BAY AREAS:

Regional Governance and Flood Mitigation for Climate Change Adaptation in California and Southeastern China

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AUTHORS:

Isabel Qi[1], Zachary Lamb[1], Jessica Gordon[2], Fan Dai[2]
[1]Department of City and Regional Planning, UC Berkeley
[2]California-China Climate Institute

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LIST OF ACRONYMS

ABAG	Association of Bay Area Governments
ART	Adapting to Rising Tides
BARC	Bay Area Regional Collaborative
BayCAN	Bay Area Climate Adaptation Network
BCDC	San Francisco Bay Conservation and Development Commission
CAP	Climate Action Plan
FYP	Five-Year Plan
GBA	Greater Bay Area
IPCC	International Panel on Climate Change
LHMP	Local Hazard Mitigation Plan
MTC	Metropolitan Transportation Commission
NbS	Nature-based Solutions
OLU	Operational Landscape Unit
OPC	Ocean Protection Council
RSAP	Regional Shoreline Adaptation Plan
SAR	Special Administrative Region
SB	Senate Bill
SFBA	San Francisco Bay Area
SFEI	San Francisco Estuary Institute
SLR	Sea Level Rise
SPUR	San Francisco Bay Area Planning and Urban Research Association

EXECUTIVE SUMMARY

Coastal, bayside, and deltaic landscapes are critically vulnerable to flooding from impacts linked to climate change, including storm surges, sea level rise (SLR), and extreme rainfall. Adapting to the risk of more frequent and intense flooding events requires changes to institutions and governance practices. This report examines efforts to reduce climate-related flood vulnerability in two "Bay Area" regions on opposite sides of the Pacific: the San Francisco Bay Area in California and the Greater Bay Area in Guangdong, China. Both regions are globally significant sites of trade and innovation and enjoy a longstanding history of climate collaboration. Both are also highly vulnerable to increasing flood impacts under climate change. In light of these predicaments, we ask: how are regional governance efforts building flood resilience in the two Bay Areas? How is a regional focus mobilized in specific areas to enhance climate change adaptation planning? What are some recommended next steps?

Based on data collected from fieldwork, interviews, and policy documents in both regions, we find that climate change-related flood adaptation planning is being mainstreamed into local policy processes and that new governance arrangements often based on landscape-scales are emerging to address flood resilience. Notably, regional-scale governance has been essential in applying climate change projections to local planning in the San Francisco Bay Area and to implementing nature-based water management infrastructure in the Greater Bay Area.

To adapt urban areas to changing climatic and landscape conditions, cities and regions must share experiences and lessons learned. For the two Bay Areas, common challenges around regional-scale coordination, implementing climate-conscious policy principles and green infrastructure at scale, and adopting new modes of adaptive governance provide abundant opportunities for productive exchange.

The two regions can build on the strong existing networks between Guangdong Province and the State of California to collaborate on climate change adaptation. In addition to many relationships across businesses, universities, and people across the two regions, the memorandum of understanding to collaborate on climate action between Guangdong Province and California and the sister State/Province relationship between Guangdong Province and the State of California provide a valuable foundation for exchange on climate adaptation planning.

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1 / INTRODUCTION

Coastal, bayside, and deltaic landscapes are critically vulnerable to flooding from impacts linked to climate change, including storm surges, sea level rise (SLR), and extreme rainfall. Adapting to the risk of more frequent and intense flooding events requires changes to institutions and governance practices. According to the Intergovernmental Panel for Climate Change (IPCC), adaptation involves "various actions that help to reduce the risks associated with climate change." This report focuses on regional-scale adaptive actions to address the growing flooding risks from climate change in California's San Francisco Bay Area and the Greater Bay Area of Guangdong, China. Table 1 provides a summary of some key physical and socioeconomic characteristics of the two regions.

The San Francisco Bay Area and the Greater Bay Area in southeastern China, are taking regional approaches to adapt to flood risk. Situated on opposite sides of the Pacific Ocean, these two densely populated regions accommodate globally significant centers of industry and trade and both are vulnerable to climate change-linked flooding.

BOX 1 / OVERVIEW OF THE SAN FRANCISCO BAY AREA AND THE GREATER BAY AREA

The San Francisco Bay Area (SFBA) is often defined as the nine-county metropolitan region surrounding California's San Francisco Bay. Several planning institutions use the nine-county region as their jurisdictional territory, including the Metropolitan Transportation Commission (MTC) and the Association of Bay Area Governments (ABAG). Other regional government agencies, such as the Bay Conservation and Development Commission (BCDC) and the Bay Area Regional Collaborative (BARC), also shape regional land use planning for the nine counties.

China's Greater Bay Area (GBA) encompasses nine cities in Guangdong (Guangzhou, Shenzhen, Zhuhai, Foshan, Dongguan, Zhongshan, Jiangmen, Huizhou, and Zhaoqing) and the Special Administrative Regions (SARs) of Hong Kong and Macao. The cross-border regional planning framework of the GBA was officially initiated by the central government of China in 2019. Regional governance mainly operates through the National Greater Bay Area Development Leading Group, established by the central government to implement the Outline Development Plan for the Guangdong-Hong Kong-Macao Greater Bay Area ("GBA Outline Development Plan"). Due to the differing government systems between mainland China and the SARs of Hong Kong and Macao, in this report we focus on the nine GBA cities in Guangdong.

In both regions, mounting climate change impacts are reshaping the historical relationships between urban settlements and their bay-delta landscapes.

TABLE 1 / Snapshot of the two Bay Areas

	San Francisco Bay Area	Greater Bay Area
Population	7 million	86 million
GDP	577 billion USD	1.96 trillion USD
GDP per capita	82,429 USD	22,791 USD
Total land area	18,130 km^2	56,000 km2
Coastline length	650 km	2240 km
Filled land	630 km2 [1]	645 km2
Major local government unit	Nine counties (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma counties) and 101 municipalities	Nine cities in Guangdong (Guangzhou, Shenzhen, Zhuhai, Foshan, Dongguan, Zhongshan, Jiangmen, Huizhou, and Zhaoqing), Hong Kong, and Macao.

Both the SFBA and the GBA contain many examples of settlements that are well adapted to watery landscapes, from the houseboats and stilted settlements around San Francisco Bay to the water villages of the Pearl River Delta. Unfortunately, modern infrastructure and urban development practices have created settlement patterns in both regions that rely on rigid and often brittle systems of infrastructural control. Sea walls, levees, large-scale landfilling, and pumped drainage has enabled settlements to spread into areas previously considered off-limits to intensive development, but these practices are both ecologically destructive and prone to catastrophic failure. Even considering the hard infrastructure in place in both regions, significant amounts of waterfront land are projected to be below flood levels by century's end under current emissions trajectories (Figures 1 and 2). Mounting challenges from climate change—including the increased intensity of storms and rainfall and the challenges of forecasting such events—require an urgent reexamination of the land use practices and urban development models in the SFBA and the GBA.

1 O'Mara, K. (2020). Large Parts of the Bay Area Are Built on Fill. Why and Where? *KQED*.

FIGURE 1

Projected land area in the San Francisco Bay Area at risk of being below sea level by 2100 under a moderate emissions scenario (SSP2-4.5), based on the IPCC AR6 (2021) projection of 0.8 meters of sea level rise relative to 1900. (Source: Climate Central[2]).

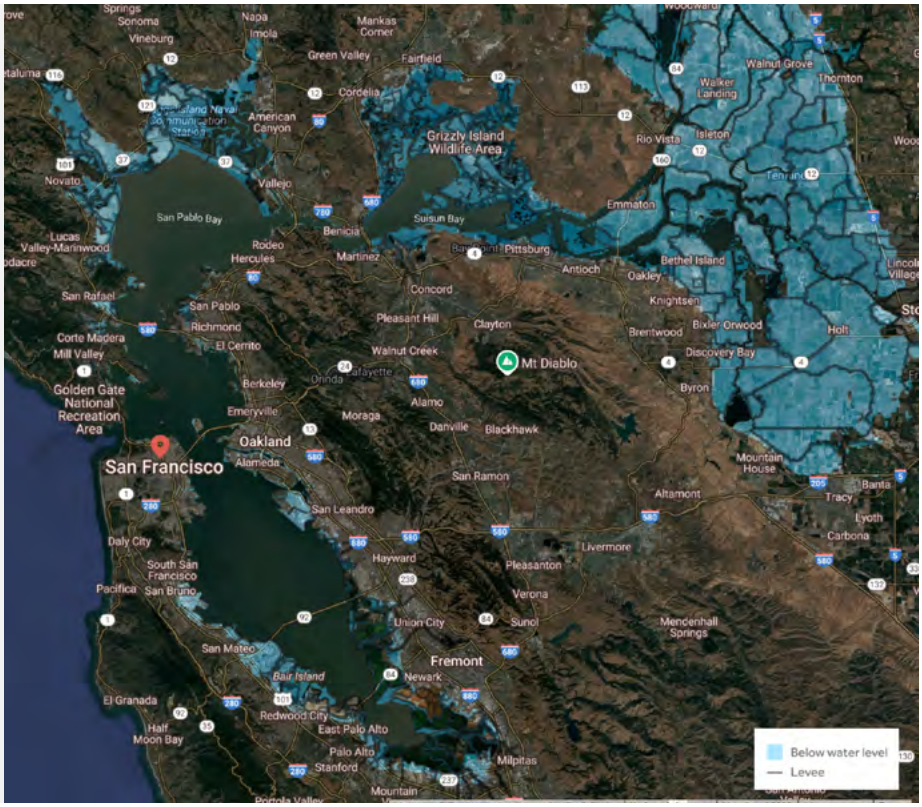

FIGURE 2

Projected land area in the Greater Bay Area at risk of being below sea level by 2100 under a moderate emissions scenario (SSP2-4.5), based on the IPCC AR6 (2021) projection of 0.8 meters of sea level rise relative to 1900. (Source: Climate Central[3]).

2 Climate Central Coastal Risk Screening Tool: Map By Water Level. https://sealevel.climatecentral.org/maps/
3 Ibid.

In the GBA, Guangzhou and Shenzhen rank first and fifth, respectively, among all global coastal cities in terms of projected annual economic losses from flooding by 2050, according to a 2013 analysis.[4] In the SFBA, property and infrastructure damages resulting from 0.9 meters (three feet) of sea level rise and intensified storms have been estimated at $70 billion by 2100.[5] Both Bay Areas have witnessed historic floods in recent years. During the winter of 2022–23, rainstorms caused six fatalities in the San Francisco Bay Area,[6] as several parts of the region experienced record rainfall, causing mudslides, evacuations, and major freeway closures.[7] In September 2023, Hong Kong was drenched by the strongest rain event in 140 years of record-keeping, killing two people and injuring 144. Across the border, Shenzhen and other cities in Guangdong Province also saw severe inundations.[8]

Notably, both regions have worked collaboratively with each other on climate change. In 2013, Guangdong Province and California signed a sister city agreement that included climate and environmental conservation collaboration and remains in force. Additionally, a separate California and Guangdong climate-focused memorandum of understanding was signed in October 2023. To implement these agreements, a series of dialogues and activities has taken place to foster collaboration and shared learning.

Drawing upon representative cases from the two Bay Area regions, we aim to answer the following questions. First, how is adaptation to flood risks being governed? Next, how are these governance models being applied to integrate climate projections and nature-based solutions to advance climate adaptation in each region? And finally, what next steps can each region take to strengthen their governance of adapting to climate change?

This report is based on fieldwork conducted in both regions in 2023 and 2024, including interviews with government officials and planning professionals. The authors also analyzed planning documents and policy reports on the topics of climate change adaptation, flood infrastructure development, and environmental policy in each region.

BACKGROUND

Climate governance needs to be adapted to address the evolving risks from climate change and floods. While local governments usually hold regulatory power over land use, these institutions face serious challenges in planning for climate adaptation due to limited spatial jurisdiction and constrained staffing and financial capacity. As a result, practitioners and researchers have increasingly turned to larger, regional scales to better plan for adapting urban infrastructure and land use to potential climate change impacts.

Regional-scale planning can facilitate effective climate change adaptation for several reasons. Since flooding and other climate impacts do not follow jurisdictional boundaries, excessive reliance on individual municipalities to mitigate these impacts may lead to maladaptation, inefficiency, and deepening

4 Hallegatte, S., C. Green, R. J. Nicholls, & J. Corfee-Morlot. (2013). Future flood losses in major coastal cities. *Nature Climate Change,* 3(9), 802–806. https://doi.org/10.1038/nclimate1979

5 San Francisco Bay Keeper. The Economic Cost of Sea Level Rise in the Bay Area. https://baykeeper.org/shoreview/economic-loss.html#:~:text=Across%20the%20region%2C%20the%20costs,replacement%20cost%20tops%20%2445%20billion

6 Castleman T., H. Smith, and G. Toohey. (2023). Tracking the deaths from California's winter storms: At least 22 killed. Los Angeles Times. https://www.latimes.com/california/story/2023-01-10/tracking-the-deaths-from-californias-winter-storms

7 Salaheih, N., H. Yan, and H. Brink. (2023). Epic flooding leads to water rescues and highway closures in California as the storm system threatens more states. CNN. https://web.archive.org/web/20230104205651/https://www.cnn.com/2023/01/01/us/california-flooding-bay-area-evacuation-warning-sunday/index.html

8 Siu, T. and F. Master. (2023). Hong Kong, Shenzhen deluged by heaviest rain on record. Reuters. https://www.reuters.com/world/asia-pacific/hong-kongs-heaviest-rain-least-140-years-floods-city-streets-metro-2023-09-08/

inequality. Addressing climate impacts at a regional level enables more comprehensive and coordinated adaptation across jurisdictions by:

- Augmenting the planning capacity of resource-constrained communities
- Facilitating the sharing of best practices
- Creating a shared adaptation vision
- Coordinating "vertically" across different levels of government
- Coordinating "horizontally" among municipalities
- Providing technical assistance
- Augmenting local planning capacity, and
- Acquiring funding for local governments.[9,10,11,12,13]

In this report, we examine regional land use planning efforts for flood resilience. Specifically, we look at two policy areas for which a regional approach is especially important: connecting climate projections to land use planning and opportunities to implement nature-based solutions. The regional planning frameworks in place in both the SFBA and the GBA provide opportunities to study climate change adaptation policies at the regional scale. While government agencies are responsible for a range of activities related to climate hazards (e.g., emergency response, recovery, and reconstruction), in this report we focus specifically on land use planning and "green" and "gray" infrastructure projects.

Flooding has always been a cross-boundary regional issue. However, with the increased frequency and scale of flooding due to climate change, coordination among neighboring jurisdictions is increasingly urgent. While large-scale infrastructure projects have often been designed to withstand extreme storms, such projects must now account for projected climate change impacts. Whereas prior infrastructure and land use planning assumed fundamentally stable landscape and climate conditions, these projects must now account for changing climate patterns and mounting risks.

Given the uncertainties in climate projections, policy-makers can frame risk in terms of *ranges* for projected climate conditions (e.g., precipitation levels) and degrees of risk tolerance for various land uses and infrastructure types. With greater economies of scale, regional planning can provide the capacity for robust scientific projections and analysis that local governments often lack.

Wide-ranging impacts from climate change are forcing researchers and practitioners to think beyond traditional solutions for the built environment. Building and reinforcing gray infrastructure, such as drainage systems, levees, and dams, is essential, but these projects disrupt ecosystem processes and remain prone to catastrophic failure. Nature-based solutions (NbS), which make use of natural processes in engineering and landscape designs, can be combined with gray infrastructure projects to minimize ecosystem impacts while boosting resilience and enhancing system performance.[14] NbS

9. Holmes, T. J., and W. H. Butler. (2021). "Implementing a Mandate to Plan for Sea Level Rise: Top-down, Bottom-up, and Middle-out Actions in the Tampa Bay Region." *Journal of Environmental Planning and Management* 64 (12): 2214–32. https://doi.org/10.1080/09640568.2020.1865885
10. Ashcraft, C., and Rosan, C. n.d. "Investing in Emerging Regional Institutions to Promote Equitable Climate-Ready Regions." Urban Affairs Review. Accessed November 3, 2023. https://www.urbanaffairsreview.com/uar-archive/investing-in-emerging-regional-institutions-to-promote-equitable-climate-ready-regions
11 Woodruff, S. C. (2022). "Coordinating Plans for Climate Adaptation." *Journal of Planning Education and Research* 42 (2): 218–30. https://doi.org/10.1177/0739456X18810131
12 Shi, L. (2019). Promise and paradox of metropolitan regional climate adaptation. Environmental Science & Policy, 92, 262-274.
13 Shi, L. (2017). "A New Climate for Regionalism : Metropolitan Experiments in Climate Change Adaptation." Thesis, Massachusetts Institute of Technology. https://dspace.mit.edu/handle/1721.1/111370
14 World Resources Institute. (2019). Integrating Green and Gray: Creating Next Generation Infrastructure.

also contribute to multiple benefits beyond climate resilience and flood mitigation, including emissions reduction, biodiversity and habitat support, water quality improvement, and recreational and aesthetic enhancement. Again, given the constraints individual jurisdictions typically face, regional governance has a key role to play in coordinating land use patterns and green and gray infrastructure projects, and in ensuring that necessary infrastructure and landscape designs are implemented efficiently, effectively, and equitably.

In Section 2, we describe flood vulnerability and its intersections with urbanization in the two Bay Areas. Section 3 discusses local and regional adaptation planning in both Bay Areas, and Section 4 applies a regional planning framework to the specific challenge of linking climate change projections to planning efforts and implementing nature-based solutions. Section 5 discusses recommendations for the two regions in the areas of regional planning, applying climate projections to planning, and implementing nature-based solutions. Section 6 explores further trans-Pacific collaboration opportunities for these two regions, and Section 7 presents concluding thoughts.

2 / CLIMATE-LINKED FLOOD VULNERABILITY IN THE TWO BAY AREAS

Flood impacts from climate change intersect with urban development in the two Bay Areas in distinct fashions. Although the pace of urban growth in the GBA has slowed since its peak in the 1990s and 2000s, it is still in a phase of significant urban expansion. Because municipal government finances rely on land leases, cities are incentivized to expand urbanization—even in flood-prone areas, and sometimes by filling in coastal marshland. These practices increase the GBA's flood exposure.

While the SFBA saw substantial land filling between the mid-19th and mid-20th centuries, urban development is now relatively stable. The region now faces severe housing shortages. Due partly to political resistance to densifying existing neighborhoods closer to the San Francisco Bay waterfront, much of the region's housing growth is taking place far from the Bay waterfront, often in the Central Valley and Delta areas, which themselves are exposed to elevated flooding and extreme temperature risks. Sea level rise poses another threat to both shorefront and Delta areas, as flooding will render some locations uninhabitable absent significant flood mitigation investments. Therefore, while the GBA faces increased flood exposure from expanded urban development, the SFBA faces more frequent and longer-lasting inundation of residential neighborhoods, posing further limitations to the existing constrained housing supply.

FLOOD RISK IN THE SAN FRANCISCO BAY AREA

Climate change-induced flood risks threaten existing housing and infrastructure throughout the San Francisco Bay Area. Future flood scenarios under climate change must account for both future sea level rise (SLR) and storm surges, which temporarily intensify flooding conditions. Both factors are expected to exacerbate flood impacts in the SFBA. According to the most recent SLR guidance from California's Ocean Protection Council, sea levels at the San Francisco tidal gauge are expected to rise between 0.5 meters (1.6 feet; intermediate-low scenario) and 2 meters (6.5 feet; high scenario) by 2100, even without accounting for storm surges or other temporary flooding events.[15]

Because many existing neighborhoods and planned housing development areas are subject to elevated flood risk, climate hazards will likely exacerbate the housing shortages that have made the SFBA one of the most expensive housing markets in the United States. Furthermore, many SFBA neighborhoods that are most exposed to flooding from rising sea levels are disproportionately home to low-income communities and communities of color, as historically the bayfront was heavily impacted by ports, landfills, and other noxious waterfront industries. Under intermediate SLR scenarios for 2100 (0.6 meters, or two feet on average across the state), annual "king tide" or large tide events would impact more than 6,200 vulnerable households.[16] Thus, increasing flood risk further threatens these communities, which already face displacement risks due to the region's housing affordability crisis.

To address the housing crisis, regional and local government entities have identified "priority development areas" for creating new housing units and jobs. However, the Bay Conservation and Development Commission's Adapting to Rising Tides (ART) assessment found that many of these areas are especially vulnerable to climate change. If today's housing plans for 2040 are built and

15 California Ocean Protection Council. (2024). Draft State of California Sea Level Rise Guidance: 2024 Science and Policy Update.

16 Bay Conservation and Development Commission (BCDC). (2020). Adapting to Rising Tides Bay Area: Regional Sea Level Rise Vulnerability and Adaptation Study.

assuming an intermediate SLR scenario, the annual king tide could flood over 60,000 units within these priority development areas by 2100.[17]

Climate change-linked flood impacts on infrastructure networks extend well beyond shorefront neighborhoods. Under intermediate scenarios for SLR by 2100, annual king tide events will flood several key road corridors, including up to 40% of State Route 37 in Marin County. Portions of other important highways including Interstate 580, State Route 237, and US-101 will also be inundated. These freeway disruptions are projected to impact nearly 1.3 million vehicle trips per day.[18]

Beyond flooding events, sea level rise will push up groundwater. Recent research suggests that groundwater rise will affect twice as much area as SLR in the SFBA.[19] Groundwater rise causes a host of problems for urban areas, including corroding underground infrastructure, impacting nearshore ecosystems, obstructing stormwater infrastructure leading to surface flooding, and mobilizing underground contaminants.[20] Within the SFBA alone, more than 5,000 contamination sites will be inundated by rising groundwater under one meter of SLR, creating serious potential public health impacts.[21],[22] Since low-income households and people of color are more likely to live near contaminated sites, these groups are more likely to be exposed to the hazards from groundwater inundation of contaminated soils. Furthermore, pumping for drainage in low-lying areas can accelerate land subsidence, exacerbating flood risks and increasing saltwater intrusion in groundwater, further corroding underground infrastructure. Rising tides from all directions are threatening urban infrastructure in the SFBA. Government agencies are faced with the dire challenge of balancing demands for additional housing and urban development against the need to reduce climate risk, especially in disadvantaged communities.

FLOOD RISK IN CHINA'S GREATER BAY AREA

Flood risks in the GBA are expected to increase dramatically due to a combination of sea level rise, intensifying storms, and increased development in flood-prone landscapes. Tidal gauges off China's coast show that sea levels have already risen over 12 centimeters (4.7 inches) since 1980.[23]

Studies on climate-related flooding in the GBA identify three main contributing factors: sea level rise, land subsidence, and storm surges. Under a high-emissions scenario, it is projected that, by the end of the century, sea levels near Hong Kong will be 65 cm higher than the baseline average from 1986–2005.[24] Impacts from SLR in the GBA will be exacerbated by subsidence of soft soils and groundwater extraction associated with urbanization. After taking subsidence into account, total SLR is projected to be 84 cm by 2100.[25]

The GBA is frequently hit by tropical cyclones due to its location in the most active tropical cyclone basin on Earth. A recent study on the effects of storm surges from tropical cyclones on coastal flooding found

17 Ibid.
18 Ibid.
19 Hill, K., D. Hirschfeld, C. Lindquist, F. Cook, & S. Warner. (2023). Rising Coastal Groundwater as a Result of Sea-Level Rise Will Influence Contaminated Coastal Sites and Underground Infrastructure. *Earth's Future*, 11(9), e2023EF003825.
20 Plane, E., K. Hill, & C. May, (2019). A rapid assessment method to identify potential groundwater flooding hotspots as sea levels rise in coastal cities. Water, 11(11), 2228.
21 Hill et al., (2023).
22 Hill et al., (2023), p.1
23 National Ocean Administration. (2017). China Sea Level Bulletin. https://www.gov.cn/xinwen/2018-03/19/content_5275590.htm
24 He, Y. H., H. Y. Mok, & E. S. Lai. (2016). Projection of sea-level change in the vicinity of Hong Kong in the 21st century. International Journal of Climatology, 36(9), 3237-3244.
25 Ibid.

that these events will cause temporary but intense inundation beyond chronic, SLR-related flooding.[26] Under a high-emissions scenario, storm surges from tropical cyclones, combined with the effects of SLR and land subsidence, are projected to increase water levels in the GBA by nearly one meter by 2100.[27]

In the rapidly urbanizing GBA region, the intersection of flooding and urbanization is dynamic and creates compound risks. It is projected that the GBA will be home to 120 million people by 2050, a nearly 40% increase over today.[28] Demand for urban development in the region has already led to the filling of 645 square kilometers of coastal estuary landscapes since the 1970s.[29] Such land reclamation contributes to flood exposure in two ways. First, most landfilling in the estuary destroys coastal wetlands, removing natural buffers against floodwaters and storm surges.[30] Second, building human settlements on soft, marshy reclaimed land places more people and infrastructure in flood-prone locations.

Several studies have examined climate change impacts in combination with urbanization and economic development to predict exposure to future flood risk. Modeling from recent research considers future impacts from extreme precipitation alongside impacts from climate change, urbanization, and socio-economic development. Precipitation is projected to be more intense across most of the GBA in 2030–2050, compared to the reference period of 1980–2020. However, flood risk from intensified precipitation will be highest in densely populated urban areas, including the cities of Guangzhou, Foshan, Shenzhen, and Dongguan. Similarly, other research highlights flood sensitivity in dense urban areas with vital infrastructure and vulnerable populations.[31] Under the high-emissions scenario, a 100-year storm in 2100 is projected to flood up to 74,000 square kilometers in the GBA, impacting up to 27 million people and threatening up to $11.1 trillion USD of exposed assets.[32]

A closer look at the cities in the GBA reveals how rapid urbanization and migration has placed particular settlement types and social groups at elevated risk. Shenzhen, Guangzhou, and other rapidly growing cities in the region feature many urban villages that are home to migrant worker populations who often struggle to access housing. Since urban villages fall outside the formal planning and regulatory regimes that govern other parts of these cities, they are more likely to have lower-quality drainage infrastructure, which can lead to elevated flood risk.[33,34] Because urbanization and flood risk interact in complex ways, researchers have called for integrating flood risks into land use planning and development, and for comprehensive flood risk management practices that go beyond land reclamation and flood protection infrastructure, which constitute the dominant approach in the GBA.[35]

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26 Chen, J., Z. Wang, C.-Y. Tam, N.-C. Lau, D.-S. D. Lau, & H.-Y. Mok. (2020). Impacts of climate change on tropical cyclones and induced storm surges in the Pearl River Delta region using pseudo-global-warming method. *Scientific Reports,* 10(1), 1965. https://doi.org/10.1038/s41598-020-58824-8

27 Ibid.

28 Yeung, Y. M. (2010). The further integration of the Pearl River Delta: A new beginning of reform. *Environment and Urbanization Asia,* 1(1), 13-26.

29 Yang, D. (2019). Between the Past and Future: The Transformation of the Pearl River Delta (Doctoral dissertation).

30 Ma, T., X. Li, J. Bai, & B. Cui. (2019). Impacts of coastal reclamation on natural wetlands in large river deltas in China. *Chinese Geographical Science*, 29, 640-651.

31 Yang, L., J. Scheffran, H. Qin, & Q. You. (2015). Climate-related flood risks and urban responses in the Pearl River Delta, China. *Regional Environmental Change*, 15(2), 379–391. https://doi.org/10.1007/s10113-014-0651-7

32 Fang, J., D. Lincke, S. Brown, R. J. Nicholls, C. Wolff, J.-L. Merkens, J. Hinkel, A. T. Vafeidis, P. Shi, & M. Liu. (2020). Coastal flood risks in China through the 21st century – An application of DIVA. *Science of The Total Environment*, 704, 135311. https://doi.org/10.1016/j.scitotenv.2019.135311

33 Shi, L., Z. Lamb, X. C. Qiu, H. Cai, & L. Vale. (2018). Promises and perils of collective land tenure in promoting urban resilience: Learning from China's urban villages. *Habitat International*, 77, 1–11.

34 Song, J., Z. Chang, W. Li, Z. Feng, J. Wu, Q. Cao, & J. Liu. (2019). Resilience-vulnerability balance to urban flooding: A case study in a densely populated coastal city in China. *Cities*, 95, 102381.

35 Chan, F. K. S., L. E. Yang, J. Scheffran, G. Mitchell, O. Adekola, J. Griffiths, Y. Chen, et al. (2021). Urban flood risks and emerging challenges in a Chinese delta: The case of the Pearl River Delta. *Environmental Science & Policy*, 122, 101–115. https://doi.org/10.1016/j.envsci.2021.04.009

3 / MUNICIPAL AND REGIONAL CLIMATE ADAPTATION GOVERNANCE IN THE BAY AREAS

Around the world, subnational governments play key roles in climate adaptation and mitigation since they often have jurisdiction over land use planning, infrastructure, housing, and community development.[36] A survey of 156 U.S. municipalities found that 60% of cities had begun adaptation planning, with 9% already in the implementation stage.[37] Recently, efforts have increased to coordinate climate adaptation governance at the broader regional scale. This section describes municipal- and regional-level flood risk governance in both Bay Areas, providing an overview of how regional climate risk governance efforts have taken shape.

Local and regional land use governance processes are drastically different in the U.S. and China. In the U.S., local governments, primarily cities and counties, have significant power in land use planning and decision-making. China's governance system is much more centralized, with local planning being substantially shaped by policies and directives from above.

Regional governance functions also take different forms in the two regions. For example, coordination across jurisdictions in California's SFBA takes the form of collaborative governance, with emphases on including a wide range of stakeholders, creating partnerships and alliances between stakeholders, and enabling joint decision-making. While this approach can be conflict-ridden, inefficient, and slow, it allows for a relatively high degree of pluralism and responsiveness to local conditions and priorities. In China's GBA, on the other hand, coordination is driven by directives from higher levels of government. Among the provincial and Special Administrative Region (SAR) units of Guangdong, Hong Kong, and Macao, coordination is done at the central level; among Guangdong's nine cities, the provincial government gives direction for regional coordination. This centralization can sacrifice local priorities to big-picture visions, but it advances clear and consistent adaptation priorities relatively quickly.

In both government systems, regional and local governance are shaped by policies and programs at the federal/central and state/provincial levels. Figures 3 through 5 display charts of the actors involved in the SFBA and GBA, as well as plans and policies for climate change adaptation. Table 2 includes a list of major federal/central, state/provincial, regional, and local government agencies and non-governmental organizations involved in climate change adaptation and flood risk governance in the SFBA and GBA.

36 Dai, F., Bedsworth, L., Lewis, J., Gordon, J., and Edwards., L. (2023). Subnational Climate Action in the U.S. and China: Where we are and opportunities for cooperation. The California-China Climate Institute.

37 Shi, L., E. Chu, & J. Debats. (2015). Explaining Progress in Climate Adaptation Planning Across 156 U.S. Municipalities, *Journal of the American Planning Association*, 81:3, 191-202, DOI: 10.1080/01944363.2015.1074526

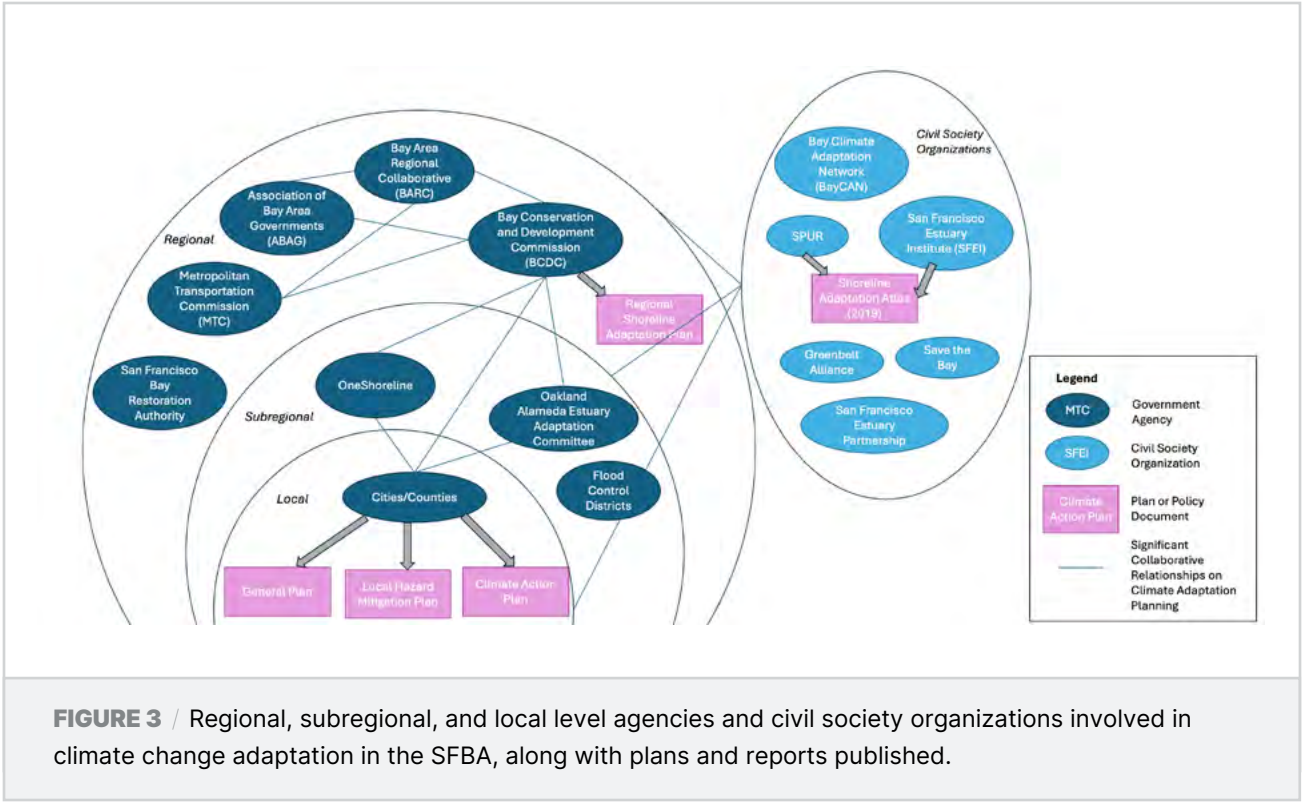

FIGURE 3 / Regional, subregional, and local level agencies and civil society organizations involved in climate change adaptation in the SFBA, along with plans and reports published.

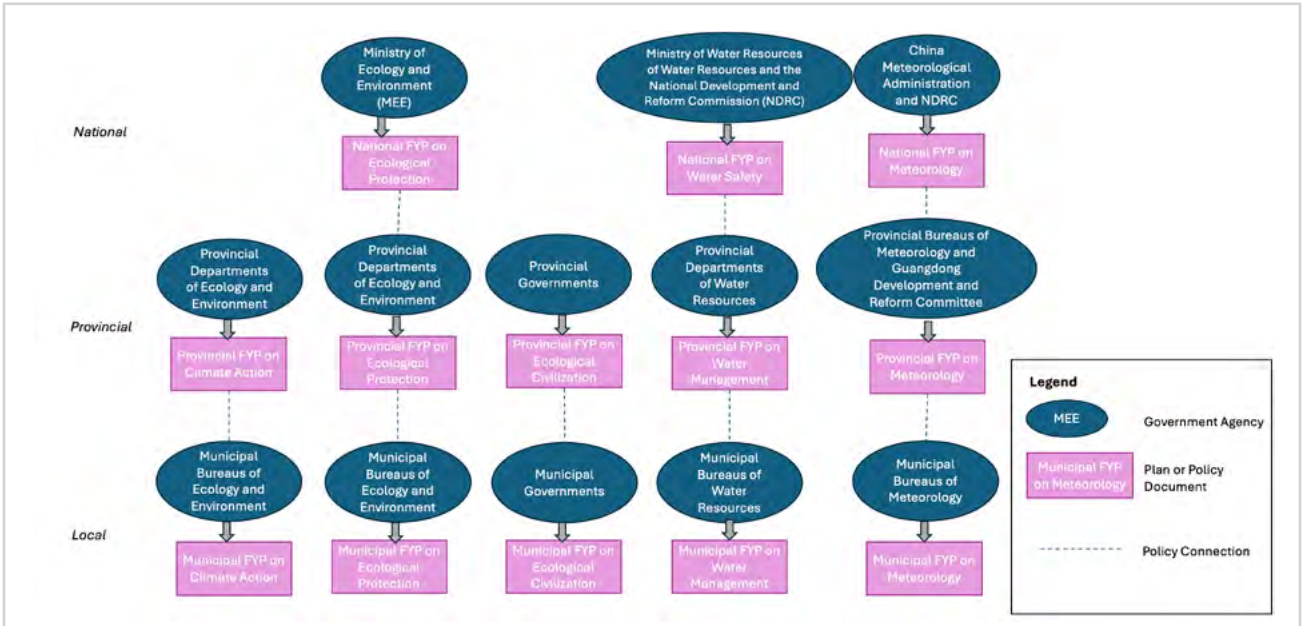

FIGURE 4 / Government agencies that create Five-Year Plans relevant to climate change adaptation in the GBA. (Policy Connection indicates that lower level governments are either required to carry out higher level policy goals or are influenced by policies from higher levels of government.)

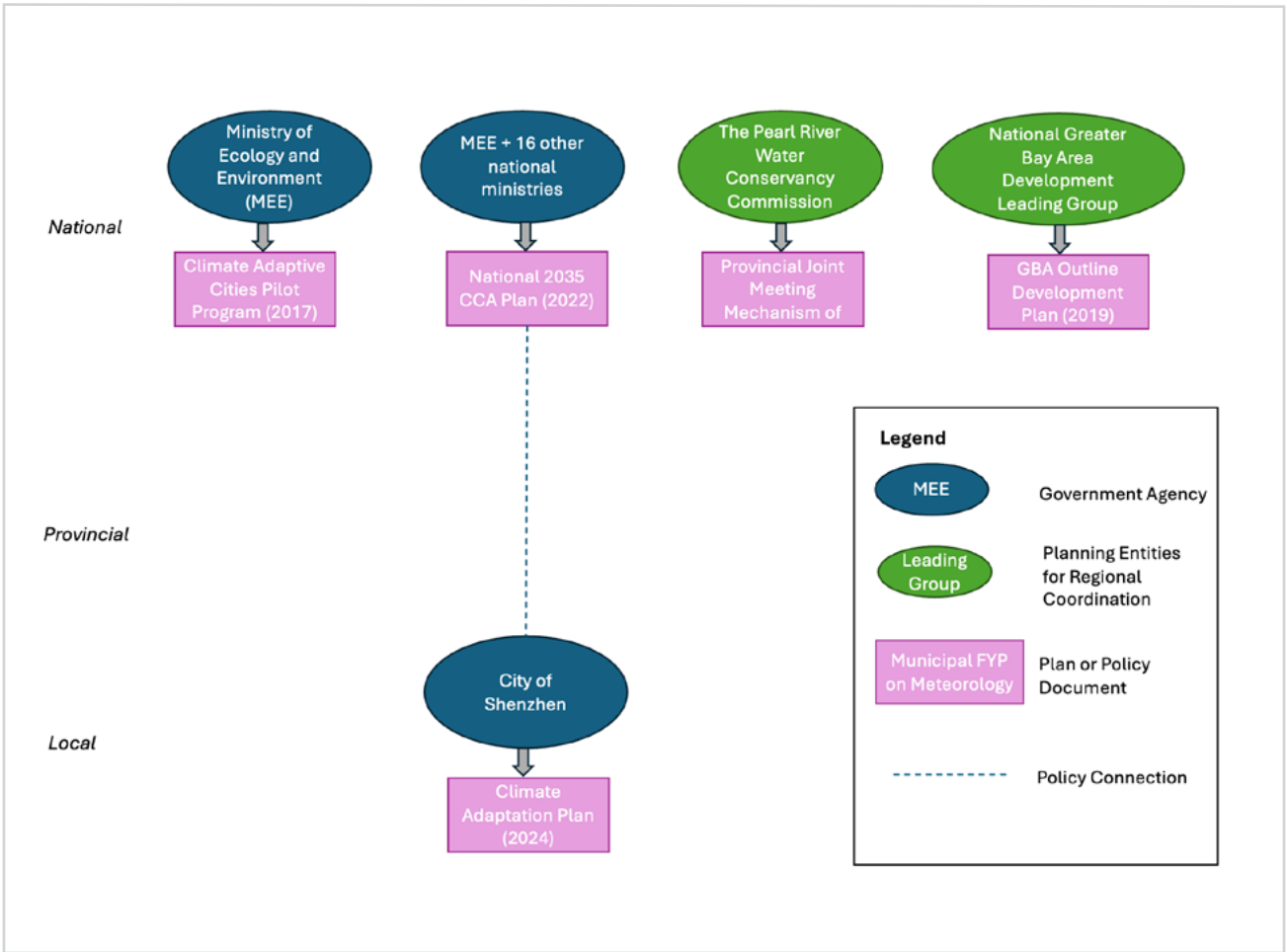

FIGURE 5 / Government agencies and regional entities involved in national and local climate change adaptation planning beyond the Five-Year Plan framework in the GBA. (Policy Connection indicates that lower level governments are either required to carry out higher level policy goals or are influenced by policies from higher levels of government.)

TABLE 2 / **Primary entities engaged in regional flood mitigation planning in the two Bay Areas**

	San Francisco Bay Area (SFBA)	Greater Bay Area (GBA)
Federal/National Government Entities	**Army Corps of Engineers:** designs and builds projects related to flood protection, dredging, etc. **Federal Emergency Management Agency:** issues grants for disaster preparedness planning and emergency relief; issues flood insurance to properties in designated flood zones through the National Flood Insurance Program	**Ministry of Ecology and Environment:** developed the national 2035 Climate Change Adaptation (CCA) Plan and ensures its implementation at the provincial level

TABLE 2 / **Primary entities engaged in regional flood mitigation planning in the two Bay Areas**

	San Francisco Bay Area (SFBA)	Greater Bay Area (GBA)
State/Provincial Government Entities	**Governor's Office of Land Use and Climate Innovation (LCI):** funds local and regional climate adaptation planning **California Strategic Growth Council:** funds local climate adaptation planning **California State Coastal Conservancy:** funds projects that enhance public access and resilience on the coast **Ocean Protection Council:** funds climate resilience planning programs and provides sea level rise projections for the California coast **California Coastal Commission:** regulates development along California's Pacific coast	**Guangdong Province Water Resources Department:** provincial greenway project including a series of waterfront flood protection, water quality, and recreation improvements to be implemented by each city **Guangdong Province Department of Ecology and Environment:** carries out Guangdong Province's portion of the national 2035 CCA Plan
General Regional Planning Entities	**Association of Bay Area Governments (ABAG)/Metropolitan Transportation Commission (MTC):** jointly conducts regional land use and transportation planning **Bay Area Regional Collaborative (BARC):** coordinates regional-scale planning agencies ABAG/MTC, Bay Conservation and Development Commission, and Bay Area Air Quality Management District	**Guangdong Urban and Rural Planning and Design Institute:** directed by the Guangdong Province Department of Housing and Urban-Rural Development, focuses on urban design and strategic planning for the GBA **National Greater Bay Area Development Leading Group:** led by the Vice Premier of the State Council, conducts high-level strategic planning for the region **Guangdong Greater Bay Area Development Leading Group (9 Guangdong cities):** led by the Party Secretary of Guangdong Province, conducts strategic planning for the nine Guangdong cities in the region
Regional Environmental Planning Entities with Relevant Authorities to Flood Mitigation/ Climate Adaptation	**Bay Conservation and Development Commission (BCDC):** conducts regional shoreline land use planning and regulates shoreline development to limit environmental harm, increase climate resilience, and promote access **San Francisco Bay Restoration Authority:** funds shoreline projects to protect, restore, and enhance San Francisco Bay	**Guangdong Urban and Rural Planning and Design Institute:** leads "Sponge City" design, resilient city design, and greenway project design for the GBA **Guangdong Research Institute of Water Resources and Hydropower:** institute for technical studies for water infrastructure and disaster recovery, directed by Guangdong Water Resources Department **Pearl River Water Conservancy Commission of the National Ministry of Water Resources:** central government-level agency conducting regional waterfront infrastructure planning, water quality regulation, and hydropower projects for the broader Pearl River basin network, including areas beyond Guangdong Province

TABLE 2 / **Primary entities engaged in regional flood mitigation planning in the two Bay Areas**

	San Francisco Bay Area (SFBA)	Greater Bay Area (GBA)
Civil Society Advocacy and Research Organizations	**San Francisco Estuary Institute (SFEI):** research, habitat restoration, and green infrastructure projects **San Francisco Estuary Partnership (SFEP):** habitat restoration, water quality improvement, and green infrastructure planning and implementation **BayCAN (Bay Area Climate Adaptation Network):** collaborative network for local government staff to share best practices **Save the Bay:** policy advocacy on habitat restoration and conservation **San Francisco Bay Area Planning and Urban Research Association (SPUR):** policy advocacy on regional climate adaptation planning and housing policy **Greenbelt Alliance:** climate resilience planning and land use policy advocacy	**The Nature Conservancy (Shenzhen):** facilitates Sponge City implementation along with other nature-based solutions such as rain gardens and green roofs; restores coastal habitat through its Shenzhen Resilient Bay program. **Shenzhen Mangrove Conservation Foundation:** organizes public education events on wetland restoration in the Shenzhen Bay
Subregional Entities	**Oakland-Alameda Estuary Adaptation Committee:** subregional adaptation planning and collaboration between the City of Alameda and City of Oakland **OneShoreline:** assists local governments in adaptation planning and creates planning policy guidance **Flood Control Districts:** construction, operation, and maintenance of levees, pumps and pumping stations, creeks and drainage ways, flow and tide gates, drainage pipes, stormwater detention basins	
Local-level Entities	Nine counties (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma counties) and 101 municipalities	Nine cities in Guangdong (Guangzhou, Shenzhen, Zhuhai, Foshan, Dongguan, Zhongshan, Jiangmen, Huizhou, and Zhaoqing), Hong Kong, and Macao

CLIMATE ADAPTATION GOVERNANCE IN THE SAN FRANCISCO BAY AREA

Local Climate Adaptation Governance

In the SFBA, municipalities conduct flood mitigation planning through a combination of general plans, local hazard mitigation plans (LHMPs), and climate action plans. In California, the general plan is the comprehensive blueprint for local governments to direct development and land use planning. State law requires local jurisdictions to produce general plans with sections (or "elements") focused on various planning concerns, including the housing element, transportation element, land use element, conservation element,

open space element, and safety element.[38] Objectives of a general plan's safety element include reducing risks to residents from natural and man-made disasters, strengthening community resilience, and ensuring emergency preparedness. In 2016, California's Senate Bill 379 was passed to require local governments to update the safety elements of their general plans to address climate adaptation and resilience strategies and to ensure consistency between LHMPs and the safety element.[39]

LHMPs include assessments of risks from various natural hazards. Common hazards in the SFBA are floods, earthquakes, liquefaction, landslides, drought, and wildfires. LHMPs also typically include hazard mitigation strategies. In some instances, climate resilience is included in existing hazard categories in the LHMP. For example, the bayside city of San Rafael included actions to address sea level rise in discussions of flood impacts in its 2017 LHMP. Specifically, it included recommendations to clear channels, elevate critical infrastructure, and improve existing berms, levees, and flood control systems.[40] Other LHMPs include dedicated chapters focused specifically on climate change hazards. The City of Alameda's 2022 *Climate Adaptation and Hazard Mitigation Plan* includes a chapter on climate adaptation and hazard mitigation, including short-term, mid-term, and long-term strategies for flood mitigation for all shorefront public facilities (e.g., parks) and flood and transportation infrastructure including seawalls, state freeways, and other major roadways.[41] San Francisco's *Hazards and Climate Resilience Plan* (2020) includes strategies such as adapting shoreline parks to sea level rise and saltwater intrusion through marsh restoration and increased plant diversity. It also calls for completing an extreme precipitation study to better understand and address the impacts of climate change.[42]

Policies relevant to climate change adaptation are also found in local climate action plans (CAPs). While CAPs often focus on assessing and reducing local carbon emissions, they can also include plans for adapting to climate impacts in topics such as energy supply and land use planning.[43,44] CAPs are usually a result of coordination across multiple local departments, including the departments of planning and building, departments of sustainability or environment, and departments of transportation. In many cases, community-based organizations and consultants are also involved in the production of CAPs. For example, *San Francisco's Climate Action Plan 2021* includes resilience to current and future natural hazards as one of four lenses, alongside racial and social equity, just transition, and public health, to assess climate mitigation actions listed in the plans. Through this assessment, the plan ensures that the potential resilience impacts of climate mitigation actions are also considered.

Sub-regional Climate Adaptation Governance

In the SFBA, multiple definitions of the "region" are relevant to interjurisdictional coordination of climate change adaptation governance, ranging from project-specific coordination between a handful of neighboring cities to planning efforts that span whole counties or even the entire nine-county metropolitan region.

In California, it is common for local governments, landowners, and other entities to establish "special districts" to enable task- and sector-specific collaboration across jurisdictional boundaries. Special districts can take many forms, including Geological Hazard Abatement Districts and Climate Resilience Districts, a new type of special district enabled by the California legislature (Senate Bill 852) in 2022.

38 California Governor's Office of Land Use and Climate Innovation. (2025). Required Elements. https://lci.ca.gov/docs/OPR_C4_final.pdf
39 California Legislature. (2016). Senate Bill No. 379. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB379
40 City of San Rafael. (2017). San Rafael Local Hazard Mitigation Plan.
41 City of Alameda. (2022). Climate Adaptation and Hazard Mitigation Plan.
42 City and County of San Francisco. (2020). Hazards and Climate Resilience Plan
43 County of San Mateo Office of Sustainability. (2022). San Mateo County Community Climate Action Plan.
44 San Francisco Department of the Environment. (2021). San Francisco's Climate Action Plan.

Flood Control Districts are among the oldest forms of special districts in the state. While the traditional tasks of Flood Control Districts (which are often county-level agencies) include activities like channel and levee maintenance and drainage upgrades, some districts have begun planning for flood hazards associated with climate change. San Mateo County's Flood Control District, recently renamed "OneShoreline," is one such agency. OneShoreline leads planning and project construction for protective infrastructure along the county's shoreline, coordinating across cities to achieve economies of scale.

While OneShoreline adapts an existing governance structure to address climate adaptation needs, other jurisdictions have created new governance configurations for interjurisdictional collaboration on flood mitigation planning. In some cases, these bodies take the form of working groups rather than formally constituted governing entities. The Oakland-Alameda Adaptation Committee is a collaborative group that includes several different shoreline stakeholders, including the Cities of Oakland and Alameda, the Port of Oakland, and the East Bay Regional Parks District. Given the proximity of these two cities, coordinating shoreline protection infrastructure across city boundaries and among other entities that control significant shorelands is imperative. This arrangement allows the two cities to jointly plan for and implement shoreline transportation and flood protection infrastructure to achieve economies of scale and avoid redundancy. It also facilitates the sharing of planning resources between the cities.

Regional Climate Adaptation Governance

Unlike most urban regions in the U.S., the SFBA has a state-chartered regional agency tasked with planning and regulation to protect a shared environmental resource—in this case, the San Francisco Bay. The San Francisco Bay Conservation and Development Commission's (BCDC) jurisdiction includes the San Francisco Bay as well as managed wetlands, salt ponds, waterways, and a shoreline band extending approximately 30 meters (100 feet) inland across all nine counties that border the Bay. BCDC was established in 1965 to produce the San Francisco Bay Plan and to regulate shoreline development in response to previous decades of rampant Bay filling and the pollution, destruction, and privatization of the shoreline.[45] The agency's mandate, as set out in the McAteer-Petris Act, focuses on two issues: regulating the filling and pollution of the Bay, and maximizing public access to it.[46] Any proposed development project within 30 meters (100 feet) of the shore must seek and receive a BCDC permit before proceeding.

In recent years, BCDC has taken a leading role in coordinating shoreline sea level rise adaptation governance across the SFBA. The Bay Plan, which provides the legal basis for BCDC's regulatory work, was amended in 2011 to address sea level rise impacts. Specifically, the amendment gives BCDC the authority to require sea level rise risk assessments for large shoreline projects and to require projects with potential public safety risks from flooding to be designed for resiliency to 2050 sea level rise projections.[47] Following the Bay Plan amendment, BCDC started the Adapting to Rising Tides (ART) program in 2011. The main contributions of the program are vulnerability assessments and a series of adaptation plans at the city, county, and subregional scales.[48] Through the ART program, BCDC partners with local jurisdictions to augment their planning capacities. Resilience studies and vulnerability assessments from ART have accelerated climate adaptation planning for many cities and counties around the Bay, including Contra Costa and Alameda Counties' shoreline resilience planning.

While the ART program focuses on vulnerability assessments to provide information for local planning efforts, BCDC's Bay Adapt program aims to develop region-wide coordination mechanisms for shoreline

45 San Francisco Bay Conservation and Development Commission. (2024). History of the San Francisco Bay Conservation and Development Commission.
46 San Francisco Bay Conservation and Development Commission. (2024). Laws and regulations.
47 BCDC. (2021). San Francisco Bay Plan Climate Change Policy Guidance.
48 Interview with BCDC staff. (2024).

adaptation planning.[49] In 2021, BCDC, in collaboration with a coalition of government agencies and non-governmental organizations, published the *Joint Platform Bay Adapt: Regional Strategy for a Rising Bay*. The *Joint Platform* includes a list of regional coordination priorities for adaptation planning and a division of responsibilities among various stakeholders.

In 2023, Senate Bill 272 was passed by the state legislature and gave BCDC further regulatory power to coordinate regional shoreline planning for sea level rise. SB 272 requires local governments to develop sea level rise plans by 2034 and gives BCDC the power to approve or deny these plans.[50] The Regional Shoreline Adaptation Plan (RSAP) planning process started in 2023 as a first step in creating a comprehensive regional plan for SB 272 implementation. A draft plan was released in September 2024, outlining eight strategic regional priorities including reduced involuntary displacement, complete and connected ecosystems, safe and strategic shoreline growth and density, reliable critical infrastructure and services, connected regional shoreline access, regional movement of people and goods, reduced contamination in environmental justice communities, and cross-jurisdictional flood risk reduction. In addition to setting the regional vision, the RSAP also provides guidelines and minimum standards for local governments to develop sea level rise plans to fulfill the regional vision.[51]

Other regional agencies also take part in flood adaptation governance by supporting BCDC-led efforts. For example, Plan Bay Area 2050, the comprehensive regional land use plan produced by the Metropolitan Transportation Commission (MTC) and the Association of Bay Area Governments (ABAG), commits MTC and ABAG to support BCDC's Bay Adapt Joint Platform and to work with BCDC to clarify responsibilities for sea level rise adaptation planning, funding, and implementation. MTC and ABAG have also collaborated with BCDC to assess the funding needed for SLR-related shoreline protection. The *Sea Level Rise Adaptation Funding and Investment Framework Final Report,* jointly published by the three regional agencies, projects $110 billion in costs to protect shoreline communities and infrastructure from sea level rise in 2050 under a moderate SLR scenario.[52] The report emphasizes that a regional approach to funding and project development is critical to ensure no area gets left behind, given the radically uneven planning and financial capacities of the region's municipalities.

Civil Society in Climate Adaptation Governance

In addition to these government agencies, a number of civil society groups contribute to climate adaptation governance in the SFBA. The San Francisco Estuary Institute (SFEI) and the San Francisco Bay Area Planning and Urban Research Association (SPUR) together developed the *Shoreline Adaptation Atlas* in 2019, mapping out 30 "Operational Landscape Units" (OLUs) for planning nature-based shoreline adaptation solutions. The term "nature-based solutions" (NbS) is increasingly applied to describe a range of adaptation strategies that "work with and enhance nature to address societal challenges"; common NbS strategies include landscape-based green and blue stormwater management infrastructure and coastal marsh and wetland restoration.[53]

The OLU framework has been widely adopted by local governments. The City of San Rafael, for example, is conducting an initial study of adaptation options for the San Rafael OLU. The Oakland Alameda Adaptation Committee defined its long-range planning scope as the San Leandro OLU.

49 Interview with BCDC staff. (2024).
50 California Legislature. (2023). Senate Bill No. 272. https://legiscan.com/CA/text/SB272/id/2841138
51 Bay Adapt. (2024). Regional Shoreline Adaptation Plan. https://www.bayadapt.org/regional-shoreline-adaptation-plan/
52 MTC/ABAG & BCDC. (2023). Sea Level Rise Adaptation Funding and Investment Framework Final Report
53 Chausson, A., B. Turner, D. Seddon, N. Chabaneix, C. A. Girardin, V. Kapos, ... & N. Seddon. (2020). Mapping the effectiveness of nature-based solutions for climate change adaptation. *Global Change Biology*, 26(11), 6134–6155, p.6135.

Non-governmental organizations also play a role in facilitating interjurisdictional learning. The Bay Area Climate Adaptation Network (BayCAN) is a collaborative network for local government staff to share best practices on climate change adaptation. It organizes meetings and shares resources on adaptation planning and funding opportunities.

Overall, climate change adaptation governance in the SFBA is characterized by a high degree of pluralism, with a wide range of participants informing plans based on local conditions and priorities. Agencies like the BCDC have begun to establish big-picture frameworks at the regional and state levels. Within these frameworks, a large number of public and private actors engage in governance for climate change and SLR based on conditions in their jurisdiction or their own areas of expertise. Local governments have adopted creative governance arrangements based on their local need to access resources or achieve specific results. However, the ability of local jurisdictions to plan for and implement adaptation measures is still substantially constrained by uneven planning and financial capacities.

CLIMATE ADAPTATION GOVERNANCE IN CHINA'S GREATER BAY AREA

National Programs for Climate Adaptation Governance

While government agencies and other actors in the SFBA have been explicitly planning for climate change adaptation for over a decade, parallel efforts in China's GBA are at an earlier phase. Where state, regional, and local agencies have taken the lead in adaptation governance in the SFBA, national policy making is central to efforts in the GBA due to China's more centralized governance model.

China's first national program for urban climate change adaptation planning was the Climate-Adaptive Cities Pilot Program (hereinafter "the Pilot Program"), started by the National Ministry of Ecology and Environment in 2017. The initial round of the Pilot Program funded 28 cities to develop adaptation plans. The central government has since declared goals for the program to expand to 100 cities by 2030 and include all cities at the prefecture level or above by 2035.[54] The most recent round of the Pilot Program added 39 cities in 2024, including Shenzhen.[55] The main objectives of the program are to improve urban climate change governance, strengthen climate risk assessments, improve risk monitoring, upgrade early warning and emergency management of extreme weather events, improve urban water management (including flood protection and water supplies), and improve the climate resilience of urban infrastructure.[56]

Subsequent research on the initial pilot cities found that 63% of surveyed cities created special plans including for drainage, flood prevention, and "Sponge City" infrastructure (i.e., green drainage infrastructure that makes use of natural drainage processes such as permeable surfaces, bioswales, and rain gardens). Nearly half (48%) of cities improved drainage through Sponge City and engineering improvements. A smaller number of pilot cities engaged in wetland restoration and protection, channel clearing, and waterfront flood protection infrastructure construction.[57]

54 Ministry of Ecology and Environment. (2023). Notice on expanding the Climate-Adaptive Cities Pilot Program. (关于深化气候适应型城市建设试点的通知.)

55 Guangdong Province. (2024). Shenzhen City was successfully selected as a national pilot city for enhancing climate-adaptive urban construction. (深圳市成功入选国家深化气候适应型城市建设试点.) https://www.sohu.com/a/779318259_121384255

56 Other objectives of the Pilot Program include strengthening the cities' ability to adapt to climate change, optimizing the spatial layout of cities to adapt to climate change, ensuring the safe operation of urban traffic, improving urban ecosystem service functions, and promoting public health actions to address urban climate change impacts.

57 Fu, L., Y. Cao, & X. Yang. (2020). Progress analysis and policy recommendation on climate adaptation city pilots in China. *Clim. Chang. Res*, 16, 770–774.

Following the initial round of Pilot Program projects, the national government mandated urban adaptation planning for all cities in its *National 2035 Climate Change Adaptation Plan*, published in 2022. This document sets out plans and targets for adaptation planning and directs provinces and municipalities to create and implement plans to reach national targets. Most provinces and municipalities are now in the process of creating plans in line with national directives.

In 2024, the City of Shenzhen became the first municipality to publish its resulting climate adaptation plan. Shenzhen's plan identifies four focus areas: safety, resilience, livability, and "Smart City." These four areas are then broken down into 17 climate adaptation indicators with quantified, near-term targets for 2025 and 2035. Targets relevant to flood mitigation include ensuring that urban flood controls can protect against a 200-year storm by 2035 and implementing Sponge City permeable surfaces to cover at least 80% of city land by 2035. To improve monitoring and early warning capabilities, the plan requires increasing weather station density and ensuring advanced warnings of meteorological emergencies at least 65 minutes prior to extreme events.

The Climate-Adaptive Cities Pilot Program and *National 2035 Climate Change Adaptation Plan* represent two different mechanisms for top-down policy direction; whereas the former provides incentives through funding and career performance recognition for local leaders, the latter contains direct mandates. Both approaches have proven effective in spurring China's cities to begin planning for climate impacts.

Five-Year Plans

Five-Year Plans (FYPs), China's traditional mechanism for centralized policy making, are increasingly being used to advance flood adaptation governance. FYPs and their implementation are organized hierarchically. The cycles of FYPs are synced among the central, provincial, and municipal levels; the current cycle is the 14th FYPs for the plan period 2021–2025.

Within a certain policy area, national-level FYPs delegate targets to provinces, and provincial-level FYPs delegate targets to municipalities to include in municipal FYPs. As a result, FYPs are usually organized according to the same policy areas across municipal, provincial, and national levels. For example, targets set in the Guangzhou Municipal FYP for Ecological Protection are typically based on equivalent targets set in the Guangdong Provincial FYP for Ecological Protection, which are based on targets in the National FYP for Ecological Protection. However, there are also instances in which lower-level authorities initiate targets before they are set at higher levels.

In some cases, climate change adaptation and flood mitigation are incorporated in municipal and provincial FYPs, though they may not be explicitly labeled as "climate adaptation." FYPs are the main documents guiding policy development for Chinese local governments, with the main plan for each jurisdiction being the Economic and Social Development FYP. Other FYPs relevant to flood hazards include plans for Climate Action, Environmental Protection, Ecological Civilization, Water Infrastructure, Urban Infrastructure, and Meteorology.

While the concepts of climate change adaptation and flood mitigation are widely incorporated into the FYPs of the jurisdictions studied, they are unevenly incorporated across different policy areas. Most jurisdictional FYPs on Climate Action, Environmental Protection, Meteorology, and Ecological Civilization include mentions of climate change adaptation. However, none of the FYPs on Water Infrastructure explicitly discuss climate adaptation despite including related topics like urban resilience, risk assessment, and meteorological disaster warnings. Flood-adaptive practices—such as

wetland restoration to rebuild natural storm surge barriers and Sponge City stormwater infrastructure construction—are included in nearly all FYPs on these five topic areas across the jurisdictions. An overview of flood mitigation and climate change adaptation in the FYPs can be found in Table A1 in the Appendix.

FYPs on the topics of Climate Action, Water Infrastructure, Environmental Protection, and Ecological Civilization in the GBA region have set several targets related to flood mitigation and climate change adaptation. Provincial and municipal governments have declared targets related to infrastructure construction, wetland restoration, and emergency warning. For example, Shenzhen pledged to create storm surge protections for the city to protect against projected 200-year events by 2025.[58] The City of Guangzhou's FYP on Ecological Protection pledges to maintain at least 1300 km^2 of wetlands by 2025.[59] Guangdong Province's Climate Action FYP aims for the average proportion of economic losses from meteorological disasters to be no more than 0.15% of municipal GDP by 2025, a decrease from 0.19% in 2020.[60] All relevant targets from Guangdong Province, the City of Shenzhen, and the City of Guangzhou are shown in Table 3.

Regional Climate Adaptation Governance

Beyond China's traditional centralized policy development system, which provides a structure for coordination, regional governance structures in the GBA provide additional opportunities for coordination on environmental planning. These regional governance structures are rooted in the central government's strong interest and robust involvement in the region's economic development and ecological governance systems.

The National Greater Bay Area Development Leading Group—led by the Vice Premier of the State Council of China and consisting of the Chief Executive of Hong Kong and Chief Executive of Macao—was created in 2018 to facilitate coordination of development in the cross-border region. The National GBA Development Leading Group is tasked with implementing the *GBA Outline Development Plan*, published in 2019. The Plan includes considerations for flood protection and infrastructure, wetland restoration, and climate change adaptation. It calls for nature-based solutions for flood protection, including strengthening wetland protection and coastal marine systems in the region. Improving infrastructure, including flood protection infrastructure, to support urban development is one of its six main development goals. Further, the Plan calls for improving management and protection of the Pearl River estuary and reinforcing seawalls and riverbank protections along the Pearl River tributaries. Although no projects for coordinating flood mitigation across borders have been announced at the time of this report, the *GBA Outline Development Plan* promises to improve such coordination, explicitly mentioning the need to work together to jointly build regional disaster monitoring, early warning, and emergency dispatch systems. The *GBA Outline Development Plan* also suggests that cross-border coordination will be a focus in this new regional framework, calling for improvements to flood control and drainage systems in both mainland cities (Zhuhai and Zhongshan) and the Special Administrative Region (SAR) of Macao.

Given the region's delta ecology, governance systems at the ecological scale of the Pearl River estuary also present mechanisms for interjurisdictional coordination of flood mitigation. The Pearl River Water Conservancy Commission, a branch of the National Ministry of Water Resources, conducts comprehensive flood protection infrastructure planning, riverflow monitoring, and emergency flood management for the entire Pearl River basin.

58 Shenzhen Municipal 14th Five-Year Plan on Water Infrastructure. (2022).
59 Guangzhou Municipal 14th Five-Year Plan on Ecological Protection. (2022).
60 Guangdong Province 14th Five-Year Plan on Climate Action. (2022).

TABLE 3 / Flood mitigation and climate change adaptation targets set by GuangdongProvince, the City of Shenzhen, and the City of Guangzhou in their 14th Five-Year Plans

Category	Guangdong Province	City of Shenzhen	City of Guangzhou
Economic Loss from Meteorological Disaster	Average proportion of economic losses from meteorological disasters shall be no more than 0.15% of municipal GDP by 2025, down from 0.19% in 2020 (Guangdong Province Climate Action FYP)		
Wetland Restoration and Natural Coastline Retention	25 km^2 of mangroves shall be restored by 2025 (Guangdong Province Climate Action FYP) No less than 52% of the wetland in the Guangdong shall be protected by 2025, up from 50% in 2020 (Guangdong Province Ecological Civilization FYP) 36% of Guangdong's coastline is natural as of 2020; awaiting national requirements to set 2025 target (Guangdong Province Climate Action FYP)	No less than 0.51 km^2 of mangroves shall be restored and improved, and natural shoreline protection shall be no less than 40% by 2025 (Shenzhen Municipal Climate Action FYP)	No less than 1300 km^2 of wetlands shall be maintained by 2025 (Guangzhou Municipal Ecological Protection FYP) Ecologies of wetlands and mangroves shall be strengthened, three wetland parks shall be renovated and upgraded, the quality of Haizhu Wetland shall be improved, 0.43 km^2 of mangroves shall be created, 1.6 km^2 of mangroves shall be protected and restored, ecological functions of the wetlands shall be enhanced, and forest cover rate shall achieve 41.65% by 2025 (Guangzhou Municipal Urban Infrastructure FYP)
Meteorological Disaster Warning	Early warnings for meteorological disasters shall be issued no less than 60 minutes in advance by 2025 (Guangdong Province Climate Action FYP)	Early warnings for meteorological disasters shall be issued no less than 60 minutes in advance by 2025 (Shenzhen Municipal Climate Action FYP)	
Flood Control Infrastructure	The compliance rate of main river embankments shall reach 85% and compliance rate of seawalls shall reach 80% in Guangdong Province by 2025; the flood control capacity of the central areas of Guangzhou and Shenzhen cities shall be no less than a one-in-200-year event; and the flood-control capacity of the central areas of other prefecture-level cities shall be no less than a one-in-100-year event by 2025 (Guangdong Province Climate Action FYP)	The flood protection capabilities of the City shall reach a level of one-in-200-year event by 2025; the storm surge protection capabilities of the City shall reach a level of one-in-200-year event by 2025; and the waterlogging control capabilities of the City shall reach a level of one-in-50-year event by 2025 (Shenzhen Municipal Water Infrastructure FYP)	The compliance rate of main river embankments shall reach 90% by 2025 (up from 80% in 2020); the flood-control capacity of the central districts shall be no less than a one-in-200-year event; and the flood-control capacity of Nansha and Panyu shall reach a level of one-in-50 to 200-year event by 2025 (Guangzhou Municipal Water Infrastructure FYP)

TABLE 3 / Flood mitigation and climate change adaptation targets set by GuangdongProvince, the City of Shenzhen, and the City of Guangzhou in their 14th Five-Year Plans

Category	Guangdong Province	City of Shenzhen	City of Guangzhou
Guangdong Province Green Trail Project	7800 km of Green Trail shall be completed by 2025, up from 773 km in 2020 (Guangdong Province Ecological Civilization FYP)	940 km of Green Trail shall be completed by 2025, up from 118 km in 2020 (Shenzhen Municipal Water Infrastructure FYP)	1506 km of Green Trail shall be completed by 2025 (Guangzhou Municipal Urban Infrastructure and Ecological Civilization FYPs)
Sponge City (Urban Drainage)		The proportion of Sponge City-compliant areas shall make up more than 60% of all urban built-up areas by 2025, up from 28% in 2020 (Shenzhen Municipal Climate Acton and Water Infrastructure FYPs)	The proportion of Sponge City-compliant areas shall make up more than 45% of all urban built-up areas by 2025, up from 20% in 2020 (Guangzhou Municipal Water Infrastructure and Urban Infrastructure FYPs)

China's central government has also experimented with innovative river governance systems. In 2016, the State Council directed the implementation of the River Chief Policy across the country. The River Chief governance system assigns each segment of a river to a "River Chief." River Chiefs are assigned at the province, prefecture, county, and township levels. This system was created in response to institutional fragmentation that resulted in a lack of coordination and conflicts among ministries that regulated different aspects of water governance (e.g., water supply, water quality, and flood control). The River Chief system is intended to enable a first-in-command leader within each jurisdiction to coordinate across different departments.[61]

For the Pearl River, the River Chief office is a platform for the River Chiefs of the Pearl River across the four levels to coordinate across jurisdictions and across water management issues. In the Pearl River watershed, the Pearl River Water Conservancy Commission collaborates with River Chiefs regularly to facilitate policy implementation, including flood control. This coordination was institutionalized through the publication of *Pearl River Basin Provincial Joint Meeting Mechanism of River Chiefs*, which requires regular meetings among the Pearl River Water Conservancy Commission and the provincial-level River Chiefs.[62]

In the GBA, climate change adaptation governance by local governments is shaped by various national programs and hierarchical policy making structures. *Regional coordination mechanisms* for flood infrastructure are linked to both economic development and ecological planning efforts. Economic development planning is organized through infrastructure development for the GBA, which is a high priority for the central government. Regional ecological governance systems are primarily organized through various institutions focused on the Pearl River estuary.

61 Jia, S., & D. Li. (2021). Evolution of water governance in China. Journal of Water Resources Planning and Management, 147(8), 04021050.

62 China Ministry of Water Resources. (2022). A special meeting was held on the cooperation between the Pearl River Commission and the Provincial River Chief Office of the Pearl River Basin. ("珠江委+流域片省级河长办"协作机制专题会议召开). http://www.mwr.gov.cn/ztpd/gzzt/hzz/gzbs/ly/202207/t20220715_1585716.html

4 / CASE STUDIES

This section focuses on two key opportunities for regional-scale frameworks to bolster adaptation preparedness: (1) by linking climate change projections to land use and infrastructure planning; and (2) by helping identify and implement nature-based solutions. To illustrate these opportunities, we present case studies from each of the two Bay Areas.

LINKING CLIMATE CHANGE PROJECTIONS TO PLANNING

Climate hazard vulnerability assessments require combining outputs from climate models with data on built environment assets, land use, and sociodemographic characteristics. While scientists have created increasingly accurate and precise models of climate change impacts, few jurisdictions have developed transparent and systematic mechanisms for incorporating these projections into policy and planning decisions. Translating climate change projections into specific planning decisions is challenging, for two main reasons. First, future climate change and urbanization processes are both uncertain and contingent; and second, land use and infrastructure planning can be subject to intense interest group pressures, as these decisions often carry enormous financial and political implications. Nonetheless, accurate assessment of climate vulnerability is an essential first step in effective and equitable adaptation planning.

There are several advantages to conducting this type of analysis at regional scales, rather than conducting city-by-city assessments. For one, city-by-city assessments can be inefficient and "impose high planning and political costs that can be prohibitive for most cities."[63] Furthermore, across the U.S., regional-scale vulnerability assessments have proven to be effective in encouraging municipalities to plan for climate change adaptation.

Below we discuss how state, regional, and regional agencies in the SFBA have helped local governments incorporate scientific climate change projections into land use planning for climate resilience. A list of agencies involved in applying climate change projections to planning in the SFBA and GBA can be found in Table 4.

63 Shi, L. (2019). "Promise and Paradox of Metropolitan Regional Climate Adaptation." *Environmental Science & Policy* 92 (February):264. https://doi.org/10.1016/j.envsci.2018.11.002

TABLE 4 / **Select institutional actors involved in applying climate projections to land use planning**

	San Francisco Bay Area	Greater Bay Area
Federal & National Government Entities	**National Oceanic and Atmospheric Administration**: publishes projected national SLR and coastal flood hazard scenarios **U.S. Global Change Research Program**: conducts periodic National Climate Assessments, which include nationwide impacts, risks, and vulnerabilities associated with climate change **U.S. Army Corps of Engineers (USACE)**: incorporates the consideration of sea level change in the planning and design of coastal flood control and erosion protection projects	**China Meteorological Administration**: climate monitoring and modeling; regional vulnerability assessments; technical support for provincial meteorological offices on regional climate analysis **State Oceanic Administration**: monitors sea levels through tidal gauges
State & Provincial Government Entities	**Ocean Protection Council (OPC)**: publishes California's sea level rise guidance, which includes SLR projections and recommendations for SLR planning and adaptation **California Coastal Commission**: uses OPC's SLR projections for regulating development along California's coast **OPC, California Natural Resources Agency, and California Energy Commission**: conduct California's statewide climate change assessments at least once every five years **California Environmental Protection Agency (CalEPA)**: its Office of Environmental Health Hazard Assessment conducts assessments of climate change impacts on health and publishes the data on the CalEnviroScreen platform	**Guangdong Province Meteorological Bureau**: conducts provincial and regional-scale climate monitoring, analysis, and vulnerability assessments **Guangdong Province Department of Natural Resources**: directs and approves territorial spatial plans of municipalities, counties, and townships in Guangdong
Regional Entities	**Bay Conservation and Development Commission (BCDC)**: uses OPC's SLR projections for regional shoreline land use planning	
Municipal Entities	**Local government entities**: required to create a local SLR plan that includes the best available science and timeline for plan updates based on conditions and projections by 2034; some local governments (e.g., the City and County of San Francisco) already have included plans for construction resilience measures based on SLR projections in their Safety Elements	**Meteorological Bureaus of the nine Guangdong cities**: local meteorological hazard mitigation, including warning systems **Bureaus of Planning and Natural Resources of the nine Guangdong cities**: municipal territorial spatial plans
Non-governmental Entities	**California Ocean Science Trust**: leads the scientific research component of OPC's Sea Level Rise Update	

SFBA: Using Sea Level Rise Projections to Inform Land Use Planning

In the San Francisco Bay Area, regional planning initiatives incorporate sea level rise projections into adaptation planning through three mechanisms: first, through regulatory requirements for permitting; second, through providing localized scientific climate modeling information for vulnerability assessments; and third, through local shoreline adaptation plans.

In California, the Ocean Protection Council (OPC), a cabinet-level entity that spans several state agencies responsible for coastal and marine policy, periodically publishes SLR projections to be used by the state's regulatory agencies. The most recent update was adopted in 2024. SLR projections in OPC's Sea Level Rise Guidance are formulated from academic research that synthesizes the IPCC's SLR projections to provide localized projections. Regional agencies like the BCDC apply these projections in their regulatory and land use planning decisions.

The BCDC ensures that SLR projections are considered in shorefront land use decisions through its permitting authority along the San Francisco Bay shoreline. The BCDC requires SLR risk assessments based on the location and projected lifespan of the development for permits for new development within 30 meters (100 feet) of the bayshore. The amended Bay Plan, which lays out BCDC's regulatory mandates, requires permit seekers to provide a flood risk assessment that accounts for "a range of sea level rise projections for mid-century and end of century based on the best scientific data available" when proposing new development or infrastructure projects.[64] Furthermore, BCDC typically requires that projects are designed to accommodate mid-century (2050) sea level rise projections. For projects that are expected to last beyond mid-century, an adaptive management plan is required to address risks associated with sea level rise through 2100. These requirements apply to all projects across the BCDC's regional jurisdiction, ensuring consistent standards across the nine counties.

The second way that SLR projections are used in adaptation planning is through informing vulnerability assessments. Vulnerability assessments for climate change-linked flooding in the SFBA demonstrate how regional and county-level agencies provide technical assistance to local governments' climate adaptation planning efforts. BCDC's Adapting to Rising Tides (ART) program assessed the vulnerability of shoreline communities to sea level rise and of Alameda and Contra Costa Counties to intensified storms, and also conducted resilience studies for the City of Hayward and the Oakland-Alameda shoreline. As a regional agency, BCDC has an interest in both facilitating region-wide assessments and assisting jurisdictions that lag behind. Through ART, it was able to apply its expertise to multiple vulnerability assessments in collaboration with local governments, achieving efficiencies that would be unavailable in a county-by-county or city-by-city approach.

In some cases, county-level sea level rise vulnerability assessments have also facilitated municipal-level adaptation planning. Marin County and San Mateo County published sea level rise vulnerability assessments in 2017 and 2018, respectively. Both assessments include sea level rise scenarios for 2030, 2050, and 2100, along with maps of flood depths for those three years given projected sea level rise and descriptions of corresponding flood impacts on neighborhoods and major infrastructure. These county-level vulnerability assessments have grounded local planning efforts and provided a basis for cities to better understand local impacts.[65]. San Mateo County's OneShoreline works with municipal governments to conduct sea level rise vulnerability assessments. The City of Burlingame's ongoing Sea Change Burlingame plan, for example, builds on OneShoreline's Sea Level

64 San Francisco Bay Conservation and Development Commission. (2020). San Francisco Bay Plan. p.44
65 City of Burlingame. Sea level rise. https://www.burlingame.org/637/Sea-Level-Rise

Rise Vulnerability Assessment, while in Marin County, the City of San Rafael's Sea Level Rise Planning Project is an ongoing feasibility study, begun in 2023, to consider potential adaptation measures for its Canal District. The latter project builds on Marin County's BayWAVE assessment and adopts its sea level rise projections. In both cases, the counties' sea level rise vulnerability assessments provided a base for cities to understand local impacts.[66]

Finally, all shore-front local governments in the SFBA are now required to plan for SLR projections in accordance with requirements set by BCDC. BCDC's draft Regional Shoreline Adaptation Plan (RSAP), published in 2024 as part of SB 272 implementation, outlines requirements for local governments to adopt a Subregional Shoreline Adaptation Plan that incorporates SLR projections. The RSAP leaves it to local governments to decide how they want to define a "subregion," which could be a city, county, or a combination of cities and counties. The Subregional Shoreline Adaptation Plans are required to include vulnerability assessments and descriptions of adaptation strategies for each of the four SLR scenarios: one anticipating 0.8 feet of SLR by 2050, and three scenarios for 2100 anticipating Intermediate, Intermediate-High, and High SLR of 3.1, 4.9, and 6.6 feet, respectively.[67]

Regional-scale adaptation studies can be critical for assessing broader factors shaping adaptation planning needs and advocating for more action and resources from higher levels of government. For example, in 2023, BCDC found a $105 billion gap between available resources and regional needs over the next few decades, garnering coverage in regional media.[68,69,70] Importantly, the report highlights the fact that adapting to sea level rise in the Bay Area will create significant financial demands for decades to come, requiring attention from government agencies across scales.

NATURE-BASED SOLUTIONS

Nature-based solutions (NbS) offer a critical tool for climate adaptation, reducing hazard vulnerability while offering a range of co-benefits such as greenhouse gas emissions reductions, biodiversity and habitat support, recreation and aesthetic improvements, urban heat island mitigation, and water quality improvement.[71] For communities seeking to reduce climate-related flood vulnerability, wetland restoration and green stormwater infrastructure are two common types of nature-based solutions that have been adopted in the SFBA, the GBA, and other urban regions.

Developing effective nature-based solutions often conflicts with the administrative boundaries of local governments, as wetlands and other ecosystems that are frequently the focus of NbS projects do not follow jurisdictional boundaries. Planning for urban green infrastructure such as rain gardens and bioswales at the regional scale requires horizontal coordination across jurisdictions to improve the efficacy of such projects. Since stormwater flows across jurisdictional boundaries, a coordinated approach can ensure that installations are placed where they will most effectively mitigate flood risk. Planning and regulating at the regional scale could also improve the efficiency of NbS projects, for

66 City of Burlingame. Sea level rise. https://www.burlingame.org/637/Sea-Level-Rise

67 More information on intermediate, intermediate-high, and high SLR scenarios can be found in section 2 Climate Change-Linked Flood Vulnerability in the Two Bay Areas.

68 BCDC. (2021). Bridging the Gap: Funding Sea Level Rise Adaptation in the Bay Area.

69 Grenier, L. and G. Sencan. (2024). Sea Level Rise in California. Public Policy Institute of California. https://www.ppic.org/publication/sea-level-rise-in-california/#:~:text=The%20San%20Francisco%20Bay%20Area,estimated%20at%20over%20%24230%20billion

70 King, J. (2023). What will it cost to protect the Bay Area from sea level rise? Try $110 billion, says state agency. San Francisco Chronicle. https://www.sfchronicle.com/bayarea/article/sea-level-rise-cost-17876701.php

71 Gordon, J., N. Dolton-Thornton, L. Bedsworth, M. Passero, F. Dai, J. Perron, & J. Sadler. (2022). Achieving a multi-beneficial nature-based climate strategy: An institutional framework for advancing subnational climate action. *The California-China Climate Institute and The Nature Conservancy.*

example by reducing the need for separate permitting by each jurisdiction. Finally, regional planning of NbS can improve equity by facilitating resource sharing and enabling more resource-constrained jurisdictions to benefit from larger-scale projects. A list of agencies involved in nature-based solutions for flood mitigation in the SFBA and GBA can be found in Table 5.

TABLE 5 / Select institutional actors involved in implementing nature-based solutions

	San Francisco Bay Area	Greater Bay Area
Federal & National Government Entities	USACE: designs and builds flood protection and beach nourishment projects that enhance habitat quality and efficiently utilize natural processes through its Engineering With Nature initiative[1]	*Ministry of Housing and Urban-Rural Development: leads Sponge City program; provides guidance for provinces and cities to plan for and build Sponge City infrastructure2*
State & Provincial Government Entities	California State Coastal Conservancy: funds projects that enhance public access and resilience on the coast	*Guangdong Bureau of Housing and Urban-Rural Development: provides guidance for cities to implement Sponge City infrastructure*
County & City Entities	*Municipal departments such as the San Francisco Public Utilities Commission (SFPUC), City of Berkeley Department of Public Works, and City of San Jose Environmental Services Department: plans and builds green infrastructure projects such as raingardens and bioswales*	*Department of Water Resources (Sponge City Division) of the nine Guangdong cities: leads and coordinates Sponge City implementation among various municipal departments* Bureau of Environment and Ecology in the nine Guangdong cities: conducts ecological protection, project monitoring, and enforcement of ecological redlines
Civil Society Advocacy & Research Organizations	San Francisco Estuary Institute (SFEI): conducts research on habitat restoration and green infrastructure projects[3] San Francisco Estuary Partnership (SFEP): supports habitat restoration, water quality improvement, and green infrastructure planning and implementation San Francisco Bay Restoration Authority: funds shoreline projects to protect, restore, and enhance the Bay Save the Bay: advocates for habitat restoration and conservation policy	The Nature Conservancy (Shenzhen): promotes ***green infrastructure*** and nature-based shoreline designs through its Shenzhen Resilient Bay program Shenzhen Mangrove Conservation Foundation: conducts public education on wetland restoration in the Shenzhen Bay

1. Actors involved in habitat restoration are in plain text.
2. *Actors involved in green infrastructure development are in italics. (In the GBA, urban green infrastructure development is part of the central government-led Sponge City program.)*
3. Actors involved in both habitat restoration and green infrastructure are underlined.

GBA: Sponge City Infrastructure

China's "Sponge City" program is a nation-wide urban green infrastructure initiative aimed at remaking urban landscapes to better absorb precipitation, reducing flood risk, mitigating subsidence, and enhancing water quality. The initiative was established in 2014 and has since been led by three central government ministries: the Ministry of Housing and Rural-Urban Development, the Ministry of Finance, and the Ministry of Water Resources. Several cities in the GBA have planned and constructed Sponge City infrastructure. National and provincial Sponge City programs have disbursed funding for local projects and Guangdong Province, and regional planning initiatives have provided technical guidance and governance structures for coordinating and standardizing the implementation of Sponge City infrastructure.

Several national and provincial policies are in place to scale up Sponge City infrastructure across the GBA region. National and provincial designations for Sponge City infrastructure incentivize green infrastructure retrofitting, both through direct monetary support and political recognition for exemplary jurisdictions and officials. Seven of the nine GBA cities in Guangdong are actively developing Sponge City infrastructure through a combination of national and provincial programs: Shenzhen and Zhuhai are National Sponge City Pilot Cities; Guangzhou, Zhongshan, and Foshan are National Sponge City Model Cities, each receiving 1.2–1.8 billion yuan (equivalent to approximately $170–250 million USD) from the national government;[72] and Dongguan and Jiangmen are Provincial Sponge City Model Cities.[73]

Guangdong's provincial government supports a coordinated approach to Sponge City development across the region through a series of policies and guidelines. Two recent policy documents, *Comments on Accelerating the Construction of Sponge Cities*[74] and *Guangdong Province's Work Plan for Systematic and Comprehensive Promotion of Sponge City Construction (2022-2025)*,[75] provide high-level direction for municipal Sponge City planning. Several other directives—including the *Guangdong Province Sponge City Construction Management and Evaluation Guidelines;*[76] *Technical Standards for Sponge City Construction;*[77] *Guidelines for the Planning and Design of Sponge City Residential Neighborhoods, Roads, and Parks;*[78] and *Technical Regulations for Sponge City Renovation in Old Towns*[79]—provide detailed standards for Sponge City infrastructure and technical support for municipalities to facilitate the uniform implementation of Sponge City designs across cities.

At the regional level, while there have not yet been explicit programs for green infrastructure or urban water infrastructure associated with GBA planning, the *GBA Outline Development Plan* offers opportunities for regional coordination on Sponge City infrastructure through its emphasis on urban infrastructure improvements to enhance regional connectivity. While infrastructure development thus far has focused on transportation infrastructure, significant opportunities exist for Sponge City projects to be integrated into region-wide infrastructure development as the GBA Development Leading Groups implement the *GBA Outline Development Plan*.

72 Sohu. (2016). The second batch of national sponge cities includes 14 cities, each of which can receive 1.2-1.8 billion yuan in subsidies. (第二批国家试点海绵城市共14城 可各获12–18亿补助.) https://www.sohu.com/a/73611004_335896
73 Guangdong Province Department of Housing and Urban-Rural Development. (2024). Promote urban water conservation and build beautiful cities. (推进城市节水，建设美丽城市.) https://zfcxjst.gd.gov.cn/zwzt/csjs/cjsw/content/post_4421035.html
74 People's Government of Guangdong Province. (2016). (广东省人民政府办公厅关于推进海绵城市建设的实施意见)
75 Guangdong Department of Housing and Urban-Rural Development (GDHURD). (2022). (广东省系统化全域推进海绵城市建设工作方案（2022–2025年）)
76 GDHURD.《广东省海绵城市建设管理与评价细则》
77 GDHURD.《海绵城市建设技术标准》
78 GDHURD.《海绵型建筑小区、道路、绿地公园规划设计导则》
79 GDHURD.《旧城区海绵城市改造技术规程》

Government prioritization of Sponge City infrastructure is reflected by its integration into various provincial and municipal FYPs on climate action and sustainable development. Guangdong Province's FYPs on Climate Action, Ecological Civilization, and Environmental Protection include policies to promote Sponge City practices for water conservation, urban greening, and climate adaptation. To meet Guangdong Province FYP targets, several cities in the GBA have set targets for Sponge City infrastructure. In the city's Climate Action FYP, Shenzhen pledged that 60% of urban land would meet Sponge City drainage standards by 2025.[80,81] Guangzhou and Huizhou adopted targets of 45% and 40%, respectively, of urban land to be equipped with Sponge City infrastructure.[82,83]

The central government initiated the nationwide Sponge City pilot program in 2015 to demonstrate the value of urban green infrastructure for improving flood resilience, water conservation, and water quality. In 2016, Shenzhen was one of 14 cities selected for the second round of National Sponge City Pilot sites. To implement Shenzhen's Sponge City projects, the municipal government established a Sponge City Office within its Water Resources Department to coordinate infrastructure design and construction across the departments of Planning and Natural Resources, Housing and Urban Development, Transportation, and Development and Reform.[84] The Guangming district pilot project, the first of two main components of Shenzhen's program, is a 25 square-kilometer area of master planned development on the outskirts of Shenzhen that is slated to include Sponge City strategies for developing parcels and streets and other public infrastructure. The second main component, new city-wide landscaping and drainage infrastructure requirements, outline specific design standards—for new housing, industrial development, open space/parks, municipal roads, public buildings, urban redevelopment, and water bodies—to implement green infrastructure strategies on a parcel-by-parcel basis. Shenzhen's early efforts at Sponge City construction have attracted officials from neighboring Dongguan and other cities to visit and learn from its experience.[85]

In the GBA, Sponge City infrastructure has been widely adopted across most cities. China's hierarchical governance structure has led to coordinated and uniform adoption of Sponge City infrastructure requirements at the national, provincial, regional, and local levels. The consolidated state ownership of urban land, combined with the abundance of new large-scale urban development projects in the GBA region, have allowed for rapid implementation of Sponge City infrastructure at scale.

80 Shenzhen Municipal 14th Five-Year Plan on Climate Action. (2022).
81 Shenzhen later updated its Sponge City targets in its Climate Change Adaptation plan published in 2024 for 60% of urban land by 2025 and 80% by 2035.
82 Guangzhou Municipal 14th Five-Year Plan on Water Infrastructure. (2022).
83 Huizhou Municipal 14th Five-Year Plan on Climate Action. (2022).
84 Interview with Shenzhen municipal government staff. (2023).
85 Interview with a municipal employee. (2023).

5 / POLICY RECOMMENDATIONS

Based on our analysis of current climate adaptation governance structures and policies, we recommend key actions for both Bay Areas below in the realms of strengthening regional planning frameworks, integrating climate projections into adaptation planning, and scaling up nature-based solutions to enhance flood resilience.

STRENGTHENING REGIONAL PLANNING

Governance structures vary considerably between California's San Francisco Bay Area and the Greater Bay Area in southeastern China, leading to significant differences in regional planning. In the simplest terms, regional planning in the GBA is relatively centralized and hierarchical, like many aspects of China's governance. In comparison, regional planning in the SFBA exhibits a higher degree of pluralism and decentralization, with many diverse actors shaping adaptation decision-making based on their interests, priorities, and various local conditions.

Despite these differences, when applying regional governance structures to climate adaptation planning, both regions face challenges in:

- Coordinating across jurisdictions
- Balancing local interests with regional needs
- Equitably distributing planning resources so that resource-constrained jurisdictions are not left behind.

Based on our survey of the distinct cross-jurisdictional arrangements for flood adaptation in each Bay Area, we recommend the following actions.

San Francisco Bay Area

Enhance Regional Coordination for Shoreline Resilience: Implement Senate Bill 272 effectively by ensuring regional agencies set minimum resilience standards, provide funding, and prevent maladaptive infrastructure that shifts risks elsewhere. Senate Bill 272 has created a mechanism for coordinating shoreline adaptation planning across the region through BCDC's Regional Shoreline Adaptation Plan and given BCDC new authority to regulate local SLR plans. Regional coordination is needed to ensure a basic level of resilience across local jurisdictions so that flood waters will not adversely impact jurisdictions with less adaptive infrastructure. Regional agencies could provide resources, guidelines, and direction to ensure that adaptation infrastructures, both green and gray, advance region-wide interests and do not simply displace risks from one area to another.

Expand Cost-sharing and Cross-jurisdictional Governance Approaches: Scale up successful models (e.g., OneShoreline, the Oakland-Alameda Adaptation Committee) by incentivizing regional adaptation governance structures with available state and federal funding. Existing regional and subregional planning projects have enabled cost-sharing and cross-subsidization among communities with varying capacities. These benefits have been created through new governance arrangements, such as San Mateo County repurposing its pre-existing flood control district to focus on shoreline resilience (OneShoreline) and the cities of Oakland and Alameda creating a joint committee dedicated to shoreline adaptation (Oakland-Alameda Adaptation Committee). These adaptation governance experiments show promise and could inspire other local governments across the region to pursue their own governance innovations to suit their circumstances. Adaptation planning actors across scales should support continued experimentation

with different governance arrangements to address extra-local adaptation needs. Incentives from state and federal funders could encourage the design of such innovative governance structures to explicitly advance cross-jurisdictional equity and bring much-needed resources to disadvantaged communities.

Broaden Civil Society Engagement: Strengthen partnerships with non-traditional stakeholders, including racial justice groups, indigenous organizations, and tenant rights advocates to integrate equity into climate adaptation planning. Planning for climate change adaptation has attracted strong engagement from many civil society groups in the SFBA, including community-based non-profit organizations and think tanks. This broad engagement creates opportunities for policy innovation and for augmenting research capacities beyond core government agencies. SPUR and SFEI's OLU framework is a clear example of innovations arising from civil society engagement. Going forward, civil society engagement could include constituencies and interest groups not frequently associated with climate change planning, including groups focused on racial justice, Indigenous rights, tenant rights, and unhoused populations.

Greater Bay Area

Leverage Existing Regional Collaborations for Adaptation Planning: Build on established water governance mechanisms between Guangdong and Hong Kong to foster climate resilience partnerships under the National GBA Development Leading Group. The region has a history of coordination across borders. For example, Hong Kong's main water supply is the Dongjiang River, which flows through Guangdong. Thus, regional water arrangements have existed between Guangdong and Hong Kong since 1965.[86] Since 2018, regional governance arrangements have mainly occurred through the National GBA Development Leading Group, which has allowed for regular communication over a range of policy topics, including issues relevant to adaptation planning. Connecting new and past regional collaborations can enable legacy governance institutions to address new threats and merge collaborative efforts to confront various water-related challenges.

Encourage Cross-City Learning for Resilience Planning: Facilitate knowledge exchange, such as sharing Shenzhen's Sponge City best practices with other municipalities, by promoting informal regional planning networks. Although the high level of attention on the GBA from the central government could enable regional planning frameworks, an over-emphasis on the top-down vision for the GBA region in policy making could stifle organic cross-city/cross-border coordination and learning. Emergent regional planning efforts in the GBA would benefit from fostering informal collaborations across jurisdictions. For instance, with appropriate institutional arrangements and incentives, neighboring cities could benefit tremendously from Shenzhen's experience pioneering Sponge City plans.

LINKING CLIMATE PROJECTIONS TO ADAPTATION PLANNING

The practice of connecting climate projections to planning is relatively new and emerging in both regions. Common challenges across both regions include:

- Creating and updating downscaled climate projections and making them applicable to planning processes
- Coordinating across different government departments, particularly between meteorological and land use planning departments
- Revising land use regulation and approval processes to reflect changing climate risks.

86 Hong Kong SAR Water Supplies Department. (2023). Hong Kong: The Facts - Water Supplies. https://www.wsd.gov.hk/en/publications-and-statistics/pr-publications/the-facts/index.html

Rooted in current practice, the following process improvements will enhance appreciation for climate risk and produce better land use planning decisions in each region.

San Francisco Bay Area

Standardize and Localize Climate Risk Assessment: Use state, regional, and local resources to develop localized adaptation plans. In incorporating climate projections into land use plans, local government planners in the SFBA have an abundance of technical support available from various agencies and nonprofit organizations, including the Ocean Protection Council's sea level rise guidance, BCDC's Adapting to Rising Tides vulnerability assessments, and SPUR and SFEI's Operational Landscape Units (OLU) framework. While these assessments have been used in some local planning efforts, significant opportunities remain for using these resources to create local adaptation plans. In applying these resources to local planning efforts, there is a need to balance standardization of land use and infrastructure development decisions with allowing local actors to make their own judgments about risk tolerance and appropriate planning time horizons.

Ensure Sustainable Funding for Local Adaptation Planning: Shift from competitive grants to long-term funding streams that enable local governments to maintain in-house climate expertise and reduce reliance on short-term consultants. Translating climate projections and regional assessments into local-scale planning requires local capacity and resources that many jurisdictions lack. Current adaptation planning funding is largely from competitive grants, which are often inaccessible to resource- and capacity-constrained jurisdictions. While research suggests that adaptation planning works best when it is flexible and open to social learning,[87] planning offices in many communities are heavily reliant on consultants who operate on a project-by-project and contract-by-contract basis, making learning and adaptive governance very difficult. Regional, state, and federal agencies could establish mechanisms to provide local governments sustainable sources of funding to support building long-term localized expertise for climate adaptation planning.

Greater Bay Area

Collaborate Across Departments to Create Holistic Climate Projections: It is not yet clear if established channels of coordination exist among departments relevant to climate projections and land use planning in the GBA. For example, the Department of Meteorology is in charge of projections for extreme weather events, whereas the Department of Ocean Affairs is in charge of monitoring sea levels. Interviews suggest there is not yet robust collaboration between these departments. Planning to adapt to future climate change must consider the combined impacts of sea level rise with storm surges and extreme precipitation. Silos among departments in charge of different components of climate impact modeling may impede future decision-making.

Strengthen Coordination Between Meteorological and Land Use Departments: Establish formal working mechanisms for integrating climate and risk projections into land use planning. By emphasizing the need to develop climate models, the provincial and municipal FYPs on Meteorology and Climate Action as well as the *National 2035 Climate Change Adaptation Plan* policy demonstrate that leaders are well aware of the need for better climate projections to guide adaptation planning. These policies suggest there is great potential for progress in developing technical guidance to support cities' climate adaptation planning in the upcoming FYP period. Near-term mechanisms for coordination across institutions must be created to ensure that new climate projections are relevant and actionable for land use planning efforts.

87 Boyd, E., & S. Juhola. (2015). Adaptive climate change governance for urban resilience. *Urban studies*, 52(7), 1234-1264.

Align Long-term Planning with Climate Projections: Extend urban development and infrastructure planning horizons beyond 2035 to account for projected sea level rise and climate risks over 50 years. Land use and development decisions made now will create long-lasting risk well beyond 2035, the horizon year of the *National 2035 Climate Change Adaptation Plan*. It is therefore imperative that land use and infrastructure planning in the GBA account for climate projections further into the future. The timeline of FYPs and the common practice of setting concrete, achievable, quantitative targets in five-year increments make it difficult to consider medium- and long-term climate and SLR conditions for land use planning. Similarly, the short time span of the *National 2035 Climate Change Adaptation Plan* is encouraging local plans to focus on short-term actions without addressing long-term changes in the climate. While the rapid pace of urbanization in the GBA necessitates effective short-term planning, long-term projections should also be used to inform large-scale infrastructure and land use decision-making. Land use planning horizons could be extended to at least 50 years into the future to ensure that urban development accounts for climate and SLR conditions through the expected useful lives of housing and infrastructure projects built today.

SCALING UP NATURE-BASED SOLUTIONS FOR FLOOD RESILIENCE

Nature-based solutions provide multiple benefits including flood resilience, emissions reduction, and habitat quality. Both the SFBA and GBA are starting to recognize these benefits and are implementing flood hazard mitigation strategies, whether through national initiatives like the Sponge City Program or through new municipal drainage approaches such as the San Francisco Public Utilities Commission's green infrastructure program.

For both regions, challenges that need to be addressed include:

- Implementing NbS at scale
- Balancing natural ecosystem preservation with urban development
- Coordinating NbS interventions across jurisdictions
- Establishing governance frameworks suited to NbS interventions that are sited and designed for effectiveness, efficiency, and equity.

Based on the governance and land ownership systems in place in each region, the following actions are recommended to facilitate implementing NbS throughout the regions.

San Francisco Bay Area

Implement the Operational Landscape Units Framework for Shoreline Adaptation: Promote multi-jurisdictional NbS planning that aligns with ecological boundaries rather than administrative ones. The OLU framework described by SFEI and SPUR in their Shoreline Adaptation Atlas provides a spatial structure for nature-based flood resilience solutions based on ecological and urbanization features rather than existing administrative boundaries. While the OLU framework has been used by select local governments (e.g., the City of San Rafael), there have been few OLU-based collaborations across local governments (with the exception of the Oakland Alameda Adaptation Committee). Applying the OLU framework could facilitate cross-jurisdictional coordination and collaboration on shoreline adaptation measures that is more responsive to ecological conditions and processes.

Integrate Anti-displacement Measures in NbS Investments: Address "green gentrification" risks by pairing climate adaptation projects with affordable housing and anti-displacement policies. Socially vulnerable neighborhoods are often the areas most in need of adaptation investments like drainage

upgrades or ecosystem restoration. However, such improvements can lead to increases in housing prices and displace disadvantaged communities in a process called green gentrification.[88] The SFBA's pre-existing housing and gentrification crises require that nature-based solutions for climate change adaptation be coordinated with anti-displacement efforts.

Greater Bay Area

Mandate NbS in Large-scale Urban Development Projects: Embed Sponge City principles into regional infrastructure planning to maximize flood resilience while protecting natural ecosystems. Large-scale urban development holds many opportunities to incorporate Sponge City-standard drainage infrastructure and other nature-based flood adaptation measures. However, the pace and scale of these developments also threaten natural ecosystems and undermine their hazard mitigation functions. Regional government bodies such as the GBA Development Leading Groups could build on the policies used to coordinate regional infrastructure in the *GBA Outline Development Plan* to guide the planning and implementation of NbS in the region to ensure efficiency, effectiveness, and equity in building out such infrastructure at scale. Furthermore, while seizing opportunities to build out nature-based drainage infrastructure in large-scale urban development projects, regional planning processes for the GBA could also push local governments to incorporate ecosystem impacts in planning for the siting and design of large-scale developments.

Coordinate Flood Protection and Ecosystem Conservation Policies: Ensure that policies on shoreline conservation, wetland restoration, and flood defense are integrated in future Five-Year Plans to prevent conflict and maximize co-benefits. Currently, ecosystem preservation policies and flood protection policies are siloed and addressed in different FYPs. However, these policies intersect and sometimes come into conflict with each other during implementation. Future FYPs or local climate adaptation plans could coordinate policies across these areas to clarify infrastructure and natural shoreline preservation for different locations based on land use and ecological and geological conditions.

88 Anguelovski, I., J. J. Connolly, H. Cole, M. Garcia-Lamarca, M. Triguero-Mas, F. Baró, ... & J. M. Minaya. (2022). Green gentrification in European and North American cities. *Nature Communications*, 13(1), 3816.

6 / OPPORTUNITIES FOR COLLABORATION

Beyond this report's three core topics of regional planning, applying climate projections, and nature-based solutions, there are several cross-cutting concerns confronting planners and other actors seeking to advance flood resilience in both Bay Areas. Collaboration and exchange from government agencies, planners, designers, and researchers in both regions could enable each to set a strong foundation for equitable flood resilience in the face of sea level rise and other climate change impacts. Three additional areas that we regard as particularly ripe for trans-Pacific collaboration are: (1) synthesizing different types of knowledge; (2) adaptive governance; and (3) water-oriented urbanism.

SYNTHESIZING DIFFERENT TYPES OF KNOWLEDGE

Planning for climate change impacts demands a synthesis of a broad array of different forms of knowledge and analysis, from ecology and meteorology to urban design, engineering, and economic development. As such, adaptation research, planning, and action demands bridging across different government ministries and departments. In California, incorporating sea level rise projections requires applying projected sea levels onto landscapes and settlements with various types of infrastructures and buildings, each with their own levels of risk aversion, to decide which time horizons and sea level scenarios are appropriate for a given project. In this process, geophysical data are combined with financial and building and infrastructure information to inform planning. In China, recent policy documents for climate change adaptation planning have repeatedly emphasized the need for meteorological departments to develop climate models and provide data for land use and infrastructure planning purposes, suggesting that a new system of climate data communication and cross-department communication are likely on the horizon. Local and regional government agencies in both Bay Areas would benefit from learning about each other's experiences with synthesizing different types of knowledge to inform climate adaptation planning.

ADAPTIVE GOVERNANCE

Changing climate conditions are rendering historical urban planning approaches insufficient. Consequently, there have been growing calls to adopt new, flexible forms of governance to deal with the complex and dynamic nature of climate change and urban systems. Adaptive governance frameworks are designed to enable "adaptive response mechanisms for continuous testing, monitoring, and re-evaluation" to anticipate changes in complex systems and respond to uncertainties.[89] Government agencies across the two regions can share lessons learned and best practices for incorporating adaptive governance measures, such as land use planning regulations that are conditioned on future climate conditions and infrastructure development pursued iteratively to allow flexibility in accommodating climate-related uncertainties. Universities, think tanks, and non-profit organizations in the two regions can also join with government agencies in exploring how processes beyond formal government-led planning can enable greater flexibility in planning for changing conditions.

89 Boyd and Juhola. (2015).

WATER-ORIENTED URBANISM

The increasing intensity and frequency of flood events and sea level rise are challenging long-standing urban design logic, which requires keeping water out of settlement areas. Changing conditions require alternative settlement forms, land use practices, and infrastructural configurations that are better-suited to dynamic landscape and climatic conditions. Although both Bay Areas have long histories of living with and near water, neither has a model for high-intensity, adaptive water-integrated urbanism that allows settlements and rising waters to coexist. Vernacular forms of water-oriented urbanism exist in both Bay Areas. Water-based communities have long been a feature of the SFBA, from Indigenous coastal Miwok and Ohlone settlements along the Bay shores to contemporary houseboat marinas in Sausalito and Alameda. Similarly, the GBA has for centuries been home to water villages that integrate water landscapes into agricultural practices for farming shrimp and silkworms. However, these practices have been disappearing, as many ponds have been filled to make room for industrial parks and other urban development. Both regions can learn from past and present forms of water-integrated urbanism to reimagine a future that allows dynamic waters to be better accommodated in urban settlements. This is an area where urban designers, architects, and landscape architects in the two Bay Areas can communicate and collaborate, seeking creative solutions to preserve and create water-oriented settlements that satisfy current and future needs.

Designers in the two regions have started reimagining urban futures that are oriented toward living with water. In 2017, the Resilient by Design Challenge in the SFBA brought designers and planners together with consultants, local governments, and community groups to develop long-term sea level rise adaptation proposals for nine locations across the region. In Hong Kong, a collaboration between the University of Hong Kong and UC Berkeley was launched in 2018 to develop design proposals for resilience to stormwater and rising seas for Hong Kong's Kennedy Town neighborhood.[90] Building on such initiatives, joint exhibitions and design competitions could bring together researchers, practitioners, and students to raise awareness of alternative urbanisms to meet future demands under climate change. Design exploration for climate- and landscape-adapted urbanism will have its greatest impact if it is grounded in diverse urbanization and landscape contexts, land ownership, governance regimes, and cultural practices.

90 UC Berkeley College of Environmental Design. (2025). Pacific Rim Urban Resilience by Design. https://ced.berkeley.edu/work/pacific-rim-urban-resilience-by-design

7 / CONCLUSION

In this report, we analyzed efforts to adapt to climate change-linked flooding in two bayside regions, the San Francisco Bay Area in California and the Greater Bay Area in southeastern China, considering efforts by various levels of government as well as civil society organizations. With climate change and sea level rise, both regions face serious potential impacts to infrastructure and housing, displacement of people, disruption of regional economies, and damage to ecosystems. Local governments in both regions are now creating plans to adapt their vulnerable infrastructure systems and settlements to climate impacts.

To adapt urban areas to changing climatic and landscape conditions, cities and regions must share experiences and lessons learned. For the two Bay Areas, common challenges around regional-scale coordination, implementing climate-conscious planning principles and green infrastructure at scale, and adopting new modes of adaptive governance provide abundant opportunities for productive exchange. The two regions should build on the strong existing networks between Guangdong Province and the State of California to collaborate on climate change adaptation. In addition to many relationships across businesses, universities, and people across the two regions, the memorandum of understanding to collaborate on climate action between Guangdong Province and California and the sister State/Province relationship between Guangdong Province and the State of California provide a valuable foundation for exchange on climate adaptation planning.

Addressing climate change has become an issue of international and diplomatic importance between the U.S. and China. Much of this effort has focused on technological exchange in areas including electric vehicles, battery supply-chain improvements, low-carbon buildings, and the energy transition.[91] This analysis suggests that beyond green technology, the two countries and their “Bay Areas” have much to share regarding governance and planning for climate change adaptation.

91 Dai, F. (2022). US and China: climate collaboration on the ground. *Nature*, 610(7933), 630.

APPENDIX

TABLE A1 / Inclusion of flood mitigation and climate change adaptation topics in FYPs

Title (English)	Mentions Climate Change Adaptation	Mentions Resilience	Mentions Meteorological/ Natural Disaster Risk Assessments	Mentions Meteorological/ Natural Disaster Forecasting or Warning	Mentions Wetland Restoration	Mentions Sponge City
CLIMATE ACTION FYPS						
Guangdong Provincial Climate Action 14th FYP	Yes	Yes	Yes	Yes	Yes	Yes
Shenzhen Municipal Climate Action 14th FYP	Yes	Yes	Yes	Yes	Yes	Yes
Ratio of FYPs that include flood-related topics	2/2	2/2	2/2	2/2	2/2	2/2
METEOROLOGY FYPS						
Shenzhen Municipal Meteorology 14th FYP	Yes	Yes	Yes	Yes	Yes	Yes
Guangzhou Municipal Meteorology 14th FYP	No	No	Yes	Yes	No	No
Ratio of FYPs that include flood-related topics	1/2	1/2	2/2	2/2	1/2	1/2
WATER INFRASTRUCTURE FYPS						
Guangdong Provincial Water Infrastructure 14th FYP	No	No	Yes	Yes	Yes	No
Guangzhou Municipal Water Infrastructure 14th FYP	No	Yes	Yes	No	No	Yes
Shenzhen Municipal Water Infrastructure 14th FYP	No	Yes	No	Yes	Yes	Yes
Ratio of FYPs that include flood-related topics	0/3	2/3	2/3	2/3	2/3	2/3
ENVIRONMENTAL PROTECTION FYPS						
Guangdong Provincial Environmental Protection 14th FYP	Yes	Yes	No	No	Yes	Yes
Guangzhou Municipal Environmental Protection 14th FYP	Yes	Yes	Yes	Yes	Yes	Yes
Shenzhen Municipal Environmental Protection 14th FYP	Yes	Yes	Yes	Yes	Yes	Yes
Ratio of FYPs that include flood-related topics	3/3	3/3	2/3	2/3	3/3	3/3
ECOLOGICAL CIVILIZATION FYPS						
Guangdong Provincial Ecological Civilization 14th FYP	Yes	Yes	Yes	Yes	Yes	Yes
Guangzhou Municipal Ecological Civilization 14th FYP	Yes	Yes	Yes	Yes	Yes	Yes
Ratio of FYPs that include flood-related topics	2/2	2/2	2/2	2/2	2/2	2/2

TABLE A2 / Regional governance functions of climate change adaptation planning

Function[92]	San Francisco Bay Area	Greater Bay Area
Create shared vision, purpose, and future for the region	BCDC's first Bay Plan, published in 1969, established the first shared vision for the San Francisco Bay with policies on topics including bay fill, public access, and shoreline habitat. The Regional Shoreline Adaptation Plan being developed for the San Francisco Bay shoreline is an ongoing process for producing a region-wide vision The Resilient by Design Challenge, the design competition for long-term sea level rise adaptation solutions in nine locations across the SFBA, provided the opportunity to envision a resilient SFBA and build momentum for regional SLR planning through landscape design projects The OLU framework outlined in SFEI and SPUR's Shoreline Adaptation Atlas envisions an ecology-centered adaptative future for the SFBA	The National GBA Development Leading Group conducts strategic planning for the region The Guangdong Urban and Rural Planning and Design Institute is the provincial-level entity in charge of land use planning and design for the GBA, coordinating with municipalities on carrying out regional planning efforts
Create regional networks	BayCAN convenes local government members, periodically hosts webinars, and coordinates a bimonthly Equity Working Group BARC convenes regional agencies across various policy areas (ABAG/MTC, Bay Conservation and Development Commission, and Bay Area Air Quality Management District) to collaborate on region-wide challenges	Periodic meetings of the National and Guangdong Provincial GBA Development Leading Groups serve as platforms for provincial and municipal entities to communicate
Coordinate vertically among levels of government	SPUR advocates for regional planning policies at the state level (e.g., SB 272) and shares regional planning guidance with local governments Mandated by SB 272, BCDC's forthcoming guidance on shoreline sea level rise plans for local governments will guide local SLR plans to align with broader regional shoreline vision	National GBA Development Leading Group communicate central government direction to provincial entities (Guangdong, Hong Kong SAR, Macao SAR)
Coordinate horizontally across municipalities	BCDC's Regional Shoreline Adaptation Plan creates a comprehensive plan for the entire shoreline of the San Francisco Bay The Oakland-Alameda Estuary Adaptation Committee leads three subregional projects, including the Sub-regional Long-term Adaptation Plan and the Oakland-Alameda Estuary Adaptation Project	The Pearl River River Chief office provides a platform for River Chiefs of the Pearl River at levels of the province, city, county, and town to coordinate across jurisdictions on various water management issues

92 Citations to literature on each regional function can be found in Section 1.

TABLE A2 / Regional governance functions of climate change adaptation planning		
Function[92]	**San Francisco Bay Area**	**Greater Bay Area**
Coordinate across policy areas	BARC's Regional System Assessment for Adapting to Climate Change brings together planning and policy activities related to climate change impacts on shoreline infrastructure, transportation infrastructure, land use, water quality, and air quality	The National and Guangdong Provincial GBA Development Leading Groups allow representatives from provincial and municipal entities to coordinate across policy areas
Allocate resources	BCDC and MTC/ABAG's Sea Level Rise Adaptation Funding and Investment Framework (2023) Governor's Office of Land Use and Climate Innovation's ICARP grants incentivize regional and local climate adaptation planning SGC's Sustainable Communities Planning Grants and Incentives (SCPGI) Program to incentivize local climate adaptation planning BayCAN's Funding Tracker is a tool for local governments and community groups to find climate change adaptation funding resources	Various central government ministries in charge of specific policy areas handles allocation of resources to local governments; for example, the National Ministry of Housing and Urban-Rural Development (HURD) distributes funds for the Sponge City program through provincial departments and municipal bureaus of HURD
Reduce barriers to planning resources and information	BCDC's Adapting to Rising Tides regional *Sea Level Rise and Shoreline Analysis Maps* provide assessments of current conditions and projections of future conditions that local governments can use in their local planning processes. ART's Adaptation Roadmap: Advancing Local Sea Level Rise Adaptation provides local government planners and other practitioners a step-by-step guide to creating SLR plans BayCAN provides consulting services, an adaptation resource-sharing platform, and webinars OneShoreline assists San Mateo County municipalities with infrastructure project permitting SPUR assists local resilience planning through sharing planning guidance with local governments and providing technical assistance to community-based organizations SFEI and SPUR's Shoreline Adaptation Atlas provides technical assistance to local jurisdictions in the form of adaptation opportunities suitable to each OLU based on local ecological and geographical factors	