Low-Carbon and Eco-City
低碳生態城市

Prof. Nora Fung-yee Tam譚鳳儀

City University of Hong Kong香港城市大學

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Hong Kong Science Museum香港科學館

Climate Change氣候變化

Caused by excessive emission of greenhouse gases (GHG)温室氣體, esp. CO_2二氧化碳

- **Sea level rise海平面上升**
- **Temperature increase温度上升**
- **Extreme weather極端氣候**
- **Unstable water resources水資源不穩**

Urban cities都市: Main contributor貢獻

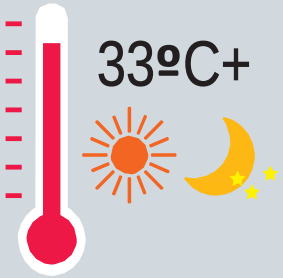
- **Cities, as aggregates of human activities, require energy in a variety of forms but much of the primary energy sources are still fossil-based化石燃料**
- **80% of world's energy come from fossil fuel, burning coal煤, oil油 and natural gas天然氣 releases CO_2: the greatest driver of climate change**
- **Cities cover <2% of earth's surface but consume 78% of world's energy**
- **Contribute 70% of world's GHG (>60% carbon dioxide)**
- **If just 100 of the world's largest cities embark on a low-C低碳 development path, global GHG decrease by 10% a year**

Cities: vulnerable to climate change

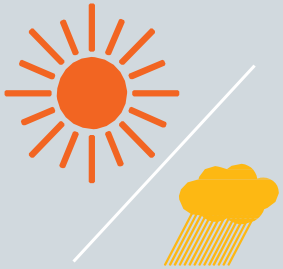
- **Hundreds of millions of people in urban areas across the world, particularly those coastal cities 濱海城市, will be affected by climate change:**
  - **Rising sea levels 海平面上升**
  - **Increased precipitation 增加降雨**
  - **Inland floods水浸**
  - **Extreme weather: more frequent and stronger cyclones 旋風 and storms暴風, and periods of more extreme heat and cold 極熱及極冷頻密**

Hong Kong Climate Change Report 2015

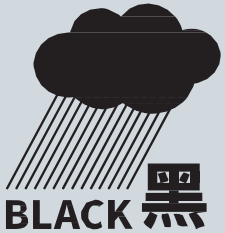
HONG KONG'S CLIMATE IN THE 21ST CENTURY



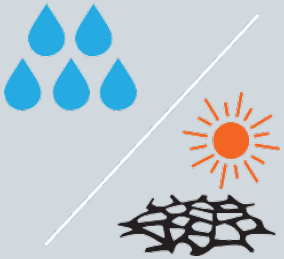
More very hot days and hot nights



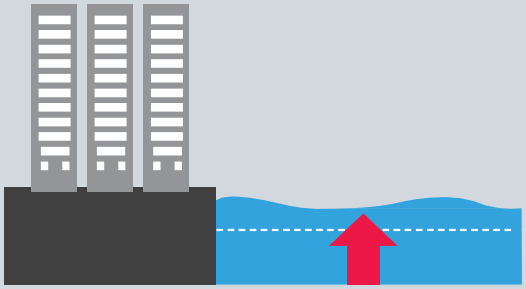
Fewer rain days but average rainfall intensity will increase



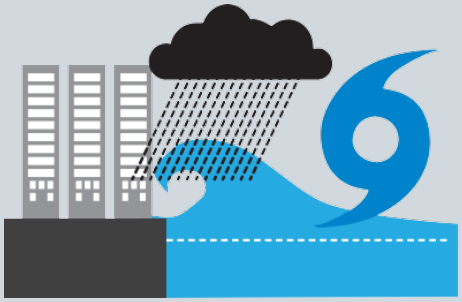
More extreme rainfall events



More extremely wet years but risk of extremely dry years will remain



Global sea level rise will lead to coastal changes all over the world, including Hong Kong



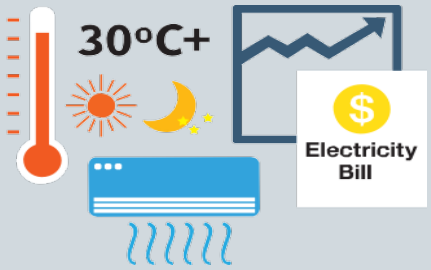
Threat of storm surges associated with tropical cyclones will rise

NEGATIVE IMPACTS

degraded environment and loss/damage

human and economic loss/ damage

extreme weather affects everyone, especially outdoor workers and those living in vulnerable areas



rising cost of living that put most pressure on low income families

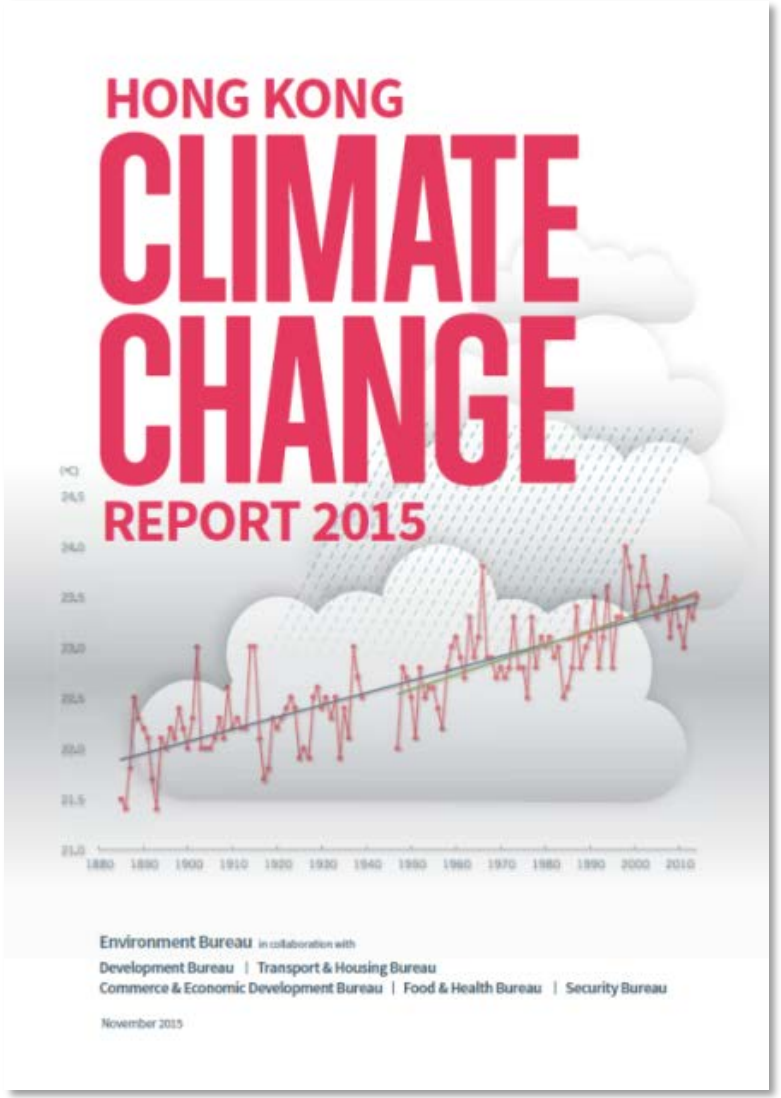
greater health impacts on those living in crowded conditions and risk of infectious diseases

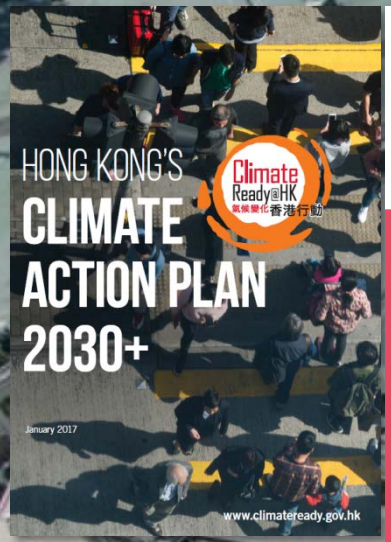
Climate change report 2015

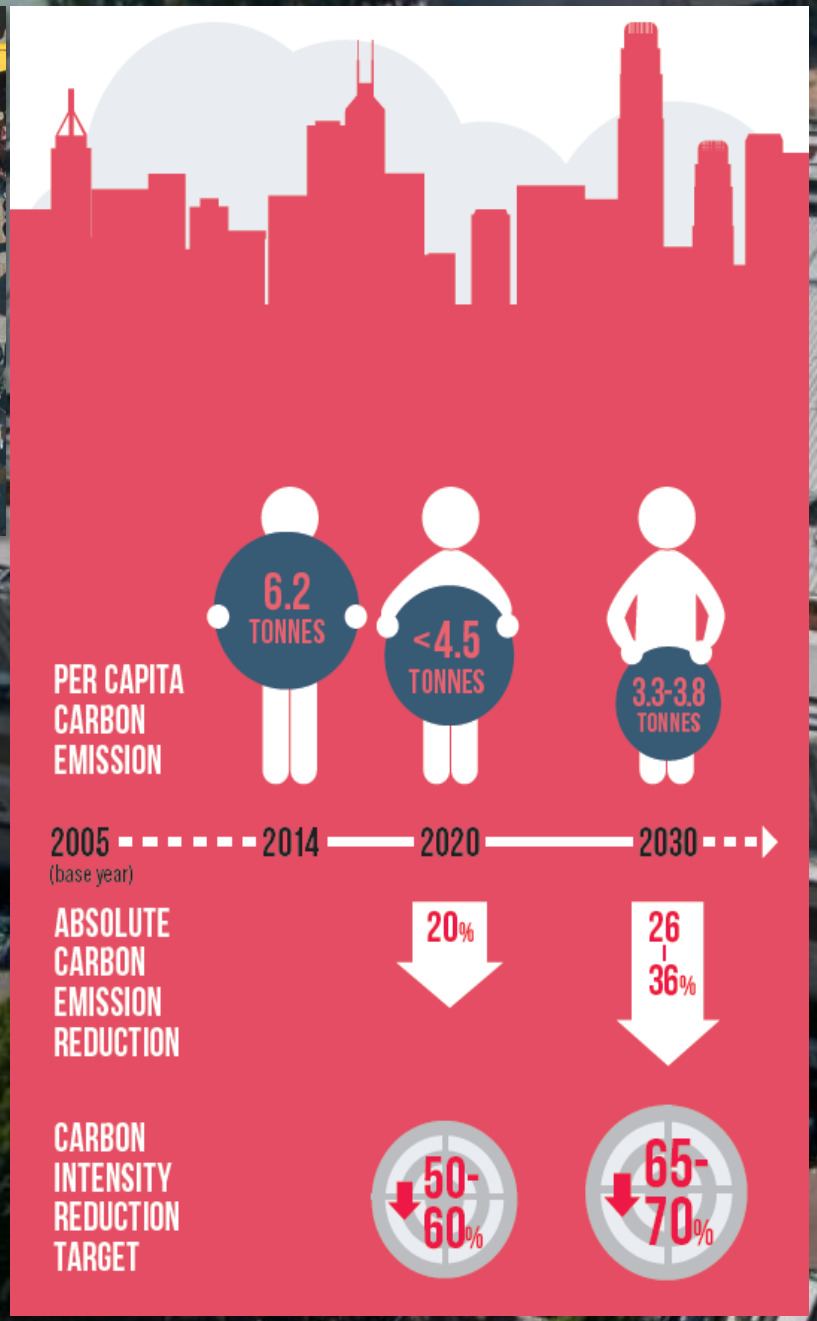
Situation in HK 香港情況

- **Total annual greenhouse gas emission: 44.4 million tonnes 總排放四千四百萬噸,人均排放6.2 tonnes per capita (2013)**
- **Carbon intensity: 0.021 Kg CO_2-e per HK$GDP**
  - **Annual mean temp: increased by 0.17ºC per decade (1986 – 2015) 平均每十年上升攝氏0.17度**
  - **Mean sea level rise: risen by 30 mm per decade (1954 – 2015)) 平均每十年海平面上升30 毫米**
  - **No winter in 2030? How about our four seasons?**
- **Are we ready to combat the pressing Climate Change problem 應對氣候變化?**
  - **Signing the Paris Agreement 巴黎協議in 2016**
  - **Targets and actions to reduce C emission (also to increase C sequestration) 減碳及固碳目標及行動**

Hong Kong Government







To become low-C city
低碳城市

Low-carbon city低碳城市

- **Definition varies as cities differ in their initial carbon endowments and economic activities, e.g., industrial vs service; cold vs hot**
- **Means to change C emission but does not compromise economic development and liveability**
- **A sustainable, efficient, liveable and competitive city with low C emission**

Eco-city生態城市

- **Merge city harmoniously with natural environment: well-planned city layout and green transportation; win-win in development-environment** 城市與自然和諧
- **Produce energy entirely through renewable resources**可再生資源 **and generate renewable energy (RE)** 可再生能源
- **Resource conservation** 資源保育 **: maximizing efficiency of water and energy resources**
- **Ultimate goal: eliminate all carbon emission (zero-carbon city** 零碳城市**) and zero-waste**零廢排放
- **Same as Low-C city, eco-cities also have the intentions of stimulating economic growth, reducing poverty, using higher population densities, and therefore obtaining higher efficiency, and improving health: liveable and sustainable** 宜居和可持續
- **Leading eco-cities: Stockholm (Sweden), Adelaide (Australia), Freiburg (Germany)**

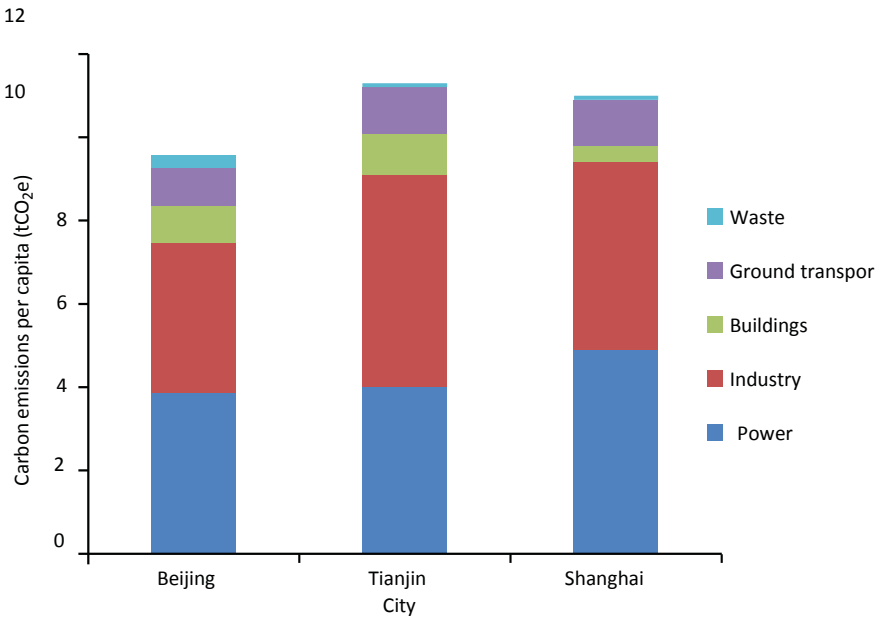
Low-carbon Eco-city低碳生態城市

- **Also call sun city, green city, smart city智慧城市……**
- **A combination of low-C city with ecological goals to achieve zero carbon emission**
- **More comprehensive and more integrated全面而完整**
- **Achieve sustainable development可持續發展**
- **In China (goal set in 2011)**
  - **230 out of 287 Chinese municipal level cities or above (81%) propose Eco-city as city building goal**
  - **133 cities (46.3%) take “low carbon city” as goal**
  - **259 cities (90.2%) put forward low-carbon eco-city goal**

Achieve Low-C Eco-city

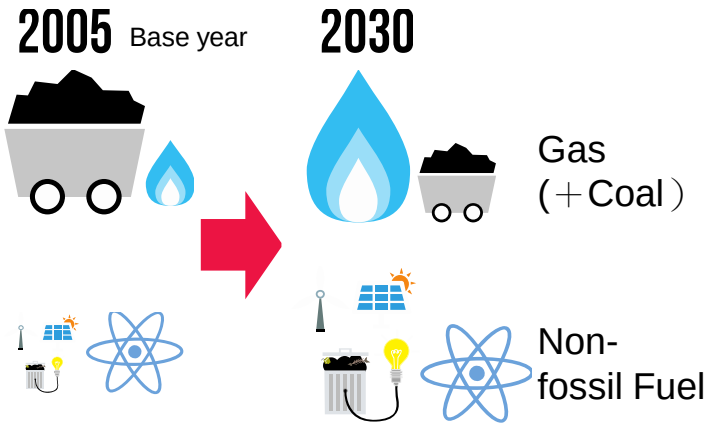
- **Reduce greenhouse gas (GHG), particularly carbon dioxide emission**
- **Sources of GHG in Hong Kong 温室氣體排放源頭 (2013)**
  - **Energy supply: electricity generation發電(68%)**
  - **Transportation運輸 (17%)**
  - **Waste廢物 (6%)**
  - **Others其他(9%)**
- **Similar pattern in other cities in Mainland China, e.g., waste: 5-10%**

Figure 5 Carbon Emissions per Capita in Beijing, Tianjin, and Shanghai (2006 estimates)

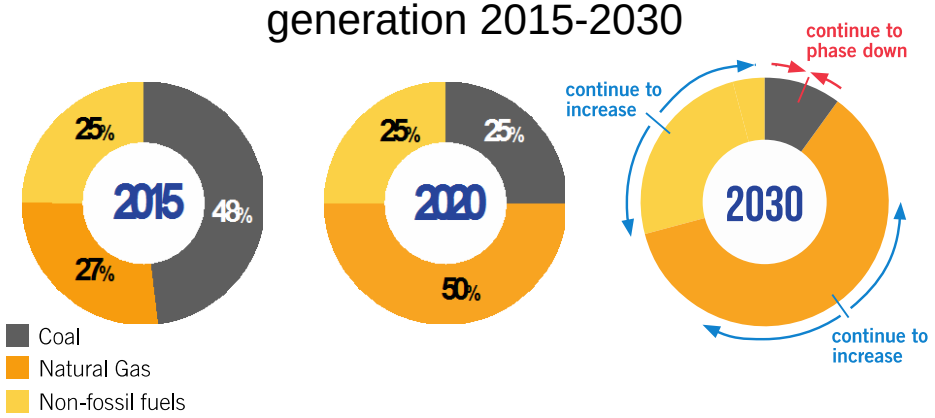


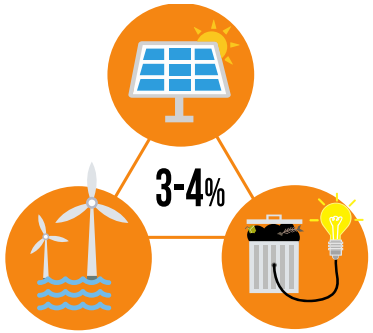
Source: Authors based on data from World Bank 2010 (see also chapter 3).

Reduce C emission: energy supply
能源供應



Reduction of coal in fuel mix for electricity generation 2015-2030





Cleaner energy source: Reduce coal but increase natural gas for electricity generation

Increase RE 可再生能源 to 3-4%, HK Government earmarked $200 million 兩億 for installation of RE in government buildings, schools, venues, communities facilities, etc.

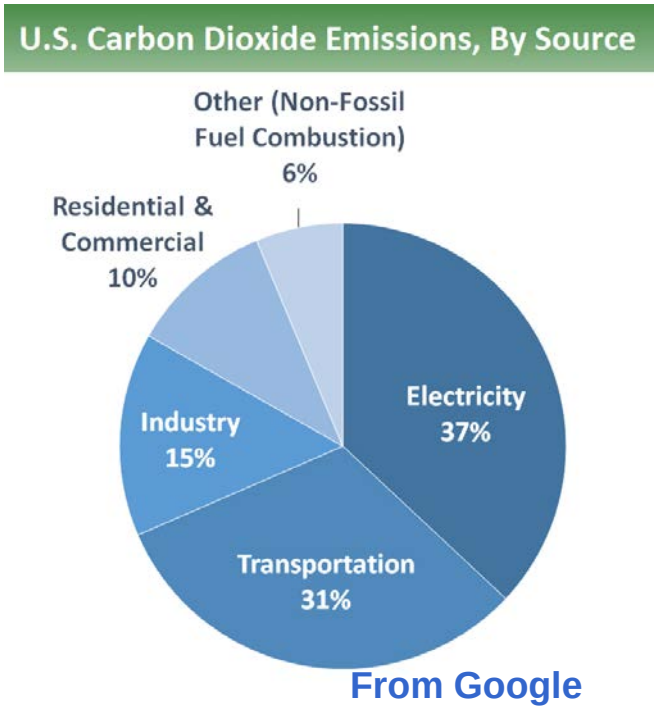
From HKSAR Government report

Energy saving 節能

- **Improve energy efficiency: illumination using LED lighting system, skylight, switch off lights, air-conditioners and other electrical appliances when not needed**
- **Green building: building materials, sun-shading device to façade**
- **Vertical greening 垂直綠化 and roof top greening 樓頂綠化, indoor planting in shopping malls 室內綠化**
- **Promote green buildings, green communities and green districts**

Transportation 運輸

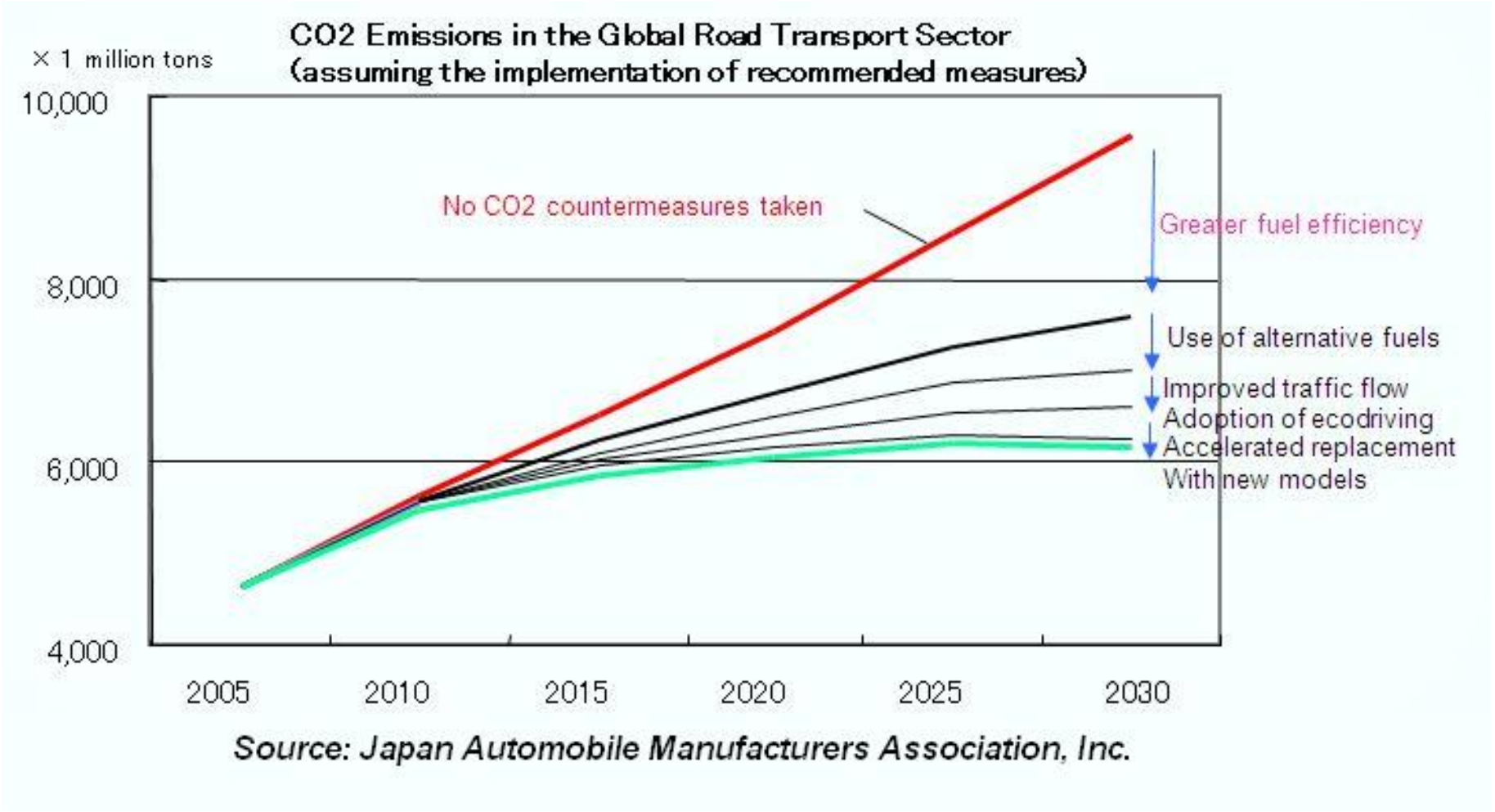
- **Shift to low-carbon urban transport : Mass and public transport, Cycling, Walking (Good network, quality and infrastructure)**
- **Effective traffic management: managing private car growth and size, reduce total level of transport activity**
- **Green transport 環保運輸 : clean vehicles such as electric car 電動車 and energy-efficient vehicles, use biofuel生物燃料 (bioethanol)**



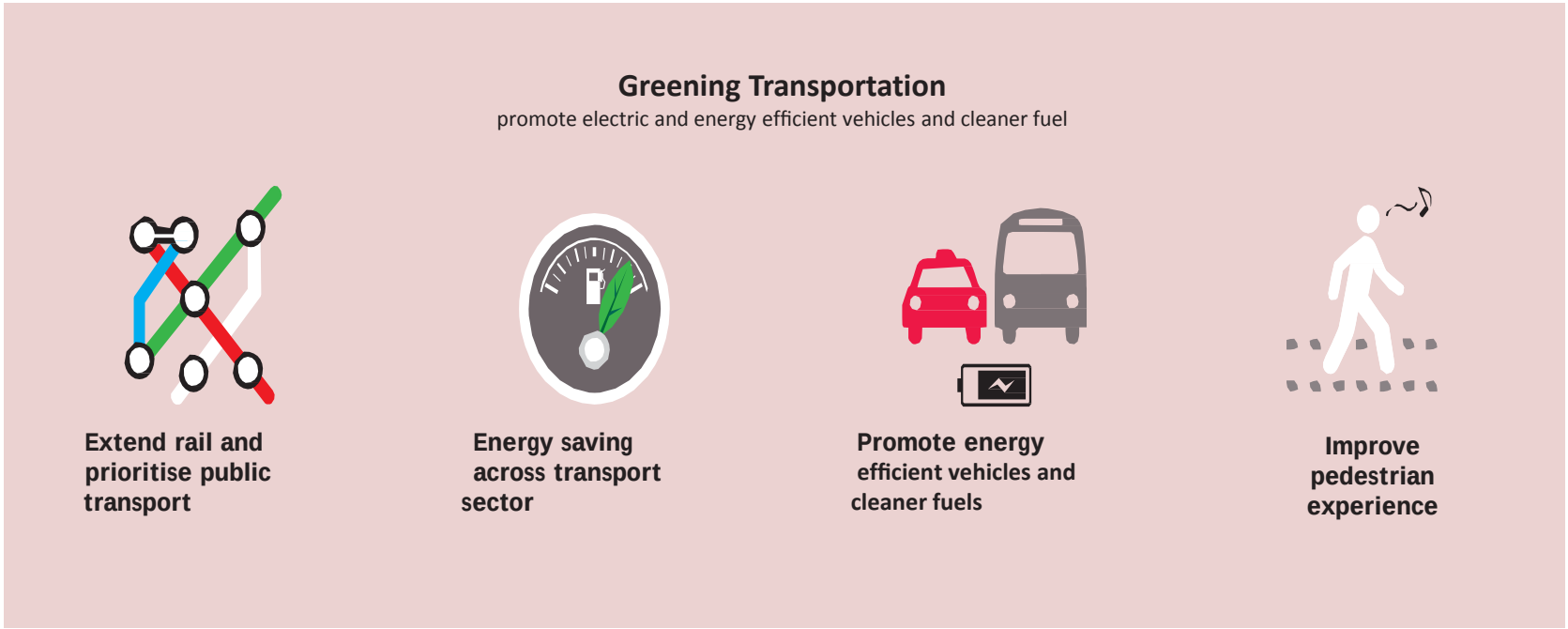
From Google

26% in China

Different means in Transportation to reduce CO_2

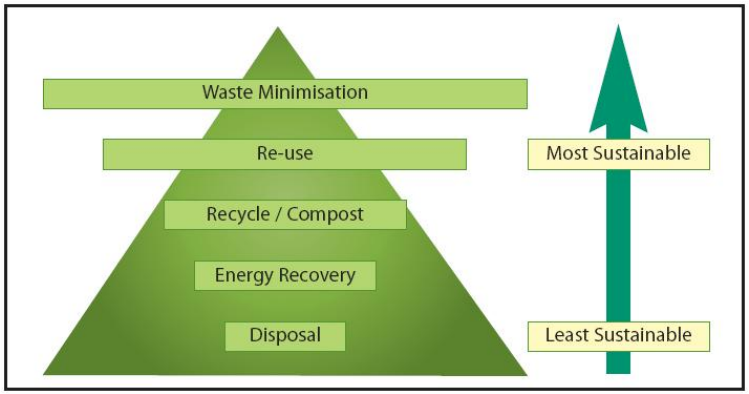


Green transportation in HK (HK Climate Change Report 2015)環保運輸



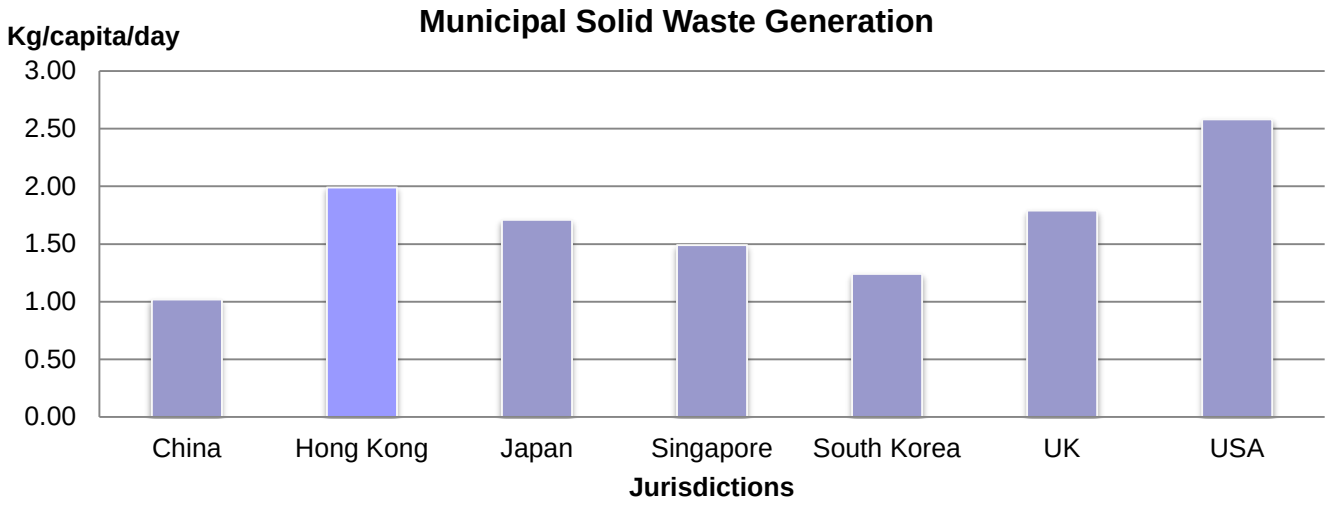
Integrated sustainable waste management
綜合可持續廢物管理

- **Management hierarchy管理等級制度 : waste minimization, source separation and reuse, recycling and composting堆肥, energy recovery and dispose**
- **Waste minimization: user charges (polluter-pay principle)污染自負, increase awareness提高意識**
- **Waste separation (wet vs dry waste) and reuse**
- **Recycling: incentives透因 for recyclables with low local prices, promote market in secondary products, infrastructure基礎設施**



Hierarchy of waste management

HK's generation of wastes
香港都市固體廢物量



MSW production in HK: higher than our neighboring cities with comparable economy

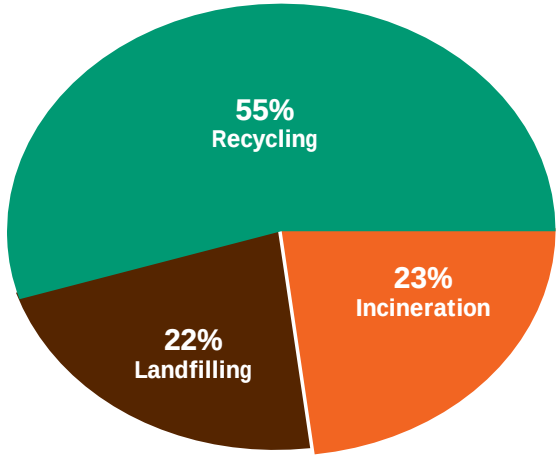
HK people produces 3,648 tonnes food waste daily, 52% landfilling and 48% recycling

Source: WHAT A WASTE - A Global Review of Solid Waste Management by the World Bank (2012)

Source: Hong Kong Blueprint for Sustainable Use of Resources, The Environment Bureau

Waste management in HK

- **Reduce MSW disposal rate by 40% in 2022 (based on 2011)**
  - **Quantity-based MSW charging 按量收費 and PRS (e.g., construction waste and glass beverage bottles)**
  - **Source separation: e.g., separate and collect food waste from wet markets, shopping malls and cooked food centers**
  - **Support on-site food waste treatment: in tertiary institutions and primary/secondary schools**
  - **Food Wise 惜食**
  - **Bring your own bag, bottles…..**
  - **Community green stations綠在區區**
  - **Promote and support recycle industries**



Target at 2022

Generate RE from organic waste

- **Green infrastructure for composting堆肥 and anaerobic digestion厭氧發酵 for organic waste (waste-to-energy) 轉廢為能**
  - **1st organic waste treatment facility (OWTF) to be commissioned in Siu Ho Wan in 2017: food waste小濠灣有機廢物處理設施**
  - **Tendering for 2nd OWTF commenced, for commissioning in 2021**

Generate RE from landfill gas 堆填氣體

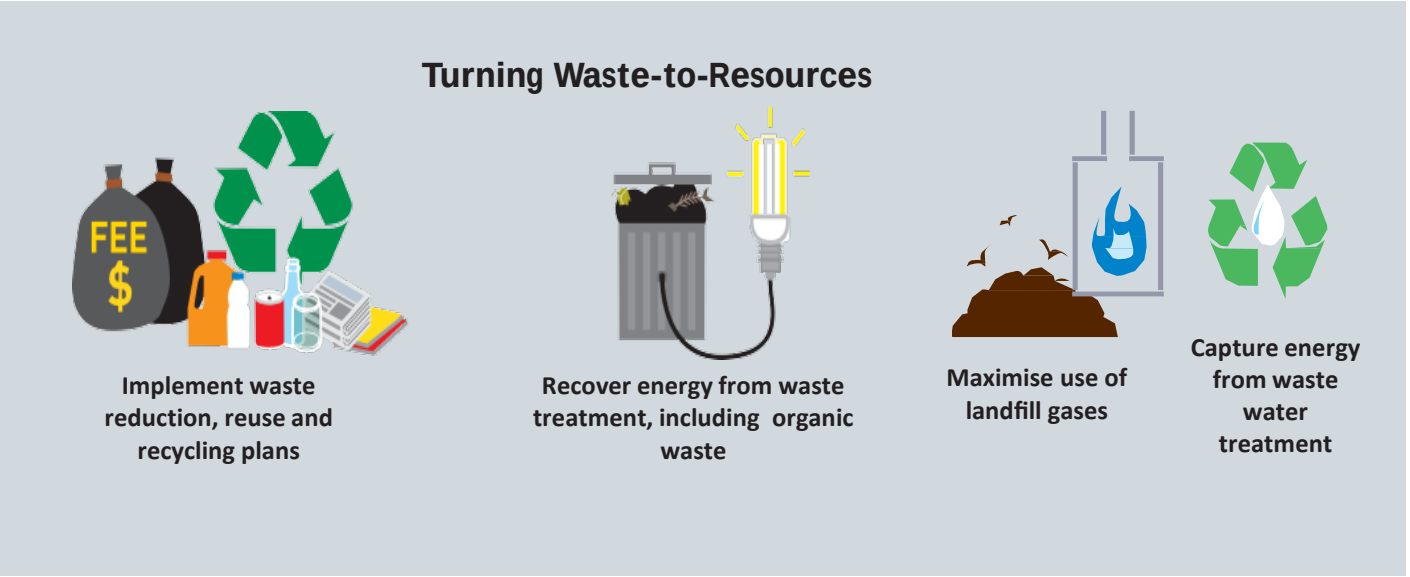
- **Landfill gas (methane沼氣 and carbon dioxide):**
  - **to generate electricity for use in on-site infrastructures, such as offices, maintenance workshop, pumping stations; and**
  - **to power the leachate (wastewater from landfill滲漏液) treatment facilities**
- **North East New Territories Landfill: generate 6415 m^3 gas h^{-1}, surplus gas is delivered to Hong Kong & China Gas (HKCG) 香港中華煤氣有限公司 in Tai Po as alternative energy**
- **South East New Territories Landfill: surplus gas will be treated (in the form of synthetic natural gas) and conveyed to HKCG's Offtake Station at Tseng Lan Shue, where treated gas will be blended with town gas**

RE from wastewater treatment

- **Low-energy anaerobic digestion to produce biogas低耗能厭氧處理產生沼氣: Biogas in Shatin, Tai Po, Shek Wu Hui, Yuen Long**
- **Solar farm at Siu Ho Wan Sewage Treatment Work**
- **Sludge treatment facility: T-park regenerates heat from incineration of sludge 淤泥焚化, incineration could be CO_2 neutral and minimize carbon emission from sludge disposal**

From HKSAR website

Turning waste to resources in Hong Kong (Hong Kong Climate Change Report 2015)



In 2022:

- **Turn 1,599 tonnes sludge into energy**
- **Turn at least 500 tonnes of food and organic waste into biogas and compost**
- **Prevent 3,900 tonnes of MSW being landfilled**
- **Turn 3,000 tonnes of MSW into energy**

Smart and green infrastructure for wastewater
智慧環保污水處理基礎設施

- **Efficient wastewater treatment: Reduce city's carbon footprint減少碳足跡 and energy consumption低耗能**
- **Decentralize treatment facility, so energy generated such as biogas from anaerobic digestion can be reused on site**
- **Reuse treated effluent, e.g. Ngong Ping**
- **Household or community level gray-water capture and recycle中水(洗盥污水)回收循環再用**
- **Alternate treatment technology with multiple functions 多功能另類處理技術, e.g., constructed wetland人工濕地**

Constructed wetland 人工濕地

- **Holistic and integrated approaches整體綜合處理: storm water protection, flood management and wastewater treatment**
  - **Solve wastewater pollution problem**
  - **Reuse treated effluent for non-portable uses非飲用水、再做水**
  - **Carbon sequestration (blue carbon sink藍碳匯)**
  - **Landscaping, leisure uses景觀、 休憩、悠閒**
- **Urban water management: increase efficiency of water resource utilization and protection, achieve “eco-city” vision (green city, clean waters)**

Constructed Wetland

- **Artificial wetland**
  - **create to mimic processes found in natural wetland ecosystems through engineering design**
  - **maximize removal of pollutants from storm water or wastewater**
  - **Create and restore wetland habitat 創造和修復濕地生境**
  - **Enhance aesthetic values 觀賞價值 and biodiversity生物多樣性**

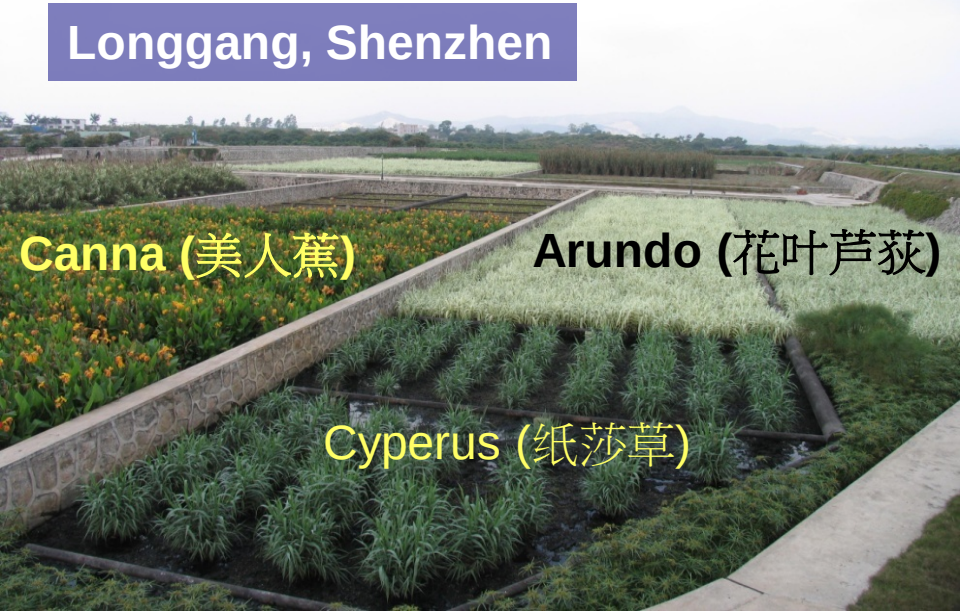
From google

Mainland

Guanlan, Shenzhen

Honghu Park, Shenzhen

Longgang, Shenzhen



Wanning, Hainan

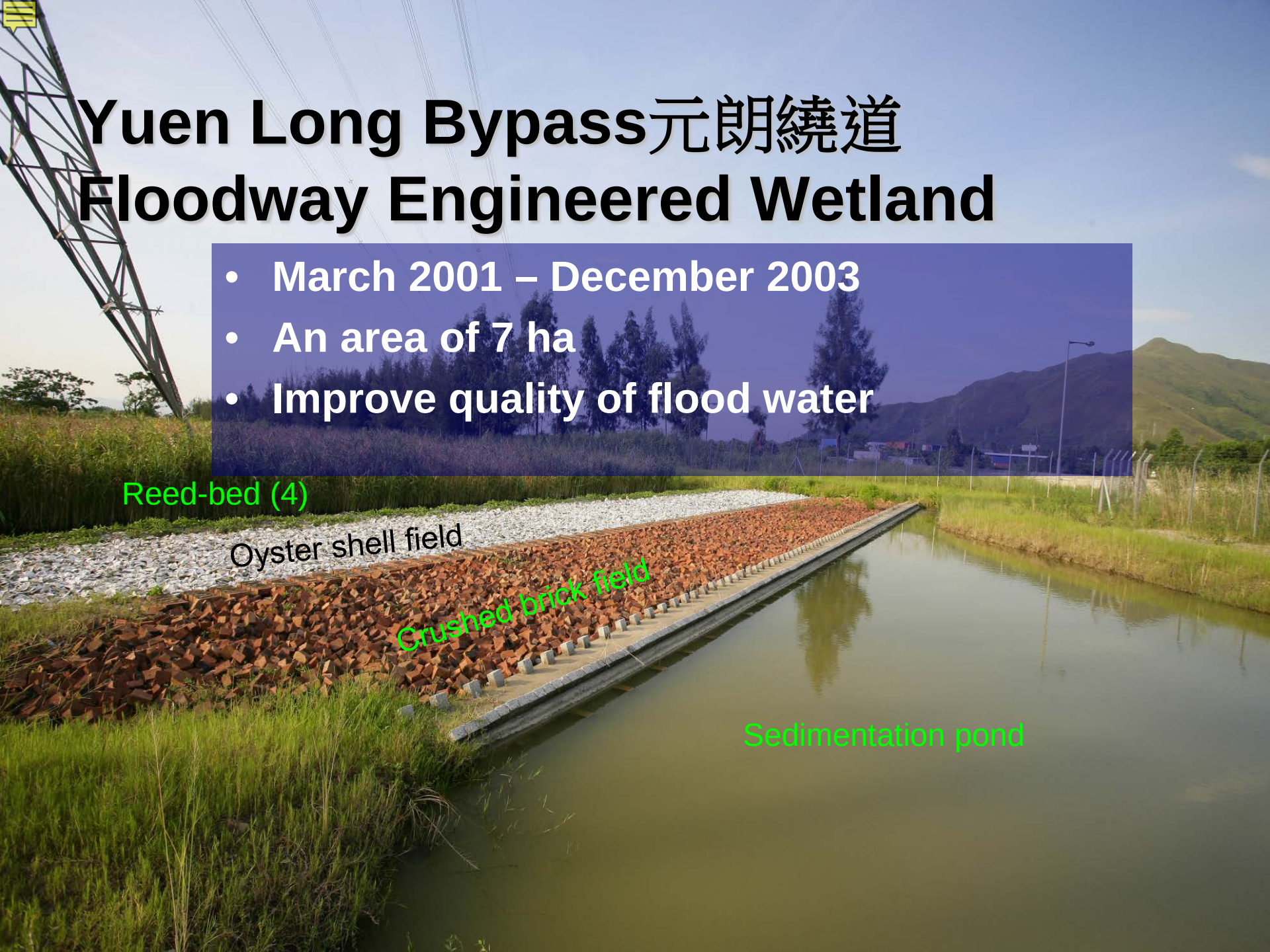
Hong Kong Wetland Park 濕地公園

- **Area: 64 ha. EMA (Ecological Mitigation Area)**
- **Purposes**
  - **Wetland Park: conservation, education and tourism facility**
  - **Reed-bed Filter蘆葦床: storm water runoff polishing**

Reed-bed Filter ~1 ha.

Yuen Long Bypass元朗繞道 Floodway Engineered Wetland

- March 2001 – December 2003
- An area of 7 ha
- Improve quality of flood water



Constructed Wetland at Lok Ma Chou Railway Station落馬洲車站

- An area of 5 ha
- Polishing treated sewage effluent and storm-water runoff
- Additional marsh area for habitat diversity

DSD R&D Study – Treat Village Sewage at Ping Yuen River using

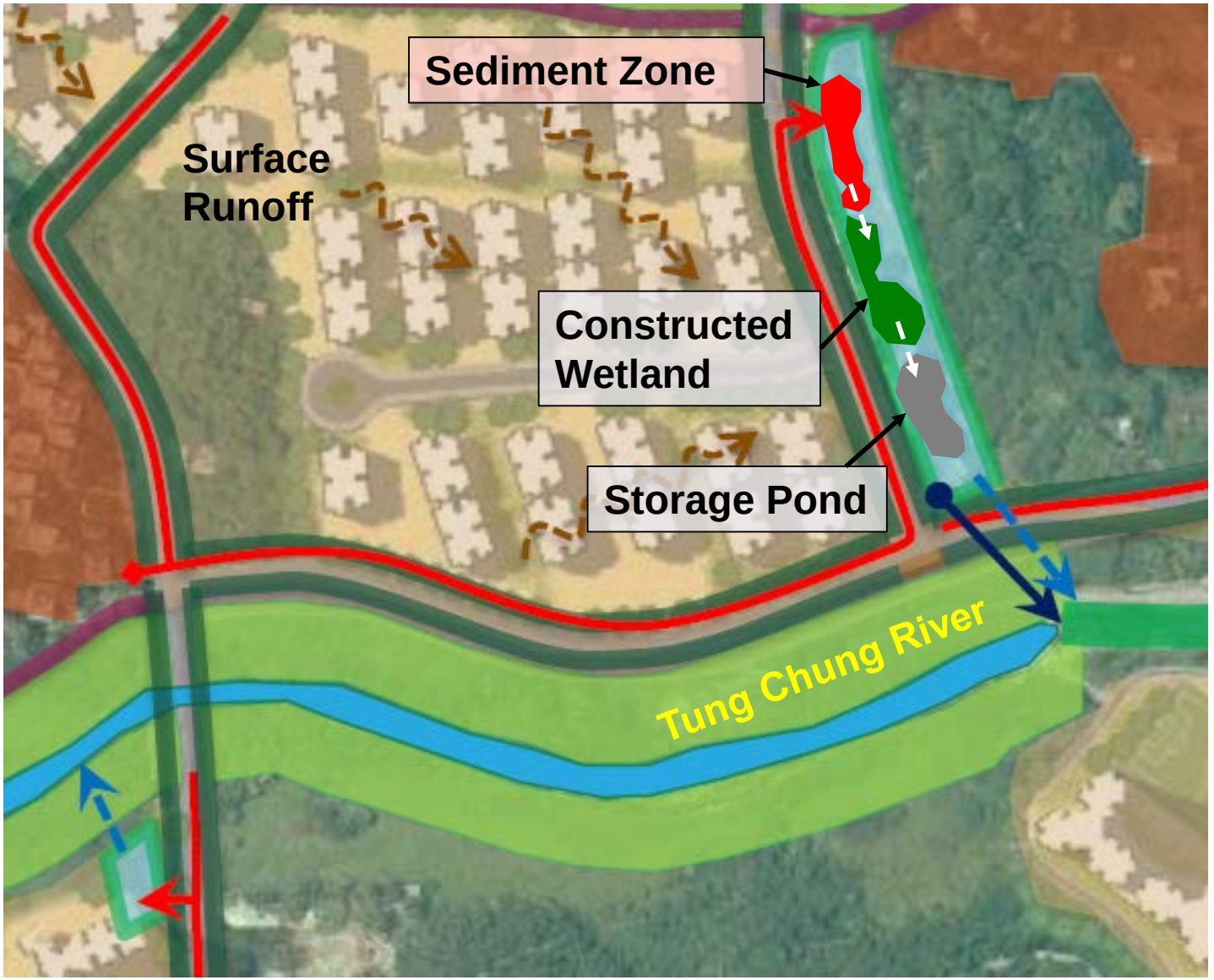
- Constructed in May 2015
- Monitoring in Progress

From DSD

DSD: Potential Site for Further Study – Ma On Kong, Yuen Long

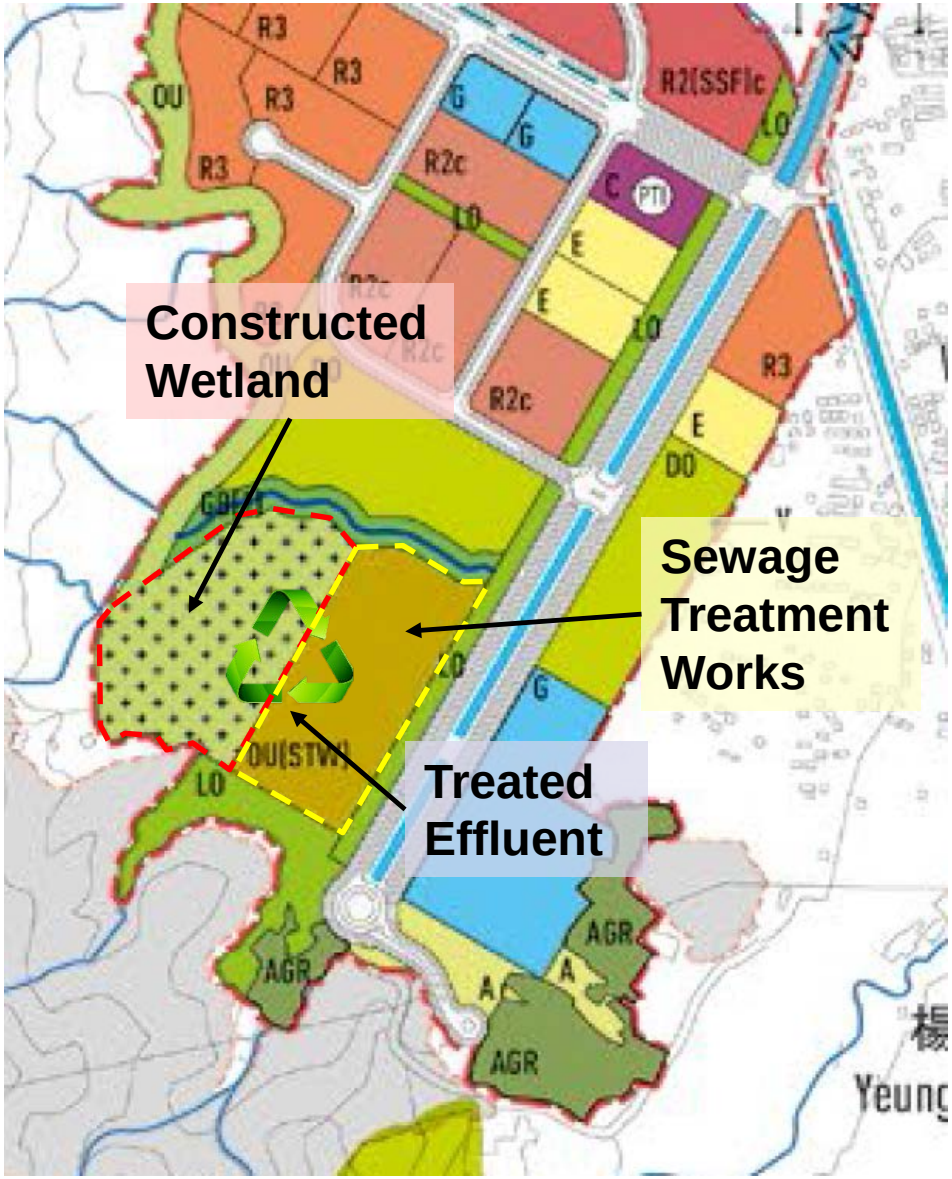
From DSD

Tung Chung New Town Extension (West)



From HKSAR

Yuen Long South Potential Development Area



From HKSAR

Constructed Wetland Plants

- **Most CW use freshwater plants淡水植物:**
  - ***Phragmites* (common reeds 蘆葦)**
  - ***Typha* (cattails)香蒲**
  - ***Canna* 美人蕉**
  - ***Acorus* 菖蒲**
  - ***Scripus* (bulrush)藨草**
  - ***Cyperus*莎草**
  - ***Iris* 鳶尾**
  - ***Eichhornia* (water hyacinths水浮蓮)**
  - **Others**
- **Brackish water 咸淡水or saline water咸水: mangrove紅樹林?**

What are mangroves?

- **Unique inter-tidal wetland潮間帶濕地found in sheltered:**
  - **Tropical and sub-tropical shores**
  - **Transit zone between land and ocean (open system), regular tidal flushing**
- **Ecological functions**
  - **Provide diverse habitats, feeding and breeding sites for coastal and marine animals**
  - **Prime nesting and migratory sites for hundreds of bird species and wildlife**

Mangroves In Mai Po RAMSAR米埔紅樹林(拉姆薩爾濕地)

Education, research, ecotourism

Birds in Mai Po

Photos taken by Prof. Wei Shyy, Provost, HKUST

Mangrove: Green kidney綠腎

- **Nature's kidney in coastal environments**
- **Retain water on land, prevents flooding in wet years and drought in dry years**
- **Store and assimilate nutrients and useful chemicals**
- **Remove harmful materials from water, dilute and filter pollutants from industrial and agricultural discharges, contaminated soil/sediment**
- **Constructed mangrove wetland wastewater treatment紅樹林人工濕地污水處理:**
  - **Low energy requirement低耗能**
  - **Less C emission低碳**
  - **Environmental friendly環保**

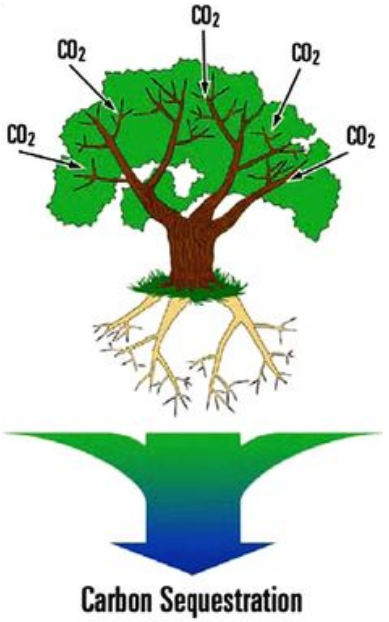
Constructed wetland: landscaping 景觀

- **With proper selection of plants選取合適物種:**
  - **Flowers throughout the years**
  - **No die off during winter**
  - **Beautiful and green**
- **Use landscape area景觀用地, including roof top**
- **Integrate with surroundings of housing estate and buildings**
- **Target for gray water and water reuse中水(洗盥污水)回收重用**

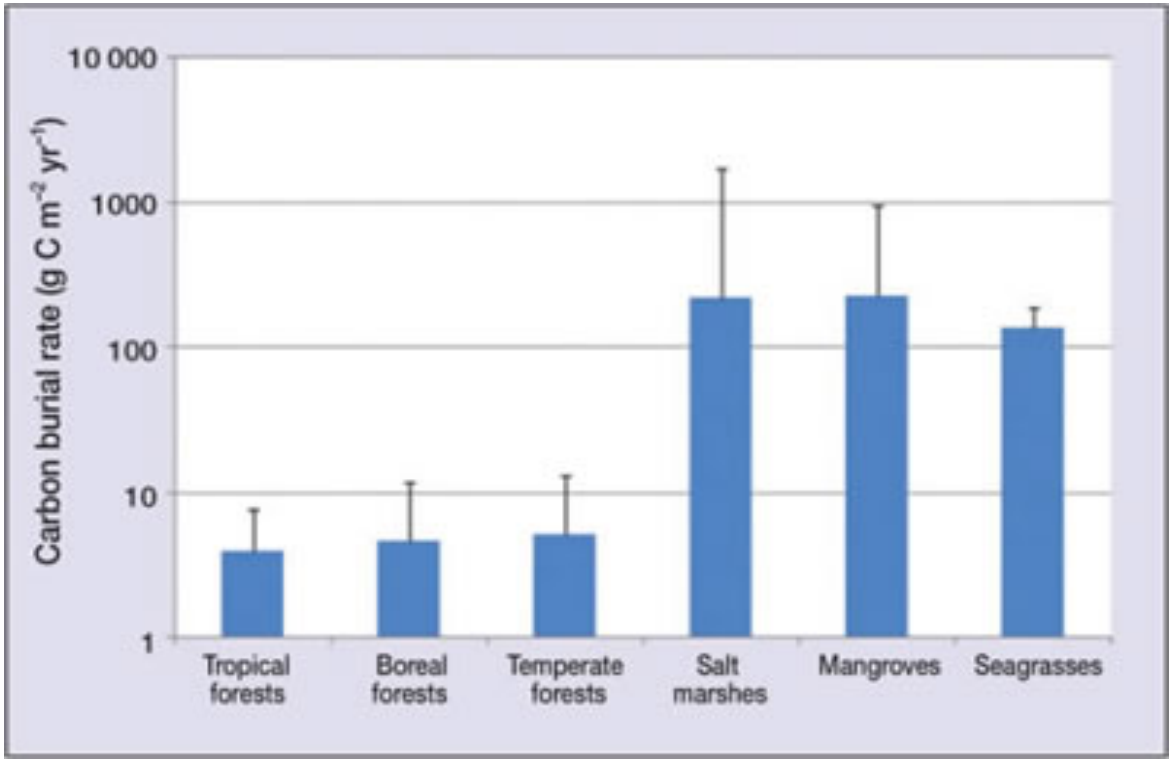
Constructed wetland in Shenzhen

Constructed and natural wetlands: Carbon sink碳匯/庫

- **Absorb carbon dioxide**
- **e.g., Mangroves**
  - **One of the most productive ecosystems and most carbon-rich forests in tropics**
  - **Contain sustainable amount of carbon (1023 kg C m^{-2})**
  - **Per hectare公頃, store up to five times more carbon than most other tropical forests around the world**
  - **Unique and highly efficient approach to climate change mitigation and adaptation**



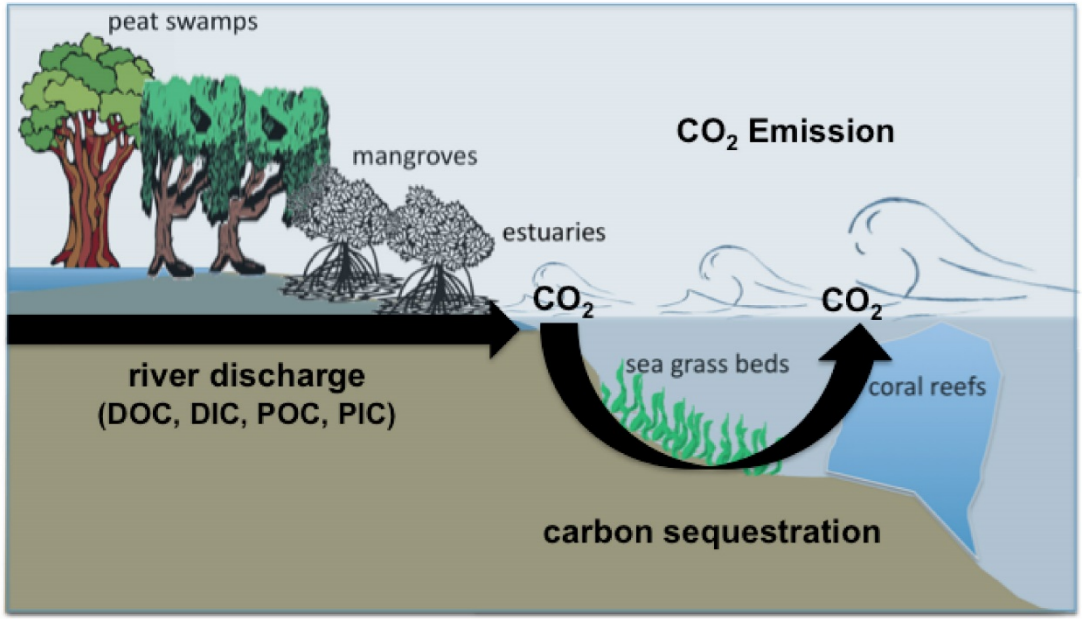
Carbon storage of different habitats



Mean long-term rates of C sequestration (g C m−2 yr−1) in soils in terrestrial forests and sediments in vegetated coastal ecosystems. Error bars indicate maximum rates of accumulation. Note the logarithmic scale of the y axis. (Source: Mcleod et al. 2011. A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering C02. Frontiers in Ecology 9(10): 552-560, DOI.)

Coastal blue carbon海岸藍碳

- **Not only mangroves, salt marshes鹽沼and sea grasses海草床also form much of the earth's blue carbon sink**
- **Coastal plants sequester carbon far more effectively (up to 100 times faster) and more permanently than terrestrial forests固碳比陸地森林高百倍**



From Google

Blue-green infrastructure
藍綠基礎設施

- **Create wetland (retention lakes)建做濕地:**
  - **C sequestration 固碳**
  - **Enhance biodiversity 增加生物多樣性**
  - **Public enjoyment提高公眾享樂、欣賞**
- **Revitalize water bodies活化水體, including drainage channels排水溝, flood retention lakes蓄洪湖, river** 河道
- **Promote vegetated banks植物堤岸**
- **Change river bottom from concrete to natural substrate: increase water recharging**

Fengtan River in Shenzhen after Revitalization深圳風塘河活化後

Revitalize of Kai Tak Nullah啟德渠 and Lung Tsun River 龍津河活化

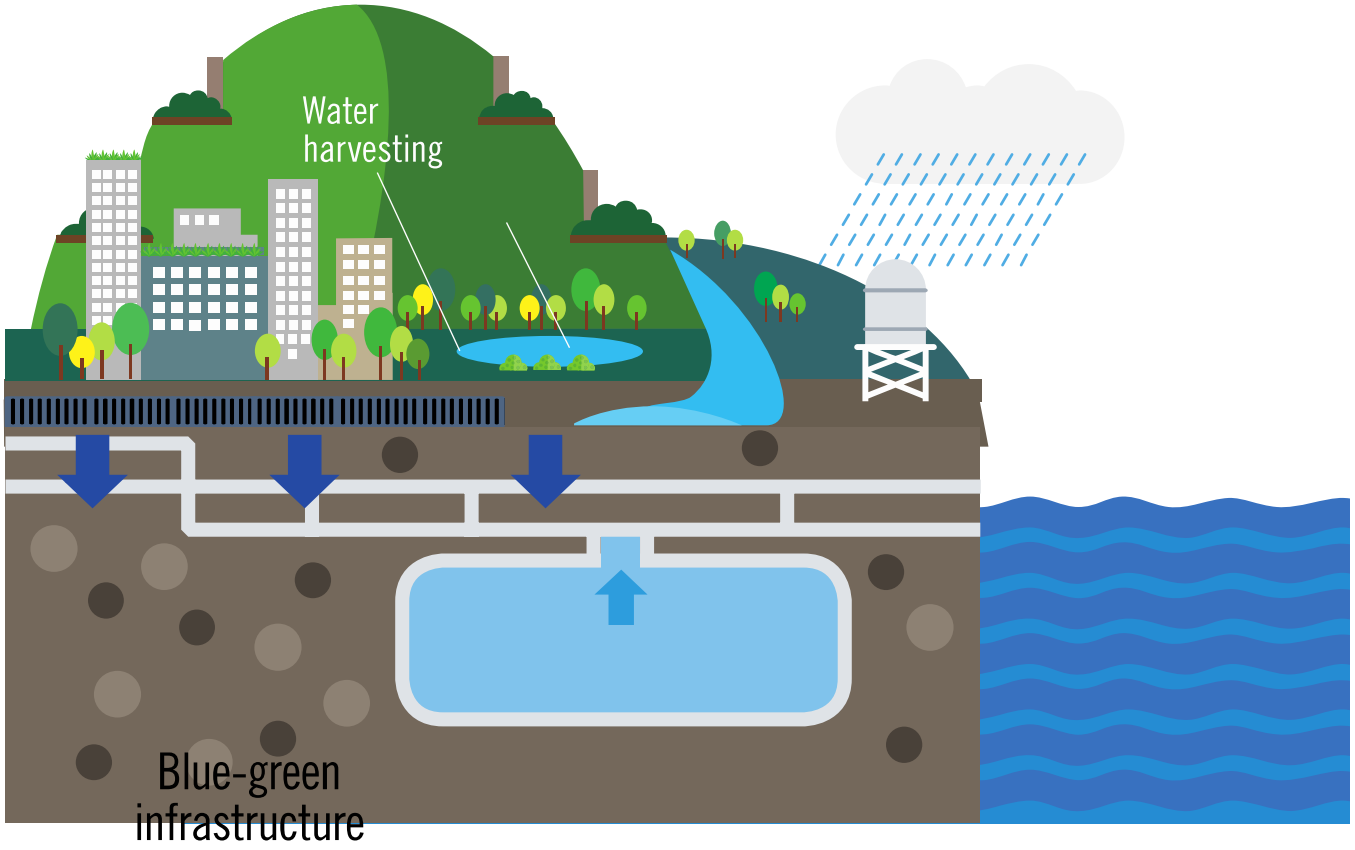
Like Cheonggyecheon清溪川 in Seoul, Korea

Kai Tak River in future

From Google

Cheonggyecheon in Seoul

Re-create wetlands, eco-river channel, vegetated river banks: HK Government Policy address (2017)



Sequester carbon by nature天然固碳

- **Conserve our Country Parks, Marine Parks and natural environments 443** 平方公里郊野公園、**24**平方公里海岸公園、**76**平方公里具特殊科學價值地點及自然保育區等
  - **Absorb CO_2** 吸收二氧化碳
  - **Provide food and water supplies** 提供食物及水源
  - **Regulate microclimates**調節微氣候
  - **Purify water**水淨化
  - **Maintain biodiversity (BSAP)** 維持生物多樣性**(**生物多樣性策略及行動**)**
  - **Enjoyment and leisure (crucial to human well-being and heath)**

Sequester C by urban forests
城市(都市)森林固碳

- **Urban forest: Planned, integrated and systematic approach to manage trees in urban areas (residential, public lands, roadsides, even highway)**規劃綜合系統管理
- **Include woodlands, groups of trees, individual trees**
- **Cover different habitats: streets, parks, even derelict corners** 棄置角落
- **Sequester and store carbon in trunks, leaves and roots**
- **Enhance biodiversity in city** 增加都市生物多樣性
- **Promote environmental health and socioeconomic well-being of urban society: improve quality of life** 改善生活質素

Urban forest and environmental health

- **Reduce GHG emission and carbon footprint**减少温室氣體及碳足跡
- **Mitigate air pollution**緩減空氣污染**and improve air quality**改善空氣負質素 **: remove nitrogen dioxide, sulfur dioxide, carbon monoxide, ozone and particulate matter** 去除氮氧化物、 二氧化硫、 一氧化碳、 臭氧、 微粒
- **Reduce smog and hazy days** 減少烟霧
- **Regulate microclimate** 調節微氣候**, reduce heat-island effect** 減少熱島效應 **by shading impervious surfaces**
- **Decrease air temperature in summer: reduce energy demand and make ambient temperature comfortable**

Success of urban forests

- **Choose right plant species: native and diverse species**選取本地及不同物種
- **Select correct location for planting: suitable habitats and green space planning** 適合足夠生境
- **Promote concepts of urban forestry** 推廣城市森林概念
- **Formulate urban forestry strategy and action** 製定城市森林策略及行動
- **Invest in management practices to ensure long-term success** 投資於管理、實踐

China’s urban forestry

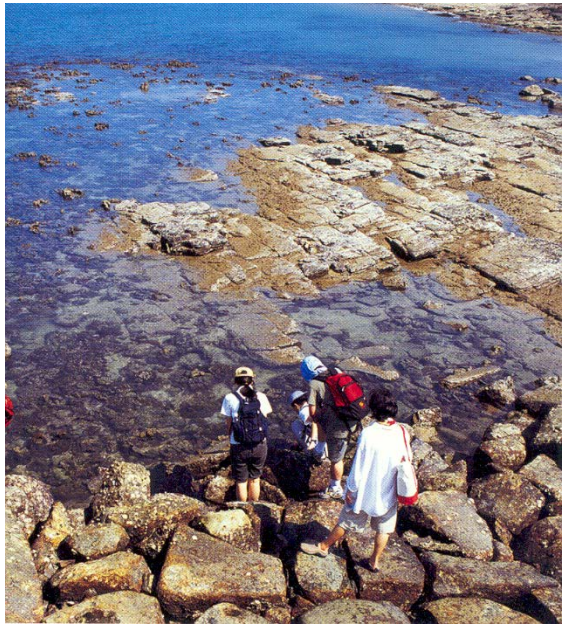
- **Since 1950, Chairman Mao Zedong: a campaign to promote tree and flower planting in areas near cities**
- **In 1981, National People’s Congress: citizen should plant 3-5 tress per year**
- **1982-1992, > 1,000 million trees were planted**
- **2050, coverage of urban forests and trees should expand to 45% of cities’ total surface in 70% of all cities according to China’s National Development Plan**
- **Over last two decades, many Chinese cities have involved in urban forestry, e.g. Jilin in Changchun, Shanghai, Guangzhou**

Natural coastline and eco-shoreline
天然和生態海岸

From HKSAR

Hong Kong coastline

- > 1000 Km natural shoreline
- Beautiful and diverse
- Rock cliffs and rocky shore
- Sandy bay
- Inter-tidal mudflat
- Mangroves

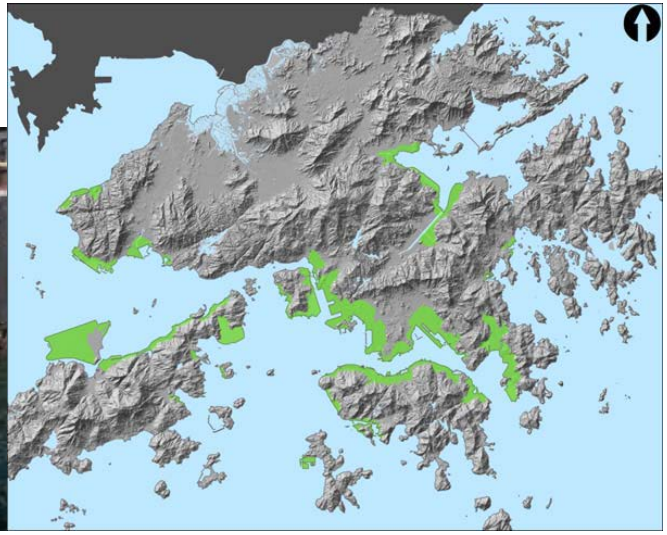


From HKSAR

Artificial shoreline人工海岸

- **Because reclamation填海 (6824 ha shown in green), natural change to artificial shorelines (190 Km)**
- **Vertical-face seawall海堤、防波堤 (low ecological value)**
- **sloping rubble seawall (simulate rocky shore)**
- **Landing step (some barnacles 藤壺)**

From google



Eco-shoreline生態海岸

- **Simulate natural shoreline and create habitats for organisms** 仿造天然海岸提高生境吸引生物聚居
- **Provide benefits to local ecosystem, including C sequestration** 固碳
- **Beautiful and diverse**
- **From concrete**混凝土 **to environmentally-enhanced seawall, e.g., replanting mangroves or grasses on artificial shore**
- **Consider eco-shore in new reclamation projects** 新填海工程 **and/or improve current concrete seawalls**改建現時海堤

Barangaroo in Sydney

Summary總結

- **Climate change causes threats to human and environment** 氣候變化危害人類及環境
- **No single solution to solve global climate change** 沒有單一解決方法
- **But cities have the ability and capacity to deal with it**
- **Smart, green and resilient Low-C Eco-city**智慧、環保、具抗禦力低碳生態城市**:**
  - **Sustainable economic and growth**可持續經濟及增長
  - **Improve environmental quality**改善環境質素
  - **Enhance environmental capacity**提升環境容量
- **Could Hong Kong be a Low-C Eco-city? Do we have sufficient green infrastructure?**

Hong Kong 2030+

- **Hong Kong 2030+: towards a planning vision and strategy transcending 2030 (跨越2030年的規劃遠景與策略)**
  - **Goal: Hong Kong is a liveable, healthy, sustainable and competitive Asia's World City宜居、健康、可持續和有競爭力亞洲國際都會**
  - **Public engagement 公眾參與**
  - **Looking forward to your engagement and your views**

Successfully combat climate change and global warming
成功戰勝氣候變化及全球變暖!

Thank you謝謝!