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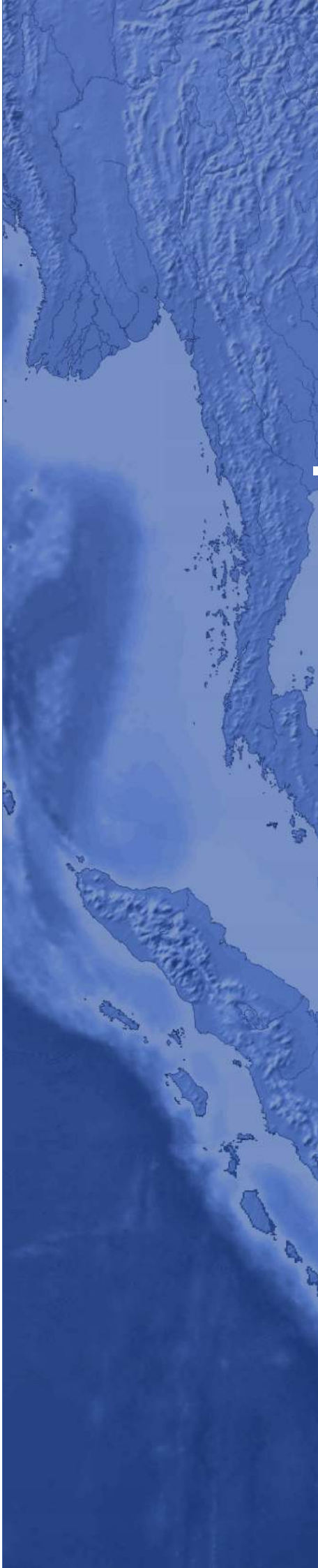
Towards a resilient society

An assessment of disaster readiness in 5 ASEAN cities

Written by The Economist INTELLIGENCE UNIT

Contents

Towards a resilient society




Bangkok, Thailand
Ho Chi Minh City, Vietnam
Kuala Lumpur, Malaysia
Singapore, Singapore
Jakarta, Indonesia

About this report

Towards a resilient society

Towards a resilient society is a report from The Economist Intelligence Unit (EIU), commissioned by the Institute of Public Policy and Development (IPPD) in Thailand. The analysis is based on The EIU's DRIOR model, which was developed for the United Nations Office for Disaster Risk Reduction (UNDRR) in 2015. This report adapts the DRIOR model to focus on disaster risk management at the city level rather than the country level, with a focus on five capital cities in the Association of Southeast Asian Nations (ASEAN): Bangkok, Ho Chi Minh City, Jakarta, Kuala Lumpur and Singapore. A scorecard assesses these five cities across five domains: institutional framework; disaster risk reduction policy, preparedness and response; economic resilience; societal resilience; and resilience of the physical environment. This report outlines the key findings and methodology for this scorecard.

Findings from the scorecard were supplemented with research and in-depth interviews with experts in the field. The EIU would like to thank the following experts for their time and insights:

- **Srini Ancha**, Principal Climate Change Specialist, Asian Development Bank
- **Riyanti Djalante**, Academic Programme Officer, United Nations University
- **Phan Duy**, Researcher, School of Geography, Earth and Environmental Sciences, University of Birmingham
- **Loretta Hieber Girardet**, Chief, Asia-Pacific, United Nations Office for Disaster Risk Reduction
- **Hans Guttman**, Executive Director, Asian Disaster Preparedness Centre
- **Abhas Jha**, Practice Manager, Urban and Disaster Risk Management, East Asia and the Pacific, The World Bank
- **Melissa Merriweather**, Architect and former Chief, Vietnam Green Building Council
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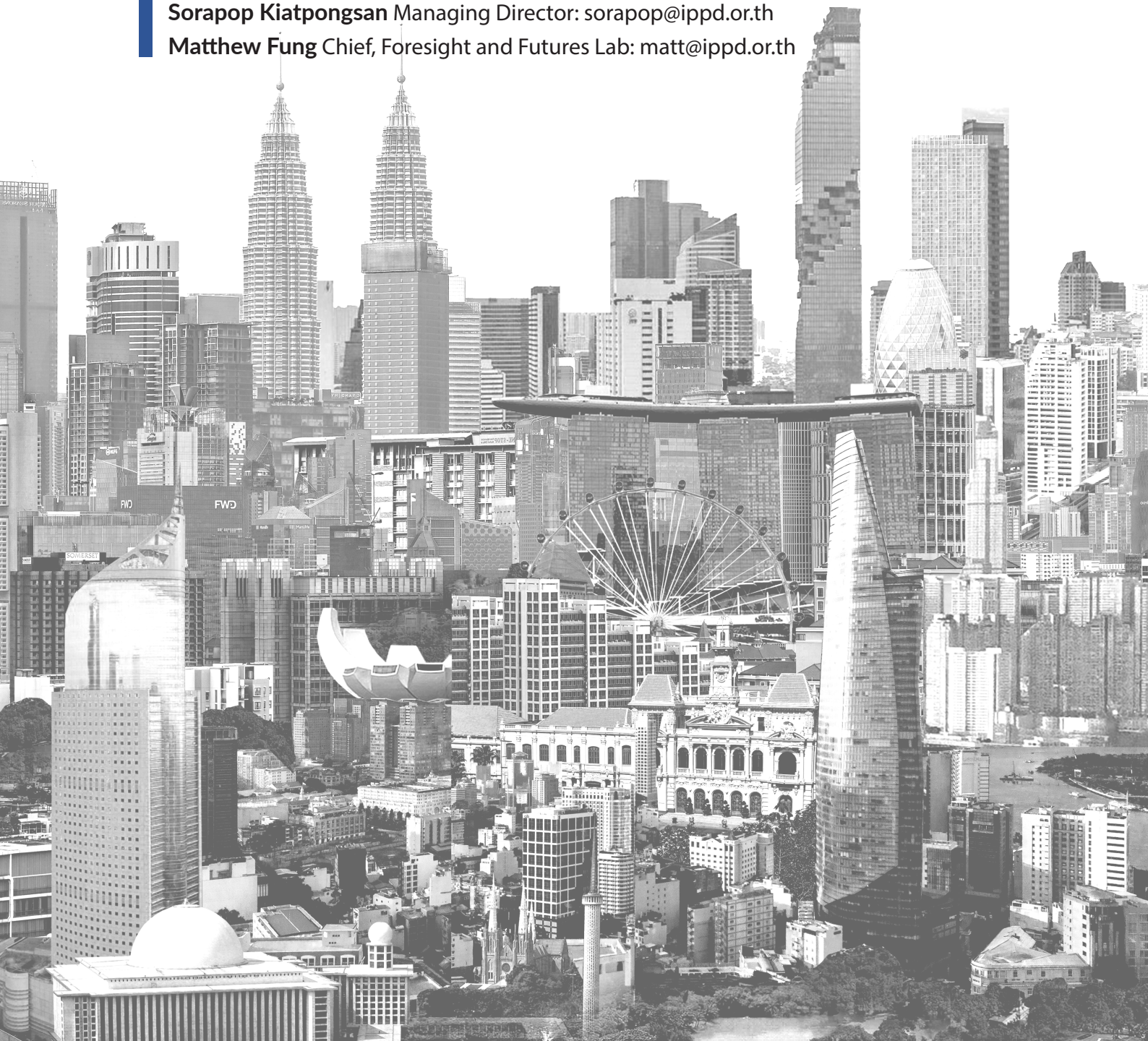

Executive summary

Towards a resilient society

A number of natural risks leave Asia highly vulnerable to climate change, including monsoonal weather, tropical climates, low-lying land and large, river-based systems. These risks have been exacerbated by economic development in the region, particularly rapid and unsustainable urbanisation alongside rivers and coastlines. As buildings, roads and concrete infrastructure encroach upon vegetation and flood plains, these cities' capacity to absorb water decreases, whether from coastal inundation or from floods caused by storms and overflowing rivers. Due to the heat-trapping effects of buildings and their materials, temperatures in cities are also higher than in surrounding areas. This means that cities in Asia are both highly vulnerable to climate change and are accentuating the loss and damage it causes through their design and construction. In the coming years, the impacts of climate change will be increasingly apparent across the region, which has one of the highest rates of urbanisation in the world (1.5% per year) and boasts more than half of the world's megacities. Asia's cities are at the core of its growth story, and their sustainability will have a significant impact on nations' future economic success.

Fortunately, central and local governments can take steps to reduce disaster risk and lower the impact of hazards. From climate-sensitive spatial planning to the enforcement of sustainable building codes, governments have the power to protect their citizens and urban economies from harm. For example, building "hard" and "soft"[1] adaptation infrastructure and making use of sensors, geospatial technology and predictive analytics can support early warning systems, which are key to protecting both people and assets. Policy decision-makers can also encourage businesses, the media and civil society to play a more active role in disaster risk reduction (DRR).

However, governments must act quickly. Emissions continue to rise, and without swift adaptation efforts the continent risks losing many of the social and economic gains it has fought so hard to achieve over the last three decades. To help Asia's city stakeholders, the Institute of Public Policy and Development (IPPD) commissioned The Economist Intelligence Unit (EIU) to produce an in-depth study that combines

city-level resilience scores with qualitative insight from experts. Covering Bangkok, Ho Chi Minh City, Jakarta, Kuala Lumpur and Singapore (which have a combined population of 35m), this project identifies common and distinct risks, from river- and storm-related flooding to landslides, heatwaves and pollution haze. A scorecard assessed these five cities across five domains: institutional framework; DRR policy, preparedness and response; economic resilience; societal resilience; and resilience of the physical environment. Based on this scorecard, each city's level of disaster risk preparedness and response was ranked as either nascent, emerging, developed or mature.

Recognising that the future of these cities will be shaped by decisions made today, this study's assessment of cities' disaster risk resilience creates a foundation for forward-looking disaster risk management (DRM) and urban planning. The key findings from our analysis are outlined below.

- Four of the five cities were scored as "mature" or "developed", indicating strong engagement with DRR, backed up by institutions and regulations. The scorecard shows strong engagement with DRM in all cities, with Singapore ranked as "mature"; Ho Chi Minh City, Jakarta and Kuala Lumpur ranked as "developed"; and Bangkok ranked as "emerging". All five cities have a sub-national entity responsible for dealing with DRM[2]. In Jakarta, Kuala Lumpur and Singapore, these entities are permanently staffed; in Bangkok and Ho Chi Minh City, the entities rely on blended staffing. Sub-national government officials have expressed active support for DRM in all five cities. Three of the five cities—Ho Chi Minh City, Jakarta and Singapore—have followed best practice in developing a clear plan for DRM monitoring. In Bangkok, there is a plan for monitoring ongoing DRM, but the evaluation mechanism is unclear. All cities except Kuala Lumpur explicitly include disaster risk in city planning, although implementation remains a challenge. In terms of regulations, building codes account for disaster risk in all cities except Kuala Lumpur. However, enforcement is a challenge, with greater emphasis placed on seismic risks than climatic risks.

- Economic and societal resilience are weak across cities. Economic resilience covers factors such as urban poverty and the presence of catastrophe insurance. Cities were categorised as weak overall in this domain, with only Singapore ranked as "mature". It is crucial to address this weakness, given the

costs associated with climate disaster events, as well as their impact on key GDP drivers such as tourism and manufacturing. Jakarta's 2007 floods caused an estimated US$565m in damage, for example, while Thailand's national growth forecast was halved following its 2011 floods. Indonesia, Thailand and Vietnam also have high proportions of people working in the agricultural sector, which can be seriously undermined by climate catastrophe, in turn driving climate-related migration to major cities. Each of the capital cities in these three countries lacks any form of catastrophe insurance, which could provide protection for citizens and businesses. There are also appreciable shares of urban poor people in all three cities. These people may have no savings or assets to help them bounce back from disasters, highlighting the clear link between climate risk and economic vulnerability. Societal resilience covers factors such as public safety and security, social cohesion and the effectiveness of the health system. None of the five cities achieved a top score of "mature" in this domain, but three cities were ranked as "emerging": Bangkok, Ho Chi Minh City and Jakarta.

- Significant gaps exist between policy and practice. The scorecard ranked countries on the presence of DRM instruments on paper, notably institutions and regulations. However, there are important gaps between rules and protocols and on-the-ground realities. Cities often produce disaster risk modelling but do not integrate this meaningfully into future planning. For instance, urban building codes frequently contain disaster risk restrictions, but these may be flouted or ignored. Fuelled by urbanisation, building continues in hazard zones, even where there is knowledge of the associated risks. There is also a lack of procedural clarity during disaster events. During Bangkok's 2011 floods, for example, over 20 different departments had mandates, resulting in co-ordination challenges. Furthermore, DRR strategies are not always sufficiently funded via parliamentary or legislative means.

- Political support exists, at least in public statements, but remedial actions often focus on hard engineering[3] solutions. Experts call for more holistic measures, such as disaster-informed spatial planning, greening of existing infrastructure and wetland restoration. In the aftermath of disasters, governments and urban bodies in the five cities frequently pursue or

consider "hard" fixes, such as levees, dykes, moats, and even artificial islands and sea walls. However, costs, logistics and timelines mean that these fixes often fail to materialise. They may also serve to divert a climate risk from one area to another, rather than mitigating that risk altogether. Experts call for more integrated approaches, such as fully implementing DRR-informed spatial planning, properly monitoring adherence to building codes and re-greening urban spaces. Therefore, public works could include multi-layered urban transport networks, recognising that blocked infrastructure during a crisis is a significant cause of human and economic harm. In order to maintain growth, eradicate poverty and respond to climate change, developing Asia needs to invest US$1.7trn in building infrastructure per year between 2016 and 2030; at present, annual regional investment is around US$881bn.[4] Cities and governments have a once-in-a-lifetime opportunity to learn from past mistakes and ensure that future infrastructure is rolled out with a strong DRR and DRM foundation.

- A wider cast of actors must be assembled to drive the urban DRR effort. The business community and civil society can play an active role in urban DRR by ensuring that their activities do not worsen disaster dynamics, and by contributing their assets, skills and capabilities to resilience efforts. Large-scale infrastructure developments involving private participation such as mass-transit and high-speed-rail projects—must include DRR. Businesses need to build contingency plans and should more actively use available analytical tools to manage and forecast environmental risks. Chambers of commerce and stock exchanges are lending some support to DRR efforts, including linking businesses to training and information, improving corporate governance by encouraging risk disclosure and reporting, and recognising and rewarding outstanding performance.[5] Donors are also helping to bridge the business and policy worlds—for example, aid agencies are providing adaptation guides and toolkits to help industrial zones and small and medium-sized enterprises (SMEs) assess vulnerabilities and develop strategies.[6] However, there are opportunities for the media and civil society to be more actively engaged. For instance, the media has an important information-sharing role to play during emergencies.

- Asian cities are leveraging technology and data. Technology plays a critical role in DRR and DRM, from social media platforms that organise community-level activity to sensors and imaging tools that identify risks such as flash floods. The five cities all show some level of engagement in this area, reflecting Asia's wider embrace of the opportunities brought by data and technology, which will only increase in the era of 5G wireless and the Internet of Things. Four of the five cities already operate a multi-hazard early warning system. Predictive technology is also improving: Malaysia is now able to issue flood warnings two days in advance (up from six hours in advance) using remote sensors, geospatial information and modelling; and Kuala Lumpur has developed a landslide prediction tool to understand topographic causal factors. Going forward, the region's cities could benefit from the explosion of geospatial data collected from tools such as drones, along with the ability to roll out sensors across urban systems. However, some of these systems are still in the development or testing phase. For example, Indonesia's early warning tsunami system failed during the recent Sulawesi earthquake, and Ho Chi Minh City is still developing its multi-hazard system (although it has collaborated with telecommunications operators to create warning systems). Experts also caution against excessive hype about the usefulness of social media tools for post-disaster response, noting that communications infrastructure is often the first to go down, preventing many citizens from using the relevant platforms in an emergency.

Introduction

Towards a resilient society

Asia is on the front line of climate change, experiencing serious hydro-meteorological disasters of increasing intensity and frequency. Six of the ten countries most affected by extreme weather between 1996 and 2015 were in Asia,[7] and in a study of 136 coastal cities, 13 of the top 20 at-risk cities were located on the continent, including three of the five cities discussed in this report: Bangkok, Ho Chi Minh and Jakarta. The same study forecasts a rise in global flood losses from US$6bn annually in 2005 to US$52bn by 2050.[8,9]

Asia's risks include both sudden-onset disasters, such as flooding, typhoons, tsunamis, storms and landslides; and slow-onset disasters, such as rising sea levels, drought, reduced air quality and increased temperatures. These risks have natural causes, including the region's tropical weather, monsoons, river systems, low-lying land and flood plains. However, they are compounded by a number of anthropogenic factors, including climate change, as well as economic development patterns that magnify the impact of disasters and produce pollutants that are harmful to human health.

Urbanisation is central to the climate risk matrix in Asia. Between 1950 and 2014 the percentage of the Asia-Pacific population living in urbanised areas increased from 18% to 48%, and this figure is expected to reach 65% by 2060. In 2014 Asia was home to 16 of the world's 28 megacities (defined as those with populations exceeding 10m) and 28 of the world's 44 large cities (defined as those with 5m–10m inhabitants). Cities are sites of economic dynamism, but they can also magnify the impact of climate hazards if they are poorly planned and/or built. This includes expanding into riskier land, as well as using materials and construction practices that affect a city's ability to absorb water—a key climate risk. All of the cities examined in this study are either coastal or adjoined to large river systems, with both planned development and unplanned human habitations encroaching into flood-prone areas. "The poor settle in the most environmentally and hazardous areas of cities," explains Abhas Jha,

a World Bank practice manager for urban and disaster risk management in East Asia and the Pacific. "The biggest driver of disaster risk is the growth of people and assets in harm's way."

In addition to placing people closer to flood and water risks, expansions in infrastructure reduce urban permeability by paving over vegetation and flood plains that play a critical role in absorbing water. Urbanisation can also aggravate risks such as rising temperatures. The Urban Heat Island (UHI) effect describes how cities trap heat by reducing ventilation and air flow through vertical building structures and "street canyons", and how they produce heat via pollutants caused by economic activity, and through the use of materials like glass, which absorb heat. The UHI effect can even change the weather: urban cloud bursts are sudden downpours caused by high temperatures, which lead clouds to retain more moisture and for longer (due to their increased weight). When these clouds pass their absorptive threshold, they release large amounts of rain back onto the city.

Faced with these risks, Asia's cities find themselves at a vital crossroads. They need to address decades of unsustainable urbanisation, and they also need to avoid repeating past mistakes as they look ahead to new projects. This carries considerable costs. For example, the Asian Development Bank (ABD) forecasts that the continent will need to invest US$20trn in infrastructure spending alone in the period to 2030.[10] Loretta Hieber Girardet, chief of the United Nations Office for Disaster Risk Reduction (UNDRR) in Asia-Pacific, describes this infrastructure investment as a "once-in-a-lifetime opportunity" to embed disaster risk reduction (DRR) from the start. This means including DRR and disaster risk management (DRM) in building codes, permit processes and spatial planning, and implementing rigorous monitoring and enforcement. Cities also need to proactively introduce green infrastructure such as parks, green spaces and green roofing; restore mangroves and protect flood plains; and restrict further building on compromised land. Investments in technology are also essential. As Abhas Jha, practice manager at the World Bank, explains: "Every US$1 invested in early warning can pay US$48 in avoided losses. Early warning systems are one of the best investments any country can make."

Making the right choices at this crossroads is of critical importance. To help Asia's city stakeholders, the Institute of Public Policy and Development (IPPD) commissioned

The Economist Intelligence Unit (EIU) to produce an in-depth study that combines city-level resilience scores with qualitative insight from experts. Covering Bangkok, Ho Chi Minh City, Jakarta, Kuala Lumpur and Singapore (which have a combined population of 35m), this project identifies common and distinct risks, from river- and storm-related flooding to landslides, heatwaves and pollution haze. A scorecard assessed the five cities across five domains: institutional framework; DRR policy, preparedness and response; economic resilience; societal resilience; and resilience of the physical environment. Based on this scorecard, each city's level of disaster risk preparedness and response was categorised as either nascent, emerging, developed or mature. The scorecard results are summarised in Table 1, and the remainder of the report provides detailed profiles of each of the five cities, based on these results. The project's methodology is outlined in the Appendix.

The global loss of human life from hydro-meteorological hazards has already fallen by a factor of ten over the past five decades, thanks to better monitoring and forecasting, along with more effective preparedness.[11,12] Continuing to identify opportunities to improve DRR and DRM in Bangkok, Ho Chi Minh City, Jakarta, Kuala Lumpur and Singapore will enable these cities to implement vital reforms that will help them prepare for the risks that await them.

Table 1: Overall scorecard result[13]

	Overall ranking	Institutional framework	Disaster risk reduction policy, preparedness and response	Economic resilience	Societal resilience	Resilience of the physical environment
Bangkok	Emerging	Developed	Emerging	Nascent	Emerging	Developed
Ho Chi Minh City	Developed	Developed	Mature	Emerging	Emerging	Emerging
Jakarta	Developed	Mature	Mature	Developed	Emerging	Developed
Kuala Lumpur	Developed	Developed	Developed	Developed	Developed	Nascent
Singapore	Mature	Mature	Mature	Mature	Developed	Mature

The five domains provide a holistic assessment of a city's disaster resilience:

Institutional framework: This domain explores a city's institutional capacity by assessing its institutions of DRM, their operational effectiveness (staffing), support from political leadership and presence of monitoring or evaluation frameworks.

Disaster risk-reduction policy, preparedness and response: This domain explores a city's disaster risk-reduction strategies and policies and its budgetary processes in the area of disaster-risk. It also assesses the city's disaster preparedness and response capabilities, in particular contingency planning for disasters, hazard monitoring, early-warning systems and other steps that enable an effective disaster response.

Economic resilience: This domain explores economic resilience—a crucial aspect of a city's capacity to build disaster resilience and absorb the short- and longer-term economic impacts of disasters. The economic-resilience domain assesses a city's economic structure and macroeconomic stability, its degree of openness to trade, its access to insurance markets, and the state of economic development.

Societal resilience: This domain explores societal resilience—a measure of how societies respond to and are able to cope with the impact of disasters. The domain assesses this resilience by looking at areas that are crucial for a society to absorb effectively the negative impact of disasters: the ability to maintain public order, the capacity to provide public services (especially in the area of health) and proxy indicators for social cohesion and women's empowerment.

Resilience of the physical environment: This domain explores the resilience of a city's physical environment. The domain assesses this by looking at indicators such as how cities protect their physical assets, the rules and regulations to make them safer, and the general quality of infrastructure and environmental governance.

This framework comprising of five key domains operates on an aggregation structure, with neutral weighting (that is, all domains are considered equally important in assessing a city's overall DRM capabilities). Within each domain, all indicators also have equal weight. Results are presented through bandings that quantify the overall level of institutional development, ranging from nascent to emerging, developed and mature.

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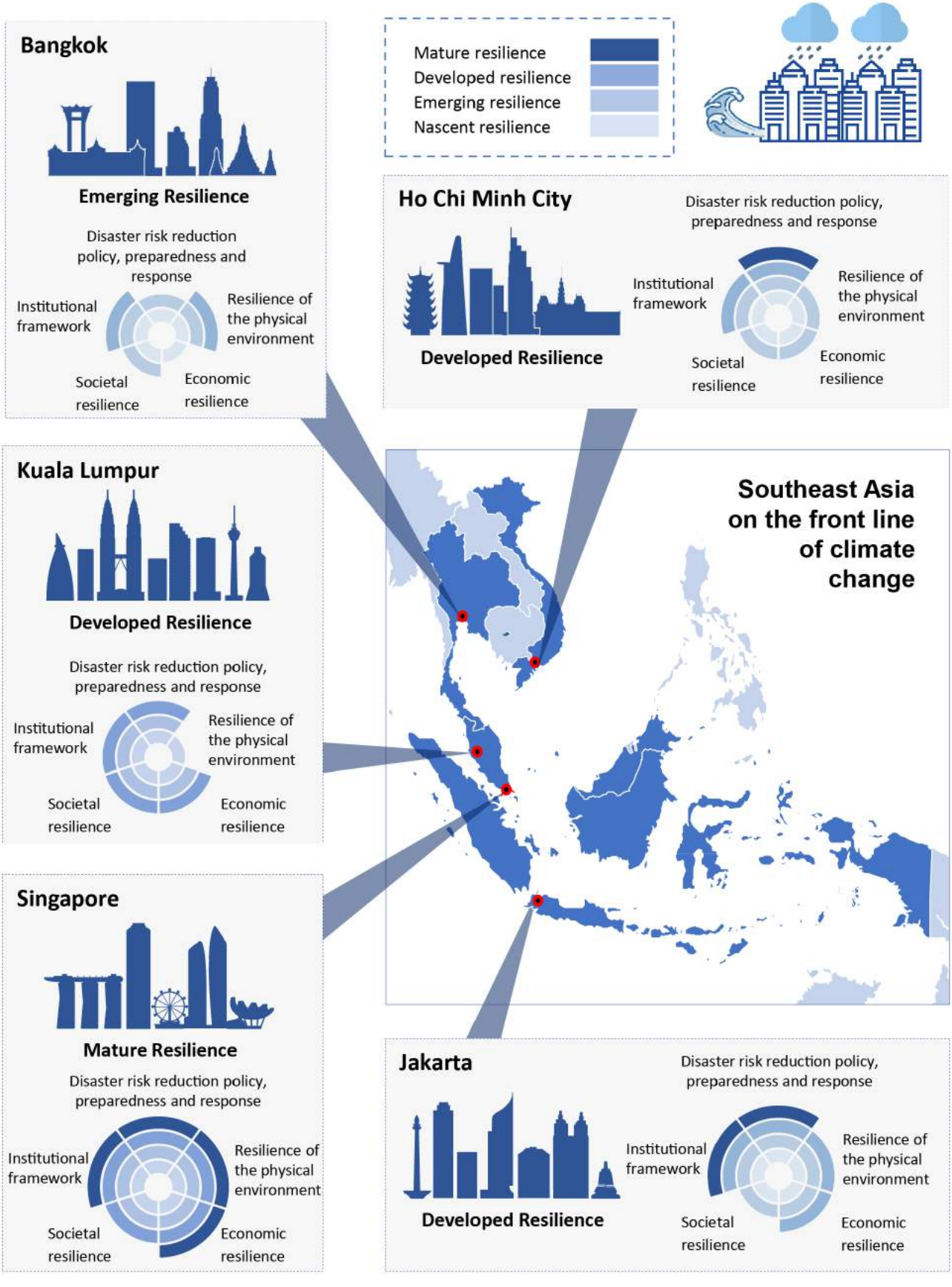
How disaster resilient are Asean cities today?



Bangkok

Thailand

Bangkok is home to 10m people and is one of Southeast Asia's most climate-vulnerable cities. Intersected by canals, this "Venice of the East" is sinking by 0.8 inches a year, and the Chao Phraya River—which flows through the city into the Gulf of Thailand—has been identified as a flood risk. Water levels in the Gulf of Thailand are rising by 4 mm a year, and Bangkok is only 1.5 metres above sea level.[14] Thailand ranked tenth in the 2017 Global Climate Risk Index, based on the occurrence of extreme weather events between 1996 and 2015.

Table 2: Bangkok scorecard

	Ranking	Normalised score (out of 100)
Overall ranking and score	Emerging	43.7
1) Institutional framework	Developed	62.5
2) Disaster risk reduction policy, preparedness and response	Emerging	50.0
3) Economic resilience	Nascent	25.0
4) Societal resilience	Emerging	26.9
5) Resilience of the physical environment	Developed	54.3

Institutional framework: The city's overall rank of "emerging" reflects concerted action to respond to these threats. Bangkok has a dedicated sub-national entity—the Department of Disaster Prevention and Mitigation (DDPM), which is part of the Bangkok Metropolitan Administration (BMA)—and there is also a national-level DDPM within

the Ministry of Interior. Bangkok is subject to a 2007 law that requires consistency between city and national disaster plans, and the 2011 floods demonstrated considerable interplay between city- and national-level preparedness. However, the city has blended rather than permanent DRM staffing, suggesting a need for greater capacity.

There has been political and fiscal support for DRM at the city level, reflected in political statements from past and present administrations, and in the most recent Action Plan and Budget (2017-2018), which includes monitoring and evaluation for key performance indicators (although the evaluation metrics and mechanisms are unclear). Disaster risk is accounted for in city planning, at least as outlined in the BMA yearly action plan. Abhas Jha, practice manager at the World Bank, also notes that Bangkok has introduced a groundwater management law, leading to positive results. The Stock Exchange of Thailand has played a positive role in helping listed companies improve their sustainability profile, encouraging disclosure and reporting, recognising outstanding performance and facilitating relevant sustainability training.[15]

However, experts identified some gaps and problems, one of which is co-ordination. According to Hans Guttman, executive director at the Asian Disaster Preparedness Centre (ADPC), over 20 agencies had a relevant mandate during the 2011 floods and "nobody took orders from anybody, which exacerbated the situation." Hard decisions have to be made during disasters and cannot be subject to political wrangling, including when to open flood control systems, and by how much; where to place temporary measures, like sandbags; and how to rank the importance of assets and infrastructures. A new law and attendant national water committee are intended to co-ordinate between 12 to 15 of these agencies, but the system has not yet been tested in a crisis situation, Guttman explains. Albert Salamanca, senior research associate at the SEI, also highlighted a lack of continuity across successive governments, with leaders discarding the ideas of previous administrations.

DRR policy, preparedness and response: Experts believe the city has not done enough to prepare for and reduce risk. Indeed, Hans Guttman describes Bangkok as "woefully vulnerable to another flood event". Proposed engineering solutions include a moat around the city, but costs and logistics have made that impossible to realise to date, explains Guttman. Lower-tech responses include replanting mangroves along the coast to retain sediment and deter erosion, and cleaning, widening and developing the city's network of canals, gates and tunnels.[16] There is also promising evidence of

"green-blue" infrastructure[17], such as an 11-acre park in Chulalongkorn University, whose underground water containers and large pond can reportedly hold a million gallons of water.[18] The private sector could draw inspiration from this example when designing proactive, sustainable building efforts in the future. Creating floating homes, informed by amphibious design principles, is another approach that seeks to work with nature's wrath, rather than outmuscle it.[19]

Economic and societal resilience: Thailand's long-term economic outlook hinges on the assumption that governments in the next ten years will enact and continue structural reforms and develop infrastructure. This will also be impacted by Thailand's unfavourable demographic profile[20] and the impact of climate change which might reveal a significant, negative impact on GDP growth and political stability.

Although poverty has substantially declined in Thailand in the last 30 years with the country rising from a low-income to upper-middle-income status in less than a generation, the country's high Gini-coefficient (which increased between 2015 and 2017) is a testament to entrenched income inequality in Thailand.[21]

Resilience of the physical environment: Urbanisation in the Bangkok Metropolitan Region (the extended urban agglomeration) has removed natural water retention and flood plains that could manage excess water, and upstream hydropower developments are blocking sediment and contributing to erosion.[22,23] Land subsidence is also a problem, driven by excessive groundwater extraction and worsened by the city's highly compressible soil, known as Bangkok clay. This is a "poorly planned city", explains Albert Salamanca, senior research associate at the Stockholm Environment Institute (SEI), Asia. "What used to be canals are now roads, so there is no room for water to be absorbed." This creates significant problems, as the Chao Phraya River flows through Bangkok on route from the north to the Gulf of Thailand. In the Great Flood of 2011, regions in northern Thailand opened their sluices after heavy rains, resulting in floods that affected 64 out of Bangkok's 77 provinces. The disaster caused over 1,000 deaths and US$45-50bn in damage.[24,25] The floods also compromised Thailand's trading position, disrupting the computer supply chain as far as Japan and the United States, and forcing the closure of seven industrial estates in the north, affecting nearly 10,000 factories.[26,27]

Table 3: Bangkok – strengths and challenges

Strengths	
Policy support	Support for DRM is reflected in the recent Action Plan and Budget (2017-2018), and disaster risk is included in city planning and design documents.
Budget	There is a partially dedicated budget for all related agencies (the DDPM, the Department of Drainage and Sewerage, the Department of Environment and district offices) and a national budget line for emergencies.
Challenges	
Monitoring	While there is an established plan for DRM monitoring, details on evaluation mechanisms and metrics are vague and unclear.
Catastrophe insurance	A National Catastrophe Insurance Fund, set up after 2011, covered Bangkok but was scrapped in 2015-16. Its current status is unclear, but such protections could provide much-needed security for businesses and investors.

Looking forward: Urbanisation has led to the paving over of green surfaces with concrete in the city. Increasing permeability by building more green spaces and using more permeable materials instead of concrete will help in controlling both land subsidence - as the water being absorbed into the ground will recharge the water table - and consequently prevent flooding in the city. The application of the design method of urban porosity used in the construction of the Chulalongkorn University Centennial Park[28], inaugurated in 2017, is a good example to learn from.

Managing Bangkok's water flow is crucial since the city is built around the Chao Phraya River and therefore everything in the city flows around the river. The river's natural flow paths of canals, conduits and waterways have been paved over with concrete by sprawling urbanisation. As flooding of these low-lying areas in the former channels of the Chao Phraya River become an annual feature, the city and national governments would need to increasingly work towards restoring the natural pathway of the river to prevent flooding in the city.

Mangrove forests have protected the city's shores from coastal erosion, and controlled the effects of heavy waves.[29] However, rising sea levels along with increased urban construction in the city has led to the loss of these mangrove forests. An innovative solution being carried out across the country, including Bangkok, has been to replant the mangrove forests that retain sediment and prevent erosion of the

city's shoreline. This could prove to be a better solution than some of the more hard engineering solutions because mangroves provide a natural barrier against coastal erosion and also serve as a shelter and breeding ground for native wildlife species.

Ho Chi Minh City

Vietnam

Ho Chi Minh City has a population of 7m, is built on the banks of the Saigon River and covers 2,000 km2. It is 0.5 to 1 metre above sea level.[30] Urban development initially focused on higher ground, but economic growth and market reforms implemented during the 1980s Doi Moi era have seen the city expand significantly into more compromised areas around the river's flood plain, including districts 4, 7, 8 and 21. One forecast (for the period to 2100) predicts that annual flood damage may grow by over one order of magnitude with adaptation, with casualties increasing five-fold to 20-fold.[31]

Table 4: Ho Chi Minh City scorecard

	Ranking	Normalised score (out of 100)
Overall ranking and score	Developed	55.0
1) Institutional framework	Developed	75.0
2) Disaster risk reduction policy, preparedness and response	Mature	87.5
3) Economic resilience	Emerging	37.7
4) Societal resilience	Emerging	48.1
5) Resilience of the physical environment	Emerging	26.8

Institutional framework: Ho Chi Minh City's local government has a dedicated and fully staffed agency—the Steering Committee for Natural Disaster, Prevention and Rescue—which was established in 1978 to take responsibility for flood and storm control. In 2015 legislation tasked the agency with DRR, preparedness and response, including implementing the national DRM law, integrating DRM plans

and upgrading infrastructure. Another relevant institution is the Steering Centre for Urban Flood Control (SCFC), established in 2008.[32]

There is political support for DRM in Ho Chi Minh City. Disaster risk is included in sub-national planning and design through city planning and directives, and there is a clear and established plan for DRM monitoring. The city is also subject to a recent 2018 directive on plans to prevent, avoid and respond to natural disasters (specifically, typhoons and storms). Ho Chi Minh City has been active in exploring international partnerships, including a strategic initiative with the Dutch government and the City of Rotterdam. (The two cities have co-operated since 2009 as part of the Connecting Delta Cities network.)[33] The private sector has also been proactively engaged. For example, the Vietnam Chamber of Commerce connects the business community and employers with training agencies to address issues such as climate change and the Sustainable Development Goals (SDGs).[34]

DRR policy, preparedness and response: One of the city's key challenges is the lack of implementation of best practices, which exist on paper but are not always put into practice. Phan Duy, researcher at the School of Geography, Earth and Environmental Sciences at the University of Birmingham, notes that the city's ability to absorb water has been compromised by past urban development patterns that did not take climate risk into account. The first urban master plan for the city was only approved in 1998, which means that rapid development in the first decade of the Doi Moi era effectively occurred with no overarching guidance.[35] More recently, developers have sought out real estate opportunities in flood-prone areas, according to Melissa Merryweather, an architect and former chief of the Vietnam Green Building Council. Merryweather adds that frequent preference for underground car-parking structures in buildings (designed to maximise economic returns from above-ground planning approvals) have disturbed the water table and limited effective infrastructure greening possibilities (such as grass bricks, which contain gaps for soil and can support higher urban water permeability).

Economic and societal resilience: Favourable demographics and deeper integration with the global economy support Vietnam's long-term economic prospects. A sustained rise in foreign investment is expected to contribute to the upgrading of technology and economic diversification.[36] However, effects of climate change may

limit the country's growth prospects by diverting limited public resources away from other sectors.

According to the United Nations Research Institute for Social Development[37], rising inequalities in income, opportunity and participation continue to threaten Vietnam's growth prospects. There are fewer opportunities today for the young regarding higher earnings and better social status than a decade ago. Although according to national statistics poverty has reduced, it is concentrated among marginalised groups in society—increasing the divide in the society.

Resilience of the physical environment: Materials and building practices are worsening heat risks. For example, skyscrapers and high-rise constructions frequently use heat-trapping glass. According to Merryweather, anecdotal evidence suggests that Ho Chi Minh City is seeing increased heat waves, although the government has not published any long-term weather data to prove this empirically. The temperature in Ho Chi Minh City is up to 10 degrees higher than in the surrounding rural areas.[38] In April 2019 Vietnam logged its highest ever temperature of 110ºF, with Ho Chi Minh City reaching 95ºF.

Merryweather argues that part of the problem is the widespread misconception that greener building practices are substantially more expensive than standard building practices, especially those that align with international certification systems such as Leadership in Energy and Environmental Design (LEED). In reality, green building costs are only likely to be 2% to 10% higher than standard costs, excluding the long-term savings delivered by green building practices. "The costliest green building certification project I've led—at double platinum—increased costs by 9.5%, and was recouped through efficiencies within 18 months. A lower certification—gold level—might increase cost by just 2% to 5%," Merryweather explains. She believes the city's planning department supports greener building but is struggling to find the right incentives for developers. Options may include tax breaks and more generous gross floor area allowances for eligible investors.

Hard engineering interventions have also been explored in Ho Chi Minh City, although they have drawn criticism. One study found that a ring dyke would protect the inner city (but increase the risk in rural areas), and that elevating at-risk areas

and dry-proofing buildings would reduce city-wide impacts at a reasonable economic cost.[39] Phan Duy, researcher at the University of Birmingham, believes that multi-layered transport could also be a useful engineering approach, as greater use of bridge structures would improve the resilience of the transport system during floods. Low-tech and low-cost innovations such as rainwater collection, green roofs, and reusing rainwater for sanitation and cleaning would also improve urban permeability. For example, adding horizontal external shading to buildings, building smaller windows and reducing the use of glass can all lower temperatures inside buildings.

Table 5: Ho Chi Minh City – strengths and challenges

Strengths	
Planning	Disaster risk is explicitly included in sub-national planning and design, supported by a 2018 directive from the city's steering committee on typhoons, heavy storms and flooding.
Institutional presence and political support	Ho Chi Minh City has a dedicated sub-national entity for DRR, with a direct budget. There is political support for DRR, evidenced through public statements and legislation.
Challenges	
Rural migration	Vietnam has a large proportion of people employed in the agricultural sector (approximately 40%). This poses an urban migration risk as more extreme events affect other parts of the country and drive inflows to Ho Chi Minh City.
Planning and resilience	There is no evidence to suggest that contingency planning is required at the city level. There is also no catastrophe insurance, although the government has indicated that it is working on this issue.

Looking forward: In order to deal with tidal flooding in low-lying vulnerable areas, Ho Chi Ming City needs to focus on swift implementation of well-meaning plans and frameworks. Although there are several plans[40] in place for more than a decade, lack of resources has limited their implementation. The city needs robust flood management policies. Some suggested measures from urban planners include changing land-use patterns, reviving the natural waterways, canals, runoff areas, building retention ponds and expanding the drainage system.

The city also faces the problem of land subsidence, which is aggravated by the unchecked extraction of groundwater. The sprawling urbanisation of the city and its surrounding metropolitan areas have driven the excessive extraction of groundwater, as its 13 million inhabitants dig bore wells into the ground to extract water for their

daily needs. The draining of these underground aquifers are leading to compaction and causing the city's land to sink deeper. The city government is beginning to recognise this as a challenge and has also issued a plan to close groundwater wells and reduce groundwater extraction across the city. These efforts need to be accompanied by specific regulations or penalties for violations—a lack of which may dilute the effects of these well-intentioned and much required regulations, thereby doing little to control the land subsidence.

Jakarta

Indonesia

Jakarta is home to over 10m people and lies next to the Java Sea, on a low alluvial plain intersected by 13 rivers. It is one of the most climate-vulnerable cities in the world: parts of the city could be entirely submerged by 2050, and over 40% of its population are already technically living below sea level.[41,42] Decades of unsustainable building on swamps, excessive aquifer drainage and reduced upload vegetation have all driven the city's subsidence.

Table 6: Jakarta scorecard

	Ranking	Normalised score (out of 100)
Overall ranking and score	Developed	69.9
1) Institutional framework	Mature	87.5
2) Disaster risk reduction policy, preparedness and response	Mature	100.0
3) Economic resilience	Developed	62.7
4) Societal resilience	Emerging	36.5
5) Resilience of the physical environment	Developed	63.0

Flooding is a recurring threat in Jakarta. The city has suffered four major floods in recent history (in 1996, 2002, 2007 and 2013), with the 2007 flood causing an estimated US$565m in damage.[43] In April 2019, in response to both flooding and subsidence, the government announced a US$33bn plan to move the country's official capital to Borneo. Srini Ancha, principal climate change specialist at the ADB, explains that "Jakarta has passed the threshold in terms of land subsidence." Tsunamis are also a prominent risk but are not explored in detail in this study, which focuses specifically on climate events.

Institutional framework: Jakarta's institutional framework is ranked as "mature". The city has a dedicated, directly funded and permanently staffed sub-national body; political support from the city's governor, as measured through public statements; and an established monitoring and evaluation plan. It also scored in the top band for incorporating disaster risk into urban planning, and for the presence of a multi-hazard early warning system.

Institutional efforts ramped up considerably following the 2004 Indian Ocean tsunami. In 2007, for example, a new law created the National Agency for Disaster Countermeasure,[44] which Riyanti Djalante, academic programme officer at United Nations University (UNU), describes as "very important recognition of the importance of disaster management and risk reduction". Creating this agency strengthened accountability by providing a lead co-ordinating entity and marked a shift away from disaster management and towards risk reduction (the previous lead agency was the Ministry of Social Affairs). At the city level, a dedicated sub-national entity forms part of the Regional Disaster Management Agency network and is responsible for protecting citizens and increasing preparedness and management capacity. The Regional Disaster Management Agency is required by regulation to have permanent staffing. Other institutional actors include the Indonesian Agency for Meteorology, Climatology and Geophysics, which is leading the development of early warning systems, although this work is focused on earthquakes and tsunamis.

There is both political support (evidenced by public statements) and regulatory support for DRR in Jakarta. The city has created DRM evaluation mechanisms (and requires evaluations to be conducted at least once a year), and disaster risk is included in a spatial planning and zoning bylaw. A Jakarta Provincial Government Regulation of 2010 stresses the need for buildings to take disaster risk into consideration, and a 2016 Ministry of Public Works and Housing regulation requires buildings to consider earthquake risk. The city is also pursuing or considering hard engineering approaches, including the creation of artificial islands to act as a coastal wall, at a cost of US$40bn. This initiative is meant to be completed by 2025, but Srini Ancha, principal climate specialist at the ADB, notes that it has faced resistance for both environmental and cost reasons.[45] Indonesia's former president, Susilo Bambang Yudhoyono, also initiated a partnership with the World Economic Forum in 2011, leading to an alliance focused on tapping the knowledge and expertise of the engineering and construction industries and bringing together business, policy and

humanitarian actors.[46] One of the alliance's strategies is to organise secondments for engineering and construction staff to work with relief agencies during disasters, so they can share their competencies and expertise.[47]

DRR policy, preparedness and response: Businesses are also engaging with DRR as a commercial opportunity in Indonesia. Willis Re, an insurer, developed a flood model for Jakarta after the 2007 floods, which can be used to advise insurance clients in the country and the region. Modelling capabilities increase the appeal of insurers to both current and future clients, and they also encourage businesses to cover their risks. This can minimise financial loss and disruption, and can help to prevent companies from avoiding investment opportunities in Jakarta due to concerns about natural disasters.[48]

Riyanti Djalante, academic programme officer at UNU, notes that Indonesia is implementing the principles of the Sendai Framework, which emphasises the importance of lowering risk. However, experts warn that building norms are falling short of best practice. "Past development has ignored risks. Floodplains have been indiscriminately used for building heavy infrastructure and aquifers are disappearing," explains Srini Ancha, principal climate change specialist at the ADB. In some instances, this reflects a disconnect between policy and practice. For example, a 1989 decree prohibited development in conservation areas or on irrigated agricultural land, but this decree was ignored.[49] Similarly, although the issuing of land permits was frozen in 1996 in response to rapid development and real estate speculation in peri-urban areas, this policy was relaxed the following year, potentially due to pressure from developers. Conflicts of interest have also created problems. For example, land-use plans have been prepared by consultants who simultaneously sought involvement in land-use projects.[50] It remains to be seen whether poor practices in the past will limit the impact of new measures designed to lower disaster risk. If implemented, a land-use law passed in 2008 would only reduce river discharge by between 0.1% and 5.6%.[51]

Economic and societal resilience: Indonesia's population is relatively young. This is expected to drive an expansion in the working-age population, thus strengthening the country's long-term economic outlook.[52] However, growing inequality in the country is a major concern. The gap between the rich and the poor in Indonesia has risen faster than any other country in South-East Asia, in the past

two decades.[53] The poorer sections of the society, particularly women, face wage discrimination and insecurity at work. Access to higher-skilled and higher-paid jobs is also limited for many Indonesian workers as the public education system is underfunded.

Resilience of the physical environment: Both Jakarta and Indonesia more broadly have sought to leverage data and technology, especially following the 2004 tsunami. "Indonesia has excellent data and a very good understanding of the risks Jakarta faces," notes Loretta Hieber Girardet, chief at the UNDRR, Asia-Pacific. For example, Jakarta has led the way in deploying (with donor support) the Insafe system, an open-source mapping tool that allows policymakers to conduct scenario analysis. "You could put assets, like schools and hospitals, and overlay past disasters to see what the impact would be if you had the same level of flooding," explains Hieber Girardet. The system was so effective it has been moved nationwide. Other notable technology initiatives include the Jakarta Smart City Programme, launched in 2014, which included crowd-sourced smartphone applications through which users could report incidents, including floods.[54] This project included the rollout of air quality monitoring stations and the creation of units to regularly measure river water levels.[55] Jakarta is also home to an innovative app called PetaJakarta, an open-source, real-time, online map of the city that filters tweets about flooding to improve flood map accuracy. By verifying geotagged photos and combining the information with official data, this app is able to create a more reliable online flood map.[56]

Jakarta has faced some technology challenges, however. Components of the network of buoys donated after the 2004 tsunami disaster have been neglected, stolen and vandalised, compromising the system during the 2018 earthquake on the island of Sulawesi, which claimed over 800 lives.[57] A sophisticated system of sensor nodes, sound waves and cables, which could recognise underwater changes, remains in testing and development for many reasons, including funding shortfalls.[58]

Table 7: Jakarta – strengths and challenges

Strengths	
Institutional development and a multi-hazard warning system	Jakarta has a dedicated, directly funded and permanently staffed sub-national body and has introduced a multi-hazard early warning system.
Policy	Disaster risk is accounted for in spatial planning by-laws, although implementation is lacking. Indonesian law requires sub-national governments to formulate and implement contingency plans for natural hazards.

Challenges	
"Path dependence"	Decades of unsustainable building practices, combined with the city's natural vulnerabilities, may have caused irreversible subsidence issues, necessitating the drastic measure of moving the political centre to Borneo.
Vulnerable populations	A large proportion of the national population works in the agricultural sector, which increases the impact of flooding on livelihoods and could exert additional pressure on cities due to distressed migration. Jakarta also suffers from considerable urban poverty, which leaves many people vulnerable.

Looking forward: According to a study conducted at the Bandung Institute of Technology, at the current rate 95% of North Jakarta is likely to be submerged by 2050.[59] This is primarily owing to the excessive groundwater extraction. This compacts the soil around the underground aquifers and causes the ground to sink. To arrest this sinking, the city administration should limit the use of groundwater. Currently, 60% of the city's water requirements are met through groundwater. Provision of piped water to households and businesses is needed to reduce the rate of groundwater extraction, which would pause the subsidence of land.

To strengthen its flood defences,[60] the Jakarta administration has taken measures to revive the city's natural drainage mechanism. Unchecked and unplanned urbanization has led to the proliferation of semi-permanent dwellings near the canals and waterways of the rivers. In the absence of proper waste disposal systems, the residents of these dwellings directly dump waste in to these rivers, blocking the rivers' natural flow and causing floods in the city. One measure to prevent this has been dredging of these rivers – cleaning the rivers, canals and waterways of waste to enable the flow of the rainwater into the Java Sea. Dredging of the Ciliwung River is one such programme underway. Additionally, the programme also proposed the resettlement of the dwellings along these waterways. However, the resettlement plans were met with severe opposition from residents. While this may not solve the problem entirely, it controls the overflow of the Ciliwung River. Similarly dredging other rivers may contribute to the strengthening of the city's natural flood control mechanism.

Kuala Lumpur

Malaysia

Malaysia is a flood-prone country. In 2014, for example, flooding in the northern states saw record numbers of evacuations.[61,62] Kuala Lumpur sits in the basin of two major rivers, the Klang and the Gombak, and is steadily encroaching on these rivers due to population growth.[63] Flash floods caused by seasonal rains regularly overwhelm the drainage system, creating a recurring hazard. In 1971 catastrophic floods displaced 180,000 people.[64] Landslides are an associated risk, as Kuala Lumpur has a significant population residing on hillsides.[65]

Table 8: Kuala Lumpur scorecard

	Ranking	Normalised score (out of 100)
Overall ranking and score	Developed	53.6
1) Institutional framework	Developed	62.5
2) Disaster risk reduction policy, preparedness and response	Developed	62.5
3) Economic resilience	Developed	74.0
4) Societal resilience	Developed	54.7
5) Resilience of the physical environment	Nascent	14.5

Institutional framework: In Kuala Lumpur, the State Disaster Management Relief Committee (JPBBN) and the Malaysia Civil Defence Force (APM WP) are responsible for planning, co-ordinating and monitoring the implementation of DRR education, training and awareness strategies. The JPBBN shares its staff with other parts of the city's government, but the civil defence force is permanently staffed. There has also been political engagement with DRR in Kuala Lumpur.

Kuala Lumpur also stands out for its community-level engagement. The Civil Defence Emergency Response Team, established by the Malaysian Civil Defence Force, engages with local community organisations, including volunteers, to lead community-level DRR. "They are trying to do smart partnerships with private and civil society organisations and academics, so they can organise high-impact community-based DRR in the city," Razak explains. The country's large private-sector players have also engaged with DRR efforts. For example, Petronas and UEM have participated in volunteer relief efforts, and Sime Darby assisted with the development of food shortage mitigation strategies.[66]

DRR policy, preparedness and response: After the 1971 flood, interventions focused on infrastructures such as levees and holding ponds, flood bypasses, sediment traps and mechanisms to increase river capacity. Despite these efforts, the frequency of flooding events continued to increase.[67] Various other interventions have been implemented since then, including the Storm Water and Road Management Tunnel (SMART; completed in 2007), which diverts water before the Klang and Ampang Rivers merge.[68] Following the 2014-15 floods, which led to the evacuation of over 230,000 people and the displacement of up to 1m people,[69,70] Malaysia formed the National Disaster Management Agency (NADMA) to co-ordinate national disasters and manage risk reduction funding, devolving some power to local decision-makers. [71]Dr Khamarrul Azahari Bin Razak, senior lecturer at Malaysia's Disaster Preparedness and Prevention Centre, notes that overall co-ordination has since proved effective. Other key national bodies include the Department of Irrigation and Drainage, which develops flood mitigation infrastructure.

Key challenges for the city include obtaining clearer information on how to integrate DRR into urban planning, along with more detailed monitoring for DRM.

Economic and societal resilience: Malaysia has been successful in diversifying its economy from one that was primarily agriculture and commodity-based, to one that is increasingly focused on manufacturing and services sector. Less than 1 percent of Malaysian households now live in extreme poverty. Though there still remains substantial income inequality in Malaysia as compared to other East Asian countries, it is steadily declining.

Malaysia is well placed to make solid productivity gains in the next 20 years, aided by an expanding workforce. A relatively large domestic ethnic-Chinese population gives Malaysia a special advantage as closer trading relations develop with China.[72]

Resilience of the physical environment: The former mayor, Ahmed Phesal, introduced precautionary measures to improve the city's slopes to prevent landslides, and Razak reports that Kuala Lumpur City Hall (which administers the city) is taking "significant steps by mainstreaming disaster risk reduction into development planning". This includes integrating risk into infrastructure and transport planning and implementation. Razak also notes that there is growing awareness in the construction sector about the value of using more resilient materials and greener technology.

Razak adds that Kuala Lumpur, and Malaysia more broadly, are making use of technology for DRR purposes, including remote sensors, geographical information systems and modelling. As a result, flood forecasting and early warning systems developed by the Department of Irrigation and Drainage are improving. "Before 2015", Razak explains, "the system was able to predict monsoon flooding about one day before and the community would receive the warning about six hours before. The current system can predict flooding seven days in advance and give a warning to the local community about two days before the flooding." For flash floods, Razak adds, predictions are now possible "six hours before, and residents may receive the warning about three hours before. This helps to disseminate the information early to the communities who are affected in high-risk areas." The KL Slope Information System is another important asset, using remote sensing and photography to understand topographic factors triggering landslides.[73]

Table 9: Kuala Lumpur – strengths and challenges

Strengths	
Budget	Reflecting best practice, there is a dedicated budget line at the national level through the NADMA and relevant departments, and at the state level, which the APM WP and the JPBBN can access.
Early warning	While not city-specific, Malaysia has multi-hazard early warning systems. The tsunami system uses sirens, SMS, mass media and public announcements, and the Department of Irrigation and Drainage has developed mobile applications for flood warnings.
Challenges	
Planning and design	Disaster risk is included in national-level planning and design documents, but no policies, directives or plans have been issued by the government of Kuala Lumpur. Some agendas on disaster risk are included in the state structure plan, but these contain little detailed information on how urban planners should address disaster risk.
Contingency planning and insurance	There are national-level disaster contingency plans but no city-level equivalents. Kuala Lumpur also appears to lack any city-level catastrophe insurance mechanism.

Looking forward: Rising mean sea levels, coastal flooding, changing rain patterns and more frequent extreme weather events are likely to afflict Kuala Lumpur due to climate change. Flood occurrences are particularly getting more frequent in recent years in big cities like Kuala Lumpur along with Penang and Kuchung, where rapid urbanisation is taking place. The Department of Irrigation and Drainage (DID) identified three main factors that cause flash floods in Kuala Lumpur – rapid urban development including housing and highways, inability of rivers and drainage systems to handle the flow of river and rapid water flow and sedimentation due to rapid development near water catchment areas.

City government should initiate more programmes such as the SMART tunnel[74] project, which particularly addresses the issue of flash floods in critical city centres. Continued timely prediction of floods in river basins across Malaysia is critical now and in the future, so that citizens are better informed on flood warnings.


NOVOTEL

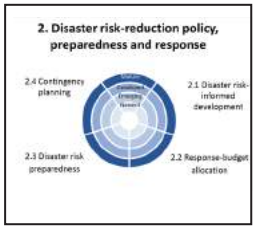
Singapore

Singapore

Singapore faces a lower level of climate risk than the other cities in our study. Situated in Southeast Asia, yet just outside the Pacific Rim of Fire, it has been spared from earthquakes, tsunamis, volcanoes and major flooding.[75] However, its coastal location leaves its population of 5.6m vulnerable to rising sea levels, and extreme weather is increasing the likelihood of flash floods. Temperatures are also rising, partly due to the UHI effect, with authorities forecasting a mean increase of 4.6°c over the next century.[76] At least 80% of Singapore's population reside in high-rise buildings, which means that a disaster of any kind could carry a major death toll.[77]

Table 10: Singapore scorecard

	Ranking	Normalised score (out of 100)
Overall ranking and score	Mature	87.8
1) Institutional framework	Mature	87.5
2) Disaster risk reduction policy, preparedness and response	Mature	100.0
3) Economic resilience	Mature	100.0
4) Societal resilience	Developed	54.1
5) Resilience of the physical environment	Mature	97.5



Singapore received the highest score in our scorecard, reflecting both its developed income status and the quality and efficiency of the government's public services.

Institutional framework: As a city-state, the institutional dynamics are national rather than sub-national, as it has the same institutions for both the city and the nation.

At an organisational level, the city-state has implemented an integrated plan for DRR. The Whole-of-Government Integrated Risk Management Policy Framework seeks to improve risk awareness among both the government and the general public. It also recognises that hazards affect different agencies, enabling them to work together to manage risks.[78]

The Ministry of Home Affairs is the primary authority responsible for emergency preparedness and disaster management. It oversees two emergency agencies, the Singapore Civil Defence Force (SCDF) and the Singapore Police Force, which are charged with planning, co-ordinating and implementing DRR programmes.[79] The SCDF has a permanent staff of 5,100 people, and its activities include providing community relations programmes for emergency preparedness and ensuring that locals are readied for a crisis. It also educates Singapore's population about water rationing, evacuation, rescue and first aid.

DRR policy, preparedness and response: Authorities have been successful in reducing Singapore's vulnerability to rainfall extremes, averting severe floods seen elsewhere in the region. A system channels rainfall into a river, through a tank that can store enough storm water to fill 15 Olympic-sized swimming pools. Minimum requirements for reclaiming land have been strengthened (land must now be at least 4 metres about mean sea level, up from 3 metres),[80] and a national sea-level programme will soon be launched, with the aim of developing "robust" projections and planning for long-term changes.

Given its proficiency in disaster preparedness,[81] Singapore is a key player in disaster management in the Asia-Pacific. The SCDF maintains a dedicated, 76-person team whose job is to provide urban search and rescue or humanitarian assistance to countries affected by major disasters.[82] It also runs a programme with several Asia-Pacific and European countries to exchange information on emergency preparedness and disaster management.

Economic and societal resilience: Singapore, a high-income economy, is ranked among the world's richest countries. The city-state is primarily supported by its manufacturing and services sectors—the twin pillars of Singapore's high valued-added economy. It also ranks highest in the most recent World Bank Human Capital Index, indicating the best access to health and education opportunities.

However, income inequality is high in Singapore. The Gini-coefficient reached a high of 0.482 in 2007 and 0.478 in 2012—indicating high levels of inequality. These figures have tapered since then, reaching 0.452 in 2019, however economic inequality could have negative impacts on social cohesion diluting the ability of different segments in the society to come together at a time of crisis. At an absolute level, Singapore has the highest per capita income and the lowest poverty rates in the region.

Resilience of the physical environment: Droughts are becoming increasingly common, however, leaving Singapore vulnerable to water shortages. (The city-state already imports about half of its daily water supply.) Despite this, enforced water rationing has not occurred for more than half a century, thanks to effective policies implemented by the national water agency. Singapore can adapt to drought by ramping up its desalination efforts, as well as its successful water reclamation project, known as NEWater.[83] Singapore's private-sector collaborations have also proved helpful. Its water agency, PUB, has built close links with local and international water companies and tertiary institutions to keep abreast of new technologies and develop desalination facilities through public–private partnerships, as part of Singapore's efforts to become a "hydro-hub" despite the scarcity of natural freshwater.[84]

Residents of Singapore are exposed to high levels of haze—an air-borne mixture of pollutants including soot particles and carbon dioxide. This is caused by forces outside of its control, namely the burning of forested land in Indonesia.[85] In 2013 Singapore experienced one of its most serious haze events, marking the first time air quality deteriorated to the point where it became hazardous to human health. Authorities advised the general public to minimise outdoor activities, and to wear N95 masks if they needed to spend time outdoors.[86,87]

Table 11: Singapore – strengths and challenges

Strengths	
Planning and preparedness	Disaster risk is accounted for in sub-national planning, particularly rises in sea level—Singapore's key climate threat. It also operates an effective and well-developed multi-hazard early warning system and is host to the Southeast Asia Disaster Risk Insurance Facility (SEADRIF), a regional climate and disaster risk financing and insurance pool for countries in the Association of Southeast Asian Nations (ASEAN).
Institutional presence and political support	Singapore has a dedicated, permanently staffed DRR agency, with a dedicated budget and strong political support and monitoring frameworks. The government formed a haze task force in 1994 to co-ordinate efforts. By 2013 this included representatives from 23 government agencies.
Challenges	
Sea-level threats	Rising sea levels pose the greatest risk to Singapore, and storm events could upend its highly developed economic infrastructure.
Temperature	Singapore is regularly exposed to haze, an air-borne mixture of pollutants including soot particles and carbon dioxide. This is caused by forces outside of its control, namely the burning of forested land in Indonesia.

Looking forward: Singapore has mature systems, policies and frameworks to deal with natural disasters. Nonetheless, it is not completely immune to climate change. A low-lying tropical island where 30% of the area is less than 5 metres above sea level, it is exposed to the threat of rising sea levels. Some of the other challenges that it may face are rising temperatures and reduced rainfall.[88]

Recognizing the gravity of the situation early on, the government has already invested in building a research centre (Climate Research Singapore, established in 2013) that focuses on decoding the impact of global warming and climate change on Singapore. The centre also runs regional collaborations to study the impact of climate change in Southeast Asia.[89] Recognising its exposure to rising sea levels and risk of flooding from heavy rainfalls, Singapore has implemented measures to safeguard its built structures from these risks. In 2011, the government implemented guidelines that raised the minimum land reclamation level from 3 to 4 metres above sea level. In 2019, the government further mandated that all new developments be built at least 4 metres above mean sea level and more than 4 metres for critical infrastructure such as airports and ports.[90]

Singapore's vast green spaces integrated within the urban set-up make them valuable carbon sinks and control the urban heat island effect. The city's land-use, land use-change and forestry sector (LULUF) has been a net carbon sink. Under these policies, the city will continue to witness an expansion of its green spaces and will preserve its forests and mangroves. These measures safeguard against coastal erosion, regulate temperatures and can limit flooding from heavy rains.[91]The use of social media during a natural disaster stepped up during the Haitian earthquake of 2010, when platforms helped to keep people informed around the world and launch crowd-funding campaigns.[92] Humanitarian groups have also leveraged digital data—for example, to identify population movements based on mobile phone activity, and for public communications, advocacy, fundraising and community engagement purposes.[93,94]

Social media and digital innovation

In Asia, social media has been used to spread information during disasters and respond to governance shortfalls. During the Bangkok floods in 2011, for instance, a Facebook page was created to consolidate accusations that community leaders were stealing relief funds (by requiring a paperwork fee from individuals seeking to access their entitlements). This led to an official response from the deputy prime minister.[95] In Jakarta, WhatsApp and Facebook groups have been used to communicate changes in river levels through photo-sharing, leveraging a perceived increase in trust in information collected from citizens, rather than official sources.[96]

While social media can help to spread information during a disaster, this strategy is also fraught with risks. First, distilling valuable situational data from conversational content can be challenging. Second, rumours and false information need to be carefully handled. Third, social media access could be limited during a disaster, which may warrant a focus on simpler technologies, such as mobile phone text messaging. "There's been a rise of using telecommunications and, particularly, co-operation between the disaster agencies and the telecom operators of pushing out warning messages and advice," explains Hans Guttman, executive director of the ADPC. "But that often reverts to quite simple text messages, because you want to reach everyone, and you can't just be dependent on particular apps that people may or may not have installed." Guttman adds that communication infrastructures are often one of the first to fail during disasters, hindering response measures based on digital technology. These risks suggest that conventional media should play a more active role in sharing information, rather than merely reporting on a disaster event. In Bangkok's 2011 floods, for instance, the media focused on discussing the business and financial implications of the disaster, rather than actively providing citizens with information and assistance. [97]

Conclusion

Charting a resilient future

The framework assessed in the previous section of this report sets the path of future trajectory for the five ASEAN cities. The success of this framework in controlling the subsidence of these cities is dependent on the intensity, efficiency and urgency of the actions that we take today. Understanding where each city currently stands is critical to planning for the future. The similarities in the geographical outlay of these cities make for some common problems and consequently some common solutions that can be implemented. This section of the report summarises a few critical foresight factors for the five ASEAN cities.

Bangkok—work with nature

For a sinking city only 1.5 metres above sea level, the threat of being submerged is real and immediate. Under a business as usual scenario, land subsidence, increased flooding from torrential rains, and coastal erosion caused by rising sea levels would hasten the sinking of Bangkok. According to World Bank estimates, 40% of the city could be submerged by as early as 2030.

Increasing permeability by building more green spaces and using more permeable materials instead of concrete will help in controlling both land subsidence - as the water being absorbed into the ground will recharge the water table - and consequently prevent flooding in the city. Managing Bangkok's water flow around its rivers is crucial to prevent flooding of low-lying areas. Replanting the mangrove forests that retain sediment and prevent erosion of the city's shoreline could prove to be a better solution than some of the more hard engineering solutions because mangroves provide a natural barrier against coastal erosion and also serve as a shelter and breeding ground for native wildlife species.

Ho Chi Minh City—flood management, not control

The city faces annual flooding, tropical storms, heavy rains, upstream discharges from reservoirs and excessive groundwater extraction. Despite having in place a robust institutional framework to address urban disasters, the city government's performance in on-ground implementation of adaptation measures remains significantly lacking.

In order to deal with tidal flooding in low-lying vulnerable areas, Ho Chi Minh City needs to focus on swift implementation of well-meaning plans and frameworks. The city needs robust flood management policies. The city also faces the problem of land subsidence, which is aggravated by the unchecked extraction of groundwater. The city government's efforts to close groundwater wells and reduce groundwater extraction across the city should be further accompanied by specific regulations and penalties for violations.

Jakarta—hold the water

Jakarta is plagued by two complementary problems. One is land subsidence, which is causing the city to sink and the other is frequent flooding that the city experiences annually, and which further compounds the sinking of the city.

To arrest this sinking, the city administration should limit the use of groundwater. Provision of piped water to households and businesses is needed to reduce the rate of groundwater extraction, which would pause the subsidence of land. Unchecked and unplanned urbanization has led to the proliferation of semi-permanent dwellings near the canals and waterways of the rivers. Proper dredging of these rivers is needed—cleaning the rivers, canals and waterways of waste to enable the flow of the rainwater into the Java Sea.

Kuala Lumpur—beat the flash floods

Flash floods have increasingly become frequent and severe in Kuala Lumpur. The Department of Irrigation and Drainage (DID) identified three main factors that cause flash floods in Kuala Lumpur – rapid urban development including housing and highways, inability of rivers and drainage systems to handle the flow of river

and rapid water flow and sedimentation due to rapid development near water catchment areas.

City government should initiate more programmes such as the SMART tunnel project, which particularly addresses the issue of flash floods in critical city centres. Continued timely prediction of floods in river basins across Malaysia is critical now and in the future, so that citizens are better informed on flood warnings.

Singapore—early riser

Although the city-state has mature systems, policies and frameworks to deal with natural disasters. Nonetheless, it is not completely immune to climate change. Besides being exposed to rising sea levels, some of the other challenges that it may face are rising temperatures and reduced rainfall.

Recognizing the gravity of the situation early on, the government has already invested in research that focuses on decoding the impact of global warming and climate change on Singapore as well as the wider Southeast Asian region. It has implemented measures to safeguard its built structures from the risks of rising sea-levels and has also implemented guidelines that raised the minimum land reclamation level from 3 to 4 metres above sea level.

As a part of its commitments under the Paris Climate Agreement, the government has taken measures to slowdown and ultimately cap its carbon emissions by 2030. In March 2018, the government passed 'The Carbon Pricing Act' in parliament, which led to the implementation of the carbon tax in January 2019—it imposes a tax on industrial facilities that generate carbon emissions beyond 25000 tonnes.[98] The tax starts at SGD5 and will be raised to between SGD10 to SGD15. The city is also taking steps to reduce its reliance on electricity generated from natural gas and adopt more of solar power.

The future of these cities depends on the actions that their governments take today. Governments are increasingly recognising the importance of disaster mitigation and preparedness. As this report reveals, most have adopted new strategies, technologies and other approaches to protect their citizens and national assets. Most are also looking to adopt forward-looking solutions that focus on preparedness.

Leaders are increasingly expressing their support and commitment in disaster-risk policies. Both developed as well as developing cities are setting aside dedicated budgets to meet the potential cost of disasters. Almost all cities rank low in either economic or societal resilience, or both—indicating neither the city governments have the capacity to absorb the economic impacts of disasters nor are societies well-equipped to cope with the impact of disasters.

The way forward is to prepare well for the future. Cities and governments have an once-in-a-lifetime opportunity to learn from past mistakes and ensure that future infrastructure is rolled out with a strong DRR and DRM foundation.

Appendix

Methodology

The Economist Intelligence Unit (EIU) developed a scorecard to assess disaster risk preparedness in five key cities in the Association of Southeast Nations (ASEAN): Bangkok, Ho Chi Minh City, Jakarta, Kuala Lumpur and Singapore. The scorecard was inspired by The EIU's DRIOR model, which was developed in 2015 for the United Nations International Strategy for Disaster Risk Reduction (UNISDR), now the United Nations Office for Disaster Risk Reduction (UNDRR). The scorecard assesses cities on disaster risk preparedness and response, including their supporting policies, regulations and institutions, as well as their economic development. The scorecard assesses these cities across five domains: institutional framework; disaster risk reduction (DRR) policy, preparedness and response; economic resilience; societal resilience; and resilience of the physical environment.

EIU analysts and researchers conducted extensive research into city-specific disaster risk and preparedness factors and produced a qualitative scorecard to inform the evaluations. This research was modelled through an interactive workbook, allowing for city comparisons and the identification of best practices, trends and insights.

The scores for each city are an aggregate of all the underlying indicators. Each domain was assigned an equal weighting (20%), with each indicator within a domain equally weighted (25%). Table 12 provides details for each domain, and for the indicators nested within it, along with the scoring criteria. Based on their performance in the scorecard across the five domains, cities were given one of the following four rankings for their level of disaster risk preparedness and response: nascent, emerging, developed and mature.

1. Institutional framework		Weight: 20%
Indicator	**Scoring criteria**	**Source**
1.1 Dedicated sub-national institutions responsible for disaster risk management (DRM) Are there dedicated sub-national entities (e.g. agencies, committees, offices within a sub-national ministry) explicitly tasked with the direction and co-ordination of disaster risk management (DRM), defined as (1) disaster risk reduction (DRR) and (2) preparedness and response measures?	0: No. There are no entities responsible for dealing with (1) or (2) at the sub-national level. 1: Partially. There is at least one sub-national entity explicitly responsible for dealing with (1) or (2). 2: Yes. There is at least one sub-national entity explicitly responsible for dealing with (1) and (2).	EIU research
1.2 Operational effectiveness Staffing Does the leading sub-national entity responsible for DRM have a dedicated staff?	0: No. 1: Partially. There is blended staffing, where resources are borrowed from or shared with other entities. 2: Yes. There is permanent staffing.	EIU research
1.3 Support from political leadership Have leading government members at the sub-national level (e.g. municipal member, mayor, governor or council -head) expressed active support for DRM since January 1st 2015?	0: No. 1: Yes.	EIU research
1.4 Monitoring and evaluation plan/framework Is there a clear and established plan/framework for the monitoring of ongoing DRM activities (e.g. a sub-national programme) defining (1) evaluation mechanisms, (2) metrics and (3) frequency of evaluation?	0: No. 1: Partially – (1), (2), or (3). 2: Yes, all three.	EIU research

2. Disaster risk reduction policy, preparedness and response		Weight: 20%
Indicator	**Scoring criteria**	**Source**
2.1 Disaster risk–informed development Is disaster risk explicitly included and accounted for in sub-national planning/design (e.g. through policies, directives, urban development plans/ strategies)?	0: No. 1: Yes.	EIU research

2.2 Response – budget allocation Does the leading sub-national DRM entity have direct access to a dedicated budget line for disaster risk preparedness and response?	0: No. There is no dedicated budget line. 1: Partially. There is a dedicated budget line at the national level that the sub-national entity can tap into. 2: Yes. There is a dedicated budget line at the sub-national level.	EIU research
2.3 Disaster risk preparedness Does the city operate a multi-hazard early warning system (e.g. SMS alerts to disseminate mass messages)?	0: No. 1: Yes.	EIU research
2.4 Contingency planning Are sub-national governments required to formulate and implement contingency plans for natural hazards?	0: No. 1: Partially. This is only required at the national level. 2: Yes. This is required at a sub-national level.	EIU research

3. Economic resilience		**Weight: 20%**
Indicator	**Scoring criteria**	**Source**
3.1 Macroeconomic stability Is there a prevalent structural macroeconomic risk at a country level which could impact the regional economy of the city (that is, high volatility of GDP growth, high public debt/GDP, and high gross external debt/GDP)?	0: No. 1: Yes.	EIU research
3.2 Diversification of the economy Is there increased reliance on agriculture? What proportion of the labour force is employed in the agricultural sector?	0: Yes. At least 20% of the labour force are employed in the agricultural sector. 1: No. Less than 20% of the labour force are employed in the agricultural sector.	EIU research
3.3 Insurance markets Is catastrophe insurance available at a sub-national level?	0: No. 1: Yes.	EIU research
3.4 Poverty level What is the urban poverty headcount ratio at the national level?	%	World Bank

4. Societal resilience		Weight: 20%
Indicator	**Scoring criteria**	**Source**
4.1 Safety and security What is the level of public safety in the city?	EIU Liveability Index Score 0-100, 100 = best	The EIU Liveability Index
4.2 Social cohesion Income inequality What is the city-level Gini coefficient?		EIU research
4.3 Health systems Current health expenditure per capita, PPP (current international $)	0-100, 100 = best	World Bank
4.4 Women's empowerment What is the difference between the male and female literacy rates in the city?	% difference	EIU research

5. Resilience of the physical environment		Weight: 20%
Indicator	**Scoring criteria**	**Source**
5.1 Quality of existing infrastructure What is the overall quality of existing infrastructure in the city?	EIU Liveability Index Score 0-100, 100 = best	The EIU Liveability Index
5.2 Critical infrastructure resilience Does the city have a critical infrastructure plan updated in the last five years?	0: No. 1: Partially. There is a plan but it has not been updated in the last five years. 2: Yes. There is a plan and it has been updated in the last five years.	EIU research
5.3 Implementation of building codes Does the city have building codes that account for disaster risk?	0: No. 1: Yes.	EIU research
5.4 Identification of vulnerability and risk of disruption Do sub-national governments carry out predictive disaster scenario analysis, and are the results incorporated into subsequent infrastructure planning?	0: No. 1: Partially. They do, but there is no evidence of incorporation into future planning. 2: Yes. They do, and the results are incorporated into future planning	EIU research

City scores

	Weight	Bangkok	Ho Chi Minh City	Jakarta	Kuala Lumpur	Singapore
Overall		**43.7**	**55.0**	**69.9**	**53.6**	**87.8**
1) Institutional framework	**20.0%**	**62.5**	**75.0**	**87.5**	**62.5**	**87.5**
1.1 Dedicated sub-national institutions responsible for disaster risk management (DRM)	25.0%	100.0	100.0	100.0	100.0	100.0
1.2 Operational effectiveness: Staffing	25.0%	50.0	50.0	100.0	100.0	100.0
1.3 Support from political leadership	25.0%	50.0	50.0	50.0	50.0	50.0
1.4 Monitoring and evaluation plan/ framework	25.0%	50.0	100.0	100.0	0.0	100.0
2) Disaster risk reduction policy, preparedness and response	**20.0%**	**50.0**	**87.5**	**100.0**	**62.5**	**100.0**
2.1 Disaster risk-informed development	25.0%	100.0	100.0	100.0	0.0	100.0
2.2 Response – budget allocation	25.0%	50.0	100.0	100.0	100.0	100.0
2.3 Disaster risk preparedness	25.0%	0.0	100.0	100.0	100.0	100.0
2.4 Contingency planning	25.0%	50.0	50.0	100.0	50.0	100.0
3) Economic resilience	**20.0%**	**25.0**	**37.7**	**62.7**	**74.0**	**100.0**
3.1 Macroeconomic stability	25.0%	100.0	100.0	100.0	100.0	100.0
3.2 Diversification of the economy	25.0%	0.0	0.0	0.0	100.0	100.0
3.3 Insurance markets	25.0%	0.0	0.0	100.0	0.0	100.0
3.4 Poverty level	25.0%	0.0	50.6	50.9	96.1	100.0

	Weight	Bangkok	Ho Chi Minh City	Jakarta	Kuala Lumpur	Singa-pore
4) Societal resilience	**20.0%**	**26.9**	**48.1**	**36.5**	**54.7**	**54.1**
4.1 Safety and security	25.0%	0.0	37.5	12.5	62.5	100.0
4.2 Social cohesion: Income inequality	25.0%	100.0	54.8	41.3	51.6	0.0
4.3 Health systems	25.0%	7.5	0.0	0.2	18.7	100
4.4 Women's empowerment	25.0%	0.0	100.0	91.8	86.1	16.4
5) Resilience of the physical environment	**20.0%**	**54.3**	**26.8**	**63.0**	**14.5**	**97.5**
5.1 Quality of existing infrastructure	25.0%	67.0	57.0	52.0	58.0	90.0
5.2 Critical infrastructure resilience	25.0%	0.0	0.0	0.0	0.0	100.0
5.3 Implementation of building codes	25.0%	100.0	0.0	100.0	0.0	100.0
5.4 Identification of vulnerability and risk of disruption	25.0%	50.0	50.0	100.0	0.0	100.0

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