

Article

Assessing the Disaster Resilience of Megacities: The Case of Hong Kong

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Abstract: Many megacities are facing potential threats from various disasters, especially in the face of climate change. However, evaluating the resilience of megacities is not well established in both the academia and practice field. Using Hong Kong, which is a megacity ranked as the city in Asia with the highest risk for natural disasters, as a case study, we demonstrated the effort of assessing the resilience of a megacity. The Sendai Framework Local Urban Indicators Tools that was developed by the United Nation Office for Disaster Risk Reduction (UNISDR) was adopted as the main tool in this study, and a mixed bottom-up participatory and top-down method was utilized in the evaluation process. This is an innovative and participatory approach that is not commonly adopted in assessing the resilience of cities. The study found that Hong Kong is disaster resilient in that it mainstreams disaster risk in its development and that it dedicates sufficient financial resources. However, Hong Kong may improve on its disaster governance and encourage cooperation between the government and society to identify disaster risk and share information, particularly in the face of climate change and calls for more sustainable development.

Keywords: Hong Kong; disaster risk reduction; resilience; UNISDR Sendai Framework

1. Introduction

Cities are the primary habitation of human beings. According to the United Nation (UN)'s most recent Word Urbanization Prospects, 54% of the world's population lived in urban areas in 2014, and this number is expected to increase to 66% by 2050 [1]. Moreover, cities are responsible for 70% of the global GDP [2]. Disasters and catastrophic events are threatening the safety and the sustainability of cities. Both nature-induced and human-made disasters can disrupt everyday life, causing economic loss and infrastructure damages, as well as the injury or loss of human life. They not only create immediate humanitarian crises but also affect the development of a city in the long term. The rethinking of the concepts like vulnerability, resilience, and sustainability may encourage city planners to integrate disaster mitigation into the recovery process and reshape the development philosophy of a city. Building a sustainable city requires increasing its resilience to disaster and catastrophic events [3]. Disaster resilience provides a framework for understanding, assessing, and managing disaster risk [4,5].

Resilience is 'an umbrella concept for a range of system attributes that are deemed to be desirable' [6]. The definitions of resilience vary according to different academic disciplines and their applications of the concept [4,7]. In the area of disaster risk reduction (DRR), resilience refers to the ability of a system to avoid suffering irreparable damage from disasters [8]. For a city to be resilient,

it should be able to reduce hazards and withstand disasters [8,9]. Wamsler and colleagues (2013) suggest that a disaster resilient city can be understood as a city that can reduce or avoid current and future hazards, reduce current and future susceptibility to withstand hazards and establish functioning mechanisms and structures for disaster response and disaster recovery [10]. Specifically, the United Nations Office for Disaster Risk Reduction (UNISDR) defines resilience as *“The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions”* [11].

When considering the significance of cities and the importance of resilience to cities, building city resilience has become a global campaign in the last decade, with strong support from separate UN divisions (UNISDR, UNDP, and UN-Habitat) and international development agencies, like the Department for International Development (DfID) of the United Kingdom [2]. Within these city resilience propagating activities, the 100 Resilient Cities Network that was pioneered by the Rockefeller Foundation and the UNISDR’s ‘Making Cities Resilient’ campaign, are the two most influencing ones [8,12]. The UNISDR’s city resilience programme sketches the necessary characteristics of a disaster resilient city. If a city has an inclusive, competent, and accountable local government that is concerned with sustainable urbanization, and that commits the necessary resources to developing capacities to manage and organize itself before, during, and after a natural hazard event, the UNISDR would define it as a resilient city [13]. Though many cities all over the world have joined either the 100 Resilient Cities Network and/or the UNISDR’s ‘Making Cities Resilient’ campaign, and many of them have submitted their strategic plans, rarely have their city resilience been examined systemically. This is particularly so among the megacities.

Hence, this paper attempts to contribute to current knowledge by providing an in-depth analysis of a megacity’s resilience using Hong Kong as a case. Asia is the world’s most disaster-prone region [14], as far as we know, this is the first effort of assessing city resilience of a big city in Asia, though there are some cases in Europe [15,16] and some efforts at the micro community level in Asia [17]. Therefore, we believe that this paper can enlighten future studies about city resilience and sustainable development.

2. Methods

2.1. Risks and Disaster Management in Hong Kong

Since 1997, when Hong Kong returned to the Chinese sovereignty after a century of colonial rule, the city has been a special administrative region of the People’s Republic of China. This vibrant metropolis is located in the Pearl River Delta region (PRDR) of the southern part of China, and is one of the leading financial centers in the world [18]. In 2016, the population of Hong Kong was approximately 7.34 million. People of Chinese descent comprise the vast majority of the population, with foreign nationals comprising only 8.6% of the populace. The city’s economy is characterized by free trade, low taxation, and minimum government intervention. Hong Kong is the world’s eighth largest trading economy, and, as of 2016, it has a labor force of around 3.945 million [19]. According to the World Economic Forum’s Global Competitiveness Report 2017–2018, Hong Kong is ranked the sixth most competitive economy in the world [20].

Hong Kong faces various natural hazards every year. The types of natural disasters in Hong Kong include exceptionally heavy rainfall, storm surges, thunderstorms, and tropical cyclones [21]. These events cause floods, landslides, and other incidents, with the potential of severe casualties and the devastation of transportation and other critical infrastructures. Hong Kong has been ranked as the city with the highest natural disaster risk in Asia, according to the inaugural Sustainable Cities Index [22]. Fortunately, Hong Kong has not had a large-scale natural disaster that caused significant economic losses or human casualties in more than five decades. The last major natural disaster was the storm surge of Typhoon Wanda in 1962, which killed about 183 people and claimed the third place on the list of Hong Kong’s deadliest typhoons since 1884 [23]. This low incidence of natural disasters

has indeed led to a more complacent outlook and a predisposition towards low levels of disaster preparedness among Hong Kong people [24–26].

However, the global weather has become more unpredictable due to climate change [27,28]. Cities around the world are attempting to address these new and unprecedented climate challenges. Hong Kong is not exempted from these concerns [29,30]. In 2015, the Hong Kong government released its first Climate Change Report, which highlights Hong Kong's efforts to cope with climate change and describes the challenges of the city in response to extreme weather conditions [31]. These challenges include significant increases of temperature, rainfall, and sea levels. The current Chief Executive (then Chief Secretary for Administration) spearheaded a Steering Committee on Climate Change in early 2016, which called upon ten policy bureaux and three departments to outline the long-term policies for Hong Kong in this regard [32].

Despite few catastrophic natural disasters in the past, and there is currently little likelihood of a terrorist attack in the city, the Hong Kong government pursues an emergency response management system. It establishes policies, principles and emergency response operations for crises arising from natural disasters and terrorist attacks. Since 1996, Hong Kong has developed and instituted a 'Three Tier' emergency response system in order to ensure timely and appropriate responses. The Tier 1 Response ensures that emergency services (such as the Hong Kong Police Force and the Fire Services Department) operate entirely under the direction, monitoring, and support of their commands. The Tier 2 Response is triggered by an event requiring the attention of the Government Secretariat, such as those that threaten life, property, and security, and that may require a more complex response. The Tier 3 Response is activated in the event of serious and widespread threats to life, property, and security that may require a more significant governmental response. In tandem with this emergency response system, there are currently six contingency plans for dealing with the following events: (a) natural disasters, (b) aircraft crashes, (c) the salvage of crashed aircraft, (d) maritime and aeronautical search and rescue, (e) emergencies at the Daya Bay nuclear power stations, and (f) the coordination of emergency response operations by the Hong Kong Special Administrative Region (SAR) [33]. Simple guidelines in the event of major disasters and emergency telephone lists are also made available to the public on the Hong Kong Government Security Bureau website. These guidelines provide basic information, simple precautions on how to avoid panic and to protect oneself from a mishap.

In sum, Hong Kong, as one of the most competitive megacities in the world, faces various hazard threats. Although catastrophes rarely occur, it remains to be a city with a high probability of experiencing natural disasters, especially in the face of climate change. Natural hazards only become disasters when the affected society is vulnerable [34]. In other words, there are no pure 'natural' disasters, the occurrence of a natural hazard event and the existing of the vulnerability of the impact area are the two necessary prerequisites of a disaster [35]. Hence, investigating the resilience of Hong Kong can provide lessons for us, in general, to understand the risk governance, disaster and emergency management, and also to shed light on the sustainable development of cities in the face of climate changes.

2.2. The Assessment Tool

This study employed the Sendai Framework for Local Urban Indicators (LUI) Tools developed by the UNISDR for cities to measure the resilience to disasters (also known as Scorecard). It is designed to assist local stakeholders in assessing their disaster risks and in implementing DRR policies in cities.

The Local Urban Indicators recently developed by UNISDR based on their earlier "Ten Essentials for Making Cities Resilient" conceptual framework was used. With the proclamation of the Hyogo Framework for Action 2005–2015 (HFA), international attention has been focused on making cities resilient to disasters. The UNISDR launched a worldwide campaign that was entitled 'Making Cities Resilient: My City is Getting Ready!' in 2010. It aimed to promote resilient and sustainable urban communities through policies that were undertaken by local governments to reduce disaster risks.

The “Ten Essentials for Making Cities Resilient” is a conceptual framework for this campaign to help urban leaders implementing DRR policies [13]. In 2015, the Third UN World Conference for Disaster Risk Reduction adopted the Sendai Framework for DRR for 2015 to 2030, with an emphasis on addressing urban risks. The ‘Local Urban Indicators’ was then developed to ‘enable cities to assess their own disaster resilience’ based on the ‘Ten Essentials for Making Cities Resilient’ framework that was updated concerning the Sendai Framework for DRR (2015–2030) [36].

The Local Urban Indicators proposed four layers of measurement. In each layer, there are different numbers of indicators. The layer zero, which is used for national level measurement, contains six indicators. The layer one has 31 indicators, while the layer two has 77 indicators, and the layer three has 122 indicators. With more indicators, the resilience measurement would be more accurate, regarding both dimensions and the measurement unit. When considering the uniqueness of the Hong Kong city and the measurement accuracy, as well as the efforts needed, we adopted the layer one measure that has 31 indicators in this analysis.

The 31 indicators are categorized according to the Ten Essentials of Making City Resilience, and each essential domain has different numbers of key indicator questions (Table 1). By answering these indicator questions, cities and local actors can establish baselines, measure their levels of resilience, identify gaps, implement solutions, and share comparable data across governments [13]. The evaluators give a score ranging from zero (no risk/no effort) to five (lots of risk/lots of efforts) to each of the indicator question together with the key stakeholders. The description of the options/answers to each of the indicator question was presented after the question. Take the indicator 1.1 for example; the indicator question is “DRR is a key consideration throughout the City Vision (CV) and/or Strategic Plan (SP) safeguarding the city to achieve its goals”. The zero score means “No risk factors are identified”. The one score means “Risk factors are not considered in the CV/SP”. Two means “Risk factors are on the agenda for discussion”, three means “Risk factors are in the process of being identified for the CV/SP”, four means “Risk factors are identified and included in some detail in the CV/SP”, while five means “Present and future risks are fully considered in the CV/SP with scientific data and multi-stakeholder hazard information supporting strategic decisions”. The mean values of the ratings within each essential domain were calculated as the score of that domain, so the ratings to the ten essentials can be compared and mapped.

We followed the recommended assessment process that was recommended by the UNISDR when answering the indicator questions [13]. First, we carefully consulted available documents on open access e-resources and websites of the Legislative Council of Hong Kong and related government departments. Next, we consolidated a comprehensive report based on consultations to answer the related measures for DRR. Five relevant stakeholders were invited to a workshop to provide feedback and to comment on the existing measures, as proposed by the UNISDR. These stakeholders included a district councilor (equivalent to a mayor), a community leader with medical training, a manager of the local non-government organization, and two academic scholars. Once the responses of the stakeholders were incorporated, the outcome was sent to all of the relevant stakeholders (including governmental departments not present in the workshop) for further comments. A group of three experts from Taiwan were invited to Hong Kong to assess its risk identification and mitigation in one of the 18 districts in Hong Kong, with reference to the report. Besides, the final results were presented in four local and international conferences across 12 months, including a high-level forum that was organized by the United Nations in Florence, Italy, on 16 June 2016 for further feedback and discussion.

Table 1. United Nation Office for Disaster Risk Reduction's (UNISDR's) The Ten Essentials for Making Cities Resilient and the Local Urban Indicators.

Essentials	Indicators
1. Governance for Disaster Resilience	Indicator 1.1. DRR is a key consideration throughout the City Vision and/or Strategic Plan safeguarding the city to achieve its goals. Indicator 1.2. The city has the necessary authority and resources to satisfy local DRR requirements. Indicator 1.3. Responsibility (lead department) is defined for various aspects of disaster resilience within the city. Indicator 1.4. The city has in place a mechanism that prioritizes resources towards electively lowering risks that local assessments have identified as significant.
2. Identify, Understand and Use Current and Future Risk Scenarios	Indicator 2.1. The city undertakes the technical and multi-stakeholder analysis of current and future threats and hazards to identify citywide exposure and vulnerability. Indicator 2.2. Information on disaster risks is integrated into the city's long-term planning. Indicator 2.3. The city has a regularly updated data platform that enables stakeholders and the wider population to access and exchange risk-related information.
3. Strengthen Financial Capacity for Resilience	Indicator 3.1. The city has in place an adequate financial plan (or procedures) and sufficient resources to allow resilience-building activities to be realized, including long-term climate adaptation. Indicator 3.2. The city has in place a specific budget, the necessary resources and contingency fund arrangements for local DRR. Indicator 3.3. There are means in place to ensure adequate financial support for protecting vulnerable segments of the city's population.
4. Pursue Resilient Urban Development and Design	Indicator 4.1. Urban plans are informed and influenced by up-to-date risk information. Indicator 4.2. Urban plans consider cross-cutting issues of urban resilience. Indicator 4.3. There is a mechanism/process to implement risk-sensitive urban planning. Indicator 4.4. The city develops, updates and enforces the use of building codes and standards, according to relevant hazards and the effects of climate change.
5. Safeguard Natural Buffers to Enhance Ecosystems' Protective Functions	Indicator 5.1. There are solutions in place to address current and future environmental risks (e.g., green and blue infrastructure). Indicator 5.2. The city protects and restores ecosystems to the extent that they offer sufficient adaptation to and mitigation of current and future risks.
6. Strengthen Institutional Capacity for Resilience	Indicator 6.1. The roles and responsibilities of disaster resilience are legitimized in DRR legislation. Indicator 6.2. Processes are in place that strengthens and share the knowledge and skills of stakeholders involved in disaster resilience. Indicator 6.3. Processes are in place to facilitate top-down and bottom-up communication, strengthening the knowledge and awareness of the general public. Indicator 6.4. The city uses the capacity of the private sector and civil society for DRR.
7. Understand and Strengthen Societal Capacity for Resilience	Indicator 7.1. The city provides social support to the poorest parts of the city, increasing their capacity and lowering their vulnerability to disaster. Indicator 7.2. Current social cohesion and social capacity in the city are understood. Indicator 7.3. The city has in place sufficient processes to strengthen social capacity.
8. Increase Infrastructure Resilience	Indicator 8.1. The city owns and implements a critical infrastructure plan or strategy to protect its critical infrastructure, utilities, and services. Indicator 8.2. Protective/risk-mitigating infrastructure (e.g., flood defenses, seismic design) is in place where needed and is appropriately maintained.

Table 1. Cont.

Essentials	Indicators
9. Ensure Effective Disaster Response	Indicator 9.1. There is a disaster management/preparedness/emergency response plan outlining city mitigation, preparedness, and response to local emergencies. Indicator 9.2. The city has made arrangements to continue critical functions even in an emergency situation. Indicator 9.3. The city is connected to relevant early warning systems.
10. Expedite Recovery and Build Back Better	Indicator 10.1. There is a strategy or process in place for post-disaster recovery and reconstruction, including economic and societal aspects. Indicator 10.2. If required, the city would effectively implement the concept of 'Build Back Better'. Indicator 10.3. The city learns from other cities with a similar risk profile.

2.3. The Uniqueness of the Approach

We creatively used a mixed bottom-up and top-down approach in our assessing process. A top-down approach is commonly applied to resilient city making around the world. When considering the unique political structure and status of Hong Kong as a “special administrative region” of the People’s Republic of China, and the government officials’ broad understanding of the concept of disaster risk reduction (DRR), we adopted a mixed bottom-up and top-down approach that was led by an academic institution in collaboration with local authorities. We first critically reviewed the government reports and data. Then, we invited relevant governmental departments for input and revision of the measurement, as well as report, which was eventually launched by the authorities. The academic institution has, in this case, capitalized on its advantageous position to serve as a nexus for the government, non-governmental bodies as well as the communities in assessing the resilience of a city.

3. Results

Based on our assessment results using the Sendai Framework Local Urban Indicators Tools (or Scorecard), Hong Kong’s integrated disaster resilience scored 4.2 out of 5 (see Figure 1 and Table 2), indicating a satisfactory performance of the integrated performance of disaster resilience.

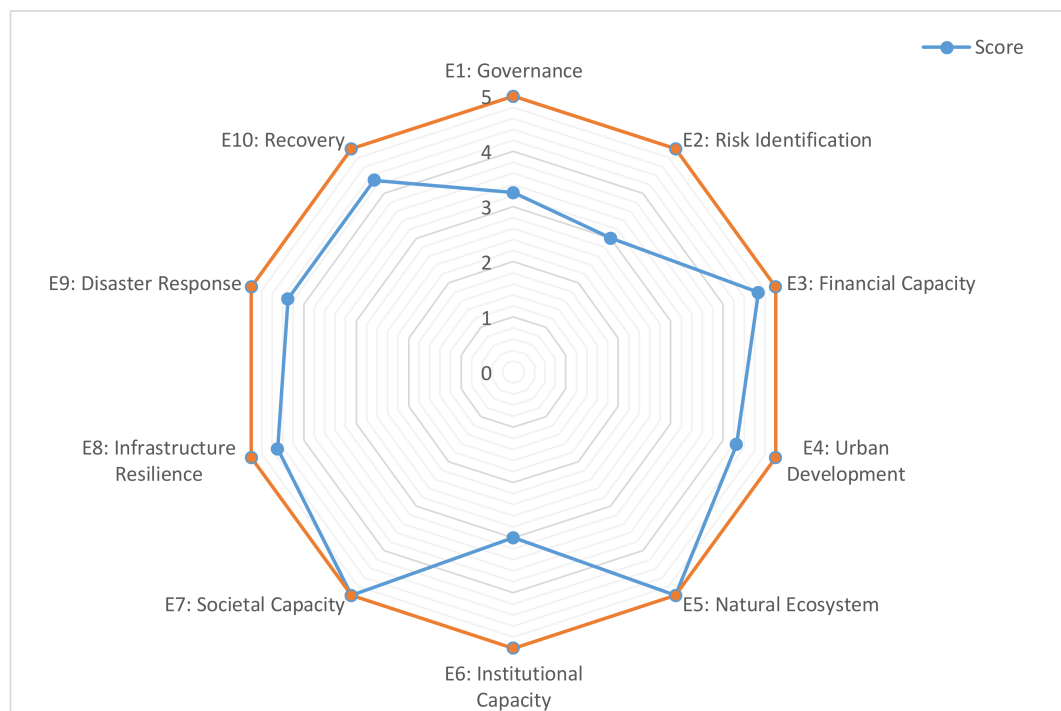


Figure 1. Resilience Building Performance of Hong Kong.

Table 2. Resilience Building Performance of Hong Kong.

Essential Areas	Score
E5: Safeguard Natural Buffers to Enhance Ecosystems’ Protective Functions	5.0
E7: Understand and Strengthen Societal Capacity for Resilience	5.0
E3: Strengthen Financial Capacity for Resilience	4.7
E8: Increase Infrastructure Resilience	4.5
E9: Ensure Effective Disaster Response	4.3
E10: Expedite Recovery and Build Back Better	4.3
E4: Pursue Resilient Urban Development and Design	4.3
E1: Organize for Disaster Resilience	3.3
E6: Strengthen Institutional Capacity for Resilience	3.0
E2: Identify, Understand and Use Current and Future Risk Scenarios	3.0
The integrated average score of Hong Kong	4.2

Table 2 shows the score of Hong Kong regarding the UNISDR toolkit according to performance.

The findings suggest that Hong Kong is a disaster resilient city, in that it: (1) mainstreams DRR in its development, (2) maintains sufficient financial resources for DRR, and (3) defines governmental policies and standard operating procedures for disasters. The following sections highlight these dimensions.

3.1. Mainstreaming DRR in Development

Hong Kong mainstreams DRR into its development according to five essential areas of the Local-Urban Indicator Tools: Essential 5 (Natural Ecosystem), Essential 7 (Societal Capacity), Essential 8 (Infrastructure Resilience), Essential 9 (Disaster Response), and Essential 4 (Urban Development).

In Hong Kong, urban planning follows a risk-sensitive design (Essential 4). The Hong Kong government ensures that the infrastructural environment is assessed and made disaster-resilient to a great extent (UNISDR, 2015c). Urban design solutions are used to improve resilience throughout the city. Hong Kong's building practices are regularly updated to meet international standards. For example, steel structures in Hong Kong are designed to be resilient to disasters. Codes for the design of steel structures in Hong Kong were initially derived from the London Byelaws and then brought into conformity with the British specifications for the use of structural steel, known as BS 449. In 1987, Hong Kong managed to publish its own code. In 2005, the code was revised and renamed as 'Code of Practice for the Structural Use of Steel 2005' to encourage the use of structural steel to benefit stakeholders, the environment, and society. This code is in line with Hong Kong's vision to develop a technology-driven and knowledge-based society. The 'Code of Practice for the Structural Use of Steel 2011' was issued after a three-year review, with a consideration of the latest design and technology for constructions of steel. The 2011 edition was updated for practicing engineers and practitioners in the construction industry.

The natural ecosystem has a protective function against hazards (Essential 5). The Hong Kong authority safeguards its natural buffers to enhance the protective functions that are offered by these natural ecosystems. It identifies, protects, and monitors critical ecosystems services that augment disaster resilience. Specifically, these services include some preservation projects. The Protection of the Harbour Ordinance (CAP 531) is an example of a project attempting to limit land reclamation in the surviving waters of Victoria Harbour. The Harbour Ordinance establishes a statutory principle recognizing the harbor as a public asset and a natural heritage of Hong Kong. As a result, no one can undertake reclamation projects in the harbor unless exceptional circumstances. To maximize the extent and benefit of ecosystems, 24 country parks are designated for nature conservation, countryside recreation, and outdoor education. Also, there are 22 special areas (outside parks) that are created mainly for nature conservation. The designation and protection of these parks and designated areas are enforced by five different government ordinances, such as Country Parks Ordinance (CAP 208) and Country Parks and Special Areas Regulations (CAP 208A).

There is a culture of mutual help regarding DRR activities in Hong Kong (Essential 7). The government encourages the understanding and strengthening of the societal capacity for resilience, thus cultivating an environment for social connectedness and promoting a culture of mutual help with DRR education. Despite Hong Kong having few disasters, there is still considerable social cohesion regarding providing assistance after disasters in distant locations. Hong Kong's societal capacity can be observed by the significant public donations to other areas, such as the 2008 Wenchuan Earthquake and the 2010 Yushu Earthquake in mainland China, the 2011 Great East Japan Earthquake and Fukushima Disaster, and the 2013 Typhoon Haiyan in the Philippines.

As of 2016, Hong Kong Red Cross had received US\$180 million in donations for the 2008 Wenchuan Earthquake to support emergency relief, reconstruction, recovery, and disaster preparedness programmes [37]. After the 2010 Yushu Earthquake, the Hong Kong government provided US\$16 million, while the public raised about US\$17 million for relief and reconstruction (Wolong, 2016). For the 2011 Great East Japan Earthquake, Hong Kong Red Cross received more than US\$21 million within six months [38]. The Consulate-General of Japan in Hong Kong wrote to the media, specifically

to the Radio and Television of Hong Kong (RTHK), to thank the city for its support during the 2011 Great East Japan Earthquake [39]. For the 2013 Typhoon Haiyan in the Philippines, the Hong Kong Red Cross received over US\$0.6 million from the public [40].

The societal capacity for disaster resilience also addresses education in DRR to create a culture of mutual help and promote disaster knowledge. This involves the active engagement of academic institutions in DRR activity, such as the Collaborating Centre for Oxford University and The Chinese University of Hong Kong for Disaster and Medical Humanitarian Response (CCOUC), the Hong Kong Disaster Medicine Association, the Hong Kong Polytechnic University (PolyU), the University of Hong Kong, and the Hong Kong Jockey Club Disaster Preparedness and Response Institute (HKJCDPRI). These institutes offer continuous disaster-related training programmes to graduate students as well as the general public. In CCOUC, there are fellowship programmes for non-governmental organizations and researchers in Hong Kong and beyond. Whereas, PolyU offers graduate courses for disaster management and disaster nursing. The HKJCDPRI has training courses on disaster response for the general public and supports local NGOs in their implementation of disaster education campaigns through partnership programmes. Besides, some international NGOs are also active in engaging the community in DRR activities, such as the Hong Kong Red Cross and Oxfam Hong Kong.

Hong Kong has sufficient risk-mitigating infrastructure based on risk information (Essential 8). The Hong Kong authority assesses the capacity, adequacy, and linkages between critical infrastructure systems, upgrading these as necessary according to disaster risks (UNISDR, 2015c). Hong Kong owns and implements a critical infrastructure plan to protect its utilities and services. The Critical Infrastructure Security Coordination Centre (CISCC), which was established in 2011, aims to protect critical infrastructure and reduce the city's vulnerability to terrorist attacks through effective coordination among all of the stakeholders [41]. The CISCC consults relevant governmental bureaux and departments before classifying any premises as critical infrastructure. For example, the CISCC consults the Transport and Housing Bureau before classifying a premise as dangerous. The CISCC categorizes critical infrastructures in Hong Kong into various sectors, and a 24-h hotline has been launched to receive reports.

Adequate preparedness is based on effective emergency response plans and early warning systems (Essential 9). The Hong Kong authority creates and updates disaster response plans and communicates policies to all of the stakeholders with its organizational structure. Insofar as effective response plans are concerned, the Hong Kong government has a set of Contingency Plans, such as the 'Contingency Plan for Natural Disasters' (2015) and 'The Government of the Hong Kong SAR Influenza Pandemic Preparedness Plan (2014)'. These plans coordinate different governmental departments to facilitate collaboration during emergencies. For example, when Typhoon Nida (August 2016) brought heavy rainfall and strong winds to the city, the Hong Kong government activated its emergency monitoring mechanism as part of the Contingency Plan for Natural Disasters [42].

3.2. Sufficient Financial Resources for DRR

Hong Kong has considerable financial resources for DRR purposes (Essential 3). The Hong Kong authority understands the economic effect of disasters and the need to invest in resilience by identifying and developing financial mechanisms that can support resilience activity (UNISDR, 2015c). Referring to the 2016–2017 Budget of the Hong Kong government, there is an annual expenditure on disaster prevention and the preparedness for DRR-related departments (see Table 3). For instance, US\$165 million was apportioned to the Civil Engineering and Development Department (CEDD) from the Civil Engineering Fund to enhance landslide prevention measures. In view of the landslide risks, in the 2015–2016 Budget the Hong Kong government granted a special allotment of around US\$129 million to the Geotechnical Engineering Office (GEO) to launch a Landslip Prevention and Mitigation Programme (LPMitP) to systematically address the risk that is associated with both human-made slopes and natural hillsides (HKSAR's Financial Services and the Treasury Bureau, 2015). This demonstrates that adequate resources are available to be apportioned to support local DRR initiatives.

Table 3. 2016–2017 Hong Kong Government Budget Items and Amounts for Disaster Prevention and Preparedness.

Department	Item	Budget 16–17 (US\$)
Hong Kong Observatory (HKO)	Promotion of public awareness of, and community preparedness for, natural disasters	31 million
Civil Engineering and Development Department (CEDD)	Landslip preventive measures	165 million
Lands Department (LandsD)	Maintenance of human-made slopes on unallocated and unleased government land	70 million
Agriculture, Fisheries and Conservation Department (AFCD)	Maintenance of nature conservation and country parks	86 million
Drainage Services Department (DSD)	Maintenance of drainage and erosion protection	44 million
Education Bureau (EDB)	Repairs to slopes of aided schools served with Dangerous Hillside Orders	26 thousand

In addition, Hong Kong has the financial capacity to provide humanitarian assistance to disaster-affected areas outside of Hong Kong. This helps Hong Kong to proactively learn first-hand about the disaster management of other cities and increase its resilience (Essential 10). The Hong Kong authority has been developing appropriate pre-disaster plans in response to identified risks, which ensures that immediately after any disasters the needs of the most affected are of the top priority during post-disaster response and recovery. With few disasters of its own in recent decades, Hong Kong has been able to provide emergency relief to victims elsewhere, with the aforementioned examples of the mainland China, the Philippines, and Japan. Also, in order to reduce the possibilities of epidemics from entering into Hong Kong, the city's authorities study the measures that have adopted by other countries to contain diseases.

3.3. Disaster Governance

Hong Kong's disaster governance is generally limited according to the assessment with reference to Essential 1 (Governance), Essential 2 (Risk Identification), and Essential 6 (Institutional Capacity). The organizational structure (Figure 2.) for understanding and acting on reducing disasters risks should be further strengthened in Hong Kong (Essential 1). Specifically, the Hong Kong authority has yet to build up an organizational structure with clearly identified processes that are necessary for reducing disaster-related exposure, effects, and vulnerabilities in Hong Kong. For instance, DRR is not part of a key policy consideration in Hong Kong yet. Disaster risk factors remain on the agenda for discussion, but they are not incorporated into the city's vision for future development. More specifically, climate change related measures on Hong Kong's government webpage mainly pertain to greenhouse gas emissions, even though it is known that climate change creates additional unseasonal and unpredictable hazards [31]. Information on natural disaster risks that is related to climate change is mostly provided by the Hong Kong Observatory, which is a technical governmental department that is responsible for weather forecast [43].

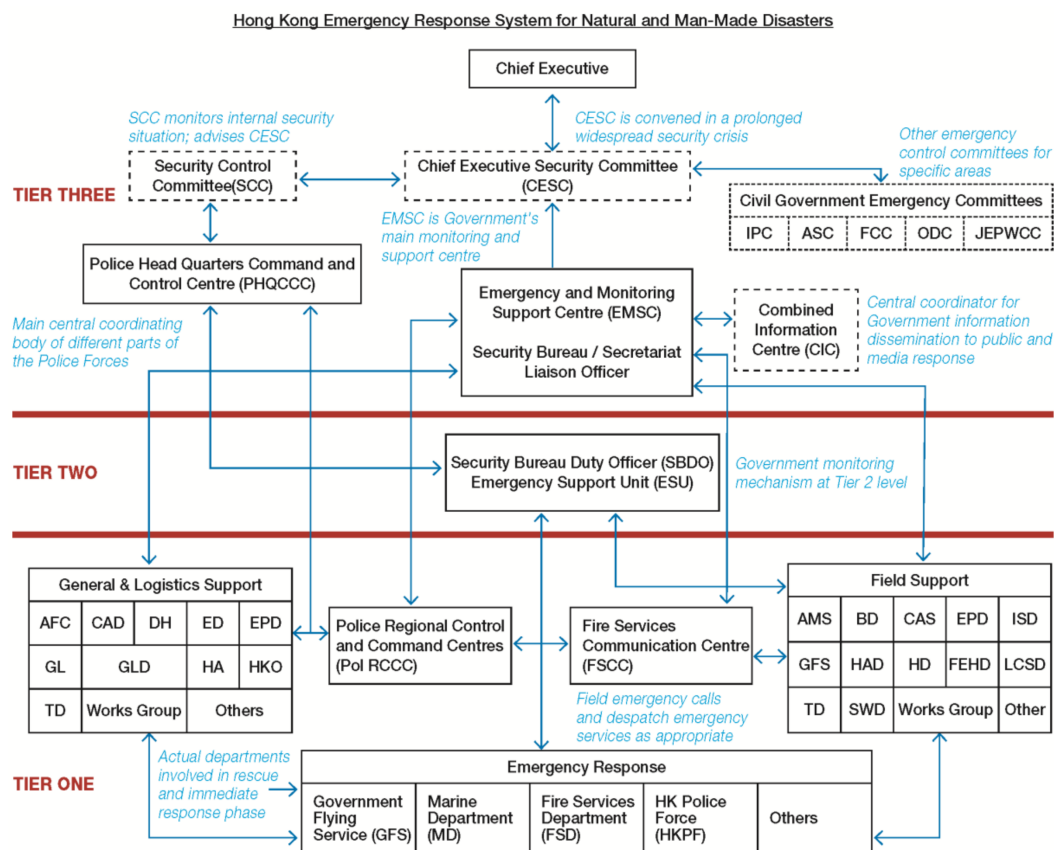


Figure 2. Hong Kong Emergency Response System in graphic form (Adopted from policy brief, Hong Kong's Emergency and Disaster Response System, prepared for Hong Kong Jockey Club Disaster Preparedness and Response Institute (HKJCDPRI), by Chan, Yeung, and Lo (2016)).

Despite the city's lack of vision in relation to natural disaster, Hong Kong has the necessary plans and resources to satisfy local DRR requirements in terms of event response activities. The Hong Kong government's Emergency Response System has a diagram in place that indicates relevant departments' responsibilities, capacities, and competencies, which is periodically monitored and reviewed, and prioritizes different types of stakeholders. The aforementioned Three Tier System of the Emergency Response System operates through the three principal phases of emergency response (rescue, recovery, and restoration).

Generally, resource allocation in Hong Kong follows a hazardous event-driven pattern, which means that resources are allocated to fields and departments based on the severity of disasters or incidents. In other words, resources for DRR are responsive in nature. It can be argued that Hong Kong's organizational structure for DRR is focused on response and coordination during emergencies, rather than on the strategies for long-term risk reduction.

Furthermore, Hong Kong lacks disaster risk identification (Essential 2). The Hong Kong authority needs to do more to identify and understand their risks, including hazards, exposure, and vulnerabilities, and use this knowledge to inform decision making. Hazard maps are partial in coverage and are not well disseminated in Hong Kong. The Hong Kong Observatory (HKO) has been monitoring distant earthquakes since 1921 using long-period seismographs. In 1979, the HKO established a short-period seismograph network for monitoring local tremors. At present, it operates a standalone seismograph network of eight short period seismograph stations and two broadband

seismograph stations in Hong Kong for determining the epicenters of locally felt earthquakes and for monitoring earthquakes worldwide.

Fully comprehensive, detailed, and current risk maps for the entire city, covering various hazards, assets, and populations at risk, are not available. Due to the lack of hazard maps in Hong Kong, it is apparent that disaster risks are not integrated into the city's long-term planning. For instance, facing the gradual rising of sea levels in Hong Kong and the adjacent areas, the HKO researches climate science (on global sea level projections, land stability, and subsidence) to better protect those coastal areas with a history of flooding. However, there is no evidence to suggest that the HKO's research outcomes (e.g., a map illustrating areas vulnerable to surge storms in Hong Kong) have been employed for better land use planning by relevant departments [31]. Nonetheless, the information on hazard and risk is publicly available and easy to access via official government websites. For example, information on typhoons, rainfall, temperatures, relative humidity, mean wind, and visibility can be easily found on the HKO's website. In addition, information provided by the HKO is readily available to the public by means of different forms of social media, such as Youtube, Twitter, Weibo, Wechat, and Tudou, and can be leveraged to disseminate information related to risks.

Hong Kong's institutional DRR capacity is considered weak as compared with the other essential areas (Essential 6). The Hong Kong authority should do more to ensure that all of the institutions that are relevant to a city's resilience have the capability to discharge their roles. Most DRR policies are observed in Hong Kong, with a clear delineation of roles and responsibilities among different government departments, according to related ordinances (as shown in Table 4). However, Hong Kong's DRR related legislation relates mainly to construction, urban planning, and environmental laws. Important elements of the DRR legal framework, as suggested by international organizations, are absent in Hong Kong. The gaps include having a central institution to provide leadership, or umbrella laws to regulate disaster risks by establishing mechanisms for cross-sectoral coordination; or, a law for establishing local statutory funds dedicated to DRR gathered from a variety of funding sources [44].

Table 4. An Overview of Legislation Related to Disaster Risk Reduction (DRR) in Hong Kong.

DRR	Ordinances
Environmental Risk Reduction	Waste Disposal Ordinance (CAP 354); Water Pollution Control Ordinance (CAP 358); Air Pollution Control Ordinance (CAP 311); Noise Control Ordinance (CAP 400); Ozone Layer Protection Ordinance (CAP 403); Dumping at Sea Ordinance (CAP 466); Environmental Impact Assessment Ordinance (CAP 499); Hazardous Chemicals Control Ordinance (CAP 595); Product Eco-Responsibility Ordinance (CAP 603); and Motor Vehicle Idling (Fixed Penalty) Ordinance (CAP 611)
Landslide risk reduction	Building Management Ordinance (CAP 344); Buildings Ordinance (CAP 123)
Urban Planning	Town Planning Ordinance (CAP 131)
Response and Relief	Emergency Relief Fund Ordinance (CAP 1103)
Flooding related	Sewage Services Ordinance (CAP463)

Besides legislation, there are few processes for strengthening the knowledge and skills of different stakeholders that are involved in building disaster resilience. Generally, the public sector has more opportunity to strengthen its knowledge and skills than the civil society. Moreover, there are few effective processes for exchanging or sharing knowledge and skills across sectors. Although institutionalized information is shared across governmental departments during emergencies, there are few mechanisms for enhancing information sharing between the government and civil society, especially regarding the knowledge and skills about disaster resilience. Moreover, the public awareness of disaster risk is part

of the institutional capacity. In Hong Kong, top-down communication is in place to strengthen the knowledge and awareness of the general public by methods, including SMS, mobile apps, and public exhibitions. One good example is the Community Weather Information Network (Co-WIN), which was established jointly by the Hong Kong Observatory, the Hong Kong Polytechnic University and the Hong Kong Joint-School Meteorological Association in 2007. This network aims to assist schools and other organizations in setting up automatic weather stations to promote weather education and to provide the public with comprehensive weather information covering a wide range of area. As of 2015, this effort included 148 member organizations.

4. Discussion

This study assessed the resilience of Hong Kong using the Sendai Framework Local Urban Indicators Tools developed by UNISDR. Overall, Hong Kong can be considered to be a disaster resilient city because it mainstreams disaster risk in its development and dedicates sufficient financial resources. Nevertheless, Hong Kong may do better, particularly in improving its procedural capacity for disaster governance. Generally, Hong Kong's disaster management system focuses on emergency response and building resilience physically. There is limited institutional building for disaster management and a lack of long-term DRR strategy and vision. In Francesch-Huidobro's study on Hong Kong's climate change governance, she points out that Hong Kong's response to climate change is 'sectoral' in nature, as confirmed by our study, in that DRR is 'defined narrowly according to the bureaucratic set-up and failing to adopt a holistic and integrated approach' [29]. This limitation of Hong Kong's DRR strategy reveals a critical vulnerability. The absence of a comprehensive vision of DRR may weaken Hong Kong's disaster resilient capacity, particularly in relation to the low disaster risk preparedness of Hong Kong's general public [45].

Hong Kong has not experienced large-scale natural disasters that cause significant casualties in the past five decades. In part, this is related to the government's conscientious efforts in enforcing physical preventive measures after each extreme event [29]. Ironically, Hong Kong's society may be less resilient to disaster given the low frequency of disasters and the government's continual investment. A clear and long-term DRR vision is critical in order to ensure sustainable social resources for promoting disaster resilience among Hong Kong people.

The increasing challenge that is presented by climate change and by the region's unstable socio-political dynamics may create new and unpredictable disaster risks. At the moment, as this study shows, Hong Kong may be considerably resilient. However, the absence of a long-term vision that addresses impending hazards and risks and the city's inexperience with disasters suggest that it remains unclear if Hong Kong is well positioned to cope with a potentially volatile future.

Designing, assessing, and improving the resilience of cities, which are complex systems is not easy [46]. The resilience assessment is one of the first important steps to build city resilience. Our study demonstrated a useful case of assessing the resilience of megacities using the Local Urban Indicators Tool advocated by UNISDR. We creatively used a mixed bottom-up and top-down approaches in the evaluation process, because it's important to understand the resilience from multi-stakeholders, not just social elites and decision makers [47]. Thus, this paper can enrich current knowledge about assessing the resilience of cities.

Moreover, the finding of this study intrigued us to rethink about the resilience of what, to what, and with what [48]. The infrastructure protection, ecological conservation, and financial investment to city resilience in Hong Kong are considerable, but the institutional capacity, especially the involvement and coordination between the private sector and civil society [49] that is need to be improved in current disaster and emergency management systems. A knitted society is always resilient to disasters because social capital is the least damaged capitals in disasters [50], and it plays important facilitating roles in the recovery process [51,52]. As a city has not experienced big natural disasters for decades, it is unwise to be under planned or ignore the potential risks, especially in the face of climate change [27]. It should be remembered that rarely people thought that a hurricane would swipe the New York City

before the Hurricane Sandy in 2012 [53,54]. Preparing for the worst scenarios with the inclusion of vulnerable population [55–57] and working with multi-stakeholders together are critical to improving the resilience of cities [5].

5. Conclusions

This paper reports our efforts of assessing Hong Kong's resilience to natural hazards using a city resilience assessment tool of the UNISDR. We use a mixed bottom-up and top-down participatory method to investigate the city's resilience. The infrastructure, sufficient financial support, and well-protected ecosystems are the strengths of Hong Kong's resilience, while the disaster and emergency management system, especially the pre-disaster mitigation and preparedness investment, and the lack of multi-stakeholder involvement and the participation of communities, are the city's weakness.

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