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Key Elements of Attentions for Enhancing Urban Resilience: A Comparison of Singapore, Hong Kong and Hangzhou

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Abstract: Urban resilience is an attractive concept among academies and governments with the increasing severity of climate change and relevant disasters in cities. Few studies have been conducted to compare the key elements of attentions for enhancing urban resilience among Asian cities, although resilience is context-dependent. This study aims to compare the key elements of attentions for enhancing urban resilience among Singapore, Hong Kong and Hangzhou. A comprehensive literature review and expert interview validation were used to solicit the preliminary elements of attentions for enhancing urban resilience. Planners and researchers in the field of urban planning were surveyed to assess the significance level of the preliminary elements in the three case cities, as professional knowledge is required in the survey. Statistics were used to identify the key elements of attentions in the three case cities. Results demonstrate that the three cities have various elements of attentions for enhancing urban resilience despite sharing many similarities, which also demonstrate the guidance limitation of the general urban resilience framework. It also provides a reference for other international comparisons.

Keywords: urban resilience; elements of attentions; comparison; Asian cities

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1. Introduction

1.1. Research Background

Urban resilience is a popular topic with the rapid development of cities, which are the key spaces for human activities around the world. How to cope with uncertainty and risk, including the rapid development of technology [1], social crisis [2], financial crisis [3], climate change [1], and disasters [4,5], is critical for cities to realize sustainable development goals. Urban resilience is proposed as an ideal guideline for urban development and governance, frequently discussed in the government and academe. Godschalk [6] pinpointed that a resilient city is a sustainable network of physical systems and human communities. Campanella [7] defined urban resilience as the ability of a city to recover from destruction. Wu and Wu [8] interpreted urban resilience from the ability of a city to persist without qualitative changes in its structure and function, despite the disturbances. Lhomme et al. [9] defined urban resilience as the ability of a city to absorb disturbance and recover its functions after a disturbance. Meerow et al. [10] defined urban resilience as "the ability of an urban system to maintain or rapidly return to desired functions in the

face of a disturbance, adapt to change, and quickly transform systems that limit current or future adaptive capacity". The resilience of what to whom is the key basis to comprehend disruptions and concerned systems regarding urban resilience, even though the consensus of defining urban resilience is still not achieved [10].

Various studies have investigated how to achieve urban resilience. For example, Jha et al. [11] emphasized that urban resilience depends on the resilience of sub-systems, which comprise infrastructure resilience, institutional resilience, economic resilience and social resilience. Ahern [12] proposed a suite of strategies for building urban resilience capacity: multifunctionality, redundancy and modularization, (bio and social) diversity, multi-scale networks and connectivity, and adaptive planning and design. Ribeiro and Gonalves [13] concluded that urban resilience is realized through redundancy, robustness, connectivity, independence, efficiency, resources, diversity, adaptation, innovation, inclusion and integration. Shamsuddin [14] determined that the characteristics of a resilient system include extensive coordination, maintaining adaptability, divergent time horizons and diverse outcomes. Xu and Shao [15] asserted that robustness, efficiency, diversity, redundancy and physical connection are important for physical resilience, while social connectivity, social capital construction, sustainable paths, flexibility and convertibility are the keys to social resilience.

Many cities have formulated strategies to enhance urban resilience. The Rockefeller Foundation launched the first Global 100 Resilient Cities project in 2013, which further advanced the programs of enhancing urban resilience. For example, New York proposed 13 initiatives in the field of neighborhoods, buildings, infrastructure and coastal defense to enhance urban resilience to withstand the impacts of climate change and other 21st century threats in the "One New York Strategy". Specific indicators, which include eliminating disaster-related long-term displacement (more than one year) of New Yorkers from homes by 2050, reducing the Social Vulnerability Index for neighborhoods across the city and reducing average annual economic losses resulting from climate-related events, are proposed to effectively advance the mission of building a resilient New York [16]. Sydney conducted a report called "Resilient Sydney: A strategy for city resilience" and listed five directions in a five-year action plan of 35 actions classified into the flagship, supporting and aligning actions to enhance urban resilience. It is emphasized that the government organizations and communities should understand the risks and respective responsibilities, collaborate with each other, and invest resources to take actions [17]. London formulated the "London City Resilience Strategy 2020" and proposed 21 action plans under the resilience projects of people, place and processes to realize urban resilience by considering both immediate risks and a wider range of shocks and stresses [18].

Comparative studies have also been conducted in terms of urban resilience, as different cities may face different systems and disruptions. For example, Muñoz-Erickson et al. [19] used data from a survey of nine US and Latin American and Caribbean cities to explore how the concept of urban resilience was framed across multiple governance sectors, which include governmental, non-governmental, business, research, and hybrid organizations. Framings converge with definitions of resilience as the ability to resist, cope with, or bounce back to previous conditions, whereas sustainability, equity, and social-ecological-technological systems' perspectives are rarely associated with resilience. Woodruff et al. [20] compared policies and programs of the 101 largest cities in the US that tangibly affect resilience. It was found that different dimensions, such as funding and the level of needed commitment, may explain the empirical patterns of policy adoption of urban resilience better. Nedaei et al. [21] compared the resilience of Tehran and Mashhad to identify the strengths and weaknesses of these two cities and found that both the cities are weak in terms of resilience indicators and sub-indicators, but Mashhad is more resilient than Tehran. However, few studies have been conducted to compare the key elements of attentions for enhancing urban resilience among Asian cities. This insufficiency presented barriers for comprehensively understanding the practices or needs for enhancing urban resilience in the rapid development of Asian cities.

1.2. Research Objective

This study aims to compare the key elements of attentions for enhancing urban resilience among Singapore, Hong Kong and Hangzhou. The three cities were chosen partly due to the convenience of collecting relevant data by the authors and partly due to certain representations. Singapore and Hong Kong are usually model cities in Asia, while Hangzhou is an emerging first-tier city in China, which has the responsibility of exploring various Chinese strategies, e.g., demonstration zone for common prosperity. The research is organized as follows. Section 2 identifies the preliminary elements of attentions for enhancing urban resilience through a literature review. Section 3 introduces the research method. Section 4 presents the results. Section 5 conducts in-depth discussions with regard to the results to ensure clear understandings. Section 6 concludes this research, specifies the limitations of this study and presents potential directions for future study.

2. Literature Review and Preliminary Elements of Attentions for Enhancing Urban Resilience

City, as a complex social ecosystem, is vulnerable to various shocks and disturbances from the outside world and itself. As priorities rapidly evolve and change due to technological advances, climate change and population growth, systematic planning under the concept of resilience can contribute to the sustainable development of cities. However, Klein et al. [22] determined that the previous research does not have a clear and operational definition of resilience. Therefore, one way to achieve sustainable development is through resilience frameworks. The purpose of the resilience framework is to identify factors, such as the types, characteristics and spatial distribution of disturbances faced by the city, as well as to guide the future of the city with the concept of adaptability.

The existing research on the urban resilience framework is mainly divided into two directions. One is a comprehensive resilience framework research based on multiple dimensions. The Resilience Alliance, as an early international organization that conducts urban resilience research, proposes four priority themes for urban resilience: governance networks, metabolic flows, built environment and social dynamics [23]. The Rockefeller Foundation and ARUP proposed the city resilience framework (CRF) in 2014, which includes Health & Wellbeing, Economy & Society, Infrastructure & Environment and Leadership & Strategy [24]. Cutter et al. developed the disaster resilience of place (DROP) and baseline resilience indicators for communities (BRIC) to provide the baseline of measuring community resilience from the perspective of community capital [25,26]. Jabareen attempted to establish a multidisciplinary conceptual framework to support urban resilience, thus proposing the resilient city planning framework (RCPF) [27]. This framework mainly includes four parts: vulnerability analysis matrix, urban governance and prevention and uncertainty oriented planning, with each part comprising three to four elements. By analyzing 20 urban cases, Desouza et al. proposed a conceptual framework of urban resilience, which includes design, planning and management, and divided cities into physical systems and social systems at the macro level [28]. The pressure faced by cities comprises natural, technological, economic and human pressure. Moreover, the disaster resilience scorecard developed by UNISDR assessed community resilience from the perspective of ten key tasks of disaster prevention and mitigation [29]. A quick risk evaluation tool developed by UNISDR assessed community resilience from the perspective of required abilities to cope with common disasters derived from the Sendai Framework for Disaster Risk Reduction 2015–2030 [30]. The other direction is an urban resilience framework based on specific risks or a single system. Joerin et al. proposed a climate disaster resilience index (CDRI) model based on five dimensions of the economy, institution, nature, material and society [31]. Sun et al. developed a seismic resilience evaluation model for the electrified community based on system dynamics [32]. Hernández et al. developed a typhoon risk index to measure community resilience from the perspective of disaster risk and vulnerability [33]. Müller et al. proposed a model to measure rural community resilience based on the carbon cycle [34]. Previous studies have provided good references to understand the concept of

urban resilience, relevant impact factors and measurement methods. Table 1 summarizes the general resilient city frameworks covered in this literature review.

Table 1. Summary of general resilient city frameworks.

Framework	Organization/Author (s)	Country Applied	Latest Publication Year
City Resilience Framework	The Rockefeller Foundation [24]	Multiple Countries	2014
Disaster Resilience of Place (DROP)	Cutter [25]	USA	2008
Baseline Resilience Indicators for Communities (BRIC)	Cutter [26]	Multiple Countries	2014
Resilient City Planning Framework (RCPF)	Jabareen [27]	Multiple Countries	2013
Community Based Resilience Assessment (CoBRA)	United Nations Development Programme [35]	Multiple Countries	2014
EnRiCH Community Resilience Framework	Canadian Centre for Security Science, Defence Research and Development [36]	Canada	2014

Note: The authors only highlighted the more comprehensive frameworks. Do note that there are other resilient frameworks that focuses on specific areas, such as hazards or social aspects. Specific indicators are not listed due to the page limit. The detailed information of each framework can be found in the corresponding reference.

Through the analysis, various countries and organizations have different perceptions of the characteristics of resilience, resulting in a different focus of various frameworks. For example, Jon and Reghezza-Zitt found that Seattle resilience planning encourages neighborhood-driven sub-systems that can enhance social cohesion and information sharing, while Paris' resilience planning is becoming a channel that fosters dialogues across various institutions [37]. Chelleria and Baravikova found that the US (similarly to Asia) prefers a "bouncing back" approach with an emphasis on robustness as a key characteristic of resilience, while both researchers and practitioners across the EU tend to define urban resilience as linked to bouncing forward or a concept integrating bouncing forward and back approaches [38]. A detailed analysis of the selected frameworks helps in identifying the key themes, as shown in Table 2. These themes highlighted what the key city stakeholders perceive to be key city functions that are relevant to enhancing urban resilience.

Most urban resilience frameworks cover a few topics: resilience planning, environment, community, social, disaster risk management, governance and economy. However, in the context of climate change and urbanization development, the importance of energy, water, material and waste, green building and green transportation, and innovation in resilient cities has gradually become prominent. Natural resources, such as energy, water and material resources, are the basis for human production, life and wealth creation [38]. With the advancement of industrialization, urban construction and economic development have an increasing demand for natural resources [39]. The increasing natural disasters and environmental pollution events have put forward higher requirements on the natural resources' carrying capacity of cities [40]. Effective management of resources, ensuring resource security, and improving the ability to deal with environmental pollution are important requirements of a resilient city [41–43]. Infrastructure is the basis for social development and the improvement of people's quality of life, as well as the basic requirement of resilient cities [44,45]. Energy conservation and emission reduction in buildings and transportation have a profound impact on the sustainable use and development of energy [46,47], which may directly affect urban economic development. Technological innovation enhances the dynamic nature of urban carrying functions, plays an important role in economic growth, improves resource utilization efficiency and renews urban facilities [48], which is also a key means for cities to cope with external disturbances.

Although the resilience framework is a hot area of urban resilience research, the depth needs to be further deepened. The study areas are mainly concentrated in the United States and Europe, and few studies have compared the key elements of attentions for developing resilient cities in Asian cities. Therefore, this paper synthesized the existing multi- and

one-dimensional frameworks and added the general overlooked issues of energy, water, material & waste, green building & green transportation, and innovation to form the preliminary elements of attentions for enhancing urban resilience. An interview with the planners and researchers in the field of urban planning was conducted in January 2015 to validate the preliminary indicators by deleting irrelevant indicators or adding missing important indicators. A total of nine categories, which comprise energy, water, material & waste, environmental planning, green building & green transportation, community, economy, governance and innovation, with thirty-five indicators were derived, as shown in Table 3. The relationship between the various indicators is not a simple addition, rather, it is interrelated and mutually supportive.

Table 2. Comparison of themes in resilient city frameworks.

Framework	Themes					
	Resilience Planning	Environment	Climate/Water/Energy Society	Disaster Risk Management	Governance	Economy
City Resilience Framework	♦	♦	♦		♦	♦
Disaster Resilience of Place (DROP)	♦	♦	♦	♦	♦	♦
Baseline Resilience Indicators for Communities (BRIC)		♦	♦		♦	♦
Resilient City Planning Framework (RCPF)	♦	♦	♦	♦	♦	
CoBRA	♦	♦	♦	♦	♦	

Source: The themes are collated from the respective frameworks themselves. Specific indicators can be found in the corresponding reference listed in Table 1.

Table 3. The preliminary elements of attentions for enhancing urban resilience.

Category	No.	Element	References
Energy	EN1	Energy Efficiency for Infrastructure & Public Amenities	[49]
	EN2	On-site Energy Generation	[50]
	EN3	Energy Management Plan & System	[41]
	EN4	Site Planning & Building Orientation	[51]
Water	WA1	Water Strategy	[39]
	WA2	Stormwater Management	[42]
	WA3	Alternative Water Source	[52]
	WA4	Water Efficient Landscape	[42]
	WA5	Water Efficient Fittings for Infrastructure & Public Amenities	[53]
Material & waste	MW1	Waste Management and Segregation	[40]
	MW2	Resource Management	[43]
	MW3	Low Impact Materials and Sustainable Products for Infrastructure & Public Amenities	[43]
	MW4	Sustainable Construction for Infrastructure & Public Amenities	[54]

Table 3. *Cont.*

Category	No.	Element	References
Environmental planning	EP1	Flood Risk Assessment & Management	[55]
	EP2	Adapting to Climate Change	[1]
	EP3	Noise Pollution	[56]
	EP4	Site Selection	[51]
	EP5	Environmental Management System	[40]
	EP6	Self-sufficiency & Accessibility Within District	[57]
	EP7	Conservation & Integration of Existing Structure	[58]
	EP8	Green & Blue Spaces Within District	[59]
	EP9	Future Provision & Connections	[60]
	EP10	Land Use	[61,62]
Green building & green transportation	GBT1	Green Buildings Within District	[44]
	GBT2	Green Urban Design Guidelines	[45]
	GBT3	Green Transport Within District	[46]
	GBT4	Public Transport Facilities	[47]
Community	CO1	Stakeholder Engagement, Feedback & Evaluation	[63]
	CO2	Public Awareness & Education	[64]
	CO3	Green Lease	[65]
	CO4	Inclusive Design	[45]
Economy	EC1	Economic Impact	[50]
Governance	GO1	Community Management of Facilities	[66]
	GO2	Design Review	[67]
Innovation	I1	Green Features & Innovations	[48]

3. Research Method

3.1. Study Area

This paper uses three typical Asian cities as study areas: Singapore, Hong Kong and Hangzhou. Table 4 shows a general comparison of the three cities.

Table 4. A general comparison of the three Asian cities.

Study Area	Area (sq km)	Total Population	Population Density (Per sq km)	Regional GDP (Trillion US$)	Characteristic
Singapore	724.4	5,685,800	7848.98	0.34	Coastal city, developed city, high population density, shortage of resources
Hong Kong	1106.66	7,481,800	6844.20	0.35	Coastal city, high population density, high economic level
Hangzhou	16,850	11,936,000	708.37	0.23	Coastal city, urbanization, digitalization, historical city

Source: The corresponding government's public information in 2020.

Singapore is an island city in Southeast Asia, and its urban construction has always been hailed as a role model. As an urban developed country with a land area of only 724.4 km^2, a population of 5.68 million and a regional GDP of USD 0.34 trillion (2020 data), three urgent challenges to Singapore's national governance were observed: labor shortage, insufficient water supply and lack of land area. Statistics in 2017 show that the population density of Singapore is the second highest in the world [68]. At the same time, the problem of population aging and declining fertility rates is becoming worse, and the labor force gap is expanding, which is affecting the development of the country's overall economy. Moreover, population growth directly leads to insufficient land area and doubts about water supply [69]. Therefore, the Singaporean government plans to increase the land area by expanding land reclamation. In addition, the newly reclaimed land will also help in collecting and storing rainwater, alleviating the shortage of water resources in Singapore. In terms of systems and planning, The Singapore Sustainable Blueprint 2015 aims to extend the 2030 targets laid out by the first blueprint. In 2019, the Urban Redevelopment Authority (URA) of Singapore released the "Singapore Master Plan (2019)", which takes building a sustainable and resilient city as one of the directions for urban development. In conjunction

with relevant documents issued by other departments, Singapore has formed a spatial planning system guided by the concept of resilience.

Hong Kong, which is located on the southeast coast of China, is one of the world's leading financial centers. Hong Kong has a small spatial scale (1106.66 km^2 in area) and dense population distribution (6844 people/km^2) [70]. Against the backdrop of climate change and rising sea levels, Hong Kong's sustainable development faces greater challenges. First, Hong Kong was recognized as the city with the highest risk of natural disasters (e.g., tropical cyclones) in Asia in the inaugural Sustainable Cities Index [71], while the average annual loss of multiple disasters in Hong Kong is around USD 1138.64 million. Second, Hong Kong faces water security challenges, including floods [72] and severe water shortages [73]. Over-consumption has become a prominent problem in Hong Kong. Hong Kong has one of the highest daily consumption of drinking water per capita in the world [73]. Third, population growth, economic development and shortage of land supply have made housing a major challenge that affects the resilience of Hong Kong [74]. With the accelerated aging of the population, the elderly living alone has also become a topic that needs attention [75]. Therefore, the government has formulated a series of policies and initiatives to promote the resilience of Hong Kong actively. In 2019, the Hong Kong Planning Department released "Hong Kong 2030+", which focuses on reconciling the contradiction between high-density environment and future urban upgrading. The vision is to make Hong Kong a livable, competitive, and sustainable city. The Environment Bureau has published various plans, which include "Energy Saving Plan for Hong Kong's Built Environment 2015–2025+" and "Hong Kong Blueprint for Sustainable Use of Resources 2013–2022".

Hangzhou is the capital city of Zhejiang Province, located in the Yangtze River Delta region. By 2020, the total area of Hangzhou was 16,850 km^2 with a resident population of 11.936 million in 2020, and the city's GDP is 1.61 trillion RMB, accounting for 24.87% of Zhejiang province's GDP, and the urbanization rate had reached 83.29% [76]. As a typical coastal city in eastern China, Hangzhou has a complex and diverse terrain and a subtropical monsoon climate. In the context of global climate change, Hangzhou's rapid urbanization is dominated by population growth, industrialization and land use, thus bringing a series of economic, environmental and social security issues, such as land use restructuring [77], underground space development [78], heat island [79], flood disasters [80], air pollution [81], and affordable housing provision [82]. These problems have seriously affected the resilience of the city and are unconducive to the sustainable development of the city. Moreover, as a city with a long history, Hangzhou needs to balance the relationship between economic development and the protection of historical legacies in the process of urban construction [83]. In order to achieve high-quality development, in 2020, Hangzhou issued the "Proposal of the Hangzhou on Formulating the Fourteenth Five-Year Plan for National Economic and Social Development and the Long-term Goals for 2035", thus emphasizing the importance of enhancing urban resilience. As the birthplace of the City Brain and the leader of the digital economy, Hangzhou devotes itself to digitalization reform. In 2021, Hangzhou formulated the "14th Five-Year Plan for Comprehensive Disaster Prevention and Mitigation in Hangzhou", which aims to build Hangzhou into a demonstration city for integrated intelligence and safe development and to improve the city's disaster monitoring and early warning, risk prevention, public services and emergency response ability.

Thus, investigating the key elements of attentions for enhancing urban resilience in Singapore, Hong Kong and Hangzhou can provide general lessons for risk governance, disaster and emergency management, and urban sustainable development under climate change in Asian cities. Three reasons exist for selecting these three cities as study areas. First, the three cities are developed cities, and their flow of people, materials, capital, technology and information is highly concentrated, but they all face uncertainties and challenges brought by issues related to climate change, urbanization and globalization. Second, although Singapore, Hong Kong and Hangzhou all attached great importance to the construction of resilient cities, due to their unique geographical locations, urbanization

development stages and governance strategies, cities need to focus on various priorities in the process of resilience development. For example, in high-density cities such as Hong Kong and Singapore, the number of residents in one building may be equal to several administrative units in low-density cities [84]. Singapore is an independently developed city-state, while Hong Kong and Hangzhou are administrative regions in China. The differences in institutions may lead to differences in urban governance capabilities. Therefore, each situation requires a different approach and ability to deal with emergencies. Third, the three cities not only represent the most cutting-edge urban development models in Asia, but they also have different priorities in the process of building resilient cities due to various cultural and developmental environments. Hong Kong is an example of the localization of international urban planning due to its historical and geographical relationship. Singapore is the epitome of Asia's creative frontier city. Hangzhou is a representative city of the Chinese mainland's digitalization and urbanization. Therefore, the comparison of the resilience of these three cities can provide a meaningful reference for the construction of resilient cities.

3.2. Research Process

In order to realize the research objective, this study took a series of research steps. The first is to conduct a questionnaire survey (Appendix A) to collect data to assess the significance level of the preliminary elements of attentions for enhancing urban resilience in Singapore, Hong Kong and Hangzhou, respectively. The second is to conduct statistical analysis to identify the key elements of attentions for enhancing urban resilience in the three cities. The third is to compare and discuss the similarities and differences in key elements of attentions for enhancing urban resilience in the three cities. The specific research process is introduced as follows.

Based on the preliminary elements of attentions for enhancing urban resilience identified from the literature review, which is summarized in Section 2, this study made a questionnaire to collect data assessing the significance level of the preliminary elements. The questionnaire had three parts: a brief introduction to the survey, background information of the interviewees and an invitation to assess the significance level of the preliminary elements. The significance level was assessed between 1 and 5, with 1 having the least significance and 5 with the highest significance. The same questionnaire was used in the survey of the three cities. The English version was used in Singapore and Hong Kong, while the Chinese version was used in Hangzhou in consideration of the dominant language in the three cities. Efforts have been spent to minimize information losses during the translation. The target respondents of the questionnaire survey were planners and researchers in the field of urban planning because professional knowledge is required in the survey. A random survey was used by sending an email to or interviewing the planners and researchers on the contact list of the authors. Owing to the limited access to the professional group, a snowball technique was used to increase the response rate by requesting the respondents to send the questionnaire survey to their friends or colleagues qualified to fill the survey [60]. The survey was stopped when no new information can be obtained through snowball techniques.

The questionnaire survey in Singapore was conducted from January to April 2015. Sixty questionnaires were sent to potential respondents through a webpage link in an email. A total of 34 effective responses were received for a response rate of 56.67%. The questionnaire survey in Hong Kong was conducted between January and March 2016. Eighty questionnaires were sent to potential respondents via a webpage link in an email or conducted by interview. A total of 32 effective responses were received for a response rate of 40.00%. The questionnaire survey in Hangzhou was conducted between March and May 2016. A total of 106 questionnaires were sent to potential respondents through a webpage link in an email or conducted by interview. A total of 41 effective responses were received for a response rate of 38.68%. The statistics of the background information of the

respondents in the three cities are shown in Table 5. To validate the findings, a follow-up round of interviews was also conducted in August and September 2020.

Table 5. Statistics of background information of the respondents in Singapore, Hong Kong and Hangzhou.

		Singapore (n = 34)	Hong Kong (n = 33)	Hangzhou (n = 41)
Year of work experiences	Mean value	4.5	3.7	4.1
Type of institution	Governmental departments (%)	32.35	15.15	19.51
	Research institutions (%)		45.45	31.71
	Industry (%)	67.65	39.40	48.78

The average significance level of the preliminary elements of attentions for enhancing urban resilience in Singapore, Hong Kong and Hangzhou was calculated using the effective questionnaires collected. Statistics of mean and standard derivation were performed. The indicator with an average significance value above 4 was identified as a key element of attentions for enhancing urban resilience in corresponding cities. These key elements were further compared to find the similarities and differences in the three cities. Section 4 presents the specific results of this study.

4. Results

Results can be found in Table 6, which shows 14 elements whose average significance level is above 4 for Singapore, 13 elements for Hong Kong, and 14 elements for Hangzhou. For Singapore, the EP3 (*Noise Pollution*) is ranked as the lowest significance, while that for Hong Kong is EP1 (*Flood Risk Assessment & Management*) and for Hangzhou, it is EN2 (*On-site Energy Generation*).

Figure 1 demonstrates the differences in the significance level of each category for elements of attentions for enhancing urban resilience. *Innovation* is the highest priority for Singapore and Hangzhou, while *Material & Waste* is the highest priority for Hong Kong. This difference is echoed by socio-economic conditions. Singapore and Hangzhou placed a much higher priority on innovations for urban development and management through their various governmental policies. Hangzhou is recently considered as a digital city, which takes innovative technologies, e.g., cloud computing and artificial intelligence, to advance urban governance and solve the serious problems of traffic jams. On the other side, Hong Kong is facing increasing problems related to the limited land for waste landfills; therefore, relevant elements in the *Material & Waste* category are prioritized. In addition, Singapore takes the highest priority in the categories of *Green Building & Green Transportation*, *Community* and *Innovation* among the three cities. Hong Kong takes the leading role in the categories of *Energy*, *Water*, *Material & Waste*, *Environmental Planning* and *Economy* among the three cities. Hangzhou takes the leading role only in the category of *Governance* among the three cities.

Figure 2 demonstrates the significance level of each element of attentions for enhancing urban resilience in the three cities. This research defines the elements with an average significantly higher than 4 as key elements of attentions for enhancing urban resilience in the case city. Among the 14 significant elements for Singapore, WA1 (*Water Strategy*), MW2 (*Resource Management*), GBT4 (*Public Transport Facilities*), and CO1 (*Stakeholder Engagement, Feedback, & Evaluation*) are the elements of the three highest significance. MW1 (*Waste Management and Segregation*), EP10 (*Land Use*) and GBT3 (*Green Transport within District*) are the elements ranked with the three lowest significance. Among the 13 significant elements for Hong Kong, MW2 (*Resource Management*), MW1 (*Waste Management and Segregation*), and CO2 (*Public Awareness & Education*) are the elements of the three highest significance. MW4 (*Sustainable Construction for Infrastructure & Public Amenities*), GBT2 (*Green Urban Design Guidelines*), and I1 (*Green Features & Innovations*) are the elements ranked with the

three lowest significance. Among the 14 significant elements for Hangzhou, EP2 (*Adapting to Climate Change*), WA1 (*Water Strategy*) and EN3 (*Energy Management Plan & System*) are the elements with the three highest levels of significance. EP7 (*Conservation & Integration of Existing Structure*), EP10 (*Land Use*), WA5 (*Water Efficient Fittings for Infrastructure & Public Amenities*), EP8 (*Green & Blue Spaces within District*) and GBT2 (*Green Urban Design Guidelines*) are the elements with the two lowest levels of significance.

Table 6. The average significance level of preliminary indicators in Singapore, Hong Kong and Hangzhou.

Element	Singapore (*n* = 34)		Hong Kong (*n* = 33)		Hangzhou (*n* = 41)	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Energy Efficiency for Infrastructure & Public Amenities	**4.18**	0.67	**4.21**	0.65	**4.07**	0.69
On-site Energy Generation	3.71	0.76	3.48	1.25	3.27	0.92
Energy Management Plan & System	3.50	0.66	**4.06**	0.66	**4.10**	0.77
Site Planning & Building Orientation	3.18	0.97	**4.09**	0.72	3.80	0.71
Water Strategy	**4.32**	0.81	**4.09**	0.72	**4.12**	0.84
Stormwater Management	3.47	0.61	3.64	1.03	3.56	0.81
Alternative Water Source	3.06	0.69	3.64	1.08	3.56	0.95
Water Efficient Landscape	3.38	0.55	3.82	0.77	3.66	0.66
Water Efficient Fittings for Infrastructure & Public Amenities	3.74	0.71	3.94	0.83	**4.02**	0.79
Waste Management and Segregation	**4.00**	0.74	**4.30**	0.73	3.95	0.74
Resource Management	**4.24**	0.65	**4.39**	0.66	**4.07**	0.69
Low Impact Materials and Sustainable Products for Infrastructure & Public Amenities	3.53	0.56	3.94	0.9	3.54	0.81
Sustainable Construction for Infrastructure & Public Amenities	**4.09**	0.45	**4.03**	0.64	3.90	0.7
Flood Risk Assessment & Management	3.59	0.61	3.45	0.87	3.41	0.84
Adapting to Climate Change	**4.06**	0.69	**4.09**	0.91	**4.17**	0.89
Noise Pollution	2.79	0.41	3.91	0.84	3.39	0.97
Site Selection	3.74	0.51	3.76	0.87	3.63	0.8
Environmental Management System	3.91	0.62	**4.06**	0.7	**4.05**	0.59
Self-sufficiency & Accessibility Within District	**4.15**	0.61	3.94	0.79	3.93	0.75
Conservation & Integration of Existing Structure	3.38	0.6	3.67	0.85	**4.00**	0.74
Green & Blue Spaces Within District	**4.18**	0.52	**4.09**	0.58	**4.02**	0.61
Future Provision & Connections	3.74	0.62	3.88	0.7	3.73	0.67
Land Use	**4.00**	0.65	3.91	0.8	**4.00**	0.77
Green Buildings Within District	3.97	0.58	3.88	0.78	3.68	0.76
Green Urban Design Guidelines	3.94	0.65	**4.03**	0.68	**4.02**	0.72
Green Transport Within District	**4.00**	0.7	3.91	0.8	3.78	0.79
Public Transport Facilities	**4.21**	0.48	3.97	0.77	3.88	0.71
Stakeholder Engagement, Feedback & Evaluation	**4.21**	0.73	3.76	0.9	3.85	0.99
Public Awareness & Education	3.85	0.66	**4.24**	0.79	**4.05**	0.8
Green Lease	**4.09**	0.62	3.64	0.82	3.85	0.88
Inclusive Design	3.68	0.77	3.67	0.74	3.73	0.87
Economic Impact	3.12	0.69	3.70	0.92	3.51	0.81
Community Management of Facilities	3.65	0.65	3.91	0.77	3.85	0.73
Design Review	3.74	0.62	3.76	0.83	**4.07**	0.72
Green Features & Innovations	**4.15**	0.74	**4.03**	0.68	**4.05**	0.74

Note: the average value above 4 indicates key elements of attentions of the case city.

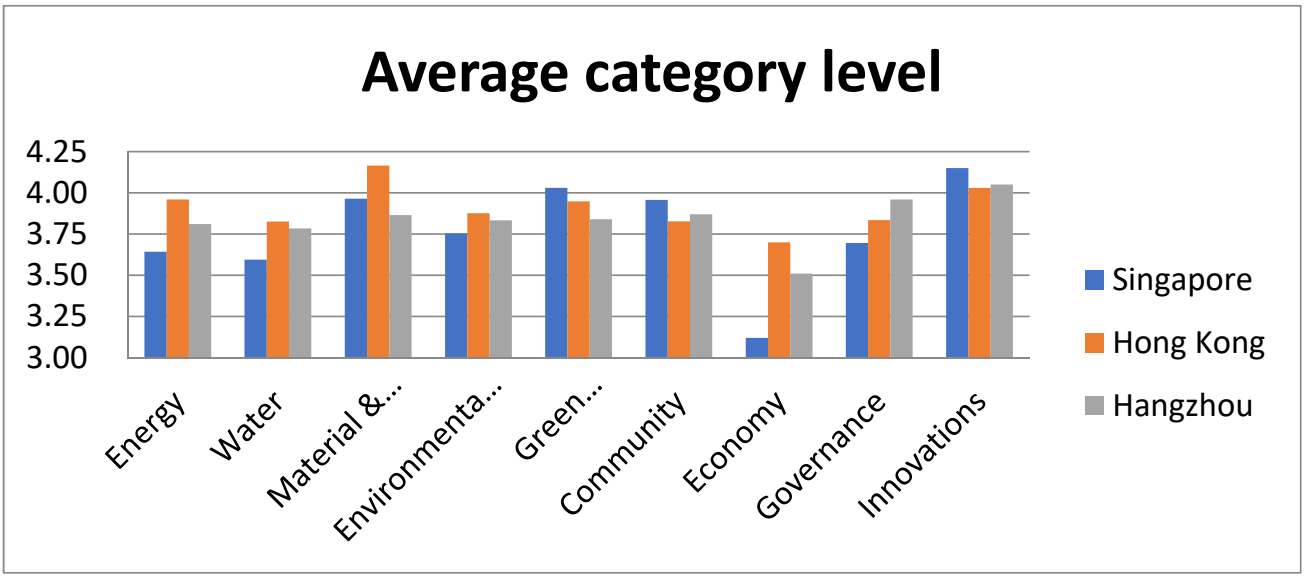

Figure 1. Importance of each category of elements of attentions for enhancing urban resilience in the three cities.

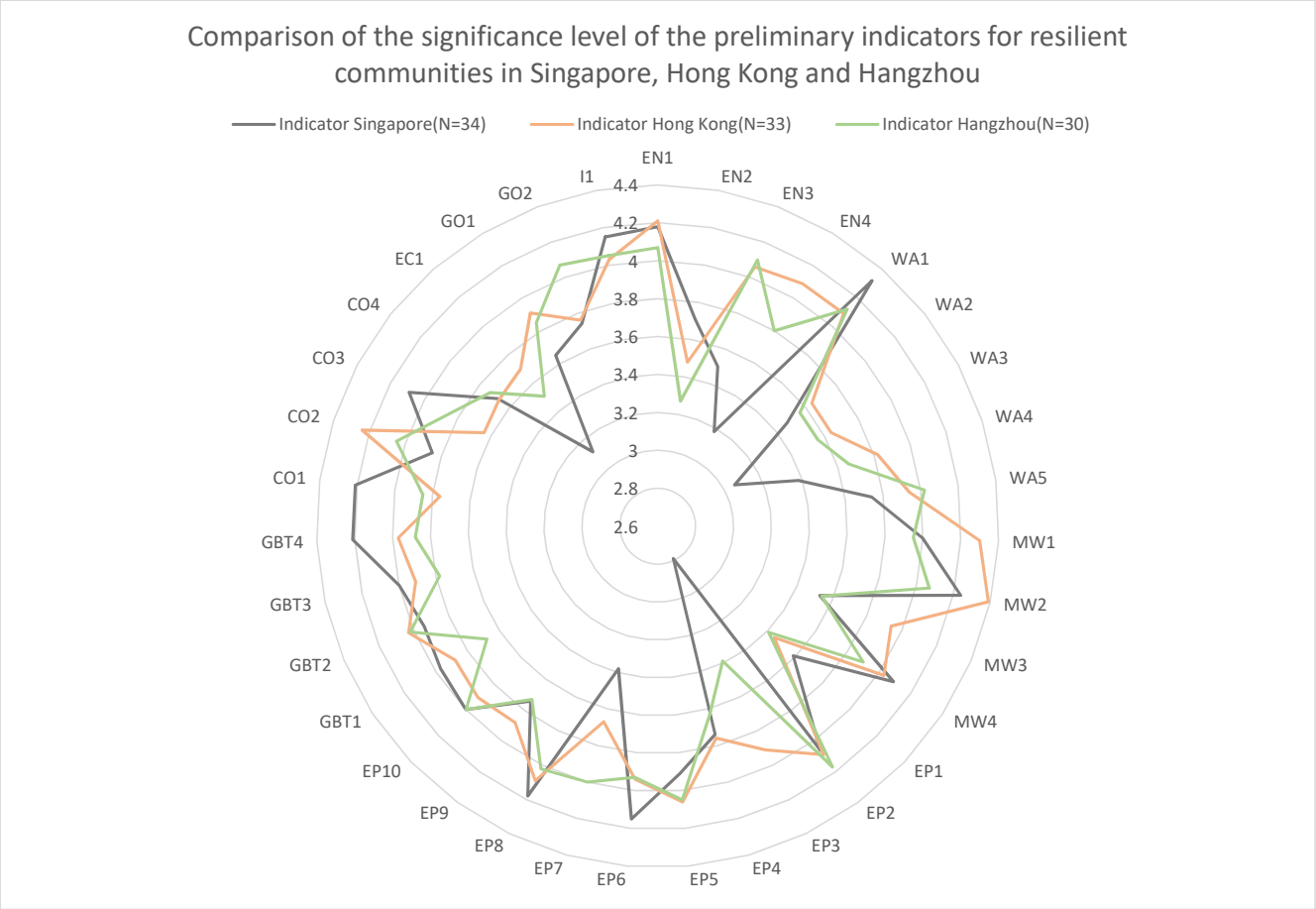

Figure 2. Comparison of the significance level of the preliminary elements of attentions for enhancing urban resilience in Singapore, Hong Kong and Hangzhou.

5. Discussions

The three cities have different key elements of attentions for enhancing urban resilience (see Figure 2). Although the elements EN1 (*Energy Efficiency for Infrastructure & Public Amenities*), WA1 (*Water Strategy*), MW2 (*Resource Management*), EP2 (*Adapting to Climate Change*), EP8 (*Green & Blue Spaces within District*), and I1 (*Green Features & Innovations*) have varying average significance, they are the common elements for all three cities. EN3 (*Energy Management Plan & System*), EP6 (*Self-sufficiency & Accessibility within District*), GBT3 (*Green Transport within District*), GBT4 (*Public Transport Facilities*), CO1 (*Stakeholder Engagement, Feedback, & Evaluation*), and CO3 (*Green Lease*) are the six significant elements emphasized by Singapore. By contrast, EN4 (*Site Planning & Building Orientation*) is the single significant element emphasized by Hong Kong, while WA5 (*Water Efficient Fittings for Infrastructure & Public Amenities*), EP7 (*Conservation & Integration of Existing Structure*), and GO2 (*Design Review*) are the three significant elements that Hangzhou emphasized. The following section will thoroughly discuss the identified key elements of attentions for enhancing urban resilience in the three cities.

In terms of *Energy*, *Energy Efficiency for Infrastructure & Public Amenities* is the common key element in the three cities. Previous studies determined that improving the energy efficiency of infrastructure and public amenities is useful for enhancing the ability of cities to cope with external disturbances, e.g., climate change and supply shortage. Energy efficiency is a huge concern of the three cities, which cannot produce sufficient energy by themselves. For example, Hangzhou proposed to replace existing buses in urban areas with new energy vehicles in the 2020 government work report (A breakdown of key responsibilities in the 2020 government work report). Singapore proposed integrated planning and sound governance to ensure secure, competitive and sustainable energy supply (Energising Singapore: Balancing Liveability and Growth). *Energy Management Plan & System* is the common element for Hong Kong and Hangzhou. An improved energy management plan and systems can bring higher energy efficiency in the building operation and management stage. This result reflects that Hong Kong and Hangzhou still have much room to improve the performance of their energy management plans. Hong Kong also emphasizes *Site Planning & Building Orientation* in the *Energy* category. In a high-density city such as Hong Kong, the site planning and relevant building orientation affect whether natural resources, e.g., wind and light, may be sufficiently utilized, which further affects energy consumption in the construction and operation and management stage. Hong Kong's building practices are regularly updated to fulfill international standards. For example, steel structures in Hong Kong are designed to be resilient to disasters. Therefore, Hong Kong should also pay due attention to optimizing site planning and building orientation to save energy.

With respect to the *Water* category, *Water Strategy* is the common key element in this category among the three cities. Singapore and Hong Kong are troubled by sufficient water for use because of their geographical constraints. Hangzhou is worried about the quality of water and formulates policies to cope with sewage water, flood and urban waterlogging, as well as further ensuring the water supply and saving water. Therefore, *Water Strategy*, or ensuring sufficient quality water, is important for the three cities. A series of measures were adopted to promote the water strategy. For example, Hangzhou implemented projects to ensure sufficient water resources (Hangzhou Disaster Prevention and Mitigation Action Plan). Hong Kong formulated Desalination-A Critical Element of Water Solution for the 21st Century. Singapore proposed to create a robust system to manage the impact of rising sea levels and changing weather with multi-functional water storage projects. Hangzhou also stresses the importance of *Water Efficient Fittings for Infrastructure & Public Amenities*, because its utilization efficiency of water for infrastructure and public amenities is still quite low compared to other cities. Hangzhou proposed to promote the construction of zero-direct sewage discharge areas and speed up the construction of flood control and drainage projects, such as the Bapu Pumping Station (A breakdown of key responsibilities in the 2020 government work report).

With regard to the category of *Material & Waste*, *Resource Management* is the common key element among the three cities. Waste resource management affects the material used and waste generated during the construction stage. All three cities are concerned with improving the management of their resources to achieve more sustainability and resilience. Better waste resource management enhances resourcefulness, redundancy and efficiency of the urban system, which can improve urban resilience. For example, Hong Kong proposed the "Hong Kong Blueprint for Sustainable Use of Resources 2013–2022" and "A Clean Air Plan for Hong Kong". *Waste Management and Segregation* and *Sustainable Construction for Infrastructure & Public Amenities* are two common key elements for Singapore and Hong Kong. Efficient waste management can reduce the generation or increase the reuse of construction waste, which helps achieve sustainability. The *Sustainable Construction for Infrastructure & Public Amenities* is useful to provide critical support for resilient cities. For example, the Hong Kong government ensures that the infrastructural environment is assessed and made disaster-resilient to a great extent [30]. Singapore proposed a new future city initiative which focused on advanced building methods, resilient infrastructure, new spaces and sustainable cities.

In terms of *Environmental Planning*, *Adapting to Climate Change* and *Green & Blue Spaces within District* are two common key elements in this category among the three cities. Hangzhou, which held the G20 meeting in 2016, actively promoted the "Paris Agreement" as soon as possible, to enhance the priority position of environmental sustainability in the structure and expedite the green financial development. China is promoting the implementation of the 2030 Sustainable Development Agenda program, and Hangzhou actively responds to the policy and strives to move forward. *Environmental Management System* is the common key element for Hong Kong and Hangzhou. This element emphasizes an improved environmental management to achieve sustainability and resilience. *Land Use* is the common key element for Singapore and Hangzhou. Unlike the high-density utilization in Hong Kong, Singapore and Hangzhou still have room to improve their land use, to realize sustainability and resilience. *Self-sufficiency & Accessibility within District* is the distinctive key element for Singapore, a concern that is a natural response to the limited resources within the city. *Conservation & Integration of Existing Structures* is the distinctive key element for Hangzhou, which has many existing structures built throughout its long history. Therefore, the conservation and integration of existing structures are important to realize cultural sustainability and to better utilize existing resources. The conservation measures can further enhance the social cohesion with a common memory, improve social capital and further increase urban resilience.

Concerning the category of *Green Building & Green Transportation*, no common key element is found in the three cities. *Green Urban Design Guidelines* is the common key element for Hong Kong and Hangzhou. This result indicates a current lack of such guidelines. The respective governments should explore such issues and develop appropriate guidelines according to the local conditions. *Green Transport within District* and *Public Transport Facilities* are distinctive key elements for Singapore because of the dispersed distribution of housing in the city and the huge demand for transportation. Singapore made the "Land Transport Master Plan" and promoted a transit-oriented approach to development and planning, which aims to make public transport the preferred mode of transit, through improved connectivity and better services.

In the *Community* category, *Public Awareness & Education* is the common key element for Hong Kong and Hangzhou, thus reflecting the lack of direct guidelines to initiate resilient cities in these cities. Public education should be conducted to promote the public's awareness of resilient cities. For example, Hangzhou proposed to build a platform for urban safety publicity and education and promote the construction of a multi-functional base integrating urban disaster reduction and prevention, building fire safety, road traffic safety, occupational safety and health, and other real scene experiences, as well as practical operations to avoid disasters (Three-Year Action Plan of Hangzhou City to Create a National Demonstration City for Security Development (2018–2020)). *Stakeholder Engagement*,

Feedback, & Evaluation and *Green Lease* are distinctive key elements for Singapore. These concerns reflected the awareness of the importance of stakeholder management and the green lease in Singapore.

The element of *Economic Impact* is not identified as a key element of attentions for enhancing urban resilience for the three cities. This meant that the economic issues are not that important compared with other indicators for the interviewees. The alternative interpretation is that the three cities have a sufficient budget to consider more than the economy in promoting resilient cities. In addition, *Design Review* is the distinctive key element in the *Governance* category in Hangzhou, a result indicating the comparatively low design quality and high concern for government departments.

6. Conclusions

6.1. Research Significance

Enhancing urban resilience is critical for cities to withstand the rapidly changing world and potential disasters. This study compares the key elements of attentions for enhancing urban resilience among Singapore, Hong Kong and Hangzhou. The findings demonstrated that the three cities have varying elements of attentions in enhancing urban resilience despite many similarities. Singapore has taken the highest priority in the categories of *Green Building & Green Transportation*, *Community* and *Innovation* among the three cities. Hong Kong has taken the leading role in the categories of *Energy*, *Water*, *Material & Waste*, and *Environmental Planning* among the three cities. Hangzhou has taken the leading role only in the category of *Governance* among the three cities.

The findings demonstrated the similarity and difference between elements of attentions among the three cities, which are deeply rooted in the economic development and governance backgrounds. Therefore, we should be cautious when using a general framework or specific model derived from one case to conduct a comparative analysis of urban resilience. The localization of developing and measuring urban resilience is necessary while learning from international cases. Common key elements of attentions reminded the government to learn from one another to find more useful measures to enhance urban resilience. Due attention should be paid to various elements of attentions generated based on the local conditions of each city. This research also provides a reference for other international comparisons.

6.2. Limitations and Future Study

Several limitations were observed in this paper. First, the findings were derived from data collected in 2015 and 2016. Although the comparison and uncovered reasons are worthwhile, progress has been made in the past five years around the world. Updated analysis and a comparison in the time series can be conducted to further deepen the understanding. In addition, the framework and elements of attentions for enhancing urban resilience should also be updated with socio-economic development and a deepened understanding of urban resilience. For example, COVID-19 provides a chance, and also new requirements, to comprehend urban resilience. Second, the sample size for analyzing the experts' opinions was limited. Therefore, the derived results may be more indicative than representative. It can provide certain references or implications when considering enhancing urban resilience in the case cities. Yet, it should be cautious to generalize the findings, which may not be suitable for this study. Future studies can consider increasing the sample size with support from some official channels when making plans for resilient cities. Third, this study investigated the elements of attentions for enhancing urban resilience with a top-down approach with an expert centric approach in the survey. The views of residents can be indirectly reflected by the planners and governmental officers, who are assumed to include public opinions before making planning or policies. Yet, the bottom-up approach to enhancing urban resilience is also important, which means that the direct views of the residents should be considered in such a condition. Future studies can be conducted to compare the differences in elements of attentions between the top-down

and bottom-up approaches. Fourth, the key elements of attentions were identified based on the comprehension of interviewees, which is partially subjective. As more and more cities formulate strategies for enhancing urban resilience, comparisons based on these official documents is an alternative and objective approach to identify the similarities and differences of elements of attentions. Last, the comparison is conducted only among three Asian cities. Future studies can be conducted to compare the key elements of attentions for enhancing urban resilience among cities with significantly different cultural and governance backgrounds. The comparison of large samples of different cities is also beneficial for explaining why different cities pay similar and various attentions when enhancing urban resilience.

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Appendix A

Questionnaire Survey Sample

Dear Sir/Madam,

We are a joint research group to investigate the key elements of attentions for enhancing urban resilience in Singapore, Hong Kong and Hangzhou. The research group promotes the development of resilient cities in facing challenges like climate change. This study aims to find the significant elements of attention that should be paid to in developing such cities. All data would be kept confidential and just used for research. Please answer the following questions according to your work experience.

Thank you again for your kind support.

Best wishes

1 The Joint Research Group of Resilient Cities

(1) General Information of Respondent

(2) Company type:

(A) Governmental departments; (B) Research institutions; (C) Industry

(3) Years of relevant work experience:

2 Significance level of the preliminary elements of attentions for enhancing urban resilience

Please rate the significance level of the following elements of attentions for enhancing urban resilience between 1 and 5 with 1 as the least significant, while 5 as the most significant.

Category	No.	Element	Meaning	Significance Level
Energy	EN1	Energy Efficiency for Infrastructure & Public Amenities	Energy modeling or calculation to include energy demand and operating carbon emissions for infrastructure and public amenities	
	EN2	On-site Energy Generation	Introduction of on-site generation of energy for self-sufficiency in common areas	
	EN3	Energy Management Plan & System	To design and incorporate energy monitoring and/or control system to facilitate energy consumption monitoring and management for public facilities	
	EN4	Site Planning & Building Orientation	To minimize heat gain/loss by use of passive solar strategies to reduce the energy demand	
Water	WA1	Water Strategy	To develop water management plan to minimize water demand through efficiency and appropriate supply-side options	
	WA2	Stormwater Management	Introduction of treatment of stormwater run-off before discharge to public drains and to reduce frequency of flooding in community	
	WA3	Alternative Water Source	To introduce possible alternative water sources for non-potable usage to reduce use of potable water	
	WA4	Water Efficient Landscape	To reduce water demand by introducing drought resistant plants in landscape design	
	WA5	Water Efficient Fittings for Infrastructure & Public Amenities	Introduction of use of water efficient fittings	
Material & waste	MW1	Waste Management and Segregation	To increase recycling and have proper disposal of waste and provide waste management infrastructures	
	MW2	Resource Management	To promote resource efficiency by reducing waste during construction and throughout lifecycle of development	
	MW3	Low Impact Materials and Sustainable Products for Infrastructure & Public Amenities	To encourage use of environmentally friendly products	
	MW4	Sustainable Construction for Infrastructure & Public Amenities	To encourage recycling and adoption of designs, practices and materials that are environmentally friendly and sustainable in the construction of infrastructure and public amenities	

Category	No.	Element	Meaning	Significance Level
Environmental planning	EP1	Flood Risk Assessment & Management	To demonstrate that development is appropriately flood resilient and resistant	
	EP2	Adapting to Climate Change	Climate change adaptation plans made in accordance to current best practice and planning policy	
	EP3	Noise Pollution	To mitigate impacts of noise, which includes mitigation of existing sources of noise, reducing potential noise from future sources, and protecting potential noise-sensitive areas	
	EP4	Site Selection	To avoid use of greenfield sites and take proper remediation measures carried out on contaminated land to restore land for use	
	EP5	Environmental Management System	To introduce planning, design and management integration to adopt an environmentally friendly management system and practices during development	
	EP6	Self-sufficiency & Accessibility Within District	To ensure sufficient range of facilities provided in the community to meet the needs and to increase accessibility to key facilities for all the people	
	EP7	Conservation & Integration of Existing Structure	Conservation, preservation or restoration of historic remains, buildings, or natural spaces or views	
	EP8	Green & Blue Spaces Within District	To provide adequate green and blue spaces for the city	
	EP9	Future Provision & Connections	To encourage plans for future adaptability and flexibility of urban development	
	EP10	Land Use	To maintain sufficient land for use and improve ecological biodiversity	
Green building & green transportation	GBT1	Green Buildings Within District	To introduce adoption of green building practices in building design, construction and retrofitting	
	GBT2	Green Urban Design Guidelines	To ensure key green features are carried out throughout all levels of urban development	
	GBT3	Green Transport Within District	To introduce green transportation in the city	
	GBT4	Public Transport Facilities	To conduct traffic modeling for the city to assess and make improvement to existing transportation facilities	
	CO1	Stakeholder Engagement, Feedback & Evaluation	To conduct residents' feedback survey or engage in public consultation exercise to gather feedback to enhance quality of living environment in common areas	

Category	No.	Element	Meaning	Significance Level
Community	CO2	Public Awareness & Education	To introduce sustainable lifestyle and integration within the community through outreach of education program to increase public awareness on urban resilience	
	CO3	Green Lease	To encourage green lease as an alternative to regular economic rental models	
	CO4	Inclusive Design	To ensure inclusive urban design by encouraging construction of built environment that optimizes accessibility for all residents	
Economy	EC1	Economic Impact	To ensure community contributes to local area by enhancing, diversifying or adding employment opportunities and/or skills training	
Governance	GO1	Community Management of Facilities	To support communities in active involvement in developing, managing and/or owning selected facilities	
	GO2	Design Review	To ensure masterplan's design supports a vibrant, healthy and functional and inclusive city	
Innovation	I1	Green Features & Innovations	To support any innovation within design, planning and construction of the city through recognition of sustainability and resilience related benefits	

3 Please add any elements of attentions and their significance level that you think is important for enhancing urban resilience.

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