China and US Case Studies: Preparing for Climate Change

Hong Kong: Improving Coastal Resilience and Managing Urban Heat

Alison Szalwinski and Joanna Lewis

China-US Case Studies Project: This report is part of a series of six case studies (http://www.georgetownclimate.org/US-China-case-studies) that explore how subnational actors (municipalities, states, and special administrative regions) in the United States and China are building resilience to natural hazards, extreme weather, and climate change. These case studies examine efforts to adapt to impacts in three US and three Chinese jurisdictions, including efforts to prepare for: (i) increasing coastal flooding due to more frequent and intense coastal storms and rising sea levels in coastal Louisiana and Shanghai; (ii) increasing water scarcity in Austin, TX, and Beijing; and (iii) increasing heat waves and urban heat islands in Washington, DC, and Hong Kong. These case studies are oriented toward building resilience to the weather and climate related impacts being experienced in each jurisdictions; these actions are not always explicitly linked to climate change, and we do not evaluate the effectiveness or appropriateness of the specific activities undertaken by each jurisdiction.

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Introduction

Surrounded by water and steep, hilly terrain, Hong Kong is vulnerable both to coastal storms and landslides. One of the wealthiest regions of China, Hong Kong has the capacity to take advanced actions to address its climate related vulnerabilities. As a Special Administrative Region of China, Hong Kong has the flexibility to experiment with policies that frequently differ from those of Mainland China.[1] Its experience with coastal resilience may provide useful examples to other parts of coastal China and beyond.

Background

The island of Hong Kong is located in a sub-tropical climate off of China's southern coast. It lies in the center of a typhoon zone, and an average of 2-3 typhoons per year affect the city. The terrain of much of

[1] The Special Administrative Regions of the People's Republic of China are autonomous territories that fall within the sovereignty of the People's Republic of China, yet do not form part of Mainland China.

Hong Kong is hilly and mountainous, consisting of both natural and man-made slopes. Having undergone rapid urbanization, Hong Kong is home to over seven million people and is one of the most densely populated regions in the world. A 2010 study conducted by the Environmental Protection Department of Hong Kong identified several different areas where Hong Kong faces significant vulnerability to climate change and therefore needs effective adaptation strategies. The primary threats identified included extreme temperatures and heat waves, heavy rainfall, sea level rise, high winds, and landslides.[2]

Map of Hong Kong
Source: Google maps

Hong Kong is facing an increasing threat of flooding from typhoons, heavy rainfall, and sea level rise. Hong Kong meteorological observations have shown that average rainfall has been on the rise in the past century and is forecasted to rise 11 percent from an average of 2324 mm per year (91.5 inches/year) in 1980 to 1999 to an average of 2572 mm per year (101.3 inches/year) in 2090-2099.[3] This is a particular issue when combined with storm surges during typhoons. Typhoon Hagupit in 2008 and Typhoon Koppu in 2009 saw record storm surges that flooded the Town Center of the Tai O area of Hong Kong. While so far there is not sufficient evidence to demonstrate a climate-driven increase in the frequency of typhoons

[2] Environmental Resource Management, *A Study of Climate Change in Hong Kong - Feasibility Study: Appendix C - Hong Kong Vulnerability and Adaptation Assessment* (Hong Kong: Environmental Protection Department, December 2010), http://www.epd.gov.hk/epd/english/climate_change/files/1_CC_Final_Report_Eng.pdf

[3] Lennon H.T. Choy, Winky K.O. Ho, and Stephen W.K. Mak, "Toward a Low Carbon Hong Kong: A Proposal from the Institutional Perspective," *Habitat International* 37 (January 2013): 124–29, doi:10.1016/j.habitatint.2011.12.011.

affecting Hong Kong, there is some evidence that the strength and severity of typhoons reaching Hong Kong in the coming years may increase.[4]

Sea-level rise is also causing increased flooding, which is of particular concern since Hong Kong is surrounded by water. Hong Kong's islands (of which there are 263) and peninsulas have 733 meters (1/2 mile) of coastline.[5] Accounts from Hong Kong sources differ on the actual amount of sea-level rise, but the most conservative estimates show that the mean sea-level rise in Hong Kong will be more than 5.7 cm (0.2 feet) by 2030.[6] The Hong Kong Vulnerability and Adaptation Assessment emphasizes that sea-level rise is variable in different locations around Hong Kong, rising at 2.4 mm per year from 1954-2007 in North Point and Quarry Bay, and 2.7 mm per year from 1963-2007 in Tolo Harbor.[7]

Heavy rainfall and typhoons not only impact flooding, but also produce higher risks for landslides in the hilly regions of Hong Kong. Hong Kong's Geotechnical Engineering Office (GEO) has been doing studies of Hong Kong's landslide risks for several decades, and has assessed that "the number of natural terrain landslides would increase exponentially with rainfall intensity" while the situation with man-made slopes, often in need of structural reinforcement, would be even worse. Heavy rainfall in June of 2008 caused over 2,500 landslides on both man-made slopes and natural hillsides, and much of the damage and loss of life resulting from typhoons in Hong Kong are caused by landslides.[8]

A final impact of climate change that Hong Kong must address is extreme temperatures, mainly related to heat rather than cold. Hong Kong has seen a rising number of very hot days, a trend that is projected to continue over the next century at a higher rate than the rate of global temperature increase.[9] This is in part due to the urban heat island effect, where heat is absorbed during the day by buildings and concrete surfaces and then released during the night into the city air.[10] According to the Hong Kong Vulnerability and Adaptation Assessment, the number of hot nights rose from 8 nights per year in the 1960s to 15 nights per year between 1980 to 1999.[11]

Actions to Improve Resilience

Flooding

In response to many of the climate-related threats facing Hong Kong, the government has begun to plan and implement projects to build resiliency. Much of Hong Kong's focus has been on adapting to the impacts of severe weather events, in particular flooding from typhoons and heavy rainfall events. Acknowledging the increasing flood risks posed by heavy rainfall, in 2007 Hong Kong's Drainage

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[4] Kwok Loon Chan, *Climate Issues in Hong Kong: Mitigation and Adaptation*, September 7, 2006, http://www.conservancy.org.hk/monitor/climate/Climate_Issue_Hong%20Kong.pdf; Environmental Resource Management, *Hong Kong Vulnerability and Adaptation Assessment*.

[5] Central Intelligence Agency, "Hong Kong Special Administrative Region of China," *CIA World Factbook*, 2014, https://www.cia.gov/library/publications/the-world-factbook/geos/hk.html.

[6] Mee Kam Ng, "A Critical Review of Hong Kong's Proposed Climate Change Strategy and Action Agenda," *Cities* 29, no. 2 (April 2012): 88–98, doi:10.1016/j.cities.2011.08.001.

[7] Enivonmental Resource Management, *Hong Kong Vulnerability and Adaptation Assessment*.

[8] Ibid.

[9] Chan, *Climate Issues in Hong Kong: Mitigation and Adaptation*.

[10] Ibid.

[11] The criteria for "hot nights" is a daily minimum temperature ≥ 28.0 degrees C (82.4 degrees F). Environmental Resource Management, *Hong Kong Vulnerability and Adaptation Assessment*.

Services Department undertook a large project to build a new drainage tunnel on Northern Hong Kong Island that was completed in late 2012.[12] The Drainage Services Department spent USD $220 million on building the 1.2-kilometer (0.75-mile) main tunnel, a 2.5-kilometer (1.55-mile) branch tunnel, six intakes, a stilling basin[13] and an outfall that are designed to withstand 50-year rainstorms.[14] Hong Kong has several underground storage tanks to absorb runoff during major storm events and prevent flooding, including a large storage facility under the Happy Valley Race Track.[15]

Additionally, Hong Kong has in place an extensive flood warning system, initiated by the Hong Kong Observatory. When the Observatory issues a Red or Black Rainstorm Warning or a Typhoon Warning Signal 8 or above,[16] the Emergency Control Center of the Drainage Services Department immediately goes to work to take preventative measures and remind residents in low-lying areas about the flood risks involved.[17]

Photo of Photo Warning of Slope Upgrading Construction
Photo by Joanna Lewis, Hong Kong, December 2013.

To address the increasing number and severity of storm surges around Tai O, the Hong Kong Civil Engineering and Development Department (CEDD) put in place a new sea wall, completed in 2011, at 4mDP (meters above Principal Datum[18]). The two typhoons of 2008 and 2009 resulted in sea levels of 3.53mPD to 3.77mPD, so the goal for the new sea wall was to prevent surges at those historic levels from occurring again.[19] In 1990, the

[12] Drainage Services Department, *Design and Construction of Hong Kong West Drainage Tunnel* (Hong Kong: Government of Hong Kong, n.d.), http://www.dsd.gov.hk/others/HKWDT/eng/background.html.

[13] The stilling basin is to allow flow collected to steady, and to trap silt.

[14] AECOM, *Hong Kong Drainage Tunnel Completed*, November 12, 2012, http://www.aecom.com/News/Inside+AECOM+News/2012/Hong+Kong+drainage+tunnel+completed.

[15] Happy Valley Underground Stormwater Storage Scheme. http://www.legco.gov.hk/yr10-11/english/panels/dev/papers/devcb1-1798-1-e.pdf

[16] For more information on Hong Kong Tropical Cyclone Warning signals see: http://www.hko.gov.hk/publica/gen_pub/tcws.pdf. For more information on rainstorm warning signals see: http://www.hko.gov.hk/wservice/warning/rainstor.htm.

[17] Environmental Resource Management, *Hong Kong Vulnerability and Adaptation Assessment*.

[18] A Hong Kong surveying term that refers to a height of 1.230m below average sea level

[19] Faith Chan et al., *Rich Delta, Costly Flooding* (Hong Kong: Civic Exchange, November 2010), http://www.academia.edu/566122/RICH_DELTA_COSTLY_FLOODING.

Works Department released guidelines for works projects to take the rate of mean sea-level rise into account when planning and constructing government projects. The guidelines noted the potential for a 10 mm per year rate (0.4 inches/year) of mean sea-level rise resulting from climate change, however it did not issue any binding regulations for projects to follow.[20]

Landslides

Landslides (also called landslips) are a particular area of focus for the Hong Kong government due to the heavy loss of life and property damage they cause. To improve the vulnerability of the man-made slopes, Hong Kong has had in place a Landslip Preventive Measures (LPM) Program since 1976 that recently concluded in 2012. While the risks to the man-made slopes have improved significantly due to this longstanding program, only recently has Hong Kong begun to address the risks to natural slopes that urban development on steep slopes has caused. To this end, Hong Kong began a new rolling Landslip Prevention and Mitigation Programme (LPMitP) in 2010. The LPMitP selects hillsides and slopes for studies and then implements necessary landslip prevention projects in areas under the government's responsibility. Slopes owned by private individuals that are assessed to be in danger are addressed through Building Ordinances.[21] According to the Civil Engineering and Development Department website, the GEO has also begun research into the best use of vegetation as an erosion-control measure as another component of its landslip adaptation agenda.

Photo of Landslide Prevention Terracing and Drainage Gutters along Hong Kong's Slope
Photo by Joanna Lewis, Hong Kong, December 2013.

[20] Environmental Resource Management, *Hong Kong Vulnerability and Adaptation Assessment*.

[21] Civil Engineering and Development Department, *Ongoing Projects: Landslip Prevention and Mitigation Programme (LPMitP* (The Government of the Hong Kong Special Administrative Region, n.d.), http://www.cedd.gov.hk/eng/projects/landslip/land_lpm.htm.

Urban Heat Island

To address the issue of urban heat island, Hong Kong has had an urban greening policy since 2003, strengthened in 2010 by the creation of The Greening, Landscape and Tree Management (GLTM) Section under the Works Branch of the Hong Kong Development Bureau. According to the Hong Kong government website, the Works Branch has "developed strategies which aim to improve the coordination and effectiveness of greening efforts within the current regime, and to make greening an integral part of future public works projects."[22] According to Sarah Liao, the Secretary for the Environment, Transport and Works, these efforts have increased the total amount of greened area in urban Hong Kong by 130 hectares since 2003.[23] Finally, similar to its well established warning system for heavy rain and typhoons, Hong Kong issues health warnings for times of extreme heat or cold and puts particular emphasis on information and services for the elderly during periods of extreme heat.[24]

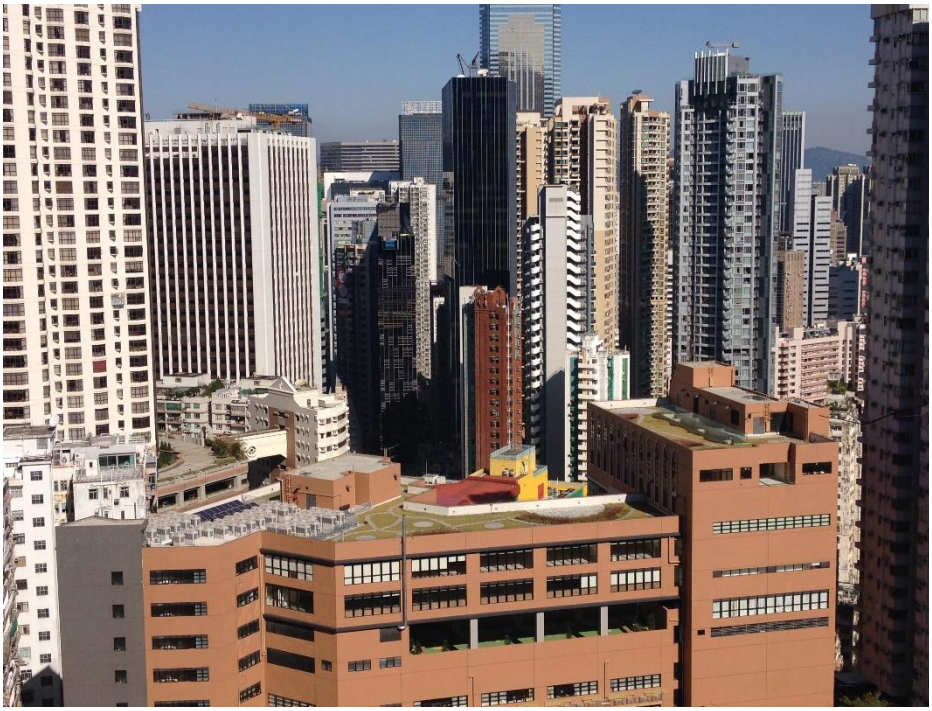

Photo of Green Rooftops in Hong Kong.
Photo by Joanna Lewis, Hong Kong, December 2013.

Lessons Learned

Critical assessments

The policies Hong Kong has implemented to improve the city's resilience represent an important step in addressing threats posed by climate change. Some experts have questioned the efficacy of some of the programs, however, and point out the need for certain improvements to existing policy. The Hong Kong Vulnerability and Adaptation Assessment itself asserts that the efforts to reduce urban heat island are not yet stringent enough and it calls for mandatory requirements on new building codes and guidelines.[25] A critical review of Hong Kong's Climate Change Strategy and Action Agenda called for the government to

[22] Development Bureau, *Urban Greening Efforts in Hong Kong*, Hong Kong Legislative Council meeting (Hong Kong: The Government of the Hong Kong Special Administrative Region, November 2, 2005), http://www.devb.gov.hk/en/publications_and_press_releases/press/index_id_3526.html.

[23] Ibid.

[24] Environmental Resource Management, *Hong Kong Vulnerability and Adaptation Assessment*.

[25] Ibid.

go beyond listing the vulnerable areas and adaptation options, and called for a risk assessment to determine spatial and sectoral impacts. The authors assert "the proposed adaptation options and measures are rather skeletal including only very broad directions such as monitoring, institutional strengthening and capacity building, disaster management and emergency planning, research and investigation and education and public awareness." [26]

Lessons for National Governments

While there is still a need to improve existing policies and mandates that affect climate resilience, several of Hong Kong's successful programs could provide a useful model to the central Chinese government and to other sub-national governments throughout China and the world. Hong Kong's large-scale initiation of assessments to understand its vulnerabilities to climate change provides a useful starting point to begin identifying adaptation measures. In addition, Hong Kong's well established and broad spectrum of warning signals for a number of dangerous events, including heat waves, typhoons, heavy rain, flooding, landslides, health hazards, and high wind, can be an easily replicable step for notifying the public when they are in danger and helping them take preventative action against harm.

The importance of local government leadership on climate change is stressed in a report on adaptation measures issued by a group of Hong Kong businesses. Their report found that in addition to regulation, the government "can exercise the power of example… and the power of the purse," and that "[t]hese actions—without or prior to regulatory requirements—can persuade businesses to conduct their own inquiry and investment programs."[27] As a hub of business for China, the adaptation policies set by the Hong Kong government can influence businesses both on the mainland and around the world to adopt their own adaptation initiatives or encourage other governments to take similar measures.

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Prepared by Alison Szalwinski and Joanna Lewis. Please contact Joanna Lewis (jil9@georgetown.edu; https://sfs.georgetown.edu/Joanna-Lewis) with any questions.

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[26] Ng, "A Critical Review of Hong Kong's Proposed Climate Change Strategy and Action Agenda."

[27] Climate Change Business Forum, *The New Normal: A Hong Kong Business Primer on Climate Change Adaptation* (Business Environment Council, April 2013), http://www.climatechangebusinessforum.com/en-us/research_04292013.