MITIGATING CLIMATE RISK IMPACT TO REAL ESTATE VALUE IN THE GREATER BAY AREA

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Urban Land Institute

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Contents

Executive Summary

In response to evolving climate conditions, the real estate industry of China's Greater Bay Area (GBA) must coordinate its resilience measures to protect the hundreds of millions of people and trillions of dollars of assets concentrated in the region while reconciling varied interests of real estate industry sector participants. This report draws on knowledge from leaders in investment, development, insurance, and government and local nongovernmental organisations in addition to prevailing research, reporting frameworks, and case studies to understand how climate risk is currently addressed in the GBA real estate transaction process.

As the GBA grows and develops, regional hazards such as storms, flooding, sea-level rise, extreme heat, and drought continue to worsen and become more frequent in the region as a result of climate change. Left unchecked, climate change will continue to increase the number and size of damage claims against insurance policies, cause defaults on loans, and jeopardize real estate value across the GBA. Consequently, there is a shared desire throughout the region to identify ways of preventing long- and short-term losses, keep abreast of global environmental, social, and governance (ESG) priorities, and attain compliance with forthcoming government-imposed real estate reporting requirements as well as internal ESG requirements.

The objective of this report is to determine whether climate risk is being incorporated into real estate transactions and what can be done to further address the accelerating risk of climate change. This report identifies the climate risks threatening the real estate sector in the GBA and examines actions taken or planned by developers, equity and debt investors, insurance companies, nongovernmental organisations, and government actors to account for and mitigate known risks. Building on these findings, the report proposes additional measures to address current hurdles that are hindering climate action and provides example investment opportunities that have successfully increased resilience in communities worldwide.

Whilst all interviewees for this report were aware of transition and physical risks, at present, the main form of risk that appears in the cost of real estate transactions is transition risk associated with the decarbonisation of real estate. This is driven by the preference of foreign investors for "green buildings", the ability of developers to recover the cost of greener buildings from tenants, and the planning efforts of local and national governments to enhance the region through green infrastructure and a cleaner electric grid. Despite interviewees' awareness of potential physical risk to assets, they demonstrated a lack of consensus on the details of factoring this risk into costs and mitigative actions, including any deliberate devaluation of property because of known hazards. Among interviewees, such devaluations associated with climate risk have been limited and often reactive.

Short hold periods, insufficient incentives, and a lack of available data further challenge real estate actors in addressing physical climate risk. To address these issues and create a more resilient GBA, most interviewees felt that both the People's Republic of China and Special Administrative Region (SAR) governments (particularly Hong Kong SAR) should impose reporting requirements, supply robust and relevant data, and develop physical infrastructure to support more resilient development. Many interviewees

Case Studies in This Report

To illustrate the value of addressing physical climate risk, the following case studies are presented in the report:

- Meeting the sponge city imperative with floodable parks;
- Inter-sectoral collaboration for catastrophe insurance in Shenzhen;
- Implementing hazard-resistant building codes and nature-based solutions in Miami;
- Managing water and development through inter-sectoral coordination and innovation in Rotterdam;
- Ensuring thermal comfort in dense urban areas in Singapore; and
- Securing adequate potable water through periods of unprecedented drought in San Diego County.

identified ways that private enterprise could contribute and engender positive change by ensuring new construction and existing buildings anticipate climate change impacts in the years beyond typical building hold periods. Among the consequences for inaction on physical risk are disinvestment from risk-prone areas, interruptions to business continuity, physical damage to public and private assets, mounting costs of repairs and clean-up, and the real potential for loss of life and livelihoods due to extreme weather events. Such impacts can be mitigated by working across sectors, providing authoritative data on current and future climate conditions, and leveraging guidance and support from governments and major regulatory authorities. Furthermore, the return on investment by private and public sectors can be enhanced by capitalizing on resilience co-benefits.

In summary, the imperatives arising from this report are as follows:

- Increase collaboration between government and industry sectors.
- Strengthen government leadership towards change – particularly to address physical risk.
- Conduct consistent and robust physical risk assessments for assets.

Introduction

China's Greater Bay Area (GBA), in addition to having the most concentrated real estate value in the world, is also one of the most vulnerable regions to climate change. As the GBA continues to grow, develop, and engage in global markets, concern is widespread about how investors and other key players in the real estate industry are balancing their environmental, social, and governance goals (ESG) with efforts to address climate risk and maintain the long-term value of assets. This report identifies the climate risks threatening the real estate sector in the GBA and examines what concrete actions are being taken (or are on the horizon) by developers, equity and debt investors, insurance companies, nongovernmental organisations (NGOs), and government entities to mitigate these known risks, leveraging exclusive interview feedback from leading firms in the region. Building on these findings, the report proposes additional measures to fill gaps and identifies potential investment opportunities which have seen success in communities across the world.

FIGURE 1 China's Greater Bay Area

An Introduction to the Geography and Economy of China's Greater Bay Area

China's Greater Bay Area is located along the continent's east coast and includes the Hong Kong and Macao Special Administrative Regions in addition to the municipalities of Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Jiangmen, and Zhaoqing (see figure 1). The GBA spans about 56,000 square kilometres, and as of 2020, its population was about 86.2 million with a gross domestic product (GDP) of US$1.7 trillion. The scale of the GBA is enormous, especially when compared with other major metropolitan regions. For instance, the San Francisco metropolitan area is only about 1,400 square kilometres, and it has a population of about 3.3 million and a GDP of US$995.1 billion; meanwhile Tokyo, widely regarded as the largest metropolitan area in the world, spans about 2,200 square kilometres and has a population of some 44.3 million and a GDP of US$1,991.6 billion.[1]

"It is important for investors and financiers to take steps to prevent the erosion of value forecasted for assets that are poorly designed, inefficient and outdated, in a world which is increasingly prioritizing well designed, energy-efficient and modern buildings which have lower environmental impact."

— Real estate professional

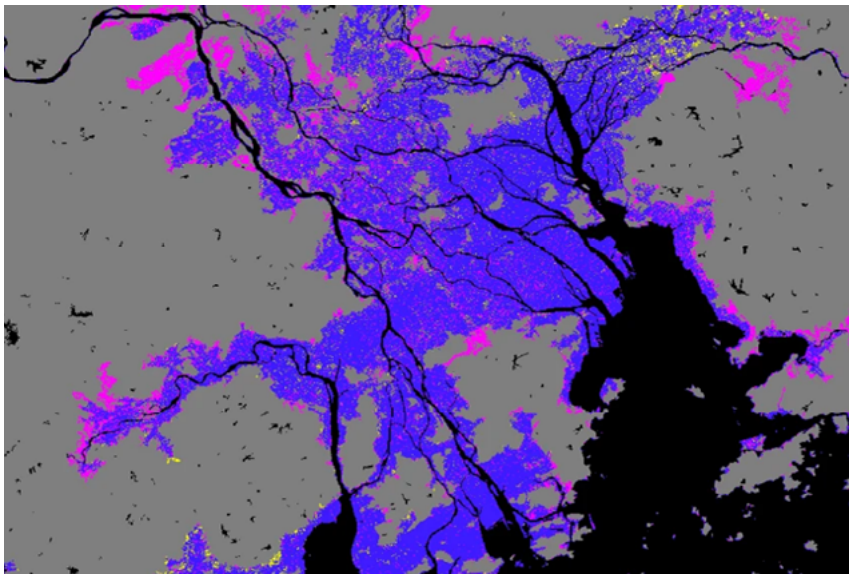
Part 1: Climate Risks Threatening Real Estate in the Greater Bay Area

Overcoming the gap between knowledge of ongoing and forthcoming threats posed by climate change and coordinated mitigative action is one of the most pressing and difficult challenges of the modern age; this challenge is manifest worldwide but is especially critical within the GBA. Currently up to 93 million people in mainland China reside below the 2050 average annual flood level, and some of the most populous, economically burgeoning, and vulnerable urban centres of the continent are located in the GBA (see figure 2).[2] Even though more than 90 percent of individuals in China believe that climate change is occurring, meta-analysis of major surveys of public perceptions on climate change reveals a gap in survey data availability for business communities, and many respondents believed government should shoulder more responsibility for response.[3] Feedback from report interviewees corroborated the findings of these studies for firms in the real estate sector; and while awareness can help bring key stakeholders to the table, acknowledgement of shared responsibility and discourse followed by action between actors in both government and the private sector will be keys to protecting the GBA.

The Sixth Assessment Report (AR-6) by the Intergovernmental Panel on Climate Change (IPCC) sheds some light on projected impacts in the GBA, highlighting that storms, flooding, sea-level rise, increased temperatures, and drought are among the pressing regional hazards for the East Asia region (EAS; see figure 3). According to AR-6, in the last year, tropical cyclones in the EAS region have grown more numerous and stronger at a faster rate. The typical trajectory of storms has shifted poleward, and precipitation has increased in frequency and intensity causing landslides in some mountain areas.[4] The Hong Kong Observatory corroborates this, noting that the frequency of intense rainfall from typhoons has been increasing over the last 50 years.[5]

Sea-level rise remains a threat to physical infrastructure in the region as well, with relative sea level increasing faster than the global average accompanied by loss of coastal area and shoreline retreat. Temperatures also appear to be rising as sea level increases: the report notes that heat extremes have increased while cold extremes have decreased throughout Asia with droughts becoming more frequent in the EAS region (particularly Shenzhen). The GBA specifically experienced a more intense increase in heat risk compared to areas that are inland and less urbanized. Projected impacts from AR-6 and other regional studies are summarized by hazard type in figure 4.

FIGURE 2 Sea-Level Rise Projections for the Pearl River Delta



Pearl River Delta, China

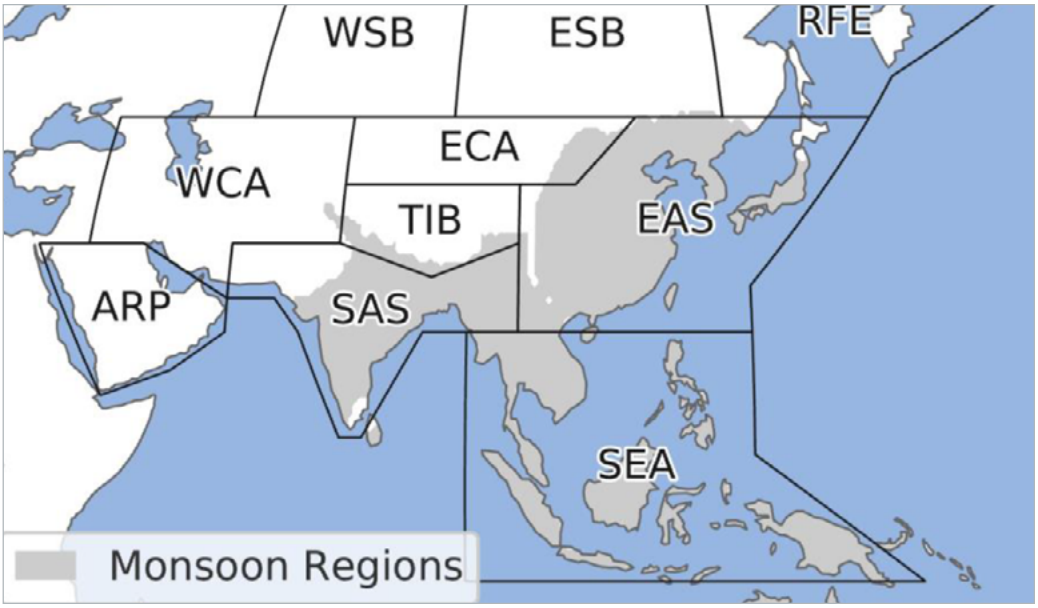
Areas below water level according to:

- CoastalDEM only
- SRTM only
- Both
- Current water bodies

Note:
CoastalDEM - a high-accuracy digital elevation model (DEM) for coastal areas
SRTM - uses radar observations to construct DEM

Source: Scott A. Kulp and Benjamin A. Strauss, "New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding," *Nature Communications* 10 (2019).

FIGURE 3 IPCC AR-6 Asia Region Map



Source: IPCC AR-6 Regional Factsheet for Asia: https://www.ipcc.ch/report/ar6/wg1/downloads/factsheets/IPCC_AR6_WGI_Regional_Fact_Sheet_Asia.pdf.

FIGURE 4 Anticipated Climate Impacts by Hazard Type

The Pearl River Delta (PRD) spans many of the GBA's municipalities and is located in south-central Guangdong Province.[6] The PRD is subject to strong monsoons, geological changes caused by river erosion and deposition, and land subsidence in coastal areas. Urbanisation in the PRD has altered existing natural systems, increasing vulnerability to flood and other related climate hazards. The population of the PRD is anticipated to increase to more than 120 million people by 2050.[7] As the region's urban development continues, so will friction between geological and climatic conditions and the built environment.

Flood	Major cities of the PRD such as Guangzhou, Shenzhen, and Hong Kong will be further exposed to coastal, pluvial, and fluvial flood risks in the coming decades.[8] Poor drainage, extreme weather, and storm surge will continue to exacerbate this flooding throughout the PRD.[9]
Storm	It is predicted that average and heavy precipitation (including East Asian monsoon precipitation in the long term) will increase over much of Asia.[10] This increased precipitation will in turn increase risk of other hazards such as landslides.[11]
Sea-level rise	The regional mean sea level will continue to rise.[12] The Hong Kong Observatory expects annual mean sea level to rise more than 20 centimetres by 2050.[13] Sea-level rise can increase the height of storm surge and will threaten the region's supply of freshwater for consumption, irrigation, and industrial uses within the PRD.[14]
Temperature increase	Heat extremes throughout East Asia will continue to increase over the coming decades.[15] Heat risk will also continue to increase and will be made worse by the urban heat island effect precipitated by continued rapid population growth and development within the region.[16]
Drought	Droughts will continue to become more frequent in much of continental East Asia, particularly in Shenzhen; they will also increase risk of urban water scarcity within the region for their duration.[17]

For real estate, both the physical and transitional risks associated with climate change have financial impacts. Physical risks, such as extreme weather, rising temperatures, and drought can lead to increased insurance premiums, higher capital expenditure and operational costs, and decreased liquidity and value of buildings. Transitional risks, which centre on the economic, political, and societal responses to climate change, can cause properties, and even entire metropolitan areas, to become less appealing to investors, tenants, and residents because of climate change–related events, leading to the potential for some individual assets to become obsolete. Further, research shows that unquantified risks to assets stemming from climate change impacts will affect infrastructure and supply chains. One study conducted in 2020 by McKinsey noted that there could be "profound economic and political consequences within the lifetimes of people alive today," due to "concentrated threats" within the Asia-Pacific region.

Physical and Transition Risks

Risk to assets from climate change impacts are categorized into two types: transition and physical. Transition risk is defined as "the risks related to the process of adjustment towards a low-carbon economy," while physical risk is defined as "economic costs and financial losses resulting from the increasing severity and frequency of: extreme climate change-related weather events (or extreme weather events) . . . ; longer-term gradual shifts of the climate . . . ; and indirect effects of climate change".[18] Transition risk might include impacts of new laws governing climate risk disclosure or shifting priorities of tenants in favour of more sustainable building features. Physical risk might encompass costs incurred from damages inflicted on physical structures during increasingly intense or frequent weather events. See figure 5 for more examples of physical and transition risk.

FIGURE 5 Examples of Climate Risk

Physical risk	**Catastrophic events**	Extreme weather such as hurricanes and wildfires.
	Changes in weather patterns	Gradual changes in temperature and precipitation – such as higher temperatures, rising sea level, increasing frequency of heavy rain and wind, and decreased rainfall – which are likely to exaggerate the impact of catastrophic events.
Transition risk	**Market**	The possibility that markets vulnerable to climate change will become less desirable over time. Rising capital costs to pay for building and maintaining infrastructure to manage climate risks.
	Policy and regulation	Regulations to address climate change – e.g., climate risk disclosure, tougher building standards, carbon pricing, emissions caps, changes to subsidies – as well as changing policies for providing funding for infrastructure or rebuilding after major events.
	Resource availability	Changes in the availability of key resources such as energy and water, including water scarcity.
	Reputation and market position	Growing stakeholder preference to work with companies incorporating climate risk into investment decisions, and consumer preference for real estate products incorporating climate mitigation.

Adapted from table in Urban Land Institute and Heitman, "Future-Proofing Real Estate from Climate Risks" (2018).

According to the IPCC AR-6 Working Group II report, Guangzhou and Shenzhen are among the 20 largest coastal cities anticipated to have the highest flood losses by 2050 with a 7 percent loss in GDP anticipated in East Asia due to water-related impacts.[19] Guangzhou was identified as the world's most economically vulnerable city to sea-level rise with potential losses estimated at US$254 million per year under just 0.2 metres of sea-level rise (under more aggressive climate change scenarios, estimated losses by 2050 sit at US$331 billion).[20] Moreover, the IPCC report notes that East Asia and the Pacific has a US$75 billion deficit in coastal protection, while a separate report published in 2017 by the Asian Development Bank (ADB) states that East Asian countries will collectively need to invest US$1.07 trillion per year in infrastructure until 2030 to "maintain [their] growth momentum, eradicate poverty, and respond to climate change".[21]

Despite the overwhelming evidence attesting to substantial financial risk and need for significant investment within the region due to ongoing and imminent threats, no universally accepted methods for conceptualizing and quantifying risk have emerged, nor has coordinated action among real estate industry actors taken place towards mitigation of transition and physical risk by private or public entities within the region. Although a unified response to climate risk in the GBA is lacking and an overarching regulatory framework is still under development, some forward-thinking developers, equity and debt investors, and insurance companies are beginning the process of assessing, pricing, and mitigating this risk in their respective parts of the real estate value chain.

Part 2: Differing Priorities, Limited Action

Although a coordinated effort to factor risk into property valuation has not yet been adopted in the GBA, actors across the real estate value chain may (intentionally or unintentionally) respond to climate hazards in ways that in turn affect the price of real estate. This report is informed in part by interviews with industry professionals operating in the GBA, including developers, equity and debt investors, insurance companies, and NGOs. These groups are key players in determining the price of property in the region, driving action on climate change, and guiding the construction of infrastructure as well as residential and commercial structures.

Private Interests

The following subsections seek to answer the questions of whether, and how much, climate risks are factored into the property valuation process in the GBA. To that end, the subsections summarize responses from interviews and offer insights from desktop research concerning real estate developer, debt and equity investor, and insurance company sentiment on current and future market conditions as well status of interventions geared towards quantifying and mitigating both forms of climate risk.

Developers

Exposure / Design / Holding Period

For real estate developers, exposure, design, and holding periods were among the most typical climate risk–related factors discussed over the course of their real estate transaction process. Though developers say they are already aware of both physical and transition risks to their assets in the region, because they operate on hold periods of five to 10 years, the majority were less concerned about their projects' 20- to 30-year outlook, finding it hard to justify mitigative actions for what could be unrealized damages during their relatively short holding periods. Most developers noted that incentive to take independent action to address this (comparatively) long-term risk was limited, and few had a planned approach for dealing with physical risk.

Recognizing the increasing prevalence of tenant and investor participation in holistic risk disclosure frameworks (e.g., Task Force on Climate-Related Financial Disclosures, or TCFD) and emergent disclosure requirements in jurisdictions around the world, some leading developers are gradually setting more concrete goals surrounding physical risk. Other forward-thinking developers are anticipating and avoiding damages by conducting climate risk assessments for their properties and projects, leveraging existing climate-risk assessment technologies – particularly to identify potential impacts in the next 10 to 15 years.

Physical improvements to property are common hazard mitigation strategies employed by leading developers concerned about climate risk. For example, media outlets have highlighted concrete actions taken by New World Development, Hang Lung Properties, Swire Properties, Sino Group, and Hongkong Land in response to mounting risks in the region, namely installation of flood gates, water pumps, additional plant material, and permeable pavements in addition to design of elevated entrances, bio-retention ponds, and vegetated rooftops throughout their at-risk properties.[22]

Addressing transition risk, by contrast, is more common among developers since the cost of features that reduce emissions, improve energy efficiency, and provide environmental benefits can be recaptured by current and future tenants – many of whom are predisposed to bearing the additional burden since they also benefit through attainment of ESG goals and operations and maintenance cost savings. Developers active in international markets may also be obligated to meet company-wide targets on carbon reduction and will integrate energy-efficient strategies that improve the environmental performance of their buildings while reducing their transition risk.

> "I think transition risk is beginning to be priced in. Physical climate risk is yet [to be] priced in now. Our regulators are looking for a significant amount of physical climate risk stress testing, but I question if it's drilling down into individual decisions [at] the moment."
>
> **— Debt investor**

Equity Investors

Acquisition Criteria / Key Performance Indicators

Investment firms noted that physical and transition risks were relevant to their decision-making process for asset acquisition and investment key performance indicators (KPIs). The position among interviewees was that consideration of transition risk currently takes precedence

over the consideration of physical risk. This position is bolstered by a 2022 S&P Global report listing climate transition risk and physical risk as among the three top environmental credit factors for the nation.[23] Despite the fact that physical risk is one of the top three environmental credit factors, its influence with regard to percentage of ratings (2 percent) pales in comparison with that of transition risk and waste and pollution (29 percent and 28 percent, respectively).[24]

While the position among interviewees was that transition and physical risk are important to investment in the GBA, many did not have a planned approach for addressing it (particularly physical risk). It is worth noting that pricing risk into investments transcends industry sectors and involves both public and private entities. This is especially true for mainland China and, by extension, municipalities of Guangdong Province where government is anticipated to take major action to curb emissions and build resilience in the coming years.

Though the People's Republic of China (PRC), through the China Banking Regulatory Commission, has offered green bonds and loans for nearly a decade, and Hong Kong, through the Hong Kong Monetary Authority (HKMA), has also operated a government green bond program since 2017, investors are still seeking stronger government-led economic incentives for sustainable development (e.g., more favourable terms from green loans) before making adjustments to their practices.[25] Without sufficient incentive to meet KPIs for financing instruments, investment firms of the GBA are unlikely to change their practices until they begin to experience significant losses stemming from climate hazards in the short term.

> "It feels like purely financial instrumentation like green bond and green loans [are] happening over here without having . . . a tangible impact on real performance . . . some of the criteria [attached to] the green bonds or sustainability linked loans is okay, but it does not move the needle."
>
> **— Real estate service company**

Debt Investors

Asset Resilience / Value of Green Buildings

Like all industry professionals interviewed, debt investors were aware of both transition and physical climate risk to assets, with their internal targets largely focused on addressing transition risk. By and large, debt investors interviewed did not have a planned approach for dealing with physical risk and, like developers, cited short time horizons as the main prohibiting factor in mitigating risk to commercial assets. Debt investors noted that they were concerned with the short-term resilience of assets as well as the relative value of green buildings.

Throughout China, the amount of household debt from residential mortgages – which typically have terms ranging from 10 to 30 years – has increased by US$4.6 trillion from 2015 to 2019.[26] The question of whether these assets can withstand the next record-breaking hazard event looms large for debt investors. To address this concern, some leading debt investors have advocated for coordination with and purchase of climate risk data from reinsurance providers to inform investment decisions; others relied on property insurance for coverage of events such as typhoons. In some cases, forward-thinking debt investors have established internal processes to evaluate climate risk to investment, including review by the company's chief risk officer for some types of credit risk across selected development types.

Regulators play a role in debt investors' ability to factor in climate risk by supplying data about existing and planned climate-risk mitigation measures, guidance on investment strategy, and economic incentives for green finance. HKMA, Hong Kong's central banking institution, issued a "Supervisory Policy Manual" as well as results from a banking sector Climate Risk Stress Test in December of 2021 to "assess the climate resilience of the Hong Kong banking sector as a whole and facilitate the capacity building of banks for measuring climate risks".[27] The results of the pilot stress test show that physical risks will be manifested in Hong Kong through typhoons and floods which will cause devaluation of properties alongside business disruptions.[28] More specifically, the report highlighted a 25 percent increase in expected credit losses (HK$0.7 billion to HK$17.3 billion) from residential mortgages and other property-related lending in Hong Kong (28 percent of participating banks' total lending), in addition to potential operational losses associated with climate events. The "Supervisory Policy Manual" sets forth compulsory requirements (effective at the end of 2022) for "AIs to build climate resilience by incorporating climate considerations into governance, strategy, risk management and disclosure".[29]

The People's Bank of China (PBoC) also released a climate stress test in 2022 following an announcement the previous year about forthcoming climate-risk disclosure requirements. The stress test, conducted on 21 commercial banks and two development banks, demonstrated an increasing risk of defaults on loans in high carbon sectors. Current measures in place by the PBoC include issuance of green bonds and loans and creation of a carbon emission reduction facility

(CERF).[30] In this fashion within both the PRC and Hong Kong SAR, government agencies are encouraging debt investors to be more prudent in issuing credit for development in areas vulnerable to known climate hazards, but a clear and formal process for doing so in both jurisdictions has yet to be defined.

Insurance and Reinsurance Companies

Premiums / Asset Value

Insurance providers noted that premiums and asset value were the primary climate-risk-related concerns for such companies in the GBA. Insurance companies seek to ensure that premiums accurately reflect the latest projections for hazards and are widely regarded as leaders in quantifying climate risk to assets. Insurance and reinsurance companies leverage catastrophic risk modelling (CAT modelling) to predict potential losses from climate change and destructive weather events. Insurance-sector interviewees reflect an industry approach to pricing in climate risk that was described as a "slow burn" since insurance companies can easily adjust annual premiums based on previous years' events and claims. Because the threshold for claims that can be classified as "disasters" is higher than most events, events seldom result in claims that exceed expectations. Moreover, if claims exceed this threshold, insurance companies can adjust premiums as needed to prevent additional future losses.

It bears mention that concerns about underinsurance exist in Organisation for Economic Co-operation and Development (OECD) countries. More specifically, a 2020 report by McKinsey found that "three of the four Asian OECD countries and most non-OECD Asian countries did not achieve the average insurance penetration rate of OECD countries". While property insurance is fairly commonplace throughout other parts of the globe, such as municipalities throughout North America, it is less common throughout the GBA. As of 2015, only 10 percent of the total economic losses in the Pearl River Economic Zone were insured against a hundred-year storm surge.[31] The report also notes that "appropriate insurance can encourage behavioural changes by sending risk signals, for example, discouraging development in certain locations".[32] Therefore, while insurance companies attest to having processes in place to compensate for climate hazards, property owners may not be similarly well equipped to make decisions to protect their assets.

Inter-sectoral Collaboration for Catastrophe Insurance in Shenzhen

Demand for insurance can rise in lockstep with losses because of heightened frequency and intensity of catastrophic events and mounting costs of pollution control and clean-up. At the same time, major insurance providers are seeking ways to mitigate losses from damage claims caused by the rapid global proliferation of events generating large numbers of claims. Though insurance coverage in the GBA is presently lower than in other major metropolitan regions, this is anticipated to change in the very near future in part due to this increased demand, as well as forthcoming municipal disaster insurance and countrywide regulation compelling environmental liability insurance. While the latter national policy has been under development for over a decade, a local pilot in Shenzhen, known as the Disaster Insurance Pilot or Catastrophic Insurance Framework, serves as a proof of concept for a city-scale framework for disaster insurance.

Beginning in 2014, pilot municipal insurance programs were launched in Shenzhen, Ningbo, Yunnan, and Sichuan, culminating in an even larger-scale pilot in 2016 throughout Guangdong Province. The Shenzhen project offered catastrophe insurance coverage for medical and pension costs due to residents' injury or death caused by 15 possible events including flood, tornado, typhoon, tsunami, and landslide.[33] The pilot operates on a multi-tiered structure. Tier 1 is supported by a government catastrophic risk insurance policy from the People's Insurance Company of China, Tier 2 is backed by a catastrophe fund, and Tier 3 comprises private catastrophe insurance for property losses. Swiss Re, one of only a handful of reinsurance firms active in the GBA, provided technical assistance and reinsurance for the Shenzhen pilot. While the benefits of Tier 3 catastrophe insurance for property loss have yet to be tested, this inter-sectoral collaboration has yielded benefits to individual residents in its short tenure. In 2019, a flash flood which killed nine people in Shenzhen resulted in a payout of 250,000 yuan per individual in addition to supplemental assistance for family members' relocation.[34] In the wake of Super Typhoon Mangkhut in 2018, under the Guangdong pilot's policy, 5.5 million and 20 million yuan were paid to the department of finance and to the cities of Yangjiang and Maoming, respectively, within 24 hours of the event.

Government

According to interviewees, three major barriers to capturing the cost of climate risk in real estate transactions are (1) limited availability of high-resolution data, (2) absence of clear and standardized reporting requirements for climate risk, and (3) lack of sufficient incentive for action on the typical timeframes of transactions. Governing entities across the world have, in response to mounting evidence of the economic impact of climate change, begun to adopt climate-risk reporting requirements across all industry sectors informed by emergent reporting frameworks such those established by the TCFD, not-for-profit charity CDP, and the Global ESG Benchmark for Real Assets (GRESB).[35] The PRC and Hong Kong SAR governments lag slightly behind other global actors in this regard, though they have adopted goals for pollution control and addressing transition risk, such as President Xi Jinping's 2021 announcement of the PRC's goal of achieving carbon neutrality by 2060, and Hong Kong's Climate Action Plan 2050, which addresses emissions, energy savings for buildings, transportation, and waste management.[36]

Although recommendations from interviewees tended to vary widely between industry sectors, one of the ideas on which there was shared sentiment was that to ensure climate risk is factored into real estate transactions, government needs to ensure standards for design and disclosure reflect future conditions. Some interviewees also called for greater stakeholder outreach and engagement to ensure new requirements can be implemented.

Local/Regional

The approach to addressing climate risk differs between the municipalities of Guangdong Province and the Hong Kong and Macao SARs. While the PRC leads the private sector and local governments with overarching regulations, SAR governments rely more on the market and economic incentives to drive climate-resilient development, though they have also implemented policies to address extreme weather, flood, and drought while mitigating climate change impacts.

In Hong Kong, these policies are exemplified by the Weather Warning System, Total Water Management Strategy (TWMS), Drainage Master Plan (DMP), Landslip Preventive Measures Program (LPMP), and the 2021 Climate Action plan. Macao adopted an inter-jurisdictional plan for a tidal barrier in Zhuhai in 2019 as well as a Water Conservation Master Plan. Hong Kong leads the SARs in climate change mitigation measures, having adopted numerous policies aimed at regulating sources and consumption of electricity.[37] While both Hong Kong and Macao already purchase electricity from sources in mainland China (nuclear power from Guangdong and China Southern Grid Company, respectively), dependency on external sources of energy and demand for more efficient structures and construction processes may increase as the areas continue to grow and develop, and climate change impacts challenge existing design standards and commissioning processes.

Unfortunately, because Hong Kong's electrical utility providers are privately owned, obtaining detailed information about building energy consumption within the SAR can be difficult. Developers, designers, investors, and the like in Hong Kong have expressed general dissatisfaction with the lack of sufficient publicly available data on climate risk vulnerability to make informed decisions on property acquisition and development.

In 2016, Hong Kong released its *Hong Kong 2030+* report, which informs its territorial development strategy.[38] This document outlines some of the specific city resilience initiatives and their corresponding leading agencies also reflected and expanded upon in "Hong Kong's Climate Action Plan 2050". A summary of activities, organized by agency, is provided here:[39]

Climate Change Working Group on Infrastructure (CCWGI)

- Updates design standards for infrastructure (Port Works, Design Manual, Stormwater Drainage Manual, Guidance Notes on Road Pavement Drainage Design, design guide for drainage installation for government buildings).
- Conducts the resilience study of government critical infrastructure.
- Shares experience and findings with public organisations and public utilities.
- Reports to the Committee on Climate Change and Carbon Neutrality.

Hong Kong Planning Department

- Adopts the Sustainable Building Design Guidelines.
- Adopts Hong Kong Planning Standards and Guidelines (HKPSG) for combatting the urban heat island effect and making the built environment more sustainable.
- Requires government projects to carry out air ventilation assessments.
- Creates the Urban Climatic Map to provide broad practical guidelines to improve urban thermal comfort.

Hong Kong Observatory (HKO)

- Projects mean sea level in Hong Kong.
- Monitors and forecasts weather and issues warnings on weather-related hazards.[40]

Civil Engineering and Development Department (CEDD)

- Reviews Studies on Climate Change and its Implications on the Design of Coastal Structures.
- Develops strategy for managing landslides including public education and communication.
- Ongoing improvement of high-risk slopes.

Drainage Services Department (DSD)

- Completes Drainage Master Plan studies in flood- prone areas.
- Uses technology to get real-time information about infrastructure performance.

Home Affairs Department (HAD)

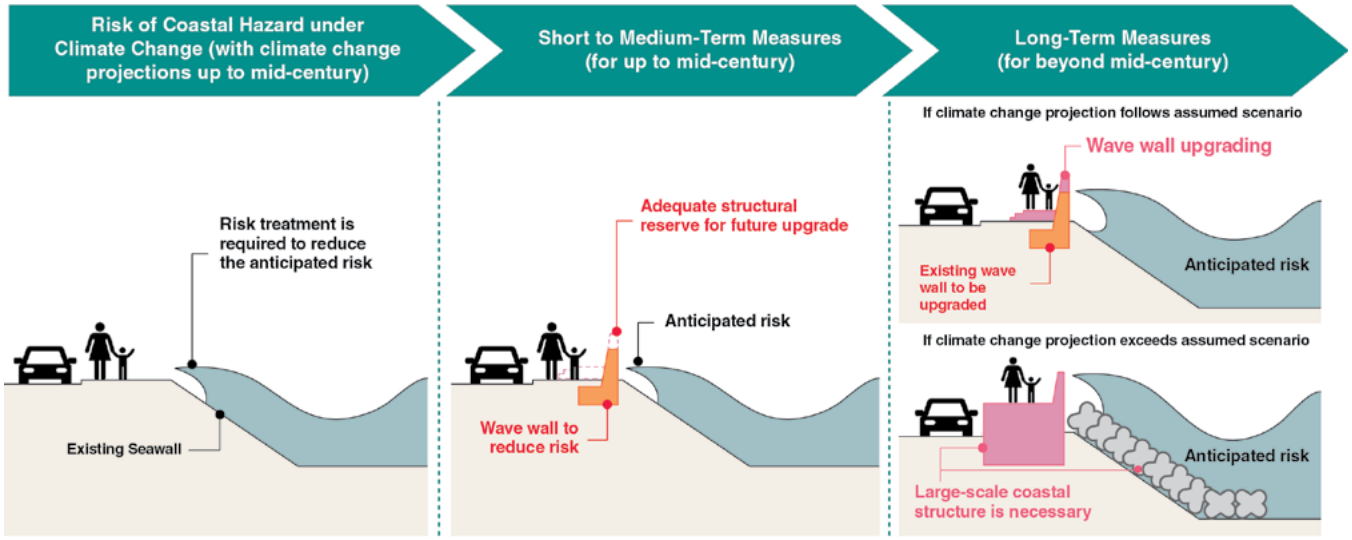
- Administers storm surge alert system.

Water Supplies Department (WSD)

- Constructs seawater desalination plant.

Reflecting on progress of the initiatives and commitments since the 2016 *Hong Kong 2030+* report, the 2021 Climate Action plan specifies creation of interagency committees (e.g., the Green and Sustainable Finance Cross Agency Steering Group, the CCWGI, and the Committee on Climate Change and Carbon Neutrality) to provide oversight and continue planning and development efforts for design and installation of new infrastructure – particularly towards building coastal resilience. Among the products of these initiatives are the HKMA's forthcoming disclosure requirements and carbon credit trading scheme in addition to a report published in 2022 by the CEDD concerning coastal hazards and measures to address them (see figure 6).[41]

FIGURE 6 Progressive Adaptive Approach



* Remark: Drainage enhancement, such as pumping station, might be needed at the back of the wall.

The 2021 Climate Action plan calls for adaptation measures, including constructing or raising wave walls, installing flood barriers behind the coastline, and installing flood barriers at building frontages. It considers (and highlights local installations) of additional measures, namely, wave walls (e.g., Sai Kung), floodwalls, various types and configurations of flood barriers (e.g., Tai O), adoption of emergency plans, pavement upgrades, and installation of water-level indicators, non-return valves (e.g., Heung Chung), and warning signage.

Source: CE 74/2018 (CE) - "Study of Coastal Hazards under Climate Change and Extreme Weather and Formulation of Improvement Measures - Feasibility Study", Final Report: https://www.cedd.gov.hk/filemanager/eng/content_961/24/Final%20Report.pdf.

Local governments of the GBA in Guangdong Province outside of the SARs are directed by the national government in their approach to climate adaptation and mitigation, with planning, funding, and constructing infrastructure projects largely managed by local governments throughout the region.[42] According to a 2021 release by the State Council Information Office of the PRC, "Responding to Climate Change: China's Policies and Actions," "[t]erritorial space planning plays a key role in preventing and controlling natural disasters and ensures that local-level meteorological disaster prevention and mitigation standards apply to all counties (districts) across the country."[43] Unfortunately, lack of coordination between jurisdictions in the GBA as well as varied system structures in Guangdong Province and SAR governments means the region's approach to building climate-resilient infrastructure to support rapid development is siloed. One 2017 study even attributes the numerous and disaggregated policies aimed at addressing climate resilience concerns in the region to a general failure to prioritize climate adaptation in political agendas.[44] Despite strong indications that specific improvements promising to address the GBA's climate hazards have been earmarked for the near future, it is unclear what their anticipated lifespans will be.[45]

Meeting the Sponge City Imperative with Floodable Parks

Sponge cities are a model for development created by the Chinese government that is characterized as a "comprehensive system of urban development including flood control, water conservation, water quality improvement, and natural ecosystem protection".[47] A report concerning green infrastructure in the GBA by HSBC further states that "the greening of infrastructure not only helps to attract global capital seeking environmental impact, but it also build resilience into fundamental facilities and systems that support the sustainable future of the GBA and reduce its vulnerability to climate change".[48]

Yanweizhou Park in Jinhua.

GBA cities are not unlike others throughout the country engaged in implementing the sponge city imperative, as evidenced by the Guangzhou Sponge City Plan, a document produced as part of the pilot sponge city construction initiative launched by the PRC in 2014.[49] With support from PRC agencies, the city of Guangzhou developed this plan intended to guide development of city-wide flood mitigation infrastructure. Other municipalities in China have begun project-specific planning towards improvements in alignment with the sponge city imperative. For instance, the floodable park concept has already seen some uptake in communities throughout China, as exemplified by the Yangtze Riverfront Park Master Plan in Wuhan.[50]

Floodable parks may seem like any other park, with sodded fields, playgrounds or exercise equipment, and walking paths, but during periods of heavy precipitation or high tides they provide much needed detention that protects surrounding communities. Yanweizhou Park, a precursor to the sponge city pilot but nonetheless another exemplar of the sponge city paradigm, was opened in 2014 and spans about 64 acres. This park features a bridge and trail network that extends out over the waters of the Wuyi and Yiwu rivers, alongside an opera house with a "water-resilient terraced river embankment" complete with native landscaping. This park was constructed in lieu of a conventional floodwall and functions in a capacity that provides a wider array of benefits to the community and local natural systems.[51] During annual flooding in monsoon season, Yanweizhou Park floods, protecting the people and structures of Jinhua from harm while reducing disruptions to wildlife habitat and hydrological systems.

Like other municipalities worldwide, GBA governments are saddled with the costly and low-visibility task of maintaining existing aging infrastructure. One example of this is the region's dike-ponds, which provided viable stormwater management in earlier years before recent rapid urbanisation but now require expensive retrofits to address current and future risk levels. Infrastructure improvements in the current day may be spurred by spatial planning efforts such as the national "sponge city" imperative, but can also be fast-tracked in the wake of unprecedented events as seen in the cases of Macao and Guangdong, which, following Typhoon Hato in 2017, announced major improvements to flood control systems through installation of a tidal barrier in Zhuhai alongside other improvements across Zhongshan, Zhuhai, and Macao.[46] Though there is a general dearth of information available to paint a comprehensive picture of current and future infrastructure availability throughout the region, given the complex intermingling of the built and natural environments throughout the PRD, the cost of protecting real estate assets in the GBA is likely to carry a substantial – and increasing – price tag.

National

Throughout 2021, the PRC made global headlines with announcements of a number of bold adaptation strategies and emissions reduction targets. That year, the PRC committed to "promot[ing] the development of green low-carbon financial products and services in an orderly manner, prepar[ing] monetary policy tools for carbon emission reduction, incorporate[ing] green credit into the macro-prudential assessment framework, and guid[ing] the banking industry and other financial institutions to provide long-term, low-cost funding for green and low-carbon projects" in its 2021 updated Nationally Determined Contributions (NDCs) to the United Nations Framework Convention on Climate Change pursuant to the Paris Climate Accord (see also figure 6).[52] The PRC also identified long-term climate goals and introduced a forthcoming carbon dioxide emissions cap in its 14th Five-Year Plan (FYP). The purpose of China's five-year plans is to set strategic goals, focus government work, and guide the activities of market and non-market entities in mainland China.[53] The 2021 FYP set an 18 percent reduction target for carbon dioxide emissions per unit of GDP and a 13.5 percent reduction target for energy consumption per unit of GDP from 2021 to 2025.[54]

In February 2022, the PRC passed its National Strategy for Climate Change Adaptation 2035, which focuses on overall guidance, communication, coordination, strengthening observation and assessment of climate change impacts, and improving the ability of major sectors and key vulnerable regions to adapt to climate change.[55] To date, concrete actions taken by the PRC towards mitigation of climate risk include ongoing afforestation of corridors, greenways, and parks to combat the urban heat island effect; monitoring sea-level change through annual surveys and assessments; regulating land reclamation and protecting coastal wetlands; and mitigating climate risk in key coastal areas.[56]

Governments across the globe are bolstering their public-sector climate action efforts with policies that incentivize or require private-sector action. With regard to disclosure of both physical and transition risks, the TCFD, CDP, and GRESB are all leaders and providers of reporting frameworks. Since its formation in 2015, the TCFD specifically has accrued 3,400 public and private supporting organisations from 95 jurisdictions around the world, including from within mainland China and Hong Kong. These frameworks are moving the market as regulators in the same jurisdictions, (e.g., the United States, the United Kingdom, Australia, and Japan) progressively adopt, or as is the case for the PRC and Hong Kong governments, contemplate adoption of, TCFD-aligned disclosure rules. In jurisdictions where regulations are adopted, such rules offer transparency and consistency to the private sector, strengthening efforts to reduce carbon emissions, address climate risk, and preserve real estate value.[57]

Climate Risk Disclosure Reporting Frameworks

- The Climate Disclosure Standards Board (CDP)
- Frameworks for Climate Risk Reporting
- Global Reporting Initiative (GRI)
- International Organization for Standardization (ISO) standards
- International Sustainability Standards Board (ISSB)
- Science Based Targets Initiative
- Sustainability Accounting Standards Board (SASB)
- Task Force on Climate-Related Financial Disclosures (TCFD)
- The UN Global Compact
- World Green Building Council Net-Zero Buildings Commitment

Part 3: Pricing Risk

At present, transition risk is the main form of risk that appears in the cost of real estate transactions. Because they are able to recover the cost from tenants, developers incorporate a wide range of amenities that improve the sustainability of structures, including appliances that conserve energy and water as well as sustainable building materials. In addition to recovering initial costs, this increased rental income and the reduced operating expenses stemming from efficient appliances and fixtures bolster the net operating income of the property. Such sustainability efforts create a favourable position for the asset in the marketplace as equity and debt investors increasingly set internal targets for portfolio emissions reductions, noting that the preferences of foreign investors for "green buildings" have been driving the market for transition risk solutions.[58] In addition, local and state governments established goals and are taking action across agencies and jurisdictions towards achieving net zero carbon emissions in the coming decades.

> "Developers who can meaningfully produce more energy-efficient properties will attract better tenants, better investment and the better value of the buildings will hold over the longer term."
>
> **— Investor**

While there was agreement among interviewees about the necessity of taking action to address physical risk of assets, there was a distinct lack of consensus on the details of factoring it into transaction costs. Debt investors are beginning to wrestle with this question and offered some detailed insights into the range of possibilities for pricing in physical and transition risk, though most actions cited are anticipatory of future regulatory requirements for risk disclosure or would inform higher-risk transactions on an ad hoc basis. To this point, debt investors are distributing surveys and requiring account managers to fill out transition and physical risk questionnaires with clients in addition to engaging major accounting firms to internally gauge capacity for climate change–related risk.

Even though all interviewees were aware of physical risk, actions to mitigate risk (including any deliberate devaluation of property due to known hazards) have been limited and often reactive. Interview feedback alluded to future physical risk having little to no direct impact on property valuation. Further to this point, firms interviewed that are engaged in property development did not have detailed local or universal standards or even internal frameworks for accounting for emergent physical risk in their business operations. Some interviewees felt that government should impose reporting requirements and build the physical infrastructure to support more resilient development; others felt that private enterprise should lead the charge, ensuring new construction anticipates climate change impacts in the years beyond typical building hold periods.

Impacts to Financing Structures

All interviewees, when asked, shared the sentiment that climate risk is not making or breaking deals. Even though the PRC and Hong Kong SAR governments have received international plaudits for implementation of green financing programs, many interviewees noted that these incentives are not sufficient to positively influence decision-making. Currently, the major transition-risk-mitigation drivers are internal ESG policies requiring deals to meet certain transition-risk-related KPIs. Since the time horizons for most transactions are 10 to 30 years, and most severe climate projections are for longer time horizons (longer than 30 years) and pivot on many factors, it is hard for banks, developers, and investors to make a business case for any improvements from retrofits to financing models, in the GBA.

Cost of Inaction

Mitigation of physical and transition risks is inextricably linked to firms' bottom lines, and all industry sectors are having to balance interests in the short and long terms. Since transition-risk mitigation has existing avenues for returns, it is much more likely to be included in a deal, but at present only limited perceived value is to be derived from pre-emptive measures against physical risk. Despite the fact that this form of risk is not consciously or holistically priced in across industry sectors, insurance premiums are nonetheless on the rise. There are also limited opportunities in the acquisition and development process to evaluate ways to factor in physical climate risk because of the large number of existing structures and the fast-moving and private nature of transactions.

Among the consequences for inaction on physical risk stemming from major weather events and chronic stressors like extreme heat are disinvestment from risk-prone areas, interruptions to business continuity, damages and

costly repairs to public and private assets, out-migration of residents, forgone benefits from mitigation incentive programs, and decreased value of assets – all in addition to widespread loss of life and livelihood. Some global investors are also concerned that climate risk could precipitate vicious cycles from rising insurance rates and infrastructure maintenance costs. Even in the absence of a major extreme weather event, a structure suddenly uninsurable because of high physical climate risk could face an immediate significant decline in value and trigger a call on debt, giving tenants cause to break their lease. At the market level, the cost to maintain infrastructure and recover from major natural disasters could increase significantly. As the cost of maintaining infrastructure becomes higher than the value of the buildings being protected, municipalities may have to make tough choices about what parts of the city are still cost-effective to save.

Though insurance providers, and some developers and investors, having assessed some of the cost of inaction, are changing their policies and practices independently and in anticipation of forthcoming regulations, the direct and indirect consequences of inaction are already surfacing in the GBA. For example, with Guangzhou and Hong Kong representing two of the top 10 cities exposed to coastal flooding, local investors who have their portfolios concentrated in the region are already seeking ways to diversify, partly out of concern for elevated flood risk.[59] "Brown discounts" applied to investors who fail to address transition risk already restrict access to financing from the PRC's green loan program. And, as climate-risk mitigation begins to strain governments' capital improvement budgets, interviewees have acknowledged that cities of the GBA are reconsidering their ability to provide broad protection for assets at risk.

Paths Forward

The goal of integrating climate risk into property valuation and the real estate transaction process can be buoyed by working across sectors, providing authoritative data on current and future climate conditions, and leveraging guidance and support from governments and major regulatory authorities. The following section summarizes the report findings and outlines fundamental shifts that must take place within the GBA to accomplish this goal.

Recommendations for Addressing Climate Risk and Real Estate

- Increase collaboration between government and industry sectors.
- Strengthen government leadership towards change – particularly to address physical risk.
- Conduct consistent and robust physical risk assessments for assets.

Increase Collaboration between Government and Industry Sectors

As expected for one of the largest metropolitan regions in the world, the real estate market in the GBA is driven by countless actors, each with varied interests. General disagreement among industry sector interviewees about what must change for climate risk to be captured in the real estate transaction process alluded to a need for a coordinated approach to guard against unintended consequences from reactive and siloed responses. Although a coordinated approach will require active discourse and in some cases concessions, much more is at stake than what current policies and procedures can capture.

Discourse between government and industry sectors should aim to address the following deficiencies identified through desktop research and interviews:

- Insufficient detailed physical climate risk data to support decision-making;
- Lack of formalized risk disclosure requirements;
- Lack of understanding among stakeholders regarding the business case for physical risk mitigation in the short term;
- Insufficient short-term incentives for mitigative action;
- Insufficient financing instruments for long-term resilience in new construction; and
- Insufficient financing instruments for retrofit of existing structures.

It is generally recommended that a Climate Resilience Coalition be established in the GBA to facilitate a coordinated approach to addressing climate risk. This might be brought about through associations of local or regional businesses and could include anchor members such as big developers and engineering consultants. This coalition, in addition to coordinating action, should serve an educational function of articulating co-benefits of physical and transition risk mitigation clearly across real estate industry sectors.

While government action is critical to deploying effective physical risk mitigation policies, as described in the next section, the private sector also has an important role to play. In particular, interviewees posed the following potential actions that could be taken by firms to facilitate mitigation of transition and physical risk in the real estate transaction process, bank financing models, and investors' investment screening processes. They are outlined according to the industry sector to which they apply:

Developers

- Leverage green bonds to achieve sustainable development KPIs where economically feasible.
- Define immediate targets for attaining green standard certifications for projects, medium-term targets for transition and physical risk mitigation by 2030, and long-term targets (e.g., achieving net zero emissions) by 2050.

Equity Investors

- Identify key physical risks across asset portfolios and five- to 10-year time horizons.
- Consider future investment and mitigative measures before acquisition and factor in added risk governance.

Debt Investors

- Take a science- and data-driven approach to assess physical risk of assets on a case-by-case basis.
- Where appropriate, adhere to regulators' requirements for risk disclosure and mitigation.

Strengthen Government Leadership towards Change – Particularly to Address Physical Risk

Most interviewees expressed desire for and are anticipating physical risk mitigation policies by both the Chinese and Hong Kong SAR governments. Government will likely assist the real estate industry in its transition from reactive measures to proactive measures by reducing costs, creating and bolstering incentive programs, establishing assessment and reporting standards, and reconciling time horizons. This could be accomplished through ongoing revision to planning documents such as the PRC's Five-Year Plan and the next iteration of the *Hong Kong 2030+* report. Other policies and guidelines on the horizon are those that would coordinate utilities with and between PRC and SAR government to guarantee availability of clean energy and water. Some also expect the Hong Kong SAR government to install necessary infrastructure, particularly to preserve the central harbour waterfront area's embedded businesses and financial interests. If this comes to pass, government should in turn increase investment in large-scale adaptive infrastructure to bolster resilience of areas outside this region and improve connectivity of people to resources throughout the SAR.

> "Developers should not get incentives from lenders, but from government."
>
> **— Investor**

More broadly, the SAR and Guangdong Province governments must ultimately branch out from emissions and pollution control and adopt rules for reporting on and adapting to both transition and physical risk factors. This could be accomplished through widespread adoption or pilot of more ambitious risk mitigation requirements across the real estate project life cycle. For example, at the time of sale, transaction conditions should be required to contemplate 50-year or even 100-year events as opposed to only 25 years, designs for new construction and renovation should be designed to withstand more severe flood and storm conditions, and existing structures should be covered by either municipal or individual insurance policies covering disaster-related losses.

Conduct Consistent and Robust Physical Risk Assessments for Assets

Data availability was cited as a major hurdle by interviewees across all industry sectors. While the IPCC Assessment Reports describe climate change impacts for the broad region of "East Asia" and several climate research organizations offer publicly available sea-level rise and coastal risk mapping services for the GBA, additional data inputs, processing power, modelling capabilities, and subject matter expertise (among other things) are needed to inform asset-level real estate decision-making.

This lack of access to reliable information about current and future conditions stymies coordinated response by impeding attempts to make informed investment decisions about specific properties and confounds attempts to compare performance across firms' portfolios. Reasons for limited data availability differ between Hong Kong and the rest of the GBA. In the Hong Kong SAR, the private sector operates or owns many of the municipality's critical assets, and government agencies do not aggregate and distribute sufficient data to the public to enable informed decision-making based on the landscape of existing infrastructure and projected impacts to properties.[60]

> "[The] real estate sector need to assess and manage climate risk on both mitigation and adaptation aspects. Damage due to extreme precipitation in the past few years has been reminding us that climate risk is not only a long-term risk. Relevant data such as precipitation and other extreme weather events is crucial for the assessment. Collaboration between government and industry sectors can improve the data availability as well as mitigation and adaptation strategy that leads to security and prosperity."
>
> **— GBA climate risk assessment expert**

The PRC's position on data availability may be summarized in the following excerpt from a 2021 release by the State Council Information Office of the PRC:

> "Strengthening monitoring, early warning and disaster prevention and mitigation capabilities. Systems for natural disaster risk monitoring, investigation and assessment, early warning and forecasting, and comprehensive risk prevention have been optimized. China has established a nationwide long-term sequences disaster database for various meteorological disasters and completed a national level refined meteorological disaster risk early warning service platform. With the establishment of a comprehensive system that integrates air, space and land, Mainland China now publishes regular reports on national natural disaster risks. The government has promulgated national disaster prevention and mitigation plans to guide disaster prevention, mitigation, and relief work in the context of climate change, carried out nine key projects for strengthening natural disaster prevention and control, monitoring, early warning, consultation, and evaluation of severe convective weather, melting glaciers, and dammed lakes."[61]

To resolve the data availability issue, the PRC and SAR governments must provide relevant and robust data to support real estate industry actors.[62] In practice, that would necessitate identifying means of sharing information about locations and capacities of climate resilience–related interventions throughout the region (e.g., existing and planned critical infrastructure), obtaining access to privately maintained sources (e.g., building energy consumption data), and developing a system for data interoperability allowing for analysis and comparison across jurisdictions. It is worth noting that there may be limitations in governments' ability to provide high resolution data since it is difficult to predict meteorological events such as typhoons. Running models for these events tends to be computationally expensive, although availability of such insights is quickly expanding as climate risk analytics providers launch new assessment tools.

The Emerging Landscape of Climate-Risk Software

Learn how investors are navigating the complex and varied approaches of climate risk analytics providers.

Part 4: Regional Risks and Mitigation Opportunities

As investments in real estate and infrastructure are made, goals can be met, and value can be generated by prioritizing strategies that protect real estate and communities from the impacts of climate change. The benefit/cost ratio (BCR) of proactive hazard mitigation has been analysed by the National Institute of Building Sciences in the United States, which found that for every US$1 invested in resilience, an average of US$6 is saved in recovery costs.[63] This research is echoed in ULI's *Business Case for Resilience in Southeast Florida* report, which outlines the returns from investments in resilience infrastructure in South Florida, where coastal property values may soon decrease because of climate change.[64] For every US$1 invested in community-wide adaptations, the region will see about US$2 in benefits. These adaptations can offer US$37.9 billion in economic benefits for the region and support 85,000 job-years (defined as one year of work for one person). The BCR is even higher (4:1) for building-level adaptations.

The scale of savings outlined in these reports demonstrates the benefit of resilience strategies. Many specific options are available to public and private entities in the GBA specifically to mitigate transitional and physical climate risks, add value, and support economic growth, and this report subsection considers regional hazard mitigation options and their co-benefits through review of sample interventions. This review also acknowledges tradeoffs that might need to occur to maximise hazard mitigation benefits when implemented at scale. The examples discussed in this section largely focus on physical infrastructure investments in municipalities around the globe and are organised according to the regional hazard identified in the IPCC's Sixth Assessment Report.[65]

Typhoon

Typhoons, also known as tropical cyclones and hurricanes, are intense circular storms that originate over warm tropical oceans.[66] Losses from damages caused by Super Typhoon Mangkhut, which struck the GBA in 2018, totalled about HK$4.60 billion in Hong Kong alone.[67] Many sources speculate that Typhoon Mangkhut will not be the last super typhoon to strike the GBA in the near future.

Example Typhoon Mitigation Measures

- Risk assessment and municipal vulnerability studies
- Adoption of building codes for structures that can withstand wind, flood, and storm surge
- Installation of nature-based solutions
- Public incentive programs for mitigative measures[68]

Implementing Hazard-Resistant Building Codes and Nature-Based Solutions in Miami

Value Add

- Avoided losses
- Enhanced property value
- Improved insurance ratings
- Reduced insurance premiums

About Miami

- Coastline – 142 km^2
- Rainfall – 1,712 mm
- Population – 442,241
- Population density – about 4,700 people/km^2
- GDP – US$365,051,489[69]

When Hurricane Andrew swept across the East Coast of the United States in 1992, killing 65 people and destroying 25,524 homes, the Florida Building Commission moved quickly to adopt new building code standards that would prevent future losses to life and property from the storms that buffet the United States' southern peninsula each year between the months of June and November. In the years following the storm, the state building code underwent

extensive review and revision to correct construction, design, and inspection process flaws contributing to the unprecedented damages seen in South Florida's communities, including the city of Miami. Today, the Florida Building Code not only serves as the standard for development for municipalities throughout the state, but it is also a model for other countries' building codes as well as a gold standard for design firms.

A study conducted by the Insurance Institute for Business & Home Safety (IBHS) following Hurricane Charley in 2004 found that improvements to the codes adopted in 1996 in Florida resulted in a 60 percent reduction in residential property damage claims and a 42 percent reduction in damage severity based on the cost of the claims.[70] Even today, Florida's building code is continually updated to better guard construction against threats from hazards such as fire, wind, flood, and storm surge.

Development and property management firms throughout the state are also reaching beyond building codes in their consideration of the nexus between hazard mitigation for physical assets and the natural environment in their activities in the state. Hong Kong and London-based developer and property manager, Swire Properties known for developing Brickell City Centre in Miami's downtown area, has achieved success in steering local planning efforts towards use of green infrastructure in Biscayne Bay to protect against storm surge. In January 2021, the United States Army Corps of Engineers proposed a plan to address the increasing risk of storm surges and a sea-level rise in Biscayne Bay and the Miami downtown area, both of which are near Swire Properties' Brickell City Centre development. While the proposal met the engineering criteria, the solution risked compromising the functionality and future appearance of the waterfront.

To preserve the beauty and accessibility of the waterfront, Swire Properties engaged an engineering firm to research, design, and propose a hybrid and more natural long-term environmental solution to preserve Miami's urban coastline. Formally presented in February 2021, the plan envisions a series of barriers to dissipate wave energy, including a combination of submerged oyster reefs and flood protection earthen berms in the bay. This plan, which also meets engineering criteria, has provided a platform for municipalities to discuss viable nature-based solutions as an alternative to physical barriers against flooding.

Additional Resources

- The Federal Emergency Management Agency (FEMA) released a nationwide study of loss prevention from building codes across the United States demonstrating how planning for and constructing resilient structures can offset the cost of future damages.
- Building code modifications made in the aftermath of Hurricane Andrew in the early 1990s were based on the cyclone-resilient building standards of Queensland, Australia.

Sea-Level Rise

The National Aeronautics and Space Administration (NASA) note that recent rates of sea-level rise are unprecedented in the past 2,500 years.[71] Local impacts of sea-level rise can vary significantly across geographies, and many coastal regions across the globe, including those in the GBA, are already experiencing unprecedented storm surges and flooding that threaten both commercial activity and critical infrastructure such as Hong Kong's Victoria Harbour and four of the region's seven airports.[72]

Example Flood Mitigation Measures

- Green infrastructure
- Floodable parks
- Sponge cities
- Traditional grey infrastructure solutions: seawalls, retention/detention areas
- Development standards

Managing Water and Development through Intersectoral Coordination and Innovation in Rotterdam

Value Add

- Added amenity
- Increased developable land
- Marketing advantage
- Rental premiums

About Rotterdam[73]

- Coastline – 30 km
- Rainfall – 850 mm
- Proportion and meters of land above sea level – 85 percent < 5 m below mean sea level
- Population – 640,000 (2019)
- Population density – 3,060 people/km^2
- GDP – US$201 billion (2019)

Eighty-five percent of the city of Rotterdam in the Netherlands is located less than five metres above mean sea level. Most maps displaying future climate projections for the region show Rotterdam and the surrounding area as completely inundated, yet the city remains relatively safe

from encroaching waters and is considered a global leader in water management. Part of Rotterdam's secret for success lies in what is known as the Dutch Diamond model in which sustainable development is coordinated across government, civil society, knowledge institutions, and the private sector. Backed by a €1.3 billion allocation (2019–2023), the approach supplies funding to localities for pilot projects that align with program objectives aiding in fulfilment of Rotterdam's climate adaptation strategies.

At the local scale, Rotterdam's Weatherwise Program adopted in 2019 involves a district-by-district approach to risk assessment and climate adaptation. This program provides co-financing and other financial incentives for climate resilience solutions, such as water retention and green buffers, and coordinates action with social housing corporations, real estate developers, and private homeowners as well as city government, district water boards, and other local partners. The Weatherwise program has created a landscape for innovative design solutions for development in areas prone to flooding, including floating housing and public amenities and floodable public spaces.

Additional Resources

- New York City's Brooklyn Bridge–Montgomery Coastal Resiliency project involved extensive coordination between local governments and the public. Town halls, toolkits, models, and other engagement activities helped ensure the project served recreation and flood protection needs of the community.

Floating Pavilion

A 1,550-square-metre floating structure commissioned by the city of Rotterdam and designed by deltasync and Public Domain Architects was constructed in the Rijnhaven Harbor in 2010. This structure, known as the Floating Pavilion, is presently used as a conference and exhibition space (see photo) and is only one of several floating structures installed in Rotterdam's waterways.[74] One other noteworthy example of floating structures implemented in the city is a floating dairy farm in Merwehaven designed by Beladon.[75] Because floating structures such as these are unique forms of development, application of appropriate building regulations and pushback from the public pose significant challenges to implementation, but such structures pose possible alternatives to conventional land reclamation activities.

Floating Pavil Joen in Rotterdam designed by deltasync and Public Domain Architects.

Benthemplein's Water Square.

Water Square

In urban centres, where land is at a premium, it can be difficult to accommodate stormwater retention, recreation, and the myriad of other uses vying for already limited and expensive space. Municipalities worldwide that are saddled with this challenge are experimenting with the concept of multifunctional open space in the form of floodable parks. Similar to the flood resilience goals of China's Sponge City Imperative featured earlier in this report, Rotterdam's Water Square (constructed in 2013) located in Benthemplein highlights stormwater management in its floodable park concept. In addition to providing the surrounding community with a place to skate, a space to hold public performances, and a versatile area for soccer, basketball, or volleyball when weather conditions are good, the square raises awareness about the critical function of stormwater management infrastructure by storing rainwater in pools during periods of heavy precipitation.[76]

Rising Temperatures

It is estimated that there were 356,000 heat-related deaths worldwide in 2019, and according to a 2021 study examining heat risk throughout China, under all future climate change scenarios, heat risk is projected to be highest within the PRD.[77] The study also states that in its worst-case scenario, 65 million people within the region would live in increasingly dangerous conditions. As global temperatures continue to rise, deaths from heat will likely rise as well. As populations fight to stay cool, utility providers, building commissioners, and design professionals will be challenged to take measures to transition to clean energy sources, reduce peak loads, and preserve the habitability of structures and public spaces.

Example Extreme Heat Mitigation Measures

- Installation of cooling stations
- Installation of plant material (e.g., green roofs, green walls, right-of-way planting, foundation planting, green infrastructure)
- Afforestation of parks and open space
- Planning to increase percentage of land area dedicated to green space
- Building design/retrofit (e.g., building orientation, passive cooling, energy-efficient building envelope, HVAC system performance)

Ensuring Thermal Comfort in Dense Urban Areas in Singapore

Value Add

- Added amenity
- Business development
- Energy savings
- Enhanced property value
- Improved building user experience
- Marketing advantage
- Reduced operating costs
- Rental premiums

About Singapore

- Coastline – 30 km
- Coastline – 203 km (main island only)
- Rainfall – 249 mm
- Mean temperature – 27.9°C
- Population – 3,298,634
- Population density – about 800 people/km^2
- GDP – US$396,986,900[78]

Singapore, located in the Southeast Asia region, as defined by the IPCC in AR-6, is anticipated to see future warming that is slightly less than the global average. However, urban areas throughout the region experience higher temperatures due to the urban head island effect, and Singapore currently sees a 7°C variance in temperatures (as of 2020 – up from 4.5°C in 2004).[79] In response to mounting concerns over thermal comfort and energy consumption, the government of Singapore has engaged in tree planting programs and is re-evaluating its approach to regulation of building design in partnership with research foundations and academic institutions. The Cooling Singapore initiative, led by the Singapore ETH Center (Swiss Federal Institute of Technology and Singapore's National Research Foundation) is assessing current conditions of Singapore's built environment and exploring ways to mitigate urban heat island effect through architecture, urban design, green and blue infrastructure, and adoption of new technologies.[80] Many of the interventions recommended over the span of this initiative are being implemented at scale or as pilots. For example, Singapore is considering vehicle fleet electrification which could mitigate up to 85 percent of heat emissions and is implementing use of "cool materials" on buildings while looking to partner with building owners and suppliers of cool materials for pilots.[81]

Efforts to combat extreme heat in Singapore are not limited to those by government and academia. The country's private sector is continually innovating. For instance, the CapitaGreen office tower, a 701,049-square-foot commercial development located in Singapore's downtown core, is an exemplar for energy-efficient cooling and "green" building design. The tower is able to reduce annual energy bills by 10 percent through a "petal-like" rooftop feature referred to as a "cool void crown" that draws in cool air. The structure also features a double-skin facade, 55 percent vegetation coverage around the perimeter of the structure, and additional architectural features that maximise natural lighting and reduce heat gain.

Additional Resources

- Life Hub @ Daning is a large-scale, retail-anchored mixed-use project in the Daning neighbourhood of Zhabei District, Shanghai, China. Life Hub features trees, green roofs, green building facades, and shading structures to reduce ambient temperatures in pedestrian areas. The massing and orientation of the buildings also create "wind tunnels" through the main plaza.
- Singapore Gardens by the Bay is a 101-hectare park featuring solar-powered "supertrees" which cool and beautify public space. These "trees" provide shade and act as heat exhaust venting air from a nearby energy centre.
- Singapore Eco Smart Forest Town is an innovative new settlement to be constructed by Singapore's government containing 42,000 new homes in the island's western region. This development will have energy-efficient centralised cooling and a car-free town centre among other climate-friendly features.
- Link REIT throughout its 50 markets in Hong Kong SAR implemented a Fresh Market strategy through renovation of existing structures to improve air circulation.

Drought

Drought can be defined as a deficiency of precipitation over an extended period of time (usually a season or more), resulting in a water shortage.[82] Conditions of drought affect ability to meet immediate water demands in and across regions and are growing in prevalence and severity across the globe requiring localities to reduce consumption of water and evaluate alternatives for use of potable water sources.[83]

Example Drought Mitigation Measures

- Desalination
- Water reuse/recycling
- Voluntary design features for indoor/outdoor water conservation[84]
- Compulsory water conservation through regulation
- Conservation incentive programs
- Pricing/tax interventions
- Watershed management
- Leak repair

Securing Adequate Potable Water through Periods of Unprecedented Drought in San Diego County

Value Add

- Avoided losses
- Reduced operating costs
- Water savings

About San Diego County

- Coastline – 113 km
- Rainfall – 249 mm
- Population – 3,298,634
- Population density – about 800 people/km^2
- GDP – US$240,411,072[85]

Drought is one of the more insidious and wide-ranging climate hazards anticipated to affect the GBA. Even though the area is largely located in coastal regions, potable water is not. As the GBA and other similarly situated regions develop economically and become more densely populated, demand for vital resources, including water, increases. Therefore, when inland areas serving as sources of potable water for a region experience drought, coastal areas must find new ways of obtaining water. Because drought affects such

large regions, mitigation must be coordinated across all levels of government and will require action across industry sectors. In the United States, federal agencies like the Cybersecurity and Infrastructure Security Agency (CISA) and the Department of Agriculture (USDA) monitor drought in communities and provide technical assistance with planning for long-term impacts, while states and communities implement policies and galvanise communities towards the goal of improving water conservation and efficiency.

San Diego County, located in the southwest United States, is facing the challenge of both supplying water to its densely populated urban areas and ensuring water needs for its more rural agricultural sector. Both needs are met through an urban-rural water conservation partnership where local farmers are rewarded for agricultural water conservation measures. These regional efforts allowed the county's major urban centre, the city of San Diego, to maintain the same city-wide water use in 2010 as in 1995 despite a growth in population of more than 400,000. In addition, San Diego County executed agreements for purchase of potable water from local desalination plants to ensure that affordable water remained available without depleting natural sources, but this water comes at a cost for waste disposal and energy consumption.

Additional Resources

- A report from the Asian Development Bank describes various national interventions, including the Ecological Compensation System of Yunnan Province, a payment and incentive system that supports sustainable ecosystems and provides stable financing for conservation.
- World Bank Group report on Groundwater Management Initiatives through drought in India and Pakistan.

Notes

Introduction

1. Figures sourced from Hong Kong Trade Development Council (HKTDC), Research, Statistics of the Guangdong-Hong Kong-Macao Greater Bay Area, 2020.

Part 1: Climate Risks Threatening Real Estate in the Greater Bay Area

2. Climate Central, "Coastal DEM Report," 2019, https://www.climatecentral.org/pdfs/2019CoastalDEMReport.pdf.

3. Binbin Wang and Qinnan Zhou, "Climate Change in the Chinese Mind: An Overview of Public Perceptions at Macro and Micro Levels," *WIREs Climate Change* 11, no. 3 (2020), doi.org/10.1002/wcc.639.

4. Intergovernmental Panel on Climate Change (IPCC), "Sixth Assessment Report, Working Group I, Regional fact sheet – Asia," 2021, https://www.ipcc.ch/report/ar6/wg1/downloads/factsheets/IPCC_AR6_WGI_Regional_Fact_Sheet_Asia.pdf.

5. Faith Chan, et al., "Urban flood risks and emerging challenges in a Chinese delta: The case of the Pearl River Delta," *Environmental Science and Policy* 122 (2021): 101–115, https://doi.org/10.1016/j.envsci.2021.04.009.

Observation from 2021 research paper on urban flood risk in the PRD. This paper also notes that the return period of intense rainstorms (defined as 100 millimetres/hour) decreased from 37 to 19 years over the past century, and the intensity of short-term intensive rainfall increased from 110 millimetres to more than 1,340 millimetres from 1984 to 2010.

6. Not to be confused with the Pearl River Economic Zone, which excludes the Hong Kong and Macao SARs and includes only parts of Huizhou and Zhaoqing.

7. Chan, et al., "Urban flood risks and emerging challenges in a Chinese delta."

8. Chan, et al., "Urban flood risks and emerging challenges in a Chinese delta."

9. Chan, et al., "Urban flood risks and emerging challenges in a Chinese delta."

10. From findings summarised in the IPCC AR-6 WGI report.

11. IPCC, "Climate Change 2022 Impacts, Adaptation and Vulnerability, Summary for Policymakers," https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_FinalDraft_FullReport.pdf.

The IPCC Working Group II (WGII) Sixth Assessment Report notes linkage between hazards such as precipitation and landslide and extreme sea-level rise and storm surge.

12. IPCC AR-6 WGI report.

13. Chan, et al., "Urban flood risks and emerging challenges in a Chinese delta."

Observation from 2021 research paper on urban flood risk in the PRD. This paper also notes that the return period of intense rainstorms (defined as 100 millimetres/hour) decreased from 37 to 19 years over the past century, and the intensity of short-term intensive rainfall increased from 110 millimetres to more than 1,340 millimetres from 1984 to 2010.

14. Jiaxi Wang and Bo Hong, "Threat Posed by Future Sea-Level Rise to Freshwater Resources in the Upper Pearl River Estuary," *Journal of Marine Science and Engineering* 9, no. 3 (2021): 291, https://doi.org/10.3390/jmse9030291.

Recently published studies assess the impact of sea-level rise on storm surge and saltwater intrusion.

15. IPCC AR-6 WGI report.

16. Ziqian Wang, Zhixiang Xiao, Chi-Yung Tam, et al., "The projected effects of urbanization and climate change on summer thermal environment in Guangdong-Hong Kong-Macao Greater Bay Area of China," *Urban Climate* 37 (2021), https://doi.org/10.1016/j.uclim.2021.100866.

17. From findings summarised in the IPCC AR-6 WGI and IPCC AR-6 WG II.

18. See also the Basel Committee on Banking Supervision, Consultative Document, "Principles for the effective management and supervision of climate-related financial risks" (2021).

19. World Bank, *Managing Coasts with Natural Solutions: Guidelines for Measuring and Valuing the Coastal Protection Services of Mangroves and Coral Reefs, WAVES Technical Report* (Washington, DC: World Bank, 2016), https://openknowledge.worldbank.org/handle/10986/23775.

20. World Bank, *Managing Coasts with Natural Solutions*.

21. Asian Development Bank (ADB), *Meeting Asia's Infrastructure Needs* (Manila: ADB, 2017), https://www.adb.org/sites/default/files/publication/227496/special-report-infrastructure.pdf.

Report featuring 2015 statistics by ADB. The East Asia region includes the People's Republic of China, Hong Kong, the Republic of Korea, Mongolia, and Taipei.

Part 2: Differing Priorities, Limited Action

Private Interests

22. Eric Ng and Martin Choi, "Climate Change: Hong Kong property firms are assessing risks and improving resilience, as extreme floods and storms loom on horizon," 2022, https://www.scmp.com/business/article/3171150/climate-change-hong-kong-property-firms-are-assessing-risks-and-improving.

Interventions from specific developers according to interviews by the *South China Morning Post*.

23. S&P Global Ratings, "Key Themes 2022: A World Redefined," 2022, https://www.spglobal.com/ratings/en/research/pdf-articles/220404-esg-risks-negatively-influence-over-us-4-trillion-of-debt-at-rated-companies-in-asia-pacific-101450297.

Environmental factors are the first component of the ESG Credit Factors framework formulated by S&P. E factors describe how private and public entities interact with, influence, and respond to changes in the physical environment. E factors encompass climate transition risk, physical risk, natural capital, and waste and pollution.

24. S&P Global Ratings, "Key Themes 2022."

25. Organisation for Economic Co-operation and Development (OECD), "Developing sustainable finance definitions and taxonomies in China," 2020, https://www.oecd-ilibrary.org/sites/5abe80e9-en/index.html?itemId=/content/component/5abe80e9-en.

The OECD conducted a review of both the bond and loan program taxonomies.

26. Logan Wright and Allen Feng, "COVID-19 and China's Household Debt Dilemma," 2020, https://rhg.com/research/china-household-debt/.

Article by Rhodium group concerning rising household debt throughout China

27. Hong Kong Monetary Authority (HKMA), "HKMA publishes the results of the pilot climate risk stress test," press release, 2021, https://www.hkma.gov.hk/eng/news-and-media/press-releases/2021/12/20211230-3/.

28. HKMA, "Pilot Banking Sector Climate Risk Stress Test," 2021, https://www.hkma.gov.hk/media/eng/doc/key-functions/banking-stability/Pilot_banking_sector_climate_risk_stress_test.pdf.

29. HKMA, "Supervisory Policy Manual (SPM): GS-1 'climate risk management'," 2022, https://www.hkma.gov.hk/media/eng/doc/key-information/guidelines-and-circular/2021/20211230e2.pdf.

Article concerning rising household debt throughout China. The climate stress test encompassed 27 banks, including 20 major retail banks, seven branches of international banking groups accounting for 80 percent of the sector's total lending.

30. Graham Caswell, "PBoC warns of defaults following climate stress test," 2022, https://greencentralbanking.com/2022/02/21/china-defaults-climate-stress-test-pboc/.

31. Swiss Re, "Promoting Nat Cat Insurance to flatten impact curves – A conversation with John Chen, President Swiss Re China," 2020, https://www.swissre.com/en/china/news-insights/natural-catastrophes/nat-cat-development-in-china.html.

The trend of low coverage may be slowly changing, according to this article featuring an interview with John Chen of Swiss Re China who indicates that more people are purchasing natural catastrophe insurance.

32. McKinsey Global Institute, "Climate risk and response in Asia," 2020, https://www.mckinsey.com/business-functions/sustainability/our-insights/climate-risk-and-response-in-asia.

33. Anastasia Telesetsky and Qihao He, "Climate Change Insurance and Disasters: Is the Shenzhen Social Insurance Program a Model for Adaptation," *Boston College Environmental Affairs Law Review* 43 (2016): 435510, https://heinonline-org.prx.law.columbia.edu/HOL/P?h=hein.journals/bcenv43&i=506.

34. World Bank, "The Development of Catastrophe Insurance in China: An Exploration," 2020, https://www.gfdrr.org/en/feature-story/development-catastrophe-insurance-china-exploration.

Government

35. CDP, https://www.cdp.net/en.

36. Hong Kong SAR, "Hong Kong's Climate Action Plan 2050," 2021, https://www.climateready.gov.hk/files/pdf/CAP2050_booklet_en.pdf.

37. Coco Du and Christine Loh, "Toward a more open and collaborative climate change policy framework in Hong Kong and Macao within the Guangdong-Hong Kong-Macao Greater Bay Area," *Chinese Journal of Population, Resources and Environment* 18, no. 3 (2020): 179–187, https://doi.org/10.1016/j.cjpre.2020.03.001.

Because of their small geographic areas, both SARs have limited capacity for renewable energy generation compared with mainland China.

38. Hong Kong Planning Department, *Hong Kong 2030+: A Smart, Green and Resilient City Strategy*, 2016, https://www.pland.gov.hk/pland_en/p_study/comp_s/hk2030plus/document/Hong%20Kong%202030+%20A%20SGR%20City%20Strategy_Eng.pdf.

39. Du and Loh, "Toward a more open and collaborative climate change policy framework in Hong Kong and Macao."

40. Hong Kong Observatory, "About the Hong Kong Observatory," https://www.hko.gov.hk/en/abouthko/aboutus.htm#:~:text=The%20Hong%20Kong%20Observatory%20is,warnings%20on%20weather%2Drelated%20hazards.

41. Civil Engineering and Development Department of Hong Kong and AECOM, "Study of Coastal Hazards under Climate Change and Extreme Weather and Formulation of Improvement Measures – Feasibility Study: Executive Summary," 2022, https://www.cedd.gov.hk/filemanager/eng/content_961/24/Summary_English_Final.pdf.

42. Yenpeng Jiang and Paul Waley, "Who Builds Cities in China? How Urban Investment and Development Companies Have Transformed Shanghai," *International Journal of Urban and Regional Research* 44, no. 4 (2020): 636–651, https://doi.org/10.1111/1468-2427.12918.

43. The State Council Information Office of the People's Republic of China, "Responding to Climate Change: China's Policies and Actions," 2021, http://www.scio.gov.cn/zfbps/32832/Document/1715506/1715506.htm#:~:text=In%202020%2C%20mainland China%20started%20the,vulnerable%20regions%20to%20adapt%20to.

44. Maria Francesch-Huidobro, "Climate Resilience in the Greater Bay Area of China – The Role of Technological Innovation," 2019, https://www.kas.de/documents/265079/265128/V3_latest_Climate+Resilience+in+the+Greater+Bay+Area+of+China+%28final+version%29pdf/2d08532f-8a59-7c57-1d6a-4608622bb589?version.

45. The State Council Information Office of the PRC, "Responding to Climate Change: China's Policies and Actions," 2021, http://www.scio.gov.cn/zfbps/32832/Document/1715506/1715506.htm.

46. The State Council Information Office of the PRC, "Responding to Climate Change: China's Policies and Actions."

47. Meng Meng, Marcin Dabrowski, and Dominic Stead, "Shifts in Spatial Plans for Flood Resilience and Climate Adaptation: Examining Planning Procedure and Planning Mandates," *Sustainability* 12, no. 1 (2020): 105, https://doi.org/10.3390/su12010105.

48. HSBC, "Bay Area Green Infrastructure Investment and Opportunities," 2021, https://www.sustainablefinance.hsbc.com/sustainable-infrastructure/greater-bay-area-green-infrastructure.

49. Meng, Dabrowski, and Stead, "Shifts in Spatial Plans for Flood Resilience and Climate Adaptation."

50. Sasaki, Wuhan Yangtze Riverfront Park, https://www.sasaki.com/projects/wuhan-yangtze-riverfront-park/.

51. Benedict Hobson, "Terraces of plants in Yanweizhou Park 'control floods in an ecological way'," *Dezeen*, Dec. 7, 2015, https://www.dezeen.com/2015/12/07/terraces-of-plants-yanweizhou-park-control-floods-ecological-turenscape-landscape-architecture-china/#.

52. United Nations Climate Change, Nationally Determined Contributions Registry, https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/China%20First/China%E2%80%99s%20Achievements,%20New%20Goals%20and%20New%20Measures%20for%20Nationally%20Determined%20Contributions.pdf.

53. Ashwin Kaja, Sean Stein, and Ting Xiang, "China's 14th Five-Year Plan (2021–2025): Signposts for Doing Business in China," *Covington* (blog), Apr. 6, 2021, https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/China%20First/China%E2%80%99s%20Achievements,%20New%20Goals%20and%20New%20Measures%20for%20Nationally%20Determined%20Contributions.pdf.

54. BSR (blog), "China's Climate Goals, the 14th Five-Year Plan, and the Impact on Sustainable Business," Apr. 28, 2021, https://www.bsr.org/en/our-insights/blog-view/mainland China-climate-goals-the-14th-five-year-plan-sustainable-business-impact#.

55. The State Council Information Office of the PRC, "Responding to Climate Change: China's Policies and Actions."

56. The State Council Information Office of the PRC, "Responding to Climate Change: China's Policies and Actions."

57. Veronica Poole and Kristen Sullivan, "Tectonic shifts: How ESG is changing business, moving markets, and driving regulation," *Deloitte Insights*, Oct. 29, 2021, https://www2.deloitte.com/us/en/insights/topics/strategy/esg-disclosure-regulation.html; The Japanese Government Financial Services Agency, "The JFSA's Strategy on Sustainable Finance (July 2021–June 2022)," 2021, https://www.fsa.go.jp/en/news/2021/20211104/01.pdf.

Part 3: Pricing Risk

58. Stephanie Vierra, "Green Building Standards and Certification Systems," 2022, https://www.wbdg.org/resources/green-building-standards-and-certification-systems.

Cost of Inaction

59. There is debate about whether the trend is completely attributable to climate risk. For instance, investors could be interested in other real estate markets in mainland China and Asia Pacific to avoid being beholden to Hong Kong for profit.

Paths Forward

60. Du and Loh, "Toward a more open and collaborative climate change policy framework in Hong Kong and Macao."

61. The State Council Information Office of the PRC, "Responding to Climate Change: China's Policies and Actions."

62. Maria Francesch-Huidobro, "Climate Resilience in the Greater Bay Area of China"; Rebecca Nadin, Sarah Opitz-Stapleton, and Xu Yinlong, eds., *Climate Risk and Resilience in China* (Routledge, 2016).

See also recommendations posed in *Climate Risk and Resilience in China*, which proposed development of regional climate models, methodology for integrating risk assessment into planning, assessment of effectiveness of current adaptation policies and measures for rapid and slow onset events, study of options for transfer of risk, financial mechanisms, and institutional arrangement to reduce exposure to loss and damage, and raise awareness and build capacity among stakeholders.

Part 4: Regional Risks and Mitigation Opportunities

63. National Institute of Building Sciences, "Natural Hazard Mitigation Saves: 2018 Interim Report," https://www.iccsafe.org/wp-content/uploads/NIBS_MSv2-2018_Interim-Report-summary.pdf.

64. Urban Land Institute, *The Business Case for Resilience in Southeast Florida: Regional Economic Benefits of Climate Adaptation* (Washington, DC: Urban Land Institute, 2020), https://knowledge.uli.org/reports/research-reports/2020/the-business-case-for-resilience-in-southeast-florida?_gl=1*1q8jvwn*_ga*ODcxMzY4MDA4LjE2MzM0NjU2ODA.*_ga_HB94BQ21DS*MTY1NzMxMjk0MS42MzEuMC4xNjU3MzEyOTQxLjA.

65. IPCC, "Climate Change 2022", section 10.4.6.2 Key drivers of vulnerabilities.

Typhoon

66. Joseph Zehnder, "tropical cyclone," *Encyclopedia Britannica*, https://www.britannica.com/science/tropical-cyclone.

67. Chun-wing Choy, Man-chi Wu, and Tsz-cheung Lee, "Assessment of the damages and direct economic loss in Hong Kong due to Super Typhoon Mangkhut in 2018," *Tropical Cyclone Research and Review*, 2020, https://doi.org/10.1016/j.tcrr.2020.11.001.

68. Federal Emergency Management Agency (FEMA), *FEMA Resources for Climate Resilience*, 2021, https://www.fema.gov/sites/default/files/documents/fema_resources-climate-resilience.pdf; Navva Sedigh, "Equity in Resilience: Planning for Hurricanes," Center for Climate and Energy Solutions blog, Sept. 14, 2021, https://www.c2es.org/2021/09/equity-in-resilience-planning-for-hurricanes/.

69. 2020 GDP for the Miami–Fort Lauderdale–Pompano Beach, Florida, Metropolitan Statistical Area, according to the U.S. Bureau of Economic Analysis.

70. Institute for Business & Home Safety, "Hurricane Charley, Charlotte County, Florida, August 13, 2004," 2004, https://ibhs.org/wp-content/uploads/wpmembers/files/Hurricane-Charley-Natures-Force-vs-Structural-Strength-Executive-Summary_IBHS.pdf.

Sea-Level Rise

71. National Aeronautics and Space Administration, "Sea Level, in Global Climate Change, Vital Signs of the Planet," https://climate.nasa.gov/vital-signs/sea-level/.

72. Dharisha Mirando and Debra Tan, "Thirsty and Underwater: Rising Risks in Greater Bay Area," 2019, https://www.chinawaterrisk.org/resources/analysis-reviews/thirsty-and-underwater-rising-risks-in-greater-bay-area/.

73. Centre for Liveable Cities and Urban Land Institute, *Building Climate Resilience in Cities Worldwide: 10 Principles to Forge a Cooperative Ecosystem* (Singapore: Centre for Liveable Cities and Urban Land Institute, 2020), https://knowledge.uli.org/-/media/files/research-reports/2021/clc-uli-building-climate-resilience-final-feb2021pdf?rev=98ca3c1d22704d929ea263850310b3a9&hash=B703E42F9B51A84185BFA7B09A79DE05.

74. DeltaSync, "Floating Pavilion Information Brochure," https://www.blue21.nl/wp-content/uploads/2018/10/infobrochure-floating-pavilion.pdf.

75. Amy Frearson, "Floating Farm in Rotterdam is now home to 32 cows," *Dezeen*, May 24, 2019, https://www.dezeen.com/2019/05/24/floating-farm-rotterdam-climate-change-cows-dairy/; Tamara Thiessen, "Netherlands floating farm paves way for self-sustainable agriculture – could China be next?," *South China Morning Post*, Dec. 4, 2018, https://www.scmp.com/lifestyle/food-drink/article/2176344/netherlands-floating-farm-paves-way-self-sustainable.

76. David Bravo, "'Water Square' in Benthemplein," *Public Space*, June 12, 2020, https://www.publicspace.org/works/-/project/h034-water-square-in-benthemplein.

Rising Temperatures

77. "Health in a world of extreme heat," editorial, *The Lancet*, Aug. 21, 2021, https://doi.org/10.1016/S0140-6736(21)01860-2.

78. World Bank, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=SG. GDP for Singapore as of 2021.

79. Faris Mokhtar, "This Is How Singapore Keeps Its Cool as the City Heats Up," *Bloomberg CityLab*, Dec. 1, 2020, https://www.bloomberg.com/news/features/2020-12-01/singapore-climate-change-reducing-heat-takes-trees-and-technology.

80. ETH Zurich, "Strategies for Cooling Singapore," 2017, https://doi.org/10.3929/ethz-b-000258216.

81. Singapore Ministry of Sustainability and the Environment and Urban Redevelopment Authority, "Factsheet on Singapore's Efforts to Mitigate the Urban Heat Island Effect," https://www.mse.gov.sg/cos/resources/cos-annex-j.pdf.

Drought

82. University Nebraska-Lincoln National Drought Mitigation Center, "Drought Basics," https://drought.unl.edu/Education/DroughtBasics.aspx.

83. IPCC, "Climate Change 2022, Impacts, Adaptation and Vulnerability Summary for Policymakers."

84. Center for Climate and Energy Solutions (C2ES), "Resilience Strategies for Drought," 2018, https://www.c2es.org/wp-content/uploads/2018/10/resilience-strategies-for-drought.pdf; Cybersecurity and Infrastructure Security Agency with the National Drought Resilience Partnership, "Drought and Infrastructure: A Planning Guide," 2021, https://www.cisa.gov/sites/default/files/publications/Drought_and_Infrastructure_A_Planning_Guide_508c.pdf.

85. 2020 GDP for San Diego–Carlsbad, California (Metropolitan Statistical Area) according to U.S. Bureau of Economic Analysis.

86. C2ES, "Resilience Strategies for Drought"; Jim Robbins, "A Quiet Revolution: Southwest Cities Learn to Thrive amid Drought," *Yale Environment 360*, Apr. 26, 2022, https://e360.yale.edu/features/a-quiet-revolution-southwest-cities-learn-to-thrive-amid-drought.

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