other purposes during dry weather. The stormwater system will make the site at Musicon climate change resilient.

The system combines rainwater harvesting with an activity park. Three separate rainwater basins are used for collecting water, in which rainwater is led down a long open channel to the first basin. When the first pool has exceeded capacity, rainwater then proceeds to the second and third basins. The third basin is designed to handle 10-year rain events. The entire complex can store up 23,000m^3 of water and is fully integrated into the canal system and brings rainwater to the adjacent lake [51].

The Musicon case demonstrates how recreational use can be integrated with drainage basins. Such integration embeds multiple functions into a facility, making efficient use of the drainage basins and channels and turning the facilities into welcoming and acceptable use to the general public.

Roskilde Skate Park

REVITALISING RIVER CHANNEL (HUNG SHUI KIU NEW DEVELOPMENT AREA)

Sustainable strategies in respect of town planning, urban design, transport and green infrastructure have been incorporated in the development of the Hung Shui Kiu New Development Area (HSK NDA) to achieve efficiency, carbon emission reduction and sustainable living. In this regard, natural river resources are integrated with sustainable urban drainage, landscape design and leisure/ recreational spaces. Major innovative measures include:

(1) Retention lake

As a regulating measure to overall drainage system and as a micro climate cooling mechanism through integrated design with the open space system for public enjoyment.

(2) Regeneration of river channels

Revitalise the river channel system of the HSK NDA to enhance the ecological system in the channel and introduce riverside promenades with pedestrian walkways and cycle tracks to inject vitality of the area. The regenerated river will be the major green spines, breezeways and view corridors which enable better integration between different neighbourhoods and with the adjacent Tin Shui Wai New Town.

(3) Community farming

Explore the development of community gardens in open space and amenity areas to promote green living.

Revitalising river channel - Hung Shui Kiu New Development Area

Sewage

6.28 Traditionally, sewage is directed to sewage/ waste water treatment works for processing and discharging into sea. Yet, under the mounting pressure of water scarcity, sewage can be processed for further non-potable usage, thereby saving the precious water resources. (*See case study - Singapore's Deep Tunnel Sewerage System and Changi Water Reclamation Plant)* Apart from processing for re-use, sewage can also be utilised for energy production. Wastewater can be supplied to support algae growth, and the biomass obtained afterwards can be transformed to produce power, heat or cooling with the water cleaned for usage. On the other hand, sewage heat pump has the potential to harness the energy in sewage for showers, washing machines, dishwashers, etc.

DEEP TUNNEL SEWERAGE SYSTEM (DTSS) AND CHANGI WATER RECLAMATION PLANT (WRP) (SINGAPORE)

The two phases of DTSS is considered to be a solution to meet Singapore's long term needs for used water collection, treatment and disposal. The concept of the DTSS is to use deep tunnel sewers to convey used water to centralised water or discharged to the sea through outfall. With the completion of the two phases of DTSS, the existing intermediate used water pumping station and conventional WRPs can be freed up for other development.

Changi WRP is at the heart of DTSS Phase 1. It is situated on a 32 hectare of reclaimed land and can be expanded to handle an reclamation plants (WRP) located at the coastal areas. The used water is then treated and further purified into clean reclaimed water called "NEWater" [v]. Used water will undergo a series of water treatment process in the WRP, including coarse screening, sedimentation and purification. The treated water will then be discharged through two deep sea outfall pipes or sent to the NEWater Factory for further three stages purification process to NEWater, viz. microfiltration, reserve osmosis and UV disinfection.

[v] NEWater is high-grade reclaimed water produced from the treated water that is purified using advanced membrane technologies. This high-grade reclaimed water has passed more than 100,000 scientific tests and surpasses World Health Organisation requirements. Since 2003, NEWater has been used mainly for industrial and air-con cooling purposes at wafer fabrication parks, industrial estates and commercial buildings, freeing up large amounts of potable water for other uses. It currently meets 30% of Singapore's water needs and is expected to reach 55% by 2060.

Waste

6.29 Waste contributed to about 5.7% of the total GHG emission in 2013 [52]. Given the limited capacity of the existing landfills, there is a need to address the waste management challenges and develop a sustainable waste management regime. The Government promulgated the "Hong Kong Blueprint for Sustainable Use of Resources 2013-2022" in May 2013 and the "A Food Waste & Yard Waste Plan for Hong Kong 2014 – 2022" in February 2014 to map out a comprehensive resource management strategy with targets, policies and action plans for the coming years up to 2022 with a view to promoting "Use Less, Waste Less" mode of living. Aggressive targets have been set to reduce both the per capita disposal rate of municipal solid waste (MSW) and landfill disposal of food waste by 40% by 2022. To achieve the above MSW and food waste reduction targets and to maximise waste diversion from landfills, the Government has taken multiple and concurrent actions comprising policies and legislations, social mobilisation and infrastructure provision. Apart from these actions and measures, consideration could be given to the discussion of the following two categories – Waste Collection & Sorting and Waste Treatment.

Waste Collection and Sorting

6.30 Automatic Refuse Collection System (ARCS) is a system for transporting the waste via a network of underground pipes. Rubbish bins, the drop off point of the system, will be connected via the pipes to the collection station where waste are sealed in container for ensuing transportation when the containers are full [53]. Different technology (optical/ X-ray separation system, etc) will be installed for sorting of various types of waste, enhancing the efficiency of waste sorting vis-à-vis the traditional manual sorting system.

6.31 Alternatively, waste and recyclables can be collected through the "iceberg collection system" in which bins with bulk of storage space hidden underground are utilised [54]. Such an additional storage can reduce the frequency of collection. The bin can be easily lifted up and transported by a standard "comb lift" vehicle. It can lower the frequency of transportation of waste and recyclables by road traffic. Smart Waste Management System can enhance the efficiency of collection and separation and reduce the cost of doing so. A smart bin can compact waste and recyclables for more space within the bins with automatic notification for arranging cleaning contractors to clear the bins. A smart tag can be applied on the bins. Every time when the bins are emptied, the chip is scanned

for recording the weight and contents of the waste and recyclables, and utilised for charging the users. GPS tracking of the vehicles for waste and recyclables transportation can help devise the most efficient driving routes for optimising the efficiency of waste and recyclables collection.

6.32 The Government established the Steering Group on the Modification of Recycling and Refuse Collection Facilities in Public Places in February 2016. Taking into account the objectives of facilitating waste reduction and resource recovery, effective implementation of quantity-based municipal solid waste charging, and balancing the need for upholding environmental hygiene and cost-effectiveness in the use of public resources, the Steering Group will review existing situation regarding the provision of recycling and refuse collection facilities in public spaces and recommend necessary modifications.

Figure 10 Iceberg Collection System

Waste Treatment

6.33 As for waste treatment, various techniques are available to reduce the volume of waste and convert the waste into energy or other valuable resources. (*See case study – Denmark's waste-to-energy approach*) For example, organic waste can be processed into agricultural fertiliser via composting, biogas via anaerobic digestion and fish feed [55]. Food waste and sewage sludge can be co-digested for the production of biogas as a source of renewable energy at sewage treatment plants with anaerobic digestion facilities. In Hong Kong, the use of anaerobic digestion for biogas and power generation will offer the highest potential. Tallow and waste oil can be further processed for production of biodiesel for use as a source of renewable energy in transport and building.

6.34 Incineration involves combustion of waste with air. Energy recovery is possible, and can take place in the form of hot steam for electricity generation or district heating, or a combination of two. Alternative thermal treatment tends to reduce, if not completely eliminate, the amount of oxygen, in the treatment process so as to turn the waste into energy rich intermediates, which upon further processing, can be used for recycling and energy recovery. EPD has commenced a study for planning of future waste management and transfer facilities in September 2015. The study will identify additional strategic and regional waste facilities for bulk transfer and treatment of solid waste to meet Hong Kong's long term needs up to 2041. It will explore a variety of issues, including technology choices of the additional waste facilities. The additional waste facilities identified shall meet the following four broad objectives:

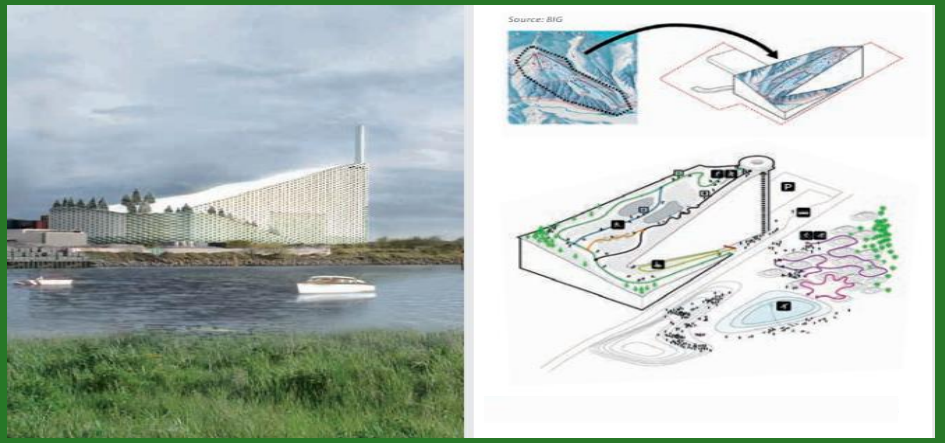
- maximising resources recovery from waste;
- optimising synergy of waste management technologies and land use;
- minimising disposal of untreated or unsorted solid waste at landfills; and
- minimising the need of vehicular traffic for transportation of waste.

WASTE-TO-ENERGY APPROACH (COPENHAGEN, DENMARK)

Waste-to-energy plant forms an integral part of Denmark's waste management system. About 29% of solid waste generates in Denmark is treated at waste-to-energy plants per annum. In 2013, the City Council of the five municipalities (Copenhagen, Dragor, Frederiksberg, Hvidovre and Tarnby) had decided to establish a new facility, namely "Amager Bakke" ("Amager Hill") in the outskirts of Copenhagen to replace the adjacent old waste-incineration plant [56].

The plant burns waste collected from 500,000 – 700,000 inhabitants and 46,000 companies in and around Copenhagen. It is designed to utilise 100% energy content to the waste and 25% more energy will be recovered from the same amount of waste than the existing plant. NO_X emissions and sulphur content of smoke will also be reduced by 85% and 99.5% respectively. The new plant is expected to offset emission of 107,000 tonnes of CO_2 emissions per year compared to a conventional coal-fired plant.

Apart from being an incineration plant, with a height of 85m, it will also feature a ski slope on its roof top to offer a unique recreational amenity for the city residents to engage in alpine and sports activities, or simply enjoy a spectacular view of Copenhagen. More than just production, Amager Bakke is designed to create recreational amenities that help inspire the city residents to embrace a healthier and more active lifestyle. Moreover, it represents a visionary approach to urbanisation of the future, showcasing a model for global inspiration of how to integrate a green waste-to-energy plant with recreational urban space.



Amager Bakke features a artificial ski slope
Source: Volund (Amagar Bakke) - http://www.volund.dk/~/media/Downloads/Brochures_-_WTE/Amager_Bakke_-_Copenhagen_-_Denmark.pdf

Energy

6.35 Nowadays, there is an imminent demand for a higher level of energy efficiency, given the volatile energy price, call for plummet in GHG emission as well as the aspiration for lessening the reliance on fossil fuels. In Hong Kong, electricity generation accounted for 68.3% of the GHG emission, the largest source of GHG emission in 2013 [52]. Hence, energy sector plays a pivotal role in cutting GHG emission, via enhancing energy efficiency and the use of cleaner fuels including renewable energy.

6.36 Hong Kong's existing buildings account for some 90% of the total energy use [11]. Hence, the building sector represents the largest, most effective way for energy and resources conservation. Through cutting back energy usage at individual building, emission of GHG and other pollutants can be tumbled while energy costs can also be reduced. Furthermore, the level of resilience of buildings to climate change and natural hazards can be strengthened by certain building design elements and ultimately enhance the well-being and comfort of the inhabitants.

6.37 Ensuing are discussions of technologies in relation to energy production and consumption, namely generation and storage, transmission and distribution, demand management tools as well as energy usage in the building aspect.

Energy Generation

6.38 Distributed energy (DE) refers to the generation of electricity by a variety of modular power-generating facilities at the point of consumption, rather than at a centralised power plant. Renewable energy sources, including wind and solar energy, can be leveraged in the DE system but it has to be equipped with some kind of Energy Storage System (ESS). ESS technology can help cater for the peak demand of electricity consumption and reduce capital investment in generation facilities. In this regard, ESS technology is essential for the successful development of DE. However, ESS technology is still evolving at this stage. Germany, for example, is investing more resources in the development of more "space-efficient" storage facilities. Noting from current international studies, ESS may still need further research regarding how their cost-competitiveness could be improved. Hence, their deployment levels are very limited at this stage, and DE equipped with ESS is unlikely a prevalent mode of DE system for the time being.

6.39 Other energy generation methods such as co-generation/ tri-generation, i.e. simultaneous production of electricity with the recovery of heat for cooling and heating, can also provide another option for DE system.

Transmission and Distribution

6.40 The use of ICT enables the sensing of voltage and current flow in the transmission system, by which the transmission system itself can respond to the data to optimise its own performance for higher transmission efficiency. Automatic forecast and response to the attack of energy system is also possible so that the energy system itself with a higher level of energy security can be ensured. Other infrastructure could be considered, like low impedance cables for better power flow control and fault current limiter to cap the amount of current flowing through the system during a fault. These render better quality control on transmission and stability of electricity supply.

Demand Management Tool

6.41 On this front, the installation of advanced metering infrastructure and smart display allows collection and measurement of data on energy usage as well as instant communication between consumer and utility grid in either an active or passive way. The former way of communication would incur deliberate choices by consumers to shift the electricity consumption pattern while the latter one involves delegation of authority by consumers to external entities for modifying the consumption. In both ways, changes could be made to the electricity use to lower the consumption during peak hours.

6.42 Smart grid is an electricity network that links up the power stations, power grids and electricity users and uses ICT to monitor and manage the transport of electricity from various sources of generation to end-users [11]. (*See case study – France's smart grid at Fort d'Issy*) Apart from the incorporation of renewable energy and demand management measures, one of the salient features is the possibility of two-way energy flow instead of the one-way electricity flow in the traditional grid network. Hence, surplus electricity from a building can be exported for sale or usage to other buildings in a smart grid system. Also, fault detection of the energy system can be achieved at a higher level of precision, enhancing the level of energy security. Notwithstanding, pre-requisites such as an established electricity market and institutional arrangements might need to be in place in order to realise the benefits.

Figure 11 The New Headquarters of EMSD

Source: "A New Chapter, The Story of EMSD Headquarters" of EMSD - http://www.emsd.gov.hk/minisites/new_hqs_commemorative_booklet/htm_en/05/s07.htm

SMART GRID (FORT D'ISSY, FRANCE)

IssyGrid is the first pilot project for a district–level smart grid [vi] in France. Its goal is to enable the city's inhabitants to save money by pooling complementary energy needs and resources of offices, homes and businesses, and by levelling energy consumption peaks [57].

IssyGrid covers renewable energy generation, consumption, storage and overall optimisation. First, all types of energy consumption are measured. Second, resources are put in place for power generation (solar PV, cogeneration, etc) and storage. Finally, energy generation/ consumption/ storage systems are pooled and managed as an entity in order to identify new ways to optimise energy use [58]. Upon completion, the smart grid will eventually cater for the needs of approximately 2,000 homes, 5,000 inhabitants and 10,000 employees over a floor area of 160,000m^2 of offices.

By gathering the live data using the smart meters installed in concerned households which are connected to the city's data analysis centre via interconnected information systems, the service provider is able to advise and encourage consumers to consume at "the right time" to reduce peak demands. In turn, users can compare their consumption data with those of similar households and get advice on how to consume in a smarter way.

Fort d'Issy

[vi] A smart grid is an electricity transmission and distribution network with built in ICT application. Smart meters are installed in each household to enable real-time meter readings. Consumers are charged for their real consumption rather than estimates based on annual use. It contributes to demand-side management, where consumers can shift their electricity consumption to off-peak time to save money. The overall effect is less redundancy in transmission and distribution lines, and greater utilisation of generators, leading to lower power prices

Building Design

6.43 A vast array of smart building design elements is available for existing and new buildings. For example, installation of exterior shading blocks, glazing of glass or the use of smart glass (a glass able to vary the light transmittance and thermal properties of windows, and adjust the sunlight entering the buildings [59]). Green roof can lower temperature rise, reduce energy consumption and minimise the runoff while installation of rainwater harvest system and water-saving devices can contribute to the conservation of water resources by collecting rainwater for non-potable uses [60]. All these can be incorporated in the design of a building. (*See case study – France's Green Office Meudon at Paris*)

6.44 On the resilience front, buildings along the coastal area should be specially designed to cope with extreme hazards. First, the buildings should be raised to keep the water out during flooding. For further protection, the ground floors of the buildings can be equipped with a flood gate and dedicated to uses that are less susceptible to flooding. Electrical and mechanical facilities should be placed high in buildings, if not roof levels, for smooth operation during hazards. Elevator systems should be equipped with a back-up power sources so that they can return to the ground floors in the event of power outage [60].

Building Operation

6.45 Home Area Network is a network of information and communication formed by the appliances and devices within a home or a building unit for supporting various household applications. Accompanied with smart grids and other ICT, it enables multiple ways communication between devices and the users. Therefore, users can automate control, monitor consumption remotely and ensure that the system is operating efficiently so that energy consumption can be minimised. Apart from the connection between inhabitants and the system, a building management system should be in place with sensors to optimise the controls of energy consuming loads throughout the buildings, such as elevators, lighting, heating, cooling, IT and security so energy consumption can be optimised. When most, if not all, buildings within a city are connected with smart metering in a similar vein, a city-wide integration platform can be forged.

GREEN OFFICE MEUDON (PARIS, FRANCE)

Green Office Meudon is the first large-scale positive-energy office building in France to showcase a new generation of positive-energy buildings [61]. The building is "green" because it produces more renewable energy than it consumes for its operation on an annual basis.

To achieve this, it puts together different technologies and features in energy generation and consumption, building design and management, and transport facilities. A notable example is the full integration of solar power generation devices with the office building, including the roof, skylight, façade, blinds and car park shelters. The annual energy production from these device totals 490,000kWh and is sold in full to the lease holder.

Another example is the bioclimatic design of the building, which is centred around the natural ventilation to eliminate the need for energy-intensive air-conditioning and take advantage of the weather outside to optimise the inside temperature. Priority is given to passive systems, including automated vents on the façades, no false ceilings in order to benefit from the thermal inertia of the concrete structure, automated external sun shades, etc. With its natural ventilation system, the office building is able to offer occupants a comfortable summer environment without using an active air-conditioning system, as the perceived temperature is even lower than the maximum local temperature.

Apart from the smart and green features, Green Office Meudon has incorporated the first Energy Performance Contract (EPC) signed with private partner. Under the nine-year contract, building operator undertakes to guarantee the owner all the operating and maintenance costs, as well as energy consumption and production levels, in accordance with predefined conditions of use and occupancy. To assist with the EPC management and green lease, a special software is designed to analyse the building's energy production and consumption in real time in terms of use and location.

6.46 Various sources of renewable energy, including solar and wind energy, can be leveraged for energy production in buildings. For example, photovoltaic cells and wind turbines can be installed or mounted to buildings. Excess electricity can be exported to the grid if possible. This can lessen the reliance on fossil fuel on electricity generation and energy for electricity transmission. Energy generation from other sources such as bio-fuel are also possible. Meanwhile, a significant portion of energy is lost in the form of heat during the energy generation process. Co-generation and tri-generation capitalises on the heat energy with the use of numerous heat-exchange measures to enhance the energy efficiency level from about 40% to 80% [vii].

Digital Infrastructure and Data

6.47 The inclusion of proper digital infrastructure would impact on the spatial planning of a city. Such elements could include sensor networks, network (wired/ wireless) connectivity and resilience, internet-ready infrastructure, and data sharing architecture, data storage, data centres, etc.

6.48 More importantly, data from multiple sources is almost always more valuable than sources that are kept in isolation. Leveraging on advanced ICT allows people, data and processes to connect real-time to facilitate more efficient and smarter use of existing resources for higher performance.

6.49 In term of spatial data, the Common Spatial Data Infrastructure (CSDI) aims to integrate relevant spatial data available in the Government. A consultancy study has been commissioned to formulate an effective CSDI development strategy for Hong Kong. Alongside with the study, the institutional arrangement, data standards and spatially related applications based on the respective areas of work will be reviewed.

Green Transport Infrastructure

6.50 Green transport infrastructure should be an in-built element of city development. This includes the provision of environmentally friendly transport and the deployment of electric, or even driverless vehicles [viii] or autonomous vehicles (AVs), the infrastructure for charging electricity for vehicles and integration with the public transportation network.

[vii] The energy efficiency of co-/tri-generation would depend on the energy end use of the installation (i.e. how the thermal energy is utilised)

[viii] The deployment of driverless vehicles should be subject to further demonstration that road safety can be maintained in the context of the traffic conditions in Hong Kong.

Resilient Infrastructure

6.51 Various issues of resilient infrastructure to climate change and natural hazards have been discussed in the preceding paragraphs. They should be a key consideration at an early planning stage. The major initiatives are proposed below:

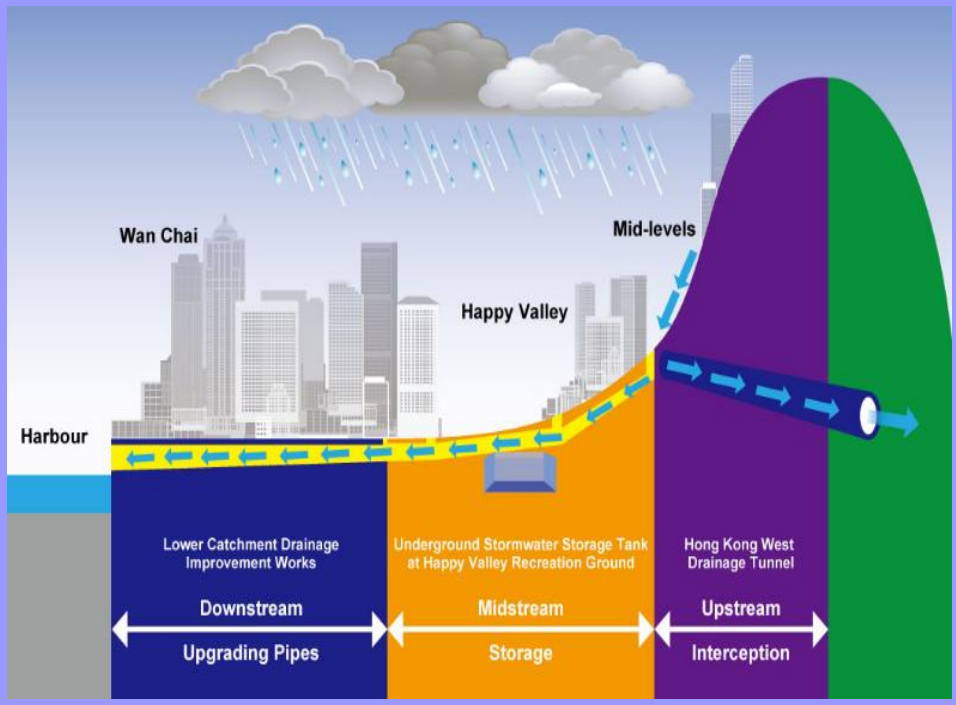
- develop sustainable drainage system and flood protection (see case study: Happy Valley Underground Stormwater Storage Scheme);
- retrofit city infrastructure to address climate change;
- extend the general lifespan of our existing buildings, possibly through building conversion and retrofitting works;
- promote climatic defensive and hazard proof infrastructure with due consideration to their locations, potential for co-location, design and operation requirements; and
- ensure appropriate siting of critical facilities and infrastructure to enhance resilience towards extreme weather conditions.

HAPPY VALLEY UNDERGROUND STORMWATER STORAGE SCHEME (HVUSS)

In a busy and densely populated area, there are limitations in carrying out extensive upsizing of the existing drains, which would also involve extensive road opening works. To avoid causing serious disruption to the public and minimising complicated diversion of the congested underground utilities, an underground storage tank could be a good solution to the flooding problem.

In order to alleviate the flooding problem in Wan Chai and Happy Valley district, DSD has constructed an underground stormwater storage tank underneath the Recreation Ground at the infield of Happy Valley racecourse. This underground storage tank will temporarily store part of the stormwater collected from the upstream catchment for attenuating the peak flow through the downstream stormwater drainage systems after heavy rainstorms. The stormwater will be discharged via pump and gravity drains to the outfall and thus greatly reduces the risk of flooding in the low-lying area.

HVUSS is Hong Kong's first application of "Movable Crest Weir" system with "Supervisory Control And Data Acquisition (SCADA)" to collect the excessive stormwater more effectively and hence resulting in a smaller size storage tank. Under this arrangement, the design capacity of the storage tank can be reduced by as much as 30% and ultimately helps achieve sustainable development by minimising the amount of excavation for construction and total construction time.



Illustrations for HVUSS

Source: DSD (HVUSS) - http://hvusss.eksx.com/index.php

7 FUTURE DIRECTIONS

7.1 The signing of the Paris Agreement in 2016 signified a collaborative international commitment to combat climate change. As a global city upholding its environmental stewardship, Hong Kong should better prepare for or even take a lead in embracing the urban challenges of the 21st century. A city strategy on the SGR principles is instrumental to achieving this.

7.2 To help creating capacity for sustainable growth, which is one of the building blocks proposed under Hong Kong 2030+, a smart, green and resilient city is proposed. It focuses on the scope that are relevant to land use planning, mobility and infrastructure in the built environment and is particularly applicable to new development areas and new neighbourhoods where comprehensive planning is more feasible.

Key Strategic Directions	Key Actions
Observing the general SGR city framework	• To apply the SGR city framework in territorial planning and the planning of new development areas/ neighbourhoods • To establish an integrated Common Spatial Data Infrastructure and ICT platform

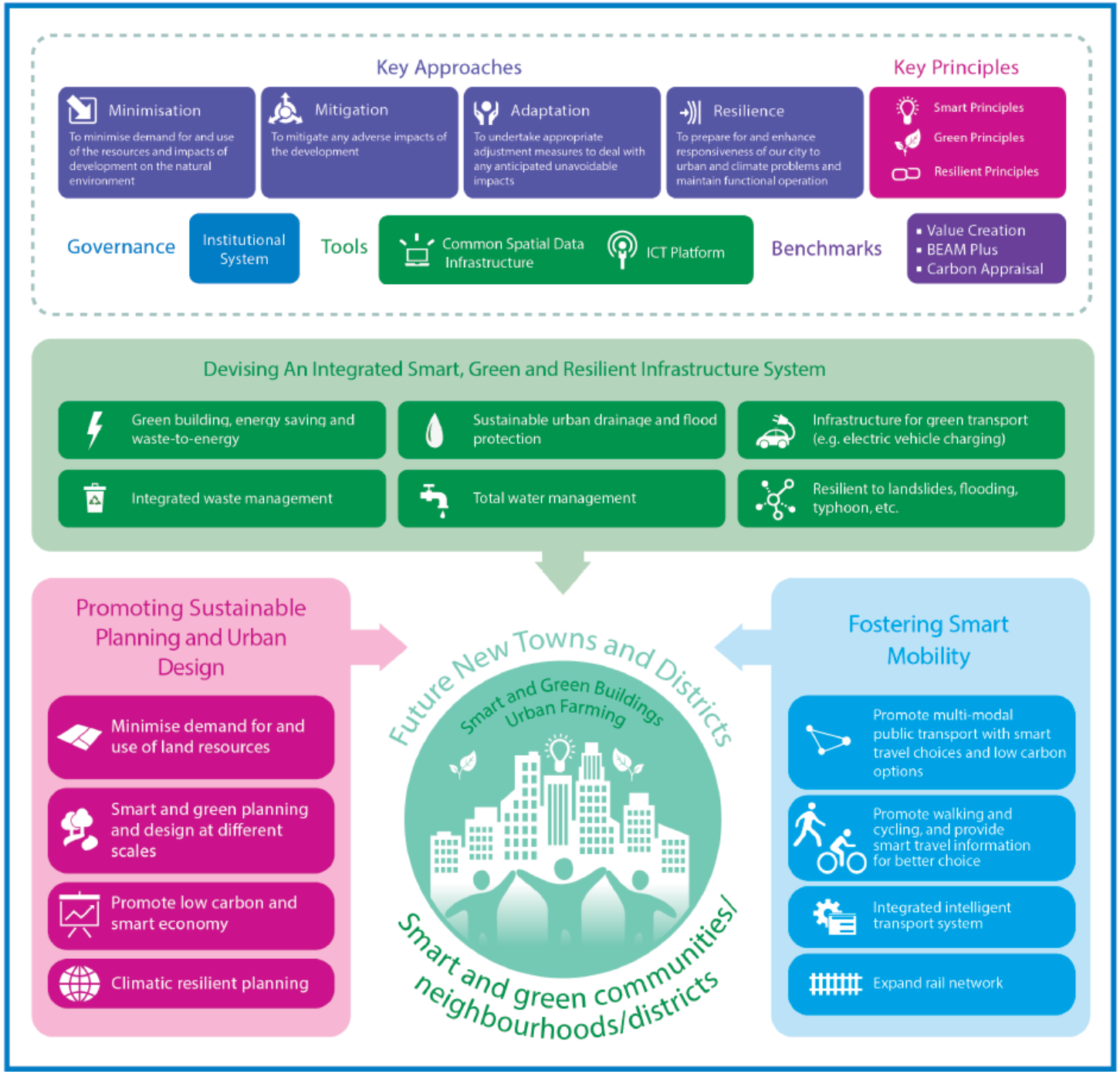


Figure 12 General Smart, Green and Resilient City Framework for the Built Environment

General Guiding Framework

7.3 The SGR city strategy embraces the proposed key approaches, key principles, governance, tools and benchmarks for promoting smart, green and resilient city development in Hong Kong. In gist, it aims to minimise demand for and use of resources, promote low-carbon smart economy and living, reduce carbon emissions, enhance city efficiency, promote business productivity, improve quality of urban living and enhance climate resilience. It is to be supported by a CSDI and a robust network of ICT. It calls for an innovative, vigilant, adaptive and forward looking mindset that permeates all levels, aspects and stages of planning and development. Most importantly, in order to fully capitalise on the of advantages of the SGR initiatives, behavioural change of the people is essential. People should be prepared to embrace a more smart, green and resilient lifestyle and this can be done through empowering the community with the necessary tools and demonstrating the benefits and feasibility of the SGR measusres.

KEY APPROACHES

Miminisation: to minimise the demand for resources in the course of development and the impacts of development on the natural environment, which is conducive to creating capacity for sustainable growth.

Mitigation: to mitigate any adverse impacts of development.

Adaptation: to undertake appropriate adjustment measures to deal with any anticipated unavoidable impacts.

Resilience: the need to prepare and enhance the responsiveness of our city in tackling urban problems, climate change and hazards as well as the ability to cope and absorb stresses and maintain functional operation.

KEY PRINCIPLES

In order to maintain development without compromising the standard of living, cities need to look for ways to use their resources more efficiently. The smart, green and resilient principles should be adhered to in developing future new towns/ neighbourhoods/ districts.

Smart Principles: include optimise use of resources and two major principles as set out in Boyd Cohen's Smart City Framework, namely smart mobility (mixed-modal access, prioritised clean and non-motorised options and integrated ICT) and smart environment (green buildings, green energy and green urban planning).

Green Principles: include the internationally accepted multi-tier resource management strategy (i.e. the 4R principles of reduce, reuse, recycle and replace), and promote environmentally friendly and low carbon footprint development. Moreover, timely provision of resource management initiatives/facilities that support waste minimisation and recycling, such as EcoPark and community green stations, is equally essential.

Resilient Principles: include the qualities of reflective, robust, redundant, flexible, resourceful, inclusive and integrated as put forward in the Rockefeller Foundation's City Resilience Framework. These resilient principles should be treated as close companion with the concept of sustainability in shaping the future planning and daily management of the cities. In particular, resilient principles should work within the context of long-term sustainability objectives, while maintaining an acceptable stability or equilibrium in spite of the turbulence of daily life.

GOVERNANCE/INSTITUTIONAL SYSTEM

The development of a SGR city requires concerted efforts of many actors, and hence an efficient and sufficient institution with a cross-sector collaboration approach is necessary to promote co-ordination for cross-cutting issues, such as integrated land use and transport planning and integrated smart, green and resilient infrastructure projects.

To bring out the full effectiveness and efficiency of these SGR measures and to facilitate these innovative ideas to flourish and turn into implementable projects, the institutional policy should foster balanced participatory governance between the government, business, research and development, and the public.

TOOLS

In the pursuit of SGR city, advanced technologies would need to be deployed through the development of advanced infrastructure, system network and data platform. Through leveraging on advanced ICT which brings together data to connect real-time, higher performance is ensured. More importantly, the provision of an environment with accessible information and communication would enable both policy makers and the community to make informed decisions for more efficient operation and optimal use of resources.

Benefiting from the robust ICT infrastructure network and leveraging on its compact built environment that is underpinned by a complex web of infrastructural and operational systems supporting various functions, Hong Kong has the potential to further strengthen its performance in pursing different spheres of smart city development. To establish an integrated and well-coordinated ICT platform to manage the development and operation of our built environment, various ICT measures should be incorporated as early as possible during the strategic planning process. In this regard, the NDAs would provide good opportunities for the development and application of an integrated ICT tool . On a territorial level, opportunity could be explored to promulgate spatial data policies and standards forming a sustainable, reliable, interoperable and sharable "CSDI"and to step up the overall management and dissemination of spatial data enabling the effective and efficient utilisation of spatial data essential to sustainable planning and development.

BENCHMARKS

To assess the overall value creation and impact associated with every stage of a development, from cradle to grave, can ensure both the cost and benefits of the developments are fully taken into account.

Moreover, to track performance, objective benchmarks will be useful. In terms of green building initiatives, for example, such benchmarking systems as BEAM Plus can be used to gauge the performance and promote a sustainable built environment.

7.4 The proposed SGR city strategy is proposed for application in territorial planning and planning of the new development areas/ neighbourhoods/ districts, as well as retrofitting/ redevelopment of the densely developed areas, with focuses on the following aspects, namely **promoting sustainable land use planning and urban design**, **fostering smart mobility** and **devising an integrated smart, green and resilient infrastructure system**.

KEY FEATURES

Promoting Sustainable Land Use Planning and Urban Design

Minimise Demand for and Use of Land Resources	➢ Optimise opportunities for low-carbon living and business at an early planning stage for NDAs and comprehensive redevelopment areas ➢ Promote comprehensive mix-use developments for better synergy ➢ Optimise the use of scarce land resources (e.g. cavern/ underground space developments, brownfield sites and land use reviews) ➢ Bring jobs closer to homes to reduce/ shorten trips ➢ Concentrate population and economic activities within walkable distance of public transport stations and nodes to reduce the need for commuting and private car trips ➢ Integrate recreational and community farming into the built environment
Smart and Green Planning and Design at Different Scales	➢ Smart homes and smart living ➢ Incorporate smart measures for ageing in place more safely with greater independence ➢ Promote smart and green measures in new buildings and retrofitting existing buildings for various uses ➢ Promote the development of smart and green communities/ districts for incorporating various SGR measures

Promoting Sustainable Land Use Planning and Urban Design

Promote Low Carbon Economy	➢ Further utilise innovation and technology and ICT for smart production and development of smart products and services, and improving work process ➢ Create a supportive tech-ecosystem with sufficient land and space at strategic locations to promote the growth of innovation and technology ➢ Make use of prototypes to demonstrate the positive impacts of the new technologies to facilitate further refinement
Promote Climate Resilient Planning	➢ Create robust, green and resilient communal facilities (e.g. community green stations and recreational and community farming in public parks/ amenity areas) ➢ Promote urban greenery (including the provisioning of urban green space with the use of native trees and other plants), blue spaces and nature conservation to enhance biodiversity ➢ Develop urban design and greening measures to improve air ventilation conditions and reduce heat island effect at the early stage of the strategic planning process ➢ Integrate environmental and urban climatic consideration in planning and building design ➢ Explore the multiple uses of public space for resilience purposes (e.g. emergency assembly points, city cleansing, stormwater retention, etc) ➢ Integrate green buildings, green neighbourhood and green infrastructure initiatives in planning

Fostering Smart Mobility

Transport Infrastructure	➢ Promote a rail-based and multi-modal public transportation network with emphasis on green mobility ➢ Expand rail options and services to formulate a resilient transport network system that is capable of accommodating disruption and changing circumstances ➢ Enhance walkability, age-friendly/ inclusive pedestrian space, easily accessible daily necessities and direct links to transport nodes ➢ Foster a cycle-friendly environment through comprehensive cycling network with supporting facilities such as underground cycle parking areas and cycle sharing facilities ➢ Foster a seamless integration of walking, cycling and public transport system
Transport Management and Operation	➢ Promote an integrated intelligent transport system in a single platform for managing real time traffic flow, pedestrian flow and cargo flow ➢ Encourage a traffic adaptive control system ➢ Disseminate real time traffic information through the use of ICT and sensors ➢ Promote walking, cycling and feeder services to facilitate first and last mile travel ➢ Promote inclusive mobility for the aged and the disadvantaged

Devising an Integrated Smart, Green and Resilient Infrastructure System

Integrated Smart and Green Infrastructure	➢ Promote energy saving, land saving, and synergy between different infrastructures (e.g. effluent reuse, waste-to-energy approach) ➢ Promote sustainable urban drainage ➢ Promote smart waste management ➢ Enhance total water management (i.e. contain growth of water demand through water conservation and smart network management and strengthen water supply by developing new water sources such as desalinated water, treated sewage effluent or recycled water from grey water and rainwater harvesting) ➢ Foster the development of ICT Platform for a smart city
Resilient Infrastructure Consideration	➢ Sustainable drainage system and flood protection system ➢ Retrofit city infrastructure (e.g. drainage and stormwater retention facilities, blue-green infrastructures, transport system, etc) to address climate change ➢ Promote climatic defensive and hazard proof infrastructure with due consideration to their locations, potential for co-location, design and operation requirements ➢ Ensure appropriate siting of critical facilities and infrastructure (e.g. hospitals, major transport routes and utility pipelines) to enhance resilience towards extreme weather conditions and other hazards

7.5 Above all, the concept of "smart, green and resilient" must be embedded in the strategic planning process so as to formulate a holistic approach for an integrated land use and infrastructure planning. In this regard, an integrated smart and green infrastructure system that strategically links up network of physical infrastructure such as integrated waste management, sustainable urban drainage and flood protection, total water resources management, etc is crucial to achieving more efficient use of resources. It should be incorporated as appropriate into the future planning of our city.

7.6 Major new developments, for example: Anderson Road Quarry Site, HSK NDA, the New Territories North development and CBD2 in Kowloon East, for example, are planned with smart, green and resilient measures. Elements of these initiatives, in particular on infrastructure provisions, are interrelated and should be progressively applied to the planning of the NDAs, comprehensive redevelopment areas or even the whole city.

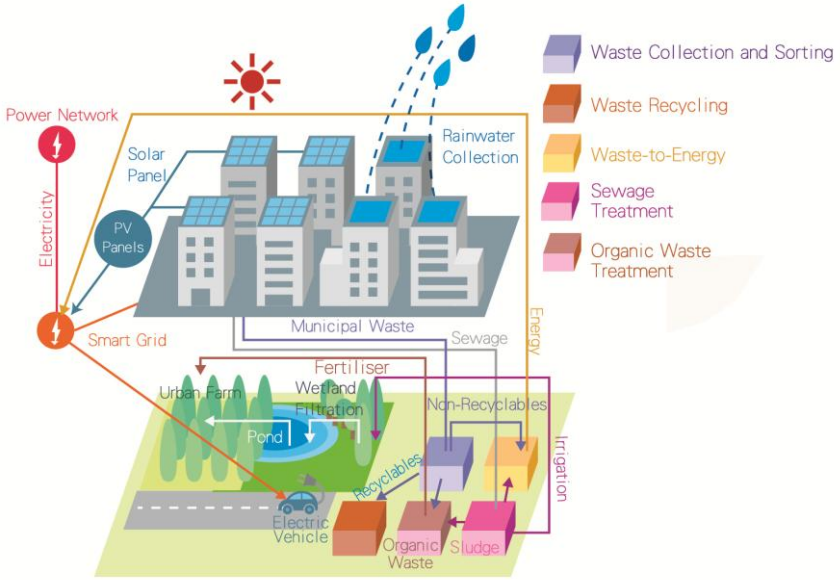


Figure 13 Integrated Smart and Green Infrastructure System

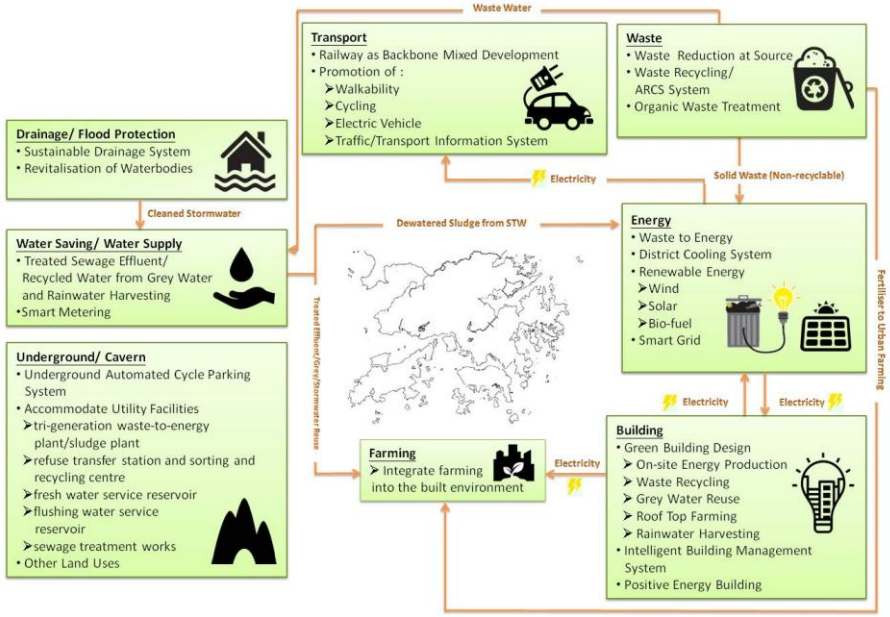


Figure 14 Integrating SGR Initiatives into Major New Developments

8 CONCLUDING REMARKS

8.1 In face of the changing local context, we need a new urban development strategy that can accommodate growth, enhance liveability and strengthen the overall competitiveness of Hong Kong as a global city. Technology and innovation play an important role and enable a new era of city development. Having said that, from a strategic planning perspective, a SGR city strategy for Hong Kong must go beyond the realm of technological development. It should be a holistic strategy which involves a better design and application of both hardware and software. The implementation of the strategy would require constant monitoring and updating. More importantly, as a part of the initiatives to promote innovation and technology in Hong Kong, the development and implementation of such strategy should permeate all levels of the built environment to facilitate urban innovations which enable us to capitalise on the full potential of our city.

8.2 A SGR city would also require concerted efforts of many actors. The Pilot Project at Kowloon East and the upcoming NDAs provide a good test-bed in Hong Kong to identify specific measures that are feasible to be undertaken in our unique urban setting and more importantly to nurture the supportive culture and institutional set up.

8.3 Finally, to promote better quality living, people should be prepared to adapt to a more SGR lifestyle and behavioural change would be necessary. For instance, while intelligent transport system can provide real-time information to enhance integration of different modes of transport, wider use of public transport, cycling or walking would require the willingness of people to adopt a green lifestyle and be more prepared in face of climate change and hazard situations. Collaborative and concerted efforts of the public and private sectors as well as individuals would be essential in pursuit of a smart, green and resilient city in Hong Kong.

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