- National Academy of Public Administration (NAPA)
- Institute for Global Public Policy (IGPP), Fudan University

Research Report

Adapting to the Impacts of Climate Change

A Comparative Study of Governance Processes in Australia, China, and the United States

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Cosponsoring organizations

National Academy of Public Administration (NAPA)

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Table of Contents

Executive Summary

The impacts of climate change are increasingly evident and intense. Global reports of floods, wildfires, droughts and heat waves remind us that death and damage tolls are often shocking, even in localities where impacts are increasingly predictable. The December 2023 proceedings of COP 28 make clear that the challenges of adapting to impacts of climate change have emerged on center stage as a second priority comparable in importance to the continuing focus on mitigation – reducing emissions of greenhouse gases (GHGs).

The Intergovernmental Panel on Climate Change (IPCC) reports that "governance" is the sole "high-level constraint" in addressing "adaptation" to climate change in all parts of the world. How are governance systems, including their formal and informal elements, responding to this challenge? Are governments and other organizations adapting and changing traditional approaches to disaster relief? How effective will any new strategies be? Will transformative changes in existing governance systems be needed?

In thinking about these questions, we have found there is a distinct lack of efforts to engage in cross-national (country to country) comparisons. Assembling a team of Australian, Chinese, and American scholars and practitioners, we have sought to address this gap. To facilitate this effort, we have focused on the development of an analytic framework to allow for systematic comparisons of the responses different governance systems adopt to deal with the challenges of adaptation. In this first report on our work, we set forth the key elements of this framework and use it to make some initial observations about climate adaptation in Australia, China, and the United States.

Mitigation and Adaptation; Adaptation governance may require transformation of current governance concepts, assumptions, tools, and institutions.

From the vantage of governance, mitigation and adaptation present profoundly different (though of course related) challenges. Mitigation is systemic; reductions in emissions of GHGs anywhere will lower concentration of these gases in the Earth's atmosphere. Mitigation strategies are often industry or sectoral based: reducing fossil fuel consumption and increasing renewables in the energy sector; increasing reliance on electric vehicles and mass transport in the transport sector; greening the food and building sectors. The mitigation focus often corresponds with traditional government organizational structures, such as departments or ministries of housing, transportation, energy, or agriculture. The key to mitigation is to build the largest possible coalition of actors willing to join forces to reduce emissions of GHGs on a global scale.

Adaptation, by contrast, is place-based. The timing and intensity of extreme of events varies among localities, and even within them. Preparation requires fine-grained (and forward looking in light of climate change) data on precipitation and temperature at detailed temporal and spatial levels. To assess threats and vulnerability, similar details on local demography, topography, infrastructure, economy, ecology, and more are needed. Floods, for example, may ravage some parts of a city while leaving other parts of the same city unscathed; heat or fire impacts may vary with local demography, ecology, and infrastructure. Decisions on adaptation measures involve not only complexity and uncertainty, but also issues of equity and fairness. For example, which neighborhoods should be "defended", and which selected for "managed retreat." At the same time, climate impacts, such as floods, do not honor local jurisdictional boundaries. There must be coordination across governments, as well as with citizens and businesses.

Learning from Comparison: Points of Entry as a Framework to Begin With

In the 21st century, there is a global English "vernacular of governance." Students, teachers, and conference goers in Australia, China, the U.S., and elsewhere, use the same English terms, such as "governance," "rule of law," "policy," "NGO," "transparency," and "PPP." However, the meanings of such terms often differ from one country to another. In relation to environmental challenges, for example, the U.S. and Australia are "law centric." China today has many environmental laws, but policies (*zhengce*), such as Five-Year Plans and sectoral plans, and crisis management are dominant governance processes. Moreover, key terms and concepts, such as the role of the Communist Party of China, have no ready analog in the western governance context.

In this context, we have proceeded by identifying Points of Entry for Comparison of efforts of governance systems to address the challenges of climate adaptation.

Point of Entry 1 deals with core common governance tools - risk analysis and planning based on the analyses. We ask: "How are Australia, China, and the U.S. making use of risk analysis and planning procedures to meet the challenges of adapting to the impacts of climate change?" *While there are substantial differences among the three systems in these terms, we find serious limitations in efforts to make use of risk analysis and planning procedures in all three countries.*

Point of Entry 2 focuses on organizational arrangements. We ask: "Who is steering the ship?" *Here, again, there are substantial differences across the three cases. But they are all limited by common perspectives and practices associated with emergency management or disaster relief.*

We conclude that in all three systems there is a need for fundamental innovation to achieve success in adapting to the impacts of climate change.

This leads us in **Point of Entry 3** to explore strategies that governance systems can adopt to improve the effectiveness of their efforts to address the impacts of climate change. *In considering options for Australia, China, and the U.S., we consider four types of response strategies: (1) adjusting center/local relations to address climate impacts, (2) transforming cross-jurisdictional arrangements to address climate impacts, (3) guiding or cushioning major demographic and economic shifts, and (4) enhancing capacity to prepare for and respond to disaster.*

Next steps for Comparison

Drawing on our initial efforts to use this framework to evaluate the experiences of Australia, China, and the U.S. regarding climate adaptation, we identify three sets of priorities for the next phase of our work: (1) in-depth case studies of response strategies (e.g., efforts to address jurisdictional impediments limiting efforts to deal with flooding or the allocation of water), (2) crosscutting analyses of tools, resources, and processes (e.g., initiatives to overcome the limitations of risk analysis in addressing climate adaptation), and (3) deepening the framework by engaging more countries and colleagues (e.g., extensions to include efforts to address climate adaptation in developing regions).

We recognize that modesty in cross-national comparisons is in order. What works in one system or one time or locale in the history of a single system may not work well in others. At a minimum, however, we believe systematic comparisons will help to identify options for addressing the challenges of climate adaptation and pitfalls to be avoided to make the strategies selected effective.

I. The Governance Challenges of Adapting to the Impacts of Climate Change and Points of Entry for Comparison

The impacts of climate change are increasingly evident and intense. Mitigation in the sense of reducing emissions of greenhouse gases has been the priority in seeking global attention. However, increasing reports of devastation from heat waves, flooding, fires, and droughts are bringing the challenge of adaptation to the impacts of climate change to the forefront of policy agendas from local to global levels. Mitigation is global. Reducing emissions of greenhouse gases anywhere lowers the concentration of these gases in the Earth's atmosphere. By contrast, adaptation is local. Adaptation calls for reducing the vulnerability of human and natural systems located in specific places to the impacts of climate change or, failing that, improving our capacity to respond appropriately once the impacts occur.

How will governance systems, at various levels, come to terms with this challenge? Will differences among governance systems lead to the adoption of country-specific adaptation strategies? How effective will these strategies be? As these questions suggest, governance is key to addressing climate adaptation. The UN Intergovernmental Panel on Climate Change (IPCC) reports that across continents, "governance" is the one common "high-level constraint" in addressing "adaptation" to climate change (see Figure 1 Text Box below). So far, however, there appears to be only a limited focus on what may be learned by comparing emerging adaptation efforts across governance systems in different countries.[1]

Our work has the goal of accelerating learning by adopting a comparative perspective. We focus, initially, on how three countries – Australia, China, and the United States - address the challenges of adaptation. Our working hypotheses include: (1) differences in governance systems will produce differences in the strategies societies adopt to meet the challenges of adaptation and in the results flowing from their implementation; (2) whether or not "best practices" (subject to modification for

1 We have been able to locate limited concerted country to country governance comparison, as we seek to do here. However, we have benefitted from numerous adaptation governance related sources. In Appendix B we provide what we hope will be an expanding list of such resources. These include collections of country adaptation plans, case studies of local impact events, reports on adaptation resources (e.g., finance, data) and threats (e.g., heat, flood), analyses of potential sectoral impacts (e.g., food, energy, health, infrastructure), and check list/templates of considerations in addressing adaptation. The institutions engaged include international organizations, government agencies, profitmaking and nonprofit nongovernment institutions, communities of practice (e.g., "resilient cities"), and further networks.

local context) emerge, the effort at comparison should stimulate useful reflection on individual country systems; and (3) while countries differ in many ways, a framework for comparison can be used to engage with additional colleagues and countries to test and deepen understanding.

To explore these hypotheses, we formed an Australia/China/U.S. climate adaptation working group to compare how the three countries are approaching adaptation. We brought together scholars and practitioners from multiple disciplines. Lead sponsors are the U.S. National Academy of Public Administration (NAPA) and the Fudan University/London School of Economics Institute for Global Public Policy (IGPP). This project builds on work of an informal network of China, U.S. and global environmental governance scholars and practitioners initiated in 2007-8. We launched the current project with a fall 2021 virtual workshop introducing comparative perspectives through case studies from each country. We proceeded with continuing discussions and related research among group participants.

The next two sections of this Introduction provide essential background on (1) the concept of governance and the locally focused challenges of adaptation governance, and, in these contexts, (2) the need to develop "points of entry" to facilitate country comparisons. Parts II and III focus on points of entry for comparison involving core governance tools and organizational arrangements and strategies for responding to common challenges. The concluding part, drawing on prior sections, identifies a range of next steps for deepening comparative learning, including the engagement of colleagues from additional countries.

We present our main findings in the body of this report. We have assembled more detailed supporting materials in appendices.

A. Governance and the Local Focus of Climate Adaptation Governance

Governance, as we will use the term, refers to a society's efforts to steer the behavior of a variety of actors to produce outcomes beneficial to the collectivity. Actors include both government agencies (and officials) and non-state actors, including social groups, for-profit and non-profit enterprises, and individuals. Of course, there are substantial differences among countries in the formal (often legal) definitions of state and non-state status and in the boundaries between governments and non-state actors. Governance also includes informal institutions (for example, networks) and informal rules (for example, U.S. "industry practices," China *qian guizhi*/tacit or hidden rules, Australian institutional culture). These, as well, may vary in form and substance within countries.

We argue that governance at the local level is key to addressing adaptation. In contrast to mitigation in the sense of reducing emissions of greenhouse gases, adaptation centers on place-based or local knowledge and action.[2] Reducing emissions of greenhouse gases anywhere lowers concentrations in the Earth's atmosphere. By contrast, the number and degree of extreme climate change attributable events (e.g., floods, fires, heat waves) and slower-moving changes (e.g., sea level rise) vary from place to place. Impacts depend on how changes in local temperature and precipitation are managed in the context of many local factors. These factors include variations in topography, demography, economies, infrastructure, ecosystems, energy, health systems, considerations of equity, flexibility of systems to move from path dependency, and more. For example, a flood that wreaks havoc in one location may leave a close-by location unscathed.

Thus, adaptation choices on actions to be taken and tradeoffs to be made will require highly local assessments, with decisions on local action likely in need of support from higher levels of government. In many cases, these decisions will go to the heart of communities' viability, involving difficult choices about changes in land use and whether to "defend in place" (individuals remain in the face of impacts) or withdraw ("managed retreat").

There is a great deal of data gathering and modeling of hazards and potential impacts pertaining to geographic regions and sectors (e.g., agriculture, energy). However, as we will discuss, far fewer tools and data sets are available to support highly localized adaptation efforts. With mounting climate-associated disaster events, there are increasing case studies of local impacts and responses. Still, there is a notable gap in cross-national comparisons of approaches to governance, a gap this project seeks to begin to fill.

2 By local, we include subnational or regional risks and impacts-for example floods or rivers that cross jurisdictions.

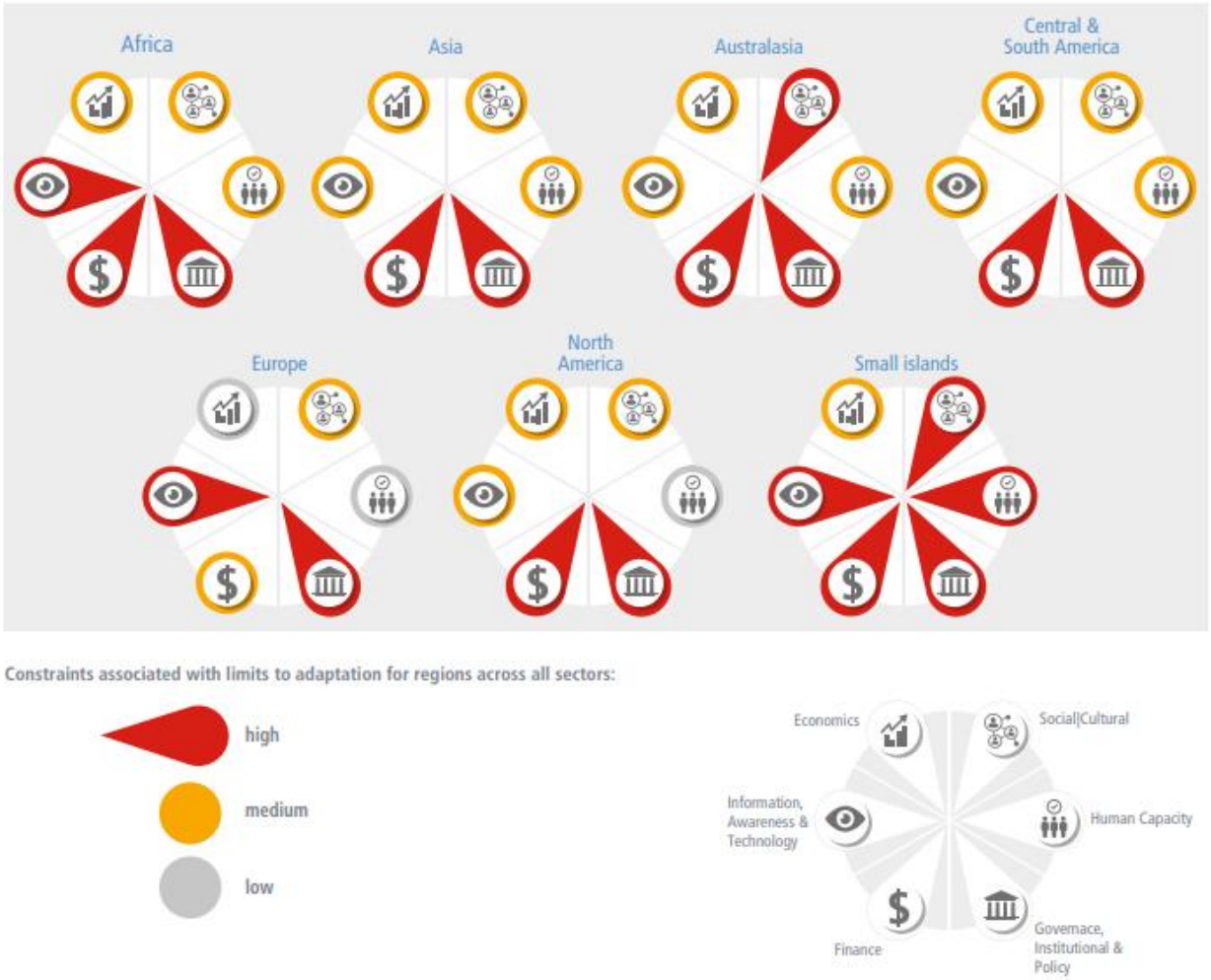

Figure 1: "Constraints that Make it Harder to Plan and Implement Adaptation:"
Note: The figure is from the Technical Summary of the Climate Change 2022: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the IPCC Sixth Assessment Report (Pörtner et al., 2022, p. 78).

B. Points of Entry for Comparing Governance Systems

To compare governance systems, we need to (1) select among numerous alternative potential starting points those most likely to serve as substantial building blocks for informative comparison; and (2) consider system differences to identify points of entry that provide "apples to apples" comparisons.

Governance practitioners and scholars identify a host of factors, oft interconnected, that are critical to effective governance, including adaptation governance. These include institutions (governmental and non-governmental), rules (laws, policies, processes), enablers (leadership, individual/corporate engagement), tools and resources (e.g., performance measures, money, human capital, data), sectors (e.g., land/ecosystem, energy, health, transport), and threats (e.g., heat, fire, flood, drought). All, today, come with underlying questions of ensuring equity.

The challenge of choosing among many factors to begin comparison is compounded by the oft different practical meaning of core governance terms among countries. There is a 21st century global English "vernacular of governance." Students, teachers, and conference goers in Australia, China, and the U.S. use the same English terms - governance, rule of law, policy, NGO, transparency, PPP, for example. *The Governance of China* is the English title of the volumes of Xi Jinping's collected works (Xi, 2014, 2017, 2020, 2022). However, such terms often have different practical meanings among systems. Moreover, there are key terms, for example the Communist Party of China, for which no ready western analog is available. In Australia and the U.S., electoral systems (and U.S. courts) have demonstrated distinctive ongoing impacts on government commitment to climate challenges.

These differences in local meanings play out in practical ways. With these differences in mind, this project builds on the work, since 2007, of an informal network that has sought to develop frameworks for comparing China/U.S./global environmental governance. (Guttman et al., 2021; Guttman & Song, 2007; Guttman et al., 2013; Guttman et al., 2018; Young et al., 2015; Zhao et al., 2020).

A first question the network asked was "if one wants to achieve environmental change in China or the U.S., what are the dominant environmental governance processes?" The U.S. is "law centric." Dominant processes are making laws in Washington (U.S. Courts, Congress, Executive Branch) and in states/localities (Federalism). China now has numerous environmental laws. However, dominant environmental governance processes feature: (1) periodic plans and other policies (*zhengce*) (technically not law under the "law on law" or *li fa fa*) and (2) crisis management (as exemplified in China's Covid response). In short, while the U.S. and China have numerous environmental laws, analyses that begin by comparing extant environmental laws may not be fruitful (Guttman & Song, 2007; Young et al., 2015; Zhao et al., 2020).

At the same time, formal differences may mask underlying similarities. Australia and the U.S. are Federal systems. China is a unitary system, with the Party governing throughout. However, all have long traditions of central/local governmental tensions and dynamics among localities that are highly relevant to governance.[3]

3 Chinese sayings with resonance in Federal systems include "*difang baohu*," ("local protectionism," both in relation to central government and other localities) and "*shang you zhengce xia you duice*" ("above is policy, below is countermeasure").

Our focus on adaptation adds a further layer of complexity to the effort to find points of entry for comparison. ***Adaptation governance may require transformation of current governance concepts, assumptions, tools, and institutions.***

From the vantage of governance, mitigation and adaptation present profoundly different (though of course related) challenges. Mitigation is systemic; reductions in emissions of GHGs anywhere will lower concentration of these gases in the Earth's atmosphere. Mitigation strategies are often industry or sectoral based: reducing fossil fuel consumption and increasing renewables in the energy sector; increasing reliance on electric vehicles and mass transport in the transport sector; greening the food and building sectors. The mitigation focus often corresponds with traditional government organizational structures, such as departments or ministries of housing, transportation, energy, or agriculture.

The potential need for transformation of core governance "tools" is further highlighted in comparison to longstanding governance challenges. For example, compared to adaptation, longstanding local efforts at economic growth permit relatively simple "performance metrics" (e.g., jobs added, tax base expanded, businesses attracted). Similarly, earlier environmental challenges (e.g., water or air pollution) provide relatively simple metrics (e.g., percent reduction in a pollutant), and may be matched to actions with relatively predictable consequences (e.g., installation of pollution control equipment). In such traditional contexts, success may be gained within the job tenure of local officials who initiate efforts.

By contrast, adaptation governance:

- Will engage complex interactions involving multiple social and natural systems;

- Will require decisions under substantial uncertainty. Large-scale investments portending deep changes in community life may be made with measures of success that may not be evident for years.

- Will likely produce winners and losers. Hard choices include, for example, whether and which individuals may need to move and at whose expense.

In this context, our effort to develop a framework for comparison begins by identifying and analyzing what we call Points of Entry (POEs) for Comparison.

In POE 1, we focus on the core governance tools of risk analysis and plans that will be essential for adaptation. The IPCC (UN Intergovernmental Panel on Climate Change) identifies adaptation risk

analyses and plans as the predicates for further adaptation action (implementation and monitoring). Thus, we ask: "What is the current state of adaptation focused risk analysis and plans in the three countries?" *We find substantial differences among the countries and, in all cases, substantial limitations.*

Turning to institutions in POE 2, we ask: "who's steering the ship?" This includes: "What are central and local government roles?" "How is organization for adaptation emerging in relation to traditional organization for event-based disaster response?" Are new forms of organization emerging to address adaptation? *Here, too, we find both substantial differences among countries, and also core inadequacies.*

In light of POE 1 and 2 conclusions, we ask in POE 3: "What are core common governance challenges that countries must address"? *We consider four types of common challenges and strategies to address them, and discuss their applicability in the three political settings.*

In our concluding section, we draw on these Points of Entry to identify next steps for work the project is beginning to undertake. Here, we have three interlocking foci: (1) deeper, comparative case study-based analyses of country approaches to the core governance challenges identified in POE 3; (2) crosscutting analysis of the role of core tools, processes, resources, and non-state institutional actors; and (3) testing the framework and broadening the comparison by engaging the experiences of additional countries.

II. Points of Entry for Comparison One and Two: Core Governance Tools and Organizational Arrangements

The UNFCCC (UN Framework Convention on Climate Change) characterizes the adaptation process as encompassing four components: (1) vulnerability assessment and risk analysis, (2) planning, (3) implementation, and (4) monitoring and evaluation (to which we further add policy learning) (See Figure 2).

For our first point of entry, we focus on the state of play regarding risk analysis and planning as the core tools that are essential first steps in this cycle. We emphasize, as the IPCC has, that there is too often a gap between risk analyses and planning, and implementation (Pörtner et al., 2022).

For our second point of entry, we turn to governmental organizational arrangements for adaptation.

The overall conclusion of this section is that existing tools and organizational arrangements for adaptation have severe limitations. This sets the stage for consideration of a third point of entry for comparison in the next section addressing core governance initiatives that may enhance the performance of adaptation.

For brevity, in this text we focus on country highlights, with some expanded case illustrations. We provide further background in appendices.

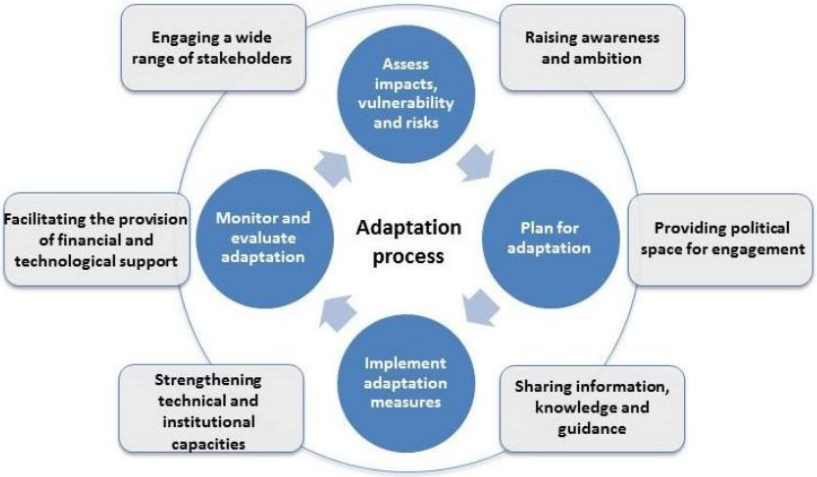

Figure 2: Adaptation Cycle under the UN Climate Change Regime (UN Climate Change, 2023)

A. POE 1: Risk Analysis and Planning

1. Risk Analysis is Difficult for Climate Adaptation

Widely used in a variety of settings, risk analysis has developed into a sophisticated and powerful set of tools. Adaptation risk analysis is a multi-step process featuring an analysis of the relevant threat(s), an assessment of the vulnerability of biophysical systems (e.g., land, water, plant and animal life) and social systems (e.g., infrastructure, energy, health) to the impacts of the threat, and consideration of the range of response options available. (Fischbach et al., 2018). Today, there are substantial limits on both adaptation risk analysis and local capacity to use these tools.

As applied to climate adaptation, especially at the local level, major limitations in conducting risk assessments include:

1. The Attribution problem: Can it be determined how much of what happens in the form of direct and indirect impacts is attributable to climate change and how much should instead be attributed to historic human conduct, such as allowing land development on land that has an historical record of floods? (Columbia Climate School, 2021; Columbia Law School Sabin Center for Climate Law, 2023; U.S. National Academies of Sciences Engineering and Medicine, 2016)

2. The Data problem: Developing data sets at the appropriate scale to capture localized, place-specific, and often spatially diverse phenomena such as extreme precipitation and its consequences is a work in progress, with differences in national resources and hopes but deep uncertainties about the role of new data technologies.

3. The Uncertainty problem: Predicting with some degree of accuracy the timing, location, magnitude, and duration of threats on a local scale is extremely challenging at this time, with further uncertainty about the prospects that new data technologies and resources may help reduce uncertainties.

4. The Capacity challenge: Local (government and individuals) capacity to make appropriate use of data and conduct analyses to support planning and implementation is currently a global challenge.

The attribution and uncertainty problems arise across levels of social organization, but the data problem is particularly challenging at the local level. It involves:

- The need for high levels of detail ("granularity") in spatial and temporal resolution of hazards. Local decisions to manage stormwater and flooding, for example, often require understanding of the frequency, intensity, and duration of precipitation at the neighborhood or even smaller levels.

- The need for knowledge of diverse local contexts and granularity regarding impacts. Assessments of vulnerability and impacts require data on local topography, land use, economies, ecosystems, infrastructure, demography, and more. As risk becomes more extreme and frequent, analysis becomes more complicated with the need to address potential "cascading impacts" affecting local energy, transport, health systems, environment impacts, food systems, local employment and businesses, and more.

Within these limits, there is variation among the three countries, particularly in the formal requirements for data collection, data management, and public access.

Australia

Australia's climate risk governance appears to be the most formally presented, when measured by laws and frameworks encompassing multiple levels of governance. We therefore treat Australia at greater length. In 2012, the Council of Australian Governments (COAG) declared that different levels of government and the private sector, "should continue to take responsibility for their own actions, assets, investments and risks while public actions and policies should be carefully targeted and should not undermine the incentives for, or capacity of, private parties to individually manage risk". However, in the period from 2013 to 2022, central government climate-related activities suffered under a conservative government that attracted support from climate skeptics. At one point, the parliamentarian who subsequently became Prime Minister, walked into Parliament with a lump of coal to demonstrate his affection for the product.

Following a change in government, the *Climate Change Act 2022*[4] provides for an Annual Climate Change Statement, issued by the Minister for Climate Change and Energy, that includes, *inter alia*, "risks to Australia from climate change impacts, such as those relating to Australia's environment, biodiversity, health, infrastructure, agriculture, investment, economy and national security" (Australian Government Federal Register of Legislation, 2023). The Climate Change Authority, an independent statutory body, is appointed to confer advisory functions to the Minister and issues an 'Annual Progress Advice Report' (Australia Climate Change Authority, 2022). The Minister's 2022 statement considers risk in the context of disaster response and government operations, acknowledging more needs to be done to understand and communicate risk (Australia Department of Climate Change Energy Environment and Water, 2022). The new central government's first budget in October 2022 allocated funds for the development, over two years, of Australia's first National Climate Risk Assessment and National Adaptation Plan.

A biennial State of the *Climate Report* has been issued since 2010 by the Bureau of Meteorology (BoM) and the Commonwealth Scientific and Industrial Research Organization (CSIRO), which play "crucial roles in monitoring, analysis and communicating current and future change in Australia's climate." (Australia Bureau of Meteorology, 2022). The biennial report includes information on monitoring, observations and projections, and the *Climate Change in Australia* website provides related models and regional projections (Australia Bureau of Meteorology, 2023).

4 Climate Change Act 2022 C2023C00092 Act No. 37 of 2022 as amended, taking into account amendments up to Safeguard Mechanism (Crediting) Amendment Act 2023.

In July 2021, CSIRO, BoM, Geoscience Australia and the Australian Bureau of Statistics (ABS) created the Australian Climate Service (ACS), following 2019-20 bushfires and the subsequent work of the Royal Commission on the National Natural Disaster Arrangement (Australian Climate Service, 2023a). ACS is to provide improved data, intelligence and expert advice on climate risks and impacts to support and inform decision-making. It is an important contributor to the National Climate Risk Assessment. ACS assesses exposure and vulnerability across four dimensions: social environment, built environment, economic environment, and natural environment. Geosciences Australia contributes to ACS risk assessment through satellite, terrestrial and hydrological monitoring of Australian land, water and ocean systems. The Australian Bureau of Statistics brings social and economic data to the ACS on "who is potentially exposed [to climate change] and how vulnerable they may be to natural hazards." (Australia Bureau of Statistics, 2022).

Under the COAG model, states and territories are to collaborate with national government to develop regional climate projections, climate change impact modeling, and reporting. Individual states have legislation to support action on climate change, although not all appear to have produced local area risk analysis.

China

A 2021 report on China climate risk management summarizes (Qi et al., 2021): (emphasis added)

> *"(1) The concept of climate risk management has not been fully integrated into the national governance system.*
>
> *"At present, the awareness of climate risk among governments at all levels and other stakeholders is still low, which affects mainstreaming of climate risks. Most climate risk management measures taken by the government are sectoral measures, and there is a lack of comprehensive, systematic, and integrated thinking to guide climate risk management. It is imperative that the Chinese government take a holistic approach to climate security, and adjust and optimize the functions of related departments from the overall perspective of climate risk management …"*

In China currently, adaptation-focused risk data generation and analysis appear to be limited, particularly in relation to public availability. In 2020, the State Council launched a first nation-wide campaign for climate-related information collection, the National Census on Natural Disaster Risks. This campaign aims to collect nationwide information on seven major categories, including numbers of past natural disasters, how local governments dealt with these disasters, evaluation of

future risks faced by cities, local governments' response capacity to natural disasters. By the first half of 2023, the campaign has been initially completed, generating over one billion entries of disaster-related data. Initiated by the central government, the campaign was implemented by local governments. However, a review of the Census's official website showed that limited detailed local data has been publicized.

Another related policy calling on China localities to develop adaptation-related data is the National Emergency Response System Plan under the 14th Five-Year-Plan (NERS Plan), issued by the National Development and Reform Commission in March 2022. Serving as an overarching plan to navigate the country's risk management and emergency response system building, the NERS Plan specifically asked cities to build risk monitoring and early warning platforms (China National Development and Reform Commission, 2022). The platforms should be responsible for risk-related data collection, risk assessment, and risk early-warning.

United States

In the U.S., climate data bases and modeling tools are being developed rapidly by government agencies, universities, research institutes, networks, and private firms (on a proprietary basis). Data and tools include a focus on temperature and precipitation, but also threats, such as wildfires, urban heat, coastal flooding, and sectors (e.g., energy, agriculture, ecosystems).

"Climate.gov," a website of The National Atmospheric and Oceanic Administration (NOAA), includes a "resilience toolkit," with links to an extensive collection of case studies, courses, experts, climate maps and further data sets (U.S. Climate Resilience Toolkit, 2023). Many other federal and state agencies and nonprofits have public websites on adaptation-relevant data and expertise, for example, the U.S. Environmental Protection Agency's "Climate Adaptation Change Resource Center-ARC X" (CMRA, 2023; U.S. Environmental Protection Agency, 2023).

NOAA's Climate Adaptation Partnership (CAP) program, initially established in 1995 under the name of Regional Integrated Sciences and Assessments (RISA), has specifically fostered the co-development of many data tools designed to assist communities in their understanding of vulnerabilities and risks to wild fires, flooding, extreme weather, and other climate-related disruptions (U.S. Climate Program Office, 2023).

The U.S interagency Federal Geographic Data Committee (FGDC), established formally in 1990, sets data standards for spatial data, central to the processes of vulnerability assessment and risk analysis for climate adaptation (U.S. Federal Geographic Data Committee, 2023a). The 2018 Geospatial Data Act updated FGDC's authorities for coordinated management of a national

geospatial data infrastructure (U.S. Federal Geographic Data Committee, 2023b). Under the Act, a government website organizes and makes publicly available over 100,000 spatial data sets.

Despite the resources available at a regional and national scale, data appropriate for local climate risk analysis and action are often missing. For example, a 2022 RAND Corporation report for the U.S. Federal Emergency Management Agency (FEMA) summarizes both the limits of data and analysis and the limits of local capacity to use it, using the example of urban flooding (emphasis added) (Clancy et al., 2022):

> *Simulation models applied to hazard risk can require significant time, resources, and expertise to develop, calibrate or validate, and update. This is especially true as higher spatial and temporal resolution is included in such models*. Local planners often need high spatial and temporal resolution to provide estimates relevant for policy and investment decisions. For example, coastal cities faced with "compound" flood threats from SLR [sea level rise], high tides, and rainfall combined might need complex two-dimensional models and emerging statistical analytic methods to understand present and future flood exposure. *To date, however, only a handful of cities have had the capacity and resources to produce such estimates* (Dewberry, 2023; Groves et al., 2018).

Summer 2023 U.S. disasters punctuate the limits of current data and analysis. As a July 2023 New York Times headline put it: "Vermont Floods Show Limits of America's Efforts to Adapt to Climate Change: The lack of a comprehensive national rainfall database and current flood maps hampers the ability to prepare for storms intensified by climate change" (Flavelle & Rojas, 2023).

Summary

While governmental and non-governmental actors in Australia, China and the U.S. are increasing efforts to assemble data sets and conduct risk analyses relating to climate change at a regional scale, policymaking, decision-making, and implementation at the local level are hindered in their efforts to address the impacts of climate change because of the pervasive lack of actionable data and analysis at appropriate spatial and temporal scales. Ongoing impacts, as we will discuss, highlight limitations where risk analyses and plans have, at least on paper, been developed.

Stepping back from Australia, China and the U.S., it is essential to note that risk analysis challenges are far greater in developing countries, with their far more limited resources. For example, the extensive 2022 report of the Global Center on Adaptation on Africa "adaptation acceleration" efforts repeatedly highlight constraints imposed by absence of "granular" risk data. The report

proposes use of an alternative "rapid climate risk assessment" and proposes a focus on "no regrets" actions likely to be of value in most/any case (Global Center on Adaptation, 2022) section II, Part B).

2. Adaptation Plans (and Implementation) are Under-Developed

Turning to adaptation planning in Australia, China, and the U.S., *our overall conclusion is that there are severe shortcomings in efforts to plan for adaptation at the local level in all three countries, much less in the phase of implementation. But the sources of these limitations differ substantially across the three countries.*

Plans, including the planning process, are another core adaptation tool. As the IPCC highlights, however, there is great variation among plans ranging from those that are plans in name only to plans that reflect serious efforts to come to terms with challenges and on to plans that are linked to well-funded implementation and evaluation programs. While many cities now have adaptation plans, the IPCC has found, with "high confidence" that "… few of these plans have been implemented, and of these fewer still are being developed and evaluated through consultation and co-production with diverse and marginalized urban communities" (Pörtner et al., 2022).(IPCC AR6 2022 Technical Summary for Working Group 2 notes, at TS.D. 14; see also TS.D. 6.2).

To begin, we draw on the framework proposed by the comparative environmental governance network mentioned earlier. In Australia and the U.S., environmental governance systems are "law centric." Plans are called for by laws, as in the case of U.S. Federal air and water laws. While China has many environmental laws, the dominant processes for making changes in environmental governance have been periodic plans and crisis management. Thus, we might expect planning for climate adaptation to be more advanced in China than in Australia and the U.S. But this is not the case.

Australia

Australia, as noted, has the most formal (and law based) multilevel government framework expressly for climate. In 2021, Australia issued a *National Climate Resilience and Adaptation Strategy 2021-2025* (Australian Government, 2021). It has currently embarked on a two-year program to prepare a National Climate Risk Assessment and National Adaptation Plan. This work is scheduled for completion by the end of 2024. The project is being led by the Federal Department of Climate Change, Energy, Environment and Water with the Australian Climate Service. Work on the adaptation plan was due to commence in July 2023 and would run in parallel with the risk assessment (Australian Climate Service, 2023b).

Plans continue at the local level. Using the State of Victoria as example, the *Climate Change Act 2017* (Vic) contains in Part Five specific requirements for adaptation action plans. This includes requirements for a statewide climate change strategy that address adaptation and emissions reduction. The Act also requires that individual ministers prepare adaptation action plans for seven designated systems that must meet specific requirements.[5] Beyond these requirements, the State has developed five community-led regional adaptation plans. Foerster and Bleby (2023) argue the Victorian legislation is one of the first examples of climate mainstreaming in the way it specifies climate considerations in decision-making.

At a municipal level, the City of Melbourne's risk analysis and planning documents include, "Climate Change Adaptation Strategy 2009," "Adaptation Action Plan 2010," and "Climate Adaptation Strategy Refresh 2017." (Melbourne Department of Environment Land Water and Planning, 2021; Victoria Department of Environment Land Water and Planning, 2021). In addition, one of the State's six community-led regional adaptation plans provides an adaptation framework for the Greater Melbourne urban area. Plans are also evident in smaller regional localities. For example, rural Strathbogie Shire, with a population of about 10,000, produced a 2022-2027 "Climate Change Action Plan" focusing mainly on mitigation, but also somewhat on adaptation (Strathbogie Shire Council, 2022).

China

China published a national adaptation strategic plan in 2013 (Grantham Research Institute on Climate Change and the Environment, 2013). In June 2022, a further National Strategy on Climate Adaptation 2035 was issued by the Ministry of Ecology and Environment (MEE) and 16 other central government agencies. The 2022 strategy explains that the country will seek to build a climate-resilient society by 2035, with significant improvements in its ability to adapt to climate change (China State Council, 2022). In contrast to the prior adaptation strategy, whose primary aim was to raise awareness of climate adaptation science among the public and to officially publicize China's national stance on adaptation, the 2035 strategy emphasizes policy implementation, mandating that all provinces draft provincial action plans for adaptation.

The MEE has also published technical guidelines to support provinces in preparing their action plans and will organize an assessment of the provincial plans for quality assurance purposes. In

[5] Adaptation action plans must be prepared for the following systems: the built environment, education and training, health and human services, natural environment, primary production, transport, water, and any other prescribed system (Clause 35, Division 2, Part 5 of the *Climate Change Act 2017* (Vic).

particular, the MEE makes it clear that the provincial plans should be action plans instead of strategic plans, the difference mainly lying in the level of detail required and the inclusion of quantitative performance metrics in the former to facilitate implementation. Approximately 2/3 of the provinces are on track to finish planning by the end of 2023, with the rest expected to finish by the first quarter of 2024. Sichuan was the first Chinese province to publish its adaptation action plan (in April 2023), possibly due to the large potential climate change impacts on the province.

As China moves beyond national adaptation strategic planning to provincial action plans, the country has maintained and will further expand the scope of adaptation experiments or "pilot projects" (*shi dian*). Local experiments have been prominent in PRC economic development. "Town and village enterprise" experiments fueled the late 20th century "opening up and reform" economic growth model (Oi, 1999). In the 21st century, China has engaged in a series of centrally steered environment pilot projects, including eco-cities, eco-industrial parks, circular economy/waste reduction projects, sponge cities, and emissions trading (Cui et al., 2021; Larson, 2009; Li et al., 2022; Lin et al., 2021; Young et al., 2015).

In 2016, China formulated the Urban Action Plan for Climate Adaptation. In 2017, the National Development and Reform Commission and Ministry of Housing and Urban-Rural Development initiated the adaptation pilot projects with a *Notice on the Pilot Program of Building Climate-Resilient Pilot Cities*. Twenty-eight cities were selected as the first batch of the climate-resilient city pilot, representing different geographic areas, sizes, and different types of climate change risks. While 28 cities were selected as pilots, our research team found public documents on only nine. Among these, contents and details vary significantly. It is noteworthy that each pilot city is required to make an action plan for urban adaptation to climate change based on climate change impact and vulnerability assessment.

In reality, although the pilot cities have made adaptation action plans, these plans are characterized as "rudimentary" by researchers, primarily due to the lack of scientific risk assessment methods (Li et al., 2020). For instance, pilot cities' risk assessments mainly draw on historical trends instead of employing professional risk assessment methods (e.g., scenario analysis). Therefore, they have identified climate risks that have previously led to disasters such as droughts or waterlogging, but other risks that have not yet manifested might have been missed. Moreover, most findings of the risk assessment conclusions are rather general and not targeted at specific industries, regions or groups of people. As previously noted, this is in part due to the lack of data as well as capacity for data analysis. Qingdao, a coastal city in Shandong Province, appears to be the only city that has engaged in comprehensive adaptation planning, based on research findings from its participation in the Adapting to Climate Change in China (ACCC) phase II.

In addition to adaptation planning, climate-resilient pilot cities in China are supposed to take adaptation actions that seek advantages, and avoid disadvantages, of climate impacts. These include taking into account climate change in urban planning; improving urban monitoring, early warning and emergency response capabilities; carrying out adaptation actions in key areas such as infrastructure, water resources, natural ecosystems, and public health; exploring innovative systems and mechanisms for climate change adaptation and strengthening international exchanges and cooperation in climate change adaptation. According to a survey-based program evaluation conducted by the National Center for Climate Change Strategy and International Cooperation (NCSC) [6], overall the first batch of climate-resilient pilot cities have made only moderate progress in terms of adaptation capacity.

Although the pilot cities have raised awareness of adaptation, improved their climate impacts monitoring capacity, and taken engineering measures to strengthen adaptation capacity, top-level policy design for adaptation remains inadequate, and city leadership still has limited understanding of adaptation compared to mitigation (Fu et al., 2020; Lin et al., 2021). In August 2023, the MEE along with seven other ministries in China issued the Notice on Deepening the Climate-Resilient Cities Pilot Program, inviting all cities, including those that participated in the first round of the pilot program, to apply by October 2023. The goal is to expand the number of climate-resilient pilot cities to around 100 by 2030. In this second round, the MEE will increase its guidance to the pilot cities, regularly track the progress of the cities, and promptly summarize and evaluate some good concepts and practices generated during the pilot process.

In addition to the "climate-resilient cities" pilot program, another "resilience" focused program is the national sponge city pilot program launched by MOHURD (Ministry of Housing and Urban Development) in two batches in 2015 and 2016, which aimed to enhance cities' resilience to flooding and waterlogging by renovating and building drainage infrastructures that act as sponges (UN Environment Programme, 2019). The sponge city pilot program took a carrot and stick approach by providing a subsidy to each pilot city and enforcing program compliance through target setting and a rigorous performance evaluation and assessment mechanism. On the other hand, the climate-resilient cities program encourages pilot cities to self-finance relevant projects and does not set quantitative targets or performance evaluation systems. Instead, every climate-resilience pilot city may propose and enforce its own targets and performance evaluation systems.

6 NCSC is the MEE think tank *(shi ye danwei)* focused on climate policymaking.

In sum, in China there appears to be a limited number of (at least publicly available) adaptation-focused local plans and limited public information on pilot adaptation projects (with project plans).

United States

The U.S. has no formal system for multilevel government adaptation plans. Plans are increasingly being produced by states and localities but in their form and substance tend to reflect the particular priorities for risk reduction in their region. While the Federal Emergency Management Agency (FEMA) requires every community to have a Hazard Mitigation Plan as a condition for receiving federal grants, FEMA has yet to issue directives on how these plans should incorporate and address future climate risk (U.S. Federal Emergency Management Agency, 2023). The U.S. does not have a national adaptation plan. Indeed, it is unclear what such an adaptation plan would even look like, given the highly heterogeneous nature of the country and the centering of land use decision-making at the state and local levels. On taking office, President Biden issued an Executive Order calling on Federal agencies to develop adaptation plans consistent with their statutory missions, and a "whole of government" approach to climate change (U.S. Government White House, 2021a). In October 2021, the White House announced the release of more than 20 agency adaptation plans (U.S. Government White House, 2022). In June 2023, the White House announced "The National Climate Resilience Framework" (U.S. Government, White House, 2023).[7]

U.S. climate adaptation planning at the regional and local level is taking place in the absence of a Federal legislative mandate. The Georgetown University Climate Center compiles adaptation plans from states and localities. The Center's website indicates a majority of states do not yet have adaptation plans at the state level. About a dozen have adaptation and/or broader climate plans that include adaptation. Nonetheless, within the great majority of states, many local plans have been developed, even in the absence of a state plan (Georgetown Climate Center, 2023b) and many states have large-scale adaptation efforts even if not collated into a single named plan.

Local plans vary considerably in scope, embeddedness of risk analysis, and recency. Many address "climate action" more generally, with core focus on greenhouse gas reductions. The climate focus may, in turn, be part of a still broader focus on local "resilience" (*Ibid.*)

Plans exist in many larger urban areas, but also smaller locale where climate impacts are anticipated or already felt. Some plans note that climate change may provide opportunities as well as challenges. For example, Rochester, New York (with a declining population of about 200,000)

[7] "The National Climate Resilience Framework" (https://www.whitehouse.gov/wp-content/uploads/2023/09/National-Climate-Resilience-Framework-FINAL.pdf).

issued a 2017 "Climate Vulnerability Assessment Report" (City of Rochester.gov). The report explained that one challenge facing the city may be "in migration" by "climate refugees," given Rochester's relatively favorable climate prospects (City of Rochester, 2023).[8]

Summary

In sum, adaptation to the impacts of climate change poses special challenges for the planning process which precedes implementation of adaptive measures. Beyond the requirement of risk analyses as predicate for planning and the need for financial as well as technical support, there is the question of "performance metrics" (*mu biao* in China plans). How will traditional concepts of performance measurement need transformation to deal with the uncertainties and time scales of climate impacts? (Boltz et al., 2022).

Finally, of course, it is one thing to create adaptation plans on paper and publicize them; it is far more challenging to mobilize the organizational capacity and resources required to implement such plans effectively. Efforts to make use of tools like risk analysis and planning unfold within complex organizational structures which provide the setting for plan development and implementation. To make progress in understanding this nexus, we turn in the next subsection to the organizations in place in Australia, China, and the U.S. that are in a position to take operational responsibility for coming to terms with adaptation to the impacts of climate change.

B. Point of Entry Two: "Who's Steering the Ship?"

In all three countries, there are traditions (covering millennia in China) of government organization to address natural disasters, such as floods, droughts, earthquakes, and wildfires. Climate impacts, however, include impacts that evolve incrementally, such as sea level rise, and more frequent and extreme versions of traditional events (e.g., once in 100/500-year floods), all with the potential of "cascading" beyond historically experienced events.

In all three countries, organization for adaptation is a work in progress. Initial points of comparison include: (1) while there are now laws and/or policies on climate, the laws or policies by which responsibility for adaptation is centrally assigned have yet to be integrated with traditional natural disaster crisis management, (2) current events show that traditional crisis

[8] The Rochester Climate Vulnerability Assessment Report explains, "For instance warmer winters may allow for a longer construction season or help boost tourism… Shifts in climate may also enable introduction of new crops and even longer growing seasons… In fact, the City of Rochester has recently experienced an influx of climate refugees from Puerto Rico as a result of Hurricane Maria in 2017…"

management is not adequate to prepare for and respond to climate impacts, and (3) as local climate impacts occur, the role for local initiatives is increasing in scale and urgency.

An overall conclusion that emerges is that organizational arrangements designed to deal with the challenge of climate adaptation are rudimentary in all three countries. Problems of institutional fragmentation and inadequate coordination across levels of governance abound. The restorative perspective embedded in most disaster relief programs may be counterproductive in efforts to address the impacts of climate change.

1. Climate Change Adaptation Is Now Formally Recognized to Some Degree in Central Government Organization

All three countries have recognized climate change as a core public challenge, but with substantially varying organizational approaches and differing approaches to adaptation.

Australia

The current Australian Federal government, which came into office in late 2022, has initiated a reorganization to address climate change, including adaptation. The eight prior years of Commonwealth government produced few adaptation initiatives. On July 1, 2022, two new federal Departments were created, the Department of Climate Change, Energy, Environment and Water (DCCEEW) and the Department of Emergency Management. DCCEEW has multiple responsibilities, including 'climate change strategy and coordination' (Australia Department of Climate Change Energy Environment and Water, 2023b). Prior to the change of federal government, it was often left to state governments, the private sector and civil society to lead on climate change. The public service requires considerable 'catch-up' in terms of both leadership and resources. This gap is attempted to be filled by philanthropy, such as The Minderoo Foundation, that is funding resilience within Australian communities (The Minderoo Foundation, 2021).

China

In 2007, following 2006 leadership's declaration that China's development would promote "ecological civilization" (*shengtai wenming*), China's State Council established the Leading Group on Climate Change, Energy Conservation, and Emission Reduction.9 With the State Council's 2018

9 In China, the creation of a leading group, comprised of Ministers (or other senior officials) of agencies relevant to a challenge is taken as a signal that a challenge has attained highest level leadership attention.

reform, the function of addressing climate change was moved from the National Development and Reform Commission (NDRC) to the newly formed Ministry of Ecology and the Environment, and the work of the Leading Group is now shared by NDRC and MEE. Specifically, the NDRC now leads efforts on carbon emissions peaking and carbon neutrality, but adaptation and detailed design and implementation of mitigation measures remain the responsibility of the Department of Climate Change of the MEE.

United States

Responsibility for adaptation is dispersed. President Biden's January 27, 2021, Executive Order called for a "Government-wide approach to the climate crisis." This includes "increasing resilience in response to the impacts of climate change." The White House Office of Domestic Climate Policy was created to coordinate government-wide activities. The Office is headed by a Climate Policy Advisor/Assistant to the President. The Climate Policy Advisor chairs a Task Force comprised of 21 heads of agencies including the Departments of Defense, Interior, Treasury, Health and Human Services, Labor, Justice, Commerce, Homeland Security, and EPA (U.S. Government White House, 2023).

2. Traditional Disaster Preparedness and Response Management are Inadequate to Deal with Emerging Climate Impacts

In all three countries, there are long traditions of central engagement with local agencies in disaster management. One of the challenges is to integrate disaster preparedness and response with the demands of adaptation. For example, the restorative perspective embedded in most disaster relief programs may be counterproductive in efforts to address the impacts of climate change. A second challenge is to address the current inadequacy of traditional disaster preparedness and response management organizations in responding to climate impacts.

Australia

More Australian localities appear, in comparison to localities in China and the U.S., to be leaders in adaptation planning. However, responses to recent flooding and wildfires have been deeply lacking. The Royal Commission inquiry following the disastrous 2019–2020 Australian bushfire season found significant shortcomings with national coordination of disaster response. This led to a succession of emergency management agencies. The National Recovery and Resilience Agency was established in 2020. In August 2022, that agency was merged with Emergency Management Australia to become the National Emergency Management Agency (NEMA 2022) within the Federal Department of Home Affairs (NEMA 2022). NEMA was intended to “provide a strategic

approach to crisis planning and response, working in collaboration with State, Territory and Municipal governments, industry and civil society." A parliamentary inquiry into the response to the catastrophic 2022 floods in northern New South Wales found agencies failed to coordinate and integrate available resources and failed to engage stakeholders. The inquiry recommended a restructuring of the state emergency services (Australia Parliament of New South Wales, 2022).

Notwithstanding adjustments in the Australia law and institutional framework, a key limitation of the current governance regime is the rigid division of labor across actors and capacity for integration and flexible coordination across levels and sectors. The roles and responsibilities of various levels of government have remained mostly unchanged since the 2012 COAG conception, with the federal government delegating the bulk of adaptation responsibilities – including actions related to infrastructure, emergency services, health, natural environment, planning, and transport – to state governments. State governments frequently distribute these responsibilities across multiple existing departments and pass them on to local governments, with weak mechanisms for coordination across units or levels.

The Australia federal government elected in 2022 continued the trend of incremental structural changes, including the creation of new departments. This is evident in the work of the Australian Climate Services and the Department of Climate Change on a National Climate Risk Assessment and Plan (Australia Department of Climate Change Energy Environment and Water, 2023a). The funding is relatively small, and the government has made no commitment to funds for implementation of the national plan it is currently preparing. Whether these structural changes significantly enhance adaptive capacity (e.g., raising adaptation awareness and ambitions, mobilizing resources, better coordinating effects across boundaries and levels, or creating more transparency about adaptation efforts and their impact) remains to be seen.

China

China is a civilizational leader in governmental (and societal) preparation for and response to natural disasters. For millennia, leaders and peoples have known there will be floods on the great rivers, earthquakes, and droughts (Elfven, 2006; Marks, 2011; Mostern, 2021; Pietz, 2015). China today has a system of meteorological disaster risk management under the authority of the Ministry of Emergency Management (MEM), with a division of responsibilities among the relevant departments and local governments and society participation. Within MEM coordinating components include the National Committee for Disaster Reduction (NCDR), the National Headquarters for Flood and Drought Control (NHFDC), and the National Headquarters for Forest

and Grassland Fire Prevention (NHFGFP). (See, Qi, Zhou, Zhao 2021 for organization chart details).

When measured by limitation of fatalities, modern disaster management might be seen as highly effective. The death tolls from the late 1800's and 1930's Yellow River floods were in the hundreds of thousands (Pietz, 2015; The Economist, 2022).[10] However, 21st century developments show continued inadequacy of disaster preparation and response.[11] For example, the 2021 flooding in the central plains transport hub city of Zhengzhou led to close to 400 deaths, including deaths in flooded subways. The Zhengzhou flood followed on a 2012 Beijing flash flood which killed 79, collapsed over 10,000 houses, and did substantial property damage. The post 2012 Beijing disaster analysis, it was hoped, would lead to improved response preparation, including in locales such as Zhengzhou (Qi et al., 2021; Zhao et al., 2022; Zhao & Qi, 2023). In summer 2023, however, Beijing urban flooding caused further deaths as well as destruction (Conroy, 2023; McDonnell, 2023; Wu, 2023). In 2022-23, floods caused deaths to people and livestock and damage in multiple provinces (Caixin Global, 2023; CGTN, 2023; Hong, 2023; Reuters, 2023; Tsui & Livingston, 2022; Zhang, 2022). Extensive flood-related property damage continues.[12]

A 2021 review of the 2012 Zhengzhou case summarizes the shortcomings of the disaster preparation and response system to 21st century challenges (Qi et al., 2021). The Zhengzhou case:

> demonstrates the following weaknesses in China's urban meteorological disaster risk management system: poor risk communications, disconnections between meteorological warnings and government responses, low risk perceptions of extreme weather events, and inadequate contingency plans. Accordingly, China's current urban meteorological disaster risk management system is insufficient and must be adapted to the fast-changing climate.

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10 The 1938 flood was caused by the destruction of dykes in Henan Province by the Kuomintang in an effort to slow Japanese Army advance in the Sino-Japanese war.

11 As noted, one core question in the study of attribution is the extent to attribute damage to climate or to prior manmade disaster response (for example infrastructure development).

12 The *Economist* reports that government flood management efforts have reduced death rates in recent years, but uninsured property damage continues to mount: (*The Economist,* 2022)

"And although China has reduced deaths from rising waters, it is poorly prepared for the economic damage that they bring. Floods in 2021 caused $23bn in losses, second only to Europe. Only 10% of those losses were insured, according to estimates by Swiss Re, a reinsurance firm. In Europe, in contrast, 32% of losses from floods were insured last year."

Policy learning following the 2021 Zhengzhou flooding was fast. But despite the fast policy learning, the 2023 Beijing-Hebei flooding reveals other key areas for improvement in the flood control system in China. Residents, businesses, and government departments all urgently need to update their risk perceptions: extreme weather events such as heavy rainstorms and flash floods are no longer black swan events (low probability, high impact), but gray rhinoceros events (high probability, high impact). Knowing that flooding was imminent but before it actually occurred, village leaders in flood detention basins in Hebei Province persuaded villagers to evacuate, yet encountered strong resistance, particularly from the senior villagers. In Zhuozhou City of Hebei Province, a city bordering Beijing and a logistics hub and warehouse center in China, many logistics parks and publishers suffered significant economic losses from the flooding. While many logistics parks and warehouses received the early warning notice that their staff should avoid going out or staying in low-lying areas and must make early preventive measures, the message was not taken seriously. Flooding might have made evacuation and early transfer of goods and equipment extremely difficult, if not impossible. But interviews with business managers also reveal the wishful thinking that it was worth taking the risk (Zhao, 2023a).

On the government's side, district governments in Beijing had organized emergency flood control drills in villages in flood-prone mountainous areas. But their simulation scenarios were usually for 50-70 millimeters of precipitation, which greatly underestimated the intensity of the actual rainstorm. Another area yet to be reinforced is the disaster compensation system for residents who suffered losses from the disasters, particularly the residents in flood detention basins (Liu, 2023). Although the Flood Control Law of China states clearly that authorities of regions and units that benefit from the flood detention basins must pay compensation and provide relief for these basins, victims of the recent flood in Hebei Province expressed deep concern over implementation of the law in reality (Bradsher, 2023). Last but not least, siting and design standards for buildings and other infrastructure need to be reexamined and constantly updated to fully reflect the latest climate change science.

United States

Responsibility for disaster response and emergency assistance in the U.S. is centered in the Federal Emergency Management Agency (FEMA) located within the Department of Homeland Security. Other agencies have specific roles and responsibilities, typically in coordination with FEMA, including NOAA, the US Army Corps of Engineers, the U.S. Coast Guard, Environmental Protection Agency, Department of the Interior, and the Department of Health and Human Services.

FEMA is designated by federal law as the lead coordinator across the government for disaster preparedness.[13]

For perspective on progress over the last 125 years, the death toll from the historic 1899 Johnstown flood following dam failure was over 2,000; about 8,000 lost their lives in the 1900 Galveston, Texas hurricane. In the 21st century flood deaths continue. The 2005 Gulf Coast Hurricane Katrina resulted in a widely criticized government response and a death toll exceeding 1,000. In 2017, Hurricane Maria is estimated to have caused approximately 3,000 deaths in Puerto Rico (Fink, 2013; Pasch et al., 2023).

Above and beyond deaths, the U.S. in 2021-23 has seen vast health and property damage related to coastal and interior flood disasters, a Texas winter storm related energy crisis, wildfires in California and other Western states, and simultaneous droughts/water shortages in the West and along the Mississippi River. In the summer of 2023, widespread record-breaking heat and northeastern rains and floods coupled with air pollution from Canadian wildfires were daily front-page news. In addition to lives lost, property damage has been enormous. With rising recovery costs, insurance companies are announcing withdrawal of coverage from California, Florida and other impacted areas (Eaglesham, 2023; McDaniel, 2023; Valinsky, 2023; Vanderford, 2023).

In short, increasing ongoing U.S. climate impacts are causing deaths and damages in localities which, according to government plans and policies were already prepared. Summer 2023 floods and wildfires highlighted the deep inadequacy of plans and policies.

3. "Home grown" efforts are emerging, especially in Australia and the U.S.

Lacking place-specific guidance from the federal government in the U.S. and Australia, locally focused "home grown" efforts are evolving to address adaptation.

Australia

In Australia, the Murray-Darling Basin is a prominent case. Basin water issues involve four states, one territory, and the Commonwealth government. Issues including allocation for irrigated agriculture, over-extraction, environmental health, dam building and infrastructure have been prominent throughout the 20th and 21st centuries. Adaptation has joined the list of challenges, even as older issues involving the interests of farmers, local communities, environmentalists and others remain unresolved.

13 See Sec. 204 of the Stafford Act: https://www.govinfo.gov/content/pkg/COMPS-2977/pdf/COMPS-2977.pdf.

The Australian Millennium Drought was a crisis that led to arrangements encompassing a mix of home-grown effort and central engagement. With water buy-backs offering the prospect of returning the basin to ecological balance, the Murray-Darling Basin Plan attracted international attention as a solution to competing demands for water at a time of diminishing supply due to climate change. However, the plan was undermined by water theft, erosion of an already weak cap, and a failure to properly consider the full implications of climate change on the Basin. The Murray-Darling Basin Plan continues, although it has been weakened by political interference and is has been unable to achieve its targets (Productivity Commission, 2023, Ombudsman NSW, 2017, Four Corners News, 2017).

Within the Basin, local communities developed their own action plans. For example, following the Millennium Drought the community of Renmark and Australia's first irrigation trust, the Renmark Irrigation Trust (RIT), decided that it would never again see its community threatened by lack of water. Renmark is a horticultural district in the downstream area of the Basin. Apart from developing one of the most efficient irrigation schemes in the world – all piped with less than two per cent water loss – the RIT embraced a range of sustainability programs that allowed it to decrease its allocation and partnered with government agencies to use its irrigation infrastructure to rehabilitate floodplains and restore ecological health. This work earned it the highest-level certification from the Alliance for Water Stewardship.[14]

In 2022, a workshop in regional Victoria (convened by Australian participants in this project) found a key limitation to be the weak capacity for genuine bottom-up participation in adaptation policy making and implementation (Spencer et al., 2022). Local communities often desire more adaptation actions, but largely rely on volunteers and small government grants. Adaption-related networks and informal knowledge exchange mechanisms abound. However, in the absence of formal governance mechanisms and resourcing to support these grassroots efforts, coordination and prioritization of adaptation initiatives across communities and large-scale cross-sector engagement remain lacking (Future Earth Australia, 2022; Spencer et al., 2022; Stanley, 2016).

China

In China, by comparison, space for coordinated and sustained local action is limited. As the 2021 report on China climate risk governance put it: "Complex climate risks require the participation of

[14] This story is retold in several places such as: Robinson, G.M.; Song, B. Managing Water for Environmental Provision and Horticultural Production in South Australia's Riverland. *Sustainability* 2023, *15*, 11546. https://doi.org/10.3390/su151511546

multiple stakeholders (e.g., the public, media, enterprises, financial institutions, and social organizations), yet currently there are limited channels and insufficient capacity for these stakeholders to participate"(Qi et al., 2021).

However, a perhaps distinct type of "home grown" local action in the area of climate adaptation involving international collaborative projects is worthy of attention. Using publicly available project databases, Pan and Zhao (2023) identified a total of 174 international collaborative projects on adaptation that Chinese cities and provinces have participated in, half at the city level and half at the provincial level. The projects date back to 1992, although the vast majority occurred after 2005. While the early projects mainly took place at the provincial or regional level, recent years have witnessed an increase in city-level international adaptation projects.

The study found that most of the international collaborative projects focus on the water resource sector, while very few targeted disaster mitigation and public health, two areas that deserve increasing attention given the growing frequency and intensity of extreme weather events. In terms of the functions played by these international collaborative projects, the vast majority provided technical assistance, capacity building and financial support for the implementation of public infrastructure and services for climate adaptation. But less than a third of the projects conducted research and risk assessment to support adaptation planning. Even fewer projects assisted Chinese local governments to develop adaptation plans and/or mainstream climate adaptation to existing policy. Larger, more economically developed cities, such as cities on the east coast and big cities in central and western China, are more actively involved in international collaboration projects on climate adaptation than small and medium-sized cities, which may increase the existing gap in climate adaptation capacity among Chinese cities.

United States

In the U.S., local governments are leading the way to address challenges that extend across local jurisdictions. Project participants provided case studies drawn from their own work, including:

- Development of a coastal protection and restoration plan for Louisiana following the 2005 Hurricane Katrina disaster (Groves et al., 2014; U.S. Coastal Protection and Restoration Authority, 2012, 2017);
- Resilience initiatives in the Jamaica Bay region of New York City following Hurricane Sandy in 2012 (Fischbach et al., 2018);

- Improved stormwater planning in Pittsburgh, Pennsylvania (Fischbach et al., 2017; Fischbach et al., 2020) and Miami-Dade and Broward Counties, Florida (Groves et al., 2014);
- Efforts in greater Los Angeles to address its persistent water supply challenges. challenges through enormous water recycling, stormwater capture, and efficiency investments. (Rosenblum et al, 2022). Major plans to use terraced wetlands to blunt the force of sea level rise in San Francisco Bay. And, at a state level, California's Water Action Plan and ongoing efforts to boost water conservation, water recycling, stormwater capture, groundwater management, and more (WR4ER, 2023, in press).[15]

These home-grown efforts have several features in common. First, the physical, ecological, and water quality challenges are not confined to a single political jurisdiction or level of government. Second, while pre-existing disaster response coordination mechanisms may have been in place, they had not been focused on adaptation challenges. In each case, a critical first step was to organize a process to bring together multiple jurisdictions so that they might work together on future planning and decision-making. These initial efforts included organizing networks comprising local, state, and at times federal government representatives; research institutes; commercial interests; private consultancies, and members of the public.

In Louisiana, for example, the critical step was to change the governance structure by consolidating state authorities into a single independent state authority. In the Jamaica Bay case, in the absence of agency consolidation, a philanthropic foundation stepped in to fund an adaptation planning exercise. This effort included the establishment of a new science institute, composed of a consortium of regional academic institutions. Among its various actions, the institute established government and peoples' advisory committees to inform the planning exercise. The committees included representatives from New York State, New York City, the U.S. Government, the New York/New Jersey Port Authority, and various non-governmental organizations with interests in the Jamaica Bay region and its resources. The Los Angeles and San Franscisco Bay experiences highlight the role of what might be called a developing culture of cooperation, even and perhaps especially, among jurisdictions that have historically competed for water resources and in economic development.

[15] Marcus, F., Doolan, J., Castle, A., Naidoo, D., & Bhagwan, J. 2020. It Takes a Team: Helping megacities build water security in the face of socio-economic and climate change challenge. Second International Conference "Water, Megacities and Global Change." Paris: UNESCO.

III. Point of Entry for Comparison Three: Core Common Adaptation Governance Challenges: Core Types of Response Strategies

Our analysis of the limitations of existing tools, plans, and organizational structures suggests that meeting the challenges of adaptation will require substantial restructuring of existing governance systems in Australia, China, and the United States. At this stage, however, our understanding both of the challenges and of institutions needed to address them is not sufficiently developed to spell out a comprehensive vision of what is required.

For the moment, therefore, we suggest a focus on comparing adjustments in existing governance processes that can contribute incrementally to meeting the challenges of adaptation and that may prove politically feasible within the confines of existing governance systems in each country.

We identify for comparison four types of response strategies centered on:

- *adjusting central government/local relations to strengthen local capacity to address the impacts of climate change;*
- *restructuring jurisdictional arrangements to improve the fit between the scope of the problems arising from the impacts of climate change and the distribution of authority to address them;*
- *enhancing measures to guide or cushion major demographic and economic shifts arising from the impacts of climate change; and*
- *improving preparedness to respond to more frequent, extreme and likely compounded impacts of climate change.*

Each of these types constitutes a cluster encompassing variants that are more-or-less well-suited to individual governance systems.

We do not claim that these four types of response strategies are mutually exclusive or exhaustive. Countries may pursue several at the same time; other types may come into focus over time. But our research so far indicates that these four are worthy of more detailed assessment on a country-by-country basis. In this section, we consider each of the four types of response strategies, paying particular attention to comparisons across the three governance systems.

A. Adjusting Central/Local Relations to Address Climate Impacts

Local governments (and individuals and non-state institutions) must play a key role in adaptation. But state/regional and national governments also will play core roles. How will central/local relations evolve to address the challenges effectively?

Developments to date suggest varied approaches. In China, a unitary state, the central authorities provide plans to guide local action and initiate pilot projects to learn about the relative merits of policy responses. In the Australian and U.S. federal systems, state and local governments have more authority to take initiatives and receive some level of direction to and support from the federal and/or state governments. In all cases, national and state governments need to assist in providing, at least, data, expertise, and funding.

Australia

As discussed, as a matter of formal public definition, Australia has the most developed framework for multilevel climate roles. However, a core question is the continuity and vision of leadership's focus on adaptation. The current Australian Federal government has initiated a reorganization to address climate change and adaptation. Again, the eight prior years of conservative government produced little progress on climate adaptation. The result of the national level focus on adaptation remains to be seen. Details of the National Climate Risk Assessment and Plan work program have now been posted, but there has been no discussion of implementation.(Australia Department of Climate Change Energy Environment and Water, 2023a) State and local governments have produced adaptation plans, but effectuation is limited.

China

In China's unitary system, guidance to localities flows down through myriad plans starting with the national Five-Year Plan and local pilot projects (shi dian). In sum, a core question is whether and how well the longstanding central/local planning and pilot project system will serve adaptation governance.

As noted, there have been 28 local climate-resilient pilot cities since 2017, and the second batch of pilots are upcoming. But there is limited public information on these pilots, and they do not appear to include the most populous coastal cities, facing sea level rise challenges. The climate-

resilient pilot city program complemented the two batches of national sponge city pilots in 2015 and 2016, respectively, which aimed to build urban water resilience. The sponge city pilot program was generally regarded as more successful than the climate-resilient city pilots, possibly due to the rigorous performance evaluation mechanism as well as financial support from the central government in the former and the absence of both "carrots and sticks" in the latter. Although at the moment there are few subnational adaptation plans, the situation is likely to change soon as all provinces are on track to formulate concrete adaptation action plans, involving quantitative performance metrics, by early 2024.

United States

In the U.S., where adaptation focus is dispersed, there is long experience with efforts to deploy Federal expertise and funding in support of localities. A core question is whether and how Federal risk expertise and funding will be linked to coherent and effective local adaption action.

Historically, numerous Federal programs and agencies provided funding and expert assistance to localities. The 2022 Inflation Reduction Act, the most significant climate-focused law thus far enacted, provides additional hundreds of billions of dollars in tax credits and subsidies to speed the transition to a low-carbon economy. The bulk appears to be focused on renewable energy and energy conservation, but there are funds for flood proofing, wildfire prevention, heat resilience, and agriculture adjustment to address climate impacts (U.S. Government White House, 2021b; Marcus, 2022).

U.S. Federal agencies (and their non-governmental experts) are examining ways to link Federal data and expertise to local adaptation funding. Most notable is the Building Resilient Infrastructure and Communities (BRIC) grant program, authorized in 2018 and administered by FEMA, to provide substantially more funding to localities for pre-disaster hazard mitigation than in the past. A 2022 RAND Corporation report for FEMA examined FEMA's approach to risk analysis and suggested a strategy for linking FEMA's grantmaking for adaption risk and social equity analyses to local planning (Clancy et al., 2022). As a condition of applying for a BRIC grant, local applicants must extend their FEMA hazard mitigation plan to provide for adaptation. The intention is to connect local government use of these tools to local government grant applications, with a focus both on reducing risk from natural hazards and assuring equity in actions taken by local governments for adaptation research and pilot projects. In addition to BRIC, the report identifies other Federal grant sources that may apply to adaptation, including the highly significant source of Community Development Block Grants (CDBG) to mitigate disaster risks and reduce losses from recent natural disasters (Clancy et al., 2022).

B. Transforming Cross-Jurisdictional Arrangements to Address Climate Impacts

The impacts of climate change often cut across established (domestic as well as international) jurisdictional boundaries. Thus, a second type of response strategy features efforts to improve the fit between the spatial scope of the impacts and the jurisdictional boundaries of relevant governance systems.

The prime global example may be the need to coordinate management of great rivers and water basins that cross jurisdictional boundaries. Historically, this need has produced governance mechanisms in all three countries. In Australia, the Murray-Darling River Basin is a prominent example. In China, there are millennia of experience with governance of the Yangtze, Yellow and other rivers that have been core to China's civilization (Moore, 2018; Mostern, 2021; Pietz, 2015). In the U.S., near-century-long efforts include management of the Colorado, Mississippi, Columbia, Snake, and other rivers in the western and mid-western U.S.; the Delaware and Susquehanna Rivers in the East; the International Joint Commission between the U.S. and Canada to govern Great Lakes boundary issues, and other regional arrangements including interstate compacts as mechanisms for agreement and dispute settlement (U.S. Government Accountability Office, 2007).

All these cases involve tensions among jurisdictions, and often as important, among competing water users (e.g. agricultural, municipal, commercial and industrial, and environmental demands), coupled with recognition of a need to cooperate. As the quotation attributed to Mark Twain has it, "whiskey is for drinking, water is for fighting." The tensions commonly relate to the allocation of scarce water (both among localities and user groups), construction of infrastructure to address floods and droughts, and, in modern times, resolution of upstream/ downstream disputes relating to industrial and agricultural pollution. Of particular concern is a common failure to take the protection of the natural environment into account. In the U.S., the groundbreaking 1970 National Environmental Policy Act (NEPA) and numerous other federal and state laws mandate consideration of environmental impacts from federally funded projects and their mitigation as part of the approval process. Results have been mixed, with some notable successes such as the reduced discharge of pollutants into most major river systems and shortfalls such as the continued excessive runoff of phosphorus and nitrogen from agricultural lands into rivers and estuaries. Australia and China have a poor record on this form of environmental protection as well in most cases due to competing economic and environmental priorities and power imbalances.

As discussed above in relation to disaster response mechanisms, there is growing appreciation that existing interjurisdictional coordination arrangements are not sufficient to address today's climate impacts.

Here, as we discuss next, evolving developments suggest several variations on approaches which merit comparative perspective: (1) revision of traditional inter-jurisdictional arrangements through formal changes of rules, oft with both central and local engagement; (2) development of what we have called "home grown" efforts to alter rules; and (3) development of networks, with varying degrees of formality, that engage state and non-state actors to consider and forward transformations. The development of these approaches (not mutually exclusive) may well vary among country systems.

1. Historic and Evolving Central/Local Coordination Arrangements are in Need of Transformation

Australia

In Australia, the late 1990s-2009 "Millennium Drought" created a major crisis for inland water in southeast Australia where the Murray-Darling Basin covers four states and the Australian Capital Territory. There was an inability to wind-back over-allocation of water, with rivalry particularly fierce between upstream and downstream states. The peak of the drought, when some were describing the basin as ecologically dead or near dead, prompted the Federal government to act and undertake a major overhaul of governance arrangements for the multi-jurisdictional basin.[16] The mechanisms for achieving this breakthrough in collaboration was the application of generous amounts of federal funding ($10 billion). More recently, the basin has been subject to unprecedented flooding with flows at the southern end of the basin in South Australia peaking at 190 gigalitres[17] a day (South Australia Department of Environment and Water, 2023). In 2006-2007, at the height of the millennium drought, annual inflow fell to 970 gigalitres or just 11 per cent of long-term average flow rates (Cock, 2023).[18]

16 For a brief description of the evolution of governance in the Murray-Darling Basin see MDBA 2023, Basin Plan history and timeline, Murray-Darling Basin Authority, https://www.mdba.gov.au/water-management/basin-plan/basin-plan-history-and-timeline

17 1 gigalitre (GL) = 1,000,000,000 litres

18 It should be noted that while Australia is well-known as the driest inhabited continent it is also distinguished by having the most variable streamflow of any continent.

China

In China, the Yellow River Conservancy Commission, created at the birth of the PRC drawing on an earlier coordination institution, coordinates the river basin across multiple provinces and autonomous regions under the Ministry of Water Resources. In the late 20th century, drying up of the Yellow River coupled with awareness of water pollution fueled by rapid economic growth led to both a renewed focus on government water management and the emergence of peoples groups to call attention to environmental concerns (Moore, 2018; Pietz, 2015). In May 2023, recognizing the need to coordinate adaptation planning in the Yellow River Basin, the MEE organized a training session for the nine provinces in the basin as they prepare their individual adaptation action plans. However, coordinated adaptation planning for transboundary climate impacts has not become an institutionalized practice in China. In mid-2022, limited water flow on the Yangtze River in western China produced impacts downstream, including in Shanghai where the river flows into the sea (Jiang, 2022; Shi et al., 2022).

United States

A century of economic development, accompanied by depletion of groundwater and periodic drought, has challenged historic arrangements for allocating water among seven western states (and Mexico) (Reisner, 1993; Worster, 2001). Declines in the water levels in 2022 at storage facilities including Lake Mead (the largest man-made reservoir in the U.S.) drew continued news reports on formerly submerged and newly emerged objects, including ships and human bodies (Chow, 2022; Falconer, 2022; Flavelle & Healy, 2023; Haynes, 2022). However, unexpectedly high 2023 rainfall facilitated a short-term (through 2026) agreement among Arizona, California, and Nevada to address allocations, with Federal assistance (Dance, 2023; Flavelle, 2023). Even so, with a view to the future, in 2023, Arizona declared that water limits compelled limitation of approval of new construction in the Phoenix area (one of the fastest growing U.S. metropolitan areas) (Flavelle, 2023; Haynes, 2022).

2. "Home Grown/ Bottom Up" Jurisdictional Arrangements are Evolving

Australia

Some local communities and local governments have initiated adaptation responses. However, despite some small incremental initiatives, the barriers in the form of lack of resources, both financial and capability, lack of leadership and buy-in by state and federal governments,

inappropriately structured grants programs when these are available, and poor inter-governmental collaboration have created frustration and inertia with the local community and First Nations people (Spencer et al., 2022). The greatest success has been with community collaboration in response to natural disasters. Local volunteer groups are speedier, better connected and more agile than emergency response agencies.

China

As China moves beyond national adaptation strategic planning to provincial action plans, the country has maintained and will further expand the scope of adaptation experiments or "pilot projects" (*shi dian*). As noted, according to the *National Climate Change Adaptation Strategy 2035* in China, there have been 28 local climate-resilient pilot cities since 2017, and the number of the pilot cities for climate adaptation will be expanded to about 100 by 2030. All the cities at prefecture level and above are required to take out their climate-resilient city construction plan by the end of 2035.

United States

In the U.S., what we have called home grown cross-jurisdictional arrangements are emerging to address climate adaptation. Key to this approach is the initial engagement of multiple levels of government, civil society groups, and enterprises. As previously described, this is what happened in Louisiana following Hurricane Katrina in 2005. Many other efforts on a smaller scale have been initiated, as catalogued by the Georgetown Climate Center. The establishment of the Southeast Florida Regional Climate Change Compact is a particularly notable example of local county-level governments banding together to fill a vacuum for forging resilient solutions left by inaction by the State of Florida (U.S. Southeast Florida Regional Climate Change Compact, 2023). Another notable example is the State of Louisiana's creation of a Coastal Protection and Restoration Authority that consolidated six existing state offices and many local authorities for the purpose of more effectively planning and implementing measures to reduce future risks from hurricanes following the devastation from Hurricane Katrina in 2005 (Groves et al., 2014; U.S. Coastal Protection and Restoration Authority, 2023).

Laws may provide for the creation of legal entities (often taking the form of authorities) that coordinate responses to challenges among local and state jurisdictions as was the case in Louisiana. In 2022, the California legislature enacted a measure allowing for the creation of Climate Sustainability Districts. These districts will have revenue-raising authority. Their adaptation related special feature is a provision for "boundary centers" to bring together climate science

experts, particularly in the field of risk analysis, with local officials and individuals (Pisano & Lempert, 2022).

3. Cross-Jurisdictional Networks with Adaptation Focus are Emerging

A third member of this cluster, often complementary to the others, is the development of networks of local officials, adaptation experts, and concerned individuals who share information and experiences.

Australia

As noted in Section IIB3, *supra*, with the example of the Murray River Basin, Australia adaptation includes cross jurisdiction networks engaging formal governmental and informal non-governmental settings.

Also noteworthy are local informal networks. An example of the latter is the emergence of local groups during a crisis that have a much stronger organizing capacity than formal government arrangements. For example, Resilient Lismore emerged from the crisis of the devastating floods in Northern New South Wales (Resilient Lismore, 2023). A nonprofit community group, Resilient Lismore used social media in a way that provided superior community communication and coordination to that offered by formal government services. Even less formally, in the Victoria village of Mooroopna, while the formal government agencies established their headquarters in the nearby City of Greater Shepparton, the local netball and football club was able to organize hundreds of volunteers through word of mouth and social media who took over the task of community support and helping flood damaged property owners (Spencer, 16 June, 2023, personal communication).

China

In China, there has been a longstanding need to coordinate management of great rivers and water basins that cross jurisdictional boundaries. *The National Climate Change Adaptation Strategy 2035* has highlighted the government-focused cross-jurisdictional networks with adaptation focus.

For example, for the Guangdong-Hong Kong-Macao Greater Bay Area, a joint consultation mechanism for disaster information sharing and management has been built up, with a focus on strengthening coordinated monitoring, early warning and emergency response to sea level rise, typhoons and marine crisis. The activities include joint planning for a climate resilience city cluster.

United States

In addition to networks focused on particular local/regional challenges (as discussed Section IIIB3, supra), the U.S. is now growing networks of adaptation experts and practitioners. These include, for example, the American Society of Adaptation Professionals (ASAP) (American Society of Adaptation Professionals), Regional Collaboratives Forum (Georgetown Climate Center, 2023a), and the Water Utility Climate Alliance (Water Utility Climate Alliance, 2023).

C. Guiding or Cushioning Major Demographic and Economic Shifts

Climate related migration, across country borders as well as within them, is a growing reality (UN Network on Migration, 2023; UNHCR, 2023). Thus, our third type of adaptation strategy focuses on how countries, and localities within them, are responding to the likelihood that climate impacts may produce, by choice or necessity, deep demographic and economic shifts within societies. Climate impacts may make it impossible to continue life "as is" in a locale. Investments in building back may not be effective; they may consume resources that would be better spent on other measures.

There may be no win/win solutions. By governance choice or by default, people (and businesses) may be faced with a need to migrate or relocate (Mach & Siders, 2021). *With climate impacts, alternatives often now termed "managed retreat" in contrast to "defense in place" are on policy agendas. In extreme cases, it may be necessary to relocate whole communities.*

1. Retreat and/or Relocation, Defense in Place (or governance inaction)

There is nothing new about large-scale demographic shifts and economic relocations. Australia, China, and the U.S. governments have long experience regarding domestic and/or cross-border

migration. With 21st century climate understanding in mind, historical researchers are (re)focusing on the role of natural disasters and climate change in past migrations (Di Cosimo, 2014, 2018).

Each of the three countries has recent, as well as historic, experience with relocation. In Australia and the U.S., post-colonial histories began with "frontier" settlement by Europeans and displacement of Indigenous populations with consequences that continue to be seen. This history includes, in the case of the U.S. for example, national laws to encourage frontier settlement (notably the 1862 Homestead Act offering settlers frontier land) and conquest of Indigenous peoples. U.S. migration has also been induced by natural disasters, famously the 1930's Dust Bowl migration (Worster, 2004). In the late 20th century, hundreds of millions of China's rural individuals moved into cities, transforming China into a predominantly urban country. Early British ideas for Australia included establishment of yeoman settlements of small-scale agriculture along inland rivers on the unceded lands of Indigenous Australians. Hence the famous declaration of the British Governor of Terra Nullius asserting that the land was unoccupied at the time of the British invasion.

In each country, laws adopted prior to focus on climate change will have an impact on adaptation governance. PRC China's *hukou* (household registration) system has played, and continues to play, a core role in demographic shifts. In the late 20th century Opening Up and Reform period, the *hukou* system was modified to permit individuals to leave hometowns to seek work elsewhere. Hundreds of millions moved from rural to urban areas, resulting in the transformation of China's demography (and economy). At the same time, under the *hukou* system, which has been undergoing local reforms, important social benefits (e.g., public education and social insurance) were tied to the locale in which the individual has a *hukou*. In the U.S. and Australia, movement of individuals has not been similarly restricted; important social benefits (e.g., Social Security and Medicare and public education) can be received wherever individuals live in both these countries.

With climate impacts, alternatives often now termed "managed retreat" in contrast to "defense in place" are on policy agendas. In extreme cases, it may be necessary to relocate whole communities.

Australia

Climate migration will be a major issue for Australia, with populations forced out of areas that become hotter and drier moving to cooler climates, such as the southern state of Tasmania. After decades as one of the worst performing economies in Australia, Tasmanian property prices have been soaring with inflows of people from the mainland. Migration into Australia will also be an

issue with many low-lying Pacific islands and major Asian cities, such as Bangkok, becoming uninhabitable due to rising sea levels. Droughts in prior food growing areas will increasingly become a major concern.

Several types of change will drive population shifts; changing climate in agricultural regions will change farming practices, crops and livestock. Horticulture farmers are likely to move out of areas expected to see rising temperatures particularly for crops that require regular frosts or higher rainfall. Wine grape growers may relocate if their expertise is tied to certain varietal characteristics. The threat of extreme events may cause people to move from areas of vary high fire or flood risk. Also, Australia's role in the Indo Pacific will require it to accommodate more climate refugees from other countries. For example, this year the Australian Government and the Government of the Pacific Island of Tuvalu signed the Australia-Tuvalu Falepili Union that provides peoples of Tuvalu with "a special human mobility pathway to access Australia" to live, study and work in Australia and access social services.[19]

Managed retreat is a core question in the context of floods. In Lismore, for example, about 300 owners have been offered buybacks by the Federal Government, at pre-flood values, following the floods in New South Wales. However, funds have run-out despite the intention to buy back 1,100 homes (Hinchcliffe, 2023). Until the 2009 Black Saturday fires in Victoria, defense in place was considered a viable approach. Households would train and acquire appropriate equipment to defend their homes in the face of approaching wildfires. However, the intensity of fire generated in the 2009 season highlighted the risks of defense in place. Some 173 people perished either attempting to defend their homes or simply trapped in a fast-moving fire and unable to escape along congested roads often made impassable by falling trees (Australia Country Fire Authory, 2023; National Museum of Australia, 2019; Teague et al., 2010).

China

Policy directed at environmental migration has been a focus in PRC China, even before current awareness of climate change impacts. Learning from recent and ongoing experience should be of immediate relevance to current adaptation challenges.

In the 1980s, China began an ecological resettlement program (Du, 2012; Wang et al., 2018; Zee, 2022). Directed resettlement has taken place most famously in relation to dam construction, notably the Three Gorges Dam on the Yangtze River (Xinhua, 2007; Zhang, 2021). Environmental

[19] Australia-Tuvalu Falepili Union (2023), Department of Foreign Affairs and Trade, Australia see https://www.dfat.gov.au/geo/tuvalu/australia-tuvalu-falepili-union-treaty.

resettlement has been deployed in relation to further environmental challenges, such as desertification in Inner Mongolia (Zee, 2022). Resettlement is also part of ongoing environmental and poverty-reduction strategy (Rogers et al., 2019; Yang et al., 2020).

United States

In the U.S., managed retreat is a matter of study, debate, and some action.

Managed retreat may involve, for example, buying out the homes of those living in the path of hazards and/or assisting in relocation. Government and private insurance constraints will play a key role in stimulating relocation. In 2023, following a wave of disasters, insurers declared limits on coverage in California, Florida, and Louisiana. Equity is emerging as a core question. Follow-up reports on disasters often emphasize rebuilding of wealthy neighborhoods (as a famous example luxury homes following repeated coastal flooding) coupled with diminished quality of life in poorer neighborhoods (Bellafante, 2022; Campo-Flores, 2022; Kaufman, 2023).

2. Focus on the Opportunities for Beneficial Outcomes

As the IPCC notes, adaptation includes taking advantages of opportunities as well as limiting harm. While uncertainties abound, some locales may fare better than others under the impact of climate change (or may be expected to fare better). For these places, the absorption of climate migrants is both a challenge to existing community resources and an opportunity for economic and civic development.

China

With Chengdu as one oft cited example, there have been years of central government encouragement of development of interior cities as alternatives to Beijing, Shanghai, Shenzhen, and other now well-developed coastal cities. Covid and new technologies, with their demonstration of options for work at a distance from offices, appear to be stimulating further migration.

United States

Commercial and cultural urban centers are dispersed among coasts and interior regions. Citizens move among coastal cities (e.g., Los Angeles or Seattle, New York, Boston or Miami), internal cities (e.g., Chicago, Atlanta), and growing smaller metropolitan areas (notably college towns)

throughout the country. Cultural changes during Covid, with its dramatic opening up of telecommuting work away from urban offices, coupled with reports of homelessness and other big city challenges, may be interacting with climate impacts to alter historic local/local dynamics.

Lasting trends are difficult to discern at this time. For example, heat waves in the summer of 2023 have prompted observations that in the U.S. people have been moving toward, not away from, locales challenged by heat waves and water shortages (The Economist, 2022).

The potential benefits from climate induced migration is being considered by some locale that have suffered economically. In upstate New York, for example, Rochester's population has declined by about a third since a 1950 peak of 330,000. As noted, the city's climate vulnerability analysis shows that Rochester has already been attracting climate migrants and, with planning, there is opportunity for benefits from further attraction. In nearby Buffalo, leadership is actively promoting the city as a destination for climate refugees (Fuss, 2022). But the challenge is highlighted by a December 2022 snowfall that left dozens dead and called into question the readiness of Buffalo, a city famed for snow and cold winter weather, for climate-exacerbated snow disasters (Kilgannon et al., 2022; Sacks & Wax-Thibodeaux, 2022).

D. Enhancing Capacity to Prepare for and Respond to Disaster

In all three countries, a common challenge is addressing the need to restructure or transform traditional emergency management systems to meet the rising challenges of climate adaptation. There is a sense in which strengthening preparedness and response capabilities is a form of adaptation. In the face of 21st century challenges, U.S. leaders promise to "build back better," and "Make America Great Again," and declare "Yes we can." China's leadership calls for "win/win" solutions, "common prosperity," and transformation to "ecological civilization."

However, as we have discussed, notwithstanding extensive experience in natural disaster response, the daily news brings continued reporting of inability of traditional response mechanisms to prevent substantial human and ecosystem damage and, too often, death. Coming to terms with the impacts of climate change may require a paradigm shift in approaches to preparedness and response, a shift away from a restorative approach and toward an alternative approach emphasizing increased resilience of homes and local infrastructure. That shift is in its earliest days in Australia and the United States.

Australia

In late December 2023 a tropical cyclone approached the North Queensland coast prompting the usual warning to batten down and prepare for high winds and rain. No one, including the national Bureau of Meteorology (BoM) appeared to be prepared for the catastrophic flooding that followed. The BoM explained that the weather system evolved rapidly requiring the Bureau to constantly adjust predictions. The federal minister admitted the warning systems "fell short" in the face of "highly unpredictable" "unprecedented amount of rain". The "water was moving so fast it wasn't possible to update everyone as quickly as things were moving." (Smee, B, 2023). But this was not a one-off, it was a similar story to the 2021-2022 flood disasters in NSW or the 2019-2020 devastating bushfire season that followed years of plans and preparation for major disasters. Despite successive inquiries and royal commissions, history keeps repeating itself. Perhaps it could be argued that fewer people are dying in natural disasters, nevertheless the ability to prepare is failing. In 2023, the government allocated funds for a 10-year program to remediate high priority flood warning infrastructure and address critical reliability risks.[20]

China

China's longstanding emphasis on crisis management as a governance process, rests on the twin propositions that disasters are difficult to anticipate but that there is much to be said for a strategy of being prepared to respond promptly and effectively when disasters do occur in specific locations. The limits of disaster planning are increasingly highlighted by events like the 2021 Zhengzhou subway flood deaths and 2023 Beijing area flood deaths, followed a decade after central government warnings from the 2011 Beijing flood disaster.

United States

As a *New York Times* article headlined on the 10th anniversary of Hurricane Sandy put it: "Why Is New York Still Building on the Waterfront? There are two simple reasons. One, it makes money. And two, people just love water" (Bellafante, 2022). A suggestive initiative emanates from the U.S. Weather Bureau located within the National Oceanic and Atmospheric Administration. The "Weather-Ready Nation" program is "a partnership developed by the National Weather Service (NWS), along with participants from weather/water/climate private sector enterprises and public sector emergency management and other public safety officials at every governmental level to enhance rapid response to emergences." The effort engages thousands of local "ambassadors," including universities and government agencies (U.S. National Weather Service, 2023; Uccellini & Hoeve, 2019).

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[20] Queensland Bureau of Meteorology. *National Disaster Warning Network*. https://www.qra.qld.gov.au/fwin/bureau-national-disaster-warning-network.

The effort was spurred by analyses of physically similar 1974 and 2011 hurricanes, which revealed that "[D]espite vastly improved forecasts and warnings enabled by new science, technology, and forecasting techniques, nearly the same number of deaths occurred during the 2011 outbreak as compared with the 1974 outbreak. This outcome had a profound impact on the NWS and throughout the enterprise, and suggested there was still progress to be made to improve preparation and response to impending extreme weather events" (Uccellini & Hoeve, 2019).

In sum, a core common question in all countries is whether ongoing impacts and experience with disaster warning, response, and relief can overcome the strong desire to provide affected people and communities with assistance to restore the status quo ante.

IV. Next Steps: Opportunities for Testing and Deepening Comparative Understanding

Drawing on our Points of Entry framework, this concluding section identifies "next step" opportunities to move forward simultaneously on three tracks. The initial approaches next steps were discussed by project participants and others at an October 2023 Roundtable convened by the Shanghai Forum.[21]

A. Case Studies of Response Strategies to Adaptation Governance Challenges

Comparative case studies of the response strategies identified in Section III can help to enhance our understanding of efforts to meet the governance challenges of addressing the impacts of climate change.

1. What can we learn from comparing efforts to develop centrally supported/integrated local adaptation strategies?

[21] For recordings of the October 2023 Shanghai Forum Roundtable, see: https://napawash.org/standing-panel-blog/climate-adaptation-governance-project-shanghai-forum-roundtable.

Though local contexts are key, adaptation requires coordination of central and local governments. In each country, there are traditions of using central databases, expertise, and financing to steer or direct local activities. In Australia, a great deal has been achieved in developing plans and strategies. But apart from infrastructure planning, there is little evidence of effective implementation. In 21st century China, the tradition of centrally sponsored experiments or pilot projects (*shi dian*) has been applied to environmental goals, including adaptation pilots. In the U.S., there are emerging efforts to link central expertise and funding with local adaptation actions.

An ongoing Next Step: Learning from comparative case studies of ongoing efforts to link central expertise and data to local plans and available funding sources.

2. What can we learn from comparing efforts to create or modify cross-jurisdictional and sectoral arrangements to address adaptation challenges?

We know that natural disasters do not honor jurisdictional or sectoral boundaries. In Point of Entry 3, we outlined three (nonexclusive) types of challenges: (1) revising historic coordination agreements to address adaptation; (2) developing new cross-jurisdictional and cross-sectoral arrangements, and (3) creating individual/official/expert networks in aid of the above.

An ongoing next step: Learning from comparison of transformations of traditional coordination mechanisms relating to water and wildfire challenges that extend across jurisdictions and sectors to address adaptation.

3. What can we learn from comparing ongoing experiences with climate impact on demographic shifts?

There is a faith in each country, oft expressed by leadership, in a vision of progress. Nonetheless, whether by policy design or accident and default, societies have long made choices requiring tradeoffs among deep social values.

A Next Step: Comparison of how governments and their communities come to terms with the tradeoff between defending in place and managed retreat. Will decisions be made by reflection and choice, left to the market, or required by governments?

4. What can we learn from comparing country approaches to transforming traditional crisis response mechanisms to address adaptation?

21st century experience in each country shows that historic natural disaster response mechanisms may not be sufficient to avoid deaths and substantial damage to human and natural resources arising from the impacts of climate change.

A Next Step: An ongoing next step; comparative learning from how countries are augmenting and perhaps transforming traditional crisis management organizations and philosophies to prepare for and respond to the impacts of climate change. Consider options for transcending the traditional restorative approach.

B. Crosscutting Analyses: Tools, Resources, and Processes

1. Comparing Tools

Public management/public policy schools in Australia, China, and the U.S. teach many of the same tools of government or policy instruments (e.g., performance metrics, monitoring and evaluation, and pilot projects), engagement of resources (money, expertise, information, and non-state actors), and policy processes (making laws and policies). But while the tools and resources are often given the same names in the global English vernacular of governance, their operation and effects differ across countries.

Next steps: Delve deeper into the tools, planning processes, and organizational arrangements considered in Points of Entry 1 and 2. Examples include:

*Performance measures (*China *mu biao).* Quantitative and qualitative measures, as long used in relation to economic growth, pollution, health care, or education, must be easy to

define, operationalize, and apply. In the case of climate adaptation, however, such measures pose new challenges. They must reach across numerous policy areas, cope with considerable uncertainties, and feature long lag times between today's decisions and eventual outcomes (Boltz et al., 2022). How are performance measures being developed to address adaptation?

Open information (China xinxi gongkai) and risk communication. Open information is a widely used tool in environmental governance, including in Australia, China (Institute of Public and Environmental Affairs, 2023), and the U.S. There is now considerable research (globally as well as in in our three countries) on whether and how open information has worked to impact decisions by companies, social groups, and governments (Guttman et al., 2013; Logan, 2021; Yale Program on Climate Change Communication, 2023). Information related to adaptation may be of special value to individuals seeking to decide where to live and companies choosing locations and supply chains as well as officials making policy choices. But ongoing disasters show that even where information such as public warnings are available, decision-makers often fail to act. What can we learn from the ways in which adaptation information is made available and, more importantly, understood and acted on by individuals, companies and other non-state actors as well as government?

Rules of the game: law, plan, policy. In relation to environmental governance, Australia and the U.S. are law-centered countries. China has many environmental laws (and environmental courts) but dominant environmental governance processes feature plans and other policies and, as Covid punctuates, crisis management (Young et al., 2015). In the U.S., state and local plans are emerging often in the absence of formal legal requirements. Australia has a relatively well-developed adaptation focused framework, but implementation is a work in progress at best. How are traditional country law and policy processes working to address adaptation, and what transformation(s) may be in order?

Risk analysis: Data, models, and related "new" technologies. As we emphasized in Point of Entry 1, suitable data and related risk analyses are predicates to addressing adaptation. Given current limitations, countries may have much to learn from one another. There are multiple questions for comparative learning. These include: to what extent are potentially useful data sources and models publicly available and on what terms? How will evolving laws at the nexus of national security, data security, and intellectual property affect access? Where data and models are publicly available, are they readily translatable from one country to another? Where data are limited or missing, how can the limitations of risk analysis be minimized?

2. Comparative Decisional Processes: Engagement of Non-State Actors

Decisions on adaptation will affect the lives of people in the most basic ways, affecting where they may live, what social services they may expect, and what basic resources including transport, energy, and medical care they can count on.

An ongoing next step: Compare how countries and localities engage the public (including nonprofit organizations and for-profit corporations and individuals) in adaptation decision-making.

3. Resources: comparative financial resource development

The amounts of money required for adaptation are often assumed to be extremely large, with debate about whether investments can be "win/win." In each country, there is the deep concern that traditional sources of public and private funds will not be adequate. New pathways for finance are being explored (for some resources see Appendix B). Here, again, there are differences among countries that invite comparative analysis. For example:

- In the U.S., property taxes historically have been a core source of local revenue. As a consequence, actions taken by U.S. localities may favor those who pay more property taxes. In 21st century China, local governments are expected to take the lead in mobilizing resources. But property taxes have played a small role. Urban revenues have been substantially dependent on payments to cities by land developers. As the China real estate market is undergoing change, what alternative local financial sources will become available for adaptation.[22]
- In the U.S., there is an established tradition of private philanthropy. In 2023, substantial new and traditional private foundation funding is focused on climate change (Inside Philanthropy).[23] What can we learn from considering how the space occupied by private philanthropy in the U.S. is occupied in Australia and China?

[22] In 2022 the University of Pennsylvania Wharton School China Center and the Fudan Institute for Global Public Policy conducted a webinar on U.S. use of property taxes and evolving China developments. (Penn Wharton 2022)

[23] Climate Works Foundation estimates that climate change giving rose 25% between 2020 and 2021 — three times faster than overall philanthropic giving — to reach between $7.5 billion to $12.5 billion."

- Private insurance companies have played fundamental roles in studying and anticipating future risks and supporting investment decisions. But, as discussed, private insurance may not be adequate to deal with adaptation. What can we learn from comparisons among countries regarding how insurance for adaptation is developing?[24]

Next steps: Consider (1) How much funding can/should come from central governments vs. local governments? (2) How much can/should come from business and other non-state actors? and (3) will the insurance industry require transformation to address the challenges of climate adaptation?

C. Deepening the Framework by Engaging More Countries and Colleagues

Australia, China, and the U.S. are rich countries, with substantial human, technological and natural resources. How useful will the framework we have developed be in thinking about climate adaptation in developing countries? For example, a framework for African development acceleration points out that a lack granularity in risk data will require use of a more limited forms of risk analysis. The deep need for, and limits of, national financial resources highlight the role of global financial organizations. At the same time, rapid economic development in many Africa countries may permit development that takes adaptation into account *ab initio* (Georgetown Climate Center, 2023a).

To conclude, we have developed a framework to organize comparative study of governance processes relevant to addressing challenges arising from the impacts of climate change. We welcome engagement with others both in applications of this framework to additional countries and cases and in suggestions for improving the framework.

[24] We note a project of the V20 (vulnerable countries) financial ministers in cooperation with member of the insurance industry to explore lower cost availability of risk data to developing countries. V20 Group. (2021). *The V20-led Sustainable Insurance Facility at a Glance.*

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Supplemental Materials

Appendix A: Background Materials Authored/Coauthored by Project Participants

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Appendix B: Further Sources Relevant to Climate Adaptation Governance

We have benefitted from numerous adaptation governance related sources. These include reports on, and analysis of, adaptation challenges, collections of country adaptation plans, case studies of local impact events, reports on adaptation resources (e.g., finance, data) and threats (e.g., heat, flood), analyses of potential sectoral impacts (e.g., food, energy, health, infrastructure), and check list/templates of considerations in addressing adaptation. The institutions engaged include the UN, Development Banks, and other international and regional organizations, government agencies, nongovernment institutions (including businesses and nonprofits), communities or networks of practitioners and scholars and further networks.

In this Appendix we provide what we hope will be an expanding list of such resources. Suggestions for additions are welcome.

International and Regional Organizations

United Nations

- Intergovernmental Panel on Climate Change: Climate Change 2022: Impacts, Adaption and Vulnerability
- United Nations: Climate Action; Climate Adaptation
- United Nations Climate Change: National Adaption Plans from developing countries
- United Nations Environment Program (UNEP): Adaptation and Resilience
- UNFCC Adaptation Committee
- UNFCCC Least Developed Countries Expert Group
- UNFCC: Local Communities and Indigenous Peoples Platform Web Portal
- UN/UNFCC: Adaptation and Resilience

Development Finance Institutions

- World Bank: Guide to Climate Adaptation in Cities
- Africa Development Bank Group: Climate Change
- Africa Development Bank: Africa Adaptation Acceleration Program
- International Monetary Fund: Climate Change; Climate Resilience

Further International/Regional Organizations

- European Commission/European Environment Agency: Climate Adapt
- International Commission for the Protection of the Danube River: Climate Change Adaptation
- OECD: Building Financial Resilience to Climate Impacts
- V20 (Vulnerable 20 Countries): Sustainable Insurance Facility; Collaborate

Global Multistakeholder Institutions

- GFDR: Global Facility for Disaster Reduction;
- Climate Cooperation China: Sino-German Cooperation on Climate Change
- C40 Knowledge: Knowledge Library
- Global Center on Adaptation: Global Commission on Climate Adaptation
    - Lessons from Local Adaptation
- Rockefeller Foundation: 100 Resilient Cities
- Resilient Cities Network

Non-State Actors (businesses, research institutes, private universities, and other private nonprofits)

Research centers/Environment focused Nonprofit Organizations

- Adrienne Arsht Rockefeller Foundation Resilience Center
- Argonne National Laboratory: Climate Risk and Resilience Portal
- Centre for Systems Solutions
- Environmental Defense Fund: Climate Resilience
- Environmental Law Institute: Climate Resilience and Hazard Mitigation;
- Natural Resources Defense Council: Climate Adaptation
- The Nature Conservancy: Resilience and Risk Management
- Rand Climate Resilience Center
- Resources for the Future: Climate Risks and Resilience
- Rocky Mountain Institute: Finance the Future; Climate Resilience
- Global Facility for Disaster Reduction and Recovery: Resilience to Climate Change
- Sierra Club Adaptation and Restoration Team
- World Resources Institute: Climate Resilience
- Urban Institute: Climate, Disasters and Environment

- World Resources Institute: Principles for Local Adoption

Profitmaking Enterprises

- AECOM: Climate Adaptation
- Duke Energy: Climate Resilience and Adaptation
- KPMG: Climate Risk and Resilience
- Marsh McLennan: Climate Resilience
- Moody's on Climate
- S&P Global: Climate Risk and Resilience
- Zurich Resilience Solutions: Climate Risk

Universities

- Berkeley Research: Energy, Climate & Environment
- Carnegie Mellon University: Compilation of US City Climate Adaptation Plans
- Carnegie Mellon University: The Center for Engineering and Resilience for Climate Adaptation
- Columbia University: Climate Adaptation Initiative
- University of Connecticut: Connecticut Institute for Resilience and Climate Adaptation (CIRCA)
- Duke University: Nicholas Institute
- Georgetown University: Adaptation Clearing House
- University of Minnesota: Climate Adaptation Partnership
- MIT: Climate Portal
- Rutgers University: Coastal Climate Risk and Resilience (C2R2) Initiative
- Stanford University: Climate Change Adaptation
- University of California Davis: Climate Adaptation Research Center
- University of California San Diego: Center for Climate Change Impacts and Adaptation at Scripps Institute for Oceanography
- Yale Program on Climate Change Communication
- US government/university adaptation science centers
    - Pacific Island Climate Adaptation Science Center
    - Northwest Climate Adaptation Science Center (University/Federal)
    - Southwest Climate Adaptation Science Center (University/Federal)
    - North Central Climate Adaptation Science Center (University/Federal)

Associations/Networks

- National Association of Insurance Commissioners: Climate Risk and Resiliency Center
- National Conference of State Legislatures: State Coordination on Climate Risk and Resilience
- American Society of Adaptation Professionals
- Climate Adaptation Exchange (CAKEx)
- Water Utility Climate Alliance: Leading Practices in Climate Adaptation

Appendix C: Participant Backgrounds

Maoliang Bu is a Full Professor at Nanjing University and Adjunct Professor at the Hopkins-Nanjing Center, which is part of Johns Hopkins University School of Advanced International Studies. His extensive research has been published in several leading academic journals, including the Journal of International Business Studies (JIBS), Strategic Management Journal (SMJ) and Journal of Comparative Economics. Prof. Bu currently serves as an Editor for several prestigious journals such as Asia Pacific Journal of Management (APJM), Business and Society, and Journal of International Management.

Louise K. Comfort is Professor Emerita and former Director, Center for Disaster Management, Graduate School of Public and International Affairs, University of Pittsburgh. She is currently a Visiting Researcher, Center for Information Technology Research in the Interest of Society, University of California, Berkeley. She is a Fellow of the National Academy of Public Administration and received the 2020 Fred Riggs Award for Lifetime Achievement, Section on International Comparative Administration, American Society for Public Administration. Her recent books include *The Dynamics of Risk: Changing Technologies and Collective Action in Seismic Events*, Princeton University Press, 2019, and *Hazardous Seas: A Sociotechnical Framework for Early Tsunami Detection and Warning,* Island Press, 2023, co-edited with H.P. Rahayu. She studies the dynamics of decision making in response to urgent events: earthquakes, tsunamis, hurricanes, wildfire, and COVID-19.

Dan Guttman is a teacher and lawyer and has been a public servant. He served as Executive Director of a Presidential bioethics Commission, was Presidentially appointed Commissioner of the U.S. Occupational Safety and Health Review Commission, directed, as special counsel, Senate investigations of US government management, and was UNDP and EU "foreign expert advisor" on China environmental law development. Following 2004-6 years as China Fulbright scholar, he has taught and worked with China, US and global colleagues developing comparative governance courses, texts, research projects at Peking, Tsinghua, Nanjing, and Shanghai Jiao Tong Universities, and is currently Professor, Tianjin University Law school, adjunct professor, Fudan University/London School of Economics Institute for Global Public Policy, fellow New York University US-Asia Law Institute. In the US he taught for many years at Johns Hopkins, and been Fellow at Hopkins, Emory and the University of California Santa Barbara. As a private lawyer he has represented cities, states, citizens, workers in energy, environment, antimonopoly, human/civil rights litigation. He is a Fellow of the US National Academy of Public Administration, cochairing

the International Panel, shared in journalism awards, and testified many times before Congress and other public bodies.

Chenyang He is a post-doctoral fellow at Institute for Global Public Policy, Fudan University. She earned a bachelor's degree in public administration from Fudan University and a Ph.D. in public policy from City University of Hong Kong. Her research interests lie in nonprofit studies, public participation, environmental policy and environmental governance. Her articles have appeared in *Public Performance & Management Review*, *VOLUNTAS, Ecological Indicators, Journal of Cleaner Production, Fudan Public Administration Review (in Chinese)* and among others. She is currently conducting a research project exploring how to make environmental transparency work in China. Through investigating the measurement, rationale and effectiveness of environmental transparency, this project aims to explain why transparency succeeds in achieving the objectives ascribed to it under some conditions but not under others.

Yijia Jing is a Chang Jiang Scholar, Seaker Chan Chair Professor in Public Management, Dean of the Institute for Global Public Policy, Co-Director of London School of Economics-Fudan Research Centre for Global Public Policy, and Director of the Fudan-Arab Research Centre for Global Development and Governance, Fudan University. He conducts research on privatization, governance, social organizations, and collaborative service delivery. He is founding editor-in-chief of the journal Global Public Policy and Governance and a founding co-editor of the Palgrave book series, Governing China in the 21st Century. He is a co-editor of International Public Management Journal, and was an associate editor of Public Administration Review and editor-in-chief of Chinese journal Fudan Public Administration Review. He served as a vice president of International Research Society for Public Management. He received his BA/MA in Economics from Peking University, MA in Sociology from University of Maryland College Park, and Ph.D. in Public Policy from the Ohio State University.

Rebecca Kihslinger is the Senior Science and Policy Analyst at the Environmental Law Institute and Director of ELI's Wetlands Program. Rebecca conducts research on local, state, and federal wetlands law, policy, and management. She has led multiple projects on compensatory mitigation policy and practice, including studies focused on the state of stream compensatory mitigation, improving compensatory mitigation project review, and in-lieu fee implementation across the country. Rebecca also leads ELI's work on climate resilience and hazard mitigation. Her work is focused on advancing nature-based solutions by promoting partnerships among natural resource agencies and organizations and hazard mitigation planners and building the capacity of communities to identify risks and vulnerabilities, plan for the future, and develop projects that build resilience and meet local needs. Dr. Kihslinger earned a PhD in Animal Behavior from

University of California, Davis and a BS in marine science from the University of South Carolina, Honors College.

Debra Knopman is an adjunct researcher at the RAND Corporation and a professor at the Pardee RAND Graduate School. She also is a Co-Chair of the Board of Directors of the Henry Luce Foundation, Vice Chair of the Council of the Austrian-based International Institute for Applied Systems Analysis (IIASA), Chair of the US Committee for IIASA, and a member of the Board of The Asia Foundation. She served as a Vice President of RAND and Director of RAND's Justice, Infrastructure, and Environment Division from 2004 to 2014 and as a Principal Researcher from 2014 to 2022. Her expertise is in hydrology, environmental and natural resources policy, systems analysis, and public administration. Her project work spans a range of topics including adaptation of urban regions to a changing climate, long-term water management, capability development planning for the Air Force, policy options for disposition of nuclear waste, and the design of a National Research Fund for Qatar. She served for six years (1997–2003) as a member of the Nuclear Waste Technical Review Board (Presidential appointment) and chaired the board's Site Characterization Panel. She was the director of the Progressive Policy Institute's Center for Innovation and the Environment from 1995 to 2000. From 1993 to 1995, she served as Deputy Assistant Secretary for Water and Science, U.S. Department of the Interior. She had previously been a Research Hydrologist at the U.S. Geological Survey (USGS) and later chief of the Branch of Systems Analysis in the USGS Water Resources Division. From 1979 to 1983, she served first as Legislative Assistant for energy and environmental issues to Senator Daniel P. Moynihan (NY) and then as a Professional Staff Member of the U.S. Senate Committee on Environment and Public Works. In 1978–79, she lived and worked in Taiwan as a Luce Scholar. She earned her Ph.D. in geography and environmental engineering from Johns Hopkins University, her M.S. in Civil Engineering from MIT, and her B.A. in chemistry from Wellesley College.

Wanxin Li is highly experienced with evidence-based and transdisciplinary policy research for achieving sustainability transitions. Having had the privilege of working with the World Bank, OECD, and Tsinghua University, she contributed significantly to discovering why and how socio-technological and institutional innovations emerge and make impacts, in the context of the multi-level governance structure in China. Her research output appears in tier one academic journals such as Nature and Land Use Policy. Besides the academia, her work has been well received by policymakers, practitioners, and international organizations. For example, she was invited to speak at the OECD International Conference on Environmental Compliance Assurance in Paris, and the Trade and Environment Session of the WTO Public Forum in Geneva. She is also highly effective in guiding students to learn the craft of designing and executing problem driven independent projects. For example, she directed students to invent transparent recycling bins and to promote green

mega-events at the Hong Kong Rugby Sevens games. It was selected as one of the flagship projects presented at the Climate Change Stakeholder Engagement Forum held by the Hong Kong SAR Government on July 12, 2016.

Beibei Liu is a professor of Environmental Planning and Management at the School of the Environment in Nanjing University. With a background in environmental system analysis and environmental policy analysis, she is now working on environmental sustainability and climate resilience of agri-food and infrastructure systems, as well as developing cost-effective strategies to better adapt to an uncertain climate with less environmental impacts. Her research has been published in international journals, including Nature Food, Nature Water, ES&T and others.

Elizabeth Losos is an executive in residence at the Nicholas Institute for Energy, Environment & Sustainability and adjunct professor at the Nicholas School of the Environment. Her work focuses on how to promote sustainable and resilient infrastructure through policy research on infrastructure standards, environmental and social impacts, and enabling conditions. Dr. Losos also heads the **ISLE Initiative**, a global network of learning hubs to build sustainable infrastructure capacity through case-based peer learning. She is co-convener of the **Resilience Roadmap** Project, an initiative to support US federal agencies and their partners in building equitable climate resilience. She also is the Duke lead for **Infrastructure for Good**, a research initiative of Economist Impact in partnership with Deloitte and the Nicholas Institute; the centerpiece of the program is a barometer that compares infrastructure ecosystems in countries around the world. Losos formerly was president and CEO of the Organization for Tropical Studies (OTS), a global consortium of universities and research institutes with the mission of promoting education, research, and the responsible use of natural resources in the tropics. Prior to her tenure with OTS, Losos was the director of the Smithsonian Institution's Center for Tropical Forest Science, a global network of large-scale forest demography programs.

Felicia Marcus is currently the Landreth Visiting Fellow at Stanford University's Water in the West Program and is an elected Fellow of the National Academy of Public Administration and the American College of Environmental Lawyers. Felicia was most recently Chair of the California State Water Resources Control Board after having served as Regional Administrator of the U.S. EPA Region IX and as head of the City of Los Angeles' Department of Public Works in addition to senior leadership in national non-governmental organizations. She has experience as a private and public interest sector attorney and has worked on issues across the West spanning water supply, water rights, and water quality in addition to experience in other sectors like energy, toxics, and land use. She is also a member of the Water Policy Group, an international network of former and current high-level water and is also one of the three US members of the Joint Public Advisory Committee of

the North American Commission on Environmental Cooperation in addition to serving on many boards and advisory committees. Felicia graduated cum laude from Harvard College (East Asian Studies), has her JD from New York University School of Law, and attended Hong Kong University (Rotary Fellowship).

Huiling Ouyang has an interdisciplinary educational background including Environment Sciences, Psychology, Biological Science, and Atmospheric Sciences. Her main research interests include health impact of climate change, risk assessment, climate change adaptation and governance. She is now an Engineer at the Department of Atmospheric and Oceanic Sciences/Institute of Atmospheric Sciences, Fudan University, and served as the assistant to the Executive Director at the IRDR International Centre of Excellence (ICoE) for Risk Interconnectivity and Governance on Weather/Climate Extremes Impact and Public Health (RIG-WECEIPHE), Fudan University.

Ye Qi is the Acting Head of CNCC Thrust and IPE Thrust of Hong Kong University of Science and Technology (Guangzhou) and Director of Jiangmen Laboratory of Carbon Science and Technology. Prior to joining HKUST in January 2019, he was the Cheung Kong Professor of Environmental Policy and Management at Tsinghua University's School of Public Policy and Management, and the Volkswagen Professor of Sustainability at Schwarzman College. From April 2014 to January 2019, he was Senior Fellow at the Brookings Institution and the Director of Brookings-Tsinghua Center for Public Policy. He was appointed as Cheung Kong Professor of Environmental Science at Beijing Normal University from 2002-2005. Ye's research areas include Chinese environment and energy policy, environmental policy and governance, climate change and global environmental governance, sustainability science and governance and sustainable urbanization.

Personal webpage

Kyle Romano is a research analyst at the National Academy of Public Administration. He has provided research support for more than ten Academy studies. Recently, he has served on Academy projects assessing the National Park Service's land acquisition program and NOAA's National Marine Sanctuaries System. He graduated from the Indiana University School of Public and Environmental Affairs, where he earned a Master of Public Administration. He attended the University of Central Florida for his undergraduate studies, where he earned a B.A. in Political Science and a B.S. in Legal Studies.

Michael Spencer is a consultant who teaches and conducts research at Monash University in Melbourne and is the Asia Pacific Lead for the Centre for System Solutions, a European non-profit that helps governments and others navigate complex problems using systems thinking. Previous

positions include founding chair of the Edinburgh-based Alliance for Water Stewardship, head of marketing and communication at the Forest Stewardship Council International Centre in Bonn, head of corporate citizenship at the National Australia Bank, Vice-President Communication at BHP Billiton, head of communication at BHP, General Manager at the National Institute of Economic and Industry Research (Melbourne), Senior Adviser to the Premier of Victoria, head of the Victorian Government Media Liaison Unit and a senior journalist and news producer. The focus on his work is on environmental governance, water, climate and solutions conflicts between humans and nature.

Janet Stanley has an Honorary position at the University of Melbourne, is an Associate with The Centre for Rural Criminology at the University of New England and Visiting Professor at Hiroshima University. Prior positions include Chief Research Officer at Monash University Sustainability Institute; Senior Manager, Brotherhood of St Lawrence, a major welfare organization; Principal Researcher Institute of Family Studies, Australian Government; and partner in a consultancy business. Janet specializes in inter-disciplinary work across policy, system design, and at operational and community levels. She works in the areas of social policy, transport, urban planning, equity, wellbeing, child welfare, climate change, adaptation, wildfire, project evaluation and the environment. Janet's work includes over 100 peer-reviewed publications, including six books and her work has led to policy and practice changes within a range of fields.

Xu Tang is a Professor at the Fudan Development Institute (FDDI) and the Department of Atmospheric and Oceanic Sciences/Institute of Atmospheric Sciences (AOS/IAS), specializing in climate change adaptation, weather/climate extremes, risk and interconnectivity analyses, and climate governance. He is the Executive Director at the IRDR International Centre of Excellence (ICoE) for Risk Interconnectivity and Governance on Weather/Climate Extremes Impact and Public Health (RIG-WECEIPHE), at Fudan University (FDU-IRDR-ICoE-RIG-WECEIPHE). Furthermore, Prof. Tang is the Senior Scientific Advisor of the International Programme Office (IPO) at IRDR, a collaborative effort between ISC/UNDRR. He is also a member of the Committee on Disaster Risk Management at the World Federation of Engineering Organizations (WFEO-CDMR) and a member of the Alliance of Alliances on Water and Disaster Management under the leadership of the UN High-Level Experts and Leaders Panel (AoA/UN-HELP). Before joining Fudan University, Prof. Tang served as the Director of the Weather and Disaster Reduction Services Department (WDS) at the World Meteorological Organization (WMO), the specialized agency of the United Nations, from 2013 to 2019. During his tenure, he led the coordination efforts for the development and initiation of the Global Multi-hazard Alerting System (GMAS) and played a key role in launching the International Network on Multi-Hazard Early Warning Systems (IN-MHEWS) in collaboration with 22 other international organizations during the third United

Nations World Conference on DRR (WCDRR-III) and in organizing International Multi-Hazard Early Warning Conferences held in 2017 (Cancun, México) and 2019 (Geneva, Switzerland).

Personal webpage

Franz Wohlgezogen is a Senior Lecturer of strategy and leadership at the Faculty of Business and Economics, University of Melbourne. He serves as a champion for the UN's Principles for Responsible Management Education (PRME) at the Faculty, leads the Impact Team of the Academy of Management's "Organizations and the Natural Environment" Division, and is a fellow at the Center for Evidence-Based Management (CEBMa.org). He was previously a faculty member of Bocconi University, Italy, and holds a PhD from Northwestern University. His research investigates issues of governance, organization design, cross-boundary collaboration, and strategy implementation – particularly with regards to organizations' efforts to address sustainability and climate change. Across his research, teaching, and engagement work he advocates for transdisciplinary and interdisciplinary practice to advance responsible management.

Dr. Jingyuan Xu is an assistant professor at Institute for Global Public Policy (IGPP), Fudan University and a researcher at LSE-Fudan Center. She received her B.A. in International Politics from Fudan University and Ph.D. in Public Policy from the City University of Hong Kong. Dr. Xu's research focuses on global environmental and climate governance, collaborative governance and public finance management. Her recent work has appeared in *Public Administration Review*, *Climate Policy*, *Environmental Politics*, *Public Money and Management*, *Environmental Education Research*, among others. She is the principal investigators of several research projects funded by CPSF and NSFC. She is the program director of Master Program in Global Public Policy (MGPP). She teaches courses on Chinese Public Policy, Public Financial Management, and Qualitative Research Method.

Yuan Xu is an Associate Professor in the Department of Geography and Resource Management and leads the Environmental Policy and Governance Program at the Institute of Environment, Energy and Sustainability at the Chinese University of Hong Kong (CUHK). He is currently serving as the President of the Professional Association for China's Environment (PACE). He has published widely on energy and environmental policy, governance and strategy, and technological and industrial development, covering fossil fuels and renewables. His recent monographs include *Environmental Policy and Air Pollution in China: Governance and Strategy*, and *Residential Electricity Consumption in Urbanizing China: Time Use and Climate-Friendly Living* (co-authored), both published by Routledge. Before joining CUHK in August 2010, he received a Ph.D. in public policy from the Woodrow Wilson School of Public and International Affairs, Princeton University, USA. He was a postdoctoral research associate at the Industrial Performance Center,

Massachusetts Institute of Technology, USA. He also holds an M.S. degree in climatology, a B.S. degree in atmospheric sciences and a bachelor's degree in economics, all from Peking University, China.

Oran Young is a renowned Arctic expert and a world leader in the fields of international governance and environmental institutions. Dr. Young has been involved in leading position in global change research for several decades, among others as founding chair of the Committee on the Human Dimensions of Global Change of the US National Academy of Sciences; chair of the Scientific Steering Committee of the international project on the Institutional Dimensions of Global Environmental Change; founding co-chair of the Global Carbon Project; and from 2005 to 2010 the Scientific Committee of the International Human Dimensions Programme on Global Environmental Change. He is the author of more than 20 books. His recent books include On Environmental Governance: Sustainability, Efficiency, and Equity (2013) and Governing Complex Systems: Social Capital for the Anthropocene (MIT Press 2017).

Huiyu Zhao (Joy) is a senior scholar of environmental resources law at Koguan Law School of Shanghai Jiao Tong University in China. Research has focused on comparing environmental laws between China and the United States, litigation on climate change, animal welfare law, and ecological law. She has worked full and/or part time In China's procuratorial system, the Shanghai Environmental Protection Bureau and the Ministry of Environmental Protection. She has been a Visiting scholar at Maryland Carey Law School in the US.

Xiaofan Zhao is Assistant Professor at the Division of Public Policy of the Hong Kong University of Science and Technology. Prior to joining HKUST in January 2021, she was a post-doctoral fellow at the School of Public Policy and Management, Tsinghua University (2018-2020). She holds a BS in environmental engineering with honors and with distinction (2009) and a MS in management science and engineering (2010), both from Stanford University, and a PhD in public administration from Tsinghua University (2018). She has worked for the Climate Policy Initiative Beijing Office as well as the World Resources Institute. Her research mainly focuses on climate change, energy, and environmental policies.