

Institutionalizing Uncertainty: Exploring how infrastructure stakeholders can prepare for uncertain climate futures

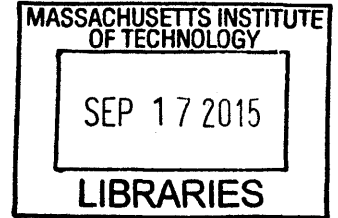
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Abstract

Climate change poses a range of threats to our infrastructure systems. Efforts to respond are complicated by the uncertainty and complexity involved. The uncertainties are pervasive, going beyond scientific and technical issues to include significant governance challenges. This dissertation examines how stakeholders are likely to make project-level decisions in practice, and how we can support better processes. It considers the implications of using multiple scenarios as a way to frame uncertainty, and of bringing multiple stakeholders together for decision-making. It is also concerned with the differences across governance regimes, focusing on Boston, Singapore and Rotterdam. The research process featured a role-play simulation (RPS) exercise run with participants as a way to introduce issues and facilitate experimentation.

Participants overwhelmingly favored flexible approaches as a way to proceed despite uncertainties, making the best possible decisions today while leaving options open as conditions change and learning occurs. Unfortunately, this research suggests that there are substantial barriers to institutionalizing flexibility. Participants were also extremely positive on the use of scenarios as a way to frame uncertainty. However, the exercise runs underscored the challenges associated with their use; scenarios encourage users to consider the implications of an uncertain future, but can concurrently deny them the single standards they are familiar with using. Another key finding is that adaptation planning efforts are *deliberative processes* in which facilitation, the behavior of participants, and process design matter; the choices participants made had significant implications on exercise outcomes. Finally, participants behaved differently across the three cities, underscoring the importance of wider governance norms.

This dissertation concludes with three recommendations: First, the development of *boundary organizations* that can foster the dynamic institutions necessary to advance flexible adaptation. Second, given the importance of salient, credible and legitimate

scientific and technical information, I recommend the use of *joint fact finding* (JFF) techniques. Because of the dynamic nature of climate adaptation, I suggest that JFF be explicitly iterative in nature. Scenarios can help JFF groups to consider the uncertainties involved. Third, I recommend that researchers consider using exercises as tools for action research, particularly when considering nascent and complex issues like climate adaptation.

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**Institutionalizing Uncertainty:
Exploring how infrastructure stakeholders can
prepare for uncertain climate futures**

**Chapter 1 – Introduction:
Hypotheses, research design, and literature review**

Introduction

This dissertation research project explores how infrastructure stakeholders can better prepare for uncertain climate futures. It considers how uncertainty can be institutionalized into planning and decision-making, with particular consideration given to ‘flexibility’ as an adaptive response; alternative approaches of multi-stakeholder decision-making; and the use of multiple scenarios for framing uncertainty. It also examines the implications wider governance regimes or institutional environments have on how uncertainty is addressed and climate adaptation advanced. It is focused on the adaptation of infrastructure systems, and transportation infrastructure in particular, in large, developed coastal cities.

Adaptation is becoming critically important as ever more acute climatic changes become increasingly inevitable. Early efforts to address climate change focused on reducing greenhouse gas emissions in order to avoid the impacts, and mitigation remains an important goal. However, most experts now agree that we are ‘locked in’ to fairly substantial climatic changes, including increases in temperature and associated sea level rise and shifts in weather patterns (IPCC, 2014). Climate adaptation may be necessary in most sectors, but is particularly important when it comes to infrastructure systems, as they are typically built with the expectation that they will remain operational for decades. As a result, managers need to consider not only current climatic conditions and assessed risks in their planning and decision-making, but also potential future risks throughout the life of their infrastructure. The long-term nature of infrastructure planning and decision-making exacerbates the uncertainties present. Preparedness for extreme events is a critical component of adaptation and disaster response may be increasingly inevitable, but this research focuses more on the long-term adaptation of infrastructure in response to dynamic and uncertain climatic conditions than on responses to extreme events.

Over 100 decision-makers and other stakeholders were engaged in this research. They came from transportation and other agencies at all levels of government, and from other stakeholder groups in the three case cities – Rotterdam, the Netherlands, Boston, United States, and Singapore. As discussed in this chapter, these cities were chosen because they have some things in common, including their coastal vulnerabilities, but vary based on their respective governance regimes. Decision-making in Boston happens within a neopluralist and neoliberal paradigm; Rotterdam within a neo-corporatist paradigm; and Singapore within a semi-authoritarian paradigm.

Participants were engaged in various ways to generate a rich set of qualitative and quantitative data. The primary interventions were half-day workshops in each of the cities. The workshops featured a role-play simulation (RPS) exercise that put participants into a realistic yet fictitious situation somewhat similar to their own, involving a transportation infrastructure planning challenge. There are two versions of the exercise, which were played by different but similarly constituted groups of participants in each city. One version includes scenarios (i.e., multiple possible futures) and the other a more conventional risk assessment forecast. This allowed for examination of the differences in process and outcomes when multiple scenarios are introduced. Exercise debriefings, pre- and post-workshop surveys, preliminary and follow-up interviews, and background research were other sources of information.

This dissertation is comprised of six chapters:

1. ***Introduction: Hypotheses, research design, and literature review*** – This first chapter establishes the background for the rest of the dissertation. The next section introduces the research questions and hypotheses that drove the research. The section following outlines the research design and process followed. The final section introduces the six literatures that this research relates to – climate adaptation planning; institutional theory; collaborative planning and governance; uncertainty and flexibility; scenario planning; and the use of role-play simulation exercises in action research.
2. ***Rotterdam Case*** – The second, third and fourth chapters examine each of the cases individually. Each of these chapters follows a similar structure. Part 1 establishes the context, outlining: The climate vulnerabilities; climate preparedness (i.e., adaptation) efforts; how infrastructure planning and decision-making happens in general, particularly in the key areas of land transportation infrastructure and coastal defense; and the governance model and its characteristics. Part 2 focuses on the ‘research process and outcomes’, and contains the following sections: Research design and process; summaries of the outcomes for each of the exercise runs; and results of the pre- and post-exercise surveys. Part 3 concludes the chapter by summarizing some of the general themes that emerged.
3. ***Singapore Case*** – Follows a similar structure to the Rotterdam Case.
4. ***Boston Case*** – Follows a similar structure to the Rotterdam Case.
5. ***Research Findings: Recurring themes and comparative analysis*** – This chapter presents a series of findings based on data drawn from across the three cases. Some of the findings are general in nature, including: The pervasive nature of uncertainty; the predilection towards flexibility as a way of proceeding with planning and decision-making despite uncertainty; some of the barriers to institutionalizing flexibility in practice; and the importance of process in adaptation planning efforts. Other findings highlight the differences among the three cases, suggesting the need for different approaches. The issues focused on here are: Awareness of climate risks;

adaptation planning efforts; status of climate adaptation in practice; barriers to adaptation; the role of interests in decision-making; the roles of state and non-state actors in planning and decision-making; priorities in management; the nature of internal deliberations; and the variability in response to uncertainties. The final section of this chapter examines the differences between scenarios and risk assessments as alternative ways of framing uncertainty. It draws on the comparative outcomes between the risk assessment and scenarios versions of the RPS exercise, and reflections of participants that played each.

6. ***Implications and Recommendations*** – The final chapter draws some implications from the research findings, and makes a set of recommendations for planners, policy-makers, researchers and other stakeholders. These recommendations are in the following areas: Collaborative adaptive planning and policymaking; making scientific and technical information work; and role-play simulation exercises for action research.

Research questions and hypotheses

This research project is intended to enhance our understanding of how complex risks characterized by uncertainty and dynamism - like those associated with climate change - can be institutionalized (i.e., integrated) into infrastructure planning and decision-making. It is not intended to conclusively test hypotheses, but rather to provide a greater understanding of how policies and practices are emerging, might continue to emerge, and can be supported around a relatively nascent and unresolved challenge in planning and decision-making. That is, it is largely a theory building enterprise.

Nonetheless, two explicit research questions, four hypotheses, and a set of sub-hypotheses served as the point of departure for this research. These questions and hypotheses guided the research design discussed in the next section of this chapter. The research findings presented in the three case chapters and analyzed in the comparative (5th) chapter largely respond to them.

Research questions

This research focuses on how infrastructure managers and other stakeholders are starting to integrate climate change into their planning and decision-making, and/or may do so in the future as attention to the risks associated with climate change increases and adaptation to changing conditions becomes an expected part of their processes. To this end, the research questions this dissertation project set out to answer are:

As infrastructure managers and other stakeholders grapple with complex and uncertain risks, like those posed by climate change, how are they likely to make decisions in practice? How can we support more effective decision-making?

Hypotheses examined

1. **Importance of process** - Facilitated multi-stakeholder deliberation can help groups to advance adaptation planning and decision-making to address wicked problems with institutional ambiguity, uncertainty and conflicting interests and perspectives.
2. **Value of scenarios** - Using multiple scenarios as a tool for framing uncertainty and making decisions despite its persistence enhances adaptation planning efforts.
3. **Differences across governance regimes** - We will see differences across governance regimes, which are currently underappreciated and unaccounted for in adaptation planning, yet are key to the development of best practices.
4. **Role-play simulation exercise** - A workshop that brings stakeholders together to wrestle with a simulated challenge can enhance their awareness of the issue(s) being examined, and how they might be resolved both technically and process-wise.

In addition to these four core hypotheses, a set of sub-hypotheses were proposed at the outset of this research enterprise. They were:

1. Importance of process

The following sub-hypotheses were proposed around the importance of process in collaborative efforts to advance adaptation planning and decision-making:

- A. **Facilitation skills** - The exercise runs were somewhat contingent on the performance of those assigned the key facilitation role (i.e., Deputy Director of the Transportation Agency). I attempted to minimize problems by asking my partner agencies in each city to recommend people that they felt could do this well, and by providing detailed instructions. Nonetheless, I hypothesized that different approaches to and levels of competency in facilitating would have implications on the groups' trajectories and outcomes reached.
- B. **Individual negotiation skills and personalities** - In the same vein as the previous sub-hypothesis, each person invariably brought their own personality and approach to negotiation to the role they filled. The advantage of running each version of the RPS exercise five times, and at least twice in each city was that I could identify consistencies. For other features of the processes and conclusions of each group, I hypothesized that I would find that individual skills and personalities would be factors.

2. Value of scenarios

The following sub-hypotheses around the value and impact of introducing multiple scenarios to decision-making were proposed:

- A. **Greater attention to process** - The introduction of a new element to decision-making will render the entire process more open to critique and discussion. I expected that when the facilitators in each group brought up the issue of assessing the options against the scenarios to evaluate robustness, one or more participants would question the broader decision-making process, and that this concern with how decisions will be made and the groups' interactions facilitated would persist. That is, a Pandora's box of attention to process design would be opened that could result in delays, frustration and/or more pressure on the facilitators. On the other hand, it may result in the emergence of better process design.
- B. **Uncomfortable engineers** - Those trained as engineers would be concerned and uncomfortable with the lack of a single variable forecast of future conditions on which decisions can be based. Engineers are trained to work with estimates and associated probability distributions, adding additional factors of safety as prescribed. I expected engineers to be uncomfortable with using multiple possible futures, particularly when they are qualitative with no probabilities attached and thus cannot be translated into engineering parameters easily. I expected this discomfort to translate into a push to choose the most appropriate scenario, or to disregard them altogether.
- C. **Favoring of flexibility**- I expected the explicit recognition of multiple possible futures to lead to the favoring of flexibility as a response to uncertainty, over other approaches including using the worst-case scenario or deferring to experts.
- D. **Scenarios as ammunition** - I expected that parties would attempt to use the scenarios to justify their various positions. That is, the introduction of scenarios will inherently diminish disagreements or reveal the correct path forward to a degree greater than the introduction of any other form of data does. In fact, because scenarios embrace rather than reduce uncertainty, they may contribute to more persistent disagreement. I expected that some participants would argue that their respective positions are most appropriate in light of the range of scenarios, while others will favor certain scenarios over others as a justification for their positions.
- E. **Different coalitions** - The scenarios would lead to the formulation of different alliances or coalitions than are otherwise present. Some parties would feel compelled to plan for the forecast in the non-scenario version, whereas they would feel more free to consider alternative options in the scenarios version, leading them to different positions and thus different relationships to others.
- F. **New forms of discourse will emerge** - Because the scenarios make uncertainty explicit, the discourse would focus much more on making the best choice in the face of multiple possible futures. In contrast, the single forecast version would lead most parties to justify their positions on the basis of it (or, conversely, based on discrediting it).

3. Differences across governance regimes

The following sub-hypotheses were proposed around the expected differences across the three governance regimes examined:

- A. **Consensus vs. conflict** – Different regime types allow for varying degrees of disagreement. In some it is normal to seek consensus, while in others it is held that the best outcomes are crafted in tension. I expected participants in Rotterdam and Singapore to seek consensus, and for the quest for broad agreement to be quite natural for participants. In contrast, I expected participants in Boston to fall into conflict more naturally.
- B. **Deference vs. disagreement** – Beyond the varying proclivities towards consensus vs. conflict writ large, I expected varying degrees of comfort with disagreement across hierarchical levels. I expected that participants in Rotterdam and Boston would be much less conscious of the status of the various roles and much more open in their expressions of disagreement regardless of who may be more or less senior. In contrast, I expected the discourse to be much more guarded in Singapore, and that participants would be much more conscious of the in-built hierarchy among roles and deferent towards those they view as senior.
- C. **Today vs. tomorrow** – I expected to find that decision-makers in Rotterdam are, in general, paying more attention to uncertain future risks at some economic cost today, compared to decision-makers in Boston, which are relatively more concerned about incurring costs that turn out to be unnecessary. I did not have an expectation of how players in Singapore would respond a priori.
- D. **Proactive vs. reactive** – I expected that participants in Rotterdam would, in general, emphasize a more proactive approach both in the game and in their statements and survey responses. In other words, they lean towards taking action today to protect from future possible risks. In contrast, I expected decision-makers in Boston to favor more reactive responses. Again, I did not have a pre-established expectation for Singapore.

4. Role-play simulation exercise

The following sub-hypotheses were made around the expected efficacy of the role-play simulation (RPS) exercise as a tool for use with multi-stakeholder groups considering how to tackle a nascent issue like adaptation to climate change:

- A. **Increased recognition of climate risks** – I expected participants to come in with varying opinions on how significant of a threat climate change poses to their infrastructure, and that their degree of recognition would increase as a result of the exercise.

- B. **Increased recognition of uncertainty** – In addition to increased recognition of the need to consider climate change adaptation, I anticipated that participants' recognition of the importance of uncertainty as a factor would also increase.
- C. **Increased confidence** – While I expected some discomfort with the use of multiple scenarios (see above), in general I expected participants to leave feeling more confident that they can and will find ways to address the risks posed by climate change. I also allowed for the counter-possibility that the game would decrease confidence by exposing people to risks they were previously ignorant of.
- D. **Multiple actors, multiple decision points** – The role-play simulation (RPS) exercise run with participants was designed to simulate multi-stakeholder face-to-face dialogue, which may be unusual to those playing in all three cities. I expected participants to explicitly confirm afterwards that this is somewhat unusual, and that the questions being addressed are typically dealt with (if at all) piecemeal in various fora. I assumed that they would largely be positive on the value of this approach vis-à-vis the status quo. In particular, I expected that they would confirm that such processes can effectively up-end norms, leading to quicker and more creative innovation among stakeholders.

These hypotheses and sub-hypotheses were investigated using a role-play simulation exercise, interviews, surveys and background research in three case cities – Singapore, Rotterdam and Boston. The goal was to assess their accuracy, particularly with regards to how climate adaptation is evolving in each case, or may in the future. The research methods employed to examine them are outlined in the next section of this chapter. The findings are compared to these hypotheses and sub-hypotheses in chapter 5 (the comparative chapter).

Research design and process

The research design followed in this dissertation project is outlined in *table 1.1* below. The research questions and hypotheses introduced in the previous section were translated into three independent variables:

- **Governance regime (IV #1)** – Research was conducted in three different cities chosen as archetypes of very different governance regimes. This allowed for comparison and contrast across the three cases.
- **Stakeholder engagement (IV #2)** – The exercise most of those engaged in this research participated in (discussed further below) featured a simulated multi-stakeholder deliberative process. Participants' experiences and reflections on this experience were compared to their status quo approaches to planning and decision-making.

- **Tools for framing uncertainty (IV#3)** – Two approaches to framing uncertainty were compared – multiple scenarios and a more conventional risk assessment forecast. These were compared by running two versions of the exercise with similarly constituted groups in each city, one with scenarios and one with a probabilistic forecast.

The dependent variables assessed were the **decision-making processes and outcomes** in each of the permutations of independent variables. These were examined both in the context of the exercise runs discussed further below, and in the debriefings, interviews, surveys, and background research.

Table 1.1 – Research design

Independent variable 1 – Governance regime					
Neo-corporatist <i>Rotterdam</i>		Semi-authoritarian <i>Singapore</i>		Neopluralist/neoliberal <i>Boston</i>	
Independent variable 2 – Stakeholder engagement					
Multi-stakeholder deliberation <i>Versus status quo</i>		Multi-stakeholder deliberation <i>Versus status quo</i>		Multi-stakeholder deliberation <i>Versus status quo</i>	
Independent variable 3 – Tool for framing uncertainty					
Scenarios	Risk assessment	Scenarios	Risk assessment	Scenarios	Risk assessment
Dependent variables: Decision-making process and outcomes <i>(reflected both in the exercise, and debriefings and follow-up interviews)</i>					

Case selection

This research project was conducted in Rotterdam, Singapore and Boston. This is a *purposive sample*, based on their respective governance regimes (IV #1). Each city, and it’s wider region and country, is archetypal of a different model: Decision-making in Rotterdam happens within a largely neo-corporatist paradigm; Boston within a neopluralist and neoliberal paradigm; and Singapore within a semi-authoritarian paradigm. These regime typologies are further introduced in the theory section of this chapter, and expanded upon in the case chapters focusing on each. These cases do not represent a comprehensive cross section of all cities, but three important models of decision-making. The intent is not to exhaustively examine infrastructure adaptation in all contexts, but to investigate the similarities and differences in three different contexts.

While Boston, Singapore and Rotterdam vary as archetypes of different governance regimes, they are similar in important ways, providing some degree of consistency (i.e., control of confounding variables). All three are harbor cities, with extensive coastal infrastructure. As discussed in the three case chapters, all face recognized coastal

vulnerabilities due to climate change. Economically and culturally important parts of all three cities are constructed close to sea level on landfill and/or drained land reclaimed from the sea. All three have climate adaptation efforts underway at some level, and are part of many of the same global networks, including the Rockefeller Foundation's (2015) *100 Resilient Cities* (2015) network and the *C40 Cities Climate Leadership Group* (2015). While the risk of coastal flooding associated with sea level rise and storm surge is certainly not the only threat climate change poses to cities, including these three, it was focused on in this research for the sake of consistency and simplicity. Transportation infrastructure systems were also focused on, although other systems, including coastal defenses, are also discussed in the case chapters.

This selection of cases did introduce some confounding variables that need to be accounted for. First, the levels of government and mix of agencies involved in infrastructure planning vary across these three cities. In Boston, municipal, regional, state and national agencies all have roles. In contrast, Singapore is a city-state with only one layer of government. These differences are intertwined with their respective systems of governance. Fragmentation in Boston is both a result and product of its neopluralist nature. A more hierarchical model is possible in Singapore because there are not different levels of government to contend with each other. Another factor that had to be accounted for was the state of the environment at the time of intervention, and history of potentially climate change-related events in each city or region. For example, while it did not significantly impact Boston directly, Hurricane Sandy changed how stakeholders in the Boston region see climate risks, and the planning and rebuilding efforts in the New York region are coloring impressions of what the Boston area might do to adapt. Fortunately, no major weather or climate-related events impacted the three cities during this research project.¹ Participants' perceptions of the drivers of change and what they have learned from events in their respective cities, and elsewhere, were discussed during interviews.

Research process

The research process - which is illustrated in *figure 1.1* - involved seven steps, completed in each of the three case cities. Background research was conducted to develop a detailed understanding of: The projected climate risks for each city/region; the climate adaptation initiatives (both planning and concrete adaptive measures) being conducted by the various levels of government, agencies, and other stakeholders; their respective infrastructure planning processes, particularly around land transportation and coastal defense; and the nature of governance and decision-making in each case. Preliminary interviews were conducted to triangulate and fill gaps from the desk research, and establish relationships with various agencies in each city. They were particularly valuable for getting a sense of the unofficial story and unwritten norms. Data gathered also informed the development of the role-play simulation (RPS) exercise run with participants. Preliminary interviews were conducted with approximately 80 individuals across the three cities. A copy of the interview protocol used for these semi-structured interviews is attached as *appendix 1*.

¹ The Boston region experienced a historically severe winter in 2015, which some associated with climate change, but the research interventions in Boston were conducted before these events occurred.

Figure 1.1 – Research process



Half-day workshops run in each of the three case cities were at the heart of the research process. 76 people participated – 14 in Rotterdam, 30 in Singapore, and 32 in Boston. Participants included in some cases, but were not always the same as those interviewed prior. They came from a variety of agencies and other stakeholder groups relevant to infrastructure planning and decision-making, and transportation infrastructure in particular. In Boston, for example, participants came from various city agencies, including the Transportation Department and Boston Redevelopment Authority; various state agencies, including different branches of the Department of Transportation and the Office of Coastal Zone Management; the U.S. Department of Transportation regional office and Volpe (research) Center; and various non-profit organizations and private consultancies. Participant recruitment was based on *purposive (expert) sampling*, conducted in partnership with local partners in each city, employing a snowball technique to work outwards. Local partners were integral to the success of both recruitment and the organization of the workshops. They were: TNO (research institute) and Rijkswaterstaat (national infrastructure agency) in Rotterdam; the Civil Service College (a government agency), with support from a manager from the Ministry of Transport in Singapore; and the Boston Society of Architects, The Boston Harbor Association and the City of Boston in Boston.

Workshop participants completed pre-exercise surveys, which served four research purposes: First, they collected demographic information to get a better sense of who participated. Second, they provided a snapshot of participants' current decision-making norms. Third, they provided insights into their perceptions of the risks and uncertainty posed by climate change, uncertainly more broadly, and the level of preparedness of their respective organizations. Fourth, surveys were conducted both before and after the exercise to discern if participating in the exercise had any impact on participants' perceptions. The pre-exercise survey is attached as *appendix 2*.

The workshops revolved around a role-play simulation (RPS) exercise, which, as discussed in more detail later in this dissertation, is a type of serious game designed to put participants into a simulated environment to quickly expose them to: An emerging issue (climate risks in this case); possible responses; potential decision-support tools and alternative methods of decision-making; and the various interests and perspectives of different stakeholders. They could learn and experiment in a low-cost, simulated environment. The exercise specifically designed for this research is called *A New Connection in Westerberg*. Participants are placed in a fictitious yet realistic situation in which a group of stakeholders has been brought together as a special working group to consider if and how they can collectively reconcile some recently identified and still

uncertain climate risks with plans to construct a new road, which may be vulnerable if certain design options are chosen (IV #2). While the case presented in the RPS is highly simplified, participants in all three cities could relate it to their own situations.² The same exercise was run in all three cities to allow for direct comparison of the processes and outcomes. Each participant filled one of seven roles in the exercise. They were given shared general and individual role-specific ‘confidential instructions’ that outlined their interests, and provided additional information that they could share with the rest of their groups as they wished. The exercise was developed based on best practices in RPS design, building on extensive work done through the MIT Science Impact Collaborative and associated organizations. Early versions were piloted, first with student volunteers to test the mechanics, and then with participants in Boston and Rotterdam similar to those that would later play the game to test its resonance and viability with those in the case cities.

There are two versions of the *Westerberg* RPS – one asks participants to assess their options against four plausible but mutually exclusive, qualitative scenarios of the future, while the other provides a more conventional risk assessment forecast of future climate conditions. These versions were run with roughly equivalent groups of participants in each of the case cities, with allocation done on a matched-pair basis to the degree possible. The differences in process and outcomes between the groups playing each of these versions provided an opportunity to explore the implications of using different tools for framing uncertainty as stakeholders consider their adaptation challenges (IV #3).³ The exercises ran approximately 90 minutes each time, and were video recorded, transcribed and coded for analysis.

The RPS exercise runs were immediately followed by debriefings in which participants reflected on what happened during the exercise, how similar or different the simulated experience was to what they face in their real-world settings, and how the differences and similarities may inform real-world planning and decision-making. These sessions provided critical opportunities to ‘ground truth’ what happened in the exercise, and discuss the situations, opportunities and barriers in each city. The debriefings were focus group style and informal, but loosely followed the questions attached as *appendix 3*. They were also video recorded, transcribed and coded for analysis.

The workshops concluded with post-exercise surveys. These surveys filled two purposes: First, some questions from the pre-survey were asked again to examine if and how the workshop experience changed participants’ perceptions on various issues. Second, participants were directly asked about the RPS exercise and workshop experience, to get a sense of how similar (or different) it was to their real-world experiences, and validate it as

² Design features that participants in all three cities could relate to were purposefully included, and flagged when the games were introduced during the workshops.

³ The two versions of the RPS exercise are available via the Program on Negotiation at Harvard Law School’s Teaching Negotiation Resource Center (<http://www.pon.harvard.edu/store/>).

a tool for learning and research. The post-exercise survey completed by participants is attached as *appendix 4*.⁴

Semi-structured one-on-one interviews were conducted with most participants in the days following the workshops to better understand their perspectives and how they changed in light of this experience. These typically lasted around an hour, allowing for further discussion around the themes that emerged from the workshops. Participants' pre- and post-exercise surveys were not anonymous, so they could also be followed-up on during the interviews. The interview instrument loosely followed during these interviews is attached as *appendix 5*. As with the preliminary interviews, these discussions were informal in nature and tailored to each interviewee's survey responses, previous comments, and actions during the RPS exercise they participated in.

Analysis of results

Unless an interviewee objected to being recorded, which happened in only one instance (a follow-up interview), the preliminary and post-exercise interviews, RPS runs, and debriefings were audio or video recorded. These recordings were transcribed.⁵ The author coded the transcriptions in a qualitative research program called TAMS Analyzer, using a code list that was developed based on the preliminary interviews and evolved throughout the project. The code list, which includes definitions of each code, is attached as *appendix 6*. Participants were also tagged based on their city, real world role, role in the RPS exercise, and version of the exercise they played. TAMS provides various tools for qualitative analysis, including the ability to easily identify frequencies and patterns among codes, and extract coded sections. These tools were used to identify patterns and intensity, and extract quotations that illustrate key themes.

Statistical analysis was conducted on the pre- and post-exercise surveys. Participants identified themselves on both surveys, allowing for matched-pairs analysis. In particular, Wilcoxon signed-rank tests were run on various questions to test for statistical significance in shifts from pre- to post-exercise. As evinced throughout this dissertation, this test allowed for statistical power despite the relatively small sample sizes.

Internal, construct and external validity

Various confounding variables threaten the internal validity of this research. In terms of data collected on the basis of the variance in governance regimes across cases, there was significant risk that other factors – including cultural differences around such things as willingness to engage in the RPS and openness during the debriefs – would confound the differences. One way in which this was addressed was by using various methods -

⁴ Very minor changes were made to the survey instruments from one city to the next, with the most significant alteration being the addition of a couple of questions for the Boston group. The pre- and post exercise surveys attached as *appendices 2 and 6* are those used in Boston. Furthermore, slightly different versions were run with the scenarios versus risk assessment groups. These are the instruments used with the scenarios participants.

⁵ The author transcribed the majority of audio and video files, but used an external transcriber in some instances. The RPS runs in the Netherlands were conducted in Dutch, so a project partner at TNO both transcribed and translated the video files.

interviews, debriefings, surveys, and participant observation – to collect data. Fortunately, participants in all three cities were generally very open to participating in the exercises, and genuine in their reflections afterwards. I was pleasantly surprised by the frankness of their comments in various cases.

Ensuring that differences in outcomes were not the result of dissimilarities in composition across the various groups conducting the RPS - both within and across cities/cases – was necessary. As discussed above, local partners were instrumental to getting appropriately comprised groups for each exercise run. While extremely successful in this regard, the groups were not perfectly matched. Differences in composition and the implications are discussed in the case chapters and comparative chapter.

There was also substantial threat that the design of the RPS exercise would introduce bias. Extensive pre-testing was done to hone it as an instrument. More importantly, the debriefings and follow-up interviews provided opportunities to ‘ground truth’ the exercises against participants’ own experiences.

Another potential threat was language difficulties. Fortunately, English is the dominant language in Boston, language of government and business in Singapore, and almost universally spoken in the Netherlands. However, the exercise runs in Rotterdam were conducted in Dutch to remove any language barriers, with the recording transcriptions later translated into English for coding and analysis. The debriefings, interviews and surveys were all conducted in English.

Achieving substantial external validity is a challenge in this research, particularly given the small sample sizes. To some degree, this is an acknowledged and accepted limitation in this theory building enterprise. The goal of this research is to develop a deeper theoretical understanding of the influence of the independent variables – different governance regimes; multi-stakeholder collaborative process versus the status quo; and multiple scenarios versus a single forecast – on the dependent variable: how emerging, uncertain climate risks are into infrastructure planning and decision-making. I believe that the lessons learned have currency in a wider set of situations as cities around the world grapple with how to respond to climate change, including via adopting more flexible approaches.

Background: Literature review

This research focuses on the institutionalization of uncertainty - and the uncertainties associated with adapting to climate change in particular – into infrastructure planning and decision-making. The nascence of climate adaptation, and fact that it often requires cooperation across traditional institutional boundaries, make it characteristic of what Hajer (2003) calls *policy-making in the institutional void*. That is, policy-making in un- or weakly established institutional environments. Adaptation is further complicated by the fact that it often happening in situations with:

- High degrees of uncertainty and complexity (IPCC, 2014; Walker, Haasnoot and Kwakkel, 2013);
- Conflicting knowledge claims (van Buuren and Edelenbos, 2004) and climate information usability gaps (Lemos, Kirchhoff and Ramprasad, 2012);
- Competing interests and priorities (Susskind, 2010); and
- Unclear and intertwined allocation of responsibility (Moser & Ekstrom, 2001).

This research project advances theory on how climate change adaptation may be integrated into infrastructure planning and decision-making. It focuses on how uncertainty can be managed, and on ‘flexibility’ as a response to uncertainty in particular. It provides a more nuanced examination of how adaptation is unfolding, and may unfold further, under different governance regimes. This work draws on and aims to speak to six literatures that are interconnected in many ways: Climate adaptation planning; institutional theory; collaborative planning and governance; uncertainty and its management, with particular attention to flexible/adaptive approaches; scenarios as a way to frame uncertainty; and the use of role-play simulation exercises for action research.

Efforts to understand and intervene in complex systems have traditionally neglected their organizational and institutional elements (Bea et al., 2009). Recent work acknowledges the need to recognize and accommodate these elements if systemic change is going to be possible, but there is insufficient scholarship on how this happens in practice. This dissertation focuses on how to manage uncertainty and complexity in decision-making, considering the institutional dynamics.

Climate adaptation planning

Climate change strains the ability of planners and decision-makers to sustainably manage urban environments, including key infrastructure systems (de Sherbinin, Schiller and Pulsipher, 2007; Dorfman et al., 2011; HM Government, 2011; Rosenzweig et al., 2011). It presents a set of threats that vary from region to region, but include: Sea level rise and associated coastal flooding and salt water intrusion; more frequent and intense storms; prolonged periods of drought and associated water scarcity; heat waves; and shifting ecosystem ranges and disease vectors, and biodiversity loss (IPCC, 2014).

The IPCC defines *adaptation* as (2014: 5): “The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities”. Climate adaptation planning, which is the focus of this research, involves the intentional integration of currently felt climatic changes and potential future climate risks into planning and decision-making. It has emerged as an area of practice and research focused on helping planners and decision-makers to better understand, prepare for and respond to the risks and uncertainty climate change poses (Adger et al., 2007; National Research Council, 2010; Schipper and Burton, 2009). The IPCC (2014) asserts that adaptation decisions made today will shape the level of risk communities face in the future. Adaptation planning is happening at a wide variety of scales, in a wide variety of places around the world, ranging from the City of Rotterdam’s

Climate Change Adaptation Strategy (Rotterdam Climate Initiative, 2013) to the *President's Climate Action Plan* (Executive Office of the President [of the United States], 2013). Some plans are cross-sectoral, while others are sector-specific, like the District Department of Transportation's (2013) *Climate Change Adaptation Plan* in the City of Washington, United States. Most of these planning processes are government-led, while non-governmental organizations play key roles in some cases, as The Boston Harbor Association has in various efforts in that region. This research focuses on adaptation planning around transportation infrastructure in large coastal cities.

Risks, adaptive capacity and *resilience*, which is the capacity of a system to cope with events or changing conditions, are not equally distributed among different populations (Berrang-Ford, Ford and Paterson, 2011; IPCC, 2014). That is, different groups face different types and levels of threat, and have varying capacity to prepare and respond based on spatial, socioeconomic and other factors. This research acknowledges the disparities present in any community and attempts to respond to them in its recommendations. However, it is focused on adaptation in large coastal cities with highly developed infrastructure systems. It does not speak to the critically important work necessary, and being done, in the developing world context. It also focuses on coastal climate threats, and not on the myriad of other threats infrastructure systems face, including more frequent and intense heat waves and droughts.

A variety of guidelines and resources have been developed to inform adaptation planning efforts. Some of these were produced by government agencies, like the U.S. Environmental Protection Agency's (EPA, 2014) *Being Prepared for Climate Change: A Workbook for Developing Risk-Based Adaptation Plans*. Private consultancies are another source of information, including PricewaterhouseCoopers (2010) *Adapting to climate change in the infrastructure sectors* report. Non-governmental organizations, including foundations and alliances of municipalities, play various prominent roles as sources of information, coordination, and general support. The Georgetown Climate Center's (2015) *Adaptation Clearinghouse* is a source of information, particularly for local and state officials in the United States. ICLEI-Local Governments for Sustainability's (2015) *Resilient City* program provides resources and support internationally. The *C40 Cities Climate Leadership Group* (2015) is a network of many of the world's largest cities that makes its various resource materials available to all. C40 also supports thematic sub-networks, like the *Connecting Delta Cities* network, which is headquartered in Rotterdam.

Some initiatives provide not only information, tools, and networking opportunities, but also material support. Cities selected to participate in the Rockefeller Foundation's (2015) *100 Resilient Cities* network receive: The funding and guidance to hire a 'Chief Resilience Officer' to lead their efforts; extensive expertise from the public and private sectors as they develop a 'robust resilience strategy'; and networking opportunities with other member cities around the world. Members are expected to apply the 'City Resilience Framework', which focuses on the following 12 'drivers', rooted in four 'essential dimensions' (Rockefeller Foundation, 2015):

- *Health & Wellbeing*

- *Meets Basic Needs*
- *Supports Livelihoods and Employment*
- *Ensures Public Health Services*
- *Economy & Society*
 - *Promote Cohesive and Engaged Communities*
 - *Ensure Social Stability, Security, and Justice*
 - *Foster Economic Prosperity*
- *Leadership & Strategy*
 - *Promote Leadership and Effective Management*
 - *Empower a Broad Range of Stakeholders*
 - *Foster Long-Term and Integrated Planning*
- *Infrastructure & Environment*
 - *Provide and Enhances Protective Natural and Man-Made Assets*
 - *Ensure Continuity of Critical Services*
 - *Provide Reliable Communication and Mobility*

There is significant variability from case to case, but research suggests that most adaptation planning efforts are *aspirational*, rather than involving concrete measures, and reactive to stimuli, rather than proactive (Berrang-Ford, Ford and Paterson, 2011; Bierbaum et al., 2014). Various barriers preventing more substantial action on climate change adaptation have been identified, including (Bierbaum et al., 2014; Friend et al., 2014; Funfgeld, 2010; Lemos, Kirchhoff and Ramprasad, 2012; Levin et al., 2012; Moser and Ekstrom, 2010):

- Weak signaling of the threats and low level of concern;
- Policy and legal restrictions;
- Competing interests and priorities;
- (Real or perceived) insufficient climate information at the local level;
- Problems with the saliency, credibility and/or legitimacy of the information;
- Insufficient governance and staff capacity;
- Gaps between climate risks and existing planning and decision-making procedures;
- Insufficient mechanisms for assessing risks and adaptive options, and making adaptation decisions;
- Limited funding and resource constraints;
- Unclear allocation of responsibility;
- Institutional stickiness that limits change; and
- Irrational discounting of the future.

While not all, many of these barriers are governance related. They are not scientific or technical challenges, but constraints related to the institutional environments within which planning and decision-making takes place. Measham et al. (2011) find that it is these factors - 'institutional context', 'competing planning agendas', and 'leadership' - that are the most substantial barriers to adaptation. This is not surprising, given how important institutional norms and procedures are to the ways in which factors are accommodated in matters like infrastructure planning (Marshall, 2013). These factors are inherently

contextual, and require attention to the specificities of each institutional environment. Anguelovski and Carmin (2011) find that, despite the international networks focused on adaptation, the institutionalization of urban climate governance is being driven primarily by endogenous factors; local efforts are engaged in 'urban entrepreneurship' based on their particular goals, resources, barriers, and opportunities.

Adaptation to climate change must accurately account for the behavior of individuals, organizations, and institutions (Berkhout, Hertin and Gann, 2006). It must be about the governance processes and planning tools, and not simply technical matters (Birkmann et al., 2010). It must also recognize the interconnected nature of infrastructure systems and governance challenges associated with approaching adaptation comprehensively, particularly in fragmented planning and decision-making environments (Bollinger et al., 2014; Camacho, 2009).

This dissertation examines how climate adaptation planning is evolving – and/or may evolve – in different institutional environments. It aims to better understand how adaptation can be advanced in different institutional contexts, and made more responsive to their particularities.

Institutional theory

Scholarship in institutional theory explains how and why streams of planning and decision-making generally follow particular patterns, and may be slow to uptake new challenges not traditionally within the explicit domains of responsible agencies. In the public sector, governance typically follows well-entrenched institutional norms, or patterns, that make systemic change, cooperation outside of established, discrete relationships, and flexibility over time difficult (Baumgartner and Jones, 2009; Downs, 1967; Perrow, 1986; Powell and DiMaggio, 1991; Pressman and Wildavsky, 1984). Institutional norms have evolved over time to effectively manage persistent problems. However, emerging issues that involve significant uncertainty and complexity - like those associated with adapting to climate change – may go beyond what is possible under existing arrangements. More flexibility and cooperation across boundaries is required. This dissertation research examines the institutionalization of climate adaptation into planning and decision-making.

Governance (or policy) regimes, including their institutional norms and standards and how they relate to infrastructure planning, are not universal (Marshall, 2013). A variety of factors reflect and influence how and why they vary across space and time. This research focuses on governance in three different case cities and their wider countries: Rotterdam, the Netherlands; Boston, the United States; and Singapore. It considers how their respective regimes may influence their adaptation decisions. From an institutional theory perspective, these cases are interesting because they are archetypal of three distinctive governance regimes. These regime typologies are introduced briefly below, and in more detail in the case chapters. As noted previously, this is in no way a representative cross-section of all regime types, but rather a sampling of three models that are prevalent in large, highly developed coastal cities.

Rotterdam operates within a neo-corporatist framework of decision-making. In the neo-corporatist model, employers, workers and the state formally negotiate as 'social partners' to reach sector and even economy-wide agreements on issues including wages and employment conditions (Wiarda, 1997). Rather than interacting in a predominantly adversarial fashion, parties are expected to come together and reach consensus. Scholars have variously emphasized and downplayed both the importance and collaborative nature of neo-corporatism, but generally agree that this model is significantly reflected in Dutch decision-making (Wiarda, 1997; Woldendorp, 2005). There is also debate around the degree to which neo-corporatism translates to policy spheres beyond labor, but the evidence suggests that environmental issues can and do enter neo-corporatist agendas in countries with a strong tradition of following this model, including in the Netherlands (Glasbergen, 2002; Jahn, 1998; Schreuder, 2001).

Some argue that neo-corporatism is the natural governance regime for the Netherlands, including in the area of environmental management, because of the long tradition of 'poldering'. The polder model is rooted in the centuries-old practice of farmers and other landowners pooling their resources and reaching agreement by consensus on how they will manage water in their flood-prone districts (i.e., 'polders'). In the 1980s the polder model emerged as a descriptor for the practice of reaching broad consensus on economic and environmental policies in the neo-corporatist tradition (Schreuder, 2001). As discussed in the Rotterdam chapter, interviewees regularly described the 'polder mentality' as 'the way we do things'. There is also substantial academic literature suggesting that poldering is an important phenomenon in the setting of environmental policy (Glasbergen, 2002; Schreuder, 2001). It is notable, however, that some question the influence of the polder mentality in practice, noting that there is still substantial adversity (Woldendorp, 2005). The transferability of the polder model to other countries has also been questioned (Schreuder, 2001).

Decision-making in Boston occurs within a neopluralist governance paradigm. In this model, a range of interest groups continuously competes over the evolution of policies, ultimately shaping them via the influence of their diverse contentions (Dahl, 1962; Lindblom, 1977). The state is not a single actor, but a set of actors with varying interests across agencies and departments, and levels of government that influences the decision-making process. While early pluralist theory painted a rosier picture of balanced interests, Lindblom (1977), Domhoff (2010) and others have noted the overwhelming influence of certain groups in a world of vastly uneven power imbalances. While consensus may be reached in a neopluralist paradigm, the dominant interactions are adversarial.

The governance regime in Boston may also be characterized as liberal or neoliberal, as the state is a comparatively weaker actor in what is an overwhelmingly market-oriented economy that places high value on individual rights (Harvey, 2007; Jahn, 1998). The state plays a major role in the provision and management of infrastructure, but these activities are typically framed in the service of the private economy, and private companies under contract do much of the actual work. It is notable that the neoliberal paradigm is dominant in most western democracies – private management contracts have, for example, also become common in Dutch infrastructure provision. However, notably lower expenditures

on infrastructure and more constraints on what the state can do (e.g., in terms of public takings) suggest that the government is a relatively weaker actor in the United States. The laissez faire mentality conducive to neoliberalism is deeply entrenched in the underlying ethos (Friedman, 1962).

Singapore's decision-making environment is top-down and at least somewhat authoritarian in nature (Haley and Low, 1998; Ortmann, 2011; Rodan and Jayasuriya, 2007). The city-state's highly capable and generally well-regarded civil service engages in extensive planning for all facets of the economy and society (Tan, 2008). For example, over 80% of the population resides in government-provided and managed housing (Housing and Development Board, 2014). The government plays a critical role in planning and service provision, but not to the exclusion of private enterprise; markets and central planning operate in a synergistic way, facilitating impressive economic growth and social welfare (Huff, 1995). The state also works hard to engender high quality physical and sociocultural environments in what is in every way a highly constructed landscape (Henderson, 2012).

The Singapore model is not, however, without its criticisms, including on human rights and democratic grounds. Singapore effectively operates as a single-party state with the government exerting its authority to maintain stability and advance what it sees as the interests of the nation (Henderson, 2012; Ortmann, 2011; Rodan and Jayasuriya, 2007). Micro-management has historically led to significant prosperity and a high capacity to manage problems, but has been criticized for its inflexibility. Critics contend that the focus on stability and planning at the expense of a more risk-taking entrepreneurial mentality will have negative economic consequences in an increasingly globalized world (Haley and Low, 1998; Saywell, 2002). In the political arena, there is concern that the traditionally meritocratic and highly capable civil service will, over time, devolve into an elite oligopoly that focuses on self-maintenance ahead of material performance (Tan, 2008). The state has opened windows for public participation, but very much on its own terms (Rodan and Jayasuriya, 2007).

This dissertation investigates how the differences and similarities between these three governance models impact their approaches to adaptation planning. The approaches each city/country is taking to adaptation, and how participants responded to the situation presented in the RPS exercise are considered in each of the case chapters. Comparative analysis is presented in chapter 5.

Collaborative planning/governance

Multi-stakeholder collaborative planning (or governance) is normatively advanced as a powerful way to engage the range of decision-makers and other stakeholders associated with a particular problem or management challenge, bringing them together to collectively analyze the situation, solicit and evaluate information, and seek out solutions that are both robust and widely supported (Ansell and Gash, 2008; Innes and Booher, 2010; Margerum, 2011; Susskind and Cruikshank, 1987). It is proposed as a remedy to the barriers to effective and efficient interaction often present in institutions and networks of institutions.

While far from the norm, collaborative practices are being implemented in various places and under a variety of conditions. Research suggests that deliberative processes can foster new discourses to advance adaptive action (Hobson and Niemeyer, 2011).

Most governance regimes involve networks of decision-makers and other stakeholders, either formally or informally. However, the status quo often involves networks of entities or individuals making decisions separately either in parallel or succession, complemented to varying degrees by ad hoc informal interactions between players. Collaborative planning processes aim to make these interactions more explicit by bringing stakeholders together. The argument is that resolving complex problems that cross traditional institutional lines demands a concerted and collective focus on new ways of thinking, sources of information, and flexibility over time.

Collaborative planning takes a variety of forms in practice. The consensus building approach (CBA) emphasizes convening representatives from the various stakeholder groups in face-to-face meetings to identify creative solutions that substantially meet everyone's interests and concerns (Susskind, McKernan and Thomas-Learner, 1999). Common characteristics of the CBA include: The involvement of neutral third-party facilitators; the preparation of situation or conflict assessments, based on interviews, prior to convening; an emphasis on the various underlying and priority-ranked interests of each party, and how they might be traded across for mutual gains; and the creation of single-text documents by the group to ensure that actionable and genuinely supported plans are developed. Most other schools of collaborative planning employ similar techniques, emphasizing the effective engagement of multiple stakeholders to facilitate widely supported pathways forward.

While notable criticisms of collaborative planning exist (Few, Brown and Tompkins, 2007; Foster, 2002; Layzer, 2008), there is substantial evidence that it can lead to better outcomes when the conditions are right (Ansell and Gash, 2008; Innes and Booher, 2010; Margerum, 2011). An important question is whether, and how, collaborative planning can make a difference in situations rife with complexity and uncertainty, such as those present under climate change. The CBA has been framed as a way of engaging with and more successfully managing complex adaptive systems, yet more work is necessary to fully appreciate the benefits, limitations and barriers of collaborative governance in such situations (Innes and Booher, 1999). Few, Brown and Tompkins (2007) suggest that the uncertainty and long-term nature of climate change exacerbates the problems associated with the power imbalances present in all participatory processes. Whether or not this is true, and if asymmetric power ultimately dooms the efficacy of collaboration in the adaptation arena remains an open question worthy of more attention. Margerum (2011) suggests that collaborative processes are more successful when embedded within the institutional fabric of management and decision-making processes, and across networks of processes. An important corollary question is how to better embed multi-stakeholder collaboration into existing institutional regimes. The relative lack of up-take thus far suggests that this is not easy.

This dissertation examines the potential opportunities for and barriers to collaborative planning in the three case study locations. It considers the implications of their respective governance regimes on how multi-stakeholder planning and decision-making is, or might, work in practice.

Uncertainty

Uncertainty is a reality in all planning and decision-making. Systems are dynamic in nature and often difficult to predict. No one knows what the future will bring. In the face of these uncertainties, infrastructure planning typically involves following institutionalized heuristics, established models or forecasts of the future, and established standards (Rahman, Walker and Marchau, 2008). Modeling and forecasting procedures are often enshrined in government law and policy, and are reflected in organizational and professional norms and the allocation of organizational resources. Forecasts cannot divine what will actually happen, but they get it right often enough that their legitimacy is kept in tact. In the words of a participant in this research, quoting Box and Draper (1987), “all models are wrong, but some are useful”. This employment of models as useful tools to advance decision-making, despite their fallibilities, may be considered what Simon (1956) called ‘satisficing’.

A critical question is whether or not the models and forecasts associated with adapting to climate change are satisfactory enough – whether from a technical or political perspective – to be incorporated into planning and decision-making in ways similar to how air quality, economic growth, traffic demand, and other models are utilized. That is, can planners and decision-makers simply treat climate forecasts as they would these other models, make decisions based on them, and have a reasonable degree of confidence that they will be making the right decisions.

Many argue that climate change involves a higher degree of uncertainty, and thus necessitates new approaches (Birkmann et al., 2010; Bollinger et al., 2014; Eakin and Lemos, 2010; Lemos, Kirchoff and Ramprasad, 2012). Uncertainty exists at multiple levels. In terms of climatic change itself, there are multiple possible emissions scenarios, based on different economic growth and technological change trajectories; and different global circulation models of how greenhouse gas concentrations will actually alter the climate (Sainz de Murieta, Galarraga and Markandya, 2014). Climate models used to support decision-making at the local level involve substantial additional uncertainty because of the nature of downscaling from global models; the uncertainties are compounded (Termeer et al., 2011). Furthermore, the uncertainties are not only substantive in nature (i.e., about the data itself). They also result from unpredictability around how socioeconomic and biophysical systems will respond to climate change (Biesbroek et al., 2011; Moser and Ekstrom, 2010).

Rahman, Walker and Marchau (2008) categorize the situation infrastructure planners and decision-makers find them in vis-à-vis climate change as ‘deep uncertainty’. Deep uncertainty is a condition in which “analysts do not know, or the parties to a decision cannot agree on, (1) the appropriate conceptual models that describe the relationships

among the key driving forces that will shape the long-term future, (2) the probability distributions used to represent uncertainty about key variables and parameters in the mathematical representations of these conceptual models, and/or (3) how to value the relative desirability of the various outcomes” (Rahman, Walker and Marchau, 2008: 43). Uncertainty is not one element of the decision-making process, but pervades the cascade of plans and decisions. Mearns (2010) uses the term ‘meta-deep uncertainty’ to describe the fact that there is not even agreement among decision-makers, climate scientists and other stakeholders around how important it is to decision-making that uncertainty in climate models be reduced, and that consensus on this matter may be impossible to achieve. She is skeptical of the focus on constructing ever more complex climate models, asserting that we need “a truly balanced research program that also [provides] sufficient funding for in-depth vulnerability assessments and investment in improving or expanding decision making protocols under deep uncertainty” (Mearns, 2010: 84). That is, we need to figure out how to work with uncertainty rather than solely on how to resolve it. This is particularly powerful argument given that Mearns is a highly regarded climatologist (i.e., modeler) herself.

This dissertation aims to enhance our understanding of uncertainty as a factor in climate adaptation planning and decision-making.

Flexibility and other approaches to managing uncertainty

There are various possible ways to respond to uncertainties about the future: Decision-makers may focus on robustness, building to the worst-case scenario; take a more passive reactive wait-and-see approach; or incorporate flexibility into their plans and decisions, intentionally leaving windows for adaptation as events unfold and learning occurs. Each of these approaches offers advantages and disadvantages, and may be more or less appropriate in different circumstances.

The reactive approach involves responding to events or changing conditions as they unfold (Berrang-Ford, Ford and Paterson, 2011). It can be appropriate when the risks of waiting are deemed tolerable, the costs of being proactive would be high and uncertainties obscure the identification of the best options. Regardless of whether or not it is optimal, the reactive approach is often the default; actors are motivated when they experience events first-hand, and motivating action proactively can be difficult if not impossible (Committee on U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning: Coastal Risk Reduction et al., 2014; Measham et al., 2011).

Robust infrastructure is able to handle the anticipated range of possible futures without requiring significant modification – the infrastructure is designed to be strong, rather than nimble (Birkmann et al., 2010). This approach is appropriate when the consequences of not taking precautionary action could be severe, the costs associated with taking action now are low (or provide important co-benefits), and/or there is relatively little uncertainty. In the Dutch context, the Delta Works, which protect most of Holland with dikes and other flood control infrastructure up to 1 in 10,000 year flood events, is an example of robustness (Ministerie van Verkeer en Waterstaat, 2007). This extremely robust level of protection is

deemed necessary because the consequences of flooding could be catastrophic in the extremely densely populated region below sea level. In Singapore, the government has invested aggressively in increasing water independence via extensive rainwater catchment and storage, desalinization, and the NEWater wastewater recycling system (PUB, 2014). Singapore has a bilateral agreement to purchase water from Malaysia and thus these efforts may not be necessary, but the country identified water security as a national priority and thus chose to invest in an extremely robust approach.

A flexible or adaptive approach involves taking action today, but explicitly keeping as many options open as possible for adjustments in the future as conditions change and new information emerges (Committee on U.S. Army Corps of Engineers Water Resources Science, Engineering, and Planning: Coastal Risk Reduction et al., 2014). It is most appropriate when doing nothing is risky, but uncertainty about the future makes taking decisive action now difficult. In the context of climate adaptation measures, it represents a middle-way between the 'anticipatory', 'proactive', and 'ex ante', versus the 'responsive', 'reactive', and 'ex post' dichotomy (Smit et al., 1999).

Infrastructure involves the articulation of built systems, and thus is in large part a matter of engineering and design. If infrastructures are to be flexible and adaptive, they typically need to be designed accordingly. Rather than reducing uncertainties as much as possible and building to the best estimates of future conditions with the standard risk factors - assuming both that the future can be well enough understood and will be relatively stable - infrastructure is built such that it can respond to changing conditions and increasing understanding over time (de Neufville and Scholtes, 2011; Taneja, 2013). Taneja defines the concept nicely in her book, *The Flexible Port* (2013: 73-74):

A flexible or adaptable [infrastructure] can be altered or employed differently, with relative ease, so as to be functional under new, different, or changing requirements, in a cost-effective manner (which essentially means, to maintain, or even improve service levels, with little or no extra investment).

Rather than building infrastructure that is insufficient and difficult to enhance to meet actual needs, or 'white elephants' that are overbuilt and waste resources, infrastructures are adapted to efficiently and effectively meet the requirements placed upon them in as close to real-time as possible. Empirical analysis suggests that, while flexibility has a cost, adaptive approaches can provide significant value (Cardin and de Neufville, 2008; de Neufville and Scholtes, 2011).

While flexibility in design and engineering may be wise and empirically defensible in the face of significant uncertainties, it does represent a change from the status quo, and thus hurdles must often be overcome. In general, embracing flexibility may be as much a governance and decision-making challenge as it is a design challenge. *Adaptive Policymaking* or *Dynamic Adaptive Policymaking* is a flexible approach to planning and decision-making that allows for decisions to be made today while creating the structures for ongoing monitoring and evaluation, and subsequent adjustments over time (Marchau,

Walker and van Wee, 2010; Rahman, Walker and Marchau, 2008). Rahman, Walker and Marchau define this approach as follows (2008: 44):

This approach allows implementation to begin prior to the resolution of all major uncertainties, with the policy being adapted over time based on new knowledge. It is an innovative way to proceed with implementation of long-term policies despite the uncertainties. The approach makes adaptation explicit at the outset of policy formulation. Thus, the inevitable policy changes become part of a larger, recognized process and are not forced to be made repeatedly on an ad-hoc basis. Adaptive policies combine actions that are time urgent with those that make important commitments to shape the future, preserve needed flexibility for the future, and protect the policy from failure. Under this approach, significant changes in the system would be based on a policy analytic effort that first identifies system goals, and then identifies policies designed to achieve those goals and ways of modifying those policies as conditions change. Within the adaptive policy framework, individual actors would carry out their activities as they would under normal policy conditions. But policymakers, through monitoring and mid-course corrections, would try to keep the system headed toward the original goals.

Rahman, Walker and Marchau (2008) liken the approach to a ship travelling a long distance between two ports. The destination port (i.e., the goal) remains constant, but the exact route is sure to change during the journey in response to weather conditions, vessel traffic and other factors. The steps in the *Adaptive Policymaking* approach include (Rahman, Walker and Marchau, 2008: 47-48): Establishing the objectives, constraints and policy options; devising a 'basic policy', including what is necessary for it to succeed; adding an adaptive layer to the basic policy by identifying the ways in which it may be vulnerable, what actions may be taken in response to threats and other changes, and the 'signposts' that will be monitored to track performance and facilitate rapid response; and implementing the policy, which includes maintaining monitoring systems so that the policymaking process may be reinitiated if and when certain triggers are reached. Various tools, including the use of scenarios, can support this adaptive approach. Marchau, Walker and van Wee (2010) illustrate how a dynamic adaptive approach may be applied in transportation policymaking, outlining potential applications in road pricing, high-speed rail, and airport planning in the Netherlands. Unfortunately, each of these examples is aspirational, reflecting the challenges associated with implementing adaptive approaches in practice.

Adaptive Policymaking is just one model in a suite of tools proposed for integrating flexibility into planning and decision-making. The *Dynamic Adaptive Policy Pathways* approach builds on *Adaptive Policymaking*, factoring in *Adaptation Tipping Point* and *Adaptation Pathways* techniques which, among other things, add explicit consideration of the timing of actions, additional feedback mechanisms, and emphasize the proactive mapping of various pathways that may be followed, depending on conditions at predetermined tipping points (Walker, Haasnoot and Kwakkel, 2013). Haasnoot et al. (2013: 485) illustrate how the dynamic adaptive policy pathways approach could be applied in the Rhine Delta in the Netherlands to take "into account the deep uncertainties

about the future arising from social, political, technological, economic, and climate changes”. Once again, however, the example illustrates how such an adaptive approach *could* enhance management, but is not being applied in practice. This underscores the dearth of examples from practice, and suggests that there are barriers to implementation.

Adaptive Management, which is typically promoted as an approach to natural resource management, is similar in many ways (Williams, Szaro and Shapiro, 2009). Adaptive management emphasizes on going research and knowledge creation, rather than simply monitoring, as an important element of enhancing understanding. At its best, it also emphasizes the need for collaboration among decision-makers, scientists and other stakeholders (Williams, Szaro and Shapiro, 2009). The U.S. Department of the Interior’s *Adaptive Management Technical Guide* recommends the following steps (Williams, Szaro and Shapiro, 2009: 53): 1) Secure stakeholder involvement in and commitment to an adaptive approach; 2) devise agreed upon, clear and measurable management objectives; 3) identify possible management actions; 4) identify models that reflect different conceptions of the system; 5) design and deploy monitoring plans to track system behavior and status; 6) decide upon a management action based on objectives and current understanding; 7) monitor the system to track responses to management decisions made; 8) evaluate management decisions against goals and predictions made; and 9) cycle back to step six on an on going basis, and to earlier steps as necessary. Adaptive management programs have been implemented in practice, although these efforts are not without some criticism (Camacho, 2009; Susskind, Camacho and Schenk, 2011).

Anticipatory Governance emphasizes systemic efforts to analyze possible futures with tools like scenario planning so that a range of ‘flexible adaptation strategies’ may be proactively developed (Fuerth, 2009; Quay, 2010). Fuerth (2009: 29) defines *anticipatory governance* as “a system of institutions, rules and norms that provide a way to use foresight for the purpose of reducing risk, and to increase capacity to respond to events at early rather than later stages of their development”. Fuerth (2009: 29) goes on to suggest that the basic elements are: “a system for generating foresight in the form of alternative constructs about the future; a system for incorporating foresight into policy-making and policy – execution; and a system to provide feedback connections between results and estimates”. Quay (2010) illustrates how *anticipatory governance* is being institutionalized in Denver, Phoenix and New York.

These adaptive approaches are designed to move planning and decision-making from the ‘predict and act’ paradigm to one of ‘monitor and adapt’ when conditions are highly uncertain and dynamic in nature (Walker, Haasnoot and Kwakkel, 2013). Walker, Haasnoot and Kwakkel (2013) identify the following ‘key principles’ for success: A wide range of uncertainties should be explored in a dynamic way; short-term targets and long-term goals must be linked; and short-term actions should be taken, while a range of possible options are left open for the future. Quay (2010) adds that decision-support tools like scenarios can help to anticipate the range of possible futures; issues like capital planning and financing must be considered, as expanded upon below; cooperation is required to create the required monitoring regimes; and flexible decision-making systems need to be properly institutionalized if they are to be sustained into the future.

This dissertation examines how planners, decision-makers, and other stakeholders are responding to the risks and uncertainties posed by climate change. It focuses on ‘flexibility’, as participants identified it as the preferred approach to proceeding in the face of persistent uncertainty. It explores what flexibility means in practice, including the barriers and opportunities. The approaches introduced in this section offer significant promise, yet their relatively limited use in practice suggests that there are barriers to overcome.

Scenario planning

Scenarios (i.e., multiple possible futures) are promoted as a way to present uncertainty. Their use in planning and decision-making is not widespread, but becoming increasingly common. Scenario planning first emerged in the corporate sector as a way to devise a set of internally consistent possible futures against which alternative pathways forward can be evaluated (Chermack, Lynham and Ruona, 2001; Cornelius, Van de Putte and Romani, 2005). The idea is not to predict the future, but to recognize that there are a range of possible futures in any situation, and layout what they might look like for the sake of better decision-making today (Schoemaker 2004). Multiple scenarios provide opportunities for decision-makers to bracket the range of possible futures and make choices despite the lack of certainty. They can help decision-makers to overcome ‘overconfidence’ and ‘tunnel vision’ (Schoemaker, 1995). Various government agencies have adopted scenario planning into their toolkits, including the Federal Highway Administration in the United States (Volpe Center, 2011b), and the Centre for Strategic Futures in the Public Service Division of the Prime Minister’s Office in Singapore (Centre for Strategic Futures, 2015).

Various critiques have been leveled at the use of scenarios, including: They are subjective in nature; the limited number of scenarios can be problematic; the process is prone to political interference and constraints; and it is unclear how the scenarios connect and translate into better decisions in practice (Chermack, Lynham and Ruona, 2001; Schoemaker 2004). Bartholomew’s (2007) analysis of 80 different efforts at integrated transportation and land use scenario planning across the United States found that they frequently fell short, with the outcomes already predetermined, only cursory stakeholder involvement, substandard assessment methods, and unclear outcomes. Chakraborty et al. (2011) see promise in scenarios in the context of regional planning, but find that users frequently fail to adequately consider uncertainty and end up defaulting to a single scenario in the end. Looking at an example of scenario planning in transportation and urban planning in Portugal, Zegras and Rayle (2012) find that it has only modest impacts on participants’ propensity to collaborate in the future, in part because of challenges like ‘vague problem definition’.

Despite the challenges, various public-sector institutions are finding the explicit recognition of multiple possible futures to be valuable in their long-range planning efforts. Denver Water used a scenario planning process to move beyond the traditional “predict and plan” approach, identifying a range of possible futures and then using these to make decisions that are more flexible so that various options remain open as any number of possible “signposts” are reached over time (Quay 2010). Similarly, managers and other

stakeholders at Las Cienegas National Conservation Area in the U.S. state of Arizona have integrated scenario planning into their *collaborative adaptive management* efforts (Caves et al., 2013). It is notable that these more successful are in contexts in which the lead organization has substantial autonomy either spatially (conservation area) or institutionally (a utility with its own funding stream, managing its own infrastructure).

In the context of climate adaptation, Lempert (2012) asserts that scenarios can be valuable for both 'decision structuring' and 'choice' by presenting different potential vulnerabilities so that the most robust responses may be identified. Many adaptive measures do not require absolute certainty, but benefit from an understanding of what is possible, as this motivates flexibility and the identification of various options that can be implemented as conditions change or become more apparent (Sapuan, 2012). Moore, Seavy and Gerhart (2013) provide guidance on how scenario planning can be integrated with climate adaptation, particularly around resource management. They propose the following steps, which reflect best practices in the scenario planning process (Moore, Seavy and Gerhart, 2013: 12):

A. *Set-up and Logistics:*

1. *Define geographic scope, and overarching planning goal/workshop goal*
2. *Identify ideal participants and group size*
3. *Identify venue and facilitators*

B. *Preparing for the workshop:*

1. *Assemble data and develop a brief profile of climate change projections and impacts for the target area, highlighting what projections are most uncertain under what conditions, to provide background and support discussions*
2. *Circulate this profile and other important background information in advance to generate a shared understanding of the climatic and other drivers of change*

C. *At the workshop:*

1. *Identify shared adaptation goals, relevant planning horizon(s), and definition of adaptation*
2. *Brainstorm the most important drivers of change in resource management decisions*
3. *Rank drivers by their relative uncertainty and importance to management decisions*
4. *Define scenarios based on top two or three most uncertain/important drivers*
5. *Describe and name the scenarios*
6. *Identify top management actions for the futures of concern (robust to multiple futures/addressing worst impacts)*
7. *Identify next steps*

D. *After the workshop:*

1. *Identify opportunities to refine the scenarios based on new evidence*
2. *Plan to address data gaps*

Efforts following similar processes have been implemented in a variety of contexts. Scenario planning has been part of climate adaptation efforts in various situations, including but not limited to: The Snohomish River Basin in Washington State, USA (Alberti, Russo and Tenneson, 2013); integrated land use and transportation planning on Cape Cod in Massachusetts, USA (Volpe Center, 2011a); the 'delta scenarios' used in Rotterdam's Climate Change Adaptation Strategy (Rotterdam Climate Initiative, 2013); and the Royal Dutch Meteorological Institute's Climate Scenarios for the Netherlands (KNMI, 2014). The Intergovernmental Panel on Climate Change has also used socio-economic scenarios in their assessment work (IPCC, 2012).

Quay (2010) asserts that scenario planning can be a powerful tool for decision-makers grappling with change and uncertainty, but that it requires an ongoing commitment to monitoring and incremental decision-making; multi-agency and stakeholder engagement; and real changes in governance frameworks. An open question is if and how the results of these efforts influence project-level decisions down the line in practice. That is the issue this dissertation focuses on. It explores whether or not the provision of multiple possible futures (i.e., scenarios) makes a difference in how decision-makers and other stakeholders evaluate project-level choices. It does not examine or assess scenario planning as a process directly, but considers the value of the products (i.e., scenarios).

Role-play simulation exercises

A role-play simulation (RPS) exercise was employed in this project as a tool for action research. Exercises can engage participants to collectively consider potential threats; introduce various interests and perspectives; and facilitate experimentation with new options, tools, and approaches in a safe environment, all while providing insights from a research perspective (Schenk and Susskind, 2014; Susskind and Rumore, 2013). That is, they can facilitate reflection and learning for the sake of both participants and researchers.

RPS exercises have been employed in various contexts to explore planning and policy-making challenges, including around climate adaptation (Mendler de Suarez et al., 2012; Schenk, 2014; Susskind et al., 2015). The relative nascence of climate change adaptation as an issue means that those engaged in infrastructure management and other forms of planning and public sector decision-making have limited experience integrating the potential impacts of climate change on their long-term investments into their analysis and decision-making. The dearth of cases in which climate change has been meaningfully integrated into project-level planning makes learning from others difficult. Exercises can introduce explicit adaptation challenges to participants and ask them to work through how they might respond. The expectation is that this experience helps them to consider how they might proceed with adaptation planning in their real world situations.

When different stakeholders are brought together to play a simulation exercise, this experience helps them to understand each others' points of view, interpretations of data, and sets of interests around how to best adapt to projected climate change impacts. Decision-makers in complex environments with a range of stakeholders responsible for discrete pieces of the puzzle may not be aware of who the other players are, how they make

decisions, or what their priorities are. RPS exercises force them to confront one another and experiment with collaborative decision-making. Effective exercises can help stakeholders to appreciate the value of engaging with each other to grapple with challenges that are not currently accounted for in decision-making processes, yet may impact everyone.

Conflicts around how data should be collected, analyzed, presented, and interpreted have often impeded decision-making on a range of science-intensive policy issues. RPS exercises can help stakeholders to understand where the data is coming from and how it is being used, increasing the credibility of the information in stakeholders' minds. Scientists play a key role in providing information, but it is only useful if others have confidence in it and are able to use the data appropriately. Technical information - real or simulated - can be provided in RPS in such a way that participants have the freedom to process it outside of their traditional roles and settings. Simulations also provide a 'sandbox' in which decision makers can experiment with different ways of framing information. In the context of this research, scenarios are explored as a way of framing uncertainty. This represents both a challenge and an opportunity to test how their decision-making changes when facing multiple scenarios.

This 'sandbox' environment also provides participants with the space to explore options without committing to things they may not be prepared for or politically able to do yet in their real world positions. Participants can discuss issues in reference to the fictional scenario presented rather than their real situations, which is less threatening. Once they have gone through this experience, they may be more willing to open up and put the issues on table in the debriefings (i.e., focus groups) and in their own organizations. The hope is that any increase in willingness and ability to discuss these important issues with other stakeholders continues beyond the RPS exercise itself.

Addressing the risks associated with climate change is not an easy task, given the high degree of uncertainty, complex decision-making environments into which this new challenge must be inserted, and competing priorities. RPS exercises provide a powerful way to introduce decision-makers to the uncertain risks climate change poses; tools they can use for assessing and approaching these risks; and how they might respond in concert with other stakeholders. To be effective, exercises must acknowledge the institutional environments in which planning and decision-making is made, the competing priorities of various stakeholders, and the fact that resources are limited. They should encourage stakeholders to work together and consider new ways of making decisions - like using multiple scenarios - while recognizing existing decision-making structures.

From a research perspective, the actions of participants and reflective windows opened by the RPS were used to conduct this research. As discussed in the methods section, findings were drawn from how the participants in the various matched groups responded to the hypothetical situations in which they were placed. Just as importantly, insights were drawn from participants' reflections during the debriefings and follow-up interviews, and the significant shifts in their answers from the pre- to post-exercise surveys.

**Institutionalizing Uncertainty:
Exploring how infrastructure stakeholders can
prepare for uncertain climate futures**

Chapter 2 – Rotterdam Case

God created the earth, but the Dutch created the Netherlands. - Dutch saying

Water naar zee dragen [Carrying water to the sea] - Dutch expression for a futile activity

Living with the threat of water is in our genes - City of Rotterdam, 2013: 16

Introduction

Few places in the world have as intimate of a relationship with water as does South Holland, the densely populated Dutch province that includes Rotterdam. On the one hand, much of the province is at or below sea level, and thus in a perpetual battle to keep water at bay. Decades of continuous dyke building, pumping (the primary purpose of those classic Dutch windmills) and other infrastructural investments are essential to the viability of a prosperous and dynamic region of almost four million people. The costs associated with these measures have been substantial, and yet threats remain and the work continues. On the other hand, water has played an integral part in the region's development and success. Rotterdam is the largest port in Europe, and one of the largest in the world, thanks in large part to its location on the North Sea in the Delta of two important rivers.

Climate change may exacerbate the threats the Rotterdam region faces, particularly from both coastal and inland flooding. Various agencies at virtually all levels of government are considering these threats and how infrastructure may be adapted. Yet, the integration of climate adaptation into planning and decision-making remains an incomplete endeavor, especially at the project level. This chapter considers how adaptation planning is evolving in Rotterdam, and the wider region and country, and may continue to evolve into the future.

The first section of this chapter provides the context. It starts by enumerating the climate-related threats the Rotterdam area faces. Next, it introduces the extensive climate preparedness efforts already underway by different agencies and actors at different levels of government, and by the Port of Rotterdam. The broader processes followed in infrastructure planning, particularly for flood protection and road transportation infrastructure, are introduced next. Both the status quo and some more novel approaches taken with particular projects are introduced. Infrastructure planning and decision-making is then situated within the broader neo-corporatist framework for decision-making in the Netherlands. The distinctly Dutch polder model is discussed, and examples of how it manifests in practice are provided.

The second section of this chapter focuses on the research interventions carried out as part of this dissertation project. It starts with an outline of the research approach and design. The outcomes of the two versions of the role-play simulation exercise – one with scenarios and the other with a risk assessment forecast - conducted with two separate groups of participants in Rotterdam are then introduced. The outcomes of the exercise runs are assessed and participants' own reflections on them are provided. The results of the pre- and post-exercise surveys are introduced and assessed next. Data gathered during the exercise debrief conversations and semi-structured interviews is interwoven into the sections focusing on the exercise runs and surveys to underscore and illustrate points made. This section constitutes the primary research outcomes of this case.

The third and final section draws a synthesized set of conclusions from the research data collected and background examination of planning and decision-making in the Dutch context. It also looks forward, making various speculations on how adaptation planning and decision-making might evolve in the future. The key conclusions emphasized in this section are that:

- The governance challenges associated with advancing climate adaptation are as substantial as the technical challenges, with new institutional arrangements necessary, yet difficult to generate;
- Collaborative models of decision-making can help to advance adaptation efforts, and there is good precedent for their success in the Netherlands, but attention must be paid to process design;
- Uncertainty is an important factor in climate adaptation planning, although uncertainties not directly related to climate change, like who might make certain decisions and when, are as substantial as meteorological uncertainties, and these various sources of uncertainty must be considered in an integrated fashion;
- Participants broadly support more flexible and adaptive approaches as a way to proceed despite uncertainties, but they do not always integrate easily with established modes of making decisions and managing infrastructure over the long-term; and
- Participants liked the notion of using multiple scenarios, but their experiences suggest that it is challenging in practice, with most reverting to single scenarios to frame their arguments rather than embracing and planning against the suite of possible futures.

Context: Infrastructure, climate change and decision-making in and around Rotterdam

Climate vulnerabilities

Rotterdam, and the wider Province of South Holland, exists in a somewhat precarious relationship with the sea. The extremely densely populated region of the Netherlands is built largely on land reclaimed from the North Sea and former coastal wetlands. Approximately 90% of Rotterdam is below sea level, some by as much as six meters (ICLEI, 2014). This makes the city vulnerable to sea level rise (SLR) and storm surges, both of which are expected to increase as a result of climate change (City of Rotterdam, 2013). Beyond SLR and storm surges, this delta city is sensitive to extreme precipitation patterns and events, from long droughts lowering inland water levels on the one hand to intense storms swelling rivers and canals on the other.

The latest scenarios from the Royal Netherlands Meteorological Institute (KNMI) project SLR ranging from a minimum of 15 cm with a low global mean temperature increase (1 degree Celsius) and little change in global air circulation model up to a maximum of 40 cm with a model based on a higher global temperature increase (2 degrees) and a larger change in air circulation by around 2050 (KNMI, 2014). By around 2085, the range is 25 to 80 cm. Mean annual precipitation is projected to increase or decrease under different models, but not significantly; however, it is expected to become much more seasonally concentrated, with as much as a 30% increase in mean winter precipitation and 23% decrease in summer precipitation by around 2085 (KNMI, 2014). The frequency of winter storms is projected to increase, with the number of winter days with more than 10 mm of precipitation going up by 9.5 - 35% in the 2050 range, and 14 - 60% in the 2085 window (KNMI, 2014). While overall dryer, the intensity of summer storms may increase, with extreme rain showers and more severe hail and thunderstorms (KNMI, 2014). Existing dikes and other flood protection infrastructure becomes less robust as the sea levels rise and storms become more intense, making what was traditionally an extremely rare flood event increasingly likely over time. Likewise, areas outside the dike network become increasingly vulnerable as tides become higher and storms more frequent and intense (City of Rotterdam, 2013).

While SLR and storm surges off the North Sea may be the most obvious climate-related threats facing the Rotterdam region, they are not the only ones. More frequent and intense storms and concentrated seasonal precipitation threaten not only coastal defenses, but also increase the risks of inland flooding from swelling rivers and higher groundwater levels, which can overwhelm pumping and drainage capacity (City of Rotterdam, 2013; Delta Programme, 2013; Rotterdam Climate Initiative, 2009). Rotterdam's freshwater supply may be at risk from both prolonged periods of drought during the summers, which can lower water levels inland, and saltwater intrusion as sea levels rise rendering river water unusable for human, agricultural and industrial use further upstream (Rotterdam Climate Initiative, 2009). Lower water levels in rivers and canals can also inhibit inland shipping, which is an important part of Rotterdam's economy (City of Rotterdam, 2013). While

Rotterdam's northern European climate has traditionally been quite moderate, the average number of summer days per year over 25 degrees Celsius is projected to increase from the current 21 to approximately 36 by around 2050, and 48 by 2085, under a high temperature and air circulation change models (KNMI, 2014). Heat waves decrease comfort and increase mortality, threaten flora and fauna, and damage infrastructure (City of Rotterdam, 2013). Not all projections are grim; warmer winters can lead to reduced mortality and decrease the frequency and intensity of challenges to mobility from ice and snow (KNMI, 2014).

Climate Preparedness

While the risks are significant, arguably no other city, and wider nation, has done as much to reduce the climate-related risks they face. The Dutch have always lived precariously close to the water, and have been actively managing it since at least the 13th century (Jonkman, 2009). In more recent times, Rotterdam and the wider country have emerged as world leaders in evaluating and preparing for climate change. Various initiatives associated with different levels and branches of government are trained on addressing climate risks.

Rotterdam only exists as the city it is today because an extensive network of dikes and other flood protection measures keep the sea at bay. As per the '*Deltaplan*', most of the South Holland region sits behind an impressive dike network that is designed to handle 1 in 10,000 year flood events (Ministerie van Verkeer en Waterstaat, 2007). The *Deltaplan* was initiated in the 1930's, but picked up considerable momentum after the catastrophic floods of 1953 (see the callout box below). The *Delta Law* (1959) established a technical and economic framework for making ostensibly objective decisions on what flood protection infrastructure investments would be made and where. The approach uses a robust cost-benefit analysis. The high level of protection along South Holland's North Sea coast was deemed necessary because failure would be catastrophic - rapidly evacuating the population of 4 million people in advance of a looming storm is not realistic; hundreds if not thousands of lives would likely be lost and an important economic hub for all of Europe crippled, should the defenses fail.

Watershed event: The 1953 floods

The roots of the Dutch proclivity to aggressive climate change adaptation may be in the nation's long-standing, intimate relationship with water, but the catastrophic floods of 1953 are still regularly evoked as the force that drove the importance of strong water management home.

It is asserted that communities are typically reactive when it comes to addressing climatic risks; concrete adaptive measures are more often precipitated by extreme events than by ongoing change or forecasted but un-experienced threats (Amundsen, Berglund and Westskog, 2010; Berrang-Ford, Ford and Paterson, 2011). The Dutch case seems to support this claim. While likely unrelated to climate *change*, interviewees regularly cited the 1953 floods, which claimed more than 1,800 lives, displaced 70,000 people and destroyed a

significant proportion of the nation's farmland, as *the* watershed event that precipitated major investments in flood prevention, and ongoing vigilance to this day (Floodsite, 2008). The Delta Commission was created 20 days after the catastrophic event, and the country quickly went to work on building the most extensive flood protection system in the world (Deltawerken, 2004). The Dutch government has invested billions of Euros over the past 60 years, and most of the region is now behind dikes and other barriers designed to withstand 10,000-year flood and storm surge levels (Jonkman, 2009). The massive Maeslantkering storm surge barrier on the Meuse River in Rotterdam, which was completed in 1997 at a cost of approximately 450 EUR is a more recent example of how the Dutch have continued to take flood protection very seriously (Deltawerken, 2004).

What is interesting is that the Dutch vigilance persists 60 years later. While initially a reaction to the 1953 floods, the Dutch approach to flood risk management has become *proactive*. Looking ahead with a changing climate, and particularly sea level rise, a new Delta Commission was convened and released a report in 2008. The Commission concluded that sea level rise of 0.65 to 1.3 meters by 2100 and 2 to 4 meters by 2200 should be taken into account, and subsequently made twelve recommendations that, if implemented, are projected to cost 100 to 300 million euros per year (Deltacommissie, 2008). The recommendations include increasing the flood protection levels in diked areas by a factor of ten in the medium-term, with further strengthening likely necessary later; securing land to allow higher flow rates in the Muse and Rhine Rivers; and creating a well-funded and politically strong organization to support ongoing delta works (Deltacommissie, 2008). It is notable that the Delta Commission's report was not without criticism; among other critiques, some felt that the sea level rise projections used were extreme, given that they far exceeded both extrapolated historical trends and the Dutch Meteorological Institute's projections (Jonkman, 2009).

Beyond the 1953 floods, various interviewees noted Hurricane Katrina - which decimated a large swath of the Gulf Coast, including New Orleans, in 2005 - as a seminal event that raised the profile of climate risks. In many ways, New Orleans and Rotterdam are similar; they are both delta cities largely below sea level, and thus at the mercy of their dike networks to hold back seawater and storms. However, the levels of protection are vastly different. An incomplete network of levees poorly protected New Orleans pre-Katrina. Post-Katrina, \$14.5 billion was spent on a new flood protection and pumping network, but it is still only designed to withstand 1 in 100 year storms, which some feel is woefully inadequate, especially in light of climate change (Schwartz, 2012). In contrast, most of Rotterdam is behind barriers designed to withstand 1 in 10,000 year storms. Nonetheless, Katrina vividly reminded decision-makers and other stakeholders of the risks, and was a key impetus behind the creation of the Second Delta Committee in 2007.

While extremely robust, sea level rise and more frequent and intense storms may stress South Holland's flood protection infrastructure. The government is already considering if and how the infrastructure should be shored up as what constitutes a 1:10,000 storm changes over time. There is broad recognition, at least in the relevant technical and policy

circles, that investing in hard infrastructure flood defenses alone is not a sufficient strategy; the government has taken a three-pronged approach to prevention and management, focusing on flood protection, improved spatial planning, *and* robust emergency management (Jonkman, 2009). Flood defense with dikes, barriers and other hard infrastructure remains the most substantial, but not the only element of Dutch water management in the early 21st century. As expanded upon in the *infrastructure* section of this chapter, the Delta Programme (2013) is working to proactively enhance the country's flood control and freshwater provision infrastructure following an "adaptive and flexible approach". Analysis and proposal development are currently underway, with the expectation that a set of 'Delta Decisions' will be approved by the Parliament in 2015, quickly followed by concrete changes in project planning and implementation, following the Multi-Year Programme for Infrastructure, Space and Transport (MIRT) system (Delta Programme, 2013; see the infrastructure management section of this chapter for more information on MIRT). Impressively, the Delta Fund has a budget of approximately 1 billion Euros per year through 2028 for projects to enhance flood risk and freshwater management, and other project expenses, and concrete efforts are already underway in advance of the Delta Decisions expected next year (Delta Programme, 2013).

Rijkswaterstaat is the executive agency of the Ministry of Infrastructure and the Environment responsible for both the construction and management of water and transportation infrastructure at the national level. While the Delta Programme is an independent initiative of the national government, Rijkswaterstaat is responsible for implementing many of the recommendations. Climate change is, therefore, very much on the organization's radar as it coordinates and carries out long-term management of the country's infrastructure.

According to interviewees, climate change is a much less prominent issue on the roads (often called 'dry') side of the organization, but is emerging as an issue. According to a Rijkswaterstaat expert that advises on environmental issues and regulatory compliance:

"I think it is going to be a very important issue, but at this moment it isn't. [...] Because we are in the birth of climate change, and like with noise pollution, for example, at the beginning it's about searching for what are we going to do? How are we going to do it? That then settles, we get used to it, and it becomes business as usual. And climate change is in the phase of, its a new thing, its not business as usual. I think, I hope, in three to five years its business as usual, it's just a part of every project. [...] I think people are not [yet] aware enough [of] what the impact is.

However, the same expert noted that it is starting to emerge at the project level, citing the 'eco aqueduct' being constructed as part of the A4 motorway extension between Delft and Schiedam as an example. "One of the issues was how we are going to keep the water in the aqueduct after 10, 20, 50 years because the water is rising and the land is sinking - that was one of the first times I heard something about climate change", said the expert.

Furthermore, there is a small group within Rijkswaterstaat's Center for Transport and Navigation research and policy development arm dedicated to investigating the potential

impacts of climate change on road infrastructure, and how they may be addressed in planning and decision-making. This group is working to integrate climate change into the environmental impact assessment guidelines, which is the set of factors like air pollution and noise that projects must take into account and are assessed against. As part of this process, Rijkswaterstaat commissioned external consulting firm Deltares to conduct an extensive 'Investigation of the blue spots in the Netherlands National Highway Network' (Bles et al., 2012). The investigation considered flood risks associated with the failure of flood defenses, intense rain and changing groundwater levels, and incapacity of stormwater drainage and road surfaces, all in the context of changing climate conditions. The resulting report outlined the nature of the threats and provided very specific quantitative risk assessments on the various parts of the Dutch road network (Bles et al., 2012). The data has been filtered through various metrics to evaluate relative vulnerability, and translated into GIS-based maps and other information to directly inform decision-making (Pereboom, van Muiswinkel and Bles, 2014). According to an interviewee directly involved in the process, this data is now being used to identify and address particularly vulnerable 'blue spots' in the road network, including in and around the Port of Rotterdam. It is also translating into regular decision-making practice. Reflecting on a real-world example, the interviewee said:

Its not standard practice already, so there are two, three things: We are changing our guidelines, because [projects] have to meet our guidelines, and we have these standard rain showers that we are changing to [reflect] the changing climate, that's one thing; we take into account that there are different scenarios, but its good to take into account the worst-case scenario, because the cost may be slightly more, and then say 'well, if we don't do it, there is a lot more damage'; and then third thing is that we will do it risk-based. So as an example, they were building a tunnel [...] and were thinking 'well, are we going to make it so that no water will come into it when there is a flood, or will we let it flood?' And we said 'well, if you are building it to be climate resilient, then you build it in such a way that it doesn't flood'. [But] in the end, they count[ed] the costs, count[ed] the risks and [concluded that] the chances are so low, we will just let it flood, and then all of the electrical systems and so on will break down, but when you compare to what it costs to make it so it wouldn't flood. It's an example of weighing the risks and making decisions. We don't say you have to make everything climate proof, [you] just have to think about it. Motivate why you take certain decisions.

This integration process is largely one of convincing people that the risks associated with climate change need to be accounted for, and then codifying their consideration into existing project planning and assessment procedures. "I had to talk to my director, and also [to] the Rijkswaterstaat group that talks about what are the rules for planning – I had to convince them", said an interviewee that is driving much of the adaptation process. He added that there are some good reasons to incorporate climate risks into planning proactively, like the medium and longer-term costs associated with not doing so. Furthermore, the Delta Programme – while largely focused on water management – has a component on 'spatial adaptation' that is devising recommendations around how infrastructure can be protected and serve vital emergency management functions, should the primary flood protection system fail. In other words, while still rare, flood risk

management is starting to consider options beyond traditional containment at all cost strategies. This has spatial planning implications, including around what infrastructure is constructed and maintained, and where. Experts from the 'dry' (i.e., roads) side of Rijkswaterstaat are increasingly at the table for these conversations, rather than just their 'wet' (i.e., water management) colleagues.

It is notable that the risks climate change poses to transportation infrastructure are being considered beyond the road network. Inland shipping is also a very important part of the Dutch transportation system and may be vulnerable to climate change, particularly during periods of drought and associated low water levels, which can greatly decrease capacity. Rijkswaterstaat, and other organizations, are investigating the implications and possible responses (Krekt et al., 2010). Climate change adaptation and the implications on transportation and other infrastructure is also being framed as a spatial planning issue; the Second Delta Committee recommended that potential climate risks be factored in when considering new infrastructure investments that will shape future growth (Deltacommissie, 2008).

Enhancing Dutch knowledge of and practical capacity to address climate risks is a government priority, as evinced by substantial funding commitments. A major vehicle through which funding has flowed was the 2007-2014 Knowledge for Climate research program, which "aimed to develop applied knowledge, through cooperation between the Dutch government, [other levels of government], the business community and scientific research institutes, in order to ensure that long term decision making takes into account the impacts of climate change" (Knowledge for Climate, 2014). The program worked in eight thematic areas: Water safety (i.e., flood risk management), fresh water supply, adaptation for rural areas, adaptation for cities, infrastructure networks and hotspots, the development of high-quality climate projections, adaptation governance, and decision-support tools. Projects were explicitly client-driven, with the goal of generating knowledge that would be directly applicable. While co-financing came from various sources, the initial 50 million Euro investment was approved by the national cabinet, and much of the additional support came through governmental agencies.

An example of a Knowledge for Climate initiative is the Infrastructure Networks, Climate Change Adaptation & Hotspots (INCAH) project that this dissertation research was associated with. The 3.5 million Euro project was led by Dutch research institute TNO and involved various partners and co-financers, including Technical University Delft, VU University Amsterdam, the Ministry of Infrastructure and the Environment, and the City of Rotterdam. The INCAH project focused on generating "new knowledge for building robust climate adaptation strategies for infrastructure networks in the Netherlands", given the risks associated with rising sea and groundwater levels and increased intensity of both rainstorms and droughts (Tavasszy, 2010). The project developed a framework for considering the integrated nature of infrastructure systems, including their socio-political and technical dimensions (Bollinger et al., 2014). It also generated very specific products for assessing the impacts climate change may have on infrastructure, and evaluating possible responses, like a quantitative analysis of the risks flooding may pose to road tunnels in the Netherlands (Huibregtse, Napoles and de Wit, 2013).

The Royal Netherlands Meteorological Institute (KNMI) is the principal source for climate forecasts, providing information that is designed to be accessible to and practicably useful by decision-makers (for example, see KNMI, 2014). There appears to be little ambiguity around who is responsible for this information. Climate change-related studies, including the majority of those discussed in this chapter, generally use the KNMI data, and its veracity seems to be rarely, if ever, challenged. As discussed further below, an important 2008 Delta Commission report used climate projections more extreme than KNMI's to present an absolute worst-case scenario, and was widely questioned for doing so.

At the local level, the Rotterdam Climate Initiative - which is a partnership between the municipal government, the Port of Rotterdam, Deltalinqs (the port businesses' association), and DCMR (the regional environmental protection agency in the Rijnmond) - has been working to both reduce emissions and assess and prepare for the risks posed by climate change since 2007 (Rotterdam Climate Initiative, 2008). The Initiative established ambitious emissions mitigation and climate change adaptation goals aimed at making Rotterdam a leading center for climate change knowledge and action. The City of Rotterdam was the first in the Netherlands to appoint a *Climate Director* to coordinate its efforts. The Rotterdam Climate Proof program, which is the adaptation-focused component of the Initiative, has established as its mission to (Rotterdam Climate Initiative, 2008):

[Ensure] that Rotterdam will be climate proof by 2025. Permanent protection and accessibility of the city and the port are the key elements. The full focus of the programme is on creating additional opportunities to enhance the attractiveness of the city in terms of living, recreation, working and investments. Trendsetting research, innovative knowledge development and decisive implementation will result in strong economic impulses. Together with prominent partners, Rotterdam will become one of the world's leading innovative water knowledge cities and an inspiring example for other delta cities.

This mission is being advanced via various measures, which are outlined in the Rotterdam Climate Change Adaptation Strategy. The Strategy sets the following objectives, which reflect both the mission and risks the city faces: *The city and its inhabitants are protected from the rivers and the sea; the city and its inhabitants experience minimal disruption from too much or too little rainfall; the Port of Rotterdam remains safe and accessible; the inhabitants of Rotterdam are aware of the effects of climate change and know what they themselves can do; climate change adaptation contributes to a comfortable, pleasant and attractive city in which to live and work; and climate change adaptation strengthens the economy of Rotterdam and its image* (Rotterdam Climate Initiative, 2013: 12).

Figure 2.1 - The Rotterdam Climate Change Adaptation Strategy's approach



Source: Rotterdam Climate Change Adaptation Strategy, 2013: 27

As figure 2.1 illustrates, the Strategy is built around the *robust* infrastructural foundation that already protects and serves the city well, and is expected to do so reasonably well into the future. However, recognizing that this foundation may not be sufficient, the Strategy promotes “the large-scale application of small-scale” *adaptation* measures “in the heart of the city” to increase flexibility (Rotterdam Climate Initiative, 2013). The Strategy emphasizes stakeholders from both the private and public sectors *working together* to advance adaptation, given the shared responsibilities. It also calls for linking adaptation into other projects and programs, including transportation infrastructure management, to ensure that objectives are efficiently and effectively met.

Information provision is emphasized, under the assumption that stakeholders are not aware of the risks and adaptive measures they can take, and that shared responsibility requires shared understanding. The Initiative has employed various high and low-tech tools to disseminate information and engage stakeholders at all levels. These range from a serious game called *Rotterdam Climate Game Feijenoord* that focuses on climate proof spatial development to a *climate adaptation barometer* that outlines the phases of the adaptation process, and assesses ongoing progress towards established goals (Rotterdam Climate Initiative, 2013).

An explicit goal of Rotterdam’s adaptation strategy is to create substantial corollary *benefits* from adaptation measures, rather than seeing them as costs. The Strategy suggests that added value can be provided for the *environment* by, among other things, enhancing parklands along waterways; for the *community* by encouraging trends like urban gardening that provide health, recreational and social benefits; for the *economy* by protecting assets and keeping the port and other economic engines safe and viable, and by developing world-class expertise that can consult elsewhere around the world; and the *ecology* by adopting technologies that keep more water in the city and create natural habitats for flora and fauna (Rotterdam Climate Initiative, 2013).

While many adaptation strategies have failed to move from planning and aspiration to concrete practice (Berrang-Ford, Ford and Paterson, 2011), Rotterdam’s strategy focuses

on implementation and has seen some degree of success in advancing concrete adaption measures. Examples include: The construction of a new multi-purpose parking garage/water storage tank close to the central train station; a new 'water square' that serves various recreational purposes when dry and stores rainwater when necessary, and was the product of an extensive participatory process with the surrounding community; and a 'paving out and plants in' campaign that is encouraging landowners to remove impermeable surfaces (Molenaar et al., 2013).

Rotterdam has been very outwards looking with its adaptation initiatives, with an eye towards leading a global network of municipalities, and 'delta cities' in particular, that are effectively managing the risks associated with climate change. The publication of most strategies and reports in English is evidence of this, as is the hosting of major events, like the two Deltas in Times of Climate Change conferences.¹ The Rotterdam Climate Initiative has been a leading partner in various initiatives, including the C40 Cities Climate Leadership Group, with which it created the C40 Connecting Delta Cities Network. The Network, which has published a series of three books, facilitates knowledge sharing and the sharing of technical support to advance the 'state-of-the-art' in urban climate adaptation (Molenaar et al., 2013). It has been a vehicle for bilateral and multilateral projects between cities.

The Port of Rotterdam is *the* major economic engine of the Rotterdam region, employing almost 90 thousand people and processing almost 450 million tons of cargo (Port of Rotterdam Authority, 2015a). It is the largest port in Europe, and one of the largest in the world. Beyond container and bulk shipping, it is home to numerous oil and chemical refineries and other processing industries. The Port Authority is an independently managed corporation jointly owned by the City of Rotterdam and the national government. The Port is acutely aware of the dynamic environment it operates in, and employs sophisticated long-range planning techniques to evaluate and prepare for risks like climate change. As mentioned previously, the Port is a partner in the Rotterdam Climate Initiative. The Port employs a subject matter expert on climate change and mobility, and has devoted resources to evaluating their vulnerabilities and potential adaptation strategies. Key findings include (van der Meer, 2010; interviews):

- Open access for vessels is critical, and could be restricted under some adaptation scenarios, including more frequent closure of the Maeslant storm surge barrier;
- Several port industries require freshwater and, while not a problem now, saltwater intrusion may force the closure of water intakes, either temporarily or permanently, in the future;
- Flooding risks are limited, especially as the flood levels would be minimal on elevated quays and other outer dike areas, but should be considered in future planning;
- Inland shipping may be adversely impacted by lower water levels; and

¹ See: <http://www.climatedeltaconference2014.org>

- It is important for the Port Authority to be on top of climate risks so that port users are confident in Rotterdam's long-term viability.

Interestingly, interviewees associated with the Port largely downplayed many of the potential risks associated with climate change, at least in the short and medium-term. An interviewee noted that public safety risks associated with flooding are high-profile yet likely minimal, while lower water levels on inland shipping routes are already a problem, as barges are being forced to travel with shallower drafts and thus only partial loads. Another cautioned against being too precautionary in evaluating climate risks, as adaptive measures can come at substantial cost. He gave the example of closing and reinforcing the Maeslantkering, and forcing ships to travel through locks at substantial cost. "The biggest risk is that you do certain things that are not good, or take the wrong decisions in which you can't see the consequences. [...] It's such a complex system with a lot of functions that [...] you can compare to an ecosystem, and you know from an ecosystem that it is fairly difficult to make an intervention because it has a lot of effects - but if the ecosystem can grow gradually, it finds its own solution", said the interviewee. The Port's adaptation work is as motivated by the desire to stay ahead of the curve and proactively shape users' perspectives and government regulations as it is by the risks themselves. Nonetheless, the Port is engaging in some concrete adaptive measures. An interviewee cited the higher elevation requirements in the new Maasvlakte 2 area of the port as an example – it is being filled to 5.5 meters above sea level to reduce the chances of chemical industries being flooded. Furthermore, the Port Authority is experimenting with alternative approaches to planning that are adaptive in the face of significant uncertainties, rather than static based on fixed assumptions (Taneja et al., 2010).

Infrastructure planning and decision-making

Adaptation to climate change necessarily takes place within the wider context of infrastructure planning and decision-making. Adaptation is implemented when it is institutionalized into ongoing systems of planning, decision making, and building and managing infrastructure. This research focuses primarily on transportation infrastructure, but, given the key interrelationship with flood protection in the Dutch context, this section starts with an examination of planning and decision-making around flood protection. Examining flood protection also offers important insights into the Dutch approach to infrastructure planning and decision-making writ large, as this is the sector in which governance innovations have often first emerged.

Flood protection

Unsurprisingly for a country so intertwined with water, flood protection infrastructure has played an integral part in the evolution of the Dutch nation. It was the advent of polders², and the associated governance innovations that emerged with the creation of water boards - often called the 'polder model' - that allowed the country to urbanize and emerge as a

² A 'polder' is a reclaimed piece of land surrounded by dikes, drained with pumps, and generally managed to control the water levels.

powerful state with cities and agricultural lands largely immune to regular flooding (Hooimeijer, 2007). Aggressive flood protection has always been about more than just reclaiming and protecting land - it is symbolic and culturally significant in a land so exposed to the sea (Fleischer, 2007).

The professionalization of flood protection infrastructure management was a gradual, evolutionary process that occurred over centuries as flood management became more complex and societal expectations increased. Hooimeijer (2007) asserts that the Dutch relationship to flood waters, including the polder system, has gone through six phases of design and technology: Acceptance (-1000), defensive (1000-1579), offensive (1579-1814), early manipulative (1814-1886), manipulative (1886-1990), and adaptive manipulation (1990-).

While flood protection is certainly a much older practice, the massive reengineering of the water system - with projects like the creation of IJsselmeer Lake in the 1920's and 30's - is characteristic of the more recent manipulative phase. The 1953 floods greatly hardened the resolve to tame the water, precipitating the most significant leap into professionalized, bureaucratic planning and heavily engineered, hard infrastructure solutions. A Delta Committee was formed and developed a 'risk-based flood protection' method, conducting extensive quantitative analysis using state-of-the-art cost-benefit techniques to evaluate risks, assess costs, and develop an comprehensive plan of action (Deltacommissie, 2008; Jonkman, 2009). Expert engineers and bureaucrats subsequently reshaped the Dutch coast even further than it was already, constructing one of the most complex and expansive networks of public infrastructure ever - the Delta Works. The works, which includes dikes, storm surge barriers, locks, sluices, and various other infrastructures, cost over \$7 billion and took over 40 years to complete (Krystek, 2011). One component, the Maeslantkering storm surge barrier, alone is a feat of engineering and one of the largest moving structures on earth, with two 240 meter-long gates capable of closing off Rotterdam's inner harbor (Deltawerken, 2004). So large and complex are the Delta Works that the American Society of Civil Engineers considers them, along with the previously existing enclosure dam north of Rotterdam that created IJsselmeer Lake earlier in the 20th century, to be one of the Seven Wonders of the Modern World (ASCE, 2014).

The Delta Works are very characteristic of the manipulative phase of flood management that they fell squarely within. Planners and engineers were tasked with making the country safe, and this meant putting water in its place and keeping it there. It was a project full of scientific hubris and grand government planning; protecting the country from the possibility of future disasters by building the largest, strongest infrastructure system possible and further realigning the flow of water throughout the low-lying country was deemed a national priority and funded accordingly.

It took decades, but the Delta Works, as generally mandated in the original plan, were finally finished in 1997 with the completion of the Maeslantkering storm surge barrier (Deltawerken, 2004). However, as the works were nearing completion, planners and decision-makers acknowledged that the task of keeping floods at bay was not done in practice, and never really can be - climate change, subsidence, development and other

forces of change will continuously alter the conditions, necessitating ongoing, adaptive management (Delta Programme, 2013). Recognizing this, a high-profile second Delta Committee was appointed by the Dutch cabinet in 2007 with the explicit mandate of considering the management of water far (100, even 200 years) into the future under climate change and other forces that are acting upon both the physical environment and society (Deltacommissie, 2008).

The Second Delta Committee - also called the Veerman Committee - deemed the flood protection issues before them to be critically important, and increasingly so over time, but not acute, given the strength of the Delta Works. The Committee suggested that substantial sea level rise - up to 1.3 meters by 2100 and 4 meters by 2200 - be taken into account in long-term planning and decision-making, and identified various other threats, including changing precipitation patterns and saltwater intrusion (Deltacommissie, 2008). Natural land subsidence and population growth are also exacerbating the risks and exposure.

The Second Committee was much more holistic in its approach than the first, taking the long-term sustainability of the region and various interests - including nature protection, recreation, cultural and social values, and other sectors like agriculture and transportation - into account, rather than narrowly focusing on flood protection and traditional hard-infrastructure engineered responses. The group generated twelve core recommendations (Deltacommissie, 2008: 12-13):

1. Raise the flood protection levels by a factor of ten to protect infrastructure for the next 40 years, and then reevaluate regularly beyond that;
2. Conduct rigorous and comprehensive cost-benefit analysis when considering new plans for development in potentially vulnerable areas, and avoid externalizing the costs of vulnerable development on others;
3. Ensure that new development in areas outside dikes does not impede the flow of rivers and rising lake levels;
4. Continue with aggressive beach nourishment along the North Sea coast;
5. Also maintain the Wadden Sea Area with beach nourishment, at least until (if) sea level rise makes it no longer viable;
6. Maintain the Eastern Scheldt storm surge barrier, which, with technical interventions, should be sufficient for the foreseeable future, while conducting nourishment to support the health of the intertidal zone behind it;
7. Maintain the Western Scheldt as an open tidal zone so that navigation to Antwerp may continue, while continuing to protect surrounding polders with dikes;
8. Create temporary storage capacity for river discharge in the South-Western Delta for times when storm surge barriers are activated blocking drainage to the sea, and find alternative freshwater supplies to accommodate increased salinity;
9. Immediately implement the Room for the River and Muse Works programs to accommodate increased discharges along these key rivers;
10. Construct storm surge barriers for the Rijnmond (mouth of the Rhine River) and operate in a 'closable-open' manner;
11. Increase water levels in IJsselmeer Lake by up to 1.5 meters over time, as it becomes increasingly important as freshwater reservoir; and

12. Strengthen the political and administrative framework for flood protection by providing a cohesive planning system at the national level, creating a permanent parliamentary committee, creating a Delta Fund to pay for it, and passing a Delta Act that enshrines this administrative and financing system into the country's political and legal frameworks.

The report was generally well received, with many of the recommendations currently being implemented, or at least planned for over the longer-term. There was some criticism of the sea level rise projections the Committee used, given that they were significantly higher than those of the Royal Netherlands Meteorological Institute (KNMI), and SLR projections based on extrapolations of historically measured rise (Jonkman, 2009). Nonetheless, the government and other stakeholders generally accepted the premise that sea levels are rising and that this will, sooner or later, render the existing flood protection infrastructure insufficient. The government adopted the 12th recommendation, with the new Delta Act entering into force in 2012. Among other things, the Act established a Delta Programme for ongoing infrastructure development and management; a Delta Fund to finance the works; and a new high-level 'Delta Commissioner' position to coordinate and oversee the efforts (Delta Programme Commissioner, 2014). According to interviewees, the Delta Commissioner is highly regarded in practice, and seen as a voice for logical delta management that sits outside of, and this is relatively immune to the whims of, the political arena. The Delta Programme (2013) involves relevant actors from the central, regional and local governments, the water boards and other non-governmental actors, including representatives of the business community. The Delta Programme has a limited staff of its own; recommendations are implemented by other agencies, primarily Rijkswaterstaat.

While still using predict and act tools like cost-benefit analysis, the Delta Programme, and contemporary flood management practices in the Netherlands in general, reflect some decline in scientific hubris over time. This is representative of the emerging adaptive manipulation phase of flood management. Technicians and decision-makers no longer have complete faith that they can perfectly engineer the entire system to meet established goals. This decline may be, in part, due to the increasing complexity of societal expectations and associated policy goals over time as other issues, like environmental protection, gain prominence. Threats to ecosystem health, recreation and other resource uses make the traditional approach of simply building the largest possible network of hard infrastructure less palatable. Experts and decision-makers are also increasingly aware of the fact that they do not have all of the answers, and that they must accept persistent uncertainty and dynamic conditions, particularly with climate change (Delta Programme, 2013). This adaptive manipulation phase is characterized by the reintroduction of spatial planning, integrated with civil engineering, into the practice of water management. It is about living and working with water, rather than confining it into very narrowly defined places. Hooimeijer (2007: 87) asserts that the purely technical (i.e., manipulative) approach to water management is at its end with climate change and associated extreme water events forcing water back into cities; the appropriate response is to integrate water into the design of cities, using it creatively rather than relying on traditional pipe and pump solutions.

In practice, the adaptive manipulation paradigm is driving the development of more sensitive, efficient and effective ways to protect people and property, while also maintaining natural ecosystems and flexibility in the face of dynamic conditions. The Room for the River Programme (2014) is an example of this new approach. The Netherlands faced a couple of very precarious situations in the 1990's with extremely high volumes of water along its major rivers, testing the limits of dikes and forcing mass evacuations. Recognizing that the frequency and scale of high discharges is only likely to increase in the future under climate change, the government had two choices: The traditional approach of further enhancing the levees, or breaking with this tradition and finding alternative ways to 'make room for the rivers' - in other words, finding spaces for water to safely collect and/or absorb when levels are high, rather than channeling it downstream as quickly as possible (Room for the River Programme, 2014). While dike building and reinforcement will certainly continue in various places, the second option was chosen for a couple of reasons: First, it is deemed safer - dikes offer excellent protection up to their thresholds, but once surpassed and they are breached catastrophic flooding results. Second, the 'room for the river' approach is typically much more environmentally sensitive, as wetlands and other habitats can establish in the newly designated flood zones and freshwater is held rather than pushed to the sea as quickly as possible. This is an example of working *with* nature, rather than focusing on conquering it, and of working to meet a more holistic set of objectives, including environmental protection.

The Delta Programme (2013) provides a high-level process for establishing the overall direction of Dutch water management and coordinating activities. On the ground, Rijkswaterstaat and regional water boards carry out flood control and water management. The water boards are direct descendants of those established in the 13th century to manage polders, although today's are much larger; while historically there were literally thousands of boards throughout the country, today there are only 24. Nonetheless, the boards are still independent institutions with members both directly elected by residents and appointed by stakeholder groups like farmers and private industry. They maintain the right to levy taxes to fund their operations. Rijkswaterstaat is typically responsible for larger-scale national-level infrastructure, and the water boards for more local infrastructure within their respective areas.

Confronted with the ongoing need to actively manage water, the Dutch are not content to accept the status quo. Knowledge on how to most efficiently and effectively thrive in their environment is continuously evolving, supported by various ambitious public and private research initiatives, in addition to those associated with the Delta Programme. Among them, Deltares is a key institute for applied research in this area, with the motto of "Enabling Delta Life". Deltares has become a world leader in the management of flood control and other infrastructure in coastal regions around the world.

While ambitious initiatives like Room for the River underscore a serious commitment to more flexible and holistic approaches to water management, these principles have not necessarily been fully embraced throughout all organizations. Participants noted that progress is slow. One factor is the professional norms and training of the engineers actually designing and implementing projects. "We have to reeducate our engineers, because [they]

are educated in a linear world - its true or not true. They see that's not simply valid, so they learn to discuss risks, but they didn't learn to discuss uncertainty", said a participant.

Road transportation infrastructure

Different levels of government are responsible for different parts of the Dutch road network. The Ministry of Infrastructure and the Environment is responsible for overall policy and planning, and is guided by the Traffic and Transport Planning Act (Planwet Verkeer en Vervoer). Constructing and maintaining national and regional arterial highways falls under the purview of Rijkswaterstaat, an executive (i.e., implementing) agency of the Ministry. According to its website, Rijkswaterstaat is "responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands, [including] the main road network" (Rijkswaterstaat, 2015). Rijkswaterstaat is responsible for over three thousand kilometers of motorways and major highways, which includes 22 tunnels, 743 bridges, and various other infrastructures.

Strategic planning involves actors from various agencies and organizations, including Rijkswaterstaat, the Ministry, the government (i.e., cabinet), and external stakeholders. At the highest level, the Cabinet provides long-term guidance. One vehicle for this guidance is the National Traffic & Transport Plan (Nationaal Verkeers- en Vervoersplan), which involves wide consultation and is passed by the Dutch parliament. In a clear shift away from thinking of mobility in a vacuum, the objective of the current (2001-2020) plan is: "The Netherlands should offer everyone an efficient, safe and sustainable traffic and transportation system, whereby quality for individual users stands in a meaningful equilibrium with quality for the country as a whole" (Ministry of Transport, Public Works and Water Management, 2001: 6). The Plan established mobility, safety and quality of life as the triumvirate core aims for the transportation system. Among other things, it recommended addressing key bottlenecks, a greater market orientation (e.g., 'putting a price on mobility') and decentralization of traffic and transport policy. Priorities and plans clearly change over time as new technologies and trends emerge, and in the face of social, economic and political shifts, but the Plan was developed to provide a long-term vision. Others responded to this strategy, advancing discussion around how the Dutch network should evolve. For example, the Social and Economic Council released an advisory report expressing support for the government's 'businesslike approach' and fostering of an "effective market for mobility", but questioning how all three aims may be concurrently addressed (given the tensions between them) and lamenting the lack of guidance around how goals like reducing greenhouse gas emissions will be achieved (Sociaal-Economische Raad, 2001). The Council is a typical neo-corporatist entity, with representation from employers, employees and independent experts brought together to develop recommendations for the parliament and government on key social and economic policy issues. Environmental groups also participated in the preparation of this advisory report.

Longer-term strategic planning translates into medium-term priority setting via dialogue between the Ministry and Rijkswaterstaat, and in consultation with other stakeholders. The Ministry's Multiannual Infrastructure and Transport Program (Meerjarenprogramma Infrastructuur en Transport or MIT) provides a framework for moving from overarching

priorities to specific goals, project selection, design and implementation for transportation and water management infrastructure at the national level. For example, the Verlenging (Extension) 2011-2014, Doorkijk (Perspective) 2015-2020 MIT established the following goals for the road network: Average travel times during peak rush hour periods that are maximum one and a half times longer than during normal travel periods for the main motorways; and twice as long for urban ring roads and other key highways (Ministerie van Verkeer en Waterstaat, 2010). These specific targets guide project selection and design, while recognizing that other factors might necessitate variations and exceptions. The MIT also provides guidelines on how projects might be conducted, including their financing. For example, the 2010 MIT document outlines various funding sources, but also opens the door to exploring road pricing and encourages further development of public-private partnerships (Ministerie van Verkeer en Waterstaat, 2010). Key projects like the widening of the A15 motorway, the main highway running deep into the heart of the Port of Rotterdam, which is discussed in more detail below, are framed in the MIT, including financial information and timelines. In this case, the original 526 million Euro budget is identified, but the document notes that this is not enough and that innovative partnerships should be explored, which is how the project was executed in practice (see below for more information). The 2015-2020 section of the (2010) MIT document is more exploratory in nature, providing some foresight into what may be in the pipeline both in terms of trends and priorities, and specific projects.

Priority projects are put into the Multi-Year Investment Program (MIRT), which places them at the top of the list for government funding and other resources. Throughout this process, technical assessment plays a role, but so do political and other considerations. When it comes to making decisions around which large projects to fund and in what manner, the Minister and/or cabinet make decisions directly, typically after consultation with relevant local politicians and other stakeholders and review of technical analysis provided by Rijkswaterstaat and Ministry staff. Rijkswaterstaat analysis involves assessment against various quantitative and qualitative criteria, including RAMSHE (reliability, availability, maintainability, safety, health and economics) variables. As discussed further later in this chapter, extensive consultation is the norm; interviewees often referred to the 'polder model' when describing the Dutch predilection to consulting communities, interest groups and others when major decisions are to be made.

Rijkswaterstaat's project implementation and operations are largely carried out through seven regional offices. Rotterdam falls within the Western Netherlands South region, which is coterminous with the Province of South Holland and is headquartered in the city. Regional staff plays front-line roles in network development, management and operations. This ranges from long-term planning to the crews that perform day-to-day maintenance. Rijkswaterstaat experts in other units provide support and conduct long-term research to advance the objectives of the organization. The aforementioned 'blue spots' work is, for example, being lead through a climate-focused team in the Water, Transport and Environment unit.

Private firms and outside research organizations play various important roles in the road transportation system. Applied research institutes and engineering firms like TNO and

Deltares, which conducted much of the blue spots assessment, provide technical expertise that does not exist within Rijkswaterstaat. Technical consultants are involved in infrastructure analysis and research in many jurisdictions throughout the world, but what is somewhat unique in the Dutch context is that much of this work is done by quasi-public, or at least not-for-profit, organizations like TNO and Deltares. While universities and research institutes play key roles elsewhere, private engineering firms like CDM Smith and AECOM typically conduct much of the analysis contracted out by transportation agencies and construction firms. Multinational engineering firms, including major homegrown player Royal HaskoningDHV, are also very active in the Netherlands when it comes to project implementation, but research institutes play an outsized role. As elsewhere in the world, most of the actual construction of new roads and associated infrastructure is contracted out to private firms like Heijmans. Contractors typically work with Rijkswaterstaat throughout the project design and construction phases.

While relatively late to adopt compared to some other countries, including the UK, liberalization efforts are putting a greater proportion of road network design, construction and management into the hands of private firms. Rijkswaterstaat has largely shifted from a 'design-bid-build' model of project implementation to a 'design-build' model over the past decade (Altamirano, 2010). Traditionally, the government was responsible for shepherding capital projects through each phase and managing contracts with the various engineering and construction firms. They also performed all long-term maintenance directly. With the 'design-build' model, a single contractor is responsible for the entire design and construction process, with the expectation that they will deliver infrastructure that meets various pre-established standards. In fact, with many important construction projects - like the A4 link between Delft and Schiedam (north of Rotterdam) and the widening of the A15 out of the Maasvlakte (Port of Rotterdam) - the government is employing an even more market-oriented 'design-build-finance-operate/maintain' approach (Altamirano, 2010). Under this model, private operators are responsible for financing, constructing and maintaining the infrastructure under long-term lease agreements. The government sets out the general requirements, but has limited influence over design and implementation, and takes little risk. In the case of the A15, a consortium of four large construction, engineering and infrastructure management firms have the concession through a partnership called A-Lanes; they are fully responsible for the expansion currently underway along a 37km stretch of the highway, and for maintenance and operations for the next 25 years (A-Lanes A15, 2015).

Dutch roads are toll-free thus far, so service providers are paid by the government rather than individual users, with compensation based on meeting availability performance standards rather than usage; operators are penalized heavily for lane closures, whether due to repairs or traffic accidents (Altamirano, 2010). While these are the wider trends in Dutch road construction and management, it is notable that practice varies across Rijkswaterstaat, with different units interpreting directives in different ways. Furthermore, the consultative 'polder model' approach to decision-making in the Netherlands makes the institutionalization of a uniform, top-down approach unfeasible (Altamirano, 2010). While increasingly in private hands, the case of the Traffic Management Company (Verkeersonderneming) for the A15 described in the callout box below suggests that

government agencies still play critical roles in project implementation, even when design, construction and management are outsourced.

The provinces are responsible for the bulk of the highway networks that are not managed by Rijkswaterstaat. Rotterdam is in the Province of South Holland, which manages 550 kilometers of roadway, with a transportation budget of 370 million Euros for 2015 (Provincie Zuid Holland, 2015). South Holland is the most densely populated province, and has a complex secondary road network relied upon to work efficiently with the primary network to move people and goods – whether it be tomatoes from the greenhouses of Westland, workers to the various industries within the Port of Rotterdam, or visitors to the seat of national government in the Hague. Provinces follow somewhat similar processes to Rijkswaterstaat; they elaborate their own Multiannual Infrastructure and Transport Programs to establish priorities, and carry out both capital projects and maintenance via various forms of public-private partnerships.

The Gemeente (City of) Rotterdam's Traffic and Transportation Department is responsible for the tertiary transportation network in the municipality, which includes local roads, the extensive system of bike lanes and pedestrian infrastructure.³ Their tasks include construction and maintenance, and much of the traffic management. According to an interviewee, in recent years, the City's focus has been on non-motorized mobility, like further enhancing the bicycle network, and pedestrian crossings. Budget constraints have meant fewer large and expensive projects. The interviewee cited examples of projects that were in the planning phase before the economic downturn but did not proceed, including a tunnel and a new access road to a busy shopping area. Instead, the Department has been capitalizing on opportunities, like a major road reconstruction that was necessitated by sewer work, to redesign roads to increase pedestrian and cyclist safety and improve overall streetscape and quality of life. Traffic flow and safety are still core priorities, but issues like noise are also being addressed via improvements like the increasing use of quiet asphalt. According to interviewees, environmental concerns are regularly factored into the department's decision-making, but the risks associated with climate change are not yet on their radar. This is interesting in a city both vulnerable to climate change and at the forefront of adaptation; it suggests that, while receiving significant attention from the City, adaptation is not fully integrated throughout departmental planning and decision-making. As noted earlier, adaptation in Rotterdam, and the Netherlands more widely, seems to focus largely on flood protection as a discrete management challenge, rather than on its integration into the management of various infrastructures.

While higher levels of government are responsible for the larger roads, and thus the associated infrastructure projects, the City's Traffic and Transportation Department is party to their planning and decision-making processes. According to an interviewee in the Department, the Dutch model of consultative decision-making means that decisions can take a long time to be made, but do genuinely engage local agencies and other stakeholders.

³ In the time since this research was conducted, the Traffic and Transportation Department has been merged with other units into a larger City Development Department (see <http://www.rotterdam.nl/stadsontwikkeling>).

Between province and city is the regional municipality. Following an act of the national government that passed the senate in December 2014, the Stadsregio Rotterdam (Regional Municipality) is currently being merged with that of The Hague, forming the new Metropolitan Region Rotterdam The Hague (Metropoolregio Rotterdam Den Haag, 2015). The regional municipality does not directly manage road infrastructure, but plays a key coordinating role among municipalities, the Province and other actors in what is a highly integrated region. This is particularly critical for pieces of the infrastructure that cross jurisdictional boundaries. Much of the funding comes from block grants awarded by the national government. The Regionale Uitvoeringsagenda Verkeer en Vervoer 2011-2015 (Regional Implementation Agenda Traffic and Transport 2011-2015) is the current four-year implementation agenda; it establishes the goals for the region, and sets priorities and expectations around how they may be advanced. This agenda focuses on making the most of limited resources in the face of government cutbacks, including how the transportation system might more efficiently manage demand and make use of existing capacity, rather than focusing primarily on increasing network supply. The new regional organization is still forming, but has identified enhanced mobility and dynamic traffic management as priorities (Metropolitan Region Rotterdam Den Haag, 2012).

The importance of the Southern Randstad (i.e., greater Rotterdam/The Hague area) to the Dutch economy as the most populous and dense region of the country has precipitated various channels for regional cooperation, in addition to the Regional Municipality. The Samenwerkingsverband Zuidvleugel (South Wing Alliance) brings together municipalities, regional authorities and the Province government to coordinate activities and advance common objectives (Zuidvleugel, 2015). A current project is focusing on enhancing the international connectivity of the region; this involves various studies and consultations, and subsequent recommendations for transportation infrastructure investments. Specific forums for collaboration have also emerged around particularly complex infrastructure challenges; an example is the Traffic management company detailed in the callout box below.

The Traffic Management Company (De Verkeersonderneming)

The efficient and unencumbered movement of goods and people in to and out of the Port of Rotterdam, one of the largest in the world, is imperative to its operations. The port is a key gateway not only to the Netherlands, but to the rest of Europe as well. Goods move inland in various ways, including via river barge, rail and road. Approximately 90 thousand people work in the port, commuting in and out daily. The A15 motorway is a key transportation link for the port and wider city; it is the only highway running through the port, and proceeds eastwards towards the major industrial cities across the German border.

The A15 was experiencing congestion due increasing demand, and volume was projected to increase significantly with the major Maasvlakte 2 expansion of the port (which is discussed further in a separate box later in this chapter). The government planned to widen the motorway in response, but was faced with a major challenge: How to minimize

disruptions and maintain acceptable levels of mobility during this major infrastructure project, which is running from 2011 to 2015. The key stakeholders realized that this highway project is necessary, but feared the consequences of greatly reducing the short-term capacity during construction.

The City of Rotterdam, Stadsregio (i.e. regional authority), Port Authority, and Ministry of Infrastructure and the Environment created an innovative partnership called De Verkeersonderneming (The Traffic Management Company) in 2008 to devise and coordinate solutions to help manage this challenge. In addition to the founders, it brings together resources and representatives from various key stakeholder groups, including Rijkswaterstaat, the organization that represents firms in the port (Deltalinqs), and employee representatives. Rather than each party assuming that the problem is someone else's, they have identified creative, yet typically fairly simple, ways to minimize disruption during the A15's reconstruction. Activities have involved traffic management, mobility management and information provision. Projects have included: Coordinating and staggering shift changes among different firms; new integrated shuttle bus services; smartphone apps; recreational sports activities during peak travel times to stagger commutes; and e-bike leasing. Many solutions have emerged through a 'Marketplace for Mobility' program that was designed to help private firms launch ultimately self-sustaining mobility services; port users and employees benefit from these services directly, while overall peak demand is reduced.

The Company has been very successful in achieving its mission. "[It] is the complete example of [cooperative] behavior, were all the governments put in their money and their people, and not officially but unofficially their responsibilities [...] it's the most state of the art there is in terms of working together and daring to let go", said an interviewee. Some port users and other levels of government did initially suggest that it is the central government's road project and therefore their responsibility, but the central government refuted this argument by providing data to suggest that the bulk of the traffic on the A15, particularly at peak times, was local (i.e., within the city as opposed to long-distance). Furthermore, it is the users and local authorities that would bear much of the consequences if significant congestion manifests.

An indicator of success is that rather than being dissolved as the A15 reconstruction draws to a close, as was the original plan, the Company has been given an extension and new mandate to play a role in the Beter Benutten ('Optimizing Use') program. The program is working to reduce congestion and shorten journey times by implementing a package of "300 practical and quantifiable measures" in key bottlenecks around the country, including in Rotterdam (Platform Beter Benutten, 2015). The activities of the program are very similar to those of The Traffic Management Company. It is a collaborative effort between the national and regional governments to advance innovative solutions, with a joint investment of 600 million Euros. There is also a strong emphasis on collaborating with the private sector – the cornerstone is 'smart deals' arrangements with businesses, including tax measures, flexible work programs, e-bike campaigns and other instruments.

For more information, see: De Verkeersonderneming (The Traffic Management Company) - <http://www.verkeersonderneming.nl/english>; Port of Rotterdam Authority - <http://www.portofrotterdam.com/en>

The Traffic Management Company is an example of a problem-oriented, multi-stakeholder organization setup to address a challenge – mobility constraints during the reconstruction of the A15 motorway in this case – that is best handled collaboratively rather than by a single agency or other stakeholder. Rijkswaterstaat could not unilaterally mandate many of the Traffic Management Company’s successful initiatives, like staggering shift changes, and private firms need both coordination and data for their contributions to work. It is not a given that this kind of collaboration will emerge and be successful, so it is valuable to consider why it did in this case. Agencies have not always valued collaboration in the Netherlands. “I think all the authorities, till the end of the 1990s, thought 'it's my road, or my waterway and I know what to do and I will do that'”, said an interviewee. According to this interviewee, the change in thinking occurred when “the authorities came to think about [the network not simply as individual roads], but the total route of the one who uses [it], and he is not interested in borders, so we have to cooperate with the other authorities”. The interviewee noted the further evolution when outside stakeholders were brought into the conversation: “The next step is in the second half of the last decade [was that] we should also use the knowledge and creativity of the outside governmental organizations to solve a problem, including the knowledge of the users, [...] the employees and the employers”. Participants consistently noted the increasing degree of cooperation among authorities over time.

Asked why the Traffic Management Company partnership works, an interviewee directly involved noted the common objective and feeling among the parties that something needed to be done, but realization that responsibility was unclear. The interviewee also stressed the importance of groundwork previously laid via ongoing, informal cooperation among agency staff, even when higher-level officials did not champion it. He differentiated between the ‘managerial floors’ and the ‘working floors’, noting that those on the ‘working floors’ found themselves meeting with increasing frequency, and came to the realization that there was not much difference in opinion among them; they then brought the managerial and political levels along, convincing them of the shared interests and value of collaboration over time. Another factor is the importance of each actor continuing to feel a sense of ownership. “[This type of cooperation is] only possible if the organizations keep on recognizing that it's [their initiative]”, said an interviewee.

An interviewee directly involved in a multi-agency initiative cautioned, however, that cooperation does not represent complete trust, and that conditions can change and vibrant partnerships break down. That is, these relationships are not infallible. One persistent challenge is that authorities are often suspicious of each other; they do not want to cede turf or inadvertently support things against their own (perceived) interests. Changes in the material conditions can also cause problems. The national government has 'the biggest

wallet' and is often the source of funding for transportation infrastructure projects, even when carried out by other levels of government. While historically possessive of their funding, a shift towards more strategic network thinking in the early 2000's led the national government to allocate more funding to the provinces and municipalities, particularly when they could more efficiently and effectively address shared concerns. The relatively strong levels of funding made this easier; Rijkswaterstaat (the national infrastructure agency) was often happy to share the work. The economic downturn and subsequent imposition of budget austerity in 2009 changed all this. There was a shortage of projects, so national agencies wanted to keep what they could for themselves. Rijkswaterstaat was increasingly competing for infrastructure funds, rather than an elder partner looking to support regional efforts when most appropriate. "They won't say it loudly, but it's a human aspect of decision-making - keep yourself at work", reflected an interviewee. On the other hand, lower levels of government, as the recipients of less support from the national government, responded by calling for solutions that would be the responsibility of the national government so that they could avoid paying. An interviewee gave the example of a road near Leiden; the local governments were calling for a highway, and when asked why responded that it was 'because of the money'. When promised the funding for a regional road instead, they accepted, leading to a solution that, in the opinion of the interviewee, is appropriately scaled, more cost-effective, and more environmentally responsible. Strategic collaborations among different agencies and levels of government can be invaluable, but the myriad of factors that agencies consider when deciding when and how to engage must be acknowledged.

Problem-focused multi-stakeholder forums for deliberation, consensus seeking and institution building can help agencies and other stakeholders to address complex challenges that will require coordinated responses. The Traffic Management Company is an example of such a forum in the context of addressing substantial transportation infrastructure challenges. It is innovative and uncommon, but also not wholly unique; as detailed in chapter 4 (the Boston case), a somewhat similar, although less formal, multi-stakeholder forum emerged around the Central Artery (i.e., 'big dig') project in Boston in the late 1990's. At their best, these venues help groups of stakeholders facing significant (shared) challenges in uncertain institutional terrains to collaboratively devise approaches that maximize the individual and collective benefits while minimizing the costs. Similar arrangements may be appropriate when tackling wicked challenges, like adapting infrastructure to climate change. New fora may, in fact, already be emerging around climate adaptation, although it is unclear that they are adopting best practices from these other, similar initiatives.

One potential challenge with this type of multi-stakeholder forum is ensuring that the right parties are represented at the table, and able and willing to engage in the resulting programs. The Traffic Management Company works because it revolves around a discrete piece of infrastructure in an environment populated by agencies and other stakeholders with substantial resources and capabilities. Rijkswaterstaat, the City of Rotterdam and the regional authority are all exceptionally strong in this wealthy and well-managed region. The Port of Rotterdam is a very well funded enterprise that pays substantial attention to strategy and planning. The private firms in the port called upon to implement various

activities are typically large enterprises with the capacity to implement programs like those promoted through the Traffic Management Company. Furthermore, the port industries are well represented at the table by their association –Deltalinqs. Likewise, employees are well represented through their associations. The neo-corporatist Dutch model makes this easier, as employer and employee organizations are well established, familiar with playing roles in planning and policy-making efforts, and recognized by government agencies.

One challenge for transportation decision-makers in the Netherlands is that they have historically paid little attention to water management and other environmental risks because their colleagues responsible for keeping the country dry have been so effective. At the national level, flood protection and transportation infrastructure are actually managed by the same agency - Rijkswaterstaat - but the large organization has traditionally been functionally divided into 'wet' and 'dry' sides. Employees largely focus on and interact with colleagues only on their respective sides of that divide, pursuing different objectives and following different procedures. They would not really communicate, according to interviewees. Rijkswaterstaat has, however, been going through a reorganization in recent years that, among other things, breaks down the divide and integrates 'wet' and 'dry' employees. The goal is to facilitate greater collaboration and knowledge sharing, particularly as the lines of responsibility are blurred; flood protection specialists are increasingly forced to consider other infrastructure networks and the built environment, while transportation infrastructure planners consider how they might plan in a wetter environment. This reflects a wider trend towards integration that is embodied within, among other initiatives, the Delta Programme.

The Polder model: The wider neo-corporatist framework for decision-making

The ways in which infrastructure is managed and by whom - including how policies are crafted and implemented - are bounded and shaped by the wider norms of governance within a given country and society. As noted elsewhere in this dissertation, Rotterdam, Singapore and Boston were chosen as the case cities because they are archetypal of three very different models of governance.

Rotterdam operates within a *neo-corporatist* framework of decision-making (Slomp, 2011). In the traditional sense, the neo-corporatist (or tripartite) model is concerned with labor and the management of the economy; employers, workers and the state formally negotiate as 'social partners' to reach sector and even economy-wide agreements on issues such as wages, training and employment conditions (Slomp 2011; Wiarda 1997). Rather than interacting in a predominantly adversarial fashion, parties are expected to come together and reach consensus. It is often considered a 'depoliticization' of planning and policy-making, as parties seek agreement and the government is viewed as less polarized and serving of one constituency or another based on the preferences and political affinities of the party in power (Slomp, 2011). Scholars have variously emphasized and downplayed both the importance and collaborative nature of neo-corporatism, but generally agree that this model is significantly reflected in Dutch decision-making (Wiarda 1997; Woldendorp 2005). While the neo-corporate model has waxed and waned over the decades, it has

persisted both formally and informally within governance institutions, including the Social and Economic Council, which brings labor, management and other experts together to formally evaluate and opine on government policies (Slomp, 2011). There is debate around the degree to which neo-corporatism translates to policy spheres beyond labor and the economy, particularly given the relative absence of formal institutional arrangements like the Social and Economic Council once you move beyond labor and economic issues. However, the evidence suggests that environmental issues can and do enter neo-corporatist agendas in countries with a strong tradition of following this model, including the Netherlands (Glasbergen 2002; Jahn 1998; Schreuder 2001).

The Dutch may have a particularly strong predilection towards and distinctive style of neo-corporate model, including in the area of environmental management, rooted in the long tradition of *Poldering*. The Dutch cannot claim a monopoly on consensus-based decision-making, but it may be far more entrenched into government, business and other facets of society than is common throughout most of the rest of the world. The assertion is that there is a “distinctively Dutch style of policy making in the social and economic sphere [that is] consultation-intensive and consensus-seeking” (De Vries, 2014: 100). This Dutch approach is often referred to as *poldering* or the *polder model*, as it has its roots in the water boards that have kept the country dry since the Middle Ages (Prak and van Zanden, 2013). A polder is a low-lying area that would naturally be flood-prone, or completely submerged, but is kept dry by dikes, pumps and other infrastructure. Keeping a polder dry requires constant management. Poldering is the traditional manner in which farmers and other residents in low-lying areas of the Netherlands have come to consensus and shared collective responsibility for their respective polders - this kind of water management was not possible at an individual level and thus required collaboration among neighbors in a time before professional government bureaucracies assumed responsibility for this kind of infrastructure. Thus was born “the thousand year old traditions of meeting and consulting” (Prak and van Zanden, 2013). In the 1980s the *polder model* emerged as a descriptor for the already well entrenched practice of reaching broad consensus on economic, environmental, and other policies in the neo-corporatist tradition (Schreuder 2001).

Some argue that the polder model - both literally with water boards and conceptually as the practices were extended into other domains - has been a key factor in the success of the Dutch nation over the centuries, and is a major ingredient in today’s social, political and economic institutions (Prak and van Zanden 2013). There is substantial academic literature suggesting that poldering is an important phenomenon in the setting of environmental policy (Glasbergen 2002; Schreuder 2001). The polder model is somewhat codified within the ‘Spatial Planning Key Decision’ procedure, which sets out a set of consultative requirements for large projects – including at what phases government agencies must share information, consult with citizens and other stakeholders, and put decisions before the parliament (Kelly, 2005). It is notable, however, that some question the influence of the polder mentality in practice, noting that there still is substantial adversity in policy-making (Woldendorp 2005). Others question the exceptionalism of poldering vis-à-vis the corporatist models and institutions that emerged over similar timelines elsewhere in Europe, and are still prevalent (De Munck, 2014; De Vries, 2014). Conversely, some question the transferability of the polder model to other countries that have not followed

the same historical evolution and do not have the same conditions (Schreuder 2001). They also question the genuine continuity of the model over centuries of disruptive change. Either way, a corporatist, consensus seeking, model is well entrenched in Dutch decision-making. The key uniqueness of the Dutch model, even vis-à-vis other neo-corporatist states, may be the relative openness to debate and weak degree of deference to authority found in decision-making.

In my interviews with Dutch officials and other stakeholders, the tradition of poldering was regularly cited as 'the way we do things'. The 'polder mentality' or 'polder model' came up in the exercise debriefs, and was explicitly mentioned by eight different interviewees during our conversations. According to a government employee involved in policy development and implementation:

In general in Holland [...] it always happens that stakeholders are involved, that's part of our culture, what they call the 'polder mentality'. [...] We have to think about the interests of others, it is important. And so when you involve stakeholders, it helps to get a solution that is acceptable so there will be less opposition during the process, which makes the process easier. [Furthermore], involving stakeholders can maybe lead to different insights that can lead to a better solution - one that you maybe wouldn't think of when you do it on your own. [...In] my own work, when I make these guidelines, well you have to not just think 'well, I think this is the best way'; I need the experience of people that have to work with it, they are going to use it and if I make something they don't want to use, its useless. [...] It would be easier to not have to take into account what all the other people want, but its absolutely necessary.

It is notable that interviewees largely framed poldering in utilitarian terms. That is, as something that needs to be done to move projects forward and generate the best outcomes, rather than in ethical terms or implicitly assuming its necessity. In a similar vein to the above comment, another participant, from Rijkswaterstaat, said:

It is necessary, especially in a country like the Netherlands in which we use the word 'polder' also as a verb, which means you have to get together, otherwise it will not work. [...] especially in the work we do, if somebody wants to block the process, they always can. [...] You know, you always have 5-10% who will never agree. OK, that's the group you can force by laws. But, if this small group gets support from a little bit reluctant larger group, they are supported [and you have to change the laws].

The same interviewee framed the poldering mentality as 'Darwinistic' in that it was an effective adaptation to the conditions in the Dutch lowlands. "Adapting to the situation in this terribly wet country is cooperating [...] because in this case the water as an enemy is always stronger than you are; you can't beat it [but] you can tame it, and when there is an emergency, it is simple - no matter what you are, nobility or whatever - we will all drown, so we have to work together, and the ones who understood that were the ones that survived", said the interviewee.

While it may have been an appropriate adaptation to the conditions, interviewees noted that poldering often comes at a cost, as it takes time to seek consensus and can be antagonistic at times. “One picture of how things work is when you want to get something done and you are walking through the woods, and behind every tree there is somebody who wants you to stumble, because he also has his or her thing - 'I want you to do this', 'you haven't talked with me' - but there is a culture; we have to talk with virtually everybody to see if they are OK with it”, said an interviewee. Another opined that “sometimes it's quicker to skip all of this poldering and just make your legislation, and if the subject is not so [controversial] then it's probably easier just to go ahead”. However, the same interviewee noted that in the context of a major project she is involved with that “despite the extra time it took to design and approve the project, it led to more creative, wise and broadly accepted outcomes”. As explored in more detail in the callout box below on the participatory process around the Maasvlakte 2 project, there may be tradeoffs between the time invested in process and the quality (or at least creativity) of the outcomes; poldering may generate superior outcomes, but it takes substantial time. Either way, in a democratic environment with opinioned and empowered stakeholders like the Netherlands, unilateral, quick and unproblematic policy and project implementation may be unrealistic in most situations. Poldering may be the only viable alternative to protracted adversarial negotiations, often fought through the courts, in the face of strong and effective opposition.

As with the wider neo-corporatist model, poldering has gone through phases of popularity. The Economist (2012a) argued that the polder model went through a few years of decline, but is now resurgent. This was a sentiment shared by *Harboring Uncertainty* participants. “What I see over the past 15 years is that it goes up and down - in the 90's, it was very usual to work with participation, [and then] after that we went the other way, [with decision-makers] saying we know what the solution is and poldering is bad - now we are going back to the 90's, and a lot of projects are using participation again”, said a planner from Rijkswaterstaat. The same interviewee noted that the approach to poldering has not, however, remained static. In particular, the management of participatory processes around current projects appears to be much more professionalized. The role of different stakeholders has also changed over time. These issues are explored in more detail in the Maasvlakte 2 project case below.

Maasvlakte 2: Negotiating an Ambitious Expansion to the Port of Rotterdam

Anticipating growing demand and faced with limited options for expansion, a planning process called the Rotterdam Mainport Development Project (PMR) was initiated in the 1990's (Kelly, 2005). The PMR brought together representatives from five relevant Ministries (Transport, Public Works and Water Management, Housing, Regional Development and the Environment, Economic Affairs, Agriculture, Nature, Conservation and Fisheries, and Finance); the Province of South Holland; the regional authority; and Rotterdam and other municipal governments in the region. Nine non-governmental stakeholder groups, including environmental organizations, a trade union, and industrial and commercial interests both directly and indirectly related to the Port of Rotterdam were

also engaged to represent their various constituencies' interests. An independent facilitator and a consulting and engineering firm supported the group. The PMR's objectives were to consider how the port's viability could be maintained and the quality of life in the region enhanced, all under very tight space constraints in this very densely populated region. Three options were put forward to address the space issue - using the existing port more efficiently; integrating with other ports in the more sparsely populated southwest of the country; and expanding the port further into the North Sea on new fill - but expansion was the favored solution from the beginning (Kelly, 2005).

The process faced various hurdles, including a change of government mid-way though, which precipitated a change in how much information the Ministries were willing to share with external stakeholders. There was also some tension among the Ministries, as they did not always have shared interests and were not accustomed to having to coordinate on a project like this. While ostensibly on the same team, different agency representatives wanted 'a little bit more' for their respective areas of concern - agriculture, the environment, finances and so on (Kelly, 2005). This tension is informative, given that ministries and agencies may need to coordinate much more extensively as they grapple with emerging threats like climate change that do not fall neatly into a single agency's area of responsibility. This case would seem to support the Advocacy Coalition Framework approach, which asserts that various arms of government are often more aligned with external stakeholder groups in their respective areas of responsibility - agriculture, the environment, the economy and so on - than they are with their peer agencies (Sabatier and Jenkins-Smith, 1993). However, these tensions were not always clear externally, as the government position remained resolutely to expand the port (Kelly, 2005).

Disillusioned with the activities of the national government, concerned that they were going to be steamrolled, and seeing a window of opportunity, the environmental NGOs initiated a sidebar process with the Port Authority and Municipality of Rotterdam, called 'Vision and Daring' (Kelly, 2005). This process did not start out smoothly, but the accidental disclosure of internal correspondence among the NGOs changed the paradigm. The NGOs subsequently decided to engage in more conciliatory 'what if' conversations around what they would want should an expansion go ahead, rather than continuing to focus on why it should not proceed. That is, the discussion shifted to focusing on what an acceptable Maasvlakte 2 (i.e., expansion) would entail from the environmental and social perspectives. The environmentalists, port and city were subsequently able to reach agreement on a set of parameters for the project, altering the design of the expansion and devising a set of compensatory measures. However, their tentative agreement still required buy-in from others, including the wider environmental NGO community, other stakeholder groups - many of whom questioned why these groups had decided to meet and draft a proposal independently - and not least the relevant national government Ministries. This task proved very difficult, with the fishing and agriculture industries ultimately filing appeals, and even a lawsuit, because they felt that they had been excluded from the process and their interests ignored (Kelly, 2005).

With the prospects of a consensus agreement waning and the process and relationships

strained, professional neutral Marc Wesselink was brought in in 2005 to reorganize and reinvigorate the multi-stakeholder process (WesselinkVanZijst, 2015). The new process focused on rebuilding relationships and helping parties to engage one another following 'mutual gains principles' (Vellinga, 2007: 22): *Know the interest and point of view of other parties; Issue mapping to identify the key stakeholders; Joint fact finding; Mitigate and compensate; Take responsibility, admit mistakes and join power; Always remain reliable; Distinguish between constructive negotiation and conflict resolution; Opt for package deals; Focus on creating long term relationships; and Nobodies fool (have trust but use common sense).*

The process ultimately yielded a voluntary agreement that all stakeholders were prepared to buy into. The comprehensive and creative package was designed to address the multiple interests. Features include (Vellinga, 2007):

- Agreement that the two thousand hectare Maasvlakte 2 expansion would go ahead;
- The creation of a 25 thousand hectare marine protected area for both marine life and nesting birds;
- A 35 hectare dune restoration project elsewhere along the coast;
- Measures to make the Maasvlakte 2 more sustainable, including a commitment to a landside modal split favoring rail and inland water over road, the use of electric stacking cranes, and the construction of net zero energy buildings;
- Further advance sustainability by clustering firms to encourage lifecycle integration (e.g., use of extra power plant heat by LNG facility);
- Implement measures to maintain acceptable air quality, including restrictions on trucking fleets; and
- The construction of a 'multifunctional seawall' that would provide adequate coastal defense while featuring distinct zones for recreation (including swimming/leisure, kite surfing and fishing), nature protection, and wind turbines for energy production.

The Dutch Parliament approved the project in 2006 and Rotterdam's municipal council in 2007. Bids were evaluated, contracts signed and construction began in 2008. Construction officially concluded in 2013, and the first ships arrived in 2014, while the construction of quayside infrastructure (which is largely the responsibility of the various private tenants) continues into 2015 (Port of Rotterdam Authority, 2015b). Key stakeholders continue to meet intermittently to assess progress towards the commitments made in the initial agreement, and discuss any new issues as they emerge and require attention. An interviewee involved in the process reported in 2012 that, even with construction nearly complete, a formal stakeholder group with representatives from a dozen different constituencies, chaired by a former minister acting as a neutral facilitator, was meeting every few months to review progress, next steps and proposed revisions to the plans.

The extensive multi-stakeholder process around the Maasvlakte 2 expansion reflects a consensus-seeking mentality in Dutch decision-making. While a corporation focused on maximizing the competitiveness and overall economic performance of the Port of Rotterdam, the Authority was willing to engage in extensive deliberations with other

stakeholders out of a belief that this could generate stable and wise outcomes. However, the various hurdles encountered along the way and time it took to reach an agreement suggests that these processes do not always go smoothly.

The process around the Maasvlakte 2 is not the only example of the Port of Rotterdam engaging in a multi-stakeholder deliberative process. In fact, lessons learned from the Maasvlakte 2 process are informing other collaborative efforts. The *Port Vision 2030: Port Compass* process engaged stakeholders in planning around the future of the Port and wider region (Port of Rotterdam Authority, 2011). A wide variety of different actors were brought together in various fora to generate scenarios of possible futures, and devise a wide set of 'ambitions' – from pollution reduction to targeted education for the jobs of the future - and how the region can achieve them. Climate change was one factor on the table in the visioning process.

For more information on the Maasvlakte 2, see: <https://www.maasvlakte2.com/en>. Kelly (2005) provides an excellent analysis of the initial stakeholder engagement around this case. Information on the later stakeholder engagement process came from interviews and Vellinga, 2007.

It is notable that the polder model – understood as consensus-seeking dialogue among stakeholders to make a decision or resolve a dispute – is dynamic, adopting new tactics over time as conditions change and the state-of-the-art evolves. An interviewee directly involved in the Maasvlakte 2 process noted that consultation around projects like this has traditionally been more ad hoc in nature. This reflects a dichotomy between the more traditional, formalized neo-corporatist institutions that exist around particular labor and social welfare issues, and the informal and heterogeneous consultations that occur around projects to discuss environmental and other issues outside the framework of the traditional neo-corporatist institutions. The later phases of the Maasvlakte 2 process were characterized by the application of a more structured approach, but one that was relatively new in the Dutch context. This approach was largely adopted from outside the country - namely the 'mutual gains approach' associated with affiliates of the Program on Negotiation at Harvard Law School in the United States (see Susskind and Field, 1996). The features of the process, which were introduced in the callout box above, are archetypal of the mutual gains approach, including focusing on interests rather than positions, creating packages that meet multiple interests concurrently, and employing decision-support tactics like 'joint fact-finding'. It is unsurprising that this was the approach taken, given that the mediator hired to design and facilitate the process, Marc Wesselink, is trained and associated with this school. It is, however, an interesting turn in consultative process in the context of a society that points towards its 'thousand year old tradition of poldering'.

The story of stakeholder engagement around the Maasvlakte 2 project – from government-managed and tightly controlled consultation, through an environmental NGO-initiated sidebar, to an ultimately successful process employing the mutual gains approach -

suggests that, despite the underlying current of the ‘polder mentality’, relatively stable institutional arrangements have not yet emerged around how stakeholders should convene on issues like reconciling environmental and economic goals. At one point, the government grew concerned about control over information and aimed to restrict the consultative process, generating pushback from stakeholders. Partly in response, environmental NGOs stepped into the institutional void and attempted to reframe the situation as one in which consensus would be good for everyone, pairing with the Port Authority to generate a viable solution that would meet multiple needs (Kelly, 2005). Opposition from excluded actors necessitated further deliberations, but a solution that all (or at least most) actors could live with was ultimately found via multi-stakeholder dialogue. This is a lot of stops and starts and experimentation in a society in which poldering ostensibly comes naturally.

This is not to dispute the prevalence of the polder mentality in Dutch decision-making. To the contrary, the fact that stakeholder engagement remained a priority despite the various challenges confronted would seem to reaffirm the level of commitment to it. As noted previously, interviewees regularly invoked ‘the polder mentality’ when discussing Dutch decision-making. The invocation of the polder mentality suggests a deeper recognition among government officials that planning and decision-making, including around infrastructure, is not just a technical matter. Even engineers and more technically oriented participants in this research project noted the importance, and benefits, of engaging stakeholders. Rijkswaterstaat, which is a very technically focused agency staffed largely by engineers and rooted in quantitative models and the application of engineering standards is organizationally aware of this, as evinced by programs like the course for employees on ‘sensitivity to political and governmental issues’.

Research process and outcomes

Research design and process

As outlined more extensively in the methods section of the first chapter, this research project revolved around the use of a role-play simulation exercise (RPS) with actual transportation infrastructure-related stakeholders.⁴ Participants were solicited using a snowball technique, working outwards from key project partners – individuals in TNO and Rijkswaterstaat in this case. As in both Singapore and Boston, participants were solicited from various agencies and other stakeholder groups with real-world relationships to the decision-making simulated in the exercise.

I spoke with fourteen individuals during a first phase of *preliminary interviews*. These interviews were used to get a sense of how infrastructure planning and decision-making happens in practice in the Netherlands; what is being done to adapt to climate change; and whom else I should reach out to for the exercise itself. In the case of Rotterdam, insights gleaned were also used to design the RPS.

⁴ The RPS exercise - including an explanation of the differences between the two versions and an analysis of the efficacy of exercises for learning and research - is discussed in more detail in the first and sixth chapters.

Project partners and interviewees from the preliminary stage helped to identify and solicit participants for the two half-day RPS workshops, which were attended by fourteen participants in total (seven each time), some of whom had been interviewed during the preliminary phase. Participants came from various agencies and other organizations, including both the 'wet' (i.e., water management) and 'dry' (i.e., land transportation) sides of Rijkswaterstaat, the National Infrastructure Agency; the Port of Rotterdam; and top infrastructure consultancies Deltares and TNO. Most participants came from government or quasi-governmental agencies, with others coming from professional consultancies that work extensively with the government. One came from the primary port business association.

During the half-day workshops in February of 2013, participants first filled out pre-exercise surveys. They then received their instructions and prepared for the RPS. Participants were assigned unique roles different from those they usually fill to foster reflection and perspective taking. They were given 'confidential instructions' that outline their interests, and provide additional information that they may or may not share with the rest of the group. The exercise itself ran approximately 90 minutes each time. These runs were followed by focus group-like debrief conversations in which the participants reflected on what happened during the exercise and how that reflects and/or may inform real-world planning and decision-making. The workshops concluded with participants completing post-exercise surveys. Semi-structured one-on-one follow-up interviews were then conducted with participants in the days following; these typically lasted between an hour and ninety minutes, digging deeper into the themes that emerged from the workshops and surveys.

A New Connection in Westerberg - the exercise developed and used for this project - puts participants into a fictitious yet realistic situation in which a group of key stakeholders has been assembled to consider if and how to incorporate climate risks into project-level planning around a proposed piece of transportation infrastructure. The case bears many similarities to the expansion of the A15 motorway through the Port of Rotterdam, and other road and transportation infrastructure projects in the Rotterdam area. There are two versions of the RPS - one asks participants to use four plausible qualitative scenarios of the future, and the other contains a more conventional risk assessment forecast of future climate conditions. In Rotterdam, these versions were run as separate workshops on two separate days. Playing these two different versions with similarly constituted groups provided insights into the efficacy of scenarios versus risk assessments.

This section is divided into three parts: The first two focus on the progression and outcomes for the two groups that participated in the RPS in Rotterdam, including information gathered during the debriefs. The third section focuses on the data collected from the pre- and post-exercise surveys. Information gathered from the in-depth interviews is used throughout to reinforce observations. This interview data is interspersed because the interviews were largely used as opportunities to clarify and dig deeper into the data collected via the other research interventions.

Outcome: Risk Assessment RPS

The risk assessment group did not reach agreement. The majority of participants were willing to accept a proposal to build the road below grade, but with extra drainage pipes and a commitment from the city, and potentially port, to spend up to \$500 million on additional pumping infrastructure in the future, should it become necessary due to climate change. This was a variation of option A (so is referred to as option 'A+' henceforth), which is the status quo approach to constructing new roads in the case. The flood protection specialist was, however, unwilling to acquiesce, stating that: "I think we don't realize how vulnerable we make our selves by choosing option A, so I won't simply agree to this option; think about the costs if that road will be flooded multiple times a year". There was also some concern around whether or not the money available, including the additional \$500 million guaranteed by the city, would be sufficient for the adaptive measures, should they become necessary.

A variation of option D ('D+' henceforth) also remained on the table when the RPS concluded. It entailed reconstructing the existing road to both increase traffic capacity and, in sections, serve as a dike for flood control. This D+ proposal also included improvements to the railway network to enhance freight service. The Flood Control Specialist from the National Infrastructure Agency pledged money from her organization to assist with the reconstruction, insofar as it would also serve a flood control purpose. However, some participants expressed concerns with this option - most vocally, the Port representative and Senior Engineer from the National Transportation Agency.

Most participants ultimately expressed willingness to support either option 'A+' or 'D+', with the momentum seemingly behind A+ when the RPS concluded. The group came close to an agreement, but was unable to reach consensus. The chair invoked a full consensus decision rule, and the impasse was not bridged. The chair's unanimous consent rule allowed one party - the Flood Protection Specialist - to block agreement. Had near-unanimity been accepted, the group would have reached agreement, underscoring how much process matters.

This was also the only group of the ten that leaned towards or chose option A. One explanation for this may be the inordinate amount of attention given to it. Approximately 23 minutes were spent on this option during the first round of discussion, while only 11, 10 and 13 minutes were spent on options B, C and D respectively. It became the de facto default option, with participants acquiescing to its acceptability, if not preferability, early on. The environmentalist, for example, acknowledged that they are not keen on building new roads, but option A would be acceptable. This is further evidence of how process may influence the outcomes.

As in the scenarios exercise run, the senior engineer was opinionated, guiding the group towards certain options and away from others, which also had implications. For example, when asked for technical analysis on option C (the alternative route), he said: "In terms of getting value for money, C is really poor. It is very expensive and the capacity expansion is

limited and only for the port”. His perspective on what is *valuable* certainly ran counter to that of the Port, and could be considered opinion rather than technical fact. Similarly, when the group moved on to evaluating option D and another participant suggested discounting it, he said: “It’s indeed a big disadvantage of option D that the capacity improvement is very little; it is not enough for the coming 80 years. [...] Technically, the traffic capacity and robustness is less for option D. I would argue to drop option D and zoom in on the choice between options A and B.” These comments were made despite the fact that the technical information he had in his confidential instructions suggested sufficient capacity gains could be achieved under a D+ option that involved rail improvements.

Other experts also brought in technical information when it was convenient for them. For example, the municipal Transportation Department project manager, a character that was generally not particularly concerned about climate change, used the risk of increasingly strong winds as an argument against option C, the alternative elevated route through a coastal wetland, which she did not favor for other reasons. In the exercise debrief, she acknowledged that it was a strategic move rather than substantive concern, saying: “Yeah, for me it was very convenient [...] I just invented it, because I read about the impacts and I thought ‘well wind’”.

Key interest and value-based arguments emerged throughout the exercise. “If the risk of flooding is the only reason pro elevation and it has a lot of downsides, then I think all these downsides weigh heavier; only taking potential flooding into account is a panic reaction. I think inhabitants have to learn to live with climate change and simply have wet feet sometimes - Get used to it”, said the alderman. Conversely, the flood protection specialist said: “I am responsible to keep everybody’s feet dry, and option A is just creating an extra problem”. Even if the risks were commonly acknowledged, the parties did not necessarily have shared opinions on how they should be managed.

The notion of fairness also emerged as an issue. While his confidential instructions said that the municipality could allocate up to \$1 billion towards the project if it would lead to a better outcome vis-à-vis the city’s interests, the alderman was reticent to unilaterally guarantee up to \$500 million in support for future flood mitigation. “We are willing to guarantee [a] budget for measures that might be needed over time, and I presume the port will do this too?”, said the city official. The port representative balked, stating that it is the government’s responsibility, with the port doing its part by paying taxes and creating jobs. This almost led to an impasse, as both the alderman and other participants clearly felt this was an unreasonable response on the part of the port. Both the city and the chair continued to press the issue, with the port finally acquiescing that he would ‘look into it’. The chair concluded that segment of the meeting by stating that “this could lead to a conditional consensus agreement, when the city guarantees a part of the risk budget and the port will let us know ASAP if they also are able to guarantee a part of the risk budget”.

Uncertainty was a factor with this group. At one point, it appeared that they were also going to conclude by asking for more research, and the participants generated a list of topics: Traffic robustness, climate effects and the relative benefits that options A and D would provide. However, the senior engineer responded: “Well, my team did everything we

could, so I don't expect that there will be any more new information [...] there are just too many uncertainties". This refocused the conversation, with the chair saying: "I said we need another round, but the technical committee explained that there is no more information available. Uncertainty is uncertainty. How can we handle this, if we have to choose right now?" Participants defaulted to their initial preferences, albeit often using arguments that might resonate with others. The environmentalist, for example, called for option D "since we can pay for that one". The chair asked the group to "hold off on any new arguments" and consider if they could reach consensus. It had clearly become a negotiation rather than a shared technical challenge.

There is not one answer to the question of why the group failed to reach agreement, or to why they were gravitating towards option A+. However, thorough analysis of the exercise 'play-by-play', debrief discussion, and follow-up interview transcripts indicate that procedural factors were at least as important as the technical. The inordinate attention given to option A, the flood protection specialist's unwillingness to accept it, the chair's requirement of unanimity helped shape the outcome. The bias of the senior engineer, and the alderman's insistence on 'fairness' also appear to have been factors.

Outcome: Scenarios RPS

The group that played the *scenarios* version of the *A New Connection in Westerberg* RPS concluded with a call for more research. Option C had been removed from contention, but A, B and D were all left on the table, with specific information requests for each: For A, the question was if flooding can be prevented via remedial measures; for B, the question was how the elevated road could be made acceptable to residents; and for D, the open question was if it would meet the long-term traffic capacity needs.

Some of the information on the risks associated with each option, and how they may be ameliorated, was provided in the confidential instructions of different players, but not shared. The Transportation Agency senior engineer is intended to serve primarily as a technical resource person for the group, and introduced himself as such. However, he shortly thereafter - before others had expressed their interests and preferences - declared: "It seems clear to me that we are going for either A or B". He was vociferously against the rail option, stating that: "It will cost too much time to study the rail option - We have to take action now, and two options can be 'deleted' immediately; option D doesn't match the traffic growth and option C is expensive, gets a lot of resistance and doesn't do much for congestion". And later on: "Everything is starting to get really confusing to me; we are here for a decision on project A39 [i.e., the new road] and now everybody is talking about railroad, etcetera". This despite the fact that he was the only one with technical information on the rail options, including costing and capacity data. Asked immediately following the exercise by another participant why he shared cost information on the rail options so late in the game, the senior engineer responded: "I [would] have given the information if people would ask for it; [the Alderman] was the only one that actually asked". Others did not consider that additional information might be available, believing that it would naturally be put on the table, rather than that someone might be holding it back strategically. "I'm not an experienced negotiator, so this game makes me aware [...] I see it costs \$2.5 billion, so I

say 'OK that's 2.5 billion' and I don't think about what are the possibilities underneath that", said a participant with a more technical orientation in the real world. "We should have asked more questions to come to a better decision", said another participant. Another reflected that this dynamic is realistic, stating that: "I also experienced this as a real-life experience, because that's the way we do discussions - everyone starts talking, giving up solutions".

The chair (i.e., regional deputy director) played a dominant role in the process. Quantitatively, he intervened 67 times, while the second most active participant, the environmentalist, made 38 interventions. The chair attempted to run a considered and balanced process, but potentially discounted thorough consideration of the rail option, which was not in the general instructions but rather in the confidential instructions of a couple players so that it would emerge within the RPS. He appeared somewhat frustrated when the environmentalist insisted that the rail option be considered, saying at one point: "I just asked the question on urgency, since we have four options, and I know we are very good at taking two steps forward and one back. But I would ask everybody to not keep creating barriers. [...] Do we have the right options on the table? I just discovered that option D with rail needs to be included."

While ostensibly it was information gaps that prevented the group from making a definitive decision, participants acknowledged that the uncertainties might have been an excuse when the choices were, in fact, political rather than technical. There are "two political pathways - livability and sustainability as a stake, [and the] short-term economic growth [of the] port as a stake", said the environmentalist, adding that "in the end it really is a political choice". This theme was dominant in the debrief conversation. Participants emphasized the tradeoffs that had to be made between different values, like climate risks, mobility, environmental protection and quality of life. "It was for some people too attractive to say 'let's do more research' instead of making a decision right now", said a participant. A participant actively involved in policy-making reflected that the exercise mirrored the real world in some ways. He described the decision making process in situations like that presented in the exercise as follows:

Usually at the beginning of a decision-making process like this [is] quite open, [with] many informal contacts and meetings - you try to develop a shared vision of the problem so you have the same ideas of what the problem actually is, what directions for possible solutions there are, and what the advantages and disadvantages are so you have more or less the same information level and ideas about possible outcomes - then you get a phase where things are more going into negotiations, because I have some preferences, outcomes that are very preferable to me and things I do not like. And then the level of interaction changes - it's not so much anymore about the technically oriented people who know about the technical choices, but it gets more political. It's more about who has to gain something from a certain solution, or to lose something. What are the coalitions you can make between groups, and these coalitions, the making of them is fairly informal - a phone call here and there, you are not going to explain to your opponents what you are doing! It's something under the table, we could say, but still very important because that is where you try to estimate

the chances of reaching certain outcomes, see how much power you can generate for certain solutions. And that's a very, mostly fairly informal process, but much more politically oriented.

Some participants, including the chair, approached the negotiation as if it were a technical exercise. In the end, the group failed to choose among the options because information was withheld, biases precluded adequate consideration of what could have been a viable option (option D with rail), and the group, rightly or wrongly, concluded that more research would lead to an optimal outcome, despite the fact that they did not get all the information they had on the table. The group did not feel empowered *politically* to make a decision, and thus punted it when they could not reach consensus based on a non-existent shared technical understanding. Even the Deputy Director, who had proposed gathering additional research, acknowledged that this is ultimately a decision around interests rather than facts. He concluded by saying: "I don't think it will be easy to find consensus, and in the end it is a political decision and it is money that counts".

Pre- and post-exercise surveys

All fourteen participants completed pre- and post-exercise surveys. The survey instruments were designed to fulfill four research goals: First, they provided a snapshot of participants' current decision-making norms. Second, they gathered participants' perceptions of the risks and uncertainty posed by climate change, uncertainly more broadly, and the level of preparedness of their respective organizations. Third, surveys were conducted both before and after the exercise to discern if participating in the exercise had any impact on their perceptions. Fourth, feedback collected via the post-exercise surveys validated the benefits of RPSs as a tool for learning and research. This section outlines findings related to all four goals.

Climate change

Participants were asked a series of questions to better understand their views on climate change as an issue. They were asked similar questions pre- and post-exercise to examine if participation had any discernable impact on their perceptions.

Participants reported that they are quite aware of 'climate change and the risks it may pose'. The average response (pre-exercise) was 5 on a 7-point Likert scale from 'not at all' at 1 to 'very' at 7. The level of awareness varied across participants, with those in research and higher-level policy positions self-reporting as more aware than those in technical positions. Those involved in land transportation infrastructure positions at a technical level reported as particularly less aware. The slight increase in participants' level of awareness to an average of 5.4 post-exercise was not statistically significant (Wilcoxon's test; $p=0.05$; $N=5$, $T=2$; one-tailed hypothesis).

In general, participants expect climate change to be a fairly significant factor in their organizations' planning and decision-making over the next ten years, with an average ranking of 4.9 (pre-exercise) on a seven-point Likert scale. In comparison, the averages in

Singapore and Boston were 4 and 5.7 respectively. There was not a statistically significant shift in participants' responses from pre- to post-exercise (Wilcoxon's test; $p=0.05$; $N=6$, $T=7$; two-tailed hypothesis). The average response was similar (4.6) when participants were asked to rank the degree to which climate change is already on their organizations' radars. There was variability in responses to both questions across organizations; those working in land transportation units generally gave lower responses than those working around the Port and researchers, although the representative of port users (i.e., businesses) ranked current engagement around the issue at only two. In the follow-up interview he stated that his members are not willing to engage in conversations around adapting to climate change, and some even question why he is investing time in this - "They say 'it is so far away, it's not my interest at the moment' - When it is problematized, for example if a flood occurs, they will probably say 'well, not any more!'"

In terms of how *confident* participants are that they and other stakeholders will be able to manage the risks and uncertainties climate change poses, participants entered the workshop somewhat skeptical, with an average ranking of only 3.7 on a 7-point Likert scale. Skepticism was common across participants coming from different organizations, and from both technical and policy positions. While still low (4.1), there was a statistically significant increase in participants' confidence from pre- to post-exercise (see *table 2.1* below). This increase would suggest that the exercise experience enhanced participants' confidence that climate-related threats can be successfully addressed.

Participants were also asked to self-report on whether or not the exercise changed their level of confidence. The Likert scale question asked: *How has your confidence in the ability of your organization and other stakeholders to adapt to the risks climate change poses changed as a result of your participation in this exercise (1 being less confident, 7 being more confident and 4 being neutral)?* Most (10) reported no change and the other four reported increased confidence. There is no discernable pattern in who these four are - they came from different organizations and levels within those organizations.

Table 2.1 – Hypothesis test: Confidence in ability to adapt to climate change

H₁: One-tailed hypothesis that exercise participation increases respondents' confidence in the ability of their organizations and other stakeholders to adapt to climate change

Survey question: How confident are you that your organization and other stakeholders will be able to manage the risks and uncertainties climate change poses?

Test: Wilcoxon matched pairs signed ranks

Conclusion: The results were **significant** at the $p=0.05$ level, using Wilcoxon's test ($N=7$, $T=3.5$; one-tailed hypothesis). Therefore, the null hypothesis can be rejected and it is concluded that, on average, participants' confidence in the ability of their organizations and other stakeholders to adapt to climate change increased from before to after the exercise

Uncertainty

A key element of this dissertation is enhancing our understanding of the nature of uncertainty as a factor in planning and decision-making. Participants were asked questions about uncertainty in general, and explicitly related to climate change.

As figure 2.2 below illustrates, participants see uncertainty (not just from climate change) as a substantial factor. They were asked: *How significant of a problem is uncertainty (not just from climate change) to you as you plan and make decisions (1 being not at all and 7 being very)?* The average response was 5 pre-exercise.⁵ In the words of one participant, “[there] are so many things, like how much is the population going to grow, how much is car use going to develop, what is the economic development going to be - there are so many interests that you have to deal with [...] so this climate change is just one aspect of a very, very wide range of aspects that you have to value, that you have to judge as a politician”.

Figure 2.2 – The uncertainty factor as participants plan and make decisions

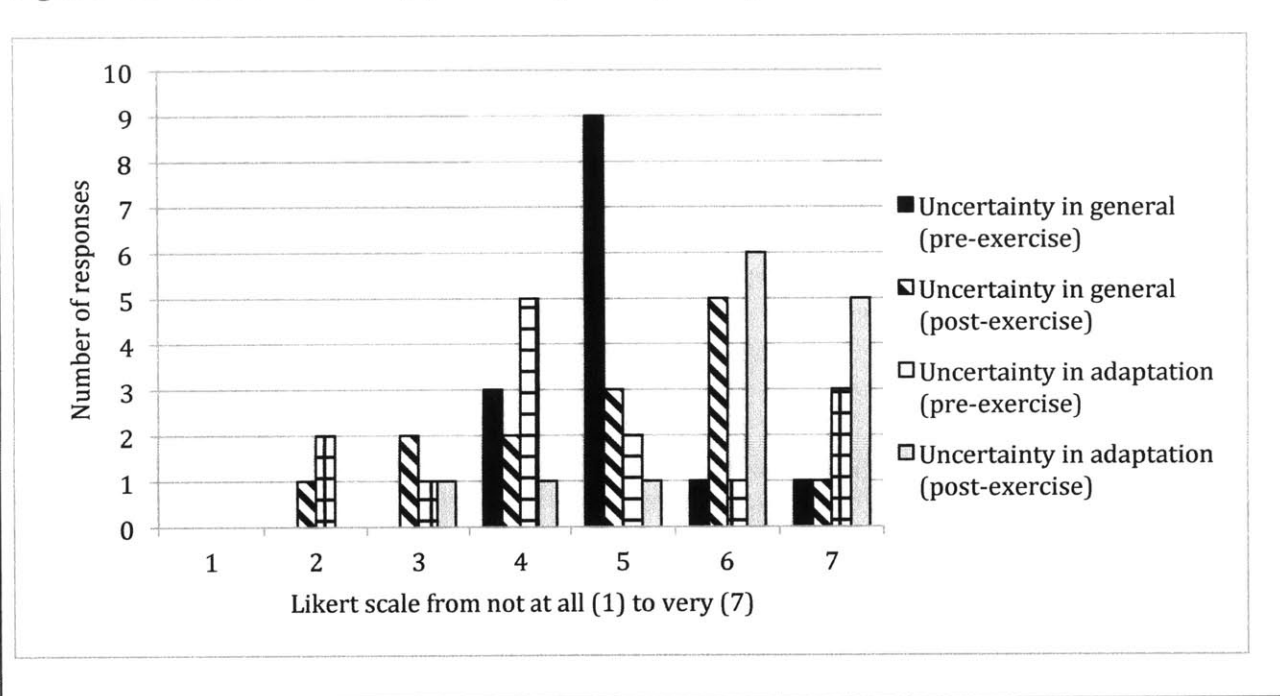


Figure 2.2 suggests that participants do not see uncertainty in the context of climate adaptation as any more or less of a factor than other uncertainty is in general in decision-making. In addition the question of uncertainty in general discussed above, participants were asked: *To what degree is uncertainty a factor in climate change adaptation (1 being not at all and 7 being very)?* The average response was, in fact, slightly lower than that for uncertainty in general in the pre-exercise survey – 4.6 versus 5. It is notable that there was a statistically significant increase in the average ranking of how much of a factor uncertainty is in climate adaptation from pre- to post-exercise (see table 2.2 below). This would suggest that the exercise enhanced participants’ perceptions of how much of a factor uncertainty may be as they start to tackle adaptation challenges.

⁵ There was not a statistically significant shift from before to after the exercise, with the average post exercise essentially unchanged at 4.9 (Wilcoxon’s test; p=0.10; N=10; T=26.5; two-tailed hypothesis).

Table 2.2 – Hypothesis test: Uncertainty factor in climate adaptation

H₁: Two-tailed hypothesis that exercise participation will shift respondents' opinions on how much of a factor uncertainty is in climate change adaptation

Survey question: To what degree is uncertainty a factor in climate change adaptation (1 being not at all and 7 being very)?

Test: Wilcoxon matched pairs signed ranks

Conclusion: The results were **significant** at the $p=0.05$ level, using Wilcoxon's test ($N=13$, $T=16$; two-tailed hypothesis). Therefore, the null hypothesis can be rejected and it is concluded that, on average, participants' opinions on how much of a factor uncertainty is in climate change adaptation planning and decision-making increased from before to after the exercise

Asked how they typically deal with uncertainties participants responded as follows:⁶

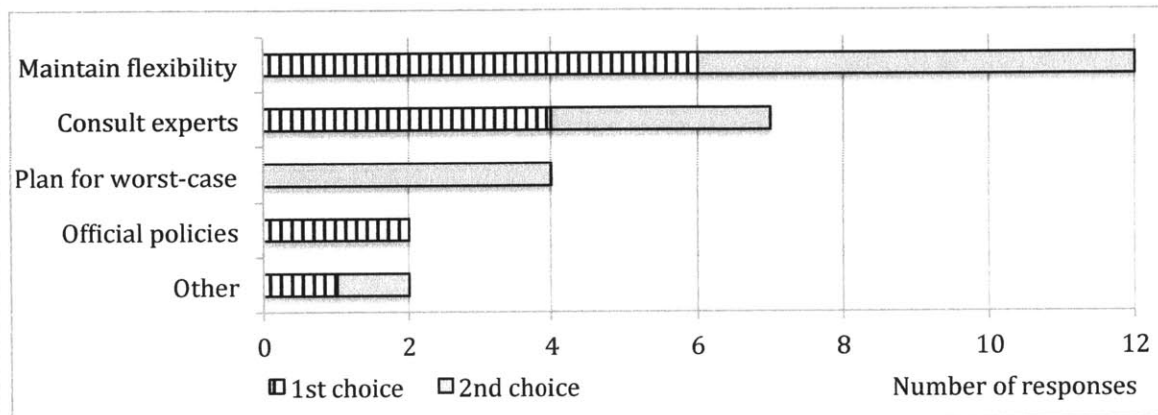
- Three participants 'follow official policies or guidelines';
- Five 'consult experts for their best projections';
- Two 'plan for worst-case scenario'; and
- Five 'maintain flexibility'.

Three participants said they take 'other' approaches, but the written-in responses of two may be interpreted as flexibility: "Adaptive monitoring of situation" and "monitor and adapt - roadmapping". The third said they "perform risk analysis".

Post-exercise, participants were asked to rank how they think uncertainty *should* be dealt with. Results are illustrated in *figure 2.3*. As can be seen, 'maintain flexibility' was the most popular option – it was the first choice of six of participants, and the second of a further six of fourteen. This positive sentiment was echoed throughout the exercise debriefs and follow-up interviews. "[We need to] learn to live with uncertainties, and think adaptively", said one participant, adding that we need to "think in scenarios and make the solution that can be no-regrets, that can be adapted for each scenario". Another participant argued that we should go beyond scenarios to truly embrace uncertainty, and consider how we can be "completely agile or adaptive".

⁶ Note that the number of responses is greater than the number of participants because some chose more than one option, although asked to 'choose only the most common or important'.

Figure 2.3 – Preference ranking of how agencies should deal with uncertainties (1st and 2nd choices of respondents)



Because the RPS exercise introduced participants to either scenarios or risk assessment forecasts as a way to manage uncertainty, participants were asked in advance if they use either in the own planning and decision-making. All of the scenarios group participants responded ‘yes’ to the question: *Do you ever use multiple scenarios (i.e., consider multiple possible futures rather than a single forecast) when you have uncertain factors in your planning and decision-making?* Participants were also asked: *How useful is/might be the introduction of multiple scenarios (i.e., multiple possible futures) in your work (1 being not at all and 7 being very)?* They were very positive about their value – the average response was 6 pre-exercise and 5.7 post on a 7-point Likert scale from ‘not at all’ (1) to ‘very’ (7). The very slight decline in the average opinion of the value of scenarios from pre- to post-exercise was not statistically significant (Wilcoxon’s test; $p=0.10$; $N=4$, $T=7.5$; two-tailed hypothesis). All but one of the participants in the risk assessment group stated that they had prior experience with ‘risk assessments or reports’. They were subsequently asked: *If yes, how well do these forecasts prepare you and other stakeholders for making decisions in the face of uncertainty (1 being not at all and 7 being very well)?* In contrast to the parallel question for scenarios participants, the average response was not particularly high pre-exercise at 4.5 on the same 7-point Likert scale. Interestingly, there was a statistically significant increase in the average to 6 post-exercise, suggesting that the experience increased participants’ opinions on the value of this kind of probabilistic risk assessment forecast (see table 2.3 below). It is important to note that this increase in favorability did not supersede but rather rise to the same level as the already high opinions participants had, on average, of scenarios.

Table 2.3 – Hypothesis test: Value of risk assessment forecasts

H₁: Two-tailed hypothesis that exercise participation will shift respondents’ opinions on the value of risk assessment forecasts

Survey question: How well do these forecasts prepare you and other stakeholders for making decisions in the face of uncertainty (1 being not at all and 7 being very well)?

Test: Wilcoxon matched pairs signed ranks

Conclusion: The results were **significant** at the $p=0.10$ level, using Wilcoxon's test ($N=5$, $T=0$; two-tailed hypothesis). Therefore, the null hypothesis can be rejected and it is concluded that, on average, participants' opinions on how well risk assessment forecasts can prepare them for decision-making under uncertainty increased from before to after the exercise

Stakeholder interactions and decision-making

Participants generally feel that engagement with other stakeholders is an important element of decision-making. The average response to the question of "How important is it that you engage with other decision-makers and stakeholders as you plan and make decisions" was 5.4 pre-exercise and 6.4 post-exercise, on a Likert scale from 1 to 7. This is a statistically significant increase in participants' opinions of how important it is that they engage with other decision-makers and stakeholders (see *table 2.4* below). This increase from pre to post-exercise would suggest that the simulated multi-stakeholder experience increased participants' already strong opinions on the importance of multi-stakeholder deliberation.

Table 2.4 – Hypothesis test: Importance of engaging with others

H₁: One-tailed hypothesis that exercise participation increases respondents' opinions on the importance of engagement.

Survey question: How important is it that you engage with other decision-makers and stakeholders as you plan and make decisions (1 being not at all and 7 being very)?

Test: Wilcoxon matched pairs signed ranks

Conclusion: The results were **significant** at the $p=0.01$ level, using Wilcoxon's test ($N=13$, $T=12$; one-tailed hypothesis). Therefore, the null hypothesis can be rejected and it is concluded that, on average, participants' opinions of the importance of engagement increased from before to after the exercise

Participants' real-world experiences would seem to confirm that structured forms of poldering (i.e., multi-stakeholder decision-making) are well entrenched in the Netherlands – eight participants (57%), including all of the participants with policy (rather than technical) positions and from non-governmental stakeholder groups reported that they had participated in 'facilitated multi-stakeholder decision-making processes' in the past. Participants rated these past processes relatively highly – the average rating was 4.6 on a 7-point Likert scale from 'very poor' at 1 to 'very successful' at 7.

The frequency with which participants meet with stakeholders outside their own departments varies widely – Three said 'more than once a day', three said 'less than monthly', and the others stated frequencies in-between. Half meet with others at least once a week. The frequency of interaction with external stakeholders correlates with participants' jobs, including their levels in their respective organizations. The three that interact more than daily are all senior, serving in management roles. In contrast, the three that interact rarely are researchers or technicians at lower positions in their organizations. This suggests that more senior and policy-oriented actors are exposed to the interests and perspectives of other stakeholders, while the more technically oriented actors have less exposure. Of the seven that meet other stakeholders at least once a week, four

characterized their interactions as ‘mostly formal meetings, but some informal’ and the other three as ‘mostly informal interactions, but some informal’.

The interviews revealed differences in opinion around how formal or informal decision-making is, but, in general, participants described interwoven formal and informal interactions throughout the process. A technical expert said that he normally provides information via (more formal) memos and brief reports that his boss subsequently refers to in (both formal and informal) meetings with other managers, both within and outside the agency, to craft decisions. Policy makers talked about the phases of formal and informal interaction. A non-governmental actor described his participation in meetings every two months with counterparts in government to talk about issues, including how they can work together, their shared goals, the obstacles they face, and who else they need to engage with. These more formal gatherings are interspersed with regular informal interactions.

A more technically-oriented participant lamented that project-level decision-making can be too informal at times, saying that decision-makers “try to sit around the table and discuss the pluses and minuses of each proposal and come to some agreement. There is some connection to the [established] criteria, but it’s not very concrete. It is really expert judgment in advising in terms of what criteria to apply – there is no guidebook or spreadsheet on how you advise. It’s too flexible at this point actually”. In contrast, a senior expert that regularly participates in decision-making processes complained that processes can be too rigid: “I would hesitate to say that most of the work is done informally. Certainly they will call each other now and then, but the processes are very well delineated and known, and they are very regular - so we are an over planned, overregulated country!” However, when pressed on this, given the emphasis others placed on the informal, he provided a more nuanced answer, stating:

I mean, if you ask about the moments that have the most impact, then I think there are very few decisions that are actually conceived in these formal settings. [...] But the formal setting has to do with accountability, and with democracy, and law so that we do things in an orderly manner, and there is a degree of transparency. It happens a lot that decisions are made informally. Do you have this expression 'hammer piece'? What comes in the meeting is already decided, but it has to go under the hammer - it has to be decided formally. Then after a formal decision, there is a report, and say an environmental group brings the process back two steps, and this is only possible if there is a formal moment in which decisions are recorded and documented and disseminated so that people can respond. [...] OK, it's almost irrelevant when decisions are conceived, because they could be conceived in a formal setting or an informal setting [...] and I didn't mean to say that the only function of formal meetings would be to decide formally, to legitimate, but they are also needed to bring information together, to align views, to prepare the decisions. And if the decision has to be made on a balcony somewhere over a swimming pool, so be it. But the big work, the real work to arrive at the decisions is done in formal meetings.

This interplay between the formal and the informal suggests coalitional negotiation dynamics at work as advocacy coalitions are formed and expanded around policy options,

and then those coalitions achieve success in the more formal manifestations of the policy arena. A participant from an important lobbying group described these dynamics:

At first you always have the phase of let's say planning and trying to convince others of the need. With the example of the new tunnel, until two years ago there was nothing official. Still, we [...] were already for let's say five years urging for a new tunnel. We had some arguments, we had some facts and figures, and we were supported by some other organizations. But it was not official. And it became official when the planning of the national government took this new tunnel into their program. And then it starts. But during that first phase of let's say not official planning, but lobbying you saw that also the environmental pressure groups were saying 'no, we don't need that', so that was a sort of national debate, informal debate, and it became formal when the national government [began] doing something.

The same participant noted that looking for 'win-win' outcomes is a strategy his organization explicitly employs when attempting to advance their interests. In addition to lobbying on the basis of the economic arguments most important to them, they promote safety and other benefits of making certain infrastructure investments that they know are likely to appeal to others. In his words, "we try to build-up a case; it will never be a perfect 100% win-win, but as much win as possible". A senior government official presented a similar picture, highlighting the fact that this kind of interests-based negotiation and coalition building is not simply the purview of external stakeholders, stating that:

[The] parties are going to manifest in the newspapers or whatever, and that's the phase when, in my experience in the Dutch setting, it's still possible to have a good conversation. Even though you have very different positions, you can still put everyone around the table and try to exchange them, both in the informal and more formal, depending on what you need in your decision-making. Usually there is an informal round, then more formal for the decision-making. [...] Of course, if there is one preferable solution that everyone can live with, you have consensus, then that would be fine, then you don't have all this fuss, but usually its not so easy and there are very conflicting interests, and [it's] really about trying to organize and balance your powers.

Interviewees noted the extraordinary pressure that local politicians put on agencies and national government officials to influence transportation infrastructure planning and decision-making. This involves both vying for investments in their areas and attempting to shape projects. "[Local officials] are lobbying the parliament, the politicians, but also the directors - [my boss] is in all kinds of conversations with the municipality of Rotterdam, the region around the Hague, the Province of South Holland; at all levels they are trying to put in their ideas", said an interviewee. While technocrats may lament this lobbying for the deviations it introduces to what they see as otherwise rational planning processes, they also harness it to advance their own positions. A Rijkswaterstaat interviewee noted that the Port of Rotterdam can be a powerful ally with its substantial influence, saying: "If you are in a project and there is something in the Hague that is not going well, there are a lot of partners and you can ask one partner to give them a call, and then the Port of Rotterdam is

very important". He went on to note that this can work for or against you, depending on the relative strength of your coalition.

Climate change and decision-making

Discussing how new factors like emerging climate threats are incorporated into planning and decision-making, interviewees described it as a somewhat organic process. According to one interviewee:

There is not such a standard way in which such a problem is dealt with; it's not 'OK, we have a meeting at that level, then that level, then Minister decides'. [...A technical expert] identifies the problem and analyses with [their] best way of thinking, and then puts it on someone's desk that [they] can reach. Then perhaps it will end up on the desk of the Minister. It is not a standard procedure. It's a lot more informal and not structured.

An interviewee directly involved in the integration of climate risks into planning and decision-making at Rijkswaterstaat described it as a 'political' process. He is trying to get climate risk guidelines integrated into project assessment, and realized that if he just went to project managers in the regional offices and said 'you have to do this' they would push back. So instead he:

[Went] with a story, 'well, the climate is changing, you can see the maps, I think there is reason because of the policy of the government but also cost' [They responded positively, saying] 'Ah, good story, I agree, but I'm not the one deciding on that, you have to talk to this guy that is in charge of the Werkwijzer Aanleg', [which is] the sort of bible for building and maintaining things at RWS. [...] And I went to this guy who's in charge of that, also the advisory board [...] I made this memo saying well this is the reason why you have to do it. And they said 'Oh, that's good. We have questions about that, we want to know how to do it, so we'd like you to make that'. So now we are going to make it, and also involve these people, and if everyone agrees I go back to this guy that is in charge and say, well, here it is for climate. You wanted it, also I talked to everybody, and now it will be part of our Werkwijzer Aanleg.

An interviewee lamented the lack of greater communication between agencies. The interviewee cited the lack of direct interaction between the Meteorological Institute (KNMI) and Rijkswaterstaat - even though they are both under the Ministry of Infrastructure and the Environment, and Rijkswaterstaat depends on KNMI's climate models when making risk assessments and subsequent design decisions - as an example. Interaction was less important when the climate data was relatively straightforward and static, but may be very beneficial as KNMI produces data, including multiple scenarios, that convey greater uncertainty around what the future will look like, and Rijkswaterstaat grapples with how to use this information.

Science-policy interaction

As noted previously, survey responses suggested that it is much less common for technical experts to be directly involved in multi-stakeholder decision-making. When asked in the interviews whether or not they *should* be, participants universally reflected that there are benefits to technical experts being more integrated into decision-making so that they have an appreciation for the needs of decision-makers and vice-versa, but that ultimate decision-making should be the purview of elected officials. “Decisions should be taken by those who are representing all people; you can't leave that to technicians [...] Yes, it is good to involve [technical experts], but it requires something of them as well - it requires that they speak a language which is understandable for politicians, and not only understandable, but it has to be useful to them”, said an interviewee. Another participant shared an experience he had organizing a conference in Rijkswaterstaat that also involved more policy-oriented officials from the Ministry. He reflected that both sides saw benefit in meeting and increasing their understanding of each other's worlds. “It's the whole chain of decision-making and interaction, and it works differently if the chain is connected - Perhaps there is some gap, and part of being very successful is that you have a good chain from the policy, from the Department of Transport, and how they connect to the project and the rest of the organization”, said the participant.

RPS exercise

Participants were asked a series of questions post-exercise to gather feedback on how much the exercise mirrored their realities, and was valuable in their opinion as a learning tool. In terms of how similar the ‘situation or problem presented’ is to their own worlds, the average ranking was 5.2 on a 7-point Likert scale from ‘very different’ (1) to ‘very similar’ (7). The ‘characters’ involved were also similar, with an average of 5. The ‘interaction between the characters’ in the RPS was also seen as relatively similar, with an average of 4.8. One factor that was poorly represented in the game is the interpersonal history among the actors. “In the real world sometimes it's more politics - give some, get some - I think that's the difference”, said a participant, adding that “people in the real world have a history together, so you know 'last time he did this, so I am going to do this', and most people last week were new faces to me”. Participants in the risk assessment and scenarios groups reported that these respective ‘tools introduced’ were somewhat but not very realistic, with an average rating of 4 for the former and 4.3 for the latter. The most common comment here was that they were very simple. “[The scenarios] are rather abstract now - it's more traffic and more weather influence, you have to be very visionary to see what the pressures will be”, reflected a participant from Rijkswaterstaat. The ‘options or solutions’ presented in the game were realistic to participants, with an average of 5.1. The multi-stakeholder, collaborative ‘method of decision-making’ used in the exercise was also regarded as similar to participants’ real-world situations, with an average 4.8. Interestingly, some of the more technically oriented participants were surprised by how ‘political’ the discussion was, while more policy-oriented participants had the opposition opinion. A senior participant from the Ministry that: “In the final phase, it gets much more political - it isn't so much about all the technical elements, they aren't so relevant any more. It's more about positions - who wants what and why. [...The exercise

was mirroring] the early phases were the discussion is still about technical issues and so on, and later it gets much more political". Participants in the risk assessment group reflected that it was unrealistic for a technical expert to block the entire process, as was the case with their simulated deliberation.

It is notable that the degree to which the exercise mirrors reality is not a direct measure of its value. In fact, participants noted that, in some cases, they learned from what was different. "I saw this discussion as sort of exploring the future if everybody would be really serious about [the climate threats], how would we deal with this, because you [...] cannot avoid the fact that it is difficult to discuss uncertainties, but you have to start with acknowledging them and taking them seriously [...] and that's what we did. But I think we are not there yet [in the real world], that people take this uncertainty that seriously", said a participant. Some of the differences between the exercise and reality highlighted challenges in current decision-making processes – A participant involved in policy-making and planning noted that flood control and transportation infrastructure decisions are very rarely coordinated, partly because, as in the exercise, they have such different goals. The exercise modeled an integrated process that is not common in practice, but may need to be come so in the future.

All but one of the participants (13 of 14) stated that they 'learned something from the exercise that they might be able to apply in their own planning and decision making'. The one that answered no stated in the follow-up interview that this was because he has participated in various similar exercises in the past. "It doesn't mean that it was not an interesting and useful exercise [...] I could also see that everyone was playing their parts quite well [...] I know that some of [the other participants] really were acting differently from their usual behavior, and so if the question is if I learned about games and how the game works, then no, but what is useful is that it makes clear how difficult such a choice is, particularly if everybody has their instructions, and does not have the tendency to go beyond those instructions", said the participant.

When asked in the follow-up interviews *what* they learned, participants' responses were almost exclusively process-related, rather than focusing on the substance of climate change or technical questions around how to adapt. Many comments related to the tensions among the participants, and the challenges and opportunities associated with reconciling the competing interests and priorities. Many reflected that the experience enhanced their appreciation of the need to engage other actors and consider their interests when you want to advance decision-making. One participant involved in advancing adaptation stated that:

[In] the end its about something you want to accomplish, that climate change is taken into account, but actually my feeling is [that the way it works is by considering] what you want to accomplish while also asking what do other people want - what are their pre-assumptions, their underlying things that they want to do - so its a lot about the social interaction, more than the actual subject itself. [...] You need knowledge, you have to know things to make good decisions, but it's also a lot about how do people interact; a lot of getting things done has to do with how do you interact. Find out what other people want, and how can we meet each other. [...The exercise is] pretty real-

world I think - you have the environmentalists, the city, the harbor - different standing points, like the harbor is just interested in getting things away from the harbor, and the city also has all of their commuting traffic and so on. I think it can help, doing this game can help people to think 'well, how do we get these things done'. And also I don't think it helps only with this specific environmental and climate subject, but also when we are negotiating about other things.

Many reflected that they learned not only the importance of process, but also what good process might entail. A recurring theme was the challenge associated with getting information on the table so that informed and comprehensive decisions may be made. Parties were surprised to see that others were not always forthcoming with information, but reflected afterwards that this is probably realistic. "I learned we don't ask a lot of questions! That was my big eye-opener [...] We leave a lot of information on the table, we only know the tip of the iceberg", said one participant. Another participant made a very similar comment about the need to ask questions and explore underlying interests, and added that it is "also very important - and I think we have a good experience here in the Netherlands - to keep everyone on the table, because otherwise you have the discussion not on the table, but in the press or in the political arena, and I know very well that if you have the discussion in the political arena it is horse-trading". A more technically oriented participant was very surprised to learn how much process can matter and thus how important good process is, stating that: "Before, a stakeholder analysis didn't really mean anything to me, but here people did their role-play so well, and kept insisting that 'we must do this or that', [so it became clear that it] is essential - the project can go or no go, and that's when my opinion changed". Another stated that it taught him to not take information at face value, but rather explore possibilities by considering what is underneath the information people share.

Participants in the exercise were intentionally assigned roles other than those they hold in the real world. One reason why this is done is to facilitate perspective taking. Five different participants explicitly noted the value in this - "It's a Dutch expression, 'when you wear another hat, you think different', so because you gave us all another role than our actual daily role at work, it really made me think - I was the Port Authority [and] it helped me to have a broader perspective on cases like this, to think from another point of view", reflected one participant.

Three participants noted that they were surprised how much impact the uncertainty factor had on the process and outcome. One cited it as the primary reason why the risk assessment group did not reach agreement. Differences in opinion around what the future will look like allowed different opinions around what should be done to persist. The two other participants that discussed uncertainty both stated that they were surprised how much climate uncertainties were emphasized, while other uncertain variables, like how much the economy and transportation demand will grow, were left largely unquestioned. However, the uncertainties were not exclusively climate change-related - questions around where the funding might come from, should further adaptive measures be necessary down the road, also remained a source of unresolved disagreement.

The value of RPS exercises, including as tools for social learning, experimentation and the fostering of collective action, is examined in further detail in chapters 1 and 6.

Conclusions

The exercise proceedings and outcomes, interviews, surveys and background research on infrastructure planning and decision-making in the Netherlands have generated various insights. The broad picture that emerges is one of actors grappling with how to effectively integrate emerging threats characterized by uncertainty and dynamism into ongoing decision-making, and the process-related obstacles they face. The fact that neither role-play group in Rotterdam was able to reach agreement on how to proceed underscores the difficulties. The challenges stakeholders face in *institutionalizing* the management of new threats like climate change into planning and decision-making is as a significant complicating factor.

Institutionalizing climate change adaptation into planning and decision-making in a tangible way is difficult, in part, because stakeholders find themselves in what Hajer (2003) calls an *institutional void*. That is, they are in territory that is not wholly governed by the rules and norms of any existing institutional arrangements. Standards and regulations around how future climate risks should be integrated into planning and decision-making are starting to emerge, but significant work remains in translating them into practice, particularly at the project level. The institutional void is also characterized by ambiguity around responsibility. In the Dutch context, this is most apparent in the divided responsibilities for 'wet' and 'dry' infrastructure. Transportation infrastructure owners have traditionally paid little attention to the resilience of their infrastructure to flooding because their counterparts responsible for flood control and drainage management have done a stellar job of keeping water at bay. As noted earlier in this chapter, that dynamic might have to change as the Dutch learn to 'live with water'.

The challenges associated with institutionalizing climate adaptation into planning and decision-making are compounded by persistent uncertainty and the dynamic nature of the changing climate. This research suggests that uncertainty is a substantial factor in adaptation planning and decision-making, particularly when it involves making concrete, project-level decisions. While fostering new institutional arrangements to address emerging issues may always be difficult work, it seems particularly challenging when many of the threats are not yet acutely felt and no one is certain when, or even if, they will be. However, as discussed previously, explicitly climate-related factors are not the only, or even the most critical, sources of uncertainty in adaptation planning. Uncertainties around policy and political choices - like who should act, when actions will be taken, and what resources will be available - are also significant factors.

The exercise outcomes, and associated debriefs, interviews and follow-up research, suggest that multi-stakeholder fora for decision-making can serve as effective venues for 'collaborative boundary work' to address wicked challenges like adapting to climate change

(Quick and Feldman, 2014). The well-entrenched neo-corporatist tradition in the Netherlands, and associated 'polder mentality' may make this kind of collaborative boundary work easier to implement – the notion of working with other stakeholders to tackle problems and make public policy and planning decisions is not foreign. However, the neo-corporatist model is well institutionalized in certain arenas, like labor negotiations, and less in others. Processes like that around the *Maasvlakte 2* expansion to the Port of Rotterdam suggest that multi-stakeholder collaborative planning can work in other domains, but they also accentuate the importance of good process design, rather than assuming that it will happen naturally because of the poldering tradition.

In the Netherlands, as elsewhere, approaches like adaptive policy making, and tools like scenario planning are being proposed, and even implemented on a limited basis. These process innovations and decision-support tools may add significant value, particularly as stakeholders wrestle with persistent uncertainty and dynamic conditions. However, their experimental use here would suggest that they must be contextualized within the governance regimes that they will operate. The interplay of substantive and interest-based factors as participants strived to make decisions underscores the notion that adapting to climate is not an optimization problem that can be managed exclusively via the deployment of more sophisticated decision-support methods. Rather, processes need to account for ongoing substantive learning and changing conditions, *and* the various interests, priorities and perspectives of the various actors with a stake. Potentially viable decision-support tools, like scenario planning, have been identified and are being experimented with, but work remains in devising the best approaches for their integration.

This concluding section of the chapter examines some of the key themes that emerged from the exercise runs, pre- and post-exercise surveys, interviews, and associated background research in the Netherlands. It also looks forward, postulating some of the ways in which infrastructure planning and decision-making may be advanced to better integrate and account for the risks posted by climate change.

Collaborative decision-making

As discussed earlier in this chapter, planning and decision-making involves both formal and informal interactions among stakeholders. Processes are typically bounded by various rules and regulations. However, a great deal of the 'ground work' happens more informally among actors across different agencies and other stakeholder groups, but within shared and well-established institutional environments. These are characteristic of what Sabatier and Jenkins-Smith (1999) call *policy subsystems*, and contesting *advocacy coalitions* within. Actors are very familiar with each other, and regularly pick up the phone to discuss issues and advocate for certain options as planning, design and decision-making evolve. These processes are punctuated by formal decision-making moments and mandated steps like public meetings, but feature substantial informal elements. The policy subsystem model in the Dutch context is somewhat more collaborative rather than adversarial in nature; the poldering tradition means that actors within many established policy domains are familiar with each other and used to seeing consensus on how to proceed. They still exist within competing advocacy coalitions, but their interactions are often consensus seeking.

A challenge is how to effectively and efficiently amend these institutions – or facilitate the creation of either permanent or temporary new ones - when new issues like climate change emerge. It is often not clear whom the various actors within an institution that has evolved to manage a particular type of infrastructure within a certain jurisdiction should look to when grappling with how to adapt. This requires what Quick and Feldman (2014) call *collaborative boundary work* to bridge across existing institutional arrangements and act in the *institutional void* (Hajer, 2003).

Prior collaborative multi-stakeholder processes – including both the engagement process that successfully facilitated consensus around the Maasvlakte 2 expansion to the Port of Rotterdam and the Traffic Management Company, which brought different actors together to limit disruptions during the rebuilding of the A15 motorway – provide models of what might work as actors assemble to advance climate change adaptation. These processes, along with others, seem to suggest that the following factors are important for success:

- Getting the right people to the table;
- Scoping processes wide enough to capture systemic complexity, but narrowly enough that they remain relevant to and able to handle specific decisions that need to be made;
- General buy-in and organizational support (including the necessary resources) among participants;
- Appropriate process design and facilitation; and
- Ensuring that processes have the support of the ultimate decision-makers, and that there are direct avenues from any outcomes back into decision-making.

The RPS processes and outcomes suggest that participants in multi-stakeholder processes in the Netherlands are less likely to show deference based on patterns of hierarchy, or perceived or real authority. This seems to lead to more frank and open discussions, but may delay definitive action compared to what is possible in more hierarchical environments like Singapore. The exercise runs in the Netherlands both featured strong facilitators, which is not surprising given the established history of similar deliberative forums in practice. The facilitators were invaluable in helping parties to effectively deliberate, but the process-related decisions they made significantly shaped the outcomes, for better or worse. Significantly, the fact that the facilitator of the risk assessment group imposed a complete unanimity decision rule was a major factor in their inability to reach agreement.

In the real world, getting the right people to the table can be a challenge, given that stakeholder groups are often large and diffuse. Intermediary stakeholder organizations play critical roles in this regard. At their best, they are savvy, representing the interests of larger constituencies when having each stakeholder at the table is neither feasible nor effective. They also translate and legitimize emerging ideas and activities among their constituents, as these organizations are often ahead of the curve, and serve as clearinghouses for information and other resources in both directions. *Deltalinqs* (the port

businesses' association) in Rotterdam is an example of such an organization. On climate adaptation and other issues, they concurrently represent their constituents and are ahead of them; they ensure that their interests are considered while contributing to processes that are not yet on their members' radars. *A Better City* (ABC – formerly the Artery Business Committee) is a similar organization in Boston; ABC is discussed in further detail in that chapter. An important question is whether or not all of the key stakeholder groups have this kind of representation. Certain groups, like business and environmental interests, are often better represented than others. While there certainly are efforts to engage more heterogeneous and hard to represent groups like *neighborhoods*, it is not clear that they are involved and represented to the same degree. Groups collaborating to address challenges may need to find effective ways to engage less active stakeholders and support their representatives in their efforts to participate when they have fewer resources, more tenuous legitimacy, and less experience in these settings.

This research also shed light on the divide between the technical and the political branches within government agencies. Interests dominate the political, while data dominates the technical. This divide is largely inconsequential when each 'side' feels like it has legitimacy in the eyes of the other, and is getting what it needs from them. The technical are asked for models (traffic models, economic growth forecasts, etc.). These models are more or less accepted by decision-makers (the political) and inform their decision-making, which is also necessarily informed by other considerations, including competing interests and priorities. Decision-makers do not want to know about the minutia of the models, they just want a best guess of the future. Participants reflected that the exercise helped them to gain new appreciation and start to overcome the general lack of mutual understanding and appreciation; this is just one of the benefits of bringing technical and political actors together within multi-stakeholder processes.

Uncertainty

The interviews, survey data and other research findings suggest that there is persistent debate around whether or not climate change is really characterized by an extraordinary degree of uncertainty, given that uncertainty is a factor in numerous ways in virtually any infrastructure-related decision-making process. Decisions must be made based on economic, spatial, technological and other models (i.e., estimations) of what the future will look like. While the opinions of those engaged through this research project vary, there are certainly some that see climate change as unexceptional in this regard, and thus the levels of uncertainty as unproblematic in and of themselves. What is apparent from the role-play outcomes and other research findings is that uncertainty around climate change can be a barrier to action.

Some argue that the emphasis on uncertainty in the context of future climate change is more a matter of perception than reality, resulting from: The ways in which climate projections are made (emphasizing the uncertainties rather than the probable risks and already apparent trends); the lack of standards and norms around how climate projections are prepared and presented; the relative nascence of climate factors on stakeholders' agendas; and the fact that we are often talking about future threats that are not yet being

experienced. In comparison, regional growth forecasts are routinely used in infrastructure planning and involve substantial uncertainties, yet the modeled projections are typically incorporated without much consternation. They are generally assumed to be 'good enough' to be useful for decision-making purposes.

A clear lesson from the exercise is that climate uncertainties cannot be separated from other factors and treated as purely scientific or technical issues. Participants struggled most when they discussed climate-related uncertainty without acknowledging the interplay with interest-based factors, like who will benefit from and who will pay for any deviations from the status quo. In these cases, uncertainty became a proxy for parties to argue their respective cases. Those that would lose from adaptation proposals on the table used uncertainty as an argument to wait-and-see, while others used the potential risks as arguments for their respective preferred options.

If the uncertainties are to be downplayed and climate change accounted for in infrastructure planning in ways similar to other modeled projections of the future, like economic growth and mobility demand forecasts, it would seem that some level of standardization of climate projections is necessary. In contrast to the United States and Singapore, there is an agency in the Netherlands that everyone looks to for practically useful climate projections and models - the Royal Netherlands Meteorological Institute (KNMI). KNMI provides not only meteorological projections, but also tools to help different stakeholders understand and make use of their models.

Adaptive planning and decision-making

As discussed earlier in this chapter, participants strongly favor taking *flexible* or *adaptive* approaches as a way to make decisions in the face of uncertainty. In practice, this entails making decisions today based on the best information available, while explicitly leaving room for modifications and additions in the future as conditions change. As an approach to engineering, there are examples of flexible design in practice as a response to potential climate change. For example, the Botlek Tunnel in Rotterdam is being reconstructed with extra cellar capacity so that larger pumps can be installed in the future, should more intense precipitation events become increasingly common, as projected. Rather than oversizing the pumping capacity today, this approach allows for the easy accommodation of the additional infrastructure in the future. While a wise design philosophy, this research suggests that there are some significant *governance* challenges preventing widespread implementation of flexibility in practice. These challenges may be surmountable, but must be recognized and attended to if decision-makers are to make progress.

One challenge is that different departments, and sometimes completely different agencies or private firms, typically manage the construction versus the management of transportation infrastructure. Those concerned with initial design and construction are responsible for delivering pieces of infrastructure that meet the defined specs on time and within budget. Those responsible for maintenance then monitor the state of the infrastructure over time and make repairs and adjustments as needed. These parties must work together much more directly in an adaptive paradigm so that designers understand

the technical capacities, operating procedures and options generally open to maintainers, and maintainers explicitly understand where and how opportunities for flexibility have been built in. This requires enhanced interactions and mechanisms for information sharing, and the right incentives to make it happen. The more novel forms of 'design-build-finance-operate/maintain' privatization that the Netherlands is experimenting with may help to align incentives and foster more lifecycle-oriented approaches, but only if properly designed and implemented. Ambiguity around responsibility across infrastructure systems may make this extremely difficult, as firms may find it more cost-effective to argue for limited liability than to proactively consider factors that are ostensibly peripheral to their core activities.

Even if the alignment is there, those on the maintenance side of infrastructure systems must have a clear understanding of when and how they might modify the infrastructure over time as conditions change and/or new information becomes available. This information can be provided and the evolution tracked using decision (or 'scenario') trees with multiple pathways. To be effective, this type of adaptive management requires clear monitoring processes and mechanisms for iterative decision-making.

Decision support: Multiple scenarios

Effective collaboration and adaptive management can help decision-makers and other stakeholders address the risks posed by climate change, but processes are often challenged by, among other things, persistent uncertainty about the future and lack of clarity around which technical information decisions should be based on. Various decision-support tools may be used to ease the transition to effective adaptation planning for infrastructure systems. However, these tools are not without their challenges and limitations.

This research explicitly focused on scenarios, which are often invoked as an effective way to make decisions despite the persistence of unresolvable uncertainty. Rather than comparing options to a single forecast or model of future conditions, decision-makers compare options to multiple possible futures (i.e., scenarios). Scenarios are being developed in practice to support adaptation efforts. The Rotterdam Climate Change Adaptation Strategy was, for example, developed using four qualitative 'Delta Scenarios' very similar those in the *Harboring Uncertainty* exercise run in this project.

Participants consistently reflected that they like the idea of scenarios, as they provide a way to think about uncertainty. Nonetheless, their value in practice when it came to the simulated project-level decision-making in the exercise was questionable; the scenarios were generally disregarded or downplayed. Despite the encouragement to use them in the instructions, participants largely reverted to the single scenario that best matched their respective estimations of what the future will look like to justify their positions. Those most concerned about climate change suggested that the option chosen should be able to handle the worst-case scenario, as that is the one they see as most likely. Those most concerned about alterations to the status quo, and least concerned about climate change, used the scenarios to emphasize the uncertainty and thus promote a 'wait and see' approach.

Scenario planning may be very useful when developing high-level strategies, but the value of the resulting scenarios when making subsequent project-level decisions is questionable.

Role-play simulation exercises and serious games

The *A New Connection in Westerberg* RPS is an important piece of this research project. Participants engaged in the exercise to gain exposure to some of the core research topics, like the use of scenarios, in a sandbox-like experimental environment. This allowed for rapid, inexpensive and vivid exposure to a set of concepts that they subsequently reflected on during both the group debrief and individual follow-up interviews.

As noted previously, participants reflected that they learned from the exercise experience. What they learned varied, but their takeaways were largely process and negotiation-related. Common answers included: What *uncertainty* means, how it might complicate decision-making, and what might be done about it; the gap between how engineers and other technical experts view this challenge and how those on the more political and policy side view it; and the need to also account for the various stakeholders' interests when devising responses to climate change, rather than seeing the task as one of purely optimizing to climate models. Participants felt that the exercises provided a great way to initiate and frame their conversations with other participants from other agencies that they had not previously talked about climate change with.

As a research tool, the 'unfreezing' that the exercise precipitated was invaluable. The exercise experience framed reflection during the focus group-like discussions that followed each run and the follow-up interviews. Participants were able to assess their own situations vis-à-vis the dynamics in the exercise, and give more informed consideration to questions like the opportunities and challenges associated with using multiple scenarios.

**Institutionalizing Uncertainty:
Exploring how infrastructure stakeholders can
prepare for uncertain climate futures**

Chapter 3 – Singapore Case

Creating a climate resilient global city that is well positioned for green growth – Goal of the National Climate Change Secretariat

We occupy the same planet and our fate is bound together. It matters very little therefore who wins the debates. If the world is destroyed we will all be in serious trouble - Lee Kuan Yew, Founding Father and First Prime Minister of Singapore on climate change

Introduction

Singapore's relationship with water and vulnerability to climate change has much in common with Rotterdam, while there are also important differences. Like Rotterdam, Singapore's landscape is highly engineered. Approximately 20% of the city-state is built on land filled and reclaimed from the sea (Koh, 2005). Singapore's economic development and multicultural society are in large part products of its strategic location on important shipping routes, and the port remains one of the largest in the world. Because of its unique geography, Singapore has not historically faced significant coastal flooding, although some predict that this might change with the climate. It has faced significant flooding from intense rain showers during monsoon seasons, and the frequency and intensity of these events seem to be increasing. Awareness of the threats and uncertainties associated with a changing climate is increasing and the government is devoting resources to understanding and adapting to them. Nonetheless, the threats associated with climate change are less acute to planners, decision-makers and other stakeholders in Singapore than they are in Rotterdam. From a governance perspective, Singapore is quite different from Rotterdam and the Netherlands. Singapore is a city-state with only one level of government, which obviates the issues of coordination and negotiation among levels of government found in most other countries. Coordination between agencies is, however, still a factor. While it appears to be liberalizing, Singapore has a semi-authoritarian system of government in which the state plays a dominant role in planning and decision-making and is rarely challenged. This chapter considers how adaptation planning is evolving in Singapore and may continue to evolve into the future.

The first section of this chapter describes the wider context. It starts by introducing the climate-related threats that Singapore faces. Next, it outlines what is being done about these threats. The broader infrastructure planning and decision-making processes, particularly for transportation infrastructure, are then introduced. Infrastructure planning and decision-making is situated within the broader semi-authoritarian framework for decision-making in Singapore.

The second section of this chapter describes the research interventions carried out with planners and decision-makers in Singapore as part of this dissertation, and highlights the primary research outcomes. It starts with a brief outline of the research approach and design. The outcomes of the two versions of the role-play simulation exercise – one with scenarios and the other with a risk assessment forecast - conducted with four groups of participants in Singapore are then introduced and assessed. The results of the pre- and post-exercise surveys are reviewed next. Participants’ reflections gathered during the exercise debriefings and semi-structured interviews are interwoven into sections focusing on the exercise results and surveys findings.

The third and final section draws a synthesized set of conclusions. It also looks forward, offering various speculations on how adaptation planning and decision-making might evolve in the future. The key conclusions emphasized in this section are:

- Issues deemed to be ‘national priorities’ receive extraordinary attention in planning and decision-making, guiding the allocation of resources. Current priorities, and in particular economic growth, may influence how adaptation planning evolves. Climate resilience is not, itself, a national priority, but could emerge as one as risks become more acute.
- Civil servants are generally deferential to hierarchical leaders at both organizational and interpersonal levels. Strong leadership willing and able to champion climate resilience must emerge if the topic is going to capture attention and resources.
- The Singaporean civil service and political elite pride themselves on being rational and methodical. Ideas are, at least ostensibly, vetted on their merits, with the notion of competing interests downplayed and discouraged. “Wicked” problems like adapting to climate change appear to threaten the rational paradigm, given the ambiguity around what is the most appropriate response in uncertain situations.
- Civil society has typically played a relatively minor role in Singaporean governance, with tight controls and limited opportunities to engage with decision-makers. Recent events suggest that this could change, with implications for who is involved in planning and the degree of influence of “outside” actors.
- Both the complex and wicked nature of climate adaptation, and the increasing involvement of non-governmental actors necessitate greater attention to process design, and deliberation and negotiation skills. A key takeaway from this research for those who participated is the importance of good deliberative processes, and impact that negotiation skills can have on the government’s ability to pursue its most important objectives.

- Flexibility and robustness may be complementary responses to uncertainty. Many participants expressed support for approaches to infrastructure planning that emphasize the worst-case scenario, but leave options open.
- Participants also reflected positively on the contributions scenario planning can make to planning under uncertain conditions, with the caveat that it is the process of developing these scenarios as a group and not the final product (i.e., the scenarios themselves) that is most valuable.
- RPS exercises can help stakeholders grapple with how to manage wicked problems, like adapting to climate change. They can introduce participants to certain risks, and provide safe, low-cost spaces for experimentation and public learning. Serious games are already being used in Singapore to train civil servants.

Context: Infrastructure, climate change and decision-making in Singapore

Climate vulnerabilities

Singapore is a densely populated city-state close to the equator in Southeast Asia. As outlined in *Table 3.1*, it faces various climate-related threats.

Much of Singapore's territory – including most of the extremely densely populated coastal zone – is close to sea level. A substantial proportion of the country's low-lying areas are built on reclaimed land, and Singapore plans to add additional land and grow by another ~14% over the next 50 years (Koh, 2005). This low-lying geography makes Singapore vulnerable to sea level rise (SLR). Mean SLR in the Straits of Singapore has averaged approximately 3mm per year in recent years, and the rate could increase dramatically as the earth warms and rainfall increases (NCCS [National Climate Change Secretariat], 2012). Projections of global mean sea level rise by the end of the century range from 26cm to almost a meter (IPCC, 2013). Average increases of millimeters per year may sound minor, but they add up when many critical assets – including the airport, marine ports, business district and critical freshwater storage reservoirs – are less than two meters above sea level (Arnold, 2007). Ng and Mendelsohn (2005) conducted a thorough inundation analysis, based on ten coastal sites, and found that between 4 and 17 km² of Singapore's territory could be completely lost by 2100, if protection measures are not taken; the value of this land is estimated to be between 3.7 and 16.2 billion (yr. 2000) USD.

Furthermore, sea level rise exacerbates the risks posed by storm surges because it reduces the protective height that seawalls, barrages and other coastal defenses provide. Because of its location so close to the equator and in straits between Malaysia and Indonesia,

Singapore has not historically faced major tropical cyclones.¹ However, Typhoon Vamei, which was the first recorded cyclone near the equator, passed just north of Singapore in 2001, causing significant flooding and damage in the region, and some forecast that climate change might make this type of event more common and/or intense (Chua, 2013; NCCS, 2012). Because Singapore's coastal defenses were not constructed to withstand major tropical storms, the country will be extremely vulnerable should they increase in frequency or intensity.

Singapore may be unaccustomed to tropical cyclones, but it is very familiar with extreme precipitation, especially during monsoon seasons. Unfortunately, climate change may be increasing the frequency and intensity of heavy rain events. There were, on average, only five days a year in which rainfall exceeded 70 mm in an hour around 1980, while by 2012 the average was ten (PUB [Public Utilities Board], 2014a; Zengkun, 2013). There has been a statistically significant upwards trend in the 'annual maximum hourly' rainfall total from 80 mm in 1980 to 110 mm in 2010 (PUB, 2014b). Recent years have seen a spate of severe flash floods, damaging property, disrupting activity and even causing death. Infrastructure systems, including key arterial roads, are disrupted when flood control infrastructure is overwhelmed (Yahoo Newsroom, 2013).

While more intense rain events may be increasingly common under climate change, the country could also face periods of prolonged drought. In fact, February of 2014 was Singapore's driest month since 1869, necessitating water conservation measures (BBC News, 2014). Singapore historically relied on Malaysia for freshwater, but has invested heavily in recent years in various technologies – including water retention, water recycling and desalinization – to advance water independence and thus security (PUB, 2015a). Singapore's ability to achieve its ambitious goals around water self-sufficiency may be challenged as precipitation patterns change, while water scarcity elsewhere increases concerns around the long-term stability of imports not only of water, but also food supplies because of their vulnerability to drought conditions.

Singapore is an equatorial country familiar with very high temperatures and humidity, and is largely adapted to its tropical environment; climate controlled buildings are the norm, tree canopies are maintained to provide shade, and infrastructure is built to handle high temperatures. Nonetheless, even higher temperatures could strain the country's capacity to manage. The annual mean surface temperature rose from 26.8°C in 1948 to 27.6°C in 2011, and even conservative estimates suggest that Southeast Asia is likely to face an increase in mean temperatures of 1.7°C this century, which is higher than the projected mean global increase of 1.1°C (NCCS, 2012). Much higher increases are possible, which could precipitate upticks in heat-related mortality and infrastructure failures. For example, electricity grids can collapse when energy demand for cooling is excessive and transmission lines are stressed with high temperatures. Temperature increases, and more extreme and intense heat events, may also threaten Singapore's biodiversity and food supplies from both domestic and imported sources, as species are no longer able to cope (NCCS, 2012).

¹ Tropical cyclones (including hurricanes and typhoons) are extremely rare close to the equator because of the Coriolis force (Irion, 2003). From a meteorological perspective, Vamei was an almost improbable event.

Changing coastal environments may also impact biodiversity, particularly in coastal mangroves and coral reefs. From a public health perspective, temperature and other climatic changes may also shift disease vectors with public health consequences.

Last but not least, climate change may involve shifting wind patterns, which could increase the frequency and intensity of days with poor air quality due to forest fires in neighboring Indonesia (NCCS, 2012). Both 2013 and 2014 saw periods of particularly intense fire-related smog, with severe implications on public health and quality of life (Watts, 2014).

Table 3.1 – Potential impacts of climate change on Singapore’s physical environment

Climate Change Effect	Examples of How the Physical Environment Could Be Affected
Increase in temperature	Changes to biodiversity and greenery; implications for public health (e.g., from heat stress, mosquitoes); greater demand on energy infrastructure (for cooling)
Change in rainfall (droughts) or intense storms	Reliability of water supplies; drainage and flooding issues; changes to geomorphology, biodiversity and greenery
Sea level rise	Erosion and flooding of coastal areas
Change in wind patterns	Public health (e.g., haze)

Source: NCCS, 2012: 72

Climate Preparedness

While not as extensive as those in and around Rotterdam and Boston, various initiatives are underway in Singapore to tackle climate change. These efforts feature extensive cross-agency collaboration and expert consultation, but with very little engagement of external stakeholders. The government sees enhancing resilience as primarily an internal responsibility and is acting accordingly. Efforts are also largely technical in nature, looking for engineering solutions to enhance climate resilience. This includes forming partnerships with foreign experts, including Dutch engineering firms like Deltares, to increase capacity and devise state-of-the-art solutions (NUSDeltares, 2015).

The National Climate Change Secretariat (NCCS), which is based in the Prime Minister’s Office, is the primary coordinating body on climate change adaptation and mitigation efforts. The NCCS was established in 2010 to “develop and implement Singapore’s domestic and international policies and strategies to tackle climate change”, with responsibility to “facilitate efforts to mitigate carbon emissions in all sectors; help Singapore adapt to the effects of climate change; harness economic and green growth opportunities arising from climate change; and encourage public awareness and action on climate change” (NCCS, 2015a).

The primary role of the NCCS is to facilitate intergovernmental cooperation at all levels to tackle climate change. At the highest level, the Inter-Ministerial Committee on Climate Change is comprised of the Deputy Prime Minister (and coordinating Minister for National Security and Minister for Home Affairs), and the Ministers for Finance, Trade and Industry,

National Development, Environment and Water Resources, Foreign Affairs and Law, and Transport (NCCS, 2015a). The ministerial group is supported by an Executive Committee, which includes permanent secretaries from each of these Ministries and is chaired by a Permanent Secretary for National Climate Change (NCCS, 2015a). Below that are thematic Working Groups – International Negotiations, Long Term Emissions and Mitigation, and Resilience – which bring together senior staff from each of the relevant ministries and statutory boards (NCCS, 2015a).² The Resilience Working Group, which is responsible for adaptation planning and policy, is comprised of representatives from: The Ministry of Environment and Water Resources, the Ministry of National Development, the Ministry of Finance, the Ministry of Health, the Building and Construction Authority, the Energy Market Authority, the Housing Development Board, Jurong Town Corporation, the Land Transport Authority, the Maritime and Port Authority of Singapore, the National Environment Agency, the National Parks Board, the National Water Agency, the Singapore Land Authority, the Urban Redevelopment Authority, and the National Climate Change Secretariat itself (NCCS, 2015a). The variety of participants reflects the different areas in which climate impacts are foreseen, and thus adaptive actions are being considered. Below the Working Group, and associated sub-group, are thematic ‘clusters’; these are issue-specific – for example ‘coastal defense’ and ‘infrastructure’. According to an interviewee, these clusters bring together and are chaired by the relevant agencies – for example, coastal defense is chaired by the Building and Construction Authority, and includes representation from the Public Utilities Board and the Land Transport Authority. The infrastructure cluster is chaired by the Land Transport Authority.

The NCCS is primarily focused on government activities, and the absence of external stakeholders in the various committees is notable. That being said, it does include some elements of outreach to other stakeholders. A ‘Public Consultation on Climate Change in Singapore’ was conducted from January through March of 2015 (NCCS, 2015b). The consultation primarily involved online ‘e-polls’ (i.e., questionnaires) in five ‘areas of action’ that stakeholders were invited to complete. The focus was on climate mitigation rather than adaptation, with questions like (NCCS, 2015b):

- In the ‘Carbon Efficiency in the Transport Sector’ e-poll: *Public transport is typically two to five times more energy efficient than private transport. Singapore aims for a public transport modal share in 2030 of 75% (2012 modal share was 63%), which will also help reduce carbon emissions. Initiatives to promote this include expanding our rail network, enhancing our bus services, and improving access to public transport via more sheltered walkways. What would encourage you to use these public modes more?*

The questionnaires were accompanied by brief background documents to inform participants and prepare them for participation. For example, the five page

² Statutory Boards are the implementing agencies of government with legally mandated authority in their respective domains. For example, the Housing and Development Board (HDB) is responsible for public housing and the Land Transport Authority (LTA) is responsible for land-based private and public transportation, including the public transit system, roads and vehicle registration and regulation. Statutory Boards typically report to a single Ministry (Transport for the LTA and National Development for the HDB), which are responsible for broader policy-making.

'Carbon Efficiency in the Transport Sector' paper provides information on the relative emissions of each vehicle mode, the initiatives the government is taking to make transportation more efficient, and some options for the future, like supporting wide-scale adoption of electric vehicles (NCCS, 2015c).

Recognizing the high degree of uncertainty and evolving understanding of the risks climate change poses, and thus need to take a flexible approach, the NCCS applies a *resilience framework* to its adaptation planning, which is outlined in *figure 3.1* (NCCS, 2012). This framework suggests that the government is taking an iterative approach - understanding the changing climate and its impacts, devising and assessing adaptation options, implementing chosen options, monitoring and evaluating their efficacy, and revising strategies in an ongoing cycle over time.

Figure 3.1 – Singapore's resilience-based approach to adaptation



Source: NCCS, 2012: 73.

The NCCS Secretariat has released various publications and communiqués on the potential impacts of climate change, what the government is doing and may do in the future, and how citizens can do their part. These include a National Climate Change Strategy, which was released in 2012. The Strategy introduces measures that have been taken or are planned with climate change in mind, including (NCCS, 2012):

- An increase in the minimum elevation of newly reclaimed land from 1.25 meters above the highest recorded tide observed before 1991 to 2.25 meters;
- The creation of a Coastal and Project Management Department devoted to coastal protection and adaptation issues within the Building and Construction Authority;

- A revamping of the drainage and flood management systems, using a forward looking risk management-based approach;
- Suppressing and monitoring mosquito populations and other disease vectors;
- Constructing buildings, infrastructure and urban spaces to promote natural cooling and reduce energy consumption; and
- Enhancing tree management and maintenance to protect biodiversity and counteract the urban heat island effect.

Beyond the increased elevation for newly reclaimed land, the government has examined the feasibility of building a Dutch-style seawall or network of seawalls (Arnold, 2007). Such a project has not been approved or even officially proposed yet, but remains an option as conditions change.

While the NCCS is the coordinating body for Singapore’s adaptation policy-making and planning, adaptive measures, whether explicitly linked to climate change or not, are implemented by various relevant statutory boards (i.e., agencies) and ministries. As noted previously, the Building and Construction Authority (BCA) established a Coastal and Project Management Department in 2008 to examine coastal protection and adaptation issues, and is working with other agencies and external experts to devise a *Risk Map Study* that presents the risks and potential responses (BCA, 2013; NCCS, 2012). This study is expected to be released at some point, but has not been yet. The BCA is already, however, building some coastal defenses; by 2013, they were maintaining 14.6km of foreshore structures (BCA, 2013). A cost-benefit analysis by Ng and Mendelsohn (2005) suggests that building such infrastructure could be a very sound investment – they estimate that coastal defenses might cost between 0.9 and 16.8 million (yr. 2000) USD annually by the year 2100, which is relatively little compared to the billions in land value potentially lost if nothing is done, as noted in the previous section. However, such a major hard infrastructure project would come with environmental and other costs, and is complicated by climate-related uncertainties around what is required when.

In addition to the aforementioned climate-specific measures, the NCCS Strategy identifies various initiatives already completed or underway that, while not explicitly happening in response to climate change, may nonetheless enhance resilience. These include: The Marina Barrage, which is a sophisticated flood control and water storage system; and new desalinization and other freshwater management infrastructure, which provides greater water independence and may mitigate impacts from changing precipitation patterns (NCCS, 2012). In general, Singapore’s sophisticated water management regime – which is examined further in the call-out box below – is enhancing resilience by diversifying and shoring up supply, and investing in drainage and water retention capacity.

The Public Utilities Board (PUB) is the statutory board responsible for “managing the country’s water supply, water catchment and used water in an integrated way” (PUB, 2015b). The water supply initiatives discussed in the callout box below fall under PUB’s purview. The PUB has also been implementing various measures to address the increasing

prevalence and severity of flashfloods. The PUB claims that it recognizes the risks, and uncertainty, climate change poses, and is taking action (PUB, 2014a: 36):

Managing flash floods in Singapore is subject to complex and dynamic factors, such as intense rainfall due to our tropical climate, the inherent low-lying nature of some areas, and the critical need to balance land needed for flood protection and for supporting the various needs of our growing population. Climate change adds further complexity to the issue as no one can say with absolute certainty how much rainfall intensities will increase and sea levels will rise.

Nevertheless, PUB has already taken measures to raise its flood protection standards in the [Code of Practice] in 2011 and is committed to improving flood protection for Singapore through its holistic “source-pathway-receptor” approach.

From a planning perspective, the PUB convened an Expert Panel comprised of prominent engineers from academia, consulting and government from around the world in 2011-2012 to assess the risks and propose a set of recommendations, which were adopted via an action plan and are informing the organization’s aggressive and forward-looking stormwater management strategy (PUB, 2014a). Most of these measures involve the construction of new or improved infrastructure to make the drainage system more robust, including new localized retention basins and upgraded canals. While heavy on infrastructure investments and direct management, some measures are softer in nature. These include the integration of a network of electronic sensors and closed-circuit television cameras to enhance monitoring. Stakeholders, including the general public, can access monitoring data in real-time online. Their plan calls for “roping in the developers” through new requirements (issued in 2014) mandating that they retain 25-35% of peak runoff on-site via various measures, ranging from conventional cisterns to more innovative and multi-use rain gardens (PUB, 2014a).

The LTA is an important player in the climate change arena, although concrete action thus far has largely been on the mitigation side. Singapore’s strict controls on private automobile use and emphasis on strong public transportation, while not driven primarily by climate concerns, complement greenhouse gas emissions reduction efforts (NCCS, 2012). On the adaptation side, the LTA has started taking steps to protect assets and maintain service levels to the degree possible during major weather events. In addition to enhancing road drainage systems with the PUB, they are in the midst of installing flood barriers at 19 of the most vulnerable mass rapid transit (MRT – i.e., light rail) stations (Sim, 2013a, 2013b). However, despite these initial efforts it is notable that climate change does not appear to be a high priority for the agency. While keen to emphasize that climate change is emerging as an issue, the majority of participants engaged through this research felt that it is not yet an organizational priority. The fact that the latest Master Plan, released in 2013, makes no mention of ‘climate change’, ‘adaptation’, ‘flooding’ or other climate keywords is further evidence of this (LTA, 2013). Small steps are being made and LTA representatives are engaged in the NCCS process, but it is not (yet) high on their agenda.

According to an interviewee, the Urban Redevelopment Authority (URA), which is the agency responsible for planning, has a small group assessing how they might respond to a changing climate. They are considering factors like the urban heat island effect, and how it might be mitigated through changes to their planning guidelines. The interviewee also noted that the climate adaptation portfolio recently shifted from the Strategic Research to the Planning Policies Department. This signifies a shift from climate adaptation being framed as a research concern for long-range consideration to it being a more immediate issue that warrants attention in terms of policy development.

Four National Taps: Singapore's water security

[Water] dominated every other policy. Every other policy had to bend at the knees for water survival. – Lee Kuan Yew, quoted on PUB, 2015c

Maintaining a stable supply of freshwater has long been a priority for Singapore. From the early days, founding Prime Minister Lee Kuan Yew was very uneasy about the city-state's reliance on Malaysia - from which it had separated and had a tense relationship - for almost all of the freshwater supply. This is unsurprising, given that Malaysia used the threat of cutting off the supply as leverage in their negotiations (Lee, 2000). The fact that a major drought overlapped with Singapore's independence in 1963 only exacerbated concerns (PUB, 2015c). In response, water sustainability was deemed a matter of national security. Various efforts have been made over the decades to increase Singapore's water self-sufficiency. This is an extremely challenging task on a densely populated island with constrained storage capacity; Singapore sees substantial rainfall on an annual basis (2,400 mm on average), but it is largely concentrated within two monsoon seasons (Ong, 2010).

Singapore's ambitious freshwater program, which is managed by the Public Utilities Board (PUB), is focused on developing and maintaining a sustainable supply from four sources, known as the *Four National Taps* (Ong, 2010; PUB, 2015a, 2015b):

- *Local catchment water* – Singapore has developed an elaborate network of 17 reservoirs fed by drains and canals, allowing for the capture and storage of rainfall on more than half of the land area. There are ambitious plans to increase this to 90% of the land surface by 2060. This is one of the most extensive rainwater harvesting systems in the world. It depends on large-scale infrastructure, including barrages enclosing all of the major estuaries, and extensive monitoring to maintain high water quality.
- *NEWater reclamation* – Singapore has developed and implemented a state-of-the-art water recycling system that uses membrane and ultra-violet disinfection technologies to turn wastewater into 'new' water that exceeds normal drinking water standards. The current NEWater plants can meet up to 30% of Singapore's water needs, but there are plans to increase capacity to supply up to 55% of the country's forecasted water demands in 2060.

- *Desalinated water* – Singapore has two desalinization plants, which are capable of meeting up to 25% of today’s water demand. Both were constructed and are operated as public-private partnerships, which is unique in Singapore infrastructure-wise. There are plans to increase desalinization production capacity so that it can continue to supply approximately 25% of water as demand increases.
- *Imported water* –Despite major investments in the other three taps, Singapore continues to purchase approximately 40% of its water from neighboring Malaysia. However, one agreement expired in 2011 and the remaining will expire 2061. Efforts to enhance self-sufficiency made renewing the first agreement unnecessary, and the goal is to have the capacity to be completely self-sufficient by 2060, should renegotiating the second agreement prove impossible or unattractive for Singapore.

These sources are conceptualized within a closed *water loop*. While the supply-focused technical solutions are most prominent, the PUB’s water management strategy also promotes water conservation on the demand side, using regulations, pricing strategies and education initiatives to encourage private and commercial users to reduce their consumption (Ong, 2010).

While not originally climate-related, Singapore’s investments in long-term water security should enhance climate preparedness (NCCS, 2012). The country’s approach to water security may also be indicative of its wider approach to enhancing resilience and managing emerging threats. It suggests an emphasis on long-term security and independence, adopting solutions that are technical in nature and highly orchestrated within strong government institutions (Ong, 2010). Technological positivism is a feature of this approach – “I never believed [water security] would be impossible forever. I thought, sometime, some place, technology will be found that would make it nearly possible”, said Prime Minister Lee Kuan Yew, who is referred to as the ‘architect of Singapore’s water story’ (PUB, 2015c). Singapore’s water strategy has components to involve citizens, especially through conservation measures, but it is largely government-driven, with little consultation and stakeholder engagement.

While climate change adaption is framed largely as a government responsibility, there is an emphasis on engaging experts from academia and research institutes both within Singapore and abroad. The aforementioned PUB Expert Panel on flood control is an example of this. The NUSDeltares ‘knowledge alliance’, which is a partnership between the National University of Singapore and Dutch research institute Deltares is another. The alliance is focused on finding ‘meaningful solutions’ to ‘essential societal challenges’, including climate change, high-density living and urban water management. It’s portfolio of projects thus far focus largely on implementing more sophisticated monitoring regimes to enhance understanding of dynamic and potentially vulnerable systems over time (NUSDeltares, 2015). Responding to questions around the spate of flash floods in Parliament, the Minister for the Environment and Water Resources couched Singapore’s response to increasing climate risks as an expert-driven endeavor (Ibrahim, 2010):

To better understand Singapore's long-term vulnerabilities to climate change, NEA commissioned a study involving both local and foreign experts. The study projects that the average daily temperature could increase by between 2.7°C to 4.2°C from the current average of 26.8°C, and the mean sea level around Singapore could rise by 24 to 65 cm, by 2100. As climate science is a complex and evolving subject, we will continue to improve our understanding as more information and data become available and climate change models become more robust. This will allow us to incorporate the latest scientific understanding on the potential impact of climate change into our infrastructure planning considerations. NEA is also working to expand its capabilities in climate science through collaborations with renowned climate institutes and the World Meteorological Organisation. In the longer-term, we will put in place additional measures as needed to adapt to the potential impact of climate change.

The NCCS Strategy makes clear that Singapore's adaptation process is a work in progress, noting that: "The ongoing work on each [climate risk] involves bringing together expertise from multiple agencies. Phase 2 of the study is in progress and will investigate the impact of climate change on public health, urban temperature profile, energy consumption of buildings, and biodiversity" (NCCS, 2012: 72). To this end, the NCCS is very research-oriented. The Strategy identifies the development of knowledge and expertise as a top priority; it calls for a stronger role for domestic research institutes, and notes the creation of both a Centre for Climate Research Singapore within the Meteorological Service Singapore and an interdisciplinary Climate Science Experts Network (NCCS, 2012). Other research institutes actively working to evaluate and devise responses to the risks posed by climate change include the Tropical Marine Science Institute, Earth Observatory of Singapore, Institute of Catastrophe Risk Management, and Maritime Research Centre (NCCS, 2015a).

The National Climate Change Adaptation Strategy and other government communications introduce some of the risks that the myriad of agencies and institutes have identified, but provide little detail. In particular, they provide relatively shallow analysis of how climate change might directly impact livelihoods and infrastructure systems. In part, this is because these assessments are in progress. More detailed analysis is being conducted as part of a comprehensive study of the impacts of climate change on various infrastructure systems and how more concrete adaptive measures might be implemented, which is due to be released in 2016 (Ee, 2014). However, it also reflects reticence on the part of the government to 'raise alarm bells' until they have a plan for addressing emerging climate threats. During this research, interviewees admitted that they have more detailed analysis internally, but do not want to share it with citizens until they have fleshed out the solutions they will propose in response. When asked about their reticence to share information, one interviewee directly involved in the government's resiliency efforts put it this way:

When we want to share information about climate change, we don't want to get people [worked up], saying 'Okay, your area is flood-prone, so in the long run [...] maybe you have to sell your house, the property price will drop', for instance. So there are certain things, which I think the government, they have a lot of consideration

before releasing certain information to minimize the potential, the situation whereby people would start to get afraid. I guess the other reason is because when we want to do something, and climate change is happening slowly, it's moving very slowly, so I guess for us we want to do, or to have some concrete plans before releasing it to the public. For instance, we have actually done quite a number of things like we have our resilient framework. So under the resilient framework we have come up with risk assessment and adaptation plans as in the framework itself, but we haven't released it to the public because we want to, okay when you tell them about the risk, the idea is to also tell them what is the solution to the risk. So they wanted something that is more complete before going to the public. Which might not be the same for other countries because they may tell, 'Okay, this is the risk, we are looking at the adaptation plans', but I think in Singapore that is not the approach. [...] The feeling that I have is that people generally want to have solutions before releasing to the public.

One feature of Singapore's emerging adaptation efforts is that they are taking a page from the traditional Dutch model in looking for highly engineered solutions; unsurprisingly, they are bringing in Dutch expertise to help (Arnold, 2007). What is very different is the internal nature of these efforts; there is little place for stakeholders outside government, beyond local and domestic experts brought in to provide technical knowledge. In contrast to the Netherlands and United States, the norm in Singapore dictates that government generally knows best, and is expected to plan and make 'rational' policy decisions that advance the common good for the long-term. The institutional norms of governance in Singapore are examined further in the next section, but it is notable that they appear to be manifesting in the realm of adaptation as well.

Infrastructure planning and decision-making

This dissertation is examining how adaptation to climate change is evolving within the domain of infrastructure planning and decision-making. It is particularly focused on the integration of climate change issues into transportation infrastructure, but interrelated infrastructure systems and planning arenas – including flood risk management and land use planning – are also considered. This section introduces the institutional arrangements in place to facilitate infrastructure planning and decision-making in Singapore. Some of the general characteristics of how planning and decision-making are approached are discussed here, although they are addressed in more detail in the next section, which focuses on the wider planning context or *governance regime* in Singapore.

One key feature of governance in Singapore is that, as a city-state, there is only level of government. This naturally eliminates some of the challenges faced in other regions, including Rotterdam and Boston, as different levels of government with overlapping and interconnected authorities, and both conflicting and complementary interests strive to coordinate and reconcile their disparate planning and decision-making. However, coordination across different ministries and agencies within the Singaporean government is still important. In fact, as discussed in the next subsection, an integrated approach to long-term planning is a hallmark of the system (May, 2004).

Master planning

A certain level of integrated long-range planning is practiced in all three case cities. In Boston, the Metropolitan Planning Organization (MPO) is one arena in which proposed transportation infrastructure projects are considered against long-range land-use plans and other projections of and aspirations for the future. However, the MPO is a relatively weak actor and, while it factors spatial planning into transportation infrastructure planning, these processes are not truly integrated. In Rotterdam, planning is certainly more integrated than in Boston, as evinced by the influence of bridging initiatives like the Delta Programme (2013) and Room for the River (2014). These are influential, well funded and broad initiatives that touch upon multiple infrastructure systems, land use planning and so on. The Dutch government also prepares an integrated National Policy Strategy for Infrastructure and Spatial Planning (Ministry of Infrastructure and the Environment, 2011). Still, long-term transportation infrastructure planning is largely siloed within processes like the National Traffic & Transport Plan and the Ministry's Multiannual Infrastructure and Transport Program.

In Singapore, the Ministry of National Development is a very powerful arm of government, with a variety of responsibilities, both directly and through its various statutory boards. The Ministry “guide[s] Singapore’s land use planning, urban redevelopment and building conservation, deliver[s] affordable and quality public housing, develop[s] an efficient construction industry to ensure a safe, quality and sustainable built environment, provide[s] and manage[s] parks, open spaces and the conservation of nature areas, maintain[s] a high standard of primary food safety and animal and plant health, as well as protect[s] consumer interest by raising the professionalism in the real estate agent industry” (MND [Ministry of National Development], 2014). The MND and the Urban Redevelopment Authority (URA), which is an MND statutory board, engage in extensive strategic planning. The relatively top-down nature of governance in Singapore, which is discussed later in this chapter, gives these plans much greater teeth compared to the more aspirational plans developed in Boston and even Rotterdam. The fact that the government directly controls much more of the built environment - the Housing and Development Board, which is another statutory board of the MND, provides housing for approximately 80% of the population – also makes top-down strategic planning easier.

The URA presents its approach to planning as follows (2015a):

The Urban Redevelopment Authority (URA) takes a long term and integrated approach in land use planning to optimise the use of our limited land in meeting the current and future needs of our people.

We work with relevant government agencies to develop broad planning strategies to guide long term planning, identify sufficient land for different needs and establish the broad pace of development. Infrastructure is then planned and developed to support the proposed land uses, and resources channeled to develop these areas over time.

We plan ahead for the needs of our future generations while taking into account social, economic, and environmental considerations in a holistic manner.

The planning and development process is comprised of three nested phases (URA, 2015a):

1. The overarching *Concept Plan* “is the strategic land use and transportation plan that guides Singapore’s development over the next 40-50 years”. It sets the broad outlines around how the country will meet its population and economic growth, and quality of life goals. It is reviewed every decade.
2. The *Master Plan* “translates the broad and long-term strategies of the Concept Plan into detailed plans for implementation over 10-15 years”. It establishes land use and infrastructure development goals for each area, guiding both public and private investments in development and infrastructure.
3. *Implementation* involves shepherding both public and private actors towards the goals established in the Master Plan. The URA works with other branches of government to coordinate targeted infrastructure investments. With private development, this involves the strategic leasing of state land and permitting review of development proposals.

The last review of the Concept Plan was initiated in 2011, and culminated in the release of an MND document in 2013, titled *A High Quality Living Environment for all Singaporeans: Land Use Plan to Support Singapore’s Future Population*. The Plan uses 2030 as the planning horizon, although elements look further into the future. One of the three core goals the Plan establishes is to provide an enhanced public transport system, particularly with improved rail service (MND, 2013). The plan sets mobility objectives, like a mode shift to 70% public transit use during peak morning hours by 2020 and 75% by 2030, and profiles how they will be achieved, like extensive investments in new and extended rail lines to increase rail density from 34 KM of rail per million inhabitants today to 54 KM by 2030 (MND, 2013). The report also emphasizes the need to foster ‘livable communities’ around transit hubs, integrating transportation infrastructure and other amenities, and outlines a new National Cycling Plan. The road network is briefly mentioned, but the emphasis is on discouraging private automobile use. Themes that emerge in the Plan are the importance of efficiently managed and highly coordinated development, which is contingent on a strong state, and faith in the latest technologies - like a state-of-the-art rail system and dynamic road pricing - to help Singapore meet its objectives.

The current Master Plan, which was released in 2014, is comprised of a map providing parcel-level detail on what land uses are permitted where and what complementary infrastructure exists or is planned, and a ‘Written Statement’ that describes how the Plan should be interpreted (URA, 2015b). It recognizes current and evolving uses while coordinating and directing growth in accordance with the broader goals and objectives established in the Concept Plan. The MND and URA coordinate with other ministries and statutory boards around the provision of infrastructure services to ensure that their development plans are complementary.

It is notable that planning happens within each of these ministries and statutory boards as well. One vehicle for this planning, particularly around changing conditions, is the *Strategic Futures* offices, which exist within many agencies. According to an interviewee directly involved in one of these offices:

What we do is we try to anticipate the trends that would shape the operating environment for Singapore and then contextualize it to [our statutory board]. Obviously, climate change is affecting the wider operating environment, not just for Singapore. I think for almost every nation. So climate change is one driving forces that we have identified and we are trying to assess the impact and we find that it's not quite easy because, I think, internationally the experts are still trying to better understand the impact. And you might understand the global impact or the macro impact, but you need to scale it down to Singapore and this is where NCCS is trying to come in. [...] So, this is just one trend, [...] we're also doing things like demographic changes, social changes, economic changes, and political changes.

The Strategic Policy Office (SPO) in the Public Service Division of the Prime Minister's Office supports long-range planning, including the 'foresight' work, and conducts strategic planning at the whole of government level. A key component of the SPO is the *Centre for Strategic Futures*, which is an internal think tank. Its mission is to "position the Singapore government to navigate emerging strategic challenges and harness potential opportunities by: Building capacities, mindsets, expertise and tools for strategic anticipation and risk management; developing insights into future trends, discontinuities and strategic surprises; and communicating insights to decision-makers for informed policy planning" (Centre for Strategic Futures, 2015). The Centre employs various tools, including what they call 'scenario planning plus', which "retains Scenario Planning as its core, but taps [into] a broader suite of tools more suitable for the analysis of weak signals, and thinking about black swans and wild cards" (Centre for Strategic Futures, 2015). They also facilitate various workshops and networks designed to help civil servants effectively and efficiently consider the future in their planning and decision-making. The Risk Assessment and Horizon Scanning (RAHS) programme is yet another arm of government focused on helping policy-makers examine and prepare for uncertain futures. The RAHS program (2015) "explores methods and tools that complement scenario planning in anticipating strategic issues with significant possible impact on Singapore". The program employs various tools and approaches, including a proprietary software product.

It is clear that centralized comprehensive planning – including both physical master planning and more strategic long-range scenario planning – is highly institutionalized in Singapore. This reflects the governance paradigm discussed in more detail below.

Land transportation infrastructure

In the context of transportation infrastructure, the Ministry of Transport and its affiliated statutory boards coordinate closely with the MND and URA as they devise their plans and make investments. Transportation infrastructure is both a central theme of the Concept

Plan, and a critical component of meeting various other planning goals, including livability and sustainability ambitions. The Master Plan dictates where and how growth should be directed, and transportation infrastructure investments are coordinated to complement. The Ministry of Transport sets the overarching transportation policies, which are largely implemented by the statutory boards. In the context of this research, the Land Transport Authority (LTA) plays a particularly important role as the Board responsible for “planning, operating, and maintaining Singapore’s land transport infrastructure and systems” (LTA, 2014a). While maintaining oversight, the Ministry delegates a substantial proportion of the responsibility for planning and decision-making to the LTA (May, 2004). The Ministry devises higher-level transportation strategies, and drafts relevant policies and legislation in response to government priorities, including regulations around private automobile usage.

The long-standing and interconnected commitments to dense, transit oriented development; a good public transportation system; and discouraging car ownership originated in the first Concept Plan in 1971 and are deeply entrenched (Barter, 2008; May, 2004). These entrenched priorities underscore the notion that transportation planning has long been intertwined with land use planning and the pursuit of other objectives. While not without its shortcomings and perhaps unintentionally in some respects, Singapore’s transportation planning addresses social, economic and environmental sustainability objectives rather than focusing exclusively on the traditional pillars of mobility and safety (Barter, 2008; May, 2004). However, the prioritization among these objectives is not necessarily clear (May, 2004). This comprehensive approach may reflect the government’s broader ‘developmental approach to reform’, which features strong state involvement and, ostensibly, a commitment to professional management, modernization and the pursuit of ‘excellence’ (Barter, 2008). This approach requires a long-term perspective on transportation planning, rather than focusing on particular problems and how they may be addressed in the short-term.

The development and implementation of land-based transportation plans - including public transportation and private automobile use - falls largely to the LTA (May, 2004). The LTA’s mission is “Connecting people and places, enhancing travel experience”, and their vision is “to create a people-centred land transport system” in which “public transport [is] the preferred choice [and...] traffic [is kept] moving smoothly on our roads [...] by optimising our road networks and enhancing safety” (LTA, 2014b). The LTA is somewhat unique in that it is responsible for virtually all ground transportation, giving it a wider perspective and ability to make decisions across transportation infrastructure systems (May, 2004). In other cities and regions public transportation systems are managed separately from roads, and road management is often fragmented across levels of government, increasing the likelihood of competition for resources rather than coordination towards shared ends. Responsibilities were also divided in Singapore - not just across agencies, but separate ministries - prior to the creation of the LTA in 1995, and systems were in practice less well integrated (May, 2004). The LTA not only consolidates responsibility for all land transportation planning and management at the organizational level, it is also structured internally such that some of the key Groups - including Policy & Planning, Engineering, and Corporate Planning & Research - focus on all aspects of the system (LTA, 2014d).

The LTA releases updated Land Transport Master Plans (LTMP) every five years to guide their work. Given the aforementioned goals and priorities, it is not surprising that the current LTMP takes a commuter-centric perspective and emphasizes increasing connectivity, enhancing service levels, and promoting livability and inclusivity – see *figure 3.2* (LTA, 2013). The Plan reinforces the goals established in the MND’s Concept Plan, including the target of 75% of trips by public transit during peak hours. It is notable that concrete performance indicators are underused in the planning process (May, 2004).

Figure 3.2 – The Land Transport Authority’s priorities



Source: LTA, 2013: 4.

While it emphasizes multiple objectives and takes a broad outlook, considering both soft and hard factors, the LTMP suggests that the LTA is looking to new infrastructure, including rail expansion, new roads and additional bus routes, to solve many of the country’s challenges. While not without delays, the length of the rail network increased from 138 to 178 km and two new expressways were opened between 2008 and 2013 (LTA, 2013). There are plans to add dozens of new trains and buses in the coming years, with plans to double the network length to 280 km by around 2020, and then increase again to around 360 km by 2030; construction is beginning on the new North-South Expressway, which is expected to open in 2020; and an extensive underground road system is being considered for the city center (LTA, 2013). In line with the government’s wider Concept Plan, the Ministry has also established cycling policies, and plans to add infrastructure here too, including expanding the cycle path network to 190 km by 2020, adding thousands of bike rack spots at rail stations, and piloting a bike-sharing scheme (LTA, 2013). The LTA is experimenting with various technologies, including upgraded dynamic Electronic Road Pricing and card-activated ‘Green Man +’ systems to allow seniors and those with disabilities more time to cross intersections (LTA, 2013).

Overall strategic planning and project-level appraisal are conducted using various model-based systems, which predict variables like projected car ownership, commuting patterns and expected responses to different interventions. A nested set of models are used, with an overall 'policy model' informing a 'strategic model', which in turn informs 'local models' that consider particular interventions (May, 2004). These are constructed using modeling techniques based on household surveys, trends analysis and other data sources. Accurate forecasting is made much easier by the multiple command and control levers the LTA has to shape patterns directly over time to bend to the predictions (May, 2004). For example, the number of cars is more or less controlled through the Vehicle Quota System and associated auctions for Certificates of Entitlement, and peak demand loads can be at least somewhat managed through dynamic road pricing (LTA, 2012, 2015). Trends in public transit use may be harder to control, but even here the close relationship to the land use planning process removes a significant proportion of the uncertainty.

Environmental monitoring is integrated, with reducing noise pollution highlighted as a goal (LTA, 2013). The LTMP emphasizes environmental sustainability, including around nature protection, providing the following example (LTA, 2013: 42):

A good example of how we weigh these factors is the proposed Cross Island Line that may either go under or skirt around the Central Catchment Nature Reserve. We have already begun a dialogue with various groups, including the nature and environmental groups and residents living near the area, to understand their concerns.

However, the Bukit Brown case, which is examined in more detail later in this paper, suggests that stakeholders do not always view these efforts as sufficient, nor feel adequately consulted.

Financially, projects are ostensibly assessed using cost-benefit analysis that considers travel time, operating costs and the safety implications for the various stakeholders. However, there is clearly a political element. Furthermore, financing is typically less of a constraint than other factors, making the economic evaluation of projects a less rigorous component of infrastructure planning and decision-making (May, 2004). This contrasts starkly with infrastructure systems in metropolitan regions like Boston that are constantly underfunded, and thus in which financing is one of the prime drivers of infrastructure planning and decision-making. This situation is, at least in part, a result of the significant income from demand management measures, which exceeds transportation infrastructure expenditures, although these revenues and expenditures are kept separate (May, 2004).

Despite the strong and consolidated role the LTA plays in Singapore's public transportation systems, actual operations and maintenance is done by two private firms - SBS Transit/ ComfortDelGro and SMRT Corporation - in a regulated duopoly (May, 2004). Both firms operate both bus and rail (Mass Rapid Transit) services on different lines under long-term tendered contracts, and manage taxi fleets (LTA, 2014e). There are additional taxi operators, but the industry is considered part of the 'public transport' network and highly regulated by the LTA (Sharp, 2005). The government does not subsidize bus and rail

operations; in fact, they are generally profitable (May, 2004). Planning and construction are, however, still managed directly by the LTA, as is oversight (LTA, 2013). The LTA maintains significant control over the public transportation system and the private operators manage the systems day-to-day.

There are other government agencies that play various roles. The Public Transport Council is a separate statutory board reporting directly to the Ministry of Transport that plays a regulatory role in bus services and the establishment of public transit fares (May, 2004; Public Transport Council, 2014). They coordinate closely with the LTA in these activities. The road network is entirely planned, constructed, maintained and managed directly by the LTA, including components like dynamic road pricing and auto and driver registration. However, the LTA must work with the Traffic Police on enforcement, preventative education and accident assessment and interpretation (May, 2004). Last but not least, the Ministry of the Environment and associated statutory boards play important roles around the development and enforcement of environmental regulations, including those related to noise and air quality; the LTA is tasked with taking remedial action when the Ministry of the Environment finds that ambient standards are being breached (May, 2004).

Flood protection

The Ministry of Environment and Water Resources (MEWR) has overarching responsibility for water management, including drainage and flood protection (MEWR, 2013). It establishes overarching policies on water management, including flood protection, to ensure that government legislation is enacted (Ong, 2010).

In much the same way as the LTA is responsible for planning and managing Singapore's land transportation infrastructure under the leadership of the Ministry of Transport, the Public Utilities Board (PUB) is the statutory board under the MEWR with comprehensive responsibility for the collection, production, distribution and reclamation of water in Singapore (PUB, 2014c). Among the infrastructure they manage is 8,000 km of drains, canals and rivers (PUB, 2014a). Water collection, management and supply tasks are consolidated under the PUB, at least in part, because they are explicitly understood and managed within a closed 'water loop' (PUB, 2014c). As outlined in the *Four National Taps* callout box in the *climate preparedness* section of this chapter, collecting and storing virtually every drop of water that falls on the island is a key component of the country's water security strategy. The challenge is that Singapore receives substantial rainfall on an annual basis, but it is largely concentrated in the monsoon seasons, resulting in periods of disruptive flooding and contrasting periods, at various times in history, of low supply (Ong, 2010). The PUB must, thus, contend not only with securing and storing water for use, but also with providing adequate drainage to handle flash flood events. However, the fact that the word 'flood' does not appear anywhere in the PUB's *Mission & Vision, Strategic Thrusts, or Service Commitments* suggests that stormwater risk management is a lower priority organizationally. Even the *stormwater management* strategy emphasizes catchment for later use, rather than flood protection. However, as introduced in the *climate risks* and *climate preparedness* sections of this chapter, flash flood events seem to be increasingly frequent and intense in Singapore in recent years as a result of both climate change and

urbanization (PUB, 2014b; Yahoo Newsroom, 2013). While not historically unprecedented, these events suggest a reversal from the trend of declining flood risks over the past 45 years. In response, the PUB tasked a panel of experts from around the world to inform this effort, and translated their findings into a *flood resilience plan*, which it outlined in the *Managing Stormwater for our Future* document (PUB, 2014a). The fact that this planning process primarily involved external experts may reflect traditionally weak internal capacity on flood management. The plan makes various recommendations around how the system can be improved in three areas: *Source solutions* involve controlling water where it falls, and include hard infrastructure like on-site detention basins and softer solutions like rain gardens; *pathway solutions* enhance conveyance by upgrading canals and constructing centralized detention tanks; and *receptor solutions* involve protecting flood-prone infrastructure, and include elevating roads and the platform levels of developments, and safeguarding underground infrastructure (PUB, 2014a). Many of these measures are already underway, including more than 300 drainage improvement projects since 2012; regulatory changes made via the 2011 Code of Practice on Surface Water Drainage to, among other things, increase the minimum platform levels for new developments; and enhanced monitoring and flood risk information dissemination (PUB, 2014a).

As is the case with transportation infrastructure, Singapore's water planning is tightly integrated with its overall land use planning; canals and other water-related infrastructure are designed in concert with other elements of the built environment (Ong, 2010). Water management can thus be understood within a broader "well coordinated institutional framework that provides an integrated 'whole-of-government' approach to land-use planning, water management, a sound built environment, and pollution control to the general environment" (Ong, 2010: 74). The Managing Stormwater plan notes that the PUB must coordinate with other government agencies, like the Housing & Development Board, to ensure that drainage systems are properly designed into new development projects from the beginning, which has not always been the case (PUB, 2014a). The PUB's Code of Practice stipulates how much water new and revamped developments must store on sight, for how long, and how and where the water may be discharged afterwards (PUB, 2014a). Regulations and incentives direct private developers towards implementing stormwater retention and other flood control measures (PUB, 2014a). The planning approval process typically involves review by the National Environment Agency (another arm of the MEWR), which evaluates for the various environment and water-related concerns, including those of the PUB (Ong, 2010). In this sense, the PUB has substantial authority, but not direct control over the entire system; they rely on other agencies and private parties to participate in the critical first phase of stormwater retention, implement and enforce regulations and so on. The PUB also works with relevant professionals - including via the Institution of Engineers Singapore, Association of Consulting Engineers Singapore, the Singapore Institute of Architects, and the Singapore Institute of Landscape Architects - to develop best practices and enhance capacity (PUB, 2014a). Last but not least, some of the actual maintenance tasks - like keeping drains clean - are contracted out (Ong, 2010).

Singapore's flood risks have traditionally come from extreme precipitation events, and thus inland flooding. As noted in the *climate vulnerabilities* section of this chapter, Singapore may be increasingly vulnerable to coastal flooding as sea levels rise and tropical storm

patterns change (NCCS, 2012; Ng and Mendelsohn, 2005). This is a component of water management that the PUB does not manage. The Building and Construction Authority (BCA) is the statutory board of the Ministry of National Development responsible for the built environment, including coastal defenses (BCA, 2014). The BCA created a unit in 2008 to investigate Singapore's coastal vulnerabilities, and develop and implement adaptive responses (BCA, 2013). The unit has made very little information on their research and future plans public thus far, but the BCA has already implemented some measures, including stipulating that any new land reclamation projects are elevated an additional meter above the previous standard, to 2.25 meters above the highest recorded tide (NCCS, 2012). The BCA is also managing 14.6 km of coastal defense infrastructure, and experimenting with different approaches, like 'geobag seawalls' (BCA, 2013). Similarly to the PUB in its areas of responsibility, the BCA is engaging technical experts and studying various approaches from around the world as it develops its understanding and capacity (BCA, 2013).

Benevolent autocracy: Singapore's semi-authoritarian model

The ways in which infrastructure is managed and by whom - including how policies are crafted and implemented - are bounded and shaped by the wider norms of governance in the country. In contrast to neo-corporatist Rotterdam and neo-pluralist Boston, the overarching approach to governance in Singapore may be characterized as *semi-authoritarian, top-down, and pragmatic* (Haley and Low, 1998; Ortmann, 2011; Rodan and Jayasuriya, 2007; Tan, 2012). While ostensibly a democracy, the People's Action Party (PAP) has governed since independence in 1959, and uses various measures - including hardball politics, constraints on free speech and alterations to the electoral system - to limit viable opposition (Chee, 2011; Economist, 2011; Singh, 2007). Founding Prime Minister Lee Kuan Yew spoke openly about the risks of democracy and importance of a strong state, and argued that economic development must precede democracy - "[Democracy's] exuberance leads to undisciplined and disorderly conditions which are inimical to development. [...] The ultimate test of the value of a political system is whether it helps [...] improve the standard of living for the majority of its people", said Lee (in Abdoolcarim and Chowdhury, 2015). While one may question the veracity of the claim, the authoritarian nature of Singapore's governance regime is presented as the most effective and rational way to proceed with public administration (Tan, 2012). This is an ideological norm that the state works hard to maintain (Tan, 2012).

The city-state's civil service is extensively engaged in all facets of the economy and society (Tan, 2008; Worthington, 2003). For example, over 80% of the population resides in government-provided and managed housing (Housing and Development Board, 2014). As outlined in the previous section, the government plays critical roles in infrastructure planning and service provision, but not to the exclusion of private enterprise. To the contrary, neoliberal economic policy and an emphasis on global economic competitiveness, and central planning operate in synergistic ways, which has facilitated impressive economic growth and social welfare, while maintaining the hegemony of the state (Huff, 1995; Tan, 2012). The state also works to engender high quality physical and sociocultural

environments in what is in every way a highly constructed and managed landscape (Henderson, 2012).

The Singapore model is not without its critics, which have concerns on human rights and democratic grounds. Singapore effectively operates as a single-party state with a government willing and able to exert its authority to maintain stability and advance what it sees as the interests of the nation (Henderson, 2012; Ortmann, 2011; Rodan and Jayasuriya, 2007). Micro-management has historically led to prosperity and a high capacity to manage problems, but has been criticized for its inflexibility. Critics contend that the focus on stability and planning at the expense of a more risk-taking entrepreneurial mentality will have negative economic consequences in an increasingly globalized world (Haley and Low, 1998; Saywell, 2002). In the political arena, there is concern that the ostensibly meritocratic civil service is, over time, devolving into an elite oligopoly that focuses on self-maintenance ahead of material performance (Tan, 2008). The state has opened windows for public participation, but very much on its own terms (Rodan and Jayasuriya, 2007).

An important question is how climate change adaptation planning is evolving, and will continue to, given Singapore's governance model. Will the propensity to master plan, risk adversity and capable civil service lead to proactive and appropriate adaption measures? Conversely, will the absence of public dialogue and broad stakeholder engagement translate into blindness to the risks of climate change or maladaptive measures? How will this model manage uncertainty? This section explains the *semi-authoritarian* and *pragmatic* Singapore model, and what it looks like in practice.

It is notable that the authoritarian nature of Singaporean planning and decision-making may be softening over time. The Economist Intelligence Unit's Democracy Index 2014 moved Singapore up a category from the previous ranking, stating that "protests have also become more prominent in countries ranging from supposedly apathetic Singapore through to more active democracies, such as India and Taiwan. In Singapore, this shift has been enough to lift the country from the status of 'hybrid regime' to 'flawed democracy'" (2015: 20). While still tightly controlled, government agencies are increasingly making their planning and decision-making public, and including consultative elements, as discussed further later in this section. The first Concept Plan, released in 1971, was not made public, while today's Concept and Master Planning processes include explicit public participation components (Barter, 2008; URA, 2015c). In the arena of electoral democracy, the opposition parties received 40% of the votes in the 2011 elections, which, while not a coup by most standards, was the highest proportion in decades and some believe a sign that Singaporeans are willing to consider alternatives to the PAP (Economist, 2011). Nonetheless, Singapore's infrastructure planning is dominated by the strong arm of the state, and by extension the Party.

National cohesion and shared priorities

One reason why the semi-authoritarian features of Singapore, including central planning and limited direct public engagement, are accepted is because of the invocation of a set of

overarching shared priorities and importance placed on national harmony. These are key components of the *social contract* between the government and the citizenry (Tan, 2010). Singapore is a very young country that has faced significant hurdles, including hostilities with its neighbors, a dearth of resources, and internal racial and political tensions. The leadership strategically pursues the construction and maintenance of a national identity, with a shared vision and shared priorities, as a means to overcome these challenges and maintain stability (Chong, 2010; Singh, 2007). These are presented within a pragmatic narrative of a young state overcoming adversity and thriving with shared values and strong leadership (Tan, 2012). Singapore's identity is rooted in principles of meritocracy and equal opportunity, although some criticize the system for favoring academic and economic performance and adherence to the system above other measures of merit (Singh, 2007). The education system reinforces these values by promoting ethnic harmony, stressing academic performance in areas like mathematics, and emphasizing skills that will contribute to economic growth (Singh, 2007). Compulsory military service for all male citizens exists not only for defense purposes, but also to foster national harmony and interracial cohesion (Singh, 2007).

The government has emphasized the importance of communitarian *Asian values*, although not without some distrust from non-Chinese ethnic groups; in the end, a set of shared *Singaporean values* have been promoted (quoted in Singh, 2007: 115):

- i. *Nation before community and society above self.*
- ii. *Family as the basic unit of society.*
- iii. *Regard and community support for the individual.*
- iv. *Consensus instead of contention.*
- v. *Racial and religious harmony.*

Intertwined with the notion of shared values is the prescription of shared national interests and priorities. These are the substantive matters that the government deems most important, and thus that are prioritized in planning and decision-making. Water has been identified as a national priority from the early days, because it is seen as an issue of national security and survival (Ong, 2010). In response, significant resources have been put into enhancing Singapore's water independence, even when ongoing reliance on water sales from Malaysia may have been more cost-effective. Economic growth is also a long-standing national priority; the government has played a significant role in nurturing and supporting the emergence of a dynamic and high-performing economy (Choy, 2010; Tan, 2010; Tan, 2012; Trocki, 2006; Worthington, 2003). "The entrepreneurial PAP operates on a government-*must-know-best* philosophy, (not a merely government-knows-best) to ensure Singapore's small size and exposure to trade and foreign direct investment (FDI) are turned into strengths", says Low (2010), adding that the country's economic development model "sometimes known as "Singapore Inc." includes various state-owned holding companies and 'government-linked corporations'. These shared priorities can obfuscate interests-based deliberation, as parties ostensibly know which issues have priority vis-à-vis others. The *rational*, and thus naturally appropriate, option is the one that best addresses the national interests.

Strong hierarchies, deference to authority

The national values and shared priorities introduced in the last section are communitarian in nature, and involve adherence to hierarchies and the invocation of a sense of duty to the nation (Tan, 2010). *Consensus* often involves deference to the most senior figure or institution, making it quite different from both the Dutch poldering tradition and modern deliberative consensus-building techniques. Several interviewees noted the importance of hierarchy in decision-making. One ascribed it, at least in part, to the legacy of Lee Kuan Yew and described it as follows:

There is a certain hierarchy in Singapore. This goes straight into the internal workings of government. Lee Kuan Yew left a certain legacy behind - in the old days, at least from what I've heard, if [he] said something, everybody listened, and so he had that primacy in the direction, and it filters down a bit. So in the political arena, [...] we are aware that certain ministers do have more say. [...] When it translates down to government, I would say the political direction sets the fundamental and broadest, highest-level direction that we should take. Everything stems out from that. So there may be some deviance, some smaller eddies, but the general direction is set. For example, if the direction from the political masters would be to cut the budget, then it would be clear that we would take the cheaper option. [...] We saw it with water resources in Singapore - when Lee Kuan Yew did mention that water must take first place, everything kind of centered around [it] for a while.

Another interviewee described how this plays out internally in government, given the relative prominence of different ministries and statutory boards, and staff within each:

For us in Singapore, it's very clear. Ministries are higher-level than stat boards. So, if you have someone from a ministry, they tend to have a little bit higher say than someone in a stat board. [For example, with] the Ministry of Transport and the Land Transport Authority, I would not say more or less, but it'd be quite clear the directives come from where. [...] So, in a sense we do give a certain amount of respect. It's there in the Asian culture system, or society. So we do give certain respect to people who hold a higher position 'cause inherently you'll think that the guy actually has a bigger picture, he oversees a bigger project.

According to Ho (2000: 157-58), this deference to authority is important both within government and vis-à-vis the citizenry:

The political tradition in Singapore favors the top-down, hierarchical model of decision-making. The well-defined, clearly demarcated hierarchical political structure is a classic pyramid organization where the immediate subordinates strictly follow commands from the top. While discretionary power is given, it is usually within the boundaries of strict directives. Even when policies are perceived to contradict public sentiments, seldom is there open and aggressive opposition against policy decisions by the authority. At most, the Forum Page – a public opinion page in the newspapers – is used as a channel to suggest and fine-tune policy decisions.

This hierarchical arrangement is generally one of cohesion, rather than might. The importance placed on cohesion and coalescence around shared national priorities is apparent in the relationship between the political and bureaucratic classes at the highest levels of decision-making. According to Worthington (2003: 171):

[The] dynamics of the relationship between the political and public sector executives is complex. It is, however, not characterized by bitter factionalisation or feuds although there exists identifiable groupings with partly opposing policy agendas and priorities. It is essentially a pragmatic, negotiated relationship which, regardless of splits within it, operates within a policy program to which all must adhere once changes to it are negotiated. Where conflict occurs it is usually over the direction of broad national strategy, personal style or policy means. The core executive culture is one wherein these conflicts are settled as quickly as possible, where entrenched schisms are strongly discouraged and members are expected to 'get on with the job' because 'we're all in the same boat' – a small boat.

Strong civil service

The civil service is responsible for executing on the significant roles the state plays in the lives of Singaporeans (Ho, 2000). It is largely subservient to the political class, but there is emphasis placed on professionalism, and elements of negotiated 'collaborative partnership' between the political and bureaucratic elites (Worthington, 2003). The dominant role the civil service plays in matters like housing reinforces its centrality to people's lives; the services provided are generally of good quality, particularly when contrasted with the sub-standard state of infrastructure and services only 50 years ago (Quah, 2010; Singh, 2007).

Significant emphasis is placed on maintaining a high quality civil service; the government aims to recruit the 'best and the brightest' out of the universities (or even earlier), they are paid comparatively well, and it is seen as a prestigious career (Quah, 2010; Singh, 2007). There are also significant opportunities for career development and ongoing education, both within Singapore and abroad. The Civil Service College is a statutory board (i.e., agency) of the government tasked with developing a 'first-class public service'; it provides training programs, publications, lectures, networking opportunities and other resources to government employees (Civil Service College, 2015). Its existence - similar organizations are uncommon in other countries - attests to the emphasis put on developing a high level of competence within the civil service.

Singapore's civil service blends elements of scientific management and customer-centric and performance-oriented service delivery, as is clear from the dual objectives of the PS21 'change movement' of the Public Service Division (2015; and Singh, 2007): High quality, responsive and courteous service to citizens; and the application of state-of-the-art management tools and techniques to constantly increase the efficiency and effectiveness of service delivery. Quah (2010: 5-9) characterizes the main features of public administration in Singapore as:

- *Macho-meritocracy* - Acceptance and promotion within both the bureaucracy and political class are based on merit (i.e., performance against criteria). Respect and deference are bestowed on those that excel in the meritocracy, and there is little questioning of the criteria itself.
- *Competing with the private sector for the best talent* – Competitive salaries and other perks, like free education in exchange for commitment to serve for a set number of years and accelerated promotions based on performance, help the civil service to acquire and retain ‘the best and the brightest’.
- *Low level of corruption* – Corruption is pursued vigorously and without exception, making it ‘high risk, low reward’ and thus rare.
- *Reliance on institutional and attitudinal administrative reforms* – The civil service has been willing and able to transform to respond to national priorities, as outlined by the political class. This was particularly important immediately post-colonialism.
- *Reliance on statutory boards for implementing socio-economic development programs* – These agencies were created explicitly to implement government objectives. They were particularly important post-colonialism when the government was shifting from largely ‘housekeeping’ functions to implementing an aggressive agenda.
- *Effective policy implementation* – All of the above characteristics, plus some others like the country’s small size, have contributed to a government that is largely successful in implementing its policy agenda.
- *Improving service to the public* – A series of internal initiatives, including the aforementioned PS21, have focused on improving service delivery. Civil servants are expected to be highly professional and courteous without discrimination, and there are genuine feedback mechanisms for citizens when they are dissatisfied.
- *Using policy diffusion to solve problems* – Singapore learns from elsewhere and adapts to the local context whenever it can, rather than starting from scratch. This also reflects a risk adversity.

Partnerships with universities and international experts are clearly nurtured and valued, but happen in close coordination, rather than the government passively receiving expertise. Think tanks like the aforementioned Centre for Strategic Futures (2015) are typically arms of the government.

Scientific positivism

Many of the characteristics of the civil service reflect the dominant paradigm. While scientific management may be out of style, or at least moderated, in most western liberal democracies, it has persisted in Singapore. As the previous sections on planning and

decision-making in Singapore illustrate, the government takes a very positivistic approach to setting goals and ‘fine tuning’ delivery in efforts at ‘continuous improvement’. Tools like scenario planning and mechanisms for cross-agency collaboration are used to enhance government performance, while the introduction of potentially conflicting interests is shunned because they might corrupt the process (Singh, 2007). Formal policy evaluation and program appraisal methods are widely employed to promote efficient and effective service delivery, but come with risks – according to Ho (2000: 161):

Professionalism runs the risks of being narrow-minded and indifferent. The Weberian fear of technocracy overpowering the need to be responsive is ever present. Such institutional aloofness probably will undermine the effectiveness and ability to design policy alternatives that take the needs of the general public into consideration.

The power put in the hands of the bureaucracy represents trust put in experts to ‘get things done’ (Ho, 2000). This may be easier for relatively uncontroversial and straightforward challenges, but not for messier problems that inherently create winners and losers, or that do not have obvious answers.

This positivist paradigm is reflected in how the government and civil service are viewed, and view themselves. While the PAP, and government in general, may act according to their own self-preservation, they claim to be concurrently acting in what they see as the interests of the nation; the party and the bureaucracy are at least perceived to be following a “non-ideological, pragmatic approach” in tackling challenges (Mutalib, 2010). While the Party may be a dominant force, it prides itself on nurturing a political elite that, much like the bureaucratic elite, is drawn corporate *headhunting* style from the top university graduates and others that have already distinguished themselves in the public and private sectors (Trocki, 2006). According to Trocki (2006: 130), this is a characteristic that was established in the early days of the PAP government: “The chosen individuals tended to have backgrounds in law, engineering, science, business management and other essentially formalist or quantitative disciplines. They were technocrats. The PAP thus came under the control of a technocratic elite representing not the people who elected them but a sort of ‘non-ideological’ or positivist commitment to ‘universal’ standards of rationality and professionalism.” By this way of thinking, governance is about paternalistic management; options that challenge this notion, like nurturing a viable alternative party, are deemed inefficient and unnecessary (Giam, 2010). The goal has been to provide a government of ‘the best and the brightest’, without much consideration of questions like *best* to whom, and *brightest* at what.

Interestingly, two different interviewees noted that *rationality* can even trump *hierarchy* in the Singaporean civil service. “We are all rational people - if something is put on the table that we all feel is serious, valuable, we will not throw it away, even if it is from the most junior person. [I am] proud to say that in the Singaporean civil service we are very rational, and very practical at the same time”, said one. In the context of climate change and the lower clout of climate agencies, another reflected that:

I think the way that we work, a lot of times people describe the Singapore civil service, as technocrats. We are fairly driven by the hard sciences, the hard numbers, so [...] if an agency who is doing some of these projections and modeling doesn't have the legitimacy or is very new, I think if they have the science behind it to back it up, and the numbers to back it up, I think people will still look to them. Because partly there's no other person to look to and partly we are so driven into looking at hard numbers that I think that is sufficient. Of course, I think, if you're talking about a higher political level of driving climate change direction for Singapore, that is beyond the science of it.

Citizen engagement

While limited, there are outlets for citizen engagement in Singapore. Furthermore, there are reasons to believe that these avenues may be increasing in breadth and depth over time. Yet, the channels for citizen engagement are, for the most part, tightly controlled by the state; the government has consolidated power and reinforced legitimacy by creating and controlling various governance institutions (Ho, 2010).

The government provides avenues for citizen engagement at different levels and stages in planning and decision-making processes. The *reaching everyone for active citizenry@ home* (REACH) agency was established by the government in 2006 to (REACH, 2014a):

- *Gather and Gauge Ground Sentiments – [REACH continues] to feel the pulse of the ground and keep the government apprised of key issues of concern amongst Singaporeans.*
- *Reach Out and Engage Citizens – [REACH works] closely with community and grassroots organisations to reach out to more heartlanders, as well as voluntary welfare groups, professional groups and groups with specific needs and interests. [REACH has] a wide variety of traditional and new media channels for citizens who are interested to engage the government, such as public forums, dialogue sessions, SMS, telephone, email, Facebook and Twitter.*
- *Promote Active Citizenry through Citizen Participation and Involvement – [REACH facilitates] the formation of workgroups to develop ideas into concrete proposals for the Government's consideration.*

REACH works with ministries and agencies throughout government to facilitate consultation on a wide variety of issues. In fact, as noted previously, a 'Public Consultation on Climate Change in Singapore', which was supported by REACH, was conducted from January through March of 2015 (NCCS, 2015b). A Citizen Engagement Handbook uses cartoons and accessible language to make the case and set the terms for public participation (REACH, 2014b). The emphasis is placed on "mak[ing] suggestions that will make life better for Singaporeans" and 'fine tuning' policies (REACH, 2014b: 19). Citizens are invited to comment on policies under development via numerous channels, ranging

from electronic media to ‘tea sessions’. REACH also accepts unsolicited suggestions and questions for government agencies.

Singapore’s long-term planning processes also provide avenues for citizen engagement. As noted previously, the first Concept Plan was not made public. In contrast, the latest round of review involved a lifestyle survey, focus group discussions, and an online survey (URA, 2015c). The URA (2015c) affirms that: “Public consultation is an important component of the Concept Plan process. Through engaging our stakeholders and the public at large, we can better understand our people’s concerns and aspirations as we plan for the future.”

While clearly more open than in the past, these efforts are still bounded, taking place on the government’s terms. They are framed as tools for optimizing policy design and implementation, rather than as manifestations of any deep commitment to democracy. In fact, the heavy use of focus groups and surveys makes these efforts more akin to business market research than to truly collaborative processes. Citizens are asked for their opinions and recommendations, and the government incorporates or disregards as it wishes, leading to potentially wiser, more informed decisions, but not necessarily to policies with greater support, or that are the products of multi-stakeholder deliberations.

Another cornerstone of citizen engagement is access to information. In Singapore, the government tightly controls what it releases. As discussed earlier in this chapter, this in part reflects the sentiment widely held in government that they should have answers to problems before acknowledging them openly. It is also a product of regulations limiting access to information, rather than mandating it – “We do have a secrecy act here that covers the whole of government; in terms of specific information or communication that goes out, that has to be a decision that is made by, in some cases the politicians or at least senior management at the government level”, said an interviewee. The preponderance of information that is released by government agencies appears to be designed to promote the work being done by agencies to engender public support. The publications made readily available – including most of those cited throughout this chapter – are more promotional in nature, rather than deep policy documents that are nuanced and acknowledge tradeoffs and heretofore unaddressed challenges. As is the case with the climate questions noted in the *climate preparedness* section of this chapter, the REACH questionnaires are often leading in nature, highlighting what the government is doing as a precursor to asking what the respondents’ think. The URA’s Singapore City Gallery features several interactive exhibits designed to impress the more than 200,000 visitors a year, and provide a compelling narrative of how far Singapore has come and the exciting things ahead, thanks in no small part to the astute management of the government (URA, 2015d). The LTA’s similar Land Transport Gallery documents the evolution of Singapore’s transportation system and promotes the current Land Transport Master Plan (LTA, 2014c). These attractions are clearly shaped to sell visitors on the government’s solutions and wider approach.

Elected officials are another pathway through which citizens engage with the government and express their interests and concerns. Despite the dominance of the People’s Action Party and close connection with the civil service, Members of Parliament (MPs) do hold the

government accountable and advocate on behalf of their constituents. In the context of the flash flooding discussed earlier in this chapter, for example, MPs called agency officials to the matt to call for action and inquire in to what could be done. However, they were also defensive of the civil service, at least publically, in noting the extraordinary nature of the events and outlining the solutions already being implemented (see PAP, 2013). MPs are key intermediaries between their constituents and government agencies. They clearly advocate to ensure that their respective constituencies needs are being met. However, their relationship with the civil service is largely one of managerial oversight, rather than serving in tension as a check.

Civil society organizations and emerging opposition

Civil society organizations can also play key roles in organizing and representing the interests of stakeholder groups. Singapore has a strong network of 'grassroots organizations' that implement government policies; collect feedback and inform government of citizens' sentiments; organize activities and awareness campaigns; and coordinate citizens in times of crisis (Singh, 2007). They are organized at both the community level (geographically) and around specific issues, like women's welfare, youth support and the particular issues of ethnic minorities. Their place in Singaporean society has traditionally been more complementary to the objectives of the government, rather than oppositional (Ho, 2010; Mutalib, 2010). In the words of Prime Minister Lee Hsien Loong (quoted in Singh, 2007: 63):

Grassroots leaders play a vital role in bonding the people and the government. They promote racial harmony, and social cohesion. They help create a sense of belonging and community spirit in HDB housing estates. They help to explain and defend government policies. They also feed back group sentiments, aspirations and frustrations to the government

The complementary rather than truly democratic nature of these organizations is intentional; they are parapolitical in nature (Ho, 2010; Singh, 2007). Most were created by the state to promote racial harmony, sponsor government programs and advance nation building, not as truly grassroots organizations that sprouted from citizens' dissatisfactions. In many respects, they coopt grassroots activism for the interests of the state. The People's Association - which is the umbrella organization for grassroots organizations, providing administrative support - is actually a statutory board of the government, chaired by the prime minister (Singh, 2007).

It is apparent that citizen engagement in Singapore is tightly controlled, with limited opportunity for true dissent. However, there are signs that this may be changing, albeit gradually. In addition to the aforementioned challenges to the PAP at the ballot box, civil society organizations are increasingly willing and able to organize and speak out against the government on issues. Protests are only permitted in one park, Speakers' Corner, but the number and size of these demonstrations has been growing - from 85 in 2011 to 98 in 2012, then 169 in 2013 (Harjani, 2014). Grievances aired in these protests have included immigration policies, increases in public transit fares, the pension system, and government

transparency and accountability. Nonetheless, some argue that these protests are unlikely to become substantial, like those in Hong Kong have, for various reasons, including tighter controls on the media and lack of true independence of important organizations like the trade unions (Loh, 2014; Trocki, 2006).

Beyond protests and elections, citizens, both individually and in groups, are increasingly willing and able to develop comprehensive critiques of government proposals. Strong opposition to the development of transportation infrastructure and housing in the Bukit Brown area, which is discussed in the callout box below, is an example of civil society cautiously organizing to challenge government proposals, conducting research to support their arguments, promoting their causes in the public sphere, and engaging with government agencies to resolutely make their case. The delay of work on the new King Albert Park MRT station because of vociferous opposition from residents of the Maplewoods condominium complex is another example; while the LTA ultimately proceeded with few amendments to their original plans, citizens were able to force various public meetings and delay the project by months (Chan, 2011). According to an interviewee from the LTA that thought the process could have been handled much better, the government lost almost a year on the project, and learned that they need to do better, and more targeted stakeholder engagement in the future.

There are various reasons why civil society organizations may be becoming more independent, and able and willing to challenge the government when they feel it is necessary. First of all, the historically key and widely supported national priorities like economic growth and national security may be diminishing in their centrality as the problems they address become less acute. Singapore is wealthy and its neighborhood more stable, so other issues, like nature protection and historic preservation in the case of Bukit Brown, are becoming increasingly important to citizens. Secondly, the population is increasingly educated and confident, and thus expects greater access to information and decision-making (Harjani, 2014; Ho, 2010). Social media also plays a role, insofar as it allows uncensored information to travel more freely, and facilitates (truly) grassroots organizing.

The government is also playing an, albeit guarded, role in allowing and even facilitating greater civil society engagement in decision-making. In the words of an interviewee from a planning agency:

A lot of times we prompt the other government agencies to also think through these issues while they are formulating the policy. And I think this public engagement thing is definitely getting more traction in Singapore [...] I think we have always, at least in [our department], we have always been quite active in public engagement, I think that the climate now is that the government wants to come across as doing more - more engagement, more open to hearing different views, making sure that there are sufficient channels for feedback and comments. So, I think it has become a little bit more overt, and yes we need to consciously think about if we should engage more than before. [...] It partly is because of the outcome of the last election, where the ruling party [received less] votes. And a lot of the issues that led up to the election outcome

[involved] dissatisfaction with how some of the infrastructure works are [proceeding], the high cost of living, congestion on transportation. So, some of these issues, they kind of catalyzed the need for broad new policies to tackle this. And I think underlying all that is that the citizens really wanted to be heard a lot more. [...] I think, politically, the climate has shifted that way, partly because of the reaction from the ground, the responses. Even our political leaders have also, some of the more senior leaders have stepped down, so there was, I suppose what we call 'new blood' coming into the political system. So there are new ministers pushing for doing things a little bit differently. So I think there is a little bit about that awakening that we need to do more, we need to demonstrate that we are doing more [engagement].

How the role of civil society will evolve in Singapore remains an open question. "The real test will come from the PM's leadership in galvanizing and rallying Singaporeans to keep faith with the government as it tackles some difficult issues that are bound to surface, and the bitter pills they must be prepared to swallow to enable the republic to sustain its hard-won prosperity", says Mutalib (2010: 52).

Bukit Brown: Civil Society Opposition to Development in Singapore

Singapore is one of the densest states in the world, with 7,500 people per square kilometer (Department of Statistics Singapore, 2014). As a result, there are few areas in which nature is largely left alone. Singapore promotes itself as a 'garden city', but most of the green spaces are artificially constructed and highly managed (Neo, Gwee and Mak, 2012; Tan, Wang and Sia, 2013). It has also displaced many of its historical landmarks and cultural places, including former cemeteries, through rapid development over the past 50 years (Perry, Kong and Yeoh, 1997; Tan, 2013b). Bukit Brown is thus a rarity – an abandoned cemetery almost one square kilometer in size with 80,000 to 100,000 graves (possibly the largest Chinese cemetery outside of China) that has become a sanctuary for wildlife, and for those looking for peace, nature and cultural heritage (All Things Bukit Brown, 2015; Economist, 2012; Lamb, 2013). One can find rare birds and statues honoring the deceased among the brush, making the area an important space for an eclectic mix of environmental and cultural heritage activists, recreational users and decedents of those buried there.

It is against this backdrop that the government has faced opposition to a planned eight-lane road, which will dissect Bukit Brown and likely portends future development in the area (Lamb, 2013; URA, 2014). In fact, one justification for the road is the future development of an HDB estate (i.e., satellite town), although this is expected only 30 years or so in the future. Only 4,000 graves will need to be exhumed to make way for the highway, but opponents charge that it will spilt the area in two and fundamentally change the character of the area. For a country in which challenges to the state are rare and typically muted, the activism to protect Bukit Brown is an interesting phenomenon. While still very civil, various opponents to development - including more traditional NGOs like Nature Society (Singapore) and the Singapore Heritage Society, informal and issue-specific groups 'all

things Bukit Brown' and SOS Bukit Brown, and international organizations like the World Monuments Watch - have employed a range of tactics to mobilize and bring pressure to bear (All Things Bukit Brown, 2015).

The Nature Society (2011, 2012) released a position paper, based on more than 20 years of monitoring, that catalogues the species of flora and fauna in the area. They conclude with a set of recommendations: Declare Bukit Brown a heritage park, and potentially apply for UNESCO World Heritage status; wait to develop transportation infrastructure until it is clear that there will be a housing estate; conduct an environmental impact assessment on the road and potential estate; charge a toll on the currently congested road to see if that alleviates the traffic problems; consider alternative routes for the proposed road; and consider burying or elevating the road, and/or reducing the proposed size (Nature Society, 2011). Aside from making proactive suggestions that consider the government's priority (i.e., traffic congestion), the Nature Society attempts to promote their concerns as complementary to the national interest, stating that (2011: 14): "This can be a challenging engineering opportunity that could showcase the talent of Singapore and set a benchmark for Asia in sustainable development". They were also careful to acknowledge the work of the government, complementing the "great effort and thought that has been put into formulating the current plans" (Nature Society, 2011: 15).

The Singapore Heritage Society also released a position paper, which is critical of the government's decision to build the road, stating that it is "deeply disappointed with the plans". The paper details the historical significance of the cemetery; calls for alternatives to the new road, like expanding the existing roads in the area, at least for the medium-term; suggests that a proper cost-benefit analysis and an environmental impact assessment should be transparently done on the project; calls for 'genuine' consultation and criticizes the shortcomings of the process conducted; and suggests that Bukit Brown be listed as a heritage site, the entire cemetery documented, and the area become a heritage park (Singapore Heritage Society, 2012). The criticism of the government's decision-making process and frank calls for 'genuine consultation' are particularly surprising in the Singaporean context, especially from an established civil society organization. The report concludes that (Singapore Heritage Society, 2012: 17): "Genuine consultation between government and civil society is not common. In reality such 'consultation' exercises are opportunities for the authorities to explain their rationale or to fine-tune decisions which have already been made. This is unfortunate because genuine consultation processes have political, knowledge and cost value." Nonetheless, the Society is careful, complementing the Prime Minister's comments on the need for 'inclusive dialogue'. The Heritage Society has also released statements, written op-ed articles, co-organized a public symposium, and is participating in the documentation process discussed further below (Singapore Heritage Society, 2013).

SOS Bukit Brown – Save *Our* Singapore is a truly grassroots effort by a small group concerned about the cultural and environmental damage the road will cause (SOS Bukit Brown, 2014). Their primary effort has been collecting signatures for a petition urging the government to reconsider the project. Reflecting their hubris, the group's highly ambitious

original goal was to collect 100,000 signatures by the end of 2011 (one for each grave); they had only collected around 2,000 by mid-2012 (Economist, 2012; SOS Bukit Brown, 2014). SOS and other groups like it rely on Facebook and other social media to spread word on the Bukit Brown issue and foster support among the public.

All Things Bukit Brown (2015) is another grassroots initiative, with the motto *Heritage. Habitat. History*. According to its website, the group is:

[A] labour of love born out of the twin desire to record history and, in a nod to our pioneers, contribute to education by sharing what we learn and find. 'We' are a loose group of strangers who became friends on the Facebook page, Heritage Singapore - Bukit Brown Cemetery. As we interacted organically, we began to have extraordinary experiences in finding our roots – of Singapore, our own families and the rich ecosystem which is flourishing in Bukit Brown. [...] As beneficiaries of this unique process, we decided to formalise this so that we can share on a more structured platform and reach out to individuals, especially educators and students. We hope a.t.Bukit Brown will be the starting point for individuals to begin their own journey of discovery, to bridge their past to the present.

a.t. Bukit Brown has become an extremely active and well-organized group, engaged in an extensive set of ongoing activities, including: Various guided walks, which have taken over 13,000 people through the cemetery; four exhibitions to raise awareness; three academic publications; widespread media coverage; and a partnership with World Monuments Fund, as discussed further below (All Things Bukit Brown, 2015). The group was awarded in the inaugural Singapore Advocacy Awards (2014).

The role of Facebook and other social media in the emergence and success of SOS Bukit Brown and All Things Bukit Brown is notable. These groups were able to materialize outside the formal channels and restrictions placed on traditional civil society groups (Kai, Pang and Chan, 2013). Social media allowed for the rapid exchange of unfiltered information and facilitated coordination among likeminded but previously disconnected activists. These groups continue to use social media and the internet to post images and messages, and promote their events, keeping the issue alive. Considering the Bukit Brown case, Kai, Pang and Chan (2013) conclude that, rather than leading to the 'demise of place', the internet is allowing connected activists to create 'micro-public spheres' in which issues can be more freely debated and the government challenged. They add that these loose networks operating in 'parallel online and offline worlds' are delivering on the promise of 'technopopulism' that more information can improve lives, yet caution that certain voices can come to dominate in this sphere too (Kai, Pang and Chan, 2013). Dissertation interviewees concurred on the importance of social media, and its ability to help more informal networks emerge and thrive outside the traditional channels. In the words of one:

Actually, if you look at the case of Bukit Brown [...], I think what's happening now is just that their voices are getting louder because of social media. I don't think it's an issue of they weren't consulted in the first place, because probably the necessary, let's

say the Heritage [Society] or the Environmental Board, would have to be consulted before the decision was honestly made. And they would have to go through, probably, certain engagement processes themselves. So I think it's because of social media, which actually amplifies the voice of these minority groups.

This comment underscores the traditional nature of government consultation through a handful of well understood and largely government controlled advocacy organizations, and how it is being undermined by heterogeneous groups of activists self-organizing in more or less informal organizations. These groups rely on social media to organize and thrive.

In addition to the local networks, activists fostered international links for support as they attempted to shame the government into reconsidering the project. The World Monuments Fund (2015) included Bukit Brown on their World Monuments Watch 2014 list – a first for Singapore – stating that:

This is a significant loss to the families of those interred there, as many graves are being relocated (or unclaimed remains dispensed at sea) for the road construction; but in destroying the cultural landscape of Bukit Brown, it is a loss to all of society. Local groups and residents, as well as the international community, are calling for more transparency on the part of the government and for a participatory environmental impact assessment that would evaluate the full social, economic, and ecological costs of the development plans and the effects on this historic cultural landscape. Inclusion on the Watch seeks to bolster these efforts and promote a better future for Bukit Brown.

Suggestions were also made to propose the cemetery for UNESCO World Heritage Site status (Tan, 2013b). All Things Bukit Brown has promoted its popular guided tours to foreign tourists as well. In fact, the cemetery was a TripAdvisor *Travelers' Choice 2013 Winner*, and ranked 16th of 665 attractions in Singapore at one point, thanks in large part to the groups tours (All Things Bukit Brown, 2013).

Ultimately, it appears that activists' efforts have not swayed the government to cancel the project. In fact, the latest plans from the URA reaffirm that much of the cemetery should eventually be removed for housing (World Monuments Fund, 2015). Nonetheless, the activism around Bukit Brown may be a harbinger of increasing willingness and capacity to organize and speak up. Among other factors, citizens, both individually and in networks, are increasingly vocal and expect a genuine hearing of their concerns. The aforementioned Singapore Advocacy Awards are evidence that activists are getting organized, and increasingly tolerated. Interviewees reflected that this kind of public pushback over a proposed infrastructure project is traditionally uncharacteristic of Singapore, but increasingly common.

Some interviewees reflected confidentially that they see things changing on the government side as well. "With environmental groups, the government is engaging more and more; we learned from Bukit Brown", said one interviewee. She added that:

[The government] needs to understand other actors and what they want, and then we can work around their 'pressure points' - It's not a question of who you want to engage, but how. Sometimes we come across as dogmatic, but [we increasingly] appreciate that we can't go into a meeting and say 'we know that this is what is best for you, and this is the way we will do it'. That is the way it used to be done, but it wasn't working anymore. Now it's more 'co-solutioning'.

There is also reason to believe that the government is cognizant of the potential threat grassroots activists may be to their authority. While they did not alter their plans, the government did make some efforts to respond, in part by re-legitimizing the traditional NGOs and supporting documentation efforts. The LTA and URA cosponsored Bukit Brown Cemetery Documentation Project (2013) has convened an expert Working Committee, which includes a representative from the Singapore Heritage Society, to 'holistically' document the graves that would need to be exhumed and the wider socio-cultural history in the area, and make the information accessible to the public via a special website (www.bukitbrown.info). In its last press release on the project, announcing that the LTA has awarded a tender to construct the road, the government concludes by stating that they will "continue to work with other agencies and stakeholders to commemorate the heritage of Bukit Brown" (URA, 2014). The government coopted some of the civil society concerns, and traditional advocates, as they moved ahead with the project but attempted to ameliorate the fallout.

For more information on the Bukit Brown case, see All Things Bukit Brown's active website (www.bukitbrown.com). The government-sponsored Bukit Brown Cemetery Documentation Project may be found at www.bukitbrown.info.

Research process and outcomes

Research design and process

Research design required a consistent approach to all three cases. That approach is outlined more extensively in the methods section of the first chapter. The success of this research hinged on engaging actual infrastructure-related stakeholders. This required strong local project partners. In this case, that was the Singapore Civil Service College, which provides training programs, publications, lectures, networking opportunities and other resources on both substantive and skills-based topics to officers at different levels across all parts of the government (Civil Service College, 2015). The College supported this work by hosting the two workshops and soliciting participants under the auspices of a training "workshop exploring the management of risks and uncertainty in infrastructure-related planning and decision-making".

Approximately 35 individuals were engaged in Singapore. A few of these people were interviewed prior to the workshops to get a preliminary sense of how infrastructure planning and decision-making happens in practice; what is being done to adapt to climate change; and who the key players are. 30 participants were involved in the workshops themselves, as discussed in more detail below. In addition to follow-up interviews with most of the workshop participants, interviews were conducted with other key actors after the workshops to gather additional information and “ground-truth” the findings.

The primary means of engaging project participants was via two half-day workshops in September and October of 2013. These workshops were attended by 14 and 16 participants respectively, which were identified and solicited using a snowball technique, working outwards from key project partners in the Singapore Civil Service College, and to a lesser extent the Ministry of Transport. As in both Rotterdam and Boston, participants were solicited based on their real-world relationships to the decision-making simulated in the exercise. They came from various branches of government: The Land Transport Authority, the Centre for Public Project Management, the Housing and Development Board, the Public Service Division of the Prime Minister’s Office (which does strategic planning), the Urban Redevelopment Authority, the Ministry of the Environment and Water Resources, the Ministry of Defense, the Ministry of National Development, and the Civil Service College. All participants but one – a university faculty member - came from inside government. While the absence of other non-governmental actors was unfortunate, the overview of decision-making in Singapore provided in the previous section of this chapter suggests that it is representative of decision-making processes in the real world; private firms may be at the table when directly relevant (i.e., there will be some sort of public-private partnership), but civil society groups are largely absent.

The half-day workshops featured two different versions of a role-play simulation exercise (RPS), but otherwise followed the same routine: Participants first filled out pre-exercise surveys. They then received their instructions and prepared for the RPS; they were given shared general and individual role-specific ‘confidential instructions’ that outline their interests, and provide additional information that they may or may not share with the rest of the group. Participants were assigned roles different from those they hold in the real world to foster reflection and perspective taking. The exercise ran approximately 90 minutes each time. These runs were followed by debriefings in which the participants reflected on what happened during the exercise, how similar or different their experiences were to those in their real-world settings, and how the differences and similarities may inform real-world planning and decision-making. The workshops concluded with participants completing post-exercise surveys. Semi-structured one-on-one interviews were conducted with most participants in the days following; these typically lasted between an hour and ninety minutes, allowing for further discussion around the themes that emerged from the workshops. Participants’ pre- and post-exercise surveys were not anonymous, so they could also be followed-up on during the interviews.

The RPS exercise designed for this project is called *A New Connection in Westerberg*. Participants are placed in a fictitious yet realistic situation in which a group of stakeholders has been brought together as a special working group to consider if and how to reconcile

some recently identified and still uncertain climate risks with plans to construct a new road, which may be vulnerable if certain design options are chosen. While the case presented in the RPS is highly simplified and clearly not Singapore, elements bear some similarities to challenges Singapore faces. The tradeoffs between constructing roads below grade versus elevating them, which is a key feature of the RPS, are actively contemplated in Singapore; most of the 12km Kallang-Paya Lebar Expressway, which opened in 2008, is underground, and the LTA is considering building a much more extensive underground road network (REACH, 2013; Tan, 2013a). Underground roads mitigate visual, noise and air pollution, and leave more land for development, but may also be more vulnerable to flooding. As evinced by the Bukit Brown case, there has also been tension in Singapore in recent years around putting roads through ecologically sensitive areas, which is another dimension in the RPS.

There are two versions of the RPS. The differences offer an opportunity to explore how different tools for framing uncertainty have implications as stakeholders consider the adaptation challenge, and the outcomes they ultimately reach. One version asks participants to consider their options against four plausible but mutually exclusive, qualitative scenarios of the future. The other contains a more conventional risk assessment forecast of future climate conditions. In Singapore, as in Rotterdam, these versions were run as separate workshops on two separate days. The number of participants – 14 for the risk assessment RPS workshop and 16 for the scenarios RPS – was sufficient for two independent groups each time. Each group played the RPS separately, but then reconvened for the debrief conversation. Having two separate groups play the same exercise each time allowed for comparison both with the participants (during the debriefs) and later, using the exercise recordings and transcripts. Playing the two different versions with similarly constituted groups provided insights into the efficacy of scenarios versus risk assessments.

The remainder of this section is comprised of five parts: The first four focus on the progression and outcomes for each of the groups that participated in the RPS in Singapore (two risk assessment and two scenarios), including information gathered during the debrief conversations. The fifth section focuses on the data collected from the pre- and post-exercise surveys. Information gathered from the in-depth interviews is used throughout to reinforce observations.

Outcome: Scenarios group #1

One of the two groups that played the *scenarios* version of the *A New Connection in Westerberg* RPS arrived at a 'D+' option that involved enhancing the capacity of the existing road, climate proofing the infrastructure, and enhancing freight rail service. They recommended that passenger rail service not be implemented now, but kept open as an option for the future. This package left \$250 million of the \$2.5 billion project budget unallocated, so they made the novel recommendation that these remaining funds be used to assist port users with the transition to rail. As discussed further below, this was a response to the port representative's insistence that they not suffer negative economic consequences from the decision made, and the rest of the group's acquiescence.

In contrast to both cases in Rotterdam and the second scenario group in Singapore, the deputy director (i.e., meeting chair) was not particularly active. She only made 23 interventions, allowing participants to interact directly with little facilitation. In fact, the process was more or less hijacked by the environmentalist. The chair's initial remarks and suggestion that they go around the table and discuss the first option (the below-grade road) were immediately countered by the environmentalist, who said: "I wonder if instead of going option by option we could do a bigger overview of what the major issues are?" The environmentalist pivoted from this to making statements about the substantial climate risks, and need to consider how technology like driverless cars might change the situation.

In general, the environmental NGO and port representatives dominated the discussion. Quantitatively, they spoke most frequently, with 71 and 70 interventions respectively. By comparison, the other participants made 20-24 interventions each. Qualitatively, the environmentalist was particularly forceful and persuasive in her arguments for option D+. She made arguments to advance her interests and perspective:

[We] all know what happens when you build a road, you get more vehicles – It's only a temporary fix to the congestion problem [...] 20 years down the line, if you haven't expanded the railway infrastructure, you are just going to be back to getting more demand for more roads, and you are going to be back to spending billions more. [...You] want to build a system that has multiple alternatives, so that if the A13 [i.e., existing road] gets flooded out you have alternatives. One way to do that is to just build another road, but that is not going to solve your vehicle density problems beyond a few years. Another is to look at a set of transportation options - so you take a lot of the heavy freight off and you put it on rail, then you use the roads for more of this flexible kind of transportation.

The environmentalist was also quick to challenge the competing arguments of others. For example, when the port representative noted that they are forecasting 15-20% growth in vehicular traffic she questioned the assumptions that went into that. Unsatisfied with the port representative's response, she pressed: "But are those predictions made assuming that vehicles operate exactly the way they do now and nothing changes, or is there any new technology, new traffic management systems?" The environmentalist ultimately forced the port representative to acknowledge that not all possible future technologies had been considered in their projections. The nature and extent of the environmentalist's interventions explain, in large part, the outcome.

When asked why they listened to the environmentalist in the post-exercise debriefing, particularly given that she was the only non-governmental actor at the table, participants emphasized that they wanted to make 'data-driven decisions'. They said that they assessed her arguments and that she made a convincing case that D+ was the most 'rational' choice. "Our NGO talks like a professor", said one participant. In other words, she succeeded based on the perceived merit of her arguments. However, participants acknowledged in retrospect that her arguments were clearly rooted in her interests. Furthermore, they stated that it is not very realistic for a 'greenie' to have an equal seat at the table, as was the case in the exercise, but that it did add value here and perhaps can in reality. In practice,

“the process of engagement is actually very, very downstream, so by the time people are brought into the discussion it’s really for info and for reference, rather than for your inputs”, reflected a participant. While they saw advantages to engagement, many were also concerned about potential disadvantages, including wasting time and the misuse of sensitive information. Many expressed faith in the government as the most capable of making ‘rational’ choices, while the exercise reflected that interests can, and perhaps should, greatly shape the outcome.

While the environmentalist was a more dominant force, the port representative did continue to express great concern with the D+ option, arguing that it would not satisfy his clients’ needs and preferences for road over rail. In particular, he made persuasive arguments that the pricing models of rail over road were unfair. Realizing that there was still funding on the table and that he was not going to succeed in blocking the D+ option, toward the end of the negotiation he creatively pitched that: “I guess the remaining \$250 million could be used for subsidizing the transition for operators from road to rail”. The environmentalist was the first to agree and a ‘win-win’ compromise had been found. It was clearly not the port’s first choice, but it was an option he could live with.

Information was shared relatively freely and early in this run of the exercise. The senior engineer disclosed the rail option, including costing details, very early, and without being asked by anyone else. In most other instances, it was the environmentalist that proposed the rail idea and the engineer provided data on it more or less freely when asked. The port was unhappy with this proposal, but the others accepted it as a viable option and it was on the table from an early stage. Similarly, the flood protection specialist noted early on that dikes on which part of the existing road is built will need to be strengthened in the near future, and freely volunteered that his agency has funds available to support this work, which could be complementary to option D. The availability of this extra money, which did not come out in any other exercise run, made option D look all the more attractive.

Outcome: Scenarios group #2

The other scenarios group also concluded with a ‘D+’ recommendation that involved enhancing the freight rail but not the passenger service in the near future. The group agreed that they would leave options A and B - the new road below or above grade respectively - open, and suggested further feasibility studies of each. This last, creative, component was added to ameliorate the concerns of the port representative who felt that option D+ would come at too great an opportunity cost. While the outcome was somewhat similar, the path to D+ differed in important ways from the first group.

The interactions were relatively balanced among the various actors in this group, with the exception that the environmentalist was the least active. This is a stark contrast to the first scenarios group. While not dominant, the Project Manager from the Municipal Department of Traffic and the Senior Engineer from the National Transport Agency did play outsized roles insofar as they emerged as sources of information that others saw as objective and trustworthy. It is notable that they approached this task differently, particularly with regards to the interests and concerns of others. While still providing technical information,

the municipal project manager tackled the interests head-on and framed his recommendations vis-à-vis the concerns of other stakeholders. In one of his early interventions, he stated:

Before I propose an option, let me just lay out some of our considerations in making this choice. [...] the Alderman has actually two competing objectives - one of which is that she needs to reduce congestion in the city itself, while at the same time managing the environmental impacts on Bloomland. So, from that point of view we would like to put forward that Bloomland may have some increase in environmental impact, but it is certainly no worse than what is actually currently going on in the city, and that the congestion in the city is a bigger issue and it needs to be solved with this additional A39. So we proceed on that basis. For [the environmentalists], the interest that you have here is protecting the environment, and we would like to choose an option that has the lowest environmental impact possible, while still being relatively quick to implement and does not have many unintended consequences. While, for [the flood protection specialist], of course, you want to have a solution that takes the long-term impacts into account, long-term flooding with climate change. Of course, with Deputy Director madam, we have done a cost analysis and I will lay that out in a bit, but safe to say that we would like to choose an option that is most cost-effective, yet takes into account our long-term planning. [...] from the Port Authority, we would like to choose an option that has the highest capacity to deal with traffic moving out from the port so it can grow quicker and make money.

He went on to (initially) propose option B and share technical information relevant to both it and the other options. What is notable is that he started by attempting to reconcile the various concerns of the different stakeholders, playing the role of what might be called an 'objective and rational consensus builder'. In contrast, the senior expert disregarded the interests of the different stakeholders. In fact, she appeared to want to actively avoid them. At two different points, she made comments like: "I would like to just put some facts and figures on the table; for us, from the engineering point of view, we don't really consider all your [political] considerations – it's a design matter". Both (attempted) to act objectively, but what they saw as an objective role differed – to the project manager, it was considering the various concerns and attempting to reconcile them in a balanced way, given the information at hand. To the senior expert, it was disregarding the interests and focusing on 'the facts'.

Option D+, which the group ultimately arrived at, was not strongly advocated for by anyone initially, but gained traction, seemingly on its (perceived) merit as the participants methodically considered the options. The municipal traffic project manager played an important role here too. Shifting away from his initial recommendation of option B, he came to support and ultimately champion D+ after evaluating the cost and capacity improvements involved, compared to those of other options. This is notable because the confidential instructions for this role are actually negative on this option, saying that: "Option D is barely acceptable; it would at least improve the existing roadway, but it does not increase system robustness". Despite this, the participant filling this role examined the facts on the table and concluded that, in his own words:

I think from a purely numbers point of view it seems to fit, because currently our shortfall is 15%, so purely by upgrading the rail network you are already covering the shortfall. And then the future growth is about 15%, which, by picking option D you are able to cover, to plan for future growth. And at the same time you are fixing the dike, reduce the environmental impact, we don't affect Bloomland, and we do it at a lower cost than options A or B.

The others were more or less persuaded, and D+ was the option chosen. In this sense, it may be said that the group had a *facts-based*, rather than *interests-based* deliberation. However, the port still played an important, interests-driven, role, as evinced by the fact that the representative was able to get a call for further research on options A and B included in the final agreement the committee reached.

Furthermore, while largely facts-based, process still mattered. In fact, the process followed was a substantial reason why the deliberations were more facts-based. The deputy director (i.e., chair) played a key role in focusing the group on technical questions, and gave the technical participants more legitimacy by explicitly and repeatedly calling on them for input. For example, after a round of introductions and expressions of priorities and concerns from each participant, she pivoted to the experts to identify what they saw as the most rational choice, saying:

I think we have a very good mix of perspectives for an interactive discussion today. So, I made a list of A, B, C and D, each option - low road, high road, through the marsh area, or expanding the existing road. So perhaps we could have [the project manager] give us a sense of which options you think the Transport Authority might select.

As in the first group, technical information was disclosed relatively freely. The D+ option was only on the table because the senior engineer introduced the possibility of rail and openly shared all of the data she had. On the other hand, she was somewhat less forthright than her counterpart in the other scenarios group, responding very openly to others when asked but putting less out proactively. In fact, the rail option emerged relatively late in the deliberation – largely because the environmentalist, who is ostensibly the champion of this option, remained quiet. The expert was asked why she did not share it earlier, to which she replied: “People didn’t ask!” This fits with the aforementioned role she took on as a technical expert that was very happy to share information, but was at arms length to and reticent to get involved with, the interests-based preferences of others.

It is notable that the scenarios had little influence on the proceedings in either of these groups, nor in Rotterdam or Boston. They are presented as a tool for the group to assess the options against four different possible futures, given key uncertainties. In the first scenarios group in Singapore, the deputy director (chair) introduced the ‘assessment of robustness’ as a goal for the meeting upfront, but the scenarios were not used or referred to at all thereafter. Many participants implicitly defaulted to the ‘wet and busy’ scenario. In the other scenarios group, the flood protection specialist did invoke the scenarios in explaining his preferences, saying:

[Option] C does well against most of the scenarios we developed - the dry and quiet, wet and busy, etcetera - so for us, the Flood Protection Agency, we would like to ask you to consider which options minimize the risks involved. We need to really take into consideration some of the possibilities of what might happen, rather than considering the possibility of what might not happen. So, let's be a bit more careful. In that sense, we want to strongly advise against option A. Even though you may have some potential protection measures, they are not guaranteed. No matter how good are the benefits involved, once there is flooding everything will go bad. So we need D, but also perhaps C.

However, it is notable that, while ostensibly a nod to the scenarios, this was ultimately a call for the group to plan for the worst-case scenario. The flood protection specialist is most focused on mitigating risks, and thus made the case against option A, which was preferable to others based on their interests and concerns, and for option D because of the additional dike work it could entail. Otherwise, the scenarios were not mentioned.

Outcome: Risk assessment group #1

As noted previously, two separate groups played the risk assessment version of the RPS exercise as part of a separate workshop, on a different day from the scenario groups. Methodologically, attempts were made to 'match' the participants so that the scenario versus risk assessment groups were similarly constituted; for example, participants from the Land Transport Authority were present both days.

The first risk assessment group settled on option B - the elevated road - with additional investments in noise, air and visual pollution mitigation. The downside of this option is the negative impacts on residential neighborhood Bloomland, so the group also agreed to fund consultants to conduct community outreach. However, it is important to note that this outreach was framed as more educational than truly consultative in nature. "[We] can support you to do a public consultation, an exhibition to educate the members of the community of Bloomland, because today we already have quite a number of expressways cutting through the city, and if you look carefully they actually cut through a huge tract of residential areas, so the new a 39 is going to cut through Bloomland, which actually has a less dense population, and so [...] we actually have traffic data and noise data and pollution data that we are able to share [to show] it's actually not really a big issue", said the Municipal Traffic Department project manager, adding that "The traffic department has also conducted some health and quality-of-life assessments, and engaged an expert from MIT to help us assess the impact of traffic on quality of life, and we find that it is no worse off or better elsewhere". Parties saw the task as one of *explaining* decisions made based on objective criteria, rather than truly *listening* and *responding* to community concerns.

Whether and how to consult citizens became an important, recurring theme. When it was proposed at a later point that alternatives A and B simply be put to residents for their consideration and preference identification, some parties were hesitant. "But the residents are also very short term in their thinking; they will, of course, say that they want [the road]

to go underground because it effects the property price and rental in the next three years, but for us as government officers we need to think of the long-term, so we must be very careful when we go and consult”, said the senior engineer. “Yeah, because I think also if you go consult, the immediate neighbors will definitely feel more impact [and] the majority may not feel so impacted, so the majority may hurt the minority”, added the environmentalist. To the port representative, this just underscored the need to educate the citizens properly – he added that “there may be good points we can sell”. A later interaction went as follows:

Alderwoman: *Shall we engage the stakeholders?*

Senior engineer: *Yes, if we were to go for B, we would definitely need to engage the stakeholders.*

Alderwoman: *Then again, just for your information, the extension of our railway into this part of the city could be very important.*

Environmentalist: *Yes, I think if you're going to engage stakeholders [it shouldn't] just be options A and B, but also option E [i.e., a D+ option with rail].*

Senior engineer: *I would like to say that maybe we do not introduce the differences between the options A and B to the stakeholders, because there is very little difference and they will consider the kind of impact that they think they will get, but I think we should just narrow down and basically just consult them on the option we think is best.*

Port representative: *I don't think that's a good idea. I mean, we are in a democratic country, we should give them the choice, and they ought to know what is available.*

Alderwoman: *When you want to consult them, I think we should let them know what are the real options, but we are the decision-makers and we still have the final say. After consulting the different stakeholders, I think we can make our best decision.*

Senior engineer: *It's harder - I think it's harder. If it comes back that 90% of the stakeholders want A and not B, then it's harder [for us to proceed with B].*

This interaction illustrates an important distinction between what the alderwoman and the senior engineer expected out of ‘consultation’ and how they believed it should proceed. The alderwoman wanted a process that managed the expectations of citizens and maintained decision-makers’ authority, but also saw it as valuable to collect citizens’ opinions and get a sense of their preferences. In contrast, the senior engineer saw this as an educational endeavor to convince citizens of the benefits of the chosen option, with the risk being that they do not go along. To her, the task was to ‘consult them on the option we think is best’ (emphasis added). This is a debate that is real in Singapore today as civil servants wrestle with how best to engage citizens.

As noted previously, the group agreed upon some mitigative measures – like sound walls and state-of-the-art pavement - to reduce the noise, air and visual pollution associated with option B. These investments were intended to allay the concerns of the alderwoman that constituents would be highly impacted by an elevated road through their community, and would subsequently punish her in the next election. The group noted that these extra measures were included to address community concerns both from a ‘technical’ and ‘lifestyle’ standpoint. The challenge was financing - option B alone was projected to consume the entire \$2.5 billion project budget, and these extra measures were estimated to cost an additional \$750 million. The alderwoman had some additional funding (up to \$1 billion) noted in her confidential instructions, which she could reveal and commit to using at her discretion. It is surprising enough that she agreed to option B - even with the additional measures, as it is still suboptimal for her - but what is even more surprising is that she agreed to bankroll these extra measures. In fact, the role confidential instructions suggest that B is the alderman’s least favorite option, and that he or she “would certainly NOT want to put [the additional funding the city can make available] towards either options B or C”. While she expressed concerns with option B, the alderwoman ultimately acquiesced in the deliberations. During the debrief, she said that she was convinced based on the ‘merit of the arguments’, stating that: "I did start to buy it, because I do have to look the greater welfare and not just the air quality or the noise. Because if you look at the jobs that will be created if there is a good network, and good accessibility to different parts of the city, I thought this could actually be good. " In other words, she was convinced that other values - like enhanced mobility and the jobs it would supposedly bring – were more important than minimizing the impacts on the residents of the neighborhood the elevated road would pass through.

It is notable that, while ostensibly technical experts, and seen as credible because of this, the senior engineer from the National Transportation Agency and the project manager from the Municipal Traffic Department were very influential actors in this group. They provided extensive advice to the group, but it was arguably colored by their preferences. This was particularly evident in the case of the project manager, who even made up information to advance his case, saying that:

The traffic department has received many, many complaints from residents in Bloomland because of congestion, because they need to make a big detour. They need to take this road and go all around this way to get downtown, and some of their families live across the river, some of their children go to school across the river, and the university is way downtown. So we receive a lot of complaints, and it can become a political [issue] for the alderman in two years time if the residents' request for traffic help is not handled well. That is why, from our perspective, options A and B are still worth considering, although you might have to deal with residents' complaints of noise and so on.

None of this – the complaints and the locations of different amenities within the city that he spoke of - was in his confidential instructions. The senior engineer appeared to be less driven by a particular agenda. When asked for her preferences early in the meeting, she responded that “maybe it's better for the committee to consider all this before I talk about

my preferences; I am rather someone who can come in and help out with technical issues and questions”. Nonetheless, she was very keen to step in and provide information throughout; she made 46 interventions, while all other participants made between 30 and 38. While typically factual, these interventions were arguably not value free. For example, she critiqued the D+ option, saying that: “The key is still this - If you go for D and not A or B, and there is congestion on the A3, then when there is accident that means [...] the port is going to be stuck [...] There is no diversion, there is no bypass”. These actors were able to have an outsized influence because of the legitimacy their expertise bestowed and because, like the environmentalist in the first scenarios group, they used fact-based arguments to advance positions that others might accept as ‘rational’.

The chair of this group (i.e., the deputy regional director) played an important, but not dominant role. She intervened 37 times, which was the third most frequent, and many of these interventions were clearly intended to help enhance the group’s effectiveness and efficiency in reaching a broadly supported outcome. She allowed the group to proceed without her intervention for periods of time, but when she saw them going down what she felt was an unproductive path, she would step in and say things like: “I want to just jump in here, [because] I think we are doing well at exploring the options, investigating, but we want to make sure we reach an agreement, propose something; if this committee doesn’t reach consensus, then the minister is going to decide, so I think its very critical that we get a short-term plan, as well as a long-term plan”. She attempted to make sure that parties were able to get their concerns and information on the table, carefully tracking on flipchart paper and asking questions like: “Have I reflected everybody’s concerns so far, because I think we should get to the next stage”. She also employed active listening techniques, saying things like: “I understand your point; what you are saying is you don’t think option D is viable, even if we approve option E [i.e., the rail, correct]?” Her style largely reflected what might be considered best practice in facilitation techniques (see, for example, Susskind and Cruikshank, 2006).

Outcome: Risk assessment group #2

The other risk assessment group reached only a tentative agreement. Most participants had come to support a D+ option based on a phased approach, reconstructing the existing road and enhancing freight rail as soon as possible, and then passenger rail if and when necessary and financially feasible in the future. However, the port representative remained unsupportive of this option and the regional deputy director (i.e., chair) was seeking unanimous agreement. They subsequently concluded that they should conduct further research on why port users prefer road to rail and if their capacity needs can be met by improving the existing road and rail (a D+ option), and then convene again to review this information before finalizing their recommendation. It is notable that the unanimity decision rule implicitly invoked by the chair played a substantial role here, as was the case with the risk assessment group in Rotterdam. However, the party holding out was different with this group - in Rotterdam it was the flood protection specialist, whereas here it was the port representative.

While the additional research they called for may have provided value to the group, this conclusion appeared to be the product of persistent protests on the part of the port representative that his interests were not being met, rather than of genuine knowledge gaps. The port representative was concerned that the opportunity costs associated with not building a new road would be too high, based on the information he had that his users prefer road to rail. The group had the capacity data on hand confirming that they could meet current and projected future demands with a D+ option, but the port user was successful in arguing that it may not be sufficient. One factor was the deputy director's attentiveness to the port representative's concerns. The representative saw the group moving towards a D+ option, and ultimately convinced the chair that this would be a bad move. She attempted to reconcile this disagreement by concluding that they should do more research to figure out if and how the port user's concerns could be ameliorated. Even this outcome left the port representative unhappy; one of his final comments as they wrapped up was: "The recommendation we made is bad for business [and] bad for the economy; what we need is something that is quick, and that can solve the problem at the moment". However, a delay to gather more information was a good way to prevent the group from making a decision that he did not like, punting it into the future and providing additional opportunities to tip the balance in his favor.

Another barrier that may have prevented the group from reaching an agreement was that relatively less information was put on the table than was the case with most other groups. For example, neither the alderman nor the flood protection specialist disclosed that extra funding might be available from their respective organizations to fund enhanced options that cost more than the \$2.5 billion budget. The alderman reflected on this factor in her follow-up interview: "One thing that came out very strongly was actually the power of negotiation and having information, because I think with information, it actually helps in decision making. [...] I was playing the role of [the alderman, and was] withholding info; it seems that if I have actually shared it, it could lead to a different outcome." While information was disclosed relatively freely in most other groups across the three cities, the lack of disclosure also appeared to be a factor in the scenarios group in Rotterdam's conclusion that they needed more information before making a decision. In this case, one factor behind why more information was not disclosed appeared to be the deputy director's hold on the process. She attempted to tightly manage the deliberations, focusing participants on what was known and discouraging creativity and the sharing of information that did not immediately help the group move along.

In general, the regional deputy director of the transportation agency (i.e., chair) played an extremely dominant role in the deliberations. She made 100 unique interventions in the process, which is more than twice as many as the second most active (the port representative). She ran a very tight process, largely dictating how deliberations proceeded, and charting everything. In fact, the group spent substantial time waiting for the chair to record notes on flipchart paper. The deputy director framed the deliberations as consensus seeking and consultative in nature, stating that:

I want to reach a consensus that meets everyone's interests as far as possible. So, we can also have negotiations and then as time permits we can consider how robust [...] it

looks against the climate report [...] My director is very keen for us to have an open conversation in which we get all the concerns on the table and try and reach a consensus recommendation, but we also have to be realistic that the decision will be with the government. So it is a consultation, but let's see how we do, because we want to have an agreement with all the parties so it will be a win-win. That is the kind of guarantee of genuine consultation we want to have.

In line with this approach, the deputy director was clearly more focused on the goal of ushering the group towards a broadly supported outcome on the narrow question of how to build the new A39 than on discussing new options or technical information. Towards the beginning of the meeting, she stated:

What I observed in the first two meetings was that we did meander quite a bit; we talked about what are our other issues in government. [...] So, today I wanted to start to narrow down and focus on what are our primary concerns. [...] We can spend more time on the options later, but let's just lay out what are your concerns with this project, building this A39.

To this end, she attempted to train participants' attention on the A39 and avoid other issues and possibilities, particularly at the early stages of the meeting. When the environmentalist initially brought up rail as a potential new option she responded that their focus is on reducing congestion problems on the *road*. The rail option was almost left off the table, but the senior expert stepped up and supported it, saying: "There is actually an additional option, which connects very closely to what [the environmentalist] has been bringing up". The chair interjected again, noting that they have a limited budget and need to be realistic, but allowed the senior expert to proceed. The senior expert explained the rail option, providing technical information, and it ended up gaining traction.

Similarly, when the flood protection specialist outlined the climate risks and how they are expected to increase over time, and expressed unease that the group might be marginalizing them with their narrow focus on traffic congestion, the deputy director disregarded her, pigeonholing her concerns as 'the infrastructure' and moving on. The deputy director was focused on getting the group to a consensus recommendation on a new A39, not in how they could complicate matters by considering concurrent flood control work, as the flood protection specialist was recommending.

As noted previously, the deputy director was looking for an outcome that all stakeholders support. However, she was particularly attentive to the port representative. She checked in to see if and how his concerns might be met, and made supportive comments like: "[The port representative] has a point, a real valid point - By the time we build this up, say 5 years down the road, if we are going to have major flooding and the existing highway is impacted, and you find yourself without the additional capacity" of an additional road it may be problematic. In contrast, when the environmentalist stated strong opposition to option C - which is the alternative route through the wetland and the port's first choice - the chair said: "It is a green land - what does it do, besides provide habitat? Does it really create any value?" This reflected her prioritization of the economy, and thus the port, over

other issues. Later in the deliberations, she acknowledged this directly, stating: “I was hoping [that] we could agree on that option - D and [rail] - so let's talk about how we can quickly meet [the capacity] need, because we cannot have the economy impacted. So, we can see how we can do a phased approach that would meet [port users'] needs as quickly as possible.” This prioritization of the economy, and thus port users, over other interests is further evinced by how frequently the participants directly representing different constituencies spoke – the port representative spoke 47 times, while the alderwoman spoke only 11 and the environmentalist only 17. Some of this discrepancy may be attributable to the individual personalities of those involved, but it also reflects the deference of the chair to the port and its concerns.

While particularly acute in the case of this second risk assessment group, the concerns of the Port Authority seemed to be taken more seriously in Singapore in general than in Rotterdam or Boston. It is reflected in the additional, creative, concessions made to the port by both scenarios groups; the acquiescence of the alderwoman in the first risk assessment group, based on the prioritization of economic factors; and the license the port representative was given to veto or delay the decision in this second risk assessment group. During the debriefs, participants spoke of the ‘national interest’ (i.e., priorities), and economic growth as being high among them. During the scenarios debrief, a participant that filled a port representative role in the exercise said:

I think the option we ended up with in both groups is actually one of the worst options ever. I'm sorry for being blunt, but it is really bad purely because it is not economically forward-looking. It is basically doing something to what you already have, its very safe. It's very now, but it's not forward thinking. [... Had] I known the national interest or the government interest, I would have pushed for this a little bit more, and there would have been a bit more tension. Because if I know that economic growth is the main part, is the national interest, the other agencies will know that, and everyone will have that in their head, and therefore option D would not be that viable.

Participants expressed discomfort with not knowing what the ‘national interest’ was in the exercise, as it would have guided their decision-making. Two different participants approached me one-on-one before the RPS runs to ask what the national priorities are in the exercise, because they were not explicitly identified. Similar concerns did not emerge in either Rotterdam or Boston.

Pre- and post-exercise surveys

29 of 30 participants completed all or part of the pre- and post-exercise surveys.³ The survey instruments were designed to fulfill four research goals: First, they provided a snapshot of participants' current decision-making norms. Second, they provided insights into their perceptions of the risks and uncertainty posed by climate change, uncertainly more broadly, and the level of preparedness of their respective organizations. Third, surveys were conducted both before and after the exercise to discern if participating in the

³ The number of responses (N) is noted for each question in this section, as not all respondents answered every question.

exercise had any impact on participants' perceptions. Fourth, feedback collected via the post-exercise surveys validated the benefits of RPSs as a tool for learning and research. This section outlines findings related to all four goals.

Climate change

Participants were asked a series of questions to better understand their views on climate change vis-à-vis infrastructure planning and decision-making. They were asked similar questions pre- and post-exercise to examine if participation had any discernable impact on their perceptions.

Participants reported middling awareness of 'climate change and the risks it may pose'. The average response pre-exercise was 4.3 on a 7-point Likert scale from 'not at all' at 1 to 'very' at 7. In comparison, the average was 5 in Rotterdam and 6 in Boston. The level of awareness varied across participants. Not surprisingly, the two participants from the Ministry of the Environment and Water Resources self-reported that they are quite aware (6 and 7). The Land Transport Authority participants self-reported as slightly less aware – two 5s and a 3. The lowest responses (1s and 2s) were from participants directly from the Civil Service College; in fact, when their responses are removed, the average level of self-reported awareness increases to 5. This would suggest that the level of awareness among those directly engaged in planning and decision-making is comparable to that in Rotterdam and Boston.

There was a statistically significant increase in self-reported level of awareness from pre- to post-exercise (see *table 3.2* below). This change would suggest that the exercise experience enhanced participants' awareness. Singapore was the only case that saw a statistically significant increase on this question. This is largely explained by the lower starting point; already high levels of awareness in the other two cities made statistically significant increases more difficult.

Table 3.2 – Hypothesis test: Self-reported awareness of climate change

H₁: One-tailed hypothesis that exercise participation increases respondents' awareness of climate change and the risks it may pose

Survey question: How aware would you say you are of climate and the risks it may pose?

Test: Wilcoxon matched pairs signed ranks

Conclusion: The results were **significant** at the $p=0.025$ level, using Wilcoxon's test ($N=12$, $T=12$; one-tailed hypothesis). Therefore, the null hypothesis can be rejected and it is concluded that, on average, participants' self-reported awareness increased from before to after the exercise

In general, participants expect climate change to be a somewhat significant factor in their organizations' planning and decision-making over the next ten years, with an average ranking of 4 (pre-exercise) on a seven-point Likert scale. In comparison, the averages in Rotterdam and Boston were 4.9 and 5.7 respectively. However, here too we get a different picture if we exclude participants from the Civil Service College – the average response increases to 4.9, the same as that in Rotterdam. There was not a statistically significant shift

in participants' responses from pre- to post-exercise (Wilcoxon's test; $p=0.05$; $N=20$, $T=62.5$; two-tailed hypothesis). The average response was similar (3.9 overall and 4.9 with Civil Service College participants excluded) when participants were asked to rank the degree to which climate change is already on their organizations' radars. There was variability in responses to both questions across organizations. In addition to the College, lower responses came from participants from the Prime Minister's Office (i.e., in strategic planning) and the highest came from those working directly on environmental issues.

One dimension of the increasing profile of climate change is whether or not the NCCS is successful in promoting the issue, and proposed solutions, among other agencies. A participant from the NCCS was positive about other agencies using their work, stating that: "I can tell you that, before new projects are coming up, we have agencies coming up to us to ask us for our opinion. [...] And the reason why they want us or they are engaging us at early stages is because they want to minimize potential destructions that could result due to climate change". Another NCCS interviewee was more guarded, stating that:

[This] is a bit complex. I guess one way to say it is some things can be imposed, some things can be facilitated, and some things may not hold true. In certain cases, it can be imposed on, say, the LTA, in certain cases it can be facilitated to educate them, in certain cases we have representation from LTA, for example on the resilience working group. But, whatever is presented or shared with them does not permeate through their ranks, or across the organization as we would like it to. In a way, it's also a matter of the dynamics, and who is there - how passionate is he about it? Is he overloaded with other items? How big is this matter for him? And even when he goes back to his organization, how able is he to push it from a hierarchy point of view, from a capability point of view.

Opinions on how much climate change is on their internal radar varied among participants from the LTA itself. One asserted that it is already on their radar, stating that:

We have seen a lot of rains these days and especially land transport is becoming a greater issue because our roads are being flooded. Sometimes it's not because of the road itself. It could be because of the drainage system, but ultimately it's the road is being flooded, and people are not happy when roads are being flooded. So, the issue comes down to whether we are doing our job, ensuring flooding does not happen or our infrastructure is climate proof. So, increasingly [...] there are a lot of considerations going on [...] because more people realize the impact and feel the impact themselves, so there are more questions. [...] We do consider the climate change on a whole, but in terms of impact, we look more towards flooding because that's what we are facing now. [...] Definitely before they build something, they already consider climate and the changes across the years. So, our structures, even underground structures, are built [...] with considerations of these flooding issues, the flood levels. So, even our underground platforms and everything, there is mitigation measures to prevent the water from coming in. You look back, looking to the future, we also look at the risk, how high our infrastructure is being at risk in terms of flooding, so there is the assessment being made and that exercise is done at the whole of

government level as well, because it's not just land transport but there's other issues. So, yeah, so the new climate change report has come out and the different agencies will have to evaluate our own structures, whether they are resilient enough or not, so that's one. And in terms of risk management, my office, [...] climate change is something that is, we are looking at and we will have to work with other agencies like the National Environment Agency, PUB, to ensure that we are prepared.

However, the other three LTA participants that have less association with the small group of employees working on climate resilience issues were less affirmative about the degree to which climate change is integrated into the large agency's planning and decision-making. One downplayed the importance of climate change, stating that "there is a team that looked at climate change but they said that right now the risk is low, so for now, because there are other things that are a little bit more important like managing the public, I think climate change may be taking a little more of a backseat". Another framed it as other agencies' responsibility, stating that:

For all this flood control, we really rely on the Public Utility Board. So for LTA, even if we build the road level, [...] we actually have to depend on another agency. They will say 'Oh sorry, you cannot just raise the road, because we don't have a proper drain, and then all this water would just gush down to the low land and will flood that area.'" So we have to work very closely with other agencies. So much so that I think all the climate change, [...] LTA is quite concerned about it, but it's not within our control.

He went on to note that other agencies, and the PUB in particular, pay more attention because it affects their 'key performance indicators'. The fourth LTA participant reflected that the 'vagueness' associated with climate change is a barrier to integration into the organization's planning and decision-making, stating that: "The problem is that climate change is too vague, and we operate at the specific level, so if the threat is so vague it is hard to translate into a operational plan that I can put on the ground. [...We] need a very specific assessment to develop a plan; that is what is so tricky about climate change, especially climate change".

A participant from a national planning agency provided a wider perspective on the profile of climate change vis-à-vis Singapore's long-term planning:

I think we definitely recognize climate change as a potentially major threat, because we're an island state. But I think, at the same time, we're also taking time to really [...] understand the science behind it, understand the projections and to keep up to date with the latest projections and then try to downscale it to what it means for Singapore. And I think it is the right approach. We are not jumping too quickly into making solutions now, when there are still a lot of these studies ongoing. It seems like we are at that mode where we want to know more and we are doing more studies. I think, on an ad hoc basis, some agencies have started to incorporate climate change scenarios into some of the design codes for platform level as well as drainage. So I think, at some of the margins of that work, I think agencies are trying to do that part [...but] I don't think it has been standardized. But it has definitely gained a lot of awareness with

agencies in the last one or two years. [...We] are very conscious about it because I think we do see that as affecting how we plan, how we do our land reclamation, how we protect our coast and also, how do we make sure that we still become and stay as a livable space.

In terms of how *confident* participants are that they and other stakeholders will be able to manage the risks and uncertainties climate change poses, participants entered the workshop somewhat skeptical, with an average ranking of only 3.8 on a 7-point Likert scale. This is similar to the average in Rotterdam (3.7) Skepticism was common across participants coming from different organizations, although it is notable that many of the highest responses came from those directly involved in climate adaptation and/or infrastructure planning and decision making (i.e., the Ministry of the Environment, the Land Transport Authority, the Housing and Development Board, and the Urban Redevelopment Authority). One reason for the skepticism is widespread belief that extensive climate adaptation activities will only be implemented in response to climate-related events. Seven different participants speculated in the follow-up interviews that climate adaptation will be reactive, stating things like: "I hate to say this, but something must happen close to us and real - it has to show that there is a clear and imminent danger that is real. Of course, that's the worst-case, but going through the normal change takes time and education to filter in, to really change people". Adaptation will become a priority when citizens feel the consequences and press the government for action. "It will come only when the people themselves feel that they're impacted, they're inconvenienced - they're caught by say intense rainfall, flooding, and it inconveniences them and so with or without climate change data or the uncertainty, even if the uncertainty remains, they will request the government to do something and that will bring about changes. [...] So it means ground-up, from the people", said an interviewee.

The good news is that most participants believe the government can react decisively if and when it becomes necessary. "If certain things happen and can provide data that changes are occurring, the government will get into it strongly. In situations like SARS, they jump into action very quickly; even the slightest hint of this kind of epidemic, we go all out to protect the country", said a participant. On the other hand, a couple of participants were concerned that climate change could emerge rather quickly, making this wait-and-see approach inappropriate. "The real issue is that we don't really exactly know how much things will change, whether or not Singapore will be drowned [...]; climate could change faster than we think".

A related issue is that, as discussed earlier in this chapter, action in Singapore takes place once an issue has been deemed a national priority. Participants largely do not see climate change breaking onto that list thus far. In the words of one:

"I think a lot of agencies are having a wait-and-see attitude because [...] we will need a very strong mandate on 'Yes, let's do this, this is the broad, overarching strategy for Singapore', and then agencies, respective policies can come in. Some agencies have started on their own, which is a good attempt, but I think it may really continue that way for some time. [...] I think, at some level, at the very top of this hierarchy, someone

would probably have to decide 'this is the strategic direction we're going for Singapore. So different plans, adaptation plans, mitigation plans all have to fit in and draft into this broader strategy'.

Should climate change adaptation increase in prioritization, it will involve the establishment of standards and greater coordination. According to interviewees, each agency will necessarily interpret the standards in different ways, but there should be calibration and a common risk assessment. Institutionalized coordination is important here. “[One] infrastructure asset that could be affected by say flooding could have down trend implications on other agencies' assets, and so if those agencies don't see the other part of that picture, then I think it's problematic. Also the other issue is all these different agencies looking at their own assets are still taking guidance from say PUB and BCA, from the standard guidelines”, said a participant.

It is important to note that, while still low (4.1), there was a statistically significant increase in participants' confidence from pre- to post-exercise (see *table 3.3* below). This increase would suggest that the exercise experience enhanced participants' confidence that climate-related threats can be successfully addressed.

Participants were also asked to self-report on whether or not the exercise changed their level of confidence. The Likert scale question asked: *How has your confidence in the ability of your organization and other stakeholders to adapt to the risks climate change poses changed as a result of your participation in this exercise (1 being less confident, 7 being more confident and 4 being neutral)?* Eleven of 28 reported no change (4), four reported feeling less confident, and the remaining thirteen reported increased confidence. This self-reported increase in confidence from pre- to post-exercise reinforces the data from the pre and post confidence questions. There is no discernable pattern in who reported feeling more or less confident.

Table 3.3 – Hypothesis test: Confidence in ability to adapt to climate change

H₁: One-tailed hypothesis that exercise participation increases respondents' confidence in the ability of their organizations and other stakeholders to adapt to climate change

Survey question: How confident are you that your organization and other stakeholders will be able to manage the risks and uncertainties climate change poses?

Test: Wilcoxon matched pairs signed ranks

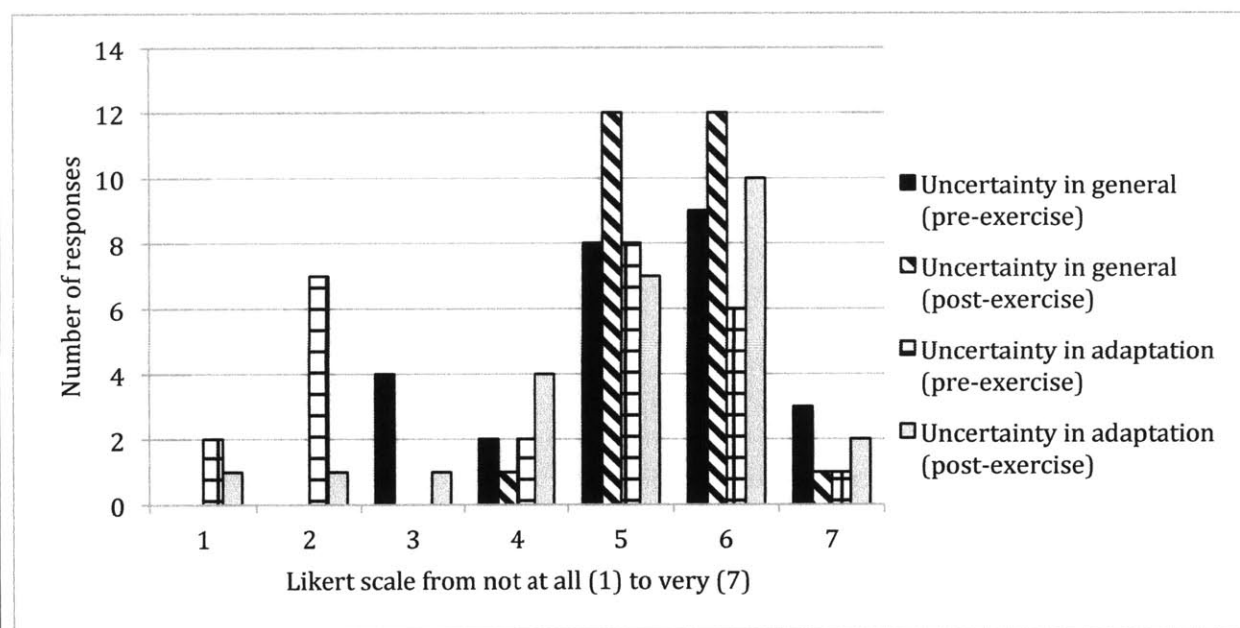
Conclusion: The results were **significant** at the $p=0.01$ level, using Wilcoxon's test (N=16, T=22; one-tailed hypothesis). Therefore, the null hypothesis can be rejected and it is concluded that, on average, participants' confidence in the ability of their organizations and other stakeholders to adapt to climate change increased from before to after the exercise

Uncertainty

A key focus of this research is enhancing our understanding of the nature of uncertainty as a factor in planning and decision-making. Participants were asked questions about uncertainty in general, and explicitly how it related to climate change.

As figure 3.3 below illustrates, participants see uncertainty (not just from climate change) as a substantial factor. They were asked: *How significant of a problem is uncertainty (not just from climate change) to you as you plan and make decisions (1 being not at all and 7 being very)?* The average response was 5.1 pre-exercise, which is the same as the average response in Rotterdam.⁴ As Rotterdam and Boston, participants see uncertainties resulting from numerous sources. “I think it’s what we are all grappling with, you know, a lot of uncertainty. [The] environment [is] volatile, uncertain, complex. [...] The main sources are social demographic changes, and [cultural changes]. I think things are changing more rapidly with technology and all that”, said a participant, adding that “there are many driving forces that cause this change and uncertainty, so with the combination of different factors”.

Figure 3.3 – The uncertainty factor as participants plan and make decisions



N=26, as only respondents that answered all four questions included

Figure 3.3 suggests that participants do not see uncertainty in the context of climate adaptation as any more significant of a factor than uncertainty is in general in decision-making. In addition the question of general uncertainty discussed above, participants were asked: *To what degree is uncertainty a factor in climate change adaptation (1 being not at all and 7 being very)?* The average response was, in fact, lower than that for uncertainty in general in the pre-exercise survey – 4.1 versus 5.1. It is, however, notable that there was a statistically significant increase in the average ranking of how much of a factor uncertainty is in climate adaptation from pre- to post-exercise (see table 3.4 below). This would suggest that the exercise enhanced participants’ perceptions of how much of a factor uncertainty may be as they start to tackle adaptation challenges.

⁴ There was a slight increase to 5.5 post-exercise, but this is not a statistically significant shift (Wilcoxon’s test; p=0.01; N=18; T=52.5; two-tailed hypothesis).

Table 3.4 – Hypothesis test: Uncertainty factor in climate adaptation

H₁: Two-tailed hypothesis that exercise participation will shift respondents' opinions on how much of a factor uncertainty is in climate change adaptation

Survey question: To what degree is uncertainty a factor in climate change adaptation (1 being not at all and 7 being very)?

Test: Wilcoxon matched pairs signed ranks

Conclusion: The results were **significant** at the $p=0.01$ level, using Wilcoxon's test ($N=12$, $T=6$; two-tailed hypothesis). Therefore, the null hypothesis can be rejected and it is concluded that, on average, participants' opinions on how much of a factor uncertainty is in climate change adaptation planning and decision-making increased from before to after the exercise

Insofar as interviewees reflected that uncertainty *is* an important factor in climate change adaptation, their comments largely related more to governance challenges and the interpretation of models than to physical uncertainty. Issues previously introduced, like the establishment of common standards and challenges associated with raising the profile of a nascent issue, are key here. “It does seem fair to say that people are not aligned on this issue”, said an interviewee. “Before the game, I didn't think [uncertainty] was really that much of a problem because it was coming from my own point of view, and after the game, after interacting with the different people who have different agendas, different priorities, I realized how, when those come together, the uncertainty can increase”, said another participant, reflecting on the experience. To some, it is a matter of paralysis because of perceived uncertainties - “It's not like a known unknown, but people seem to keep complicating the issue”, said an interviewee. She went on to note that the continuous interrogation and revision of climate models erodes trust and makes policy-making difficult. Furthermore, she argued, the proponents of these climate models must be ready to speak with conviction, justify why their models are sufficient, and stand prepared to accept the consequences when they are far off. Otherwise, potential users of this information remain confused and unconfident in their applicability and accuracy.

It is notable that some interviewees did reflect that the climate science is still too uncertain. In the words of one: “We don't pass over the climate change indicators to the different departments or groups [in our Statutory Board] for consideration. I think that's because there is a lot of uncertainty with those forecasts, there's still a lot of uncertainties. Like I mentioned our NCCS is still trying to better understand the impact of climate change on Singapore at this stage, so it is a bit premature to factor in”.

Managing uncertainty

Asked how they typically deal with uncertainties in practice, participants responded as follows:⁵

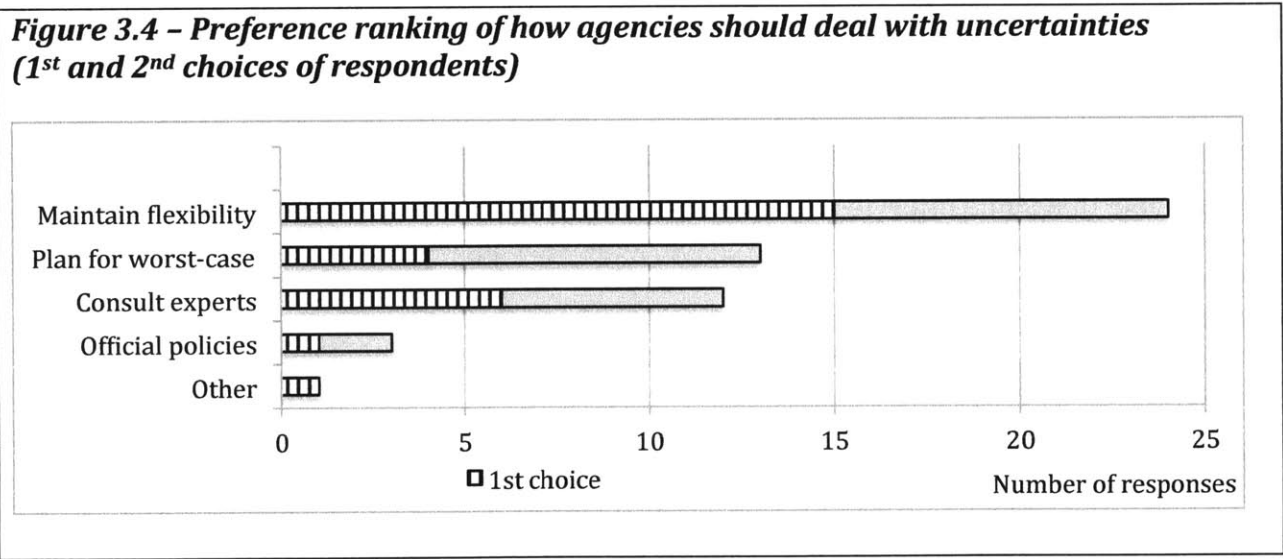
- Two participants ‘follow official policies or guidelines’;
- Ten ‘consult experts for their best projections’;

⁵ Note that the number of responses (34) is greater than the number of respondents (N=29) because some chose more than one option, although asked to ‘choose only the most common or important’.

- Ten 'plan for worst-case scenario'; and
- Twelve 'maintain flexibility'.

The ratio of responses here is similar to that in Rotterdam, with the exception that more respondents said 'plan for worst-case scenario'.⁶ This is a curious anomaly, given that Rotterdam's infrastructure planning is, at least from a climate risks perspective, arguably guided more by worst-case estimates of the future – like the 10,000 year storm threshold used for the dike system protecting most of Holland - than Singapore's. However, outside the climate issue, Singapore is perhaps just as cautious in their planning and decision-making, as evinced by the significant investments put into water security.

Post-exercise, participants were asked to rank how they think uncertainty *should* be dealt with. The results are illustrated in *figure 3.4*. As can be seen, 'maintain flexibility' was the most popular option – it was the first choice of fifteen of participants, and the second of a further nine (n=27). This positive sentiment was echoed throughout the exercise debriefs and follow-up interviews. Participants see value in flexibility in both policy-making and physical design and engineering. "The form of flexibility I like is having a plan B - what if A fails, then we can go to plan B", said an interviewee, adding that on the design side flexibility involves "the scalability of the solution, meaning, for example, now we can put up a [flood protection] barrier to 1.5 m, but what if tomorrow I want it to 5m? Can it be done easily?" Another equated flexibility with being 'nimble' and "revising policies and adapting to the situation as it changes". He noted that most policies in Singapore have sunset clauses so that they are revisited at defined intervals.



The follow-up interviews provided a more nuanced picture of these options for managing uncertainty. Most strikingly, five different participants explicitly talked about the interrelationship between maintaining flexibility and robustness (i.e., planning for the worst-case scenario). "I think what people normally do is think of the worst case scenario

⁶ Only two of 18 responses in Rotterdam were 'plan for worst-case scenario'.

and try to be a bit more flexible, in a sense, having additional resources and the space to react”, said one. Many equated flexibility with openness – “cause at the heart of it, you're always doing some kind of cost-benefit analysis, so when you're presented with an attractive proposal, an attractive option, you have the flexibility of saying yes to that, or at least being open enough to say ‘okay, persuade me about it, persuade me of this’. So I think that's also flexibility, that openness to change into new information”, said an interviewee. In a similar vein, another talked about building robust infrastructure while being flexible to different alternatives at the policy level, suggesting that the best approach is:

Plan according to what was the forecast previously, and then continuously evaluate them, so that our future infrastructure are using [this revised understanding]. So in terms of uncertainty and because we are serving the public, we will have to take, we have to be very cautious on how it's being built. Because things, we can't, it's not so easy to rebuild something, like build, rebuild a new road or build a flyover higher. So, I think in terms of how [we] actually deal with uncertainty is really putting enough cushioning into our system. [In terms of flexibility], there are a lot of policies that we make, and sometimes it goes down to how we implement certain things. So, some policies cannot be too rigid [...] Because, if policies can change, there's a bit more flexibility in how you build or maybe you don't have to build something. So if there's a shift in mindset, we might not need to build as many roads because there are less cars. So, flexibility on the top is important.

Participants also discussed the need to maintain efficiency by planning for the worst case and creating opportunities for adaptation as conditions change, but while concurrently looking for efficiencies and opportunities to optimize.

Because the RPS exercise introduced participants to either scenarios or risk assessment forecasts as a way to manage uncertainty, participants were asked in advance if they use either in their own planning and decision-making. All but two of the scenarios group participants responded ‘yes’ to the question: *Do you ever use multiple scenarios (i.e., consider multiple possible futures rather than a single forecast) when you have uncertain factors in your planning and decision-making?* As was the case in Rotterdam, this suggests widespread use of this decision-support tool in planning. Participants were also asked: *How useful is/might be the introduction of multiple scenarios (i.e., multiple possible futures) in your work (1 being not at all and 7 being very)?* They were very positive about their value – the average response was 5.6 pre-exercise and 5.5 post on a 7-point Likert scale from ‘not at all’ (1) to ‘very’ (7). The very slight decline in the average opinion of the value of scenarios from pre- to post-exercise was not statistically significant (Wilcoxon’s test; $p=0.10$; $N=10$, $T=27.5$; two-tailed hypothesis).

The follow-up interviews provided greater clarity on what scenarios are useful for. This was particularly enlightening given that, as discussed earlier, the scenarios were not really used in the RPS runs. Three participants with related experiences described the value of the scenario planning *process*, rather than the outcomes. In the words of one:

I find these exercises valuable because as a process its valuable but I wouldn't use it as a prescriptive kind of thing. [...] I would question the value of these scenarios, but I would say that the process is definitely very much valuable. Like you wouldn't put so much stock into trying to predict certain things but the attempt to understand where you are, how you got there and what you're most likely to, where you might be heading - that process is valuable [...] It's scenario planning, so, you come up with different scenarios. And your certainty of those scenarios happening will never be 100% [...] I guess, after you've been through that process, you would also be evaluating the different scenarios, and you would still have to base your decision on something. So, you're making multiple decisions. So what matters to me is that, in arriving at that decision, have you gone through a vigorous process? Have you gone through a comprehensive analysis of it? Because, ultimately, even if you are presented with like say, the four scenarios, you still have to narrow it down in order to make it actionable, in order to come up with a concrete action that you can implement. So the scenarios would have been part of that process. So, for example, in the exercise, yes, we come up with the four scenarios, but then after that we ran those four scenarios into yet another set of considerations, which is 'okay, are there any down sides?' 'No, so, what we can we do?' We selected the worst-case scenario, and then we based our decision on that. So, in a way, it's sort of also part of that analytical process.

All but three of the participants in the risk assessment group stated that they had prior experience with 'risk assessments or reports', and the three that did not were from the Civil Service College. This suggests that this kind of report is widespread as well. Participants were subsequently asked: *If yes, how well do these forecasts prepare you and other stakeholders for making decisions in the face of uncertainty (1 being not at all and 7 being very well)?* Interestingly, we see a very similar situation to Rotterdam here as well, with a notably lower average response, compared to that of the scenarios participants, pre-exercise – the average was only 4.6 on the same 7-point Likert scale. There was a statistically significant increase in the average to 5.4 post-exercise, suggesting that the experience increased participants' opinions on the value of this kind of probabilistic risk assessment forecast (see *table 3.5* below). As was the case in Rotterdam, this increase in favorability brought risk assessments to the same level of support as the already high opinions participants had, on average, of scenarios.

Table 3.5 – Hypothesis test: Value of risk assessment forecasts

H₁: Two-tailed hypothesis that exercise participation will shift respondents' opinions on the value of risk assessment forecasts

Survey question: How well do these forecasts prepare you and other stakeholders for making decisions in the face of uncertainty (1 being not at all and 7 being very well)?

Test: Wilcoxon matched pairs signed ranks

Conclusion: The results were **significant** at the $p=0.10$ level, using Wilcoxon's test ($N=7$, $T=2.5$; two-tailed hypothesis). Therefore, the null hypothesis can be rejected and it is concluded that, on average, participants' opinions on how well risk assessment forecasts can prepare them for decision-making under uncertainty increased from before to after the exercise

Stakeholder interactions and decision-making

As was the case in both Rotterdam and Boston, participants generally feel that engagement with other stakeholders is an important element in public sector decision-making. The average response to the question of “How important is it that you engage with other decision-makers and stakeholders as you plan and make decisions” was 5.7 pre-exercise and 6 post-exercise, on a Likert scale from 1 to 7. Unlike in Rotterdam and Boston, this is not a statistically significant increase in participants’ opinions of how important it is that they engage with other decision-makers and stakeholders from pre- to post exercise (Wilcoxon’s test; $p=0.05$; $N=14$, $T=50.5$; one-tailed hypothesis). This is perhaps unsurprising, given the already high average pre-exercise. What is notable is that an equal number of participants ranked the importance of multi-stakeholder engagement *lower* post-exercise than they did pre as did participants that ranked it higher (seven each).

Reflections during the follow-up interviews suggest that this divergence reflects differing views on *who* should be engaged. Participants universally emphasized the importance of cross-agency collaboration, particularly around nascent issues that are not well institutionalized yet, like adapting to climate change. “I require different inputs from different [departments], so, before we go ahead and do something, I have to talk to them, we share the same platform, I need to get their buy-in just to talk, before we can proceed”, said an interviewee. Another emphasized why cross-agency collaboration is important, asserting that: “it is human nature that [...] our focus can be limited [...] So, for example, if I’m working at the areas of transport, every single thing I see will be related to transport, the things I do, but then there might be other dimensions that I’ve not looked at. So, that’s why that could be mitigated if you [engage with] people from the other areas”. Participants downplayed tensions between different actors within government, and even between the political and bureaucratic layers. “If you notice, a lot of our leaders from the civil service move on to become political leaders; there is this very fluid transition”, said one, adding that leaders often criticize the American notion of separation of powers because “basically nothing moves”.

In contrast, and as discussed earlier in this chapter, participants were much more conflicted on the importance of engaging external stakeholders. Many expressed support for public engagement and see it expanding over time, but also noted that there are limits and drawbacks. In the words of a participant from the LTA:

It’s not really a mandate, but we try to inform the residents what is going on, and that somebody is listening to [them]. And not just that, because in the past residents would just write into various agencies, and nobody was looking after their issues. So they would say that’s not a very good government, because residents had genuine issues to raise or good suggestions, but they were not being taken up. So, we have this public engagement group [that looks] into all sort of issues for the public. But of course, a lot of people, they just want to get their ideas through, and then they will just keep carrying on, writing in, until you give way to them. [...] I think for Singapore context, it’s a very different from the American model. Because as a small country, if we want to survive, we really have to get things moving fast, and then the government will always

make it this way. Alright, we will just engage the public [around] what are the projects that we are going to [implement]. Even if the public is going to raise objections, we will still hear [them] out, we will [address] all the issues as far as possible, [...] but the project still needs to proceed on. If you really think that this is a bad government, you will have your say during the election, just vote us out. Because ultimately, we will have to pay the price. [...] Yeah, because we cannot just let projects hold up. [It will have] a big impact to our economy [...] so it's very difficult. [...] So we cannot just let the public stop us from moving forward. [But] we always say 'Alright, if you really think that [an alternative is better] then perhaps you can get somebody else to do the job'.

Another participant reflected that there are “always pros and cons to engaging the public, getting feedback and involving the public in terms of policy issues”, and opined that it is appropriate in some context and perhaps not others, like around national security issues. He noted that the civil service is rapidly learning how to enhance their public engagement, and that increasing degrees of public participation seems inevitable, given social media, public expectations and the general trajectory of society. As discussed previously, there are various reasons why participants are guarded in their opinions on the importance of engaging external stakeholders. To some, it can corrupt the pursuit of the common good and add unnecessary inefficiencies. To others, it is not viable, given the weak state of civil society and preponderance of expertise inside government. The exercise introduced the notion of directly engaging external stakeholders in policy and planning deliberations, which was foreign to many participants, and not well received by all. This explains why half lowered their opinion on the importance of multi-stakeholder engagement from before to after the exercise.

Participants' real-world experiences suggest that structured forms of multi-stakeholder decision-making are less common in Singapore than in Rotterdam or Boston. Only 12 of 29 participants (41%) answered yes to the question: *Have you ever participated in a facilitated multi-stakeholder decision-making process?* In contrast, 57% of participants in Rotterdam and 79% in Boston reported they have had this kind of experience. There is no discernable pattern in who has and has not participated in this kind of process. The 12 that have participated in a facilitated multi-stakeholder process in the past rated their experiences relatively highly - the average rating was 4.7 on a 7-point Likert scale from 'very poor' at 1 to 'very successful' at 7. This is comparable to the average in Rotterdam (4.6) and lower than that in Boston (5.6).

While participants reported engaging in facilitated multi-stakeholder processes less frequently than those in Rotterdam and Boston, the frequency of their interactions with stakeholders outside their own departments is comparable. As in the other two cities, the responses to the question of *On average, how frequently do you interact with experts and other stakeholders outside your own department as you plan and make decisions or recommendations (either in-person or electronically)?* were across the board. Six (21%) said 'more than once a day', six said 'less than monthly', and others stated frequencies in-between. 64% interact with others at least once a week, which is higher than Rotterdam and Boston. The frequency of interaction with external stakeholders correlates with participants' jobs, including their levels in their respective organizations. The senior

managers and directors interact more frequently with external actors, on average, than lower-ranking officials. Those in bridging organizations, like the Center for Public Project Management and the Centre for Strategic Futures, reported meeting with outsiders most frequently (more than daily). The formality of these interactions is similar to that in Rotterdam and Boston. Fifteen respondents characterized their interactions as 'mostly formal meetings, but some informal', thirteen as 'mostly informal interactions, but some formal' and only one as 'only formal'. Some noted that the nature of these interactions is becoming less formal over time as a new generation of civil servants cultures informal networks of civil servants to get things done. In the words of one:

Traditionally our approach was to go straight to the permanent secretaries, do a song and dance for them, and expect that they would pass directives down. More recently, because it's a small service everyone knows everyone, it's very common for us to reach out to others and say that we have this project, ask them for recommendations, meet them in workshops. We do get a lot of interconnected, informal channels - for big projects, everyone would know what everyone else is doing, particularly in a certain area like this strategic foresights work. And [these networks] help, because let's say you are starting this climate change work, you can tap into these networks. [This] interconnectedness at the staff level is with happens with the population of ideas.

As discussed earlier in the chapter, hierarchies and the role of leadership are much more pronounced in Singaporean decision-making. However, more informal interactions among staff at different levels and stages in processes are key to the development of policies and plans. Nonetheless, interactions across layers are much more formal. In the context of this research, that means that lower-level technical experts, mid-level policy makers, and political decision-makers rarely find themselves at the same table, and when they do their interactions are highly constrained.

RPS exercise

Participants were asked a series of questions post-exercise to gather feedback on how much the RPS mirrored their realities, and was valuable in their opinion as a learning tool. In terms of how similar the 'situation or problem presented' is to their own worlds, the average ranking was 4.4 on a 7-point Likert scale from 'very different' (1) to 'very similar' (7). This is lower than the averages in Rotterdam and Boston - 5.2 and 5 respectively. One key difference is that there is only one level of government in Singapore, while the exercise involves two, with separate local and national levels represented.

The 'characters' involved were also comparatively less similar, with an average of 4.6, compared to 5 in Rotterdam and 5.4 in Boston. As noted previously, non-governmental actors would not typically be involved in this kind of process in Singapore, while the RPS includes an environmentalist and a representative of the (private) port authority. Reflecting on this difference, one participant said: "We don't involve the greenies as much. It's more internal stakeholders, especially between the land use planning and the transport; they usually come to some consensus first and then they go on to the private

people. So, it's a little bit different to have different people on the table that actually have so called equal stance or equal sayings”.

The ‘interaction between the characters’ followed a similar pattern, with an average of 4.3 (the average was 4.8 in both Rotterdam and Boston). According to interviewees, this kind of multi-agency meeting happens regularly in Singapore, but the outcomes are typically more predetermined. “Usually, we, as land use planners, tend to have an opinion about what we want. So we want to do consensus, but we usually have done a fairly thorough assessment and feel that certain options are a lot better than the others, [and] it's making other agencies also see that point of view. Of course, they have other good suggestions or insights that [we consider], but I felt that the exercise was maybe overly democratic”, said an interviewee. Meeting chairs typically play central roles in this respect, which was the case with some RPS groups but not others. “Maybe something that wasn't as realistic was that the chair did not take as big of a responsibility in crafting out the decision [...]. Typically, in our setting, the chair does have a lot more say, and people will give more respect, in a sense”, said a participant. On the other hand, a couple of participants reflected that there might be *more* tension in a similar real-world situation, depending on who is at the table and the stage in the process. A more nuanced picture emerges from the numerous comments participants made on the importance of hierarchy and deference. “I guess culturally in Singapore [...] there is a lot more respect for hierarchy - so what you will see at the table is that they may not show their points so much, but I think that what was represented at the table goes on in the background, outside the scope of when the bigger bosses come together; I think it happens like that at the lower level, but when it goes up you don't see this as much”, said a participant. “I think, in our culture, what you would typically see is that when someone wants to raise a particular point, they do it in a more discreet manner”, said another. Debate occurs informally, off the record at the staff level, to forge broadly supported agreements before more senior officials meet.

Participants in the risk assessment and scenarios groups reported that these respective ‘tools introduced’ were somewhat similar to those they employ in the real world, with an average of 4.6; this is roughly comparable to the averages in Rotterdam (4.2) and Boston (4.4). As noted previously, scenarios are widely used in Singapore. The Strategic Policy Office in the Public Service Division of the Prime Minister’s Office does high-profile national scenarios intermittently, along with thematic scenarios on specific topics, including climate scenarios. According to an interviewee working in this area, “scenarios and foresight work in general, are a very common way for the Singaporean government to factor in this kind of uncertainty; with foresight, I am talking more about factoring in uncertainty, this more emergent property”.

The ‘options or solutions’ presented in the game were somewhat realistic to participants, with an average of 4.6. This is not surprising, given that, as discussed earlier in this chapter, the Singaporean government is starting to consider options like floodwalls and question the robustness of buried roads with changing climate conditions. Interestingly, participants rated the multi-stakeholder, collaborative ‘method of decision-making’ used in the exercise as somewhat similar to their real-world situations, with an average of 4.7. This is essentially the same as the average in Rotterdam (4.8) and actually higher than that in

Boston (3.9). This is a curious rating, given that, as discussed earlier in this section, stakeholder engagement is less common in Singapore. Follow-up during the interviews clarified that while external stakeholders would rarely participate in the kind of process modeled in the exercise, cross-agency collaboration is quite common. As noted above, chairs typically play a central role in these deliberations, and hierarchies have implications. However, negotiation is an important part of the process. "Of course, at the staff level we do find ways to negotiate, especially in my job [in which...] there are multiple agencies involved. [...] There is always some negotiation, because the agencies may not offer 100% upfront maybe they offer 50%, some don't offer anything at all! Sometimes we do agree to disagree. Another key issue is that the representation must be strong also - if the guy representing is not strong, it will make the collaboration very hard, because he cannot decide. So because of that, the barriers can come up early."

Participants reflected that the exercise was more or less similar to their real-world situations in different ways. However, its accuracy is not necessarily a direct measure of its value. In fact, participants noted that, in some cases, they learned from what was different. Exercises can provide safe spaces for experimentation that may not be possible in the real world. "I guess that's also the beauty of having a simulation exercise whereby people can actually use the safe environment to kind of test some of the ideas and actions", reflected a participant. The lack of clear hierarchy and open debate between technical experts and more political and policy-related actors that occurred in the RPS runs was not realistic to participants, but nonetheless interesting and potentially informative. "We have been discussing and it is of interest in Singapore what is the relationship between the political office holder and the public servant; although we didn't really mention that during our debrief, that would be one question that I would definitely want to hear from the [other participants]", noted one interviewee, adding that the important questions civil servants are grappling with include: "What do they say? Then, are they totally neutral? Can they be totally neutral? If their political office holders, their ministers, make a public decision against their advice, what should they do? That's something that [is] constantly being discussed [...] because that dilemma, that public servants always face is how could I report my boss if he decides, am I fit to offend him? Should I be politically correct, or should I ask an office holder, let him know this is my frank opinion and then let him make a decision?"

All of the participants (28) stated that they 'learned something from the exercise that they might be able to apply in their own planning and decision making'. When asked in the follow-up interviews *what* they learned, their responses largely related to negotiation and interpersonal skills, and process considerations.

For many, the fact that process matters was an important lesson. In the words of one astute participant that is regularly involved in this kind of multi-stakeholder deliberation:

My main takeaway was around how do you put in a process that [allows for] everyone's opinions [to be] heard, and I think that can be quite difficult. If you are not sensitive to the process, you can inadvertently lead to a lot of cognitive bias, and whoever shouts loudest wins, which is not conducive to this kind of multi-stakeholder engagement. There is a lot of interesting work around groupthink. That's a challenge

in all governments, because to get that high in the first place you need to conform to a certain behavior, which is not conducive to uncertainty in that sense. But there are techniques you can use, [including] systematically bringing in an outsider. There are ways of doing this, and for civil servants, of being sensitive to that - the order, where you put people and so on. There are a lot of benefits, and improvements to the quality of the discussion you can have just by thinking through those issues more strategically.

On a similar note, some realized that there are many pathways and potential outcomes in a process like this, depending on the procedure followed, personalities involved and other factors that are not directly substantive. “It is quite interesting to focus on how, and see how there are more ways than one that the decision could be altered, or affected, or influenced in one way or another”, reflected a participant. In part, this reflects the agency of individuals, or lack thereof. One participant that explicitly noted the ‘agency of individuals’ as a key takeaway for her reflected that:

I think what I took away from it is that, that it's quite arbitrary, I guess, your outcomes, because it really depends on whether people are willing to offer information and whether people are willing to ask for information. [...] I guess it has all of these wider implications because the possibility of people exchanging information so freely would depend on many different factors - the culture, the organization, the situation. So in a sense when I really think about it, it's like wow, so many arbitrary factors can impact a really important decision.

She noted that a person in the role she played in the exercise – that of a technical engineer – may not be so willing or able to share information so ‘brazenly’ in the real world Singaporean civil service. In a similar vein, the Alderwoman (i.e., community) representative that acquiesced to an undesirable (B+) option in the first risk assessment group reflected afterwards that her personality played a part:

I thought the character of the individual also impacts the decision at the end, because I sort of conceded defeat, [saying] ‘Okay, yeah, I agree with you, so okay’. I know that I'm not supposed to go towards that direction, but I sort of agreed because I feel that we should think holistically. So I thought the character of that particular individual, apart from their role, also influences how things go.

The personalities of individual participants is a critical confounding factor in attempting to generalize and learn from what happens in RPS exercises, but must be recognized nonetheless – it mirrors the messy reality around how individual personalities shape real-world deliberative processes.

Another common theme among participants’ reflections on what they learned was the value of perspective taking, and benefits this kind of RPS can provide by placing them in role of a different stakeholder. “One thing I find very useful about this gaming exercise is that you force participants to put on different hats, and so they put themselves in the shoes of that role, and that helps to get them out of their own comfort zone, the role that they are playing in office”, reflected a participant with a policy background, adding that: “They are

[subsequently] able to see the other side of the argument, the other argument, the counter-arguments, and that [...] sensitizes them to certain issues. And when they return to their portfolio, they are better able to formulate plans or strategies for that particular issue. So it broadens their perspective.” Also reflecting on why this kind of perspective taking is important, another participant said:

First you understand, then you empathize. Once you empathize with other agencies, you can be a bit more open to giving a little bit of leeway in your policy-making, because a lot of times when you formulate a policy, it's really to your agency's benefits, but sometimes we overlook that fact that it might be detrimental to other agencies, or they might have concerns. [...] But I think having this kind of role playing and then have outcomes being played out, I think allows them to be a bit more open to listening.

In a similar vein, another participant argued that perspective taking encourages parties to get information on the table: “I think, a lot of people tend to consider their own position too much, and sometimes it impedes certain decisions or stalls certain ideas, so, if someone is forced to speak a different language altogether, that's [how] more of the truth gets to come out and they realize it a bit more and maybe more willing to consider other options”, said another.

The perspectives of actors outside government are rarely directly heard in this kind of deliberative process in Singapore. To some participants, the exercise suggested that there might be value in bringing non-governmental actors to the table. In the words of one participant:

One key thing is that the government doesn't have all the answers to any solutions the country probably is facing. [...] I thought it was very useful and is quite relevant in today's context, especially where the populous is getting more vocal and they want to have a stake and have a say in policy and the issues that they encountered. So that was something interesting which I learned that because in our particular group, actually the NGO gave the most interesting perspective. [...] And that never occurred to me and that's really sometimes very true to agencies that we are working in. Sometimes we don't realize a different perspective would actually really help. So such simulation actually does help us to put ourselves in different shoes and to see what are the possible solutions we could come up with.

The importance of, and a chance to hone, negotiation skills was the most commonly cited thing that participants took away from the RPS runs. Eight different participants explicitly discussed ‘negotiation’ when asked during the follow-up interviews what they learned. Participants talked about relatively standard negotiation concepts. For example, one said: “To me, the emphasis of the workshop was how do we become stronger negotiators, because that's not something we are typically good at in the Singaporean civil service. Failing in negotiations at the government level, there's a hell of a lot at stake! So for example, just simple things, like how do you get the interests.” Another participant with extensive experience in infrastructure project management situated negotiation dynamics in contrast to the traditionally prioritized elements of scientific management, saying:

The exercise was definitely useful for training in negotiation skills, which is really needed. Negotiation is an art. Value engineering is easy because you have a target in mind, but with value management you want to set goals and each stakeholder has a different thing in mind. The question is how can we get everyone to move forward with a driving mission, and reach a simple outcome in which everyone is to get something. There are techniques you need to know, best approaches, like understanding others. Negotiation is part of what we do every day. The dynamics of groups is also a factor. The chairman calls the shots, so how they approach matters, including the degree of dissent that they tolerate, versus being more hierarchical - for example, if they look at seniority around the room it may not be the best in policymaking, for example if the climate change rep is a junior and the chairman is from trade, we know how it is going to turn out before it starts. The same is true at the political level, between ministers.

Participants frequently emphasized the importance of *mutual gains negotiation*. For example, one stated that: “I felt that the game actually allowed me to see how different parties come together to [...] talk to each other, to try to amicably come up with a solution that actually benefits all of the parties, or if not, at least there's no harm to each agency”. He went on to say that “I thought that's important and, for me, the skills of negotiating the outcome is quite difficult to acquire, but at least I have a sense of how should I be talking to people, probably to hone my skills in that direction”.

Sound negotiation skills may be particularly important if non-governmental stakeholders do become increasingly engaged in deliberations, and these processes become progressively contentious. Reflecting on how citizens are becoming increasingly vocal in their opposition to projects, a participant reflected that:

I think the skills of negotiation - being able to come to an outcome where most, if not all, parties are satisfied with what they are receiving - I think that's a relevant skill to brush up on, [...] given that we are placing more emphasis on how the public wants to be involved in planning. Like, there was this news article, I think yesterday about citizens being really unhappy with the placement of a school in front of their little forest. So, most of the residents wanted the forest to be where it is, but instead they have this school that's being built up which will clear the trees. So I understand that there were consultations, but the decision was still to go ahead, and it seems as if the decision was already made before they consulted the public. I think this is something we're still grappling with. We're starting to realize the importance that it's good to be able to negotiate effectively.

Substantively, the exercise exposed participants to certain climate risks, and methods and approaches for managing them. Participants reflected that RPS exercises can provide value here. A participant involved in pedagogy from the Civil Service College reflected that “just telling people that climate change is important, they might not be convinced, but when they do a simulation, being in the role, actually, [helps] them to appreciate the fact that climate change is [an] important considering factor”. A participant that is actively involved in Singapore's climate adaptation work increased his evaluation of how much of a factor

climate change will be in Singapore in the future from before to after the exercise, and reflected during the interview: “I guess why it changed would be that I [...] saw the people there, it was unexpected to me, but they seemed a bit more interested and aware of the subject than I expected [...] them to be”. Another participant reflected that this kind of tool can be useful for helping groups wrestle with policy challenges, but that the design must be adequately considered:

It was refreshing for me to understand how [this kind of exercise] could be used and applied to solving complex problems or solving policy issues, or making decisions. [...] I saw that it is useful because in a way, it's more effective than a one-way delivery. But there are also challenges because at the end of the program I had to think quite hard about what exactly were the key takeaways, yeah. And then if I were to do a similar program for my participants, how should I design it such that they will also walk away with very clear takeaways.

The value of RPS exercises, including as tools for social learning, experimentation and the fostering of collective action, are examined in further detail in chapters 1 and 6.

Conclusions

Various insights may be gleaned from the exercise proceedings and outcomes, interviews, pre- and post-exercise surveys and background research on infrastructure planning and decision-making in Singapore. These include: The importance of *national priorities* in determining the currency of issues; deference to hierarchy and the importance of strong leadership; the application of rationality in decision-making; the evolving role of civil-society in decision-making; the importance of process design and effective negotiation skills; the interrelationship between flexibility and robustness when grappling with uncertainty; and the value of RPS exercises when learning how to better manage wicked problems. These themes suggest that the wider governance regime significantly influences how planning and decision-making around climate change are evolving in Singapore. While uncharted terrain in many ways, preexisting institutional norms seem likely to shape how climate adaptation planning continues to evolve.

National priorities

Compared to Rotterdam and Boston, the explicit identification of and deference to *national interests and priorities* is particularly pronounced in Singapore. Certain issues, including water independence and economic development, have long been deemed priorities, and thus have received a great deal of attention. There is little ambiguity around what the priorities are, and planning and decision-making largely adheres or gives deference to them. Substantial resources have been invested in Singapore's state-of-the-art water system, despite the fact that there are long-term leases in place to secure water from neighboring Malaysia. Water independence was deemed a matter of national security, and thus the significant investments were made. Economically, Singapore went from 'the third world to the first' in less than 30 years because economic growth was prioritized. The

government focused on developing human resources and infrastructure for economic development, and nurtured the economy with a web of state-controlled enterprises and strategic partnerships to attract international investment.

In the context of the exercise runs, parties responded to the importance of national priorities – and their ambiguity in the RPS instructions – in two ways: Some found it disconcerting that no priorities were established, and asked for further guidance on what they are. Others just assumed and applied Singapore’s own national priorities. In particular, economic growth was given preeminent consideration. In two groups, this manifested as additional concessions for the port (i.e., the economic interest at the table) – one group allocated funding to support port users in their transition from road to rail, and the other committed to continue investigating options A and B so that another road could be rapidly constructed if and when necessary. The Alderwoman in a third group acquiesced to an elevated road (option B+), despite the fact that this was explicitly against the interests of her constituents in the immediate neighborhood around the road, because it would ultimately be in the ‘national interest’ by supporting job growth and greater mobility. The fourth group concluded with a call for more research (i.e., no agreement) in large part because the port representative was unwilling to acquiesce to an outcome involving no new road, and the chair was deferential to his concerns.

It is clear that climate change is not yet deemed a national priority in Singapore. “I think an area of concern would be that, at this particular point of time, the government as a whole, Singapore as a whole, has quite a lot issues on their radar - for example, the immigration issue, the transport issue, and stuff like that - so I can imagine people then would have less capacity to think about this climate change issue”, said an interviewee. Various agencies are engaging in work to enhance resilience, and the NCCS is playing an important coordinating role, but it is not yet a high-profile issue throughout the civil service. Participants’ opinions on if and how climate change might become a greater priority varied. Some feel that it will inherently be reactive; “definitely it's a problem because it's so long term - you don't see the effects that immediately [so] it is a bit off the radar - the only time that it comes onto the radar is when things go wrong, so recent flooding I think actually helps people be more aware of the need for flood protection and prevention. [...] I think that if we're talking about the policies, directions for dealing with climate change for Singapore, it's still going to be a very long-term approach, so it may not have that kind of urgency that other issues may have” said an interviewee. Whether or not they are directly climate change related, issues like more acute flooding from intense rain events and the haze from forest fires in Indonesia are increasing the profile of the issue over time. Furthermore, the groundwork is being laid via processes like the NCCS. Interviewees emphasized that the government is investing resources in understanding the problem so that it can aggressively respond as conditions change. As discussed earlier, the government is hesitant to talk about the risks it is aware of until solutions are more fully fleshed out, because of fear of ‘scaring’ citizens.

Hierarchy and leadership

Singapore’s semi-authoritarian technocratic governance model is typified by relatively strong deference to hierarchies (Ho, 2000; Tan, 2010). Compared to Rotterdam and Boston,

civil servants are much more cognizant of the hierarchical dynamics both between and within government agencies. Interviewees spoke of the implicit and explicit relationships between different ministries and statutory boards. In the words of an interviewee:

In Singapore, the ministries do have a stronger say. [...] So, when it comes to policies, you are more likely to see ministries come around the table, and have a stronger say than the statutory boards that just take it and implement it. [That is,] unless the statutory board has a big stake in it. For example, if you are talking about water, the PUB will have a big say, but in consultation with someone at the ministries. [...] From a human capacity point of view, [...] they do implicitly and explicitly try to talent manage the ministries much more closely, with somewhat higher standards. [...] When ministries come to the table, they put forth very eloquent, very logically sound [arguments]. [The ministries send] people with good ideas and very quick thinkers at the table, so they do tend to dominate the discussion somewhat more.

Participants also spoke of the hierarchical relationships at the interpersonal level, both within agencies and when actors find themselves deliberating across agency boundaries. “I think one thing is also the rank; [...] probably the [Alderman] in Singapore’s context would be the higher ranking of all, and so whatever they say, we will probably take heed, and some people will be a bit more wary. So there’s this Asian values ranking kind of thing that is in the works”, reflected an interviewee. A policy maker put it this way: “Although we try to listen to staff feedback a little bit more, very often it’s top-down, so I think there is a little bit less teamwork, in terms of conversations around the table. We are trying to do more going around the table, but there is not so much of it right now. [...] Maybe it’s the culture, maybe staff are not so open to it”.

Participants were quick to note that these strong hierarchies do not preclude debates, they just tend to happen behind closed doors, and among staff at similar levels, both within and across agencies. Interviewees involved in policy-making explained that proposals are typically more or less agreed upon before they are brought to higher-level meetings, but that they are the products of iterative processes of, often informal, discussion among staff before they get to that point. A participant involved in policy-making put it as follows:

Typically in a meeting this is what happens, and it’s not just for climate change, you see for most meetings where it involves a few agencies, or a few departments: Someone will bring a presentation, and the presentation will be crafted quite carefully. And there will be a specific recommendation, rather than options. Options may be presented, but a recommendation will be presented quite clearly. And typically this is where the hierarchy does come into play a bit in the sense that if the person has ownership, or the resources, or the funding for a specific recommendation, typically people will not challenge such a recommendation [...However, proposals] go through a lot more rounds before a recommendation is reached, although not all discussions take place in a meeting. Some discussions are more behind closed doors, formulated there and then presented, but there is a lot of email exchanges going on in the background that help to achieve the recommendation. [Before there is a meeting], typically most people will have agreed and so at the meeting, if it is a big meeting, a director level

meeting, it will be quite clear that there [will] be no big issues per se, [no] big issues that might derail the recommendation.

Nonetheless, the hierarchical nature of decision-making can have important implications when it comes to raising the profile of nascent issues like climate change. Issues may be given less attention if they are coming from weaker organizations. A participant from the NCCS acknowledge as much, and noted that this is the advantage of the way the NCCS is structured, with key ministers from across government, and their lieutenants, chairing various committees, rather than it operating as a standalone effort of the Ministry of Environment and Water Resources. This does leave the initiative dependent on abilities and willingness of these key actors from various Ministries and agencies to advance the climate resilience agenda. According to the same NCCS participant:

It is tricky, especially for us as the secretariat, to manage! And we do make tricks from time-to-time, but I would say that it is manageable. To me, its more of a people issue in the sense that you have certain chairs at different levels, that have different reputations, different capabilities, different says on certain issues. So typically, if the chair, [...] let's say if a permanent secretary, has very good networks, and even though it's a cross-cutting issue like climate change, if he has very good networks, [...] if he wants to get things going, he can make calls to his other friends and get them to push along the same lines, and you will see it come together. However, other chairs are not as strong, and then you may see it move along a little bit more slowly, or in a direction that you may not want it to be. [...] So the strength of the people controlling this platform is very important - if they are the right background. It's not just about capability, but even the right knowledge, skillsets to push it, to know how to manage and push a process to send policies along, and even, in a sense, to manage their bosses, to garner buy-in among their bosses.

In a similar vein, when asked how an important issue like climate change can be disseminated across a powerful organization like the LTA, given that it is being promoted internally by smaller teams, a policy maker responded: "Probably in the bosses - I think the bosses will have to tell [each organization] how to prioritize the resources". She asserted that it is via the allocation of resources that signals around prioritization are sent, adding that: "In all choices you have to look at resources, because resources are a reality - If you don't have enough resources there is no way you can do anything". Another participant noted that this can be challenging, as the senior officials 'have day jobs' and divided attention, so secretariats need to find ways to engage them and create 'something that is attractive'.

Participants emphasized that strong leadership is particularly important in this hierarchical environment. "I think, given the nature of bureaucracy, I think the impetus must come from [...] senior leaders in the government, where they are enlightened enough to think 'okay, actually we have this problem 10 years down the road and not five years down the road, but we have to start doing it'", said an interviewee. To the degree that they take place, meetings like that modeled in the RPS exercise would typically involve strong chairs shepherding the process. Strong leadership is seen as an ability to take in the

concerns of different stakeholders, devise an appropriate plan, and build cohesion around it. In the context of climate change, an interviewee involved in high-level planning noted the importance of emerging leadership:

Is there somebody right now in the climate change field who has the ability to rally people to their cause? [...] You would need an overall approach or mindset towards a certain issue, and whether there's somebody who's visionary enough to lay that out, and to disseminate that so that it permeates, it seeps down to the lower levels where it manifests in [our] work. Because we're talking about diffused decision-making, but they still need to be guided by some kind of overarching principle. And that might be a problem in terms of complex issues because there isn't that one person who can set a direction. And at the same time, it's also really unfair to lay that burden on a single person. So, you have say committees or organizations or whatever, but then you're just introducing more and more dynamics, and making the situation more complex again. So, I guess it's just leadership. You need people who have the kind of singular talent to really set a direction. [...] To me, what I find puzzling, is that fine balance between having a strong man who can rally everybody and basically whip everybody in line and being like a dictator. [...] When you have an overload of information, basically, you need somebody to say 'look everybody, make a decision' and move from there. It's the inability to make a decision which already is a stumbling block.

It is not necessarily obvious where leadership will come from in advancing crosscutting issues like adaptation to climate change. Yet, the emergence of strong leadership may be key to advancing this issue, given the nature of governance in Singapore.

Pursuit of rationality

While hierarchy and leadership are critically important in Singaporean governance, policy makers also emphasize rationality. Rationality may seem at odds with hierarchy, but can, in fact, be complementary; Singapore's positivistic approach ostensibly involves applying scientific methods to derive the appropriate policies and plans, and then implementing them without prejudice. By this logic, strong but fair leadership is key; open processes with more stakeholder involvement can corrupt matters, leading to less efficient outcomes. Civil servants are closely governed within hierarchies to promote the best decision-making possible and avoid corruption.

There were various examples of participants making choices and/or statements in the RPS runs based not on their interests, as described in their role-specific confidential instructions, but rather because they were convinced that it was the *rational* choice. The best example of this is the aforementioned Alderwoman that went against her constituents' interests because she was convinced that the elevated road option would be better for the common good for the wider city. As discussed earlier in this chapter, the environmentalist in the first scenarios group played an outsized role, which is abnormal in Singapore given that non-governmental actors would rarely be at the table. Participants reflected afterwards that this was because she made strong arguments that they came to accept based on their (perceived) merit. In general, participants reflected that their decision-

making was 'rational'. One participant reflected after the exercise that "once the numbers and the considerations were written on the flipchart, it pretty much was a one-sided contest; the poor port guys were like, 'okay, you win' once they saw the facts". He went on to assert that, had they not acquiesced on going with some sort of D+ option, the port representatives would have "come across as the irrational ones really", given that the proponents were "busy churning out the numbers". He was surprised that other groups in Rotterdam did not naturally reach the same conclusion.

The sense of rationality is underscored by confidence that the government is the competent party to dispassionately devise the best path forward in most situations. "In Singapore, the expertise is disproportionately within government, resources are within government. We don't even have that strong of industry lobby groups [...] and the nonprofit sector, frankly, is not that strong, definitely not that strong now", said an interviewee.

The identification of universally rational positions and policies may be particularly challenging in ambiguous situations with high degrees of uncertainty and dynamic conditions, like adapting to climate change. While it is not yet clear how Singaporean decision-makers might adapt their sense of the rational to incorporate the risks associated with climate change, it appears that it will involve an ambitious research agenda. The government is investing resources and nurturing partnerships with academic institutions both domestically and internationally, with the aim of developing a fuller understanding of the risks and possible responses. The emphasis is on enhancing knowledge and technical capacity. Relative to other jurisdictions around the world, a substantial proportion of this research capacity is within government. "For example, with our strategic foresight planning, in Singapore that is a common layer across government, in other places it would be a more complex web of think tanks and so on. There are pros and cons to both models - the plus side of our model is that we are much closer to decision-makers, whereas even if you have the best lobby groups, the best think tanks, if you can't get into that circle of decision-making, frankly it's difficult to get policy change happening on the scale that you want to", said an interviewee. She went on to state that: "My job is institutionalized dissent; there is no external lobby group to provide that, so it's internalized. Our office was created to provide a counterpoint on the future."

Evolving civil society

Despite the primacy given to *national priorities* and uncorrupted *rationality*, it is clear that differences in opinion and conflicting interests exist in Singapore. Furthermore, despite the extremely dominant role of the state, these differences are increasingly being voiced, as evinced by cases like the well-organized opposition to road construction through the Bukit Brown cemetery. 'Grassroots' organizations have traditionally played parapolitical roles at the service of the government, politely channeling feedback and good ideas, and building social harmony. However, groups of citizens are – through both formal and informal channels, like social media - increasingly vocal in their opposition to proposals they dislike. Participants' responses suggest that they are well aware of the increasing involvement of civil society in decision-making, but have mixed feelings around how and the degree to which interest groups and individual citizens should be engaged.

Some asserted that stakeholders should be more effectively engaged, especially after their experience with the RPS. In the words of one:

We haven't done really grounded stakeholder engagement, but from the exercise I thought it's really important to engage people right at the beginning. We know this is a fact, it's a bonus if you can do that. But it [struck me] even stronger after the exercise that yeah, it could be potentially more effective and efficient to engage stakeholders at an earlier time as compared to after we have made our decision and telling them 'Okay, this is what we want to do'.

Some see stakeholder engagement as another viable response to increasingly complex and uncertain situations, like those posed by climate change. "Increasingly, the problems that we face are getting a bit more complex and increasingly, at least in Singapore, there's a lot more demands for public engagement, so then decision-making has to evolve in a way such that we gather diverse views of the public, of the different stakeholders involved", said a participant. Others were more guarded. One participant reflected that the direct engagement of stakeholders, like 'the greenies' in deliberations is unrealistic, stating that:

In other countries, [...] you can afford not to be seen as fair. But in Singapore, you have to be seen as fair. So, if you want to include one environmental group, you probably have to include a whole bunch. And even if you include a whole bunch, there will be other opinions as well, and they will start asking, 'Okay, so why don't you bring in the, say, the pet lovers', for example. Or, 'Why don't you bring in the national society for bird watching', or something like that. So you end up having more and more stakeholders and, therefore, more and more diverse views. And, in a country like Singapore, efficiency is one of the things that we are very, very proud of. The more you have [engagement], the slower you become. Then, our advantage is therefore lost, in my opinion.

Participants cited various barriers and drawbacks to stakeholder engagement, including: Perceived unfairness in involving some actors and not others; capture by certain stakeholders, leading to biased outcomes; low capacity among civil society organizations; aversion to sharing information with external actors when it may be of national security or cause 'unnecessary fear'; inefficiencies, as different interests bloat proposals with their own issues; and time lost to deliberating.

What seems clear is that civil society actors are increasingly expecting to have a say when they will be impacted by government proposals. Whether or not civil servants wholeheartedly embrace it, recent events suggest that they will be progressively forced to take stakeholder opposition seriously. Fortunately, multi-stakeholder deliberation is not foreign in Singaporean governance. Civil servants regularly deliberate across departmental and agencies boundaries within government; the question is if and how to revise planning and decision-making to effectively integrate outside actors.

Negotiation and process matters

In the face of ambiguity around what the rational path forward is and increasing demands for stakeholder engagement, the processes and procedures for decision-making are increasingly important. Process and negotiation issues were chief among the takeaways participants had from their engagement in the RPS exercise. “The environment of having to negotiate for what you want, I think that was a very good learning exercise, especially when it simulates to a certain extent how negotiations would go within multiple agencies coming together, trying to push for their agenda”, reflected a participant. Participant takeaways related to negotiation and effective deliberation included: The constraints agencies face at the table; conversely, the agency of individuals; the value in appreciating others’ perspectives and interests; the complexity involved, and fact that no party has all the answers; that personalities and negotiation skills can have a significant impact on the outcomes; and that process design does matter.

It is clear from the ways in which the exercises unfolded in Singapore, their outcomes, and the reflections of participants afterwards that the experience was not purely one of optimizing plans based on objective evaluation of the risks and opportunities. This despite the emphasis participants placed on ‘rational’ and ‘objective’ decision-making. As in Rotterdam, values and interests had influence. Procedural factors – like what information was shared and what was not and who played the dominant roles – also appeared to have implications. There is value in objectively evaluating the strength and weakness of different options and veracity of different information, including around climate change, but it is impossible – and arguably undesirable – to remove the intertwined interests, values and perspectives of the different actors involved. This appears to be true even when the actors are coming together from within government, let alone from external interest groups.

Structured and facilitated multi-stakeholder forums for decision-making are comparatively uncommon in Singapore. Experiences with the RPS, and subsequent reflection, suggest that there may be opportunities for better process design. Improved approaches may become particularly invaluable as planning and decision making is complicated by issues that challenge existing decision-making regimes and institutional arrangements, and even more so as external stakeholders call for a spot at the table. While they may learn from the collaborative approaches employed elsewhere in the world – including in Rotterdam and Boston – new modes of deliberation in Singapore will need to account for the unique characteristics of their governance regime and institutional arrangements.

Flexibility and robustness

Compared to Boston and Rotterdam, more participants in Singapore characterized the government’s approach when dealing with uncertainty as ‘planning for the worst-case scenario’. Furthermore, while *flexibility* was still the most popular option when participants were asked what is the *best* way to manage uncertainty, planning for the worst case was a close second.

Rather than alternative approaches to managing uncertainty, participants largely framed flexibility and robustness as complementary responses. Planning and decision-making in Singapore may be largely typified as robust – that is, planning for the worst-case scenario – but interviewees emphasized the importance of remaining flexible to the degree possible. Some discussed flexibility in engineering terms, but most interpreted it as a broader mindset – that is, as openness to new information and possibilities as conditions change and learning occurs. In the words of one interviewee:

It may seem contradictory but I think also it can be dealt with at different levels [...] I see the need to be pragmatic and really understanding what are the real risks and what is the cost to government or the state if we were not to pay heed to the worst risk and make certain decisions. But secondly after you've decided that this is the level risk that we are prepared to tolerate and then this translates to a certain land requirement, then the next question is, 'Can we still optimize the [design]?' Can we do with other technologies that allow us to deal with the same level of risk but take away less land?

Flexibility is understood by this participant, and others, to be openness to multiple options. Some participants did recognize the engineering possibilities associated with being flexible, including in relationship to robustness. For example, an LTA interviewee noted the proactive steps they are taking in elevating new MRT station entrances, but added that they are also incorporating some flexibility by considering now (in the design phase) how the stations might be further fortified, should it become necessary.

Scenario planning is widely employed in Singapore, and generally seen positively by users. However, important nuance emerged around when and how scenario planning adds value. Participants that played the scenarios version of the RPS reflected that they were not really used in the exercise because they needed to base their decision-making on something concrete, and implicitly settled on the worst-case scenario because it was not particularly controversial or unbelievable, and would encourage them to be robust. However, these same participants noted that they have found scenario planning extremely valuable in the past because the *process* encourages stakeholders to methodically consider current and potential future conditions, and how they can best be accounted for. “Actually the process is more important than the final output, [...] because I think, due to the bureaucracy or certain tendency of the service or the government in general, sometimes things tend to get toned down or get filtered along the way or get changed along the way, but what's important is really getting people in the same room to have discussion. [...] I think it's useful to help set the stage for discussion or set the tone for discussion”, reflected a participant. Scenario planning can add value, but more as a tool to foster broader thinking in decision-making processes than for the scenarios that result.

Role-play simulation exercises and serious games

As in both Rotterdam and Boston, participants were extremely positive about the RPS experience. They universally reflected that they learned from their participation, with largely procedural takeaways, but a few substantive lessons learned as well. As discussed

previously in this chapter, participants learned about negotiation, process design and perspective taking. Some also reflected that they learned about the risks posed by climate change, and how they might be managed. There were statistically significant increases from pre- to post-exercise in participants' self-reported awareness of the risks posed by climate change, and confidence in the ability of themselves and their colleagues to address these risks. There was also a statistically significant increase in participants' impressions of how much of a factor uncertainty is in adaptation planning. These shifts suggest that the exercise had measurable impacts on the participants.

RPS exercises are being employed in Singapore to help decision-makers gain exposure to issues and experiment with new tools and approaches. The Civil Service College created a special unit – called the CSC Applied Simulation Training (CAST) team – to develop exercises for use in their various training programs. Peter Ho (2014), the former head of the Singaporean Civil Service, praised the work of this unit, noting their *Villa La Rose* policy game, which is loosely based on the dispute around the Albert Park MRT station and strong opposition from the Maplewoods condominium complex. According to Ho (2014):

This is obviously a wicked problem, with multiple stakeholders, each of whom defines the nature of the challenge and their interests differently. The game enables participants to explore the dynamics among these diverse stakeholders, how they make decisions, their assumptions and behaviours, as well as the role and use of public engagement.

The CAST exercises, and their support from the highest levels of the civil service, underscore the value of RPSs and other forms of serious gaming for helping civil servants and other stakeholders to grapple with 'wicked problems' like adapting to climate change.

**Institutionalizing Uncertainty:
Exploring How Infrastructure Stakeholders Can Collaboratively
Prepare for Uncertain Climate Futures**

Chapter 4 – Boston Case

Our Waterfront has helped make Boston the great city it is today, but it also presents challenges, and at times, threats. Climate change is increasing these risks and Boston must prepare. That is why – a few months after Hurricane Sandy devastated New York and New Jersey, and missed Boston’s high tide by just five hours – I announced Climate Ready Boston. While the City of Boston had been preparing for the impacts of climate change since 2007, Hurricane Sandy was a gut check. We needed to do more. – Former Boston Mayor Thomas M. Menino (in Spector and Bamberger, 2013)

The United States has made ambitious investments in clean energy, and ambitious reductions in our carbon emissions. We now harness three times as much electricity from the wind and 10 times as much from the sun as we did when I came into office. Within a decade, our cars will go twice as far on a gallon of gas, and already, every major automaker offers electric vehicles. We’ve made unprecedented investments to cut energy waste in our homes and our buildings and our appliances, all of which will save consumers billions of dollars. And we are committed to helping communities build climate-resilient infrastructure. – President Barack Obama (UN Climate Change Summit, September 2014)

Introduction

Boston’s history is intertwined with the sea. At 400 years, Boston Harbor is the oldest continuously active port in the Western Hemisphere (Massport, 2015a). The city emerged around the harbor as the preeminent port in New England during the colonial era, and remained a major shipping hub post-independence, landing cargo, and immigrants, from around the world, and hosting a large naval presence. Commercially and militarily, the Boston Harbor is not as important as it once was, but nonetheless remains a hub on the east coast of the America’s. As of 2013, it was the 35th largest port in the United States by cargo volume (AAPA, 2013). The Port of Boston plays various important roles, directly and indirectly supporting more than 50,000 jobs and contributing more than \$4.5 billion to the economy – it hosts a container terminal; cruise liner and ferry terminals; a commercial fishing fleet; liquid natural gas and petroleum terminals, through which most of the fossil fuel for the state passes; and a specialized autoport, which can process up to 70 thousand cars per year (Massport, 2015a).

As illustrated in *figure 4.1*, Boston was literally built around or –more accurately in many cases - *in* the harbor. Much of the City of Boston as it exists today was built on reclaimed land, including much of the downtown. Swaths of neighboring municipalities like Cambridge are also built on fill. Land reclamation allowed the city to grow while

maintaining its proximity to the sea. Unfortunately, builders over the centuries only filled as much as they had to, given the water levels and storm patterns they were familiar with, and thus portions of the city are less than four meters above sea level. Given historical tides and the protective buffer the harbor islands provide from storms, this elevation has largely proven sufficient. Boston has experienced minor flooding, but nothing catastrophic. That may, however, be changing. Sea levels are rising and tropical storms seem to be tracking further north, potentially threatening Boston. Hurricane Sandy was a wakeup call; had it hit Boston a few hours earlier or later (i.e., at high tide), the region could have experienced the kind of damage and disruption that ravaged New York and New Jersey, with up to 6% of the city flooded (Douglas et al., 2013). Add an additional 2.5 feet of sea level rise, and over 30% of the city would be flooded under a similar event (Ibid.).

Awareness of the threats climate change poses to Boston is relatively high among relevant stakeholders. Various governmental and non-governmental actors are involved in studying the threats and devising responses. Yet, concrete action has been slow to take hold. This may, in part, be a consequence of the governance regime within which Boston operates. The pluralistic nature of decision-making is characterized by fragmentation in decision-making; different agencies, levels of government and neighboring jurisdictions are responsible for various tasks, and do not always coordinate well. The laissez-faire paradigm, predilection towards individual rights and widespread suspicion of government leave many decisions in private hands, and government agencies with relatively less resources for infrastructure and other projects. Civil society organizations play outsized roles in shaping and advocating for policies. This chapter considers how adaptation planning is evolving in Boston and may continue to evolve into the future.

The first section of this chapter outlines the wider context in which Boston's relationship with a changing climate is evolving. It starts by introducing the climate-related threats that the city, and wider region, faces. Next, it provides an overview of what is being done to address these threats. The broader infrastructure planning and decision-making processes, particularly for transportation infrastructure, are subsequently introduced. Finally, infrastructure planning and decision-making is situated within the wider neopluralist and neoliberal paradigm that shapes governance in the city, region and wider United States.

The second section of this chapter describes the research interventions carried out with planners and decision-makers in Boston, and provides the primary research outcomes. It starts with an overview of the research approach and design. Two different versions of a role-play simulation exercise - one with scenarios and the other with a risk assessment forecast - were run with four different groups of participants. The outcomes of these exercise runs are summarized and discussed. The results of pre- and post-exercise surveys completed by participants are assessed next. Participants' reflections gathered during the exercise debrief conversations and semi-structured interviews are interwoven into the sections focusing on the exercise runs and surveys to underscore and illustrate points made. Interview data is used throughout the chapter, most prominently in the final section.

Figure 4.1 - Boston as a city built on fill (1630 vs. today)



Source: MPO [Metropolitan Planning Organization], 2011

The final section of the chapter draws a synthesized set of conclusions from this research, and background examination of planning and decision-making in Boston. It also looks forward, making various speculations on how adaptation planning and decision-making might evolve in the future. The key conclusions emphasized in this section are:

- Agencies and other stakeholders are increasingly aware of the risks climate change poses to infrastructure and the build environment. There are various efforts underway to document them, and introduce potential adaptive responses. With some notable exceptions, however, few concrete steps have been taken thus far in Boston region to increase resilience.
- Governance in the Boston region is typified by fragmentation across multiple different agencies at four different levels of government. There is coordination among agencies, but it is often weak, particularly at the regional level.
- Non-profit organizations, including environmental advocacy organizations and business groups, play key roles in planning and decision-making, especially around emerging issues like climate change. Many of these organizations are highly regarded and integrated into governance systems. Foundations also play an important role, particularly as funders of work on emerging issues like this.
- The disparate interests of different stakeholder groups are a key factor behind the development and vetting of policies and plans. Stakeholders use lawsuits and other mechanisms to influence processes, setting boundaries around what is possible and sometimes precipitating action that agencies would not otherwise take.
- Infrastructure systems are often subpar because of underinvestment. Resource scarcity is a key factor in how infrastructure is constructed and managed. Lack of trust in government, and thus unwillingness to fund it, may be a factor behind underinvestment.
- Political leadership is often important to the emergence of issues like climate change adaptation on policy agendas, leaving initiatives open to cancellation or significant revision when administrations change. Savvy policy entrepreneurs can work horizontally by marshaling resources and building effective networks.
- Uncertainty is a pervasive factor in decision-making, although certainly not only - or even primarily - because of climate change. Uncertainties result from changing political conditions and agency preferences, and various other factors. Participants see 'flexibility' as the best way to proceed despite uncertainty, while recognizing that the linear nature of most planning and decision-making, professional norms and standards and other barriers make this difficult in practice.
- Participants in this research project asserted that considering multiple scenarios can add value in planning and decision-making, but in practice groups in the

exercise conducted under this research quickly defaulted to considering a single (worst case) scenario. Nonetheless, scenarios make the fact that there are multiple possible futures more explicit.

- Participants were very positive about what they learned from their experience playing the exercise and participating in the workshop conducted as part of this research. Their takeaways were largely process related.

Context: Infrastructure, climate change and decision-making in and around Boston

Climate vulnerabilities

The coastal city of Boston is among the most vulnerable in the world to sea level rise and storm surges. Boston also faces other threats, including: More frequent and intense heat waves, stressing humans and infrastructure; more intense precipitation events, causing flooding and snow-related disruptions; and shifting disease vectors.

Boston faces substantial flooding risks. It has been ranked the 8th most vulnerable coastal city in the world in terms of potential economic losses due to flooding, with estimated average annual losses of 237 million USD today and over 700 million by 2050, even with some adaptation (Hallegatte et al., 2013). Climate models suggest that the mean sea level in the Boston area could rise between one and two feet by 2050, and three and six feet by 2100 (Douglas et al., 2013). The region has already experienced a rise in sea level of approximately one foot since 1900, which is about 50% more than the global average; this is largely due to subsidence, but changes in ocean circulation may also be playing a role (Horton et al., 2014). Sea level rise is a relatively slow-moving phenomenon, but becomes a much more immediate problem when compounded with the surge from a tropical cyclone (i.e., hurricane), nor'easter or other storm event. While no single storm event can be linked to climate change, the frequency, intensity and duration of hurricanes in the North Atlantic has been increasing over the past 30 years, and the trend is projected to continue with rising sea surface temperatures and other climatic changes (Walsh et al., 2014). While rarely making landfall, hurricanes seem to be tracking further north and have greater intensity (Northeast Climate Impacts Assessment, 2006). Flooding risks are particularly acute when sea level rise, storm surge and very high tides (i.e., 'king tides') culminate.

The potential impacts are stark - what is a 100-year flood today could be come a 5-year storm by 2050 and the high tide norm around 2100 (Douglas et al., 2013; Kirshen et al., 2008).¹ *Figure 4.2* illustrates the severe flooding Boston would experience at mean higher high water (MHHW) plus 7.5 feet,² which is becoming increasingly plausible under

¹ In other words, the chance of the given level of flooding occurring in any particular year could increase from ~1% to 20% by 2050, and then become the twice-daily norm by 2100.

² It is notable that this is a rather crude 'bathtub' flooding model. It does not take factors like wave action and the flooding of subsurface infrastructure into account, as models currently under development do (Douglas et al., 2013).

Figure 4.2 – Flooding in Boston at mean higher high water plus 7.5 feet



Source: TBHA (The Boston Harbor Association), 2010

different conditions, including 2.5 feet of sea level rise, which is quite possible within 50 years, and a 100-year storm surge hitting at high tide (Douglas et al., 2013). Under this scenario, 30% of the city would be inundated, along with large portions of neighboring municipalities like Cambridge and Somerville (Ibid.).

The 'Climate Ready Boston: Municipal Vulnerability to Climate Change' report found acute flooding vulnerabilities among the City's infrastructure, including: Most of the schools (many of which are designated emergency shelters); many of the police and fire stations; 1,500 units of public housing, which are on properties deemed to be 'high-priority' vulnerable; and approximately 132 miles of road, which are vulnerable at MHHW plus five feet, and an additional 300 miles vulnerable at MHHW plus 7.5 feet (Spector and Bamberger, 2013). Some of these assets already experience flooding, with others increasingly at risk as sea levels rise and temperatures increase.

Coastal storms are not the only precipitation-related threat to the Boston area. The Northeast of the United States has seen increases in average annual precipitation in recent decades, and this trend is expected to continue (Northeast Climate Impacts Assessment, 2006; Walsh et al., 2014). Furthermore, the region has experienced a disproportionately high increase in extreme precipitation relative to the rest of the United States over the past 50 years - there was a 71% increase in the volume of precipitation during 'very heavy events' from 1958 to 2012 - and this trend is also expected to continue (Walsh et al., 2014). The models suggest that increases in the frequency and intensity of precipitation events will be particularly concentrated in the spring and winter (Horton et al., 2014). With shifting conditions, the winter precipitation may fall as rain or snow; some winters may see little or no snow while others see heavy and prolonged bouts (Walsh et al., 2014). Experience with the record-breaking winter of 2015, in which 110 inches of snow overwhelmed communities, crippling the region's aging transportation infrastructure and costing the state's economy over one billion dollars, suggests that more intense winter precipitation could be highly problematic. The Intense precipitation as rainfall in other seasons can overwhelm stormwater infrastructure, causing flooding that damages property and disrupts infrastructure systems (Douglas et al., 2013). Infrastructure in the Boston area was not constructed to handle the type of flashflood event that seems to be increasingly common. More frequent and intense precipitation can also swell rivers, leading to riverine flooding (Walsh et al., 2014).

Average summer temperatures have been record-breaking in recent years, and the trend is expected to continue and possibly intensify (Walsh et al., 2014). Heat waves may become an increasingly significant threat with climate change. In fact, preliminary data from the City of Cambridge's Climate Change Vulnerability Assessment work suggests that the risks associated with extreme heat are more acute than those associated with flooding, at least in the short to medium-term. The region may face up to three times as many days above 90°F that it does currently, on average, in the 2030 timeframe and four to six times as frequently in the 2070 timeframe (Roberts and Ferguson, 2015). Put differently, Massachusetts' heat index could be similar to that of present-day South Carolina in the 2070-2099 timeframe, making a typical summer day feel 12-16°F warmer (Northeast Climate Impacts Assessment, 2006). Heat waves threaten both public health and the stability of

infrastructure systems. While many places in the United States and around the world experience much hotter temperatures and more intense heat waves than Boston can expect in the medium-term, their built environments and cultural norms are tailored to those conditions (Horton et al., 2014). As experiences in recent years in both the U.S. Midwest and Northern Europe have shown, extreme temperatures in regions with moderate continental climates can result in catastrophic loss of life and disruption to society.

Climate change is also shifting the ranges of various species, including disease vectors like mosquitoes and ticks that carry West Nile virus, Eastern equine encephalitis and other public health threats (Douglas et al., 2013).

The impacts of climate change are not felt evenly across the population. While expensive oceanfront property is often vulnerable, so are marginalized populations living in flood-prone areas; poorer-quality housing; situations with greater exposure to ground-level ozone and other pollutants; without air conditioning; and with less access to resources and alternatives (Horton et al., 2014). There are clear relationships between various socioeconomic variables - including race and ethnicity, age, gender, economic status and educational attainment - and vulnerability (Horton et al., 2014). The working class and largely immigrant neighborhood of East Boston is among the most vulnerable (Douglas et al., 2013). Community organizations like Neighborhood of Affordable Housing and academics from local universities are working to increase understanding and enhance the adaptive capacity of marginalized communities, including in East Boston, but residents often have the least access to resources, alternatives and information (Douglas et al., 2012; Lynds, 2015).

Climate Preparedness

The State of Massachusetts, City of Boston (and other municipalities in the metro region), and other actors are increasingly aware of the threats climate change poses, and are examining how they might increase their resilience, but relatively few concrete adaptive measures have been implemented thus far (Horton et al., 2014). While Hurricane Sandy was a wakeup call, bringing substantial attention to the issue, it has not, thus far at least, translated into significant investments or major policy changes in the Boston area. In the words of an interviewee:

With Hurricane Sandy we were lucky, [having] missed it by five hours. [If it had hit us], we wouldn't be having this conversation, we'd be having another. But, how long has it been since Hurricane Sandy, [and] how much has Boston really prepared? How much of Boston is prepared? How much more prepared are people now than they were one and a half or two years ago?

Furthermore, the risks were well documented before Sandy and yet the storm caught many off-guard, suggesting that the lack of action is not simply the result of insufficient awareness among decision-makers and other stakeholders (Horton et al., 2014).

Nonetheless, the high degree of attention being given to examining the risks posed by climate change and nascent groundwork should not be underappreciated. Interviewees were quick to point out that it takes time, but efforts are advancing. In the words of one:

I think its an evolutionary kind of thing, were the mitigation stuff has more of a head start. People were working on pieces of that going back 20 years, and that's were we are. We are just behind that curve on the adaptation side. It's not to say that there hasn't been a lot of work done on adaptation in certain areas, but broad department-wide vision and coordination hasn't been there.

All levels of government and many non-governmental actors are involved in various efforts to appraise the region's vulnerabilities, and are starting to devise adaptive strategies. In fact, one characteristic of climate preparedness in the Boston area is that there are *so many* efforts underway. Lack of coordination and the incomplete institutionalization of these efforts may be challenges to their ability to affect change, but they represent conscious efforts to start preparing for climate change. Another characteristic of the climate adaptation efforts in the greater Boston area is the outsized role played by non-profit organizations. This section provides a non-exhaustive overview of various efforts underway at the federal, state and local levels.

City of Boston

Boston was an early mover on the climate change issue. The City joined ICLEI-Local Governments for Sustainability's Cities for Climate Protection Campaign in 2000; joined the U.S. Mayor's Climate Protection Agreement in 2005; and has been a leader in passing energy efficiency and green building ordinances (City of Boston, 2014a). The earliest efforts focused exclusively on climate mitigation (i.e., lowering greenhouse gas emissions); according to interviewees, some were resistant to embracing adaptation because it would be 'admitting defeat' in the battle against climate change. However, by the middle of the last decade it was becoming evident that at least some degree of climate change is inevitable, and substantial change likely, necessitating adaptive measures. In 2007, then Mayor Thomas Menino released an executive order on climate action that directed City departments to integrate climate change into their planning, projects and review processes (Spector and Bamberger, 2013). This instigated various activities, including departmental reviews of the potential risks to infrastructure and programs, a new climate preparedness questionnaire for all large projects under review by the Redevelopment Authority, the explicit consideration of flooding and heat island impacts in open space and infrastructure planning, and the gradual integration of adaptation into the city's climate action efforts.

Hurricane Sandy, which largely spared Boston but wreaked havoc in New York and New Jersey in the fall of 2012, brought much greater attention to the issue. Shortly thereafter, the mayor created a Climate Preparedness Task Force involving the heads of various relevant agencies, including the Boston Redevelopment Authority, the Office of Emergency Management, the Police and Fire Departments, Housing and Neighborhood Development, Transportation, and Public Works. The results of this process were released via the 2013

'Climate Ready Boston: Municipal Vulnerability to Climate Change' report. The five key findings were (Spector and Bamberger, 2013: 7-9):

- *Climate preparedness must be an important and explicit criterion in the City's capital planning. The City's critical IT, communications, and transportation centers need particular attention.*
- *The effects of rising temperatures should be a high priority.*
- *Municipal emergency plans should be reviewed and practiced in light of the expanded risks posed by climate change.*
- *Close coordination with regional, Commonwealth [i.e., state], and federal partners is necessary to address cross-jurisdictional infrastructure vulnerability.*
- *Education, engagement, and communication—within City government and with the community—are essential for preparing for both the short-term and long-term effects of climate change.*

As outlined in the previous section, the report mapped the acute vulnerability of much of the city's facilities and infrastructure, including its transportation network and critical emergency services. The report also identified activities underway to address these threats - including the Transportation Department's Complete Streets Guidelines, which include consideration of climate risks - while reiterating that the city is only responsible for a portion of the infrastructure when it comes to interconnected systems like the transportation network (Spector and Bamberger, 2013).

The Climate Ready Boston report informed the 2014 update to Boston's Climate Action Plan, which identifies 'prepar[ing] Boston for the impacts of climate change' as one of the city's five priorities (Greenovate Boston, 2014). The Action Plan emphasizes cooperation with regional and state agencies and neighboring municipalities to advance regional preparedness; integrating climate preparedness into existing planning and public engagement processes; and ensuring that both public and private-sector projects consider the potential implications of climate change over their expected lifetimes. It identifies nine strategies and 29 actions under the 'climate preparedness' banner. For example, one strategy under the 'planning and infrastructure' banner is "integrate preparedness into all aspects of city planning, review and regulation"; one of the three actions associated with this strategy is "incorporate preparedness into all project and permit reviews - Continue to integrate climate preparedness into zoning, all project and permit review and licensing, and the regulations and guidelines that govern these processes. Review and improve waterfront development zoning" (Greenovate Boston, 2014: 60-61). Other actions called for include: Convening a 'regional climate preparedness summit'; working with community organizations to develop neighborhood-level strategies that enhance the resilience of vulnerable populations while providing jobs; protecting outdoor and manual workers; providing climate data in accessible formats; helping property owners access support and

resources to enhance their resilience; growing the tree canopy; and expanding distributed energy systems to enhance resilience (Greenovate Boston, 2014).

Both the 2013 report and 2014 plan update were prepared under the Greenovate Boston (2014) umbrella, which is: “the City’s initiative to reduce greenhouse gas emissions 25% by 2020 and 80% by 2050 and prepare for the impacts of climate change. It is a community-wide movement that seeks to engage all Bostonians in achieving these goals, while continuing to make Boston a thriving, healthy, and innovative city.” Greenovate efforts involve a variety of actors both inside and outside city government, with coordination coming from a small, dedicated team from the Office of Environment, Energy and Open Space, and the Environment Department. The city has both a Director of Climate and Environmental Planning and a separate Greenovate Boston Manager. This team is raising the profile of climate issues and supporting other teams across city government on an ongoing basis. Public engagement is a central component of the Greenovate effort. Workshops and other outreach activities, including an interactive online platform, informed the development of the action plan update, and ‘increase community engagement’ is one of the five priorities identified in the plan itself (Greenovate Boston, 2014). In addition to public engagement, Greenovate emphasizes coordination with other levels of government and neighboring municipalities; *figure 4.3* reflects the frequently noted reality that the city cannot act alone in addressing climate risks.

Figure 4.3 – Coordination required across levels of government for climate preparedness

	Transportation	Water Infrastructure
City	<ul style="list-style-type: none"> Local roads and sidewalks Complete streets design guidelines Parking 	<ul style="list-style-type: none"> Retail water distribution, waste water and storm water collection (BWSC) Groundwater overlay district (zoning)
State	<ul style="list-style-type: none"> MBTA (public transit) system State highways and parkways Airport and seaport 	<ul style="list-style-type: none"> Wholesale water supply and waste water treatment (MWRA)
Federal	<ul style="list-style-type: none"> Airport and railroad Federal highway standards (and funding) Coast Guard regulations 	<ul style="list-style-type: none"> Clean Water Act (and other regulations)

Source: Adapted from Greenovate Boston, 2014: 69

In addition to the Greenovate Boston process, the city has a Green Ribbon Commission with membership drawn from many of the leading public and private institutions (Boston Green Ribbon Commission, 2014). The Commission is co-chaired by the Mayor and a trustee from the Barr Foundation, which funds the effort. The goal is to capitalize on the insights and resources of, and facilitate buy-in among, the key pillars of the community – “Many cities have produced similar plans. But few have also enlisted the support and leadership of the local business community as effectively as Boston”, says the Commission’s website (2014).

The Boston Globe concurs, identifying the Commission as one of the ‘five things Boston is doing right now to prepare for the effects of global warming’ – “It’s rare to get CEO engagement in this kind of enterprise, which Boston’s commission has. Plus, the private sector has more financial resources than the city. Close collaboration between city and commerce has already contributed to slowing emissions and could help Boston take measures to prepare for the impact of climate change” (Fitzgerald, 2014). In the wake of Hurricane Sandy, the Commission created a Climate Preparedness Working Group to “make recommendations on the nature of public/private partnership necessary to prepare property owners for resilience in the face of climate impacts” (Green Ribbon Commission Climate Preparedness Working Group, 2013). The group’s (2013) recommendations – which included ‘help property owners reduce damage and recovery time’, and ‘align market and financial incentives’ - informed the 2014 update of the Climate Action Plan.

In practice, some city agencies are further along than others in understanding and responding to climate change. As noted previously, the Boston Redevelopment Authority has taken some steps to modify its processes and procedures. Among them, all projects subject to BRA development review (called Zoning Article 80), including institutional master plans, must complete a Climate Change Preparedness & Resiliency Checklist (Boston Redevelopment Authority, 2013). Project proponents are expected to mitigate risks identified via the checklist process. However, the questions are qualitative in nature, compliance is subjective, and, according to interviewees, some proponents are diligent while many others may not be so. In the words of one with extensive familiarity with the process:

The environment department is pushing these issues, and I don't know that it is being fully embraced, unfortunately! [One reason is the] cost and complexity of the projects. A lot of times there has been so much pre-project development by the development teams before they file officially with the city and do scoping sessions with us and the environment department is finally pulled in. By then, they've already put in so many things, kind of reluctant to blow up their whole concept.

Various interviewees also cited the turnkey nature of development as a problem. In many cases, developers are not concerned about the long-term because they sell or long-term lease once completed. So far, market signals do not seem to be strongly enticing them to take climate considerations very seriously.

The Boston Water and Sewer Commission (BWSC) is perhaps the furthest along among agencies in terms of concrete actions to enhance climate resilience. In fact, the Commission was not even asked to submit an assessment to the 2013 Climate Preparedness Task Force because a comprehensive analysis of the long-term impacts of sea level rise and increased precipitation was already underway (since 2011) as they developed their new 25-year capital asset program (Spector and Bamberger, 2013). The long-term asset program is still under development, but the BWSC’s three-year Capital Improvement Program released in 2014 notes that: “This project has reviewed all aspects of the Commission Sewer System, including the Commission’s design standards, assets, mapping, maintenance and operational practices and future impacts of climate change on the Commission’s facilities”

(Boston Water and Sewer Commission, 2014: 9). According to interviewees and presentations made by staff, the BWSC has already implemented some measures to both understand and respond to climate risks. They have installed gages throughout their stormwater network to track patterns and identify problems in real-time. They share this data with key stakeholders via an intranet to warn them when flooding may be imminent.³ Acknowledging that complete protection is impossible and may not be most effective in all cases, the BWSC is emphasizing rapid recovery. For example, a pumping station may flood, but the key systems should be protected and spare parts on-hand so that it may be brought back online quickly. Some systems – those conveying potable water in particular - are critical, and thus contingency plans have been developed around how they may be protected and brought back online quickly when disrupted. The BWSC is also building some flexibility into the system; for example, they are building redundant pipes into a new pumping station so that they may increase capacity quickly and cheaply in the future as necessary. Possible reasons why the BWSC and its state counterpart, the Massachusetts Water Resource Authority (MWRA), are further along than other agencies in preparing for the risks posed by climate change are considered in a callout box later in this section.

The Boston Transportation Department (2014) leads the interagency Boston Complete Streets initiative, which “aims to improve the quality of life in Boston by creating streets that are both great public spaces and sustainable transportation networks. It embraces innovation to address climate change and promote healthy living. The objective is to ensure Boston's streets are: multimodal, green, [and] smart”. The initiative has generated a comprehensive set of guidelines covering things like ‘street furniture’ and ‘bicycle boxes’. The initiative aims to reduce greenhouse gas emissions by promoting alternative means of transportation. Elements like enhanced stormwater management and nurturing tree canopies to counteract the urban heat island effect have adaptation benefits. Various agencies are at the table in the initiative because a ‘complete street’ is not simply a transportation matter, nor exclusively under the Transportation Department’s purview. For example, permeable paving, rain gardens and other measures to reduce flooding and pollution enter the domain of the BWSC. Complete streets also impact, and are impacted by, the built environments around them, bringing them into the domain of the Redevelopment Authority. Beyond its substantive relevance to climate change, the Complete Streets initiative is an example of an agency designing a collaborative process for engaging others when responsibility is fragmented and interests and activities need to be aligned if objectives are to be met.

Other municipalities and regional efforts

The Boston region is characterized by fragmentation across municipal boundaries. The City of Boston is one of over 100 cities and towns in the metropolitan area, and accounts for only 650,000 of the region’s 4.5 million residents (MAPC, 2015; U.S. Census Bureau, 2013, 2014). With some notable exceptions, many of the communities in the region have minimal or no climate change initiatives. Boston’s neighbor Cambridge has been particularly active,

³ According to interviewees on both the BWSC and institutional side, this communication is not simply one way. The users of this data provide feedback on if, when, and how flooding actually occurs so that they can hone in on problem spots.

with a series of initiatives. The City joined ICLEI's climate efforts in 1999, adopted a Climate Protection Plan in 2002, and has released over a dozen climate-related plans and reports since (Cambridge Community Development Department, 2015a; Climate Protection Action Committee, 2010). A standing Climate Protection Action Committee comprised of community members from both key stakeholder groups and the general public meets regularly and drafts recommendations for the city.

Cambridge's efforts have traditionally focused more on mitigating greenhouse gas emissions than climate adaptation, but the city is increasingly trained on adaptation as well. The Climate Protection Action Committee released a set of Recommendations for Adaptation to Climate Change in 2010, focusing largely on sea level rise and public health impacts (including extreme heat, ground level ozone and shifting disease vectors). Some general recommendations were provided – including 'no or low regret' options like switching to white roofs and initiating planning and design processes for long-term projects like raising the Charles River Dam – and a call was made for a deeper vulnerability assessment (Climate Protection Action Committee, 2010). In response, the City initiated a comprehensive Climate Change Vulnerability Assessment involving leadership from the relevant city departments (Community Development, Public Works and Public Health); a technical advisory committee of experts from state agencies, academia, relevant private industries like real estate; and private citizens; and a consultant team of modelers, engineers and stakeholder engagement specialists. A preliminary set of findings was released at a public meeting in March, 2015, which included: Precipitation-driven flooding and extreme heat events are likely to become increasingly acute problems, even in the 2030 planning horizon, while sea level rise will only threaten Cambridge later, and even then the risk is contingent on how the Amelia Earhart dam on the Mystic River is operated (Cambridge Community Development Department, 2015b; Roberts and Ferguson, 2015). Once the assessment work is finalized, the plan is to widely disseminate the results and develop a comprehensive preparedness plan.

Cambridge's vulnerability assessment – like similar efforts in Boston – accentuates the challenges of adapting across a jurisdictionally fragmented planning environment. The latest modeling suggests that the most significant sea level rise and storm surge threats to Cambridge are via overtopping of the Amelia Earhart dam (Roberts and Ferguson, 2015). The dam is operated by the Department of Conservation and Recreation (a state agency); the Army Corps of Engineers (a federal agency) and others have regulatory oversight; and flooding would reach Cambridge overland via neighbors Somerville and Boston. As the Climate Protection Action Committee recognized in their initial adaptation recommendations (2010: 2):

It is not possible for the City on its own to implement measures to fully protect Cambridge against future storm surge flooding. Because seawater would come from the harbor and there are routes through Boston and Somerville that will contribute flood water, a regional response is required. The committee believes that state and federal agencies are critical players in any response to this problem.

The Metropolitan Area Planning Council (MAPC) plays a regional coordination role, “promot[ing] smart growth and regional collaboration. [...They] work toward sound municipal management, sustainable land use, protection of natural resources, efficient and affordable transportation, a diverse housing stock, public safety, economic development, clean energy, healthy communities, an informed public, and equity and opportunity among people of all backgrounds” (MAPC, 2015a). The Council is comprised of representatives from each of the 101 member communities, 21 gubernatorial appointees, 10 ex-officio state appointees from relevant agencies (e.g., the Departments of Transportation and Housing and Community Development), and three ex-officio City of Boston officials; and is served by approximately 80 professional and administrative staff (MAPC, 2015a). The MAPC established a goal for the region of “being prepared for, and resilient to, natural disasters and climate change” in their 2008 MetroFuture Regional Plan (MAPC, 2015b: 2-1). In pursuit of this goal, the organization developed a Metro Boston Regional Climate Change Adaptation Strategy Report, which assesses the vulnerabilities and outlines a strategy in the following thematic areas (MAPC, 2015b):

- *Implement Mitigation as Adaptation*
 - *Implement Green Infrastructure*
 - *Institute Water Conservation Practices*
 - *Implement Energy Efficiency and Renewable Energy Measures*
- *Protect and Preserve Natural Resources*
 - *Regulation and Zoning*
 - *Ecological and Habitat Restoration*
 - *Land Conservation*
- *Protect the Coastal Zone*
 - *Revise/Create Regulations and Zoning to Protect Coastal Resources*
 - *Complete Coastal Wetland and Shoreline Restoration Projects*
 - *Consider Retreat / Land Acquisition Measures*
- *Built Environment and Infrastructure*
 - *Implement Protective Regulations and Zoning*
 - *Low Impact Development Techniques*
 - *Establish Green Building / Climate Resilient Design Guidelines*
 - *Protect Critical Infrastructure*
- *Health and Human Resources*
 - *Identify and Protect Vulnerable Populations*
 - *Build and Bolster Community Resilience*
 - *Ensure Access to Food Supplies*
 - *Prepare for Worsening Air Quality*
 - *Weatherization & Green Building Measures*
 - *Ensure Coordination and Collaboration*
- *Local Economy and Government*
 - *Internal Coordination*
 - *Budget and Resources Allocation*
 - *Identify, Support and Protect Assets Critical to an Functioning Economy*
 - *Create Resilience Networks and Cultivate Partnerships*

- *Emergency Preparedness*
- *Protect Agricultural Resources and Agro-Tourism*
- *Protection of Cultural and Historic Assets and Records*

The strategy was developed in partnership with the Tellus Institute, a non-profit research and policy organization, with financial support from the federal government’s Sustainable Communities Program and the Barr Foundation. It outlines the relevant State regulations and programs in each area; proposes new state and local regulations; makes other recommendations for both governmental and non-governmental actors; and proposes various roles for the MAPC in this work. For example, under the ‘water infrastructure’ subsection of ‘protect critical infrastructure’, the strategy recommends that the MAPC work with the Department of Environmental Protection and local water managers to make ‘resiliency’ investments, re-engineer existing systems, and work to reduce demand (MAPC, 2015b). Unsurprisingly for a regional coordinating council, two of the ‘guiding principles’ for the MAPC effort are facilitating ‘effective regional partnerships’ between municipalities, state government and the private sector, and ‘strengthened communication across institutions and communities’.

As discussed further later in this chapter, interviewees reflected that the MAPC could play an important role in cording across municipal boundaries and enhancing best practices, particularly among smaller member communities, but the organization is very limited in its authority. It does not have the jurisdiction, or the influence, to impose a comprehensive and integrated approach to climate vulnerability on the region.

Commonwealth of Massachusetts (State)

A significant proportion of the infrastructure in the metro Boston area - including the public transportation system, the arterial road network, much of the coastal defenses and the freshwater and wastewater treatment systems – is managed by state agencies. Agencies are at various stages in their climate adaptation work, although few are making concrete efforts to enhance resiliency thus far. The Global Warming Solutions Act, which was passed by the Massachusetts Legislature and signed by former Governor Deval Patrick in 2008, focused largely on greenhouse gas emissions reductions, but Section 9 is explicitly adaptation-focused. It mandated the creation of an adaptation advisory committee, with representation and expertise from transportation, water, energy, and other infrastructure systems; manufacturing; low income communities; land conservation, coastal management, and ecosystems; and local government (Commonwealth of Massachusetts, 2008).

In response, the Secretary of Energy and Environmental Affairs convened an Advisory Committee comprised of academics and researchers, representatives from key non-governmental organizations, and regional planning commissions; and a separate State Agencies Steering Committee with representation from the key departments, including Transportation, Health and Coastal Zone Management. Much of the work was done through thematic subcommittees, including one focused on ‘Key Infrastructure’, which was co-chaired by representatives of the Departments of Environmental Protection and Transportation, and included members from other agencies, academia, NGOs, utilities, and

engineering consulting (EEA [Executive Office of Energy and Environmental Affairs and the Adaptation Advisory Committee], 2011). This process culminated in the release of the Massachusetts Climate Change Adaptation Report in 2011. The report outlines the threats the Commonwealth faces, and introduces both cross-sectoral and sector-specific strategies for adapting to them. For Key Infrastructure, the report makes some general recommendations, like “Explore Possible Changes in Land Use, Design, Site Selection, and Building Standards” and “Identify Lead Times for Adaptive Construction” (EEA, 2011: 55). In the area of transportation infrastructure, the report enumerates the following potential strategies (EEA, 2011: 58-59):

No Regrets Strategies

- *Continue Maintenance of Existing Infrastructure. Maintain existing transportation infrastructure to minimize the chances of flooding or other damage that might occur before final or more permanent adaptation plans can be implemented.*
- *Expand the use of the statewide GIS-based system asset maps by combining them with updated floodplain mapping and revised peak flood flow calculations.*
- *Formulate risk-based methods to evaluate service life of infrastructure assets against adverse climate change.*
- *Update hydrologic and hydraulic analyses statewide, including engineering methods used in the calculation of peak flood flow rates, to reflect influence of climate change-induced events [...].*
- *Research and Develop Engineering Solutions. The Massachusetts Department of Transportation and Massachusetts Port Authority should work with regional and municipal agencies to identify, develop and implement solutions—including reconstruction, removal, or relocation of vulnerable infrastructure—to protect existing assets from climate change impacts in the long- and short-term.*
- *Protect Existing Infrastructure. Modifications include elevating, armoring, modifying, or relocating critical infrastructure. Airport, mass transit, port, and highway agencies should consider sizing stormwater management structures (e.g., pipes, culverts, outfalls) for future storm events and balancing upfront costs of incrementally larger structures today with the future costs of replacing an entire drainage system.*

Short-Term Strategies

- *Public and private transportation entities should adjust standard maintenance and inspection procedures to take into account climate changes impacts, including increasing the frequency of routine inspections of coastal zone and inland bridges and drainage structures and initiating comprehensive regional asset damage inventories after major storm events.*
- *Develop New Design Standards. Revise standards to be consistent with guidelines reflecting climate considerations issued by such entities as the American Association of State Highway and Transportation Officials, Federal Highway Administration, [etc...]*

Long-Term Strategies

- *Encourage innovation across transportation sectors. Encourage use of new technologies at airports for navigation aids and airfield lighting systems that function better during storm events [...]*
- *Enhance water-based transit options in affected coastal and riverine areas as a long-range transport alternative and as an interim back-up to damaged infrastructure.*
- *Develop financing mechanisms. Evaluate and implement as necessary new ways to fund the anticipated expenses, including construction and long-term maintenance and operation costs, to address climate change impacts at the state and local levels.*

The Massachusetts Climate Change Adaptation Report was intended as an initial step in the Commonwealth's efforts. It guided agencies and other stakeholders as they start to engage in, or enhance existing, vulnerability analysis and planning for short medium and long-term adaptive responses. Since its release, agencies have engaged in adaptation efforts to varying degrees, although few have moved beyond examining the risks and some have not even done that yet. According to an interviewee, the ultimate "goal is not to have one person in each organization that is 'the climate person', but rather to have everyone informed and the issue infused throughout organizations". This is an aspiration yet to be realized.

The Executive Office of Energy and Environmental Affairs plays a key coordinating role, working with other agencies and developing wider policy recommendations. The agency administers a State Revolving Fund for Climate Change Adaptation, which assists with water and wastewater infrastructure projects, "strongly [encouraging] municipalities to consider predicted climate change impacts in siting and designing their projects" (EEA, 2015). Over \$500 million was lent from the fund in 2014. The Office had a dedicated Policy Advisor for Climate Change Adaptation, although she has moved on since the election of a new governor and administration. According to an interviewee, previous Secretary of Energy and Environmental Affairs Richard Sullivan made adaptation a priority for the EEA, tasking staff to identify the most critical things to be addressed in the final years of the (now previous) Patrick administration; their assessment considered various things, including infrastructure and public health, both in-house at the state level, and at the municipal level. Twenty-seven items were identified in the Governor's subsequent \$50 million dollar investment plan. What is not clear is how much of a priority climate adaptation will be going forward, with a new administration running the state as of January, 2015.

Climate change is a significant issue for the Office of Coastal Zone Management (CZM), which is an EEA agency. The CZM's StormSmart Coasts program "provides information, strategies, and tools to help communities and people working and living on the coast to address the challenges of erosion, flooding, storms, sea level rise, and other climate change impacts. The program also promotes effective management of coastal landforms, such as beaches and dunes" (CZM, 2015). Initiatives are targeted at different constituencies. The StormSmart Communities program provides tools for local government officials, including profiles on pilot projects the CZM ran with different coastal communities, and links to

external resources. Fact sheets cover topics like ‘Landscaping to Protect Your Coastal Property from Storm Damage and Flooding’, ‘Who to Contact and What to Do Before Building or Rebuilding’ and ‘A Cape Cod Community Prevents New Residences in Floodplains’. The StormSmart Properties program is targeted towards homeowners, providing information on how they can reduce coastal erosion and storm damage with minimal ecological damage; fact sheets cover topics like ‘Bioengineering/Coir Rolls on Coastal Banks’ and ‘Sand Fencing’. The StormSmart Coasts program serves as a clearinghouse for data the CZM and other agencies have compiled on the vulnerability of coastal areas; tools include a Shoreline Change Browser, floodplain and flood insurance maps, storm surge and coastal inundation maps/models, and sea level rise impacts (Ibid.). The CZM also administers two adaptation-related grant programs: The Coastal Community Resilience Grant Program “provides financial and technical resources to advance new and innovative local efforts to increase awareness of climate impacts, identify vulnerabilities, and implement measures to increase community resilience (i.e., the ability to endure impacts associated with coastal storms and the effects of erosion, flooding, and sea level rise and to respond, recover, and adapt to consequences)” (Ibid.). The Green Infrastructure for Coastal Resilience Grant Program “provides financial and technical resources to advance the understanding and implementation of natural approaches to mitigating coastal erosion and flooding problems[, supporting] the planning, feasibility assessment, design, permitting, construction, and monitoring/evaluation of green infrastructure projects that implement natural or living shoreline approaches” (Ibid.). According to an interviewee, the expectation is that these seed grants will support the development of best practices that other coastal communities can adopt without financial support from the CZM.

One thing the CZM lacks is regulatory authority; there is little the agency can do to require municipalities and private landowners to make more resilient decisions vis-à-vis their coastal planning. An interviewee noted the guidance on adaptation they are disseminating, which says “you should use the best information available, and the project proponent - the community - should decide what kind of risk they should be agreeable to”. However, she acknowledged that they lack teeth to enforce: “We can’t require anything that is stricter than the building code. So the building code says what level you have to be at with your first floor, and you can’t require anything higher than that. You can use incentives, and I think that’s something that [is] a limitation”. The interviewee noted that even with municipal harbor planning, the city does the plan, and CZM and EEA approve those plans for development along the water with requirements that they consider climate risks but no concrete standards on what that means: “It’s a performance standard - it’s not ‘you have to build at this level’, it’s ‘how is this public amenity, this public realm going to perform in the future?’ and nobody knows what the level is going to be exactly, so it’s sort of using best guesses and what the proponent sees as how risk averse they want to be”.

The Department of Conservation and Recreation (DCR) is another EEA agency that may face substantial climate vulnerabilities, given its responsibility for, among other things: Many of the seawalls along the coast; approximately 1,500 dams directly, plus oversight of hundreds more; parks and public lands (DCR is the largest landowner in Massachusetts); approximately 500 lane miles of parkways and other roads; and water resource protection (DCR, 2015). According to DCR interviewees, the organization is starting to look at climate

data in their projections, and consider how climate change vulnerabilities might influence the ways in which they evaluate projects, prioritize and invest. A substantial hurdle is that the agency already faces \$1 billion in deferred maintenance, so is challenged with making difficult choices. Another issue they grapple with as they consider how to integrate climate change into their planning and decision-making is the question of which assets to armor and which to, in the words of an interviewee “abandon to climate change” over time. Each alternative will be more or less appropriate in different situations, but the question is where the line falls – that is, “what criteria should be applied when deciding when to armor vulnerable areas and when to let go”. Interviewees noted that, in the words of one: “This gets very political!” Even if it is technically smarter to abandon, this is not always palatable to stakeholders fond of their beach or concerned about changes to a particular parkway. In general, there are often cultural or historical reasons why people strongly resist change – they face this with dam removals and the resistance to the associated landscape changes. DCR interviewees also noted that adaptation can compete with other priorities. An example provided was the Nahant Causeway just north of Boston. The DCR has been reconstructing it because of flooding problems, and might have elevated further, but came up against permitting limitations; in particular, environmental regulations limited the degree to which they could enlarge the causeway. It can be a matter of environmental protection versus public safety. “These tensions cannot be resolved using the traditional permitting guidelines because they are not complex, not comprehensive”, reflected an interviewee. Another reflected that they faced a somewhat similar situation with Morrissey Boulevard, a coastal parkway in Boston – They are rebuilding because it suffers from significant flooding challenges already, and could be elevating substantially, but that would come at a cost in terms of the landscape and access.

The Massachusetts Department of Transportation (MassDOT) directly or indirectly oversees much of the transportation infrastructure in the state, including roads and public transit. The impacts of climate change are on the agency’s radar, although activity so far has largely been investigatory in nature, rather than involving concrete changes to infrastructure design and/or management.

A Federal Highway Administration-funded pilot project titled Climate Change and Extreme Weather Vulnerability Assessments and Adaptation Options of the Central Artery is particularly notable. The Central Artery includes sections of interstate highways 90 and 93 in Boston that are largely underground as a result of the ‘big dig’ project in the 1990’s and 2000’s, which was one of the most expensive infrastructure projects in U.S. history at an estimated \$22 billion (Murphy, 2008). Billions were spent on this critical infrastructure relatively recently – project loans will not be paid off until 2038 at the earliest – yet it appears to be quite vulnerable to flooding from coastal storm surge. The Vulnerability Assessment, which is being conducted in partnership with experts from academia and a private consulting firm (the Woods Hole Group), involves the development of very sophisticated flooding models (Miller et al., 2014). The assessment team is bringing together data from a variety of sources to develop a range of scenarios, and using Monte Carlo methods to get a probabilistic analysis of the risks. They are simulating flooding based on projections for 2030, 2070 and 2100. According to an interviewee, the initial data

already indicates that this assessment will paint a very different picture than the classic bathtub models, because of the hydrodynamic component.

Concurrently with enhancing their understanding of the hydrologic dynamics, the Central Artery Vulnerability Assessment team is evaluating the vulnerability of specific assets – including tunnel entrance and exit ramps and vent buildings – and considering how they might be better protected. “An important step when assessing risk tolerance will be deciding what is critical and what is not”, reflected an interviewee. Once the models are done they will engage with their counterparts on the operations side in the district office to understand what is critical and what is not. “Maybe if [an area] just floods a bit, the pumps can deal with it, and its not a big deal, but if infrastructure like vent building 4, which is six floors of fans and so on is knocked out, that’s big problems, it’s extremely difficult to fix”, said an interviewee. It then becomes a discussion around risk tolerance. “When we are saying 2030, it’s really about setting funding priorities now – [establishing] what the potentials are, and what we need to be funding and building now, putting into the pipeline now to prepare for 2030, which is not that far out at all obviously”, said an interviewee. The same interviewee added that decision-making is complicated by the presence of different priorities among different stakeholders. Even discussions around questions like what will be constructed over vulnerable openings along the Rose Kennedy Greenway over the Central Artery can be contentious, and must involve other actors, like the Boston Redevelopment Authority, and the general public. Taking these various factors into account, it becomes “about developing strategies for each vulnerability - in some cases, it might be de-energizing equipment, letting it flood, and then dealing with cleanup afterwards - the tunnels might be closed for a short time and some cleanup will be required, but it’s much better than [having it] closed for days and the high costs associated with replacing blown-out equipment”.

The complex modeling being conducted under the MassDOT Central Artery assessment project drew the interest of other key stakeholders, including the Cities of Boston and Cambridge and other state agencies. In fact, these municipalities and some other state and federal agencies officially joined the project, expanding the scope so that they may benefit from the results for their own analysis and planning. Several other agencies are also awaiting the results. “The public can’t be told the Charles will rise 2 feet if you live in Boston, and 3 feet if you live in Cambridge because both have ranges but decide to use different numbers”, reflected an interviewee from a different agency, adding: “We don’t want to look like bozos! We need a consensus range [so that] consultants and agencies are all playing with the same deck of cards”. “Nobody wants to conflict with anyone at this point, and because [MassDOT] has the savviest modeling, everyone is waiting for them- it’s about coordination on what we should be planning to”, said another. MassDOT is not the logical coordinator or clearinghouse for information on the impacts of climate change, but has de facto become so because they initiated this project that has wider implications than the highway assets they originally set out to examine, and is providing better information than others have. This does put substantial pressure on the agency to consider how they disseminate the results. “We are going to take a cautious roll-out approach, testing with one organization first, seeing how it is received, and then going out from there”, said a MassDOT interviewee, adding that it will certainly be released to the general public, but

with cautionary statements. Reflecting the complications associated with fragmented responsibility, limited resources and a desire to share information while not causing panic, the interviewee reflected:

I don't want to generate panic! I don't want people to second-guess where they live right now. Part of my strategy is for organizations like MassDOT, the City, and others to take the data, assess the risks, and develop strategies for advancing regional protection, rather than individual adaptation. We need to identify the hotspots and take coordinated action. But, it takes money! No one has \$1 billion to do this right away without major disruption.

The next step for MassDOT is extending the vulnerability model along the rest of the coast. There is also a separate statewide vulnerability process currently underway, which is looking at more factors than sea level rise and storm surge. It is clear that MassDOT is deeply engaged in assessing climate vulnerabilities. Thus far, however, this does not seem to be translating into concrete changes in practice. According to another interviewee that works at the agency:

I don't see anything happening yet, besides the vulnerability assessment. I think its a struggle, because we are being asked by districts that are building projects along the water, 'how are we supposed to build for resiliency?' [But] as we heard in the [RPS] workshop, there are no standards, and consultants say we are not putting our necks out to say what the standards are, even when Federal guidance comes out. [SO the question is], is it MassDOT guidance? Are we going to update our design manuals, and when does that warrant the investment?

MassDOT is substantially further along on its climate *mitigation* work (i.e., reducing greenhouse gas initiatives). Efforts are championed and supported by an internal initiative called GreenDOT that is “MassDOT’s comprehensive environmental responsibility and sustainability initiative, which entails integrating sustainability principles into all aspects of the way that MassDOT plans, designs, builds, and operates our state transportation system” (MassDOT, 2015a). An interviewee described the initiative as follows:

[GreenDOT] can act as a bridge between folks in MassDOT that have different objectives and are trying to get them achieved, and understands those objectives and constraints, [while] also understanding were folks from the outside are coming from on the environmental regulatory side, as well as the external stakeholder side. So, [it] can bring those perspectives together and act as a bit of a bridge, a convener, and hopefully enable them to talk to each other and also be able to talk to either side and try to anticipate some of the issues that may come up. [...GreenDOT knows] what EEA's issues are going to be, [and] what [the Conservation Law Foundation, an important advocacy organization's] issues will be. [GreenDOT staff] can say, 'hey, if you look at this this way then you are also avoiding this potential problem in the future'. And on the other side, maybe talking to EEA or CLF in a different venue and be in a position to educate them about those resource issues and those constraints that [MassDOT is] facing, hopefully advancing the conversation.

According to interviewees, it is unclear what role GreenDOT will play in integrating climate resilience into the agency, but it is both an option moving forward and a model of how internal champions can facilitate the integration of new issues – like responding to climate change – into large government agencies that can be slow to change.

The Massachusetts Bay Transportation Authority (MBTA) is the subsidiary of MassDOT responsible for the public transit system in the greater Boston area. As the 5th largest mass transit system in the United States with an average weekday ridership of 1.3 million passenger trips, it runs an extensive network: Three subway lines; five light rail lines; 183 bus and trolleybus routes; and 13 commuter rail routes (MBTA, 2015a). The MBTA recognizes its acute vulnerabilities to climate change, stating that (MBTA, 2015b):

Much of the MBTA network was built on or near low-lying areas and near local rivers or the ocean. Moreover, a significant portion of Boston itself is built on “landfill” that was once under water and is prone to revert to its natural state in the event of floods or significant rain fall. Unfortunately, climate change science suggests that storms with high intensity rainfall over short periods are likely to become more prevalent and more severe and that facilities such as these will be particularly vulnerable to those intense events. The MBTA recognizes the importance of protecting vulnerable, key transit assets to avoid costly replacement and negative service impacts.

The agency is currently in the process of assessing the threats posed to its assets, and is making climate change adaptation a criteria in capital investment planning – “While issues such as service criticality, safety, increased mode shift, and other criteria have long been used to decide on funding programs, the degree to which the project makes the system more resilient to climate change is now an added decision making criteria” (MBTA, 2015b). Unfortunately, the MBTA is an old system with almost \$9 billion in debt and \$7 billion in deferred maintenance (Gurley, 2015). Outdated equipment and poor maintenance greatly exacerbated the challenges the MBTA faced during record snowfall in the winter of 2015; substantial portions of the system were crippled for days, riders were stranded during regular breakdowns, and the CEO ultimately resigned amidst the uproar (Dungca, 2015). As discussed earlier in this chapter, this kind of disruptive weather – whether extreme snowfall, heavy rains or strong winds – may become increasingly common with climate change. This represents a substantial challenge to already fragile infrastructures, like the MBTA system. A scathing report commissioned by Governor Charlie Baker to assess what went wrong and how similar problems might be avoided in the future concluded that: “The catastrophic winter breakdowns were symptomatic of structural problems that require fundamental change in virtually all aspects of the MBTA” (Governor’s Special Panel to Review the MBTA, 2015: 4). Two of the Panel’s Key Findings are funding-related - *Unstable Operating Budget* and *Chronic Capital Underinvestment* - but the rest relate to poor governance: *Bottlenecked Project Delivery*, *Ineffective Workplace Practices*, *Shortsighted Expansion Program*, *Organizational Instability*, *Lack of Customer Focus*, *Flawed Contracting Processes*, and *Lack of Accountability* (Governor’s Special Panel to Review the MBTA, 2015: 6). Both financial and governance challenges may significantly constrict the MBTA’s ability to adequately prepare for the significant risks posed by climate change.

The Massachusetts Port Authority (Massport) is the separate government agency responsible for operating Boston's main international airport, two smaller airports in the area, and commercial port facilities throughout Boston Harbor. It is a public authority with a board appointed by the Governor of Massachusetts, but is completely self-financing. Massport has committed to an ambitious multi-million dollar program to both mitigate greenhouse gas emissions and address the risks posed by climate change (Abel, 2015). Many of Massport's assets are vulnerable – the airport is constructed on fill in Boston Harbor, surrounded by water on three sides. The Authority has a Resiliency Program with a dedicated program manager and working group comprised of key individuals from across the organization. The goals of the resiliency program are (Massport, 2015b):

- *Improve resiliency for overall infrastructure and operations*
- *Restore operations during and after disruptive events in a safe and economically viable time frame*
- *Create robust feed-back loops that allow new solutions as conditions change*
- *Inform operations and policy, and implement design/build decisions, through the application of sound scientific research and principles that consider threats, vulnerabilities, and cost-benefit calculations*
- *Become a knowledge-sharing exemplar of a forward-thinking, resilient port authority*
- *Work with key influencers and decision makers to strengthen understanding of the human, national, and economic security implications of extreme weather, changing climate, and man-made threats to Massport's facilities and the region*

Strategically, the Resiliency Program is working towards these goals by convening internal and external efforts to facilitate collaborative efforts to enhance resilience; conducting and compiling research to better understand the threats; fostering the incorporation of more resilient design into infrastructure projects and asset management; educating and training staff and other stakeholders on the threats and various possible responses; and creating operations plans to keep facilities operating during and/or to facilitate rapid recovery from major events (Massport, 2015b). The Authority plans to spend \$9 million over the next five years on flood protection barriers, pumps and other investments to protect the airport from storm surges, and millions more over the next decade to elevate equipment and upgrade systems (Abel, 2015). According to more than one interviewee, a challenge for Massport is the vulnerabilities in the systems they depend on, but that are beyond their control; in particular, most traffic to the airport arrives via roads that tunnel under the harbor and may be very vulnerable to flooding, or the MBTA's Blue Line subway, which is also extremely vulnerable. No matter how much Massport increases its own resilience, people and goods need to be able to get to and from the airport and marine terminals, they need energy and other utilities to operate, and so on. To this end, the Resiliency Program is facilitating networks of decision-makers from other agencies. That being said, an interviewee from a different agency noted that Massport can be protective of its knowledge and resources at times, curtailing the kind of collaboration necessary.

The Massachusetts Water Resource Authority (MWRA) is the public authority that provides wholesale water and sewer services to most municipalities in eastern Massachusetts (MWRA, 2015). The organization supplies municipal agencies like the Boston Water and Sewer Commission with bulk fresh water from their reservoirs, and receives and processes their sewerage. The agency operates the state-of-the-art Deer Island Sewage Treatment Plant, which was constructed in the 1980's and 90's as a central component of the court-mandated cleanup of Boston Harbor. The Plant is often cited as an example of foresight in climate preparedness, as engineers back in the 1980's when it was designed already accounted for some sea level rise, elevating critical components 0.58 meters (1.9 feet) higher than they otherwise would have been built (Walton, 2012). According to an interviewee, this integration of climate change was "done in a bit of a gorilla way - there was no high-level meeting on it, [they] just incorporated it into the design":

They worked backwards, given that it is a gravity-based system, calculating the head needed going in and out to the outflows, heights of the various tanks throughout the system. Someone just said 'this climate change thing is being talked about, should we factor in a bit?' They then looked at a couple studies and said 'OK, 1.9 feet'. This is not a huge increase, and may not be sufficient over the longer-term, but probably bought us 30 years of not having to worry about how to protect that infrastructure with new dikes or something. Because of this, Deer Island is close to the bottom of [the MWRA's] priority ranking of projects to address, even though it is [critical infrastructure].

The MWRA continues to take what Director of Planning Stephen Estes-Smargiassi (2014) calls a "pragmatic approach to climate change adaptation". The organization has conducted an analysis of its assets, categorized them based on the level of risk they face. The callout box below examines why the MWRA and its municipal counterpart in Boston are at the forefront of concretely integrating climate risks into their planning and decision-making, including at the project level.

Why are the Boston Water and Sewer Commission and the Massachusetts Water Resource Authority leaders in adaptation?

The MWRA and BWSC, which are responsible for potable water and sewerage at the municipal and regional levels respectively, are at the vanguard of integrating climate risks into project-level planning and decision-making in the Boston area. While many agencies are now evaluating the risks climate change may pose to their assets, few others are making concrete changes in response. Neither the MRWA nor the BWSC have taken radical steps, but both are implementing small changes to flood-proof vulnerable assets and shifting the way they make investments to enhance resiliency over time. An important question is why these agencies are ahead of their peers in other sectors and what, if anything, can be learned from that.

One reason seems to be the direct relevance of climate change, and particularly water-related threats, to water and sanitation agencies. The connection is more apparent than

with other infrastructures, like electricity or transportation. "Climate change is troublesome, but we are already an organization working with water, so its about pressing our existing capacities rather than a whole new set of problems", said an interviewee in one of these agencies. This underscores the need to make climate change relevant to agencies.

A second reason seems to be the proactive steps of strong internal champions. John Sullivan, the Chief Engineer of the BWSC, became aware of the potential threats associated with climate change early on and has been a strong voice both within and outside the organization. Stephen Estes-Smargiassi, the MWRA's Director of Planning, has played a similar role in that organization. These driving personalities were important in raising the issue, but they, and other members of their teams, were also important insofar as they laid the groundwork. According to an interviewee in one of these organizations:

We started to work on this climate change stuff way back in the mid 1990s, and from what we could tell the management was kind of skeptical, [asking] 'is this real, is it a passing fad, or is it reality?' But we kept chugging along, and then only after Hurricane Sandy did people [...] become really focused that this could be real, but we had been working on this in the background, so that is when we put out the stuff that we had been working on.

Internal champions that were senior enough to have access to resources laid important foundations. Buy-in from their superiors became important as their resource needs grew; fortunately, both had leadership that came to understand and support their efforts. After Hurricane Sandy, the MWRA decided to review their benchmark for risk tolerance, and added 2.5 feet to their 100-year flood projections. "This was a really easy sell to the senior management", said an interviewee, adding that they were "interested in seeing new numbers and understood that conditions are changing". It also helped that this new 2.5 ft. standard was similar to that being put forward by other organizations, adding legitimacy. This is now the number they use when putting out bids for infrastructure restoration work.

Third, these two agencies have relative autonomy, particularly when it comes to funding. Unlike most other government agencies, their revenues primarily come from the fees they directly or indirectly levee on water customers. This gives them a more stable revenue stream to invest in efforts like adapting infrastructure, and makes them less beholden to the changing budget priorities of political institutions. "We don't have to compete for funding with schools, housing, parks and a lot of other important things", said an interviewee, adding that "we can get six or seven people into a room and make decisions that stick".

Their autonomy is also a product of the relatively closed systems these agencies operate. While the MWRA and BWSC rely on each other (and the 60 other municipalities in the case of the MWRA), their control is relatively consolidated. "It's true that we have it easier as an agency compared to others like transportation - we know how the water behaves, but you don't tell people how to drive! It is a relatively closed system compared to complex, interconnected roadways", said an interviewee. However, they are not completely

autonomous. An interviewee cited the Muddy River Restoration Project in Boston as an example of how it can get complex. The BWSC convened stakeholders to evaluate the problem after the river flooded three times in less than 20 years, but it was unclear whose problem it was. Ultimately, the restoration project is being led and funded by the U.S. Army Corps of Engineers, but with partners from various state and local agencies (MMOC, 2015).

This examination is based on interviews with individuals both within and outside these two agencies, and examination of documents, including: Boston Water and Sewer Commission (2014); Estes-Smargiassi (2014); and Spector and Bamberger (2013).

Federal initiatives and Agencies

The Federal Government in the United States plays important roles in the management of various infrastructure systems. It directly owns and operates very little infrastructure in the Boston area, yet is quite influential through both regulatory and financial channels. It also supports the development of best practices in newly emerging areas like climate resilience, and promotes their dissemination. The Federal Government has been criticized for inaction on climate change, particularly on the mitigation side, and any measures that would require legislative approval, like signing an international climate treaty, seem unlikely under current circumstances with a Congress controlled by the Republicans and White House (executive branch) by the Democrats.

Nonetheless, the Obama Administration is exerting the executive authority it does have to advance action on climate change. This includes Executive Order 13653, which mandated: “Modernizing Federal Programs to Support Climate Resilient Investment”; “Managing Lands and Waters for Climate Preparedness and Resilience”; the creation of an interagency Council on Climate Preparedness and Resilience; and the creation of a State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience (The White House, 2013). This Task Force provided a set of Recommendations to the President in November of 2014, emphasizing the key roles the Federal Government must play in adapting to climate change, particularly vis-à-vis local, state and tribal agencies. The first recommendation was *Building Resilient Communities*, adding that: “By incorporating climate change considerations into its programs, the Federal Government can support communities as they rethink traditional approaches to land use and land management, building and infrastructure siting and design, and community planning” (State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience, 2014). The President’s Climate Action Plan, which was released in 2013, also puts adaptation front and center, stating that: “The federal government has an important role to play in supporting community-based preparedness and resilience efforts, establishing policies that promote preparedness, protecting critical infrastructure and public resources, supporting science and research germane to preparedness and resilience, and ensuring that federal operations and facilities continue to protect and serve citizens in a changing climate” (Executive Office of the President, 2013: 12). The Administration has also established itself as an important clearinghouse for climate data with the <http://climate.data.gov> hub, which contains a wealth of data from various agencies. The U.S. Climate Resilience Toolkit is another portal

the Administration operates to disseminate information on climate vulnerabilities, and promote adaptive responses (see <http://toolkit.climate.gov>).

The U.S. Global Change Research Program, which is chartered under the Federal Advisory Committee Act, brings together various key experts from both inside and outside government to generate comprehensive National Climate Assessments – the third Assessment was released in 2014 (Melillo, Richmond and Yohe, 2014). The Adaptation chapter of the Assessment largely focuses on enumerating the risks, but does include a small section on potential ‘response strategies’. It ascribes the following tasks to Federal agencies (Bierbaum et al., 2014: 675):

- *Fostering the stewardship of public resources and maintenance of federal facilities, services, and operations such as defense, emergency management, transportation, and ecosystem conservation in the face of a changing climate;*
- *Providing usable information and financial support for adaptation;*
- *Facilitating the dissemination of best practices and supporting a clearinghouse to share data, resources, and lessons learned;*
- *Dealing with and anticipating impacts that cross geopolitical boundaries, assisting in disaster response, and supporting flexible regulatory frameworks;*
- *Ensuring the establishment of federal policies that allow for “flexible” adaptation efforts and take steps to avoid unintended consequences; and*
- *Building public awareness.*

Many Federal agencies are examining the risks posed by climate change and potential adaptive responses. According to Bierbaum et al. (2014), at least 16 agencies, ranging from the Department of Agriculture to the Bureau of Land Management have activities to support adaptation. Post Hurricane Sandy, the Department of Housing and Urban Development has been leading a multi-agency Rebuilding Taskforce to learn from what happened, increase understanding of how conditions might change in the future, and rebuild in ways that enhance resilience. The Task Force and associated Federal efforts emphasize coordination across agencies and levels of government to maximize the impacts and promote efficient, effective and resilient rebuilding in an extremely complex institutional environment (Hurricane Sandy Rebuilding Task Force, 2013).

The U.S. Department of transportation (USDOT) has a Transportation and Climate Change Clearinghouse (<http://climate.dot.gov>), which includes content on climate change impacts and adaptation planning. The agency released a Climate Adaptation Plan – subtitled ‘Ensuring Transportation Infrastructure and System Resilience’ – in 2014, updating their first (2012) plan. The Plan enumerates the threats climate change poses to the nation’s transportation infrastructure, and introduces programs, policies and plans the agency has or will put in place to address them. These include: Eligibility for reimbursement of adaptation planning and resiliency features as part of Federally-funded pilot projects; billions to help transportation agencies impacted by Hurricane Sandy enhance their resilience; studies, including a multi-year program assessing the vulnerabilities of infrastructure on the Gulf of Mexico; and various outreach and educational activities

(USDOT, 2014). The Federal Highway Administration (FHWA), which is a branch of the USDOT, “strongly encourages consideration of potential climate change impacts in the transportation planning process”, and is funding a set of pilot projects being implemented by various State DOTs, Metropolitan Planning Organizations (MPOs) and other agencies to test and develop approaches to assessing vulnerabilities and increasing resiliency (USDOT, 2014: 18). The aforementioned ‘Climate Change and Extreme Weather Vulnerability Assessments and Adaptation Options of the Central Artery’ project is one such pilot project. Another (now completed) pilot project close to Boston was a collaborative effort led by the USDOT’s Volpe (transportation research) center and the Cape Cod Commission, which is the MPO for that region, called the ‘Interagency Transportation, Land Use, and Climate Change Cape Cod Pilot Project (Volpe Center, 2011). The project revolved around scenario planning to consider how integrated land use and transportation planning might proceed in the face of significant climate uncertainties. The ‘Planning for Systems Management & Operations as part of Climate Change Adaptation’ document is yet another FHWA resource enumerating the threats and presenting potential adaptive responses (Gopalakrishna et al., 2013). Similar pilot projects and resources exist on the public transportation side, including the Federal Transit Administration’s ‘Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaptation report (Hodges, 2011).

The USDOT does not directly manage transportation infrastructure in the Boston area, with the exception of the publicly-owned national rail corporation Amtrak, yet is a very influential actor via the roles it plays disseminating best practices; supporting those best practices with grants, including both thematic grants, like those for adaptation pilot projects, and stipulations included in Federal block grants; and via the regulatory oversight it has. According to an interviewee, priorities are typically set in Washington, but it is left to the regional offices to work with their State and other MPO counterparts to advance implementation. Interviewees reflected that there are probably opportunities for the regional offices to be more active on climate resilience; they are somewhat aware of the pilot projects and guidance documents, but adaptation is not yet being permeated throughout the organization as a priority. When a priority does permeate the organization, the USDOT can be influential. An interviewee reflected that:

The DOT can take the ‘bully pulpit’ when it gets behind an issue. For example, former Secretary LaHood focused on the distracted driving issue, which led to political pressure to take it seriously. As a result, it was very much on the radar and various policy responses were taken. Leadership is really important to promoting the prominence of an issue, and thus the amount of attention given to it.

However, while the USDOT can play an important leadership role, ultimate decision-making largely lies with State and local agencies - “Ultimately, the [FHWA] is a partner with the State, [so] it is their responsibility to dictate the when and where. [We] can try to influence those decisions by providing better guidance, but it’s really up to them”, said an interviewee. This is particularly true around issues like resilience for which there are not (yet) regulations. According to an interviewee:

Right now, [there is] no regulation around climate change, because [there] first needs to be legislation, and only then can there be formal regulation, [and] that legislation seems unlikely in today's congressional environment, so for now it's only 'best practice guidelines'. At this point, [there is] nothing they can do to mandate states in this regard, and states are doing very different things. Some can't talk about climate change, but they are still doing things under the auspices of 'extreme weather'.

Furthermore, according to a different interviewee, even if resilience was incorporated into the National Environmental Policy Act or other regulations, they are typically procedural and not substantive laws, meaning that agencies can still select the 'worst options', as long as they go through the assessment steps.

The U.S. Army Corps of Engineers (USACE) is responsible for a substantial proportion of the flood control and coastal defense infrastructure around the country, and source of technical expertise in many other cases. It has faced challenges and controversies, including the failure of Corps levees to protect the city of New Orleans during Hurricane Katrina in 2005, causing catastrophic damage and loss of life, which was attributed in large part to shortcomings in their planning, design, construction, and management (Andresen et al., 2007). Partly in response to those infrastructure failures, the USACE is increasingly making 'building climate resilience' a priority (USACE, 2015a). In response to Hurricane Sandy, the Corps released a comprehensive 'North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk' (NACCS) in January of 2015, which introduces a 'risk management framework' and "support[s] resilient coastal communities and robust, sustainable coastal landscape systems, considering future sea level and climate change scenarios, to manage risk to vulnerable populations, property, ecosystems, and infrastructure" (USACE, 2015b). It provides a 'risk management framework' for enhancing coastal resilience and sets the foundation for ongoing investments. The NACCS presents a comprehensive suite of options for how coastal hazards might be better addressed, including both more traditional 'hard' infrastructure and 'softer', more adaptive solutions. The NACCS also includes an explicit analysis of how new measures to enhance resilience complement or are confounded by regulations and the plans and policies of various organizations, and provides associated 'opportunities for action' (Ibid.). The NACCS was prepared in partnership with state and local authorities and other stakeholders; it makes clear the shared nature of the responsibilities while underscoring the vital roles municipalities play as "the first line of defense in hazard mitigation planning" (Ibid.).

Non-governmental actors

A characteristic of adaptation planning in the greater Boston area – and more widely throughout the State and country – is the outsized roles played by non-governmental actors. Non-profit organizations, foundations and academic institutions are key actors in researching climate vulnerabilities, and examining and promoting potential adaptive responses. They often work with government agencies, playing key coordinating roles and providing capacity when and where it is otherwise limited.

The Boston Harbor Association (TBHA) is a particularly active non-profit in this area, bringing together respected experts and stakeholders and facilitating research and planning. The organization's 2010 Boston Sea Level Rise Maps and 2013 'Preparing for the Rising Tides' report are widely referred to for their assessment of the vulnerabilities the City faces (Douglas et al., 2013). The report provides a very brief set of 'recommendations for action'. A second volume - prepared in partnership with planning and design firm Sasaki Associates and released in 2014 - focuses on 'Designing With Water: Creative Solutions from Around the Globe'. It reiterates the coastal flooding threats Boston faces, introduces the concept of 'designing with water', and profiles twelve case studies from around the world illustrating how others are "using Designing with Water strategies to decrease their potential flood damage without losing the vibrancy and livability of their communities" (Aiken et al., 2014: 2). The case studies and recommendations are targeted towards stakeholders ranging from individual property owners to regional and State government officials.

TBHA is currently running a 'Boston Living With Water International Design Competition', along with the Boston Society of Architects, the City of Boston Environment, Energy and Open Space Department and the Boston Redevelopment Authority, with financial support from the Barr Foundation and the Massachusetts Office of Coastal Zone Management. The competition sought "leading planners, designers, and thinkers to help the City of Boston and area businesses and residents develop and apply new concepts and strategies, including Living with Water design principles, to increase the City's sustainability and climate change resiliency" (Boston Living With Water, 2015). There were 50 submissions addressing one of three sites that represent different scales (*building, neighborhood and infrastructure*), and 12 semifinalists are now revising their proposals. This endeavor underscores both the key role non-governmental organizations are playing in supporting adaptation, and the integrated way in which they work with government agencies.

TBHA is not the only non-governmental organization active on adaptation issues in the Boston area. The Urban Land Institute (ULI) hosted a charrette titled 'The Urban Implications of Living with Water', with the support of the Kresge Foundation and participation of over 70 key players from the private and public sectors, including urban design, real estate and public policy professionals. Subgroups focused on four different sites in the Boston area that are representative of different typologies, and considered what can be done to enhance resiliency (ULI, 2014). Participants were challenged to think about the policy dimensions of adapting to climate change, but, as a charrette, the emphasis was on exploring physical design options. The subsequent report gained substantial media attention at least in part because of the striking graphics produced, including of canals as a water retention and management strategy in the Back Bay neighborhood of Boston.

Private foundations play critical roles supporting the work of non-profits and government agencies. They fill voids by funding and facilitating initiatives on nascent issues like climate resilience that may be seen as the role of government in Singapore, Rotterdam and elsewhere, but for which governments have difficulties finding resources to support in the U.S. context. The Barr Foundation, which is Boston based and largely focused on the region, has identified 'Climate' as one of its three program areas (see www.barrfoundation.org).

Barr has funded various initiatives, including: Components of the City's Greenovate Boston program, including the Green Ribbon Commission, which brings together thought leaders from the public and private sectors; the MAPC's Metro Boston Regional Climate Change Adaptation Strategy Report; and the Living With Water design competition, which is a joint initiative of City agencies and non-profits. Focusing on an issue like climate change and putting its substantial resources behind it, the Barr Foundation has considerable influence on the trajectory of dialogue, planning and ultimately decision-making.

Boston is rich in academic institutions, which also play important roles. While the City's first efforts on adaptation began in 2007, this was presaged by one of the earliest regional climate impact assessments in the United States – the 2004 *Climate's Long-Term Impacts on Metro Boston* study, which brought together a large team of university faculty and other researchers from various institutions to model the potential impacts of climate change on infrastructure and other systems (Kirshen et al., 2004). Boston University is situating itself as a major player on climate change and is emphasizing the city as a living laboratory for its work – various faculty are focusing on adaptation (see Pardee Center, 2015) Among many other relevant initiatives, the Pardee Center hosted a Sea Level Rise and the Future of Coastal Cities conference in late 2014. Other universities in the region, including the University of Massachusetts Boston, the University of New Hampshire and the Massachusetts Institute of Technology have adaptation projects with a focus on the Boston region. Interviewees emphasized the importance of these initiatives and associated research in providing technical information, legitimacy and the impetus government agencies need to start considering an emerging issue like climate change. For example, an interviewee working in the transportation sector emphasized the importance of the Transportation Research Board, which is a branch of the U.S. National Research Council as a major source for climate data and new ideas on how agencies might respond.

Infrastructure planning and decision-making

It is evident from the previous section – which focused on climate preparedness in the Boston region – that infrastructure planning and decision-making is highly disaggregated across numerous agencies at multiple levels of government. This section further introduces the institutional arrangements in place. The fragmented and sometimes complementary, sometimes conflicting nature of decision-making among various agencies and other stakeholders reflects the neopluralist nature of decision-making in the United States, which is discussed in more detail in the next section. This dissertation is largely focused on the integration of climate adaptation into transportation infrastructure, and thus the transportation sector is the primary focus here. Given the emphasis on coastal flooding as a climate risk, flood protection planning and decision-making is also briefly introduced.

Land transportation infrastructure

At least nine different agencies and other stakeholder groups are directly involved in land transportation infrastructure planning, decision-making, operation and maintenance in Boston. *Table 4.1* enumerates these actors and the key roles they play. It reflects the main players, but is not fully comprehensive or reflective of the complexities involved. Planning

and decision-making inherently involves various other agencies and stakeholder groups. For example, as discussed earlier in this chapter, the City’s Complete Streets initiative involves coordination between the Transportation Department, the Public Works Department (which owns and maintains the infrastructure), the Boston Redevelopment Authority (which is responsible for most land use planning), and other actors (Boston Transportation Department, 2014). *Table 4.1* also excludes the political actors involved in the decision-making process. As discussed further in the next section, political leaders at the local, state and federal levels play important roles both directly by approving projects, accounting for them in their budgets and so on, and indirectly based on the leadership and broad directives they institutionalize into the bureaucracy. *Table 4.1* does not reflect the full breadth of regulatory oversight either. For example, many projects will be subject to the Massachusetts Environmental Protection Act and/or National Environmental Policy Act, meaning they must go through environmental impact assessment processes.

Table 4.1 – Key actors involved in land transportation in Boston

Agency/stakeholder group	Roles
U.S. Department of Transportation; especially the Federal Highway Administration (FHWA) and Federal Transit Administration (FTA)	<ul style="list-style-type: none"> • Finance infrastructure projects • Technical support (including through research centers like the Volpe Center) • Statutory oversight
Massachusetts Department of Transportation (MassDOT); especially the Highway and Mass Transit Divisions	<ul style="list-style-type: none"> • State-level road infrastructure, including all interstate highways • Regulatory oversight of other transportation infrastructure
Massachusetts Bay Transportation Authority (MBTA)	<ul style="list-style-type: none"> • Public transportation system operator in the greater Boston area. Operate most services directly, but some privately contracted (including commuter rail) • Under but operated at arms-length to MassDOT
Massachusetts Department of Conservation and Recreation (DCR)	<ul style="list-style-type: none"> • Operate and maintain various parkways (e.g., Storrow Drive)
Boston Region Metropolitan Planning Organization (MPO)	<ul style="list-style-type: none"> • Regional transportation planning and coordination (<i>see below</i>) • Establish priorities for state and federal transportation funds
Boston Transportation Department (City of Boston)	<ul style="list-style-type: none"> • Planning and oversight of non-State controlled road infrastructure in Boston • Emphasis on ‘complete streets’ (i.e.,

	pedestrian and cyclist amenities)
Public Works Department (City of Boston)	<ul style="list-style-type: none"> • Responsible for construction and maintenance of City roads • Oversight of private contractors
Private construction, maintenance and/or operating contractors	<p>Various contractors in different sectors, including:</p> <ul style="list-style-type: none"> • Over 100 different private contractors do construction, repaving and other road-related work for the City • Numerous construction and maintenance contracts awarded by State agencies (roads and transit) • Contracted system operators like Keolis (MBTA commuter rail lines)
Private transportation operators (e.g., MASCO, Bridj, taxi fleets)	<ul style="list-style-type: none"> • Institutional/business alliances like the Medical Academic and Scientific Community Organization in Longwood run private shuttle networks, as do large institutions like MIT and Harvard • Private, for-profit shuttle taxi and shuttle services
Stakeholder interest groups (e.g., A Better City; Livable Streets Alliance)	<ul style="list-style-type: none"> • Lobby government agencies for transportation investments and preferred design options • Provide supporting research and thought leadership • Coordinate constituencies
Neighboring municipalities (e.g., Brookline, Revere)	<ul style="list-style-type: none"> • Neighboring municipalities run interconnected urban road networks

Funding comes through various mechanisms. Unlike in Singapore, transportation related fees and taxes do not cover expenditures, with substantial proportions made up from general government revenues. For example, while Singapore's public transportation system is self-supporting from an operations perspective, fares constitute only 31% of the MBTA's revenue, with the largest proportion coming from State sales taxes (42%) (Garvin, Cloutier and Butler, 2015; May, 2004). On the road side, tolls are collected on some State highways, but they contribute only \$357 million in revenues, which would cover only 23% of the highway proportion of the MassDOT budget (MassDOT, 2014). In total, tolls, gas taxes and other user fees cover approximately 59% of state and local road spending

(Henchman, 2014). In contrast, revenues from tolls, registration fees and other direct user fees exceed road infrastructure expenditures in Singapore (May, 2004). The Federal government provides approximately 32% of funds for capital outlays in Massachusetts, with the remainder coming from State and local revenues (National Economic Council and the President's Council of Economic Advisers, 2014). The Federal government also lends money at very low interest through programs like the Transportation Infrastructure Finance and Innovation Act.

State and local governments are dependent on Federal transportation dollars, but, unfortunately, there is an element of instability, as they are contingent on sometimes politically charged Congressional approval. This instability also exists at the state and local levels, as new administrations often establish different priorities than their predecessors and change their priorities over time. In the words of an interviewee:

We can't even function sustainably! We are year to year to year. You program for so much each year, and that's all you get, and then your Governor or your leader changes and you reset. So there is no long term thought about sustainability.

Given the plethora of actors involved, some level of coordination around transportation infrastructure planning and decision-making is essential. The Boston Region Metropolitan Planning Organization (MPO) plays an important role here. MPOs are Federally mandated organizations that bring together key stakeholders to make coordinated transportation planning decisions to allocate scarce Federal and state funds – it is typified as ‘continuing, comprehensive and coordinated’ (3-C) transportation planning (Solof, 1998). Parties from different levels of government and other stakeholder groups are expected to develop shared visions for their regions and reach consensus around which investments will best advance their shared goals. The Boston MPO’s region encompasses 101 cities and towns in Eastern Massachusetts, with a population of approximately three million people (MPO, 2015a). The MPO’s 22 voting members come from a mix of municipalities, agencies and other organizations. FHWA and FTA representatives sit as nonvoting members. The MPO is staffed by over 60 employees that provide a “permanent resource of expertise in comprehensive, multimodal transportation planning and analysis, to promote interagency cooperation, to ensure consistency among planning efforts, to reduce redundancy, and to fill gaps in the capabilities of MPO members—thus enabling the MPO’s 3C work and other, related work for member agencies to be accomplished efficiently and effectively” (Ibid.). The MPO is a branch of the MAPC for fiduciary purposes, but is de facto closer to the state, including physically with its offices in the State Transportation Building.

The MPO’s primary responsibility is three separate but related planning processes (Ibid.):

- *Long-Range Transportation Plan (LRTP)* – Guides investment for at least 20 years, defining the vision for the region; establishing the goals and objectives for reaching the vision; examining trends; and setting broad parameters around how resources should be allocated (i.e., larger projects or activities). The LRTP is updated every four years.

- *Transportation Improvement Program (TIP)* – The LRTP informs the TIP, which is the shorter-term (i.e., within four years) list of prioritized projects. Projects must be in the TIP before they can receive federal funding. Projects are evaluated using established criteria, applying a point system.
- *Unified Planning Work Program* – Database of land transportation infrastructure planning projects underway in the given fiscal year.

The MPO attempts to be holistic in its analysis, considering regional trends, and plans for land use planning, development, and employment. It also aims to be open and transparent, seeking input from constituencies via various direct and indirect mechanisms, including public meetings, ‘mini-surveys’ and close consultation with member communities.

In many ways, the MPO is a logical channel through which climate adaptation may be integrated into transportation infrastructure planning and decision-making. Interviewees reflected that MPOs can play important leadership roles on issues like this. “Some MPOs really want to be regional planners and regional leaders, and when they see a topic that they can make a contribution on and be supported politically and publically, that's all good stuff as long as it doesn't put a major strain on them; and if there is a really important new public need that has come along, like climate resilience wasn't something they would have thought of 5-10 years ago and now they are, it allows them to play a more significant role”, reflected one interviewee. Another asserted that MPOs can be more flexible than most government agencies, allowing them to agilely respond to emerging threats. The first interviewee noted that MPOs across the country vary widely in capacity, support and goals, reflecting that there is “a spectrum from those in areas with strong tradition and support for regionalism and public sector contributions to society, and others that are really, maybe more laissez-faire, or would rather leave things to the localities. So, the ability of an MPO to play a leadership role really varies. [It] also depends on whether or not they want to take on these things, it really boils down to whether or not there is support for a public sector role.” This interviewee also expressed concern with overloading MPOs and their members, which are typically resource constrained and pulled in multiple directions:

When you add one more goal, it's just something else to compete for funding. So health, for example, is another goal now competing for funds with traditional goals like congestion relief, maintaining state of good repair. If you add to it and say ‘and transportation planning should address public health, and transportation planning and investments should strengthen community resilience’, it's very hard for the MPOs and their partners to do much when the funds are already under such great pressure.

A meeting conducted under the auspices of this research with six senior Boston MPO staff underscored both the relevancy and nascent interest in this region. However, this is not yet translating into the MPO's activities in practice. Mitigation and other environmental concerns are, however, well accounted for in the 35 criteria applied to projects proposed for inclusion in the TIP (MPO, 2015b).

Some criteria, including “Improves emergency response” and “Design effects ability to respond to extreme conditions” do assess projects for characteristics like their vulnerability to flooding and value in providing evacuation routes. However, there are not yet any explicitly adaptation-related criteria. The LRTP currently under development includes a scenario planning component, but the four scenarios generated revolve around different possible investment approaches, with no mention made of changing climate conditions (MPO, 2015c). According to a staff person involved, they “hadn’t thought about climate [risks] as a variable” when designing the process, but can see it becoming one in the future. Climate risks may emerge indirectly as part of the LRTP process, if and when the MAPC starts to recommend regional growth patterns that account for the increasing vulnerability of some areas.

According to a staff person, the lack of formal recognition of and accounting for climate risks is partly a matter of institutional inertia – “We transportation planners for decades have been concerned with what comes out of tailpipes; mitigation is considered more naturally, it’s about getting people out of their cars and so on, [whereas] this is relatively newer and different”. Another MPO staffer suggested that it may be a matter of it taking time to permeate through the institutional environment, stating that: “For whatever reasons, this doesn’t occupy our time [and] criteria so far. However, towns are starting to do vulnerability assessments, so this may be in the pipeline. You have to remember that it takes time before these trends get to [us], because the newest project [before the MPO] was probably initiated five years ago”. Yet another noted that one challenge is that they are evaluating proposals at the ‘25% design stage’ while things like precipitation models and how they need to be accommodated would usually only be brought in later. This suggests that there may be value in explicitly moving forward the stage at which climate information is introduced to project planning and evaluation. Last but not least as a factor, a staff person noted the fiscal realities, stating: “You need to recognize that this is a *very* financially constrained environment”.

Flood protection

While perhaps less fragmented than the transportation sector, flood protection and coastal zone management responsibilities are also divided among various agencies at different levels of government. This section introduces some of these agencies and the challenges they face, paying particular attention to coastal flood defense and less to inland flooding associated with extreme precipitation.

At the Federal level, there are three key agencies engaged in flood protection: The U.S. Army Corps of Engineers (USACE), the Federal Emergency Management Agency (FEMA), and the National Oceanic and Atmospheric Administration (NOAA). The USACE is the branch of the Department of Defense responsible for many large public works projects across the United States and around the world, including substantial flood control and coastal defense infrastructure (USACE, 2015a). USACE coastal defense infrastructure includes levees, dams, seawalls and beach nourishment. As discussed earlier in this chapter, the USACE is engaged in various efforts to understand the potential impacts of climate change on coastal environments, including infrastructures, and how they might

respond from engineering and planning perspectives (USACE, 2015b). In general, the Corps is trained on reducing coastal flood risks by providing engineered solutions, or assisting others in doing so with their extensive expertise.

NOAA's Office for Coastal Management is focused on 'making communities more resilient'; as discussed earlier in this chapter, that includes providing explicit support as they adapt to climate change (OCM, 2015). The Office is largely focused on providing data and other resources to state and local decision-makers, rather than direct coastal management. Programs like Digital Coast provide more detailed analysis so that stakeholders may make more informed decisions. In accordance with the Coastal Zone Management Act of 1972, and other regulations introduced since, the Coastal Zone Management Program works with state agencies in various areas, including coastal conservation, pollution control, and marine spatial planning (Ibid.). One channel through which the OCM influences state and local agencies and other actors is grants (typically matching state or local funding).

FEMA is often associated with disaster response, both immediately following catastrophic events and with the recovery in the months and years following. For example, the Agency has facilitated the distribution of over \$10 billion for Hurricane Sandy recovery (FEMA, 2015a). The Boston area faced an extremely harsh winter in 2015, resulting in the declaration of 'Severe Winter Storm, Snowstorm, and Flooding', which made funding available to the state, impacted municipalities and some other actors (FEMA, 2015b). FEMA also plays important roles before disasters via its preparedness activities, which include mapping vulnerabilities and providing grants and technical assistance to help communities reduce them. FEMA's 'National Flood Insurance Program: Flood Hazard Mapping' is very influential, as it establishes flood insurance rates and requirements in coastal areas (FEMA, 2015c). Changes to the maps, which may become more common and important with climate change, typically invoke substantial pushback due to the implications for property owners; many communities have been challenging FEMA's recent round of flood risk estimates (see, for example, Ronan, 2015). The National Flood Insurance Program plays important roles in providing insurance to potentially vulnerable property owners, and sets standards around how communities must enhance their resilience in order for property owners to qualify, and for other forms of assistance.

In Massachusetts, three state agencies have primary responsibility for flood protection: The Office of Coastal Zone Management (CZM), The Department of Environmental Protection (DEP), and the Department of Conservation and Recreation (DCR), which are all branches of the Executive Office of Energy and Environmental Affairs. The state exercises control over activities in coastal zones through Chapter 91, The Massachusetts Public Waterfront Act, which "seeks to preserve and protect the rights of the public, and to guarantee that private uses of tidelands and waterways serve a proper public purpose" (DEP, 2015). Most activities that impact coastal zones require authorization under Chapter 91.

The CZM is responsible for supporting adherence to Federal and state guidelines on coastal zone management, providing both technical support and assistance to help municipalities and other stakeholders meet those standards. The CZM receives substantial financial support from the Federal government to carry out its mission. As discussed in the climate

preparedness section earlier in this chapter, the CZM (2015) has an extensive ‘StormSmart Coasts’ program, which is providing technical assistance and grants to municipalities and coastal landowners to help them enhance resilience in the face of climate change. The CZM also maintains a ‘barrier beach inventory’, along with guidelines for their management; and inventories of both public and private seawalls and other coastal structures (CZM, 2015). The latter was compiled by consultants for both the CZM and DCR, and is informative of the nature of coastal infrastructure in Boston Harbor, which include (DCR, 2009; Fontenault, Vinhateiro and Knee, 2013):

- 58% of the Boston Harbor coastline is protected, mostly by seawalls and reventments;
- Approximately a third of this infrastructure is privately owned and two-thirds public, with municipalities owning 40% and the State 60% (the Federal government owns no coastal defense infrastructure in Boston Harbor);
- The structural condition of over one-third of this infrastructure has been graded ‘C’ or lower;
- It would cost approximately \$47 million (in 2009 dollars) to bring just the publically owned infrastructure up to an ‘A’ grade, and it is not clear this includes adding an additional protection to address increasing climate risks.

The DCR is responsible for much of the state-owned infrastructure, including the critical Charles River and Amelia Earhart dams, which are vital for flood control in the Boston area (Bourne Consulting Engineering, 2009). In addition to the DCR and CZM, other State agencies play various roles vis-à-vis coastal infrastructure. For example, Massport is a major landowner along the shore in Boston.

As noted above, the City of Boston is a major owner of coastal infrastructure. Most of this is under the purview of the Boston Redevelopment Authority (Ibid.). As the City’s planning agency, the BRA is responsible for directing and regulating planning in and around the coastal zone. The Authority has a dedicated ‘Waterfront Planning’ department with the mission of balancing the various interests and uses “to promote an active, environmentally sound, and accessible Harbor that sustains vibrant waterfront neighborhoods and water dependent businesses” (Boston Redevelopment Authority, 2015). The BRA is directly involved in various waterfront projects, including the Boston Marine Industrial Park, the Charlestown Navy Yard, and the East Boston Municipal Harbor Plan (Ibid.). Climate risks are being considered in some of these instances, but whether or not the responses are satisfactory is debatable. One interviewee noted the South Station expansion and associated air rights project as an example in which the risks could be substantial, as the site is right on the water, and it is not clear that they were truly considered (see Boston Redevelopment Authority, 2006; MassDOT, 2015b). It is challenging, as this is an already extremely complex project involving the BRA, MassDOT, various other state agencies, private developers and other parties. While ground has not yet been broken, the BRA’s development plan for the site was already approved in 2006.

As with transportation planning, non-governmental organizations play various roles in coastal planning. As discussed earlier in this chapter, The Boston Harbor Association is

playing a major role in highlighting the coastal vulnerabilities, raising the profile of the issue as plans are made and projects in coastal zones advanced. The Harbor Association is also a key partner, working along side the BRA, on the HarborWalk, which is a 39-mile path along most of Boston's waterfront (Boston HarborWalk, 2014; TBHA, 2015).

In contrast to the Netherlands, in which most stakeholders have faith in the robust coastal flood defense network, American coastal defenses have been called into question, including by government agencies directly (see Andresen et al., 2007; ASCE, 2013; USACE, 2015b). Widespread distrust in their efficacy is, at least in part, a product of relatively recent failures. The massive destruction Hurricane Katrina caused along the Gulf Coast, and in New Orleans in particular, was a wakeup call to many of how poor much of the infrastructure is (Andresen et al., 2007). Hurricane Sandy was a further reminder of how insufficient coastal defenses may be, precipitating consternation and pledges to redouble efforts at all levels of government (Spector and Bamberger, 2013; USACE, 2015b). There is some debate around whether the solutions should be 'harder', like a seawall with massive gates closing off Boston Harbor, similar to those in the Netherlands, or 'softer', like restoring wetlands and coastal retreat (Bennett, 2010). Decision-making is complicated by budgetary, institutional and political constraints, and competing interests, including concerns over the environmental consequences of certain options (Ibid.).

Despite, or perhaps because of, the fragmented nature of decision-making, agencies emphasize coordination, and are tied together through funding and overlapping responsibilities. As in the transportation sector, the Federal government exerts significant pressure via stipulations it places on the grants it provides. After Hurricane Sandy, the U.S. Congress passed a law directing the USACE to develop strategies for more effective coastal storm risk management, leading to the previously discussed North Atlantic Coast Comprehensive Study (USACE, 2015b). The study underscores the important roles of state and local governments, but federal regulations ultimately mandate certain approaches, if grantees wish to receive federal funding.

Fragmented governance: Boston's neopluralist, neoliberal model

Decision-making in Boston occurs within a *neopluralist* governance paradigm. In this model, various interest groups continuously compete over the evolution of policies within more or less distinct policy domains, ultimately shaping them via the relative influence of their various positions, and their differing levels of power (Dahl 1962; Lindblom 1977; McFarland, 2007). These interest groups are composed of both governmental and non-governmental actors, with the government holding varying degrees of autonomy and authority in different situations. Furthermore, the state is not a single actor, but manifests as a set of actors with varying interests across different levels of government, and even different agencies and departments within the same administration. Other interest groups include corporate lobby groups and non-profit advocacy organizations. Groups with shared interests and perspectives cluster in what Sabatier and Jenkins-Smith (1993, 1999) call 'advocacy coalitions'. The range and complexity of actors varies, depending on the 'policy niche', with groups often trying to carve specific niches for the purposes of control

(Gray and Lowery, 2004). While consensus may be reached in a neopluralist paradigm, the dominant interactions between coalitions are often adversarial in nature.

The paradigm under which governance occurs in Boston may also be characterized as *neoliberal* - there is comparatively less state intervention in what is an overwhelmingly market-oriented economy, a strong ethos of fiscal austerity in government spending, and substantial skepticism of the government's ability to solve problems (Harvey 2007; Jahn 1998). The state plays a major role in the provision and management of infrastructure, but these activities are typically framed in the service of the private economy and private companies under contract do much of the actual work.

Fragmentation

The United States may be one nation under God but, politically, it is fractured into a multitude of jurisdictions—states, counties, municipalities, school districts, election wards and more. While necessary for governance, taxation and administration of public services, these jurisdictions, for the most part, bear little relation to the distribution of population and economic activity across the landscape. – Solof, 1998: 5

A characteristic of the neopluralist model is the fragmented nature of governance and decision-making. There are at least four levels of government in the Boston area – municipal, regional, state (Massachusetts) and federal – with different responsibilities and relationships to one another in different sectors. Compared to other parts of the world, these various actors do not always coordinate effectively. In the context of climate change, an interviewee reflected that it is “ridiculous that everyone is doing their own vulnerability assessments, and everyone is coming up with their own climate predictions. We are all right here together! [...] It is tricky, because it is [a question of] 'who is responsible for doing it?'” Another participant with comparative exposure to decision-making in the Dutch context compared the two in the exercise debrief, saying: “What I have seen from the Netherlands versus here is that there you have a very good network at the national level, regional level, and here there are a lot of different groups coming up with very good out of the box ideas with more transparency, but you don't catch all of the mistakes that you would with the better network.”

As discussed earlier, others are looking to certain agencies, including MassDOT, for information, but it is largely ad hoc and not intentional in design. An issue like climate change adaptation may be more appropriately dealt with at the regional level, given that most of the impacts will be regionally felt, and adaptive options extend across and impact multiple municipalities. However, the regional level is the weakest in Massachusetts. In the words of another participant, reflecting on the previous participant comment:

From an institutional standpoint, many of us have been concerned that in the Boston area compared to Rotterdam and Singapore, there is nothing between the municipality and the state in terms of decision-making. [...] We are lacking on both the transportation and on the climate change side from lacking an effective regional

planning network, and it all has to be negotiated between the communities and the state, and that is a pretty big gap to have to deal with.

As noted earlier, the region is highly fragmented into over 100 different municipalities, ranging in size and nature from the largely urban City of Boston with over 600,000 people, to low-density 'country suburbs' on the edge of the metropolitan area (MAPC, 2015a). As a 'home rule' state, municipalities have substantial autonomy in planning and decision-making. They must operate within state and federal laws and go to the Massachusetts Legislature for approval on certain matters, and are enticed to make certain decisions around issues to receive state and federal grants, but otherwise make their own laws and decisions (Department of Revenue, 2015). Regional agencies typically have little power. As discussed previously, the Metropolitan Planning Organization (MPO) exerts influence insofar as transportation projects may only receive federal funding if they are prioritized through its process. The Metropolitan Area Planning Council (MAPC) coordinates planning across the region and is an important source of information and technical support, but does not have any legal authority to compel municipalities to cooperate or to unilaterally implement planning changes (Commonwealth of Massachusetts, 2015; MAPC, 2015a).

Fragmentation in the Boston area is not just a matter of numerous municipalities. There is also fragmentation in service delivery among agencies at the same level of government. As discussed earlier in this chapter, there are at least six state and local agencies involved in transportation planning in Boston, and private contractors, Federal agencies and other stakeholders. The City of Boston itself divides responsibility for its road infrastructure between at least two Departments - Transportation and Public Works. "There is a constant issue with BTS and DPW kind of overlapping in some areas, and I thought the new administration was going to figure that out, and maybe they still are", said an interviewee.

It is notable that having multiple levels of government is not in and of itself unique to the United States. As discussed in the Rotterdam chapter, there are also agencies at the same four levels (national, provincial, regional and local) in the Netherlands. However, the fragmentation in terms of the number of different jurisdictions, and overlapping responsibilities in infrastructure and service provision is unparalleled.

Litigation

Debate over how litigious the U.S. is, and whether this is a point of pride or scourge, continues in the popular media (see Miller, 2013; Walshe, 2013). In the context of major infrastructure projects in Boston's recent history, lawsuits have played very important roles. The extensive Boston Harbor cleanup - which took over two decades, cost \$4.5 billion, and involved the construction of various infrastructure, including the state-of-the-art Deer Island Sewerage Treatment Plant - was precipitated by a suit filed against the State of Massachusetts and U.S. Environmental Protection Agency in the 1980s by the Conservation Law Foundation or CLF (Shelley, 2011). A once highly polluted harbor is now swimmable and fishable (Shelley, 2015). The CLF is a prominent environmental non-governmental organization based in Boston. A settlement between the Commonwealth, and the Conservation Law Foundation and City of Somerville was the impetus behind the

extension of the MBTA's Green Line through the city, which is currently underway despite the transit systems financial woes (Somerville, 2015). Interviewees noted the influence that litigation and the threat thereof, has on planning and decision-making; according to one involved in planning and project development:

It can change a lot of agreements that happen. If you don't think about what the law department is going to require you to do, you are going to be stuck having what you just spent three years doing sitting on a shelf for a year and a half while they figure out the legalities and insurance around it. So, depending on the concept, I'll just give a heads-up to our law department and say 'do we have an agreement for this? How would we begin to tailor this agreement?'

Low trust in government

Whether justified or not, one characteristic of governance in the United States is relatively low trust in government institutions. In 2015, only 41% of U.S. respondents in a global survey by Edelman (2015a) indicated that they trust government (in general). In contrast, 65% of Dutch respondents and 70% of Singaporean respondents indicated that they trust their governments (Edelman, 2015a).⁴ This lack of trust has implications on what citizens entrust the government to do, and what proportion of their income they are willing to give the government to provide services. The protracted debate over health care and the role of the government in ensuring universal, affordable access in particular is evidence of this. Reflecting on how people view the role of government in the U.S. versus the Netherlands, a participant opined:

It's a general thing in our systems, and our government. Maybe it's the way that power is distributed [...] In the Netherlands, people buy into taxes and services differently, and they expect the decisions will be made at the top and they accept it, because they believe that [agencies] are making decisions to prepare effectively, while in the U.S. it's more 'yes we'll give you some tax money, but we [will hold you] accountable for every cent you spend', and that level of accountability, mixed with our political cycles and how people get elected comes into play with a lot of political will.

In contrast to the low degree of trust in government, 65% of U.S. respondents stated that they trust NGOs, and 60% stated that they trust the business community (Edelman, 2015a).⁵ It is impossible to tease out causality, but this contrast in the level of trust in government versus civil society and the private sector is not surprising, given the prominent roles both NGOs and businesses play in planning, decision-making and service provision in the U.S. It is noteworthy that trust in the media in the U.S. is at only 43% in 2015, which is below the 27-country average of 51%, Singapore at 59% and the Netherlands at 62% (Edelman, 2015a).

⁴ Respondents were asked to indicate how much they trust government on a 9-point Likert scale, on which one means "do not trust them at all" and nine means "trust them a great deal"; a top four ranking is counted as 'trust' (Edelman, 2015).

⁵ This compares to 71% in Singapore and 62% in the Netherlands for NGOs, and 61% and 66% respectively for the business community (Edelman, 2015a).

Underfunding of government, poor quality infrastructure

The U.S. has been highly criticized for the poor quality of its infrastructure (The Economist, 2011; Markovich, 2014; National Economic Council and the President's Council of Economic Advisers, 2014). The American Society of Civil Engineers (ASCE) gave the country a D+ grade overall for the 'condition and performance' of its infrastructure, with a D for public transit infrastructure, D- for levees, D for dams, D for roads, C+ for rail, and C+ for bridges (ASCE, 2013). The ASCE (2013) gave a mixed review on the state of infrastructure in Massachusetts – it praised the work underway to address 'structurally deficient' bridges; warned of the risks posed by the thousands of aging and poorly monitored and maintained dams; largely praised investments in road maintenance and construction; and warned of the \$3 billion backlog in public transit projects. Overall, the ASCE (2013) estimates that \$3.6 trillion will need to be invested across the U.S. in the near future just to rehabilitate and upgrade existing infrastructure. These inadequacies have economic and social consequences – American's spend hours in traffic, businesses incur additional costs, and traffic fatalities result, in part, from poor road conditions (National Economic Council and the President's Council of Economic Advisers, 2014).

U.S. transportation infrastructure is not only in poor shape in absolute terms, but also relative to other countries. The World Economic Forum's (2014) Global Competitiveness Report 2014-2015 ranked Singapore 2nd, the Netherlands 4th, and the U.S. 12th overall for their infrastructure systems; and the Netherlands 5th, Singapore 6th and the U.S. 16th for the "quality of roads" subcomponent. The World Economic Forum report emphasized infrastructure as one of the twelve 'pillars' of economic competitiveness, suggesting that the U.S. is losing out because of its poor performance in this area.

The poor state of infrastructure is, in large part, a product of relatively lower expenditures. \$279 billion was spent on transportation infrastructure in the U.S. (by all levels of government) in 2014, which represents approximately 1.6% of GDP and \$870 per capita (CBO, 2015). In contrast, Singapore is projected to spend approximately 10.9 billion SGD (8.2 billion USD) on transportation infrastructure in 2015, which represents approximately 2.7% of GDP and 1,980 SGD (1,490 USD) per capita (MOF, 2015). Not only is transportation infrastructure spending lower in the U.S. relative to elsewhere in the industrialized world, it is also significantly lower, as a share of GDP, than it was during the years of infrastructure expansion in the 1950s through 70s (Markovich, 2014).

Underinvestment in infrastructure is reflective of the smaller role for and proportion of the economy entrusted to, government. General government expenditures as a percent of GDP in 2014 were 40.1%, which is relatively low by OECD (i.e., developed world) standards; in contrast, the ratio in the Netherlands is 50.4% (Heritage Foundation, 2015). Furthermore, if defense spending is excluded, this is reduced to approximately 31% in the U.S. (Center on Budget and Policy Priorities, 2015). It must be acknowledged that this rate is still quite high compared to Singapore at 17%, which is one of the lowest in the world; however, in Singapore expenditures on social security and healthcare, which are typically among the

most expensive programs, come in large part from the government-managed but individually funded Central Provident Fund (CPF, 2015; MOF, 2015).⁶

The role of private contractors

Much of the actual construction and maintenance of the road network in the Boston area – ranging from design and engineering, through paving to snow removal - is conducted by private contractors (Boston Public Works Department, 2014; MassDOT, 2015c). As discussed earlier in this chapter, MassDOT's Central Artery Vulnerability Assessment is being conducted by external consultants. An interviewee noted that this is the norm with environmental and other assessments and modeling; agencies have to hire consultants to do most of this work because of the specific expertise and work involved. While not inherently good or bad, there are potential downsides. One is that the underlying models remain the intellectual property of the consultants – every time MassDOT or another agency want to tweak parameters and do another run, they must pay the consultants to do so. Another is that consultants are brought in on a project-by-project basis, and typically expected to solve a problem and move on. In the words of an interviewee:

Often there are consultants working on a project, and I think it's often hard for them to admit that they haven't solved the problem. So, they are going to act like they solved the problem with whatever they are proposing, and I don't think that they would feel like they should say 'it's enough for now', but I think they are in essence saying that. It's 'this is what we are doing, and this meets our goals and objectives' knowing that its not going to be the answer forever.

While agency staff may be reticent to 'stick their necks out', interviewees asserted that consultants are probably even less likely to.

The Rotterdam chapter introduced various models of public-private partnerships. Privatized infrastructure provision, including both transportation and water infrastructure, is prevalent elsewhere in the United States, but not in the Boston area. While private contractors play a central role in infrastructure provision in the Boston area, they are selected through conventional project-by-project bidding processes run by city and state agencies, with the respective agencies maintaining ongoing ownership and management.

Strong role of non-governmental actors

As discussed previously in this chapter, non-governmental organizations are influential players in the evolution of infrastructure systems in the Boston area. Their involvement includes: Lobbying for their preferred options; providing technical support; and providing interfaces to their respective constituencies. Two organizations that have been particularly active in Boston on climate adaptation and transportation infrastructure respectively are The Boston Harbor Association (TBHA) and A Better City (ABC). While certainly not the

⁶ While direct expenditures may be less, the Singaporean model actually gives the government *greater* control over the economy, as the Central Provident Fund is a major economic actor.

only important organizations in these domains, they are illustrative of the impact non-governmental actors can have. TBHA's adaptation work was discussed previously in the Climate Preparedness section of this chapter. ABC's work, and in particular its formation during the Central Artery project, are discussed in more detail in the callout box below.

Boston's neighborhoods vary widely in character and thus interests and priorities. Recognizing this, the City takes a neighborhood-level approach to much of its planning and has a team of 'neighborhood coordinators' (City of Boston, 2014b). Neighborhood-level organizations are important counterparts, organizing their communities, advocating on their behalf, and engaging in service delivery. An example is Neighborhood of Affordable Housing (NOAH, 2012) in East Boston, which undertakes a wide variety of activities, including: Affordable real estate development, homeowner and renter counseling and support, youth programs, and English classes. In the area of climate adaptation, NOAH has been running workshops to raise awareness and facilitate preparedness (Douglas et al., 2012; Lynds, 2015). While neighborhood organizations work with and lobby government agencies, it is notable that they do not place all of their faith in them, including on climate adaptation. In the words of an interviewee from a neighborhood organization:

We do value the relationships we have with officials, but we can't focus too much [on them]; our resources are limited as well as our capacity. [...] Sometimes we need them for certain things, but sometimes it's not effective. [...] If I have a conversation in front of Dunkin' Doughnuts in [a local] Square with a resident who has an issue, his feedback in that ten minute conversation on the street to me is a lot more valuable than me going to [the local city councilor...]. For example, when we are doing climate change adaptation, if I know that resident A can't get out of his house in the third floor apartment and he is in a flood zone, then I know that's what I have to address, as opposed to [the councilor] saying 'yeah, this is what the city can do'. To me, [the resident's] information is much more important to see how we are going to move forward with a lot of things in the community.

Institutional and business alliances like the Medical Academic and Scientific Community Organization (MASCO, 2011) in Boston's hospital and university-rich Longwood area are a very different type of neighborhood organization, but are impactful for many of the same reasons – in particular, their integral service delivery and interface between their members and government. MASCO has its own planning staff that works with government agencies, providing additional capacity and advancing members' interests on transportation, infrastructure, open space, development and construction issues. Vis-à-vis climate risks, MASCO plays a couple of important roles: It manages a Joint Operations Center to coordinate communications and resources during emergencies, which can be climate-related in this flood-prone area. Secondly, the organization closely coordinates with the Boston Water and Sewer Commission, the state Department of Conservation and Recreation, and other agencies around flooding and other issues. For example, MASCO has access to stormwater gage and other information so that they can proactively warn their members of potential flooding conditions. In the other direction, MASCO provides data on what floods in practice to inform infrastructure improvements over time.

A Better City: The Prominence of Non-Governmental Actors in Governance

A Better City (ABC) was formed in 1989 as the Artery Business Council out of fear among the business community that the massive Central Artery/Tunnel project – often referred to as the ‘big dig’ – would massively disrupt their operations. Their advocacy evolved into an innovative partnership with similarities to the Traffic Management Company discussed in the Rotterdam chapter, although private sector rather than public sector driven. ABC became a critical conduit for information in both directions, source for creative ideas on how the project could minimize disruptions to commerce and life in Boston, and coordinator between the various business and institutional actors in the city and the project team. The organization was successful in ensuring that utility services were maintained, traffic able to flow and so on, thanks in large part to well-placed and technically knowledgeable membership and a strong core staff. It was also critically important from a political perspective, as it used its access and clout to prevent the Artery project from becoming a ‘political football’ and successfully lobbied for various policies, funding and other government decisions that would facilitate smooth implementation. Luberoff (2004a, 2004b) concludes that ABC was so successful vis-à-vis the big dig for a few reasons: The large and complex nature of the project; the significant resources the group had, both in terms of staff and members that had the ear of political leaders; the ‘responsiveness and staying power’ this staff and membership afforded, including strong technical expertise; their broad perspective and ability to tackle issues ranging from project planning to political lobbying; and tactical flexibility in employing different means to achieve their goals, working with various other actors.

Post big dig, the group changed its name and transitioned into an organization with a wider mission (ABC, 2015b): “A Better City (ABC) is a nonprofit membership organization that provides the business and institutional leadership essential for ensuring progress and tangible results on transportation, land development, and public realm infrastructure investments that are vital to sustaining and improving the Boston area's economy and quality of life”. Its membership, which includes over 100 businesses and institutions, ranging from financial services to cultural institutions, pays high dues to fund a professional staff and ensure that the organization is well resourced (Luberoff, 2004a).

The organization advocates for and provides technical expertise on various issues, including investment in the public transit system. For example, it has long championed the proposed Urban Ring bus rapid transit line, lobbying for it and providing technical reports that support the case. While an interest group, it is clearly at the table – ABC co-chaired the MBTA's Urban Ring Working Committee. ABC is playing a role, along with others, in helping large businesses and institutions to coordinate their transportation planning to minimize disruption during a spate of bridge reconstruction projects. Politically, the organization played a leadership role in the ultimately unsuccessful effort to defeat a State ballot initiative in the 2014 election that eliminated automatic annual increases in the gas tax, which were previously tied to the Consumer Price Index. Opposing what is de facto a tax cut may seem counterintuitive for a business organization, but ABC argued that the tax

revenue is important for the greatly needed investments in the transportation system.

ABC is so highly regarded that it is asked to facilitate among agencies. The South Boston Waterfront Sustainable Transport Plan is an example of this (ABC, 2015c). The complex planning process was a partnership among the Massachusetts Convention Center Authority, MassPort, the City of Boston and the Massachusetts Department of Transportation, and engaged various other stakeholders. According to an interviewee:

The South Boston Waterfront Transportation Planning Process is a great example [of multi-stakeholder collaboration], because it's four agencies working together, with a neutral party kind of managing it - A Better City, ABC. They are kind of managing it, and making sure we are all being heard and playing nice together [and that] everyone has a vested interest, all four entities, versus 'it's the city's plan, and oh, by the way, these are Massport roads and you've got to implement this vision for this roadway, even though it's yours'. So, everyone feels invested, shared responsibility.

When asked why ABC is coordinating, the interviewee responded:

The fact that they are a non-governmental. [President and CEO] Rick Dimino is a former Commissioner of the [Boston] Transportation Department, he's been in that advocacy role for 15-20 years though, so he is neutral enough, and he has good relationships with all the key players. It's an advocacy group that advocates for the city, and urban health and projects [that all can support].

One potential shortcoming is that the plan pays relatively little attention to the potential implications of a changing climate on this vulnerable area. The final report has a section called 'Plan for Resiliency' but it does not go beyond acknowledging the areas acute exposure and noting various adaptation initiatives underway in the city (ABC, 2015c). An interviewee involved in the process said that they would like to have done more, but time and resources were, as always, limited; they were 'busy with the traditional pieces of the transportation plan'.

As discussed earlier in this chapter, ABC is also engaging in various climate adaptation initiatives – among other activities, Diminio served on the Mayor's Climate Action Leadership Committee. Furthermore, ABC's role in coordinating and representing constituency interests in the face of an unprecedented infrastructure project like the big dig may be illustrative of the roles this kind of organization can play as cities and regions begin to address unprecedented climate risks.

Sources: ABC, 2015b, 2015c; Luberoff, 2004a, 2004b; Various interviewees

What is notable in all of these examples of active non-governmental organizations is that they are seen as legitimate actors, and engaged in governance either with or in lieu of the state. They gain this legitimacy and access by providing services that the government

agencies they work with are unable to; serving as conduits between their constituents and government agencies, and as neutrals among agencies; providing legitimacy in both directions (i.e., of government initiatives to their constituents and of constituent interests to the government); and by allying with agencies with shared interests, which does not mean they are afforded the same legitimacy across all of government.

An important question is why and how these advocacy and service organizations exist. The neopluralist model posits that they are often initiated and/or maintained by 'political entrepreneurs' with strong personalities and agendas; nurtured by 'patrons', which include foundations and governments; are products of social movements that evolve to become institutionalized; exist as actors within 'issue networks'; and provide exclusive benefits to their members, encouraging membership (McFarland, 2007). These characteristics largely hold true for the advocacy organizations discussed in this chapter. Despite the lack of power TBHA ostensibly has, president Vivien Li and the organization wield significant influence via their networks and political entrepreneurship. For example, Li has a seat on the influential Boston Conservation Commission, was a co-chair of the City of Boston's 2014 Climate Action Plan Steering Committee, and chairs MassDevelopment's Brownfields Advisory Group. She is highly regarded and influential in the development community - sometimes as a friend and sometimes as a foe to developers - and was even named one of the 50 most influential women in Boston commercial real estate in 2014 (Bisnow, 2014; Grillo, 2012). The work of TBHA is dependent on key patrons, including the Barr Foundation. In general, foundations play a central role in funding the work of non-profits in the United States. The TBHA evolved out of environmental concerns, and in particular the health of the Boston Harbor in the 1970s, representing the institutionalization of a social movement (TBHA, 2015). The TBHA is successful in part because it is part of various 'issue networks' - in the area of climate change adaptation, it finds itself in a productive alliance with the City's Greenovate initiative. It marshals external resources for research and thought leadership and extends the credibility of Greenovate and other efforts among those that might be skeptical of the City.

In many ways, ABC is a more conventional business interest lobbying organization. Nonetheless, it exhibits neopluralist characteristics as an advocacy organization. Like Vivien Li and TBHA, ABC it is led by a highly regarded and politically savvy 'political entrepreneur', Rick Dimino. He came out of public service and remains integrated into various political institutions - among other appointments, he is an executive committee member and former chair of the Metropolitan Area Planning Council and is co-chairing the committee overseeing the redevelopment of Boston's transportation master plan (ABC, 2015a). Underscoring the importance of networks among advocacy organizations, Dimino is actually vice-Chair of the TBHA board. While not a social movement in the strictest sense, ABC's emergence out of concern among the business community that the Central Artery project would be excessively disruptive does suggest how organizations like this manifest as the institutionalization of shared concerns among previously unorganized groups. ABC is successful in part because it allies itself with other interest groups, including key City and State agencies. ABC's membership comes from the corporate and institutional sectors; it is not clear what 'exclusive benefits' they get, except for the opportunity to interact within a network of firms concerned about similar issues.

International networking

Like Rotterdam and Singapore, Boston has emphasized international networks and knowledge sharing. It is part of various networks, including the C40 Cities Climate Leadership Group, and was chosen by the Rockefeller Foundation to receive support as part of its 100 Resilient Cities network (Greenovate Boston, 2014). As Anguelovski and Carmin (2011) note, these networks can provide resources and help disseminate best practices, but cannot replace the processes and particularities of local institutionalization.

Shifting administrations, shifting priorities

Another characteristic of governance in the United States is the instability from administration to administration. Each election offers the opportunity (or threat) to completely change (sometimes reverse) the priorities of government, and replace not only the political class but also the senior bureaucrats. This may reflect healthy democratic institutions, but is disruptive to the implementation of long-term policy agendas. "A lot of [what shapes the currency of issues] is varying shades of politics - whether it is the Governor's priority, whether there are concerns with equity with each town or city or region getting their fair share, what 'fair share' is, that sort of thing", said an interviewee. In contrast, the People's Action Party's more than 55 years of single-party rule in Singapore has provided stability in government policy, making about faces and major bureaucratic changes rare. Healthy democratic institutions in the Netherlands have facilitated shifts in the ruling party, but there is typically more consistency from one administration to the next both in bureaucratic personnel and policies.

At all levels in the U.S., administrative changes can precipitate shifts in the degree to which issues like climate change are given attention and how they are approached. In Boston, former Mayor Thomas Menino, who had championed the city's climate efforts, retired in 2013 after 20 years in office. Interviewees noted that his long tenure - and the strong networks and political capital that afforded him - allowed him to champion longer-term issues like climate change. In the words of one:

If you are not somebody like Mayor Menino, God rest his soul, that was able to establish himself for a long time and have a bit of an iron fist with [longer term] stuff that he knew needed to get done or wanted to get done, it's really difficult to get it done without paying and he even had to pay many times over the years after making certain decisions.

Menino's successor, Marty Walsh, appears to concur that the issue is important; the Greenovate Boston initiative continues, and the 2014 update to Boston's Climate Action Plan was published under Walsh's administration. However, there have been changes. Walsh appointed a new Chief of Environment, Energy and Open Space, replacing Brian Swett, who had spearheaded the creation of Greenovate Boston and other initiatives (Boston Mayor's Office, 2014). The new mayor is also overhauling the traditionally powerful Boston Redevelopment Authority, which Menino exerted significant control over

(and through), and that plays an important role in efforts to respond to climate change (McMorrow, 2014). Similarly at the State level, a new governor, Charlie Baker, assumed office in January of 2015, shifting the state from a Democratic (party) to a Republican administration. Baker appointed a new cabinet and has different priorities than previous governor, Deval Patrick, emphasizing, among other things, tighter fiscal management. As discussed earlier in this chapter, another priority for Baker is overhauling the public transportation system (Governor's Special Panel to Review the MBTA, 2015). At the Federal level, the Obama administration has used its executive authority to take action on climate change, typically in the face of opposition from the Republican-controlled Congress. Should the next President, who will assume office in 2017, be a Republican, it seems likely that most of the current administration's initiatives will end, given that many of the candidates are reticent to support government action on climate change, if they even believe it is a problem at all (Foran and McGill, 2015).

Research process and outcomes

Research design and process

The research process followed in Boston was essentially the same as that employed in Rotterdam and Singapore. It is outlined more extensively in the methods section of the first chapter. The primary means of engaging project participants was via a half-day workshop in November of 2014. The workshop was attended by 32 participants. The success of this project was contingent on directly engaging actual infrastructure-related stakeholders. This required strong local partners; in this case, that was The Boston Harbor Association (TBHA), the Boston Society of Architects (BSA), and the City of Boston. The BSA hosted the event, and TBHA and the City helped to solicit participants and provided logistical support.

Participants were solicited based on their real-world relationships to the decision-making simulated in the exercise. They came from various government agencies at all levels, including: The U.S. Department of Transportation (both the regional division office and Volpe research center); the Massachusetts Department of Transportation (various divisions); the Boston Transportation Department; the City of Boston's Office of Environment, Energy and Open Space; the Massachusetts Office of Coastal Zone Management; Massport; and the Boston Redevelopment Authority. There were also participants from various consultancies and non-profit organizations, including two different community groups. An additional 36 individuals were interviewed either before or after the workshop but did not participate. Many of the workshop participants were also interviewed either before or after the event. Interviews served to shed light on how infrastructure planning and decision-making happens in practice in the Boston region; what is being done to adapt to climate change; who the key players are; and, after the workshop, to ground truth the themes that emerged.

The half-day workshop featured two different versions of the *A New Connection in Westerberg* role-play simulation exercise (RPS) – a version with scenarios and the other with a risk assessment forecast - with half of the group playing each. This is a variation

from Singapore and Rotterdam, were the two different versions were run on separate days with different groups. Otherwise, the workshop followed the same routine: Participants first filled out pre-exercise surveys. They then received their instructions and prepared for the RPS; they were given shared general and individual role-specific 'confidential instructions' that outlined their interests, and provided additional information that they could chose to share with the rest of the group as they wished. Participants were assigned roles different from those they hold in the real world to foster reflection and perspective taking. The number of workshop participants (32) was sufficient for there to be four groups in total (two for each version), with some roles doubled up. Each group played the RPS separately. Having two separate groups play each version of the same exercise allowed for some comparison. Having similarly constituted groups play the two different versions provided insights into the efficacy of scenarios versus risk assessments. The exercise runs ran approximately 90 minutes. This was followed by a debrief conversation in which the participants reflected on what happened during the exercise, the differences between groups, how similar or different their experiences were to those in their real-world settings, and how the differences and similarities may inform real-world planning and decision-making. The workshop concluded with participants completing post-exercise surveys. The semi-structured one-on-one interviews conducted with participants in the days following typically lasted between an hour and ninety minutes, allowing for further discussion around the themes that emerged from the workshop.

While the case presented in the RPS is highly simplified and clearly not Boston, it does bear some similarities. In particular, the road project may be loosely compared to the Central Artery (i.e., big dig) project. While climate risks were not considered during design and construction, MassDOT is now evaluating its vulnerabilities and considering how it might be adapted retroactively (Miller et al., 2014). The exercise challenges participants to consider if and what they might have done differently if dynamic and uncertain climate risks were on the radar when the big dig was being planned.

The remainder of this section is comprised of five parts: The first four focus on the progression and outcomes for each of the groups that played the RPS, including information gathered during the debrief conversation. Each of these summaries discusses key interventions in nature and substance; the style of the deliberations; which players were more or less active (both quantitatively and qualitatively)⁷; and some preliminary themes that may be drawn from the process and outcomes. The fifth section focuses on the data collected from the pre- and post-exercise surveys. Information gathered from the in-depth interviews is used throughout to reinforce observations. Interview data is interspersed because the interviews provided opportunities to clarify and dig deeper into the data collected via the other research interventions.

⁷ The number of interventions each player made is discussed as an – albeit incomplete – proxy for how active they were. Because incomplete, qualitative analysis of the nature and influence of these interventions is also discussed.

Outcome: Scenarios group #1

The first group that played the *scenarios* version of the *A New Connection in Westerberg* RPS came close to an agreement, but was unable to finalize one within the time allowed. A 'D+' option that involved enhancing the capacity of the existing road and enhancing freight rail service was popular, but vociferously opposed by the Port Authority representative, because of his constituents' preference for road over rail and unhappiness that a new road would not be built. In response, the group was considering if, how, and when they might use extra funding to build a new road - in addition to the D+ option on the table - which they called 'option E'. This new road would follow an alternative route between the neighborhood of Bloomland and the wetland, avoiding the flooding risks associated with option A (because it would be elevated), the neighborhood opposition associated with B, and the environmental impacts associated with C. The group was debating whether or not this could be financed and on what timeline when the session concluded.

The deputy director (i.e., meeting chair) was very active, largely controlling the group's progression. Quantitatively, she spoke 90 times, which was by far the most frequent (the second most frequent was 61). Qualitatively, many of these interventions were procedural, but did significantly influence the proceedings. For example, she frequently answered questions raised, even when others might have had more, or different, information. She also had participants raise their hands and wait for her acknowledgement before they could speak, which stifled dialogue between participants. She colored the consideration of the options based on her preferences; very little attention was given to option C after she concluded her introduction of it by saying that it would cost "1.5 times the budget my agency is looking at, so it really makes this option prohibitive from our stand point, and this option does not address the urban congestion directly, as it is estimated that it would increase capacity by ~30%, [whereas] options A and B increase capacity by ~40%". The port representative still attempted to make a case for it, but clearly already saw that it was unlikely to pass. In general, the chair appeared uncomfortable in the role, and spent substantial time rehashing things like the ground rules while others patiently waited.

After the deputy director, the most active participants were the port representative (61 interventions), alderwoman (51) and environmentalist (50). In contrast, the more technically oriented agency representatives spoke less - the senior engineer from the transportation agency 18 times, flood protection specialist 19 times, and municipal traffic department rep 19 times. The dominance of the first three reflects the deference to the concerns of their respective constituencies, and recognition that this deliberation was in large part about balancing interests. The chair, and others, repeatedly asked or deferred to these interest group representatives on whether or not an option was something 'their constituents could live with'. For example, when the alternative route (option E) was put on the table, the chair asked both the alderwoman and the environmentalist if this might allay some of their concerns. When the port representative tried to revive option C, he asked the environmentalist: "If, by some miracle, option C worked out, would you guys be open to replicating wetlands equal to the impacted area?" Compared to Singapore, were the participants framed the project as one of achieving a shared goal, even if they were de facto

making arguments based on their respective interests, the interest group representatives were unabashed in declaring their interests and how they should be met. For example, the port representative started out by saying:

My big goal here today is to get a road going as quickly and efficiently as possible. I needed a road yesterday. We are losing money from the port every day - up to \$100 million a year because the drivers have to drive further right now, so the sooner we can get this road built, the better.

He later stated: "I don't care about the future; I have the problem now!" The interest group representatives were also unabashed in presenting their alternatives to a negotiated agreement, and using them as threats. When discussing option C, the environmentalist declared: "I simply cannot let this [route through a wetland] happen; this resource cannot be disturbed, and I will take any organization to court that wants this road". Similarly, the port representative made dire predictions if he did not get his way in securing a new road, repeatedly making statements like "if you guys can live with the layoffs [that will result from no new road], that's great". These ultimatums did not offend or turn others off; to the contrary, they attempted to allay their concerns. This was clearly a strategy that participants felt appropriate and wise strategically. At one point, the environmental rep stepped out of role and quipped "I am the CLF in this exercise", referring to the previously discussed Conservation Law Foundation.

Furthermore, these hardball ultimatums did not preclude the interest group representatives from employing skills of coalition building. Most clearly, the port representative attempted to ally himself with the alderwoman, after deducing that they had some of the same interests and that meeting her concerns would be key to seeing any project move forward quickly. To this end, he voted against option B in a straw poll mid-way through, despite the fact that it was, on paper, equally satisfactory to option A, which he supported. He also made statements like: "I like option A, because the neighborhood likes it, and it gets me a road quicker" and "If the neighborhood is happy, I'm happy".

While they spoke less frequently and had relatively less influence in the deliberations, the technical stakeholders did have some impact. The senior engineer from the Transportation Agency was able to share costing and capacity information on the rail option when the environmental representative raised it as an option. The flood protection specialist was relatively muted in raising the profile of the flood risks, but did introduce the possibility of combining dike work with rebuilding the existing A3 as part of a D+ option, and the possible extra funding this might attract from his agency. This caught the attention of participants; the ability to access extra money both here and also from the city - as the alderwoman reported that she might be able to access an additional \$1 billion if the project will benefit the city - was very attractive to participants. It shaped the deputy director's opinion on option D, with her stating: "From my agency's standpoint, money-wise that would be the best because it reduces our costs significantly, and the funding can very well come from outside, which means we are spending almost nothing in terms of what we would be spending on it".

In general, financing was a central issue in the deliberations. Financing and costing issues were raised at least ten different times in the discussion, most frequently by the deputy director. In her opening statement, she said: “The one thing I have to let everyone know is that there is a strict [budget]; the agency itself only has \$2.5 billion for the project, so any additional cost, such as if option C is chosen, would have to come from other sources”. The senior engineer was reticent to share his preferences early in the deliberations, but mentioned cost: “There are certain standards we follow, the way things are done that make sense across our network, so obviously cost control makes a lot of sense”. Later on, in evaluating option C, he framed his response in financial terms, stating that “I would just say the cost vs. benefits just aren't there”. Reflecting during the debrief the first thing the participant that played the deputy director noted was how money made a difference:

For us, once we got to option D, the alderman [...] said that she could throw in an additional \$1 billion if we avoided going through their neighborhood, which really enticed a lot of us. Of course, this left the port unhappy, as it doesn't provide the same capacity gains. And then other money - the flood protection specialist said they had some extra money that could go in from federal funds. So, financially, it was the one that was in some ways most beneficial, because funds were coming from other sources, and so the cost coming from the Transportation Agency, and I was facilitator working for the Transportation Agency, from our standpoint that was the best.

The group was very creative in coming up with alternative options. The alderwoman proposed a ‘hybrid’ A/B option - which involved building parts of the A39 above ground and parts through residential Bloomland below - early on, and it seemed like it might be the preferred option for a time. The alternative route discussed previously was initially proposed by the flood protection specialist, and gained traction when it was brought back on the table by the deputy director in her effort to seek a compromise between the interest groups, stating that:

I also see another option too, which is kind of A/B but changing the route, so there may be some environmental issues with this too, but perhaps they could be mitigated. Right now we have the route going through your neighborhood [...] but what if we were to route it along the edge? So instead of going through we are routing near the edge of what is currently the existing population area, between there and the marsh. How would that be as an option?

The deputy executive director also proposed an option that involved opening a second port further inland along the river so that it would be closer to the key motorways on the other side of the city. These creative options opened up a range of viable possibilities, but ultimately complicated matters, preventing the group from reaching agreement before the deliberations ended. They also added uncertainties that participants did not know how to deal with, because they did not have the information in their instructions.

It is notable is that climate change played almost no part in the deliberations, and questions of uncertainty even less. The group did not refer to the scenarios at all, and discussed the flood risks explicitly only once and quickly moved on. Other issues, like the pressing

capacity needs of the port, the environmental impacts of putting the highway through a wetland and the community impacts of putting it through a neighborhood far outweighed any climate concerns in the deliberations. Some assumed that flooding risks are significant, and subsequently supported options that would enhance resilience – in particular, the flood protection specialist and the environmentalist supported option D at least in part for this reason. In contrast, others – namely the alderwoman and port representative - thought it was less of an issue relative to their other concerns, and thus supported option A, despite the flooding risks.

Outcome: Scenarios group #2

The second scenarios group also came close, but had difficulty finalizing an agreement within the time allocated. They concluded with general agreement that they would build a 'D+' option with freight rail to start and were deliberating on a proposal to build a new road (likely option A) in addition. The port and municipal traffic department representatives were particularly adamant in getting an alternative route for network robustness and convenience in crossing the river. The group also concluded that they would want to do more research before making a decision – they felt that they did not know enough about the elevation of the infrastructure and associated flooding projections; the cost estimates for different options; how much funding might be secured from both the Flood Protection Agency and the City for a more elaborate project; the construction timelines for the different options; and if and how the port users might be convinced to shift to rail. The environmental representative also noted that the port itself might be very vulnerable to climate change, given its coastal location, and insisted that a vulnerability assessment should be done on it as well before they invest all this money to build a road that may lead to a flooded area.

The discussion in this group was much more balanced among the participants, with the number of interventions ranging from the Westerberg (city) Department of Traffic project manager at 31 up to the Port Authority representative at 71, and the rest falling in between. Substantively, virtually everyone contributed to the discussion. The Transportation Agency deputy director (i.e., chair) intervened 65 times. He appeared more confident, and played a more facilitative role than the chair of the first scenarios group, largely resisting shaping the outcome but employing effective facilitative techniques like active listening, asking questions like: “When you say the transportation needs of the project, [...] are you looking at the general overall traffic patterns, or simply the port?” and “It sounds like what I am hearing is that we like option D, with some initial improvements, and probably looking for some additional money?”

This was the *only* scenarios group across the three cities that paid significant attention to the scenarios in their deliberations. The chair put them front and center, having participants assess each option against each scenario to see if they could arrive at which would be best in each situation; they systematically went through each scenario and identified which option(s) would be best in each case. This accentuated the uncertainties and instigated some discussion on robustness, but participants ultimately coalesced

around assuming the worst-case scenario after the chair concluded the scenario review exercise by stating:

So now is when we craft a recommendation. [...] We talked about a lot of things, but if we had to come up with a recommendation, what do you think it should be? A, B, C or D? And what I think is important, [...] what are we planning for? What type of scenario are we planning for?

The environmentalist and alderman both said ‘worst case scenario’ (i.e., ‘wet and busy’), and no one else disagreed, so that became the design condition. The flood protection specialist’s statements suggest that she also supported planning for the worst case scenario, but she added that they should incorporate flexibility, stating that group should be “building more flexibility into some of the projects and planning decisions, understanding some of the decisions in terms of how we define flexibility in each of the options”. The alderman suggested that “if we want to consider flexibility and resiliency” the group should do the D+ option with rail while establishing the groundwork for A or another option in addition, if and when it becomes necessary. The ‘flexibility’ of this approach was attractive to most of the group.

Climate change was not the only uncertainty the group grappled with. As discussed previously, the group concluded that they would need more information on various fronts before they could make a decision. These uncertainties were, in part, a product of new options being introduced for which no one had information. They also resulted from a reticence on the senior engineer’s part to share information with confidence. While senior engineers in other groups typically spoke with certainty, the senior engineer here was very careful to caveat most information he shared, even when in his confidential instructions, saying things like:

Expanding the existing rail would cost about \$500M and increase capacity for the network overall by 15-20%, and a very uncertain estimate, which makes me very uncomfortable is that climate proofing the rail network would cost around \$250M. And just to be clear, I won’t stand behind those figures very much; they are just back of the envelope numbers.

Among other similar statements, he later said: “Well, as head of the group that was in charge of developing the cost estimates, we should be careful taking that with too much definiteness until we do our engineering designs”. This reticence to provide any more certainty was consequential; as the deliberations were drawing to a close, the Port Authority representative said: “I think, senior engineer, if you could show that we could get an increase in capacity by the D with increased freight, and our users could accommodate the growth of 15-20%, I think, if you could guarantee that, we’d be open to it”. The senior engineer felt unable to provide this assurance, responding that he “can go back and consult with our transportation traffic experts and see if they can firm up those projections and give a more rigorous basis to the effect of increasing the capacity of the railway”. This was a key factor in preventing a definitive final agreement. During the exercise debrief, a participant reflected: “We had a lot of questions, and felt like there wasn’t a whole lot of

information that was available. Our poor traffic engineer, we kind of banged on him a little bit because the pricing was quite flimsy." The pricing was, in fact, in his instructions but he emphasized the uncertainty around it, downplaying its value.

The senior engineer was also relatively hesitant to explicitly state his preference for one option over the others, presenting himself as a neutral resource person, stating that: "I want to make sure we meet the transportation needs, as we expect them to be, and whatever we do in relation to the climate change issue, we develop a project that has a clear budget, a clear role, something we can deliver on-time and in budget". In contrast, the flood protection specialist was much more confident in the data she presented and willing to express explicit support for an option. In her opening remarks, she stated:

I do want to mirror a bit about what the environmentalist was saying about considering different options for climate impacts, and looking at a number of scenarios related to potential alternative modes, maybe looking at freight [rail] as another option. We really don't want to compromise on the climate risks associated with the different types of builds and the different options we have on the table related to the roadway. In that sense, we do want to put out there that option D would be the most attractive for us. It also has the possibility of looking at a stretch that has a dike that may be compromised in a short period of time, so the new roadway reconstruction could be tacked on to some other sustainability projects related to reinforcing the dike in the area. That could lead to some more potential funding.

While the senior engineers cautiousness generated some feeling of uncertainty, the flood protection specialist's strong assertions contributed to this (D+) option remaining the prominent one throughout deliberations. Others took it as a foregone conclusion that they should do this dike work in parallel with any other option chosen, and thus used the base D option as the point of departure as they considered options.

Similarly to the first scenarios group, this group was very creative in proposing various options not in their instructions. They extensively deliberated on whether or not it might be wiser to move the port in-land along the river due to flooding concerns. While they did not have information on what costs that might entail, nor how feasible it would be, they earnestly considered different components, like how a land swap might be orchestrated with the state and how a transplanted facility might link more effectively with the north-south running A1 motorway. The chair also introduced the idea of a different route for the A39, or construction technique like tunneling the road. The idea of charging tolls on the roads was also introduced as an option for paying for a more expensive option.

Interestingly, in this group, as in the first scenarios group, there was substantial focus on the impact any highway might have on the community of Bloomland – even option A, which goes below grade. While the alderman's confidential instructions state that she or he prefers option A, in both groups the players went off-script and were reticent to accept any highway without making sure it was not going to destroy the community. In the words of the alderman in this group early in the deliberations:

I understand that this is very important for business, and industry throughout the district, but I have to say that option A, the primary option, is going to significantly impact the Bloomland neighborhood. This is a residential area, and putting a major road through it is going to be difficult. It will bifurcate the neighborhood - we've done it all throughout the country, all throughout the world, and we know this is going to be an issue, so that's my main concern - what this is going to do to residents there. I would expect and want to alleviate traffic for the city, but I'm very concerned about that.

As a participant reflecting on the experience noted, this is a legacy of highway projects destroying neighborhoods under the banner of 'urban renewal' in Boston and other cities starting in the 1940's. The idea of any highway passing through this neighborhood seems unappealing. These concerns were not as prominent in Singapore or Rotterdam.

Another interesting feature is that, similar to the first scenarios group, participants not only accepted the presence of interest group representatives, but also deferred to them for information. For example, when discussing sea level rise forecasts in 10 or 20 years, the senior engineer – who is the main resource person – looked to the environmental NGO representative and asked if her organization had done any sort of analysis. This is perhaps unsurprising in Boston, where an NGO (The Boston Harbor Association) was the primary facilitator of such a process, generating widely cited inundation maps (TBHA, 2010). The environmentalist was also quick to mention a potential lawsuit in this group, saying: "I am strongly opposed to C! And will go to court". As in the first group this threat had seemingly little impact on the tone of the deliberations, but substantive influence on what seemed palatable or realistic as an option.

Outcome: Risk assessment group #1

The first risk assessment group ended up recommending a 'D+' option, although different in constitution to those of other D+ groups. They came up with the creative option of allocating dedicated truck lanes on the renovated A3, so that freight could move with less congestion. They also decided to invest in rail, but passenger service first and freight only later if and when deemed appropriate. Most other groups with D+ agreements focused on the freight rail, with passenger service being secondary or not in their packages at all. Last but not least, they committed to starting this work on an accelerated schedule and prescribed a phased approach, with the passenger rail coming online as soon as possible to alleviate congestion during the reconstruction of the A3, and then other modifications to the road and/or infrastructure as necessary. This approach was also presented as a *flexible* way to proceed in the face of *uncertainty*, although the uncertainty was around changing transportation preferences rather than climate change. In the words of the senior engineer:

I guess one of the nuances with this, with respect to rail is, [...] if we go back to the discussion of uncertainty about the future balance between rail and vehicular traffic, is there any way of preparing for a future phase of improving the [freight] rail capacity, with some amount of investment as we improve passenger capacity, so we don't preclude that, but defer it to the future.

Others concurred, with the deputy director adding that they can always return dedicated truck lanes on the renovated A3 back to general use in the future if freight rail takes off, and stating that: “We are not doing anything that we are going to want to take back”.

This outcome with dedicated truck lanes and passenger rather than freight rail is, in large part, a result of the intransigence of the Port Authority representative, and her ability to leverage that to extract a more favorable outcome. Throughout most of the deliberations, she was unwilling to entertain anything other than a new road, questioning the accuracy of the figures given for the estimated capacity increase that improved freight rail might provide. She made statements like:

I just don't see a reduction in the use of trucking for freight. Because even if the rail was improved and there was some easing of the increased needs for capacity on rail, it wouldn't decrease the trucking. We already don't have enough capacity to get the goods to and from the port, as it is. So adding the rail isn't going to decrease the trucking, as far as we are concerned.

And later on: “Like I said, I don't think that the rail improvements would take trucks off the road, so I don't think those estimates are correct from what we've studied”. Even when others were looking for creative ways to accommodate her, she remained unsatisfied. Her inflexibility started to notably irk other participants, with them laughing at her refusal to budge and saying things like: “Well, just like we went through the first set of options, we are putting down what other people feel are alternatives, so you may still not accept that, but it's what we heard from the group, right? You are really defending your position!” And later - after she complained that “we are not going by the route that we would want!” – the senior engineer responded: “Well, tough”. A participant from a similar agency to the port authority, but that was playing a different role in this group made this comment in the game:

I'd also like to address the issue of the Port Authority, because you are the director of community and government relations, so your concern should be as much the community as the economic bottom line. The Port Authority certainly has a lot of money [...], so your concern should also be governmental relations and community benefits, and the community absolutely would not support B option. [...] I think the port authority needs to hear the community's position on this pretty clearly.

Nonetheless, her aggressive gambit worked insofar as the outcome was shaped in many ways in response to the attention she demanded – while not her first choice, passenger rail should take cars off the road, and she gained the dedicated lanes for her trucks. Afterwards, the participant from a similar authority reflected:

Well, working for [an agency like this] myself, I know you would gin up your own money to do your own thing. There would be no discussion - You wouldn't take priority over what the town wants. You'd have to be patient and attentive to what they say.

This suggests that her inflexibility was not altogether realistic, and that in reality agencies like this need to be attentive to community concerns. This statement is also enlightening on how agencies like the port authority get things done in environments with constrained resources – they do it themselves rather than waiting for government agencies. An example of this in Boston would be the Silver Line bus rapid transit line running to Boston’s Logan International Airport – the airport operator, Massport, bought the busses and is compensating their operations to facilitate free boarding at the airport (Mohl, 2013).

Despite her intransigence, the port representative did seem to recognize the need to find allies, particularly earlier in the deliberations, saying things like “as long as there is not opposition from the residents, because we need to move forward quickly” when asked if she would support an option. In fact, she drew serious concerns out of the alderwoman, who had been silent on her constituents’ strong opposition to option B (the elevated road), despite the fact that this is *the* most important issue in her instructions. The interaction went as follows:

Port rep: I have a question for the alderman - in comparing A and B, do you think the residents would put up strong opposition to B as opposed to A? Because if we are choosing between them, as a port we want to make sure there isn't a big delay and objections from residents.

Alderwoman: B is unacceptable, at least without significant noise, visual and air pollution mitigation measures. Even then, this would be as a final compromise, and not necessarily what we are hoping for.

The fact that it took this direct inquiry to invoke this feedback on the option may reflect an important dynamic in similar decision-making processes in the real world – bringing actors to the table is the first step in a robust multi-stakeholder deliberative process, but ensuring that they have the capacity and confidence to fully engage is also critical. The woman playing this role represents a neighborhood organization in the real world, and appeared unsure of when and how she should intercede in a fast-paced discussion that was ostensibly focusing on the ‘technical’ merits of different proposals. Others, including the port representative, clearly understood the implicit ‘rules of the game’, whereas she seemed not to. Her muted involvement had other implications on how the ‘zone of possible agreement’ took shape – while she did not express many strong opinions, she also did not disclose the extra funding the city might be able to provide.

Quantitatively, the disparity in the number of interactions was not as dramatic as with the first scenarios group, but also not as balanced as with the second scenarios group – the deputy director spoke most frequently, with 66 interactions, followed by the senior engineer from the Transportation Agency (57), Port Authority representative (53), Environmental Impact representative (44), alderwoman (31), flood protection specialist (29), and city Department of Traffic project manager (25). Qualitatively, the port representative and senior engineer largely dominated the deliberations. Others did make important contributions - for example, the flood protection specialist’s disclosure that option D would allow for concurrent dike reconstruction, likely attracting additional

government funding, and the corollary assumption that the road would have to be rebuilt anyways, were instrumental to D becoming the preferred option. Similarly, strong opposition from the environmentalist and municipal traffic project manager to option C quashed it relatively quickly. However, the port representative and senior engineer were the strongest voices in shaping the process and outcomes.

The senior engineer assumed a facilitative role, volunteering to map out the options and levels of support on a flipchart, interjecting regularly to confirm the statements of others, and proposing a straw poll. This was not because the deputy director was doing a poor job – she employed effective facilitation techniques and avoided stating her preferences to maintain an air of neutrality. Nonetheless, the senior engineer pivoted into being a second facilitator and was able to dominate with his data. He spoke with authority, making statements like:

I'm trying to hear other people's positions, as we'd like to get the project done. The budget we have could be used for a combination of things - what if we combined a couple of these projects, [and calculate] what is the net result in terms of congestion relief and/or added capacity. So, for example if we take this passenger rail with 10% and the estimated added capacity by improving with option D, how that compares to what we get from just doing B.

Others deferred to him for information. His approach represents a stark contrast to the senior engineer in the second scenarios group, who was very careful to highlight the uncertainty in his data. Both were looked to authoritatively, so the lack of confidence in the numbers of the senior engineer in the other group led participants to believe there was too little clarity to make a decision. In this case, the senior engineer played down any uncertainties, leading the group to feel confident that they could make a decision. It is also notable that the senior engineer was not neutral in his assertions, clearly stating his preferences at various points.

This group also had a lot of creativity. The environmentalist recommended a hybrid road-rail option with cargo moving by rail from the port to a transfer hub somewhere to the west of the city by the A1 motorway, at which it could be transferred to truck. The deputy director proposed a dedicated 'freight haul road' running through the existing rail right-of-way. The port representative objected to the former because of the added logistical issues and cost, but supported the latter. In fact, the latter was gaining substantial traction and looked like it might be the final agreement until the senior engineer reviewed his notes again and found a stipulation that the rail right-of-way is not large enough for a highway and any widening would likely face stiff opposition.

Compared to the scenarios groups, this group acknowledged the climate risks much more explicitly. The port representative downplayed their importance, stating that they need to focus more on the present, but others explicitly referred to the risk assessment when deliberating. Funding was less prominent of an issue than in the other two groups, but still explicitly talked about. For example, when a stakeholder said 'if only money wasn't an issue', the deputy director responded: "But it is! Money is an issue - Always is".

Outcome: Risk assessment group #2

The second risk assessment group reached consensus on a D+ option that involved fully climate proofing the A3 while rebuilding it, enhancing freight rail service (also with climate proofing), and adding a new passenger rail service. This package emerged quite late in the deliberations, but ultimately satisfied everyone, including the port representative. She was hesitant, but took getting more capacity online as quickly as possible as her primary concern and was convinced that this option could be executed rapidly, especially given that all of the parties were enthusiastic about it, reducing the possibilities for later opposition and thus delay.

The total budget for this package is \$3.25 billion. The national Transportation Agency has a hard budget cap of \$2.5 billion, but the alderwoman committed to providing the additional \$750 million from the city's budget. As in the other Boston groups, financing was highlighted as a factor, with the deputy executive director emphasizing in his opening remarks that 'money matters'. This was repeated at various points when the group considered more expensive options. For this reason, the ultimately more expensive final agreement only emerged as a viable option very late in the deliberations when option D was on the table and they were debating how to spend the one billion remaining, which would have been enough for some things but not everything. Seemingly out of nowhere to the others, the alderwoman said: "Well, my community actually kind of likes this idea, because we have been crossing our fingers and kind of hoping for something to go with the rail and, in fact, we are happy to throw \$750 million on the table [for] that plan". She had been holding back on revealing the availability of these extra funds, and this disclosure changed everything, providing for a comprehensive option with substantial transportation capacity improvements that incorporated climate resiliency and satisfied most other interests expressed at the table.

The deputy director played an extremely dominant role in this group, as evinced by the disproportionate number of interventions he made – 108, with the second most active, the alderwoman, intervening 44 times. This reflects his hands-on shepherding of the process. Employing active listening techniques, he would confirm the statements of others, and frequently and methodically chart the course to the next step, while being careful to maintain the confidence of the group. He engaged participants in a methodical process of evaluating each option against a range of criteria, took numerous straw polls, made sure to call on parties for their opinions, and had another participant track key elements on a flipchart. In general, his techniques could be considered quite strong. An example of the way he facilitated would be his opening remarks that clearly laid out the objectives for the group:

Thank you everyone. What a great group. From the perspective of our agency, a few things to add - we are dealing with uncertainty, so it is very important that we keep in mind robustness. This is not an exercise in problem-solution-end of the day. We are really looking at a complex problem that needs a long-term solution to deal with ongoing uncertainty. So whatever, we do, we want to make sure there is some

robustness built in. Second, we really need to reach a decision. My directions are delaying or cancelling is not possible. There is no option to kick the ball - we need to move ahead and reach a decision ourselves. We are not reaching a technical decision; we are trying to reach broad consensus as a group that can be followed up on in greater detail, so we don't want to get lost in the weeds. What we really want to do is engage each other from our own perspectives, understand each other's perspectives, and reach a reasonable type of agreement that we can all live with. [Third], money does matter, and we are not able to spend more than \$2.5 billion. I know with all the options there are different costs, so we need to consider the range of costs.

Another example would be how he brought the group back to the task at hand when they were getting into a debate by saying:

Let's put a little box around this debate between risk vs. community quality of life, and really make sure to get back to that when we get to the discussion, [...] but what I think we want to do at this point is lay out your perspective, listen very carefully, so if there is an issue of community quality vs. uncertainty, make sure to note that so we can come back to it, because that is really what you are here to do is to really make sure the community understands the risk, and that you [flood experts] recognize that there are people living adjacent to this and it really matters in the design.

One potential shortcoming in his approach was that he explicitly held the group back from discussing 'sub-options' - including adding rail to option D, or extra flood-proofing to option A - until relatively late in the deliberations, asserting that they should evaluate the options in their original format first, try to narrow down, and only then discuss how the preferred option(s) might be strengthened. This may have made options less appealing to various stakeholders than they might have been with some modifications, potentially removing them from consideration prematurely. It was also a factor in delaying the alderwoman's disclosure of the extra funds she could access.

The deputy director was also a consensus builder. For example, recognizing that the port representative was still unhappy as they finalized the package, he asked: "Can we offer something to [the port representative] that would appease some concerns?" This actually yielded what they framed in the debrief as "a side negotiation between the community and the port", in which the alderwoman admitted she had some more money beyond the \$750 million she had already put on the table and offered a further \$250 million to the Port Authority for something like a "big fancy crane". The port representative appreciated the offer, but ultimately said what they really want is for the infrastructure to be constructed as quickly as possible.

As in the other risk assessment group, the port representative made strong demands in general. After they were finished deliberating, a participant reflected: "It would have been interesting to see how much the port would have put on the table to get what they wanted". Another concurred: "Yeah, it seems like they would have deeper pockets". As discussed in the previous section, authorities like the port in this exercise would typically be looked to

for support for infrastructure projects, not insisting that less well-funded government agencies construct the infrastructure of their choosing for them.

As in the other exercise runs in Boston, the parties were very explicit in the identification of their interests and positions. The port representative explicitly talked about a better transportation link north, and quickly; the alderwoman talked of quality of life, and the idea of a community benefits agreement was raised; and the environmentalist and flood protection specialist both spoke of the valuable wetland, and goal of reducing pollution and thus desire to advance public transit.

Here too, the alderwoman stated opposition to any road through Bloomland, despite her confidential instructions suggesting that she prefers option A. She introduced her position by stating: “[I am] the alderwoman for district 4, Bloomland, and we love our quality of life, we are concerned about traffic, we would like to have some better congestion alleviation, but we are not interested in streamlining huge numbers of goods-laden trucks into our community”. As discussed earlier in this chapter, this reflects negative associations with highway projects in post urban renewal America.

While explicit in expressing their interests and positions, the participants did employ negotiation techniques and made calculated statements in efforts to sway opinion and form alliances. For example, the environmentalist’s attempted to kibosh option C, which he vehemently opposed for environmental reasons, by flagging its cost. Immediately after the deputy director’s aforementioned opening remarks, he asked: “I have a question - does that mean we immediately rule out option C, which is \$3.6B?” He used cost as an argument against C again later as well. He advocated for his preferred option by selling it as the most efficient, and easiest way to avoid conflict with the community, saying:

Perhaps we don't need a new road. Perhaps we should be more focused on improving the existing infrastructure. There is a rail line that is there today, it has a spur to the port. So rather than start this community battle over what will work for the community yet also bring more goods and services to the port, we think we are over-building when we should be focusing on the better use of existing assets, and particularly the rail asset.

While ultimately unsuccessful, the Port Authority representative and alderwoman clearly recognized some shared interests and formed an informal alliance. When discussing option A, which was one that both could support, the port representative said:

So from my perspective I'm really going to have to agree with the alderman, because when this goes out for public meetings, we want the community to be happy and to not hold this up due to their issues with this going through the community. So, I think that's the fastest track to go through the community with their blessings. If this is what is going to make them happy, I think we should go with the low road option.

Similarly, the alderwoman later expressed support for option C, which the Port Authority preferred and she could live with.

A common theme across the four groups in Boston was the readiness of the Environmental Impact representatives to threaten a lawsuit, and the ease with which the others accepted it. Similarly to in the other three groups, as soon as option C was introduced the representative stated: “While we really appreciate being part of this process, I think if C were the path we walk down, we would not have much choice but to challenge that in court, and to the extent that it does add to the uncertainty, and costs and risks, we think this is important enough that we would have to take that route to protect that wetland”. On the other side, as they were wrapping up the process the alderwoman sought to placate the port representative’s concerns that the project could take too long by stating not to worry because “we have plenty of money for lawyers [to beat back] the fringe interests [that might challenge in court]”. Afterwards, the participant that filled the environmentalist role reflected: “I do think it's interesting what lawsuits and uncertainty can do to projects; with very little 'real' leverage you can create quite a bit of leverage”. In a similar vein, a participant reflected in a follow-up interview that: “People brought to the table assumptions around legal protections, the costs of litigation, the fierceness of the [regulatory] protection”. This underscores the interdependency that the threat of lawsuits can create, giving ostensibly weak parties leverage in deliberations vis-à-vis more powerful parties and influencing the zone of possible agreement.

Similarly to the other Boston groups, the senior engineer acted as a resource person, freely sharing information. He clearly embellished some information to support or discourage options as he saw as best, opining on option C, for example: “Well, from a technical perspective its not very attractive - it's significantly more expensive, and frankly building through a marsh there is a lot of uncertainty in those cost estimates, the permitting would be a real challenge, which is going to delay the project a lot, and it doesn't provide the transportation capacity”. None of this, except the bare cost and capacity figures, was in his instructions.

As in the other risk assessment group, the chair outlined the climate risks up front. This was the only group in which a player (the alderwoman) explicitly assumed the role of being a climate skeptic. Early on she said: “Well, I would challenge anyone to show me proof. By everyone's admission, there is a lot of uncertainty, and as I said, you guys do a fantastic job [with flood protection]. So, I understand that there is always a risk of flooding, but your topnotch engineering has always maintained the best quality of life, and that's what I'm interested in, because that's what my citizenry values the most.” As the group coalesced around the final agreement and the chair asked if they should invest in the extra climate proofing, she quipped: “I don't believe in climate change, so don't look at me!” However, once they were talking about what the proofing entails she said: “If you are generally talking about higher quality construction and flood risk reduction, then I support that. It's just this climate stuff that I don't believe in”. This may be reflective of decision-making in the U.S., where it can be more effective to frame *resiliency* efforts without mentioning the term *climate change*.

Pre- and post-exercise surveys

All 32 participants completed at least part of the pre- and post-exercise surveys.⁸ The survey instruments were designed to advance four research goals:

- They provided a snapshot of participants’ current decision-making norms;
- They provided insights into participants’ perceptions of the risks and uncertainty posed by climate change, uncertainly more broadly, and the level of preparedness of their respective organizations;
- They were conducted both before and after the exercise to discern if participating in the exercise had any impact on participants’ perceptions; and
- Feedback collected via the post-exercise surveys validated the benefits of RPSs as a tool for learning and research.

This section outlines findings related to all four goals. Participants were asked similar questions pre- and post-exercise to examine if participation had any discernable impact on their perceptions. Most questions also remained the same across all three case cities for comparative purposes.

Climate change

Participants were asked a series of questions to better understand their views on climate change vis-à-vis infrastructure planning and decision-making. Interestingly, participants reported the highest level of awareness of ‘climate change and the risks it may pose’ in Boston, compared to Singapore and Rotterdam. The average response pre-exercise was 6 on a 7-point Likert scale from ‘not at all’ at 1 to ‘very’ at 7. In comparison, the average was 5 in Rotterdam and 4.3 in Singapore. Unsurprisingly, the highest rankings (i.e., 7s) were from those directly working on climate and/or sustainability issues. The only two 4s were from participants that work in transportation agencies (one state, one federal). What is interesting is the higher responses when actors are compared with counterparts in similar positions and organizations in both Singapore and Rotterdam. Here are two examples:

Position	Rotterdam	Singapore	Boston
Transportation agencies	2, 3, 3, 5, 6, 7 (4.3 avg.)	3, 5, 5, N/A (4.3 avg.)	4, 4, 5, 6, 7, 7, N/A (5.5 avg.)
Engineering consulting	3, 5, 5, 6, 6 (5 avg.)	N/A	5, 5, 5, 6, 6, 6, 7 (5.7 avg.)

The average response to the same awareness question post-exercise was 6.2, which is not a statistically significant shift (Wilcoxon’s test; p=0.05; N=9, T=11; one-tailed hypothesis). This is not surprising, given the high average response pre-exercise. A significant shift was seen in Singapore, but the pre-exercise average was lower, allowing more room for change.

In general, participants expect climate change to be a fairly significant factor in their organizations’ planning and decision-making over the next ten years, with an average

⁸ The number of responses (N) is noted for each question in this section, as not all respondents answered every question.

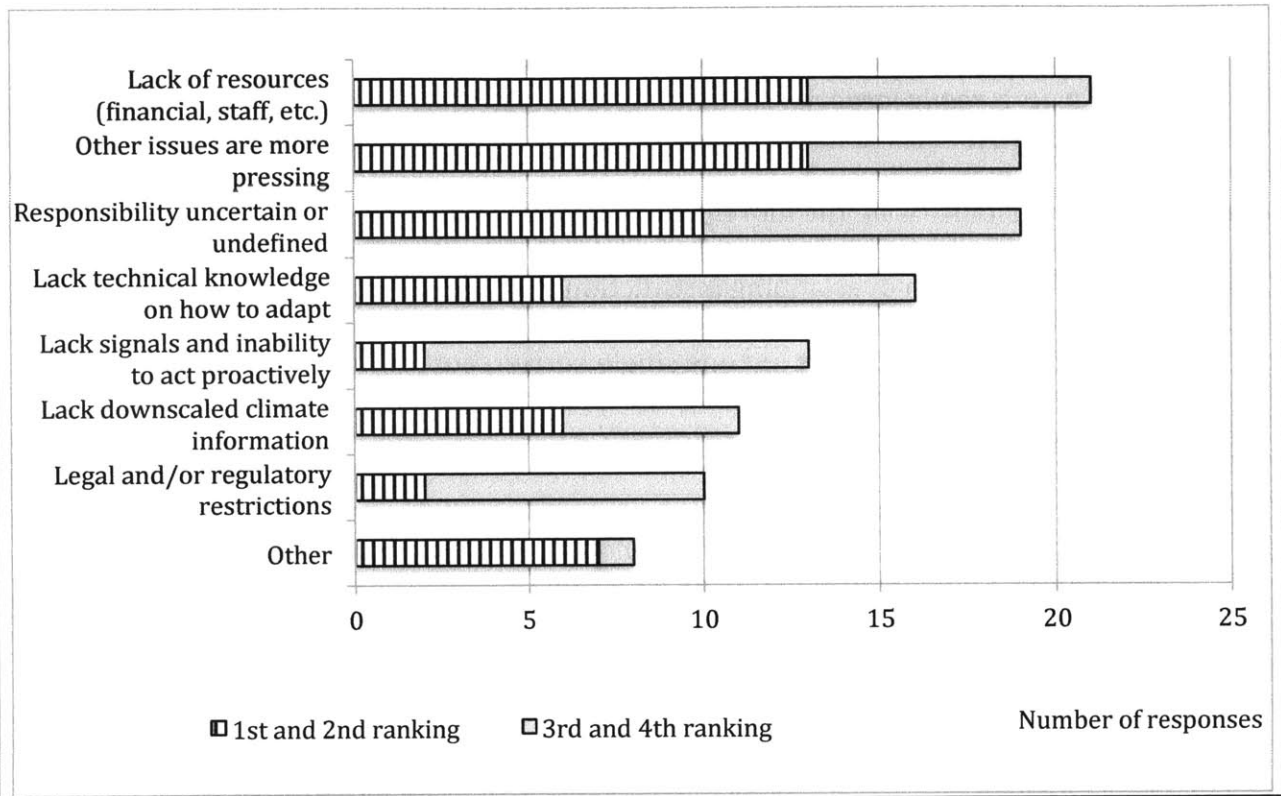
ranking of 5.7 (pre-exercise) on a seven-point Likert scale. In comparison, the averages in Rotterdam and Singapore were 4.9 and 4 respectively. There was notable variation across participants, with four of the seven 7s coming from participants working on water and/or coastal issues. Three of the six 4s came from individuals working on land transportation issues. At 5.7, there was not a statistically significant shift in participants' responses from pre- to post-exercise (Wilcoxon's test; $p=0.05$; $N=19$, $T=95.5$; two-tailed hypothesis). The average response was very similar (5.6) to the question of the degree to which climate change is already on their organizations' radars. Looking at individual responses, an interesting – if not altogether surprising – pattern here is that those working directly on climate issues gave much higher answers than their colleagues in the same organizations, but not directly responsible for climate initiatives. A participant from MassDOT managing one of their high-profile climate initiatives gave a 7 here, while other MassDOT employees that answered this question ranked it 3 and 4. Similarly, A City of Boston participant directly managing climate initiatives gave a 7, while others from the City (from various departments) answered 4, 5 and 5. This suggests a discrepancy in how far nascent climate resiliency initiatives are permeating into these organizations. Follow-up interviews largely confirmed this, with participants reflecting that climate resilience and other emergent issues are clearly rising in profile, but not yet fully integrated into planning and decision-making on the ground. In the words of one reflecting on MassDOT:

Institutionalizing a different approach is still a challenge. Even with MassDOT being as progressive as they are and having all this healthy transportation and climate change goals, GreenDOT and all this. But they are still working on how to change their project prioritization process to acknowledge all that other stuff. Because really, they are still looking at capacity, safety, the condition of the pavement and the bridge ratings, and so that was an interesting thing about the workshop, coming together around a project.

Participants in Boston were asked an additional question in the pre-survey to assess why climate change is not a higher priority than it is. The question they were asked was: *In rank order (1 being highest to 8 lowest), what are the reasons why climate change is not a higher priority in infrastructure planning and decision-making?* Figure 4.4 illustrates the first and second, and third and fourth rankings on a bar graph. According to participants, the top three barriers to climate change adaptation being higher priority are resource constraints, competing priorities, and undefined responsibility.

Resource constraints were a recurring theme during the workshop and throughout the interviews. It is clear that many see already inadequate funding for infrastructure as a particularly acute problem when resiliency efforts are asking agencies to do more. "Resource constraints are a bigger issue than climate change uncertainty", opined a participant, going on to ask: "How do you add all of these elements to a project that you can't afford to begin with? Is there a specific source to cover these costs, like certain Federal funding pots for enhancement programs?" The same participant added that: "Things get value engineered out of infrastructure projects constantly, so there is a level of 'is it worth it?'" Unfortunately, enhanced climate resiliency is often not deemed 'worth it' when resources are tight.

Figure 4.4 – Reasons why climate change is not higher priority



Resource scarcity directly exacerbates competition among priorities. Participants reflected that the competing priority is often getting badly needed infrastructure projects done without further complication and delay. "A lot of bridge projects are accelerated almost to the case of being an emergency, so I don't know that [future climate vulnerability is] ever anybody's first question", said a participant. Another similarly noted:

When I think of the Boston region, and there are differences across municipalities, but with transportation certainly we are seeing a lot of [...] new projects breaking ground, which is great, but in the context of those things no real mention yet of whether they will be impacted differently by climate 50 years from now. In Somerville, there is the Green Line extension, and having waited so long for those projects to come to fruition, or the new Assembly Square Orange Line station, everyone is so giddy about them, and not ready yet to take on mentally the more serious things of will happen not too far off in the future.

Resource constrains are not the only factor behind competing priorities. Interviewees also discussed the very real tradeoffs that manifest between enhancing climate resilience and community impacts, not dissimilar to the tradeoff between options A and B in the exercise. Two different interviewees working on road projects in vulnerable coastal environments reflected that perhaps they could have done more to elevate or protect the infrastructure,

but that would change its relationship to the surrounding environment. In the words of one of these participants:

With roadways along the water, we have to address how it ties into surroundings. And that might be why its so hard to think about, because when you really start to think about it, its a really large puzzle that has to be systemically thought out. And we are not there yet, for such a large-scale project. We always have to be in emergency mode.

Undefined responsibility is all the more problematic in a fragmented institutional environment like that found in the Boston area. As discussed earlier in this chapter, there are so many agencies with overlapping jurisdiction that it is often not clear who should (or at least will) take the lead on an emerging issue like climate adaptation. Ultimately, participants reflected that there is not one single barrier, but rather many confounding factors limiting the further integration of climate resiliency into planning and decision-making. In the words of one:

There are these larger things that just sit in the room because of [other] issues, [including] funding or other coordination stuff were people know it's a problem, but it either doesn't get funneled to the top, or it's one of those things where you think it will never be something that can fit into the budget that year. Who knows, maybe it's an election year. You wonder where that coordination falls short. If Sandy had happened here, I think we would've been shut down for months.

Lack of downscaled climate information ranked quite low as a barrier, with only three people (of 31) ranking it first, three second, and three third. This is notable because insufficient information is often assumed to be a critical barrier. The eight 'others' participants noted were: "Lack of concern and misinformation"; "cost/benefit issues for clients"; "political priorities"; "not a priority with public or elected government"; "conflicting priorities"; "how to revamp [old infrastructure]"; "denial"; and "standard of care in engineering field creates disincentive to create new technical approaches or document uncertainties - to do so creates professional liability". Many of these underscore resource scarcity, the lack of prioritization and challenges to institutionalization.

In terms of how *confident* participants are that they and their organizations will be able to manage the risks and uncertainties climate change poses, participants entered the workshop with a middling average ranking of 4.4 on a 7-point Likert scale. This is slightly higher than the averages in Singapore (3.8) and Rotterdam (3.7), but still low. It is notable that the average was lower among the six individuals working for land transportation agencies that answered this question at 3.5.⁹ In contrast, the average was 5 among those actively working on climate adaptation projects, suggesting that they have confidence in their work to help prepare for a changing climate.

⁹ The phrase "that answered this question" is used intermittently, because two participants, including a MassDOT planner actively working on adaptation projects, were late so did not complete pre-exercise surveys. In some other cases, participants chose not to answer certain questions.

The aforementioned barriers to integration explain much of the skepticism. Another reason is widespread belief that extensive climate adaptation activities will only be implemented in response to climate-related events. However, relatively slow progress in integrating adaptation into project level planning and decision-making after supposed wakeup calls like Hurricanes Katrina and Sandy suggests that even responding reactively can be a challenge. In the words of an interviewee:

We maybe are being reactive, but we can at least be a little bit smart and react to things like Super Storm Sandy by asking the question 'what would have happened if it had been six hours out of phase and hit here at high tide?' And, even if we are reacting to the last storm, and we say 'well, what if it had been exactly the same? If we rebuild and only harden to the same level, and the same storm comes through, then we are going to have to spend the same \$10-20 billion again?' If we take a look and think about what if certain parameters were different and resulted in a storm that was much more severe, then what would that mean? And maybe we harden to that.

During the debrief and follow-up interviews, participants were widely negative on the ability of agencies to conduct the kind of wide, comprehensive and integrated planning that may be necessary to holistically address an issue like climate change. In the words of one:

Compared to Singapore or even the Netherlands, the ability to have a land use planning and transportation conversation with the decision-makers, and the ability to actually come up with an action plan is a lot more nimble than it is here with all of the multiple veto points, and the fact that we really don't do much land use planning to begin with.

This same participant used high-speed rail as an example of the relative inability of government to advance complex projects, especially when they involve controversial actions. "There is obvious demand for high speed rail in the Northeast, but it's really hard to get the money to invest in that [and] something like the TGV would require a new corridor and the idea of the public sector actually getting its hands on that kind of land through eminent domain for a 300 mile rail? Other countries can do that", said the participant.

In contrast to Singapore and Rotterdam, at an average of 4.5 there was not a statistically significant increase in participants' confidence from pre- to post-exercise (Wilcoxon's test; $p=0.05$; $N=18$, $T=80.5$; one-tailed hypothesis). Participants were also asked to self-report on whether or not the exercise changed their level of confidence. The Likert scale question asked: *How has your confidence in the ability of your organization and other stakeholders to adapt to the risks climate change poses changed as a result of your participation in this exercise (1 being less confident, 7 being more confident and 4 being neutral)?* Twelve of 29 reported no change (4s), two reported feeling less confident (both 3s), and the remaining fifteen reported increased confidence (thirteen answered 5, one 6, and one 7). This reflective increase in confidence from pre- to post-exercise would seem to contradict the statistical insignificance in the increase in confidence when participants were asked indirectly. However, it may simply be that the increase in the last question was too small to

be significant, given the small sample size. It does suggest that the reflecting on the exercise experience made participants feel more confident. There is no discernable pattern in who reported feeling more or less confident.

Participants in Boston were asked an additional question in the pre-exercise survey not asked in Singapore or Rotterdam: *How confident are you that other stakeholders will be able to manage the risks and uncertainties climate change poses to infrastructure systems?* Interestingly, the average response here was notably lower than when participants were asked about they and their own organizations – 3.6 versus 4.4 on a 7-point Likert scale. This would suggest that participants have more confidence in their own organizations than they have in others.

Uncertainty

This dissertation is, in part, examining our understanding of the nature of uncertainty as a factor in planning and decision-making. Participants were asked questions about uncertainty in general, and explicitly related to climate change.

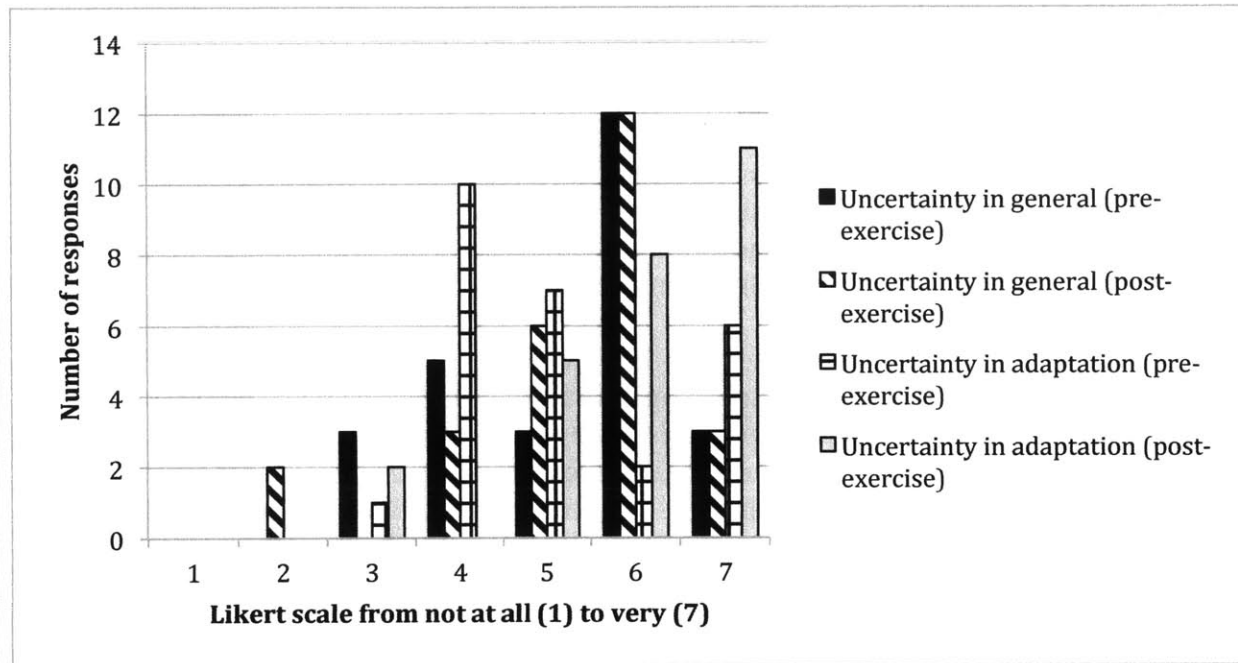
As *figure 4.5* below illustrates, participants see uncertainty (not just from climate change) as a substantial factor. They were asked: *How significant of a problem is uncertainty (not just from climate change) to you as you plan and make decisions (1 being not at all and 7 being very)?* The average response was 5.3 pre-exercise, which is very similar to the averages in Rotterdam (5) and Singapore (5.1).¹⁰ As in Rotterdam and Singapore, participants reported that uncertainty is a pervasive feature of decision-making. “The uncertainty I am dealing with so often is around things like ‘will we get this type of developer or that one’, ‘this land use or that’; it’s that kind of uncertainty, not [climate change] uncertainty, environmental uncertainty”, said one participant. In the context of the exercise, another reflected that it was frustrating to have ‘linear projections’ on various fronts, including growing traffic, that do not account for uncertainties, like the potential for a significant mode shift from private to public transportation. He noted that this is realistic, as agencies in the real world have a hard time being flexible. Participants generally understood uncertainty in broad terms in the exercise runs. In the words of a participant that framed it in terms of ‘risk’: “We focused on risk quite a bit, without necessarily always calling it risk; we were thinking of climate risk as well as economic risk, other environmental risk, community risk”. The risks associated with different options were multifaceted and uncertain.

In addition the question of general uncertainty discussed above, participants were asked: *To what degree is uncertainty a factor in how your organization views and plans for climate change adaptation (1 being not at all and 7 being very)?* At 5, the average response was very similar to that for uncertainty in general in the pre-exercise survey. As *figure 4.5* suggests, participants do not see uncertainty in the context of climate adaptation as any more or less significant of a factor than uncertainty is in general in decision-making. It is, however,

¹⁰ The very slight increase to 5.4 post-exercise was not statistically significant (Wilcoxon's test; $p=0.01$; $N=11$; $T=29.5$; two-tailed hypothesis).

notable that there was a statistically significant increase in the average ranking of how much of a factor uncertainty is in climate adaptation from pre- to post-exercise (see table 4.2 below). This would suggest that the exercise enhanced participants' perceptions of how much of a factor uncertainty may be as they start to tackle adaptation challenges.

Figure 4.5 – The uncertainty factor as participants plan and make decisions



N=26, as only respondents that answered all four questions included

Table 4.2 – Hypothesis test: Uncertainty factor in climate adaptation

H₁: Two-tailed hypothesis that exercise participation will shift respondents' opinions on how much of a factor uncertainty is in climate change adaptation

Survey question: To what degree is uncertainty a factor in how your organization views and plans for climate change adaptation (1 being not at all and 7 being very)?

Test: Wilcoxon matched pairs signed ranks

Conclusion: The results were **significant** at the $p=0.05$ level, using Wilcoxon's test (N=22, T=58.5; two-tailed hypothesis). Therefore, the null hypothesis can be rejected and it is concluded that, on average, participants' opinions on how much of a factor uncertainty is in climate change adaptation planning and decision-making increased from before to after the exercise

The debrief and follow-up interviews provided opportunities to delve deeper into what uncertainty looks like in the context of adaptation. As in Singapore and Rotterdam, participants' reflections overwhelmingly focused on governance challenges rather than scientific uncertainty. One contrasted the high degree of uncertainty around if and how resilience will be institutionalized to the decreasingly important uncertainty around the impacts of climate change:

I think we have to distinguish between uncertainty in terms of what the actual degree of climate change is, and uncertainty with respect to what our responses are. We are uncertain overall to what our responses are; in terms of regional responses, we have a lot of uncertainty in terms of what approaches we will take. [...] I think there is much more of a consensus on the likelihood of flooding and so forth, but in terms of what to do about it, that's another piece of the uncertainty question.

To some, uncertainty is merely an excuse for inaction. A participant that is actively involved in advancing the integration of climate change into planning and decision-making asserted that climatic uncertainty is actually relatively small, given all of the other imperfect models and variables that inform decision-making, but used as an excuse. He also suggested that differences in the professional norms of those generating climate models, versus other models is consequential; climatologists are scientists trained to acknowledge the uncertainties upfront, while traffic and economic forecasters are trained to generate models for policy-making that typically do not emphasize their uncertainties.

Another participant pushed back, asserting that there is a big difference between long-range planning and project-level engineering. The former necessarily uses uncertain models to make the best projections possible, recognizing that it is imperfect, while the latter has to be precise because you are talking about what is 'physically safe and suitable for the purpose'. "One [issue] is whether the long-term economic and demographic assumptions [are sufficient], the other is your engineering and design criteria, and what you are designing for". In general, it is important to note that not everyone agreed that uncertainty in climate models is insignificant, particularly insofar as they are used for shaping project-level decision-making. A consultant that participated in the exercise reflected based on his experience:

I'm a civil engineer, and engineers are great at 'here is a set of standards, now design to those standards'. I was involved in a project with the City of Boston and I went to talk to [former Chief of Environment, Energy & Open Space] Brian Swett, and he said 'we are very concerned about sea level rise'. And I said to him 'we are great at working at meeting standards and regulations, but there are not standards for this'. And he said, 'well there is so much uncertainty, there can't really be standards, so give it your best shot'. And I think that problem is really significant! There is so much uncertainty associated with sea level rise, and climate change that I think it's really hard to understand what is going to work best.

A participant that works inside government at the state level and has been involved in developing guidance noted that they are intentionally taking a flexible approach rather than prescribing concrete design standards because of the uncertainty: "That's why our guidance isn't 'here is what you need to do', but rather, here are the different scenarios, and figure out which one is comfortable to you". It is hard to concretely tell consultants and project proponents what to design to when it is not certain what will happen. This same official added:

Climate change is something that there is more general language about - even for us it's uncertain. If a project proponent was to come in and say 'what should we do?' We don't have an answer for them. 'We have these things that you should look at this and this and this, and you have to decide.' I think people want someone to tell them what they have to do [...] because they are used to that - there are rules and you have to follow the rules, and all of a sudden government is saying 'you decide, look at these options and see what's [best for you]'. I don't know if it's that loose, we definitely have opinions about where you should be and how you should build your building, but we are not going to say 'this is the elevation' it's different. It's very different.

Unfortunately, it is difficult for consultants, and in particular civil engineers accustomed to working within concrete parameters, to work with climate models that are – whether in reality or perception – uncertain. In addition to professional standards and norms, uncertainty is interwoven with many of the other barriers to action discussed previously in this chapter, including resource constraints. Reflecting on the exercise, a participant said:

So this is all just a reality of resources. Even in [this exercise], we talked about the budget first and really nothing was allowed to go above the budget. If you took climate change out of the picture, we still really can't afford the infrastructure we need. So, when you talk about uncertainty it's really difficult when there are so many needs, even absent climate change issues, how do we even begin. We are talking about allocating very, very scarce resources, and I don't know if there is a 1% chance or a 10% chance, but I've got groups in the middle part of the state that also have a major problem, and I've got a shoreline issue here - we are fighting over a very small pie, so these uncertainty issues become much harder to deal with, because it's hard to allocate resources to things that frankly that very well could happen, but there are regular bridges that are maybe subject to many traditional threats.

Managing uncertainty

Asked how they and their agencies typically deal with uncertainties participants responded as follows:¹¹

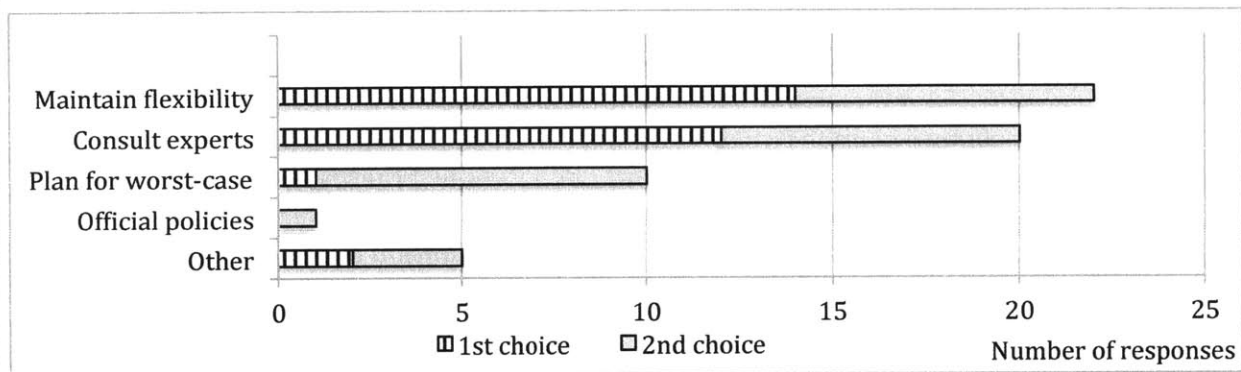
- Seven participants said 'follow official policies or guidelines' (19%);
- Sixteen 'consult experts for their best projections' (43%);
- Four 'plan for worst-case scenario' (11%);
- Ten 'maintain flexibility' (27%); and
- Two listed 'other' approaches (5%), which were:
 - *Follow existing FEMA maps and precipitation data, and attempt to get clients to think about planning and designing for future changes in climate, flooding and rainfall.*
 - *Prioritize resilient approaches.*

¹¹ Note that the number of responses (39) is greater than the number of respondents (N=30) because some chose more than one option, although asked to 'choose only the most common or important'.

This range of responses is relatively similar to those in Rotterdam, where the percentages for each of the options were: 17%, 28%, 11%, 28%, and 17% respectively. Singapore was notably different with the following percentages for the first four options (there were no 'others'): 6%, 29%, 29%, and 35% respectively. The most notable difference is the higher proportion that said 'plan for worst-case scenario' in Singapore. Potential reasons for this discrepancy are discussed in the comparative chapter (chapter 5).

Post-exercise, participants were asked to rank how they think uncertainty *should* be dealt with. The results are illustrated in *figure 4.6*. As can be seen, 'maintain flexibility' was the most popular option – it was the first choice of fourteen participants, and the second of another eight (N=29). As in Rotterdam and Singapore, this positive sentiment was largely echoed throughout the exercise debrief and follow-up interviews.

Figure 4.6 – Preference ranking of how agencies should deal with uncertainties (1st and 2nd choices of respondents)



Flexibility is seen as a way to advance despite resource constraints, and in light of the fact that building to the expected worst-case scenario may never be enough:

Flexibility is crucial, because building it to the worst-case scenario, I think we still won't always be prepared, and B, we don't have the resources for it. And again, from a national perspective because there are so many needs across the country, we can't say 'everyone should do it this way'. We try to do that in general, leave room for local flexibility.

Some did note that flexibility has a downside, particularly when it involves taking a 'wait and see' attitude. "It seemed to me that the inclination towards, you might say either kicking the can down the road or adaptive learning - wait and see and then figure out where to go, that inclination towards D could be seen as having pros and cons", said a participant reflecting on the exercise outcomes. The pros include an ability to be responsive to dynamic conditions and ongoing learning, the cons include potentially being underprepared when extreme events occur. In general, participants saw the popularity of D options in the exercise as reflective of the real world, in which some iterative steps are

being taken but little or no grand adaptive responses, and characteristic of decision-making in Boston. "It's really interesting, and maybe some of it is the bias of people who operate within the Boston and Massachusetts environment that the preference was more for the conservative, closer to status quo, but making improvements to existing infrastructure, and hardening and improving the capacity of that", reflected a participant. Another reflected: "We are very used to working under confinement".

Participants noted that there are substantial barriers to institutionalizing flexibility in practice. One of the more significant is the way in which project planning and funding currently works. It is a more or less linear and phased process that involves different actors at different times. In the words of a participant:

In transportation planning, the demands for funding drive a level of predictability in terms of time frames, which is completely oblivious to what flexibility and change is in terms of actual demand, and I think many of us who have worked on long-term transportation projects, particularly highway projects, have been struck by that. Certainly the big dig was an example of certain metrics that you have to fill [that] may or may not occur, including cost. But certainly in terms of capacity, and as we read in the paper today I believe, how quickly congestion fills in after a predicted period. So, one of the issues in this country is the institutional context in which we are working, and we have to work very hard to overcome some of those institutional barriers.

Another barrier is the previously discussed constraints placed by professional norms and standards. "Flexibility isn't really an option when you have to stamp something and leave your liability on it", said an engineer that participated in the workshop. Regulatory and political constraints were also cited as barriers. One participant reflected that we are perhaps just not good at being flexible, saying: "Most people want there to be a clear-cut answer, or clear way of saying 'we are finished, we are done, we have arrived at a certain solution', and I think you have to be comfortable saying that we're not necessarily going to arrive at a particular solution".

'Consult experts' was a close second in Boston, while it was the third most popular option in Singapore and second but far behind 'maintain flexibility' in popularity in Rotterdam. This reflects a preference for getting 'an answer' to the question of which risks should be accounted for to avoid blowback – legal and otherwise – later. A participant made a strong case for the need for experts that can provide concrete scientific data to base decisions on:

If you don't have the experts, the technical studies, the science, then the ability to move forward in a new direction is really impossible. If its just an intuitive and a qualitative sense that there is a risk problem, that may be enough to raise some concerns, but we are really in a technical world were you have to be able to make a technical case for how bad the risk is, what the danger is, what the costs are, and what the alternatives are, because you are asking, really, planning agencies and implementing agencies to really change their course, to spend money on different things, or to get more money, assuming that they don't have the flexibility to shift funds to this new program area because the funds are already in demand. You need to make a compelling case for new

funds, or different sources of funds. If you don't come forward with compelling science, and that is where the risk and the engineering and the management comes in, once you are able to establish that as a point of reference, then you can get into the debate, and the discussion and the consensus building. So, I think you really need both. We don't have this benign dictatorship where the engineer arrives at the king and the king makes the decision on the best interest of the populace, there is no king. There is a planning process, but it is going to have to factor in the technical data before it gets into the consensus building.

Because the RPS exercise introduced participants to scenarios as a way to manage uncertainty, they were asked in advance: *Do you ever use multiple scenarios (i.e., consider multiple possible futures rather than a single forecast) when you have uncertain factors in your planning and decision-making?* 24 of 28 respondents (86%) answered 'yes'. As in both Singapore and Rotterdam, this suggests widespread use of scenarios as a decision-support tool. Participants were also asked: *How useful is/might be the introduction of multiple scenarios (i.e., multiple possible futures) in your work (1 being not at all and 7 being very)?* Respondents were very positive, with an average of 6 pre-exercise and 5.9 post. This very slight decline in the average from pre- to post-exercise was not statistically significant (Wilcoxon's test; $p=0.10$; $N=9$, $T=19$; two-tailed hypothesis), which is not surprising, given that they played almost no role in the deliberations.

The workshop debrief and follow-up interviews provided greater clarity on the value of, and challenges in using, scenarios in practice. One theme that emerged is the value of scenarios in making salient that there are multiple possible futures. "It was new for me, but new in a good way; good that we could see a world in which very different things could happen", reflected a participant. Scenarios invite participants to think about different things that could happen, rather than asking them to accept or reject a single forecast of the future. Contrasting the scenarios version of the exercise to the risk assessment version during the debrief, a participant reflected:

I think scenario planning inevitably engages people in the discussion, and gives people a concrete understanding, whereas the risk assessment is kind of abstract numbers that you have to take at face value, or you dispute, but the scenarios really change how people think and get them talking to each other about it. So it's more time consuming, but there is a lot more benefit that comes out of it.

Reflecting on why the scenarios groups might have had a harder time reaching agreement, another participant asserted that the scenarios provide 'more choice'. "Our group, the risk assessment group, was always trying in our roles to deal with the cold hard facts that we were given, and we were less able to think outside the box; so, I think there are pluses and minuses for getting to a decision", said the participant. Some interviewees noted that scenario planning may be more or less appropriate in different situations. "It is easier to do for a long range vision document, long range future plan, but on a project or even corridor level it's harder to change. [...] If you want to look at different infrastructure solutions, you don't want to be changing the environmental assumptions", said one.

Participants in the risk assessment groups were asked a similar question post-exercise: *The exercise you participated in used an expert risk assessment as one way to plan in the face of uncertainty. How useful do you think this kind of an assessment is (or could be) in your own organization (1 being not at all and 7 being very)?* The average response was similar, at 5.5.

Stakeholder interactions and decision-making

As was the case in both Rotterdam and Singapore, participants opined that engagement with other stakeholders is an important element of decision-making. They were asked: *How important is it that you engage with other decision-makers and stakeholders as you plan and make decisions?* The average response was 6 pre- and 6.5 post-exercise on a 7-point Likert scale from not at all (1) to very (7). This is a statistically significant increase (see table 4.3 below), suggesting that participation increased the already high value participants place on multi-stakeholder deliberations.

Table 4.3 – Hypothesis test: Stakeholder engagement

H₁: One-tailed hypothesis that exercise participation will increase participants' opinions on the importance of engagement

Survey question: How important is it that you engage with other decision-makers and stakeholders as you plan and make decisions (1 being not at all and 7 being very)?

Test: Wilcoxon matched pairs signed ranks

Conclusion: The results were **significant** at the $p=0.025$ level, using Wilcoxon's test ($N=16$, $T=25$; one-tailed hypothesis). Therefore, the null hypothesis can be rejected and it is concluded that, on average, participants' opinions of the importance of engagement increased from before to after the exercise

In contrast to Singapore, participants emphasized engagement *both* across agency lines and with external stakeholders. As discussed earlier in this chapter, non-governmental organizations, including business interest groups, and private consultants play key roles in governance in the Boston context. In addition to providing resources, external stakeholders can actually bestow legitimacy on processes. According to an interviewee:

The [City of Boston] Environment Department doesn't have a huge capital budget, they have to do a lot of their work through grants and these partnerships like C40, the Clinton Climate Initiative and the Barr Foundation here in Boston, but people hear things about their work with these initiatives and they raise an eyebrow because they know that's a representative group of a lot of important entities. So, if you can come to the table with a project and say 'these people are supporting this, and this is why you should be interested, not just because you're saving the polar bears' - that's why those groups play a key role in city government.

However, many were quick to note that engagement is often imperfect, although potentially improving. One participant reflected that within government, "as agencies, we all operate in our silos, whether at the same level of government or different; we do our own thing and in order to break out of that and understand and appreciate what the other agencies are doing I think you have to meet somehow, and these working groups are a good

forum for that". Vis-à-vis external stakeholders, participants noted that community forums and other forms of engagement are quite standard, but that they often happen too late to have profound implications on planning and decision-making.

Participants' real-world experiences suggest that structured forms of multi-stakeholder decision-making are very common in Boston. 23 of 29 respondents (79%) answered yes to the question: *Have you ever participated in a facilitated multi-stakeholder decision-making process?* In contrast, 57% of participants in Rotterdam and 41% in Singapore reported they have. The six that answered no come from various backgrounds – three consultants, two more junior civil servants from transportation agencies, and the representative of a neighborhood association. Those that have participated in this kind of process in the past rated their experiences very highly, with an average of 5.6 on a 7-point Likert scale from 'very poor' at 1 to 'very successful' at 7. This is a notably higher average than in Singapore (4.7) or Rotterdam (4.6). Some noted that the processes they have participated in were more or less similar to that they experienced in the exercise, while to others this was something new, and positive. A participant with extensive experience in community planning reflected afterwards:

In all the projects I have worked on, I have not participated in one where analysis was done in a mixed group on the various types of uncertainty. In most projects, whether in the municipality, or whatever, a lot of this is very internal, then [there are] community meetings at specific strategic junctures [...], and maybe it was A, B or C, but this felt very multidisciplinary. What you staged for us felt foreign to me in a very pleasant way because we were such a disparate group and the points of view were quite different, and I know that was part of the exercise, but it was refreshing because I haven't had that experience professionally. [...] I've been through many a charrette, tabletop meetings, community presentations, forums for constituents, and it didn't have the feeling you created for us with the various players at the table. So my takeaway personally, I came away thinking wouldn't it be nice if some of our projects really did have this type of [interactions with a mix of different people from different levels].

Correspondingly and thus not surprisingly, participants reported that they frequently interact with other stakeholders. While in Singapore and Rotterdam participants were asked a single question about the frequency of their interactions, in Boston they were asked two separate questions to understand the frequency of their interactions with stakeholders both inside government (but in agencies other than their own) and outside government. The first question was: *On average, how frequently do you interact with experts and other stakeholders inside government, but outside your own agency (if you are in government) as you plan, and make decisions or recommendations (either in-person or electronically)?* Of the 12 participants from inside government that answered this question, the responses were: Three said 'more than once a day', four said 'once a day', two said 'once a week', and three said 'once or twice a month'. The second question was: *On average, how frequently do you interact with experts and other stakeholders outside government as you plan, and make decisions or recommendations (either in-person or electronically)?* Among the same 12 government officials, the responses were: Only one said 'more than once a day', four said 'once a day', one said 'once a week', three said 'once or twice a month', and

three said 'less than monthly'. The notable difference in responses to the two questions is that all respondents interact across agency lines at least on a monthly basis, whereas a quarter of respondents interact with external stakeholders less than monthly. Two of these three are more junior, and the third is mid-level but in a technical engineering position.

According to respondents, the formality of these interactions is a mix of formal and informal, which is similar to what was reported in Rotterdam and Singapore. Fourteen characterized their interactions as 'mostly formal meetings, but some informal', twelve as 'mostly informal interactions, but some formal' and only one each as 'only formal' and 'only informal'.

RPS exercise

Participants were asked a series of questions post-exercise to gather feedback on how much the RPS mirrored their realities, and was valuable in their opinion as a learning tool. In terms of how similar the 'situation or problem presented' is to their own worlds, the average ranking was 5 on a 7-point Likert scale from 'very different' (1) to 'very similar' (7). This is similar to Rotterdam (5.2) and higher than Singapore (4.4).

The 'characters' involved were also seen to be similar, with an average ranking of 5.4. In comparison, the average was 4.6 in Singapore and 5 in Rotterdam. As discussed above, non-governmental actors play major roles in planning processes in the United States - particularly in emerging domains like climate adaptation - so the prominent roles taken on by these actors in the exercise was not as foreign as in Singapore. Participants also found the divided interests among actors ostensibly representing the same organization - namely the alderman and municipal Department of Traffic project manager - to be an accurate reflection of reality:

One of the things I thought was interesting [was that] there were a couple of different people from the city, and they had different view points, which I thought was entirely appropriate because it's so realistic! I think that's part of our challenge, is that even within one organization you can have two different people at the table with third parties and they disagree with each other.

The 'interaction between the characters' was seen as relatively similar to participants' realities at 4.8. This average ranking is the same as that in Rotterdam, and slightly higher than Singapore (4.3). As discussed above, agencies are increasingly engaging with one another and other stakeholders in collaborative processes, but their deliberations are not exactly like those facilitated in the exercise. In fact, participants found the collaborative 'method of decision-making' less realistic, with an average ranking of only 3.9. This is notably lower than in Singapore (4.7) and Rotterdam (4.8), which is surprising given the relatively high degree of stakeholder engagement in decision-making.

Participants in both risk assessment and scenarios groups reported that these respective 'tools introduced' were somewhat although not entirely similar to those they employ in the real world, with an average of 4.4 for the former and 4.6 for the latter. As discussed earlier

in this chapter, scenario planning is being employed in various pilot projects, but is not widely practiced.

The 'options or solutions' presented in the game were also somewhat realistic to participants, with an average of 4.6. This is the same as in Singapore and slightly less than Rotterdam (5.1). Participants reflected that the idea of building a new highway was not realistic in Boston, making it less realistic, but that elements reminded them of the previously discussed Central Artery (i.e., 'big dig') project.

Participants almost universally reported that they learned something from participating in the exercise, with only one of 26 answering 'no' when asked: *Did you learn anything from the exercise that you might be able to apply to your own planning and decision-making?* Participants were also asked to answer *what* they learned in a short-answer open-ended question; responses included:

- *New, unforeseen ideas can still come up [as] hidden information comes to light late in negotiations.*
- *Stakeholders (at a table, such as this exercise) often gravitate to the immediate needs of their constituents. Thus, it's important for a few big-idea visionaries to also be present or else the creativity of solutions is much more limited.*
- *Never a clear answer/solution to a problem. Someone/something always loses.*
- *How many players/constituents are required to have input and needs met.*
- *Need to insure that my role and my mandate from employers insures I am able to voice non-agency/employer lines to help develop creative ideas.*
- *Set of standards has limited applicability to climate change issues. Who sets these? How can we work to overcome institution barriers and support consensus building? Professional norms need to change.*
- *Reminded that the best step in negotiation is getting all the cards on the table.*
- *It is difficult. We were continually looking for more information.*
- *Understanding fully the interests of all stakeholders. Importance of very robust data and risks.*
- *I learned how to look beyond the best options identified for the role I played and find mutual gains among members of the group. [However], had I given in as much in the business world outside of this exercise I may have served the shortest or longest tenure as Ports director, depending on the community and state leadership.*
- *Each role's perspective was suggested - In the real world you play a support role based on the mayor or political decision maker.*
- *Was good to see all sides and questions being asked.*
- *Reinforced importance of having all parties/decision-makers in the same room.*
- *To see the world as others see it; take a more mediated approach to conflict resolution/consensus building.*
- *Look more into where funding comes from and why. Talking about the budget upfront. Risk assessment also of traffic projections.*
- *Importance of process and ability of facilitator.*

- *Important to bring together stakeholders early to evaluate options and risk systematically. Preparing for flexibility and many possible futures is an important lens through which decisions can be made.*
- *Value of bringing parties to table at conceptual level - not responsible for final decision but committed to advocating, but also listening and compromising to move forward.*
- *It is important to interact with other stakeholders. In this case, resources committed by the community helped to arrive at a consensus.*
- *Good facilitation builds consensus.*
- *If we do bring all the stakeholders into the conversation, decision-making and planning is more thorough and not as much 'assumption' is made about varied interests.*
- *Strong preference for status quo.*
- *Using and improving existing infrastructure was a good cooperative outcome.*

The follow-up interviews provided opportunities to unpack what participants learned. 'Perspective taking' was a common theme, and in particular the value of playing a role other than your own. As one participant put it:

It gives [you] an appreciation, a respect for other people's roles. It's going to take a lot of different perspectives to figure out solutions for different aspects of climate change and adapting, and having an engineer by training play a political figure in an exercise, they have to be that person that they get annoyed with, and they have to take it on to some degree, so a forced way of getting people to look beyond themselves and get a wider perspective, and that has to be helpful.

An engineer from a public agency that participated similarly noted the value for technical actors in understanding that issues are not as simple as they might seem, and involve more than scientific facts and rigid standards:

An exercise like what you did is perfect! Unless you sit with various stakeholders at the table, you will not know what their sensitivities are. [...] As an engineer you know the legislation says [...], but unless you sit down with them you would never know their concerns so you need a mixture of political actors, engineers, public relations, and those are the kinds of things you are not taught in [engineering] school!

Participants also reflected that the exercise exposed them to an alternative process for deliberating among stakeholders. "I wish that the approach to decision-making were more like that in the real world; ultimately, decisions are made somewhat mysteriously, and I don't think that they are made so openly as part of [this type of] consensus building group", reflected a participant. She went on to assert that ideally you would have a situation like that in the exercise in which "you have a decision-maker who, through their staff or whoever is involved in the advisory group, takes the outcomes of this kind of process verbatim and takes that position, especially if consensus had been reached". Another participant noted that this kind of exercise could be particularly germane when initially bringing together multiple stakeholders, saying: "It seems like it would be particularly

useful when someone is setting up a new working group or something, giving them an opportunity to open up and understand each other; it's kind of a non-threatening environment [...] so it is useful as a way to open mindsets".

The value of RPS exercises, including as tools for social learning, experimentation and the fostering of collective action, is examined in further detail in chapters 1 and 6.

Conclusions

Various insights may be gleaned from the exercise proceedings and outcomes, interviews, pre- and post-exercise surveys and background research on infrastructure planning and decision-making in Boston. The key themes that emerge include:

- Climate risks are increasingly on the radar of agencies and other stakeholders, but few concrete adaptive measures have been taken thus far;
- Governance is fragmented across multiple agencies at four different levels of government, and coordination is relatively weak;
- External stakeholders, including both advocacy and business organizations play substantial roles, particularly around nascent issues like climate adaptation;
- Stakeholder group interests play prominently in planning and decision-making, and are often, although not exclusively, advanced through litigation;
- Underinvestment in infrastructure is an unfortunate reality, reflecting unwillingness to put resources into maintaining high standards;
- Politics plays a substantial role in if and how issues like climate change are brought on to the policy agenda, and top-down mandates are often necessary, although savvy policy entrepreneurs can work horizontally;
- Uncertainty is a pervasive factor in decision-making, and many participants believe it is best addressed by maintaining flexibility, while recognizing that this is not so easily done in practice;
- Participants believe multiple scenarios can add value, but easily default to wanting a single set of design standards when it comes time to make decisions; and
- Participants learned - largely about process and stakeholder interactions - from participating in the workshop conducted under this research project.

As in Singapore and Rotterdam, these themes suggest that the wider governance regime significantly influences how climate change is being integrated into planning and decision-making in Boston, and may evolve further moving forward. Many of these characteristics reflect what one might expect in a neopluralist and neoliberal planning environment.

Climate preparedness

The plethora of initiatives, significant media attention, and responses of those engaged in this research project suggest that the risks climate change poses to infrastructure and the built environment in the Boston region are increasingly recognized and relatively well

understood. This is especially true for those involved in infrastructure planning and decision-making. Nonetheless, concrete initiatives to increase resiliency have been limited thus far. Various agencies have produced guidance documents and require project proponents to consider the risks associated with climate change. However, these are not strict standards and the degree to which other agencies and private developers take this seriously and heed the findings varies. There are, however, positive examples, including the Spaulding Rehab Center on the harbor and the reconstruction of coastal Morrissey Boulevard. Some agencies, including the Boston Water and Sewer Commission and the Massachusetts Water Resource Authority, are also implementing concrete changes and taking steps to better protect their assets. Unfortunately, however, these concrete efforts appear to be the exception rather than the rule, with a variety of climate-related vulnerabilities left unaddressed throughout the region.

The subsequent sections of this conclusion get at various reasons why tangible progress to enhance resiliency may be moving slowly. Participants expressed middling confidence that they and their organizations will be able to manage the risks and uncertainties posed by climate change, but, on a more positive note, see opportunities to advance efforts, including workshops like that run under this project.

Fragmented governance

A recurring theme throughout this research is the fragmented nature of infrastructure planning and decision-making in the greater Boston area. There are multiple overlapping and interconnected agencies at all levels of government, the region is divided into dozens of municipalities, and it is often unclear who should assume responsibility for emerging threats like climate change that cross jurisdictional boundaries and do not fit neatly into existing institutional arrangements. Related to fragmentation is the piecemeal nature of much planning, even at the project level; projects go through various approval processes, including the Metropolitan Planning Organization (MPO) process for funding, and implementation in a more or less linear fashion. While the implementing agency usually remains constant, other actors do not. There is also weak integration in planning around interrelated sectors like land use and transportation. Participants identified this as a significant source of uncertainty:

As far as regional planning is concerned, I think that's the biggest uncertainty because it's so difficult to come to consensus on what should happen on a larger basis, as opposed to what you do on a block-by-block basis in the municipality. I think we have a big problem with uncertainty insofar as planning is concerned.

In the context of climate adaptation, various federal, state and local agencies and other stakeholders have released aspirational plans and recommendations and convened workshops, but they are typically not orchestrated with each other. In general, there is insufficient coordination among the different actors, especially at the regional scale. There are regional agencies, including the Metropolitan Area Planning Council (MAPC) and the MPO in the transportation domain. However, they have not yet assumed strong leadership roles in the area of climate resilience, and it is unclear if they would be able to for various

reasons, including: Lack of authority; resource limitations; and competing interests and priorities among those that would need to buy in. There are valiant attempts emerging to advance a regional, coordinated approach, including the recently released Metro Boston Climate Preparedness Commitment, which resulted from a Mayors Summit hosted by Boston, but it remains to be seen if they succeed (Mayor's Office, 2015).

In the absence of clear and coordinated adaptation planning, different efforts have gained currency on a more ad hoc basis. Efforts led by the non-profit Boston Harbor Association (TBHA) are highly regarded by other stakeholders in the Boston region. A sophisticated climate impacts analysis being conducted by consultants for and with the Massachusetts Department of Transportation (MassDOT), with Federal Highway Administration funding, is getting significant attention. The project was originally tasked with narrowly examining the Central Artery underground highway tunnels in the city, but later extended to cover all of Boston and Cambridge. Other agencies and actors are eagerly awaiting the results because they will provide the most sophisticated modeling of coastal flooding. There is no clear reason why MassDOT is leading a study with much wider applicability than to their own assets, but they got the funding and no one else has taken on the challenge.

External stakeholders

External actors play a substantial role in planning and decision-making in the Boston region, particularly around nascent issues like climate adaptation. The aforementioned TBHA is an example of a non-profit organization with substantial influence; it partners with the City, and other organizations and academics to produce influential reports and organize events. Despite the fact that it is an advocacy organization, it has wide credibility because it is filling gaps and coordinating where government agencies have not. It is seen as an authoritative and capable actor on this nascent issue. Other non-profits, including the Boston Society of Architects and the Urban Land Institute, are also active. Community organizations like Neighborhood of Affordable Housing (NOAH) in East Boston also play important roles. NOAH engages government officials, but is most active in working with researchers to help residents understand the risks associated with climate change and develop community-based adaptation strategies independent from government.

Foundations play key roles in setting the agenda, in large part by funding the work of non-profits and even government. An example of the latter is the support Boston's Greenovate initiative has received from the Barr Foundation. The Barr Foundation has identified climate change as a priority and is using its considerable resources to this end. Global initiatives and foundations - including the C40 Cities Climate Leadership Group and the Rockefeller Foundation's 100 Resilient Cities network - are also influential. Boston is a member of both of these networks, along with Rotterdam and Singapore.

The business community is very influential in infrastructure planning and decision-making in the Boston region. Collectively, they work through organizations like A Better City (ABC) to advance their interests. This often goes far beyond more traditional lobbying to involve partnerships with government. Like other advocacy organizations, ABC uses its resources and expertise to marshal support and advance research on issues around which they have

shared interests with government agencies. ABC also serves as a two-way conduit between the business community and government – in fact, this is why it emerged as the ‘Artery Business Council’ during the massive big dig highway project. Like TBHA, ABC has even played convening roles bringing various government agencies together to enhance collaborative efforts. On climate adaptation, efforts like the city’s Green Ribbon Commission directly engage business and institutional leaders. In the words of an interviewee at the heart of adaptation efforts in the city:

In Boston, the business community and the institutional community are very involved in the climate change conversation, and we are very fortunate that that is the case. There are some deniers, there always are, but on the whole we have an extremely supportive business community and benefit from that.

More neighborhood-specific business and institutional organizations like MASCO also play important roles. MASCO acts as a conduit between its membership and agencies like the Boston and Water and Sewer Commission and the Massachusetts Department of Conservation and Recreation on flood management issues. It also coordinates emergency response in the area, working with relevant government agencies.

External consultants and contractors are also influential. Engineering firms and other consultancies play significant roles in project design and assessment. They are contracted by and respond to the stipulations of government agencies, but their professional norms and standards of practice shape how planning and design happen. These norms are important as they grapple with how to integrate dynamic and uncertain climate risks, along with the agencies they work with. Academic research institutions also play significant roles in various respects, including providing downscaled climate data and nurturing the development of best practices in adaptation. Much of the actual construction and maintenance of infrastructure is done by private contractors; they will need to be brought along insofar as adaptation involves substantial changes to the status quo of how infrastructure is built and managed over time.

Interests and adversity

Decision-making in Singapore is heavily influenced by the pursuit of ‘national interests’. Stakeholders, particularly those inside government, are expected to more or less coalesce around these interests and make policy choices that align with them. In the Netherlands, there is a tradition of seeking consensus, often referred to as the ‘polder mentality’. In contrast, decision-making in the United States may be characterized as the pursuit of solutions that satisfy or arbitrate between multiple interests that persist in tension. In the words of an interviewee:

[In the Netherlands] they have the tradition of reaching consensus. The cultural thing that they trace back to the polder mentality, whereas we have much more of a argumentative style, with lots of veto points and maybe a suspicion of governance, and ample opportunities to block moving forward on major projects.

Both in the exercise conducted under this research and the real world, stakeholders are forthright in expressing and pursuing their interests. While their efficacy is debatable, consultative processes are designed into infrastructure projects to provide fora for interest-driven feedback. Even relations among government agencies and levels of government can be interest-driven and at times adversarial. An example of this would be the suit filed by the City of Somerville to drive the State to move ahead with a public transportation project.

In general, lawsuits feature prominently as an instrument for resolving disputes around what should be done, when, and by whom. They were influential in the region's two most prominent infrastructure projects of recent decades – the cleanup of Boston Harbor and the Central Artery (i.e., 'big dig) highway project. In the context of climate adaptation, lawsuits have not been a factor thus far in Boston, but they may very well become so as parties feel that their interests are being unfairly impacted or ignored. The threat of lawsuits certainly played prominently in the role-play simulation exercise conducted with stakeholders. In the words of one:

The litigation element is important - the transit issues here, the Boston Harbor cleanup - litigation is a very real thing here. If you look at it, the fear of litigation was a big part of killing C [option in the exercise], and the fear of the community opposing something was a big part of killing B. I think that is, I don't know if its unique to Boston, but I think it is a big part of the decision-making - very small impacted groups can have a significant impact on decision-making. Certainly you cannot say 'I think this is best for the region, it's going to get done no matter what'. B was a reasonable alternative, and community opposition basically ended B off the bat.

It is important to note that resolving interests-based disputes in the public sector does not always involve litigation, or even predominantly adversarial interactions. The exercise modeled a multi-stakeholder deliberative approach in which parties seek mutually acceptable outcomes. That is, they collaboratively seek creative outcomes that address their various interests. Some participants reflected that they have participated in similar processes in practice; collaborative planning is becoming increasingly common. The experience was new to many others, but they appreciated it and could see opportunities for similar efforts in the worlds they work in. Whether adversarial or collaborative, adaptation efforts will need to explicitly account for different interests if they are to minimize opposition and ultimately be successful. This is not necessarily an easy achievement, as the heated debates in the courts, political arena and elsewhere around if and when rebuilding should be restricted and the standards to which structures and infrastructure should be rebuilt post Hurricanes Katrina and Sandy suggest.

Resource scarcity and faith in government

Chronic underfunding is a common feature of public infrastructure in the United States. This has implications on how projects are prioritized and what is deemed possible. A common theme among the interviews conducted for this research is that it is really hard to integrate climate resiliency at the project level when proponents are already extremely

stretched for resources and are often doing the work to address an acute deficiency as quickly as possible.

Funding was a prominent issue in all four groups that played the role-play simulation exercise in Boston, while it was much less so in Singapore and Rotterdam. Participants reflected afterwards that this is unsurprising, given that it is such a prominent issue in their real world planning and decision-making. The attention to financing had implications on how they evaluated choices and the conclusions they reached - notably the universal predilection towards option D. This was seen as a 'conservative' option to maintain the status quo and adapt with as little cost as possible.

One reason for the scarcity of resources for public sector projects in one of the richest countries in the world is the relative lack of faith in the state. In both the Netherlands and Singapore, citizens entrust the government with providing high quality infrastructure and accept the commensurate taxes and fees to pay for it. In the United States, on average, trust in government is lower, and government revenues and expenditures on infrastructure are also lower. It seems probable that this will have significant implications on the ability of agencies to adequately prepare for the impacts of climate change.

Politics and leadership

'Leadership' is a theme across all three cities. However, it means different things in each case. In Singapore, leadership is the top-down definition of priorities, typically in a technocratic sense. In Boston, leadership at its best is typified as bold political action to take a long-range perspective, despite the fact that it may not be easy. Participants opined that this is unfortunately uncommon: "Even if you had a process to decide what gets rebuilt and what gets invested in, you are always going to have a political aspect to it. People that say 'no, we invested in East Boston and you cannot abandon us'."

Inside and among agencies, resource scarcity, conservative professional cultures and fear of deviating from the status quo dictate that leadership on issues like climate adaptation must, for better or worse, often come from above. Numerous interviewees said things like: "We rely on enough of a push coming from above [our colleagues] to move them off the dime, to say 'you have to listen to this, you have to take this seriously' that we have an opportunity to come in and work with the key decision makers". However, inter- and intra-agency leadership does not always manifest by force. It can also result from having strong networks, being persuasive and exuding political clout. Some interviewees cited now former Boston Chief of Environment and Open Space as an example:

He is a real champion and had some political clout as well. Things start to bubble up and he hears about them and eventually is able to articulately make his case, especially through doing good work and getting attention for doing that. [...] Even though they may have a small budget, [his office is] extraordinarily productive. I think they have been strategic about the initiatives that they proceed with. They also have a climate action plan so they are thinking strategically and proactively engage agencies like the Boston Redevelopment Authority and the Boston Transportation Department,

because they know that the BRA is unlikely to come to them, so they raise these issues and also like I said he has some political clout, so having that and exercising it.

While leadership matters, interviewees also emphasized the importance of background work done by mid and lower-level staff to prepare for the emergence of issues like climate resilience before they arrive on the policy agenda. “I do think that sometimes in order to have momentum you need to have these stealth, independent organic initiatives that happen, and they themselves generate their own momentum in interest, and then at a certain point there is a tipping point, and people become interested, and then a certain point you have so many of them that there needs to be an organizing mechanism”, said an interviewee. Less formal ‘background initiatives’ can facilitate information sharing and network development so that the scaffolding is in place when issues emerge.

Politically, priorities – including the relative prominence of climate adaptation – change with administrations. Both the City of Boston and Commonwealth of Massachusetts have gone through administration changes in recent months, throwing efforts into flux as senior staff members are replaced and priorities reset.

Uncertainty and its management

As in Singapore and Rotterdam, participants see uncertainty as a pervasive factor in their governance and decision-making. To some, climate uncertainty is nothing more than an excuse for inaction. For others, it is a factor insofar as agencies are providing ranges of possible futures when engineers and decision-makers are used to working with unitary, if still imperfect, forecasts and design standards. They are unsure of how to proceed and feel bounded by professional norms, client expectations, and the fear of lawsuits or other blowback. In general, participants reflected that uncertainty is a product of many factors, including resource constraints, and competing interests and priorities.

Participants widely favor ‘flexibility’ as the best way to proceed in the face of uncertainty. However, some cautioned that flexibility can end up devolving into a reactive, wait-and-see approach that leaves the region unprepared. Furthermore, there are substantial barriers to institutionalizing flexibility, including the aforementioned piecemeal nature of planning and decision-making. Project design and funding processes are typically linear in nature, leaving little room for ongoing learning and adaptation. Here too, professional norms typically dictate that engineers and other technical experts ‘get it right’ the first time; according to interviewees, they are reticent to put their stamp on something that is ‘good enough’ for the time being and expected to change in an iterative fashion.

‘Consult experts’ was also a popular option for responding to uncertainty. Again here, participants expressed a strong preference for getting ‘the science’ and ‘the technical expertise’ to make sure that they are responding properly. According to interviewees, many would prefer to know that they are meeting the standard, no matter how imperfect it might be, rather than being left to handle uncertainty.

Scenarios vs. risk assessment

A key component of this research project is examining if and how different tools for framing uncertainty influence the ways in which stakeholders deliberate and the conclusions they reach (or fail to reach). To this end, participants in the exercise were divided into two groups, with each playing a different version – one version included a risk assessment forecast while the other contained four different scenarios (i.e., possible futures). The differences among groups that played these two versions are discussed in greater detail in the cross-case comparative chapter of this dissertation.

A common theme across the three cities is that the scenarios groups largely ignored them, implicitly or explicitly defaulting to the ‘worst case scenario’. The one exception was the second scenarios group in Boston, which methodically considered each infrastructure option against each scenario. However, when it came time to make a decision the chair suggested that they should decide which scenario they should be designing for, which led them to plan for the worst case scenario and put the other possible futures aside.

Despite the marginalization of the scenarios, there were notable differences when compared to the risk assessment groups. Most clearly, both scenarios groups failed to reach agreement within the time allotted while both risk assessment groups did. During the debrief conversation, participants reflected that, even when not explicitly acknowledged, the scenarios provided license to accept the notion that the future is very uncertain. In contrast, the risk assessment version forced participants to either accept or reject a forecast of future conditions. This may represent a tradeoff – risk assessment forecasts simplify decision-making insofar as they provide a unitary set of parameters to which infrastructure planning and design can respond. On the other hand, such assessments make assumptions that may be grossly incorrect. Scenarios acknowledge these uncertainties, but in turn do not provide those involved in infrastructure design and planning with concrete, fixed design parameters to work with as they execute. To engineers accustomed to building to clearly delineated and more or less constant standards, this is disconcerting.

Learning from the workshop

In the spirit of participatory action research, the workshops were designed to provide benefit to the participants, in addition to the research insights gleaned. As in Singapore and Rotterdam, participants overwhelmingly reported that they learned from the experience. The lessons learned were largely process-related. Participants learned the value of perspective taking and exploring the interests and priorities of others. More technically oriented participants reported that it was valuable to see why the politics matters too. The workshop modeled a multi-stakeholder, collaborative approach to decision-making. Many participants reflected that this was interesting and appealing to them, and that this kind of effort may be valuable in their own contexts as they grapple with emerging issues, like how to adapt to climate change. More specifically, they learned how these processes can be more or less effective, including the value of getting interests on the table and of having good facilitation.

**Institutionalizing Uncertainty:
Exploring how infrastructure stakeholders can
prepare for uncertain climate futures**

Chapter 5 – Research Findings: Recurring themes and comparative analysis

Introduction

This dissertation research project is examining how infrastructure managers and other stakeholders are grappling with the complex and uncertain risks climate change poses as they plan and make decisions. As discussed in the methods section of the first chapter, it explores what their adaptation processes have looked like so far, and how they might evolve as this still nascent issue gains further traction. The research process involved: Semi-structured interviews with numerous stakeholders both within and outside government; running a role-play simulation (RPS) exercise with many stakeholders, recording and analyzing the processes and results; post-exercise debriefings; pre- and post-exercise surveys; and extensive background research. These interventions were made in three case cities – Rotterdam, Singapore and Boston. These cities were chosen because they are archetypal of three very different governance regimes – neo-corporatist; semi-authoritarian; and neopluralist respectively. Two different versions of the RPS exercise were run with similarly constituted groups of participants in each city – one with a probabilistic risk assessment and the other with four scenarios (i.e., multiple possible futures). This was done to explore the implications of these different ways of framing uncertainty on project-level planning.

This chapter outlines the research findings, looking across the three cases. It is broken into three sections: Some general findings that transcend the cases and RPS versions; comparative analysis of what happened and how participants reflected on the scenarios versus risk assessment versions of the exercise; and cross-case (i.e., city/region) comparisons. In the broadest sense, the key takeaway from this research is that climate adaptation is not simply a technical optimization problem. Effective means of managing complex and uncertain data are important, but adaptation is also a deliberative process among agencies, different levels of government, and external stakeholders with different interests, priorities and perspectives. Adaptation efforts, and associated attempts to advance adaptive policymaking, often fall short in recognizing the importance of and supporting effective deliberation.

More specifically, the key research findings are:

- *Uncertainty* – Uncertainty is a pervasive factor in planning and decision-making, and not exclusively because of climactic (i.e., scientific) uncertainty. In fact, even in the domain of climate adaptation, the uncertainties around governance questions - like

who is going to take responsibility for implementing adaptive measures and when – are at least as substantial as the model uncertainties.

- *Flexibility* – Maintaining flexibility is widely seen as an effective way to make decisions now while leaving room for alterations later to accommodate changing conditions and/or new information. Flexibility can be both a design feature, and an approach to planning and policy-making. Unfortunately, institutionalizing flexibility is challenging, particularly in traditionally linear planning processes in which responsibility is fragmented.
- *Multiple scenarios* - Stakeholders almost universally like the idea of considering multiple possible futures in their planning and decision-making, but struggle with how to use them in practice, particularly at the project level. Scenarios accentuate uncertainty for better *and* worse. They encourage users to consider the implications of an uncertain future but do not provide the single design standards or conditions that technicians and decision-makers are used to planning for.
- *Deliberation* – Adaptation planning efforts are deliberative processes that benefit substantially from good process design, and suffer when process is ignored.
- *Governance regimes* – Nascent efforts to tackle ‘wicked problems’ like climate change – including via the integration of more flexible approaches - must be sensitive to wider governance norms. The institutional environments within which adaptation planning efforts are evolving shape both what is happening in practice, and what is possible.

General findings: Adaptation as a governance challenge

The differences across cases and between the scenarios and risk assessment versions of the RPS exercise are examined later in this chapter. However, the similarities that emerged across the three cases are just as, if not more, informative. They suggest that there are important characteristics of climate adaptation, particularly as a governance challenge, that are relatively consistent across coastal cities as they grapple with how to integrate climate adaptation into their infrastructure planning and decision-making. These include: The pervasive nature of uncertainty; the popularity of, but challenges associated with, taking more flexible approaches; and the widely recognized value of collaborative, multi-stakeholder approaches to planning. Each of these is discussed in this section.

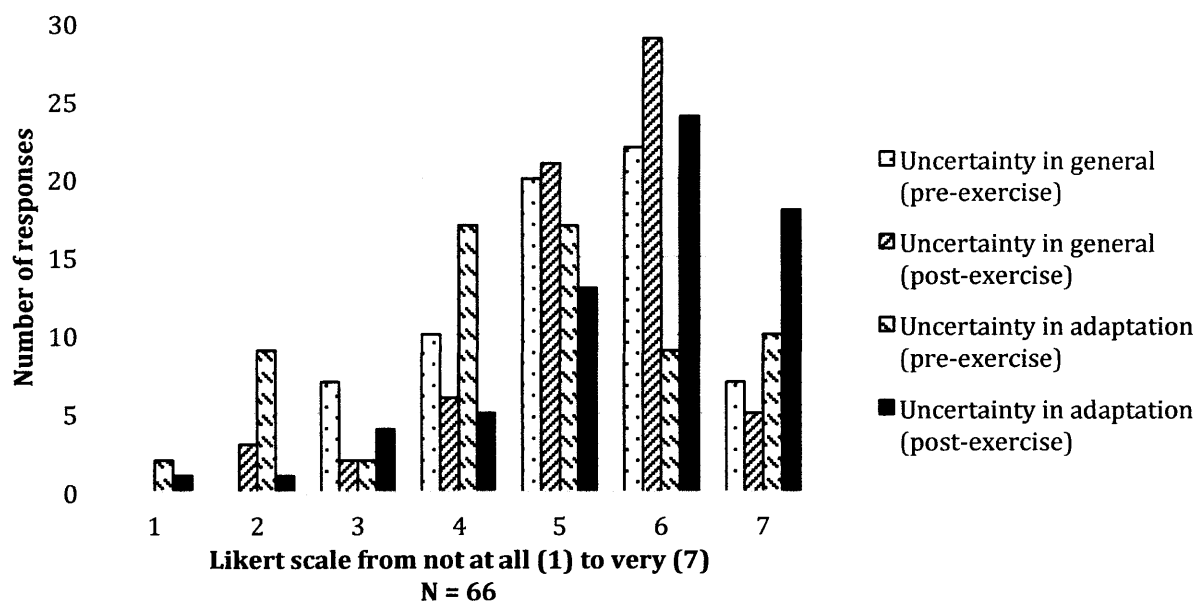
Pervasive uncertainty

Uncertainty is a pervasive factor in decision-making, and certainly not exclusive to climate change. Climate adaptation may involve a greater degree of uncertainty, but this is just as often a product of unclear institutional arrangements and unanswered policy questions as it is scientific uncertainty. Substantial questions remain, including: Which climate models should be used and when; what standards infrastructure should be protected to (i.e., what

level of risk is tolerable); what actions should be taken, and when; and who should be responsible for the various tasks involved.

Workshop participants in all three cities were asked both before and after the exercise two questions around uncertainty as a factor in their planning and decision-making: How much of a factor it is in general, and how much it is in their organizations' climate adaptation efforts. As *figure 5.1* illustrates, workshop participants engaged in this research project reflected that uncertainty is a factor throughout their planning and decision-making, and not simply when it comes to climate adaptation.¹ Post-exercise, equal proportions of participants (83%) selected five or above on a 7-point Likert scale from 'not at all' at 1 to 'very' at 7 for both questions.² In the words, of a participant in the Netherlands: "[There] are so many things, like how much is the population going to grow, how much is car use going to develop, what is the economic development going to be - there are so many interests that you have to deal with [...] so this climate change is just one aspect of a very, very wide range of aspects that you have to value, that you have to judge as a politician".

Figure 5.1 – The uncertainty factor as participants plan and make decisions



Notably, there was a statistically significant increase in how much of a factor participants felt uncertainty is in the context of climate adaptation from before to after the exercise (see *table 5.1*).³ There were statistically significant increases in all three cities, not just in

¹ Unless stated otherwise, results throughout this section are aggregated from across the three case cities. City-specific figures are provided in their respective chapters. In this case, the pattern is largely the same across the three cities.

² As can be seen in *figure 5.1*, uncertainty in the adaptation context does skew higher at the upper end of the scale in the post-exercise survey, with 27% selecting '7' versus only 8% for uncertainty in general.

³ There was not a statistically significant change in participants' perceptions of 'uncertainty in general' as factor from before to after the exercise (Wilcoxon's test; $p=0.10$; $N=39$, $T=314.5$; two-tailed hypothesis).

aggregate. This suggests that the workshops, on average, increased participants' perceptions of uncertainty as a factor in adaptation planning, supporting hypothesis 4B introduced in the first chapter. This finding may have implications as stakeholders increasingly engage in adaptation planning efforts; matters may not be as straightforward as they perceive them to be a priori.

Table 5.1 – Hypothesis test: Uncertainty factor in climate adaptation

H₁: Two-tailed hypothesis that exercise participation will shift respondents' opinions on how much of a factor uncertainty is in climate change adaptation

Survey question: To what degree is uncertainty a factor in how your organization views and plans for climate change adaptation (1 being not at all and 7 being very)?

Test: Wilcoxon matched pairs signed ranks

Conclusion: The results were **significant** at the $p=0.01$ level, using Wilcoxon's test ($N=47$, $T=193$; two-tailed hypothesis). Therefore, the null hypothesis can be rejected and it is concluded that, on average, participants' opinions on how much of a factor uncertainty is in climate change adaptation planning and decision-making increased from before to after the exercise

The exercise debrief conversations and follow-up interviews provided opportunities to delve deeper into the nature and significance of the uncertainties infrastructure stakeholders face, particularly as they start to grapple with climate change.

Opinions varied on how significant of a factor climatic uncertainties are. To some, they represent a significant barrier to decision making. "This is a very different ballgame! Climate change has so much uncertainty when compared to other issues – It's a big problem", said one participant. She went on to add: "There are so many different views, even if we just talk about sea level rise, [...and] the graph has such variation, and there is too much uncertainty to really put it in a bracket. That's the whole problem with climate change". Others asserted that climate science is no more uncertain than many of the other factors considered in long-term planning and decision-making, but rather an excuse for inaction, and unjustly focused on. In the words of a participant in Boston:

I would like to suggest that uncertainty with climate change is actually quite small, and we use it as an excuse. For example, when we went through the budget numbers [in the exercise] we acted as if they were real, and I'll just remind you how the budget of the big dig changed, and then tell me that the uncertainty in climate projections is large, compared with the uncertainty in that. And the uncertainty in demographic projections is huge, the uncertainty in economic projections is huge, and we plan on the basis of those projections all the time. The only difference is that the climate projections come out of a community that is a scientific community were it is the culture that the uncertainty is stated up front, and therefore it has the appearance of having a lot of uncertainty. But if you actually go behind all the numbers we use all the time in planning, the uncertainty in the climate numbers is small, and when we fasten on it, it's just an excuse for not taking action.

Whether or not the climactic uncertainty is substantial, participants broadly agreed that the lack of standard models and forecasts can be problematic. Other uncertainties are

typically managed by modeling them probabilistically, deciding what risk tolerance is acceptable, formalizing those parameters as standards and designing to them. In the words of a participant coming from a policy position within government:

In the [infrastructure planning] process, for example, you always have a lot of uncertainties; what is going to happen in the future is by definition uncertain. But what you do is agree on the level of investigation that you will do, and on what subjects, so you at least have that set of information to make your choice. [...] And this set of information that you generate, to the extent of how far you investigate all the possible new developments that are coming at you, is something that is agreed upon, and also something that is rather formalized in all kinds of manuals and things like that, in guidelines. So, you try to more or less make the same basis for every comparable infrastructure investment that you make. Of course all of those investments have to deal with this uncertainty, but the amount of uncertainty that you accept and the way that you look at them is something that you try to harmonize over the different projects.

Infrastructure agencies comply with norms, do their best to get their forecasts right, and ultimately satisfice. Standards are set across projects, and analysis is done on the basis of these standards and provided to decision-makers, which use that information to make decisions based on the suite of factors before them, both technical and political. Reality will inevitably be different, but the outcomes are accepted as satisfactory.

In line with hypothesis 2B in the first chapter, participants with technical positions, including both agency staff and external consultants, emphasized that it can be uncomfortable to not have a single set of design conditions; it is essentially asking them to make decisions around what threshold to meet and how much risk is tolerable. According to interviewees, not having 'rules' makes it harder and less compelling to act. In some cases, agencies have simply chosen climate projections as design conditions to build to, with the knowledge that they may not be sufficient. For example, the Massachusetts Water Resource Authority now assumes 2.5 feet of sea level rise in their 100-year storm models, and is using that benchmark as they renovate and shore up infrastructure. In the Netherlands, the Second Delta Committee suggested that up to 1.3 meters (4 feet) by 2100 and 4 meters (13 feet) by 2200 be taken into account in long-term planning and decision-making around the country's coastal defenses. The risk is that these projections are far off base and agencies either over build, wasting resources, or under build and are unprepared. As discussed in more detail in the next subsection, flexibility in planning and design may allow agencies to be responsive as conditions change.

According to participants, many of the uncertainties associated with adaptation are actually unrelated to climate data, but are really governance challenges exacerbated in unclear institutional environments grappling with how to integrate this new factor into planning and decision-making. The allocation of responsibility and presence of competing interests and priorities are key issues. They emerged even in Singapore, which, as discussed further later in this chapter, typically has the greatest degree of integration across agencies. "Before the game, I didn't think [uncertainty] was really that much of a

problem because it was coming from my own point of view, and after the game, after interacting with the different people who have different agendas, different priorities, I realized how, when those come together, the uncertainty can increase”, said a participant..

Uncertainty – both technically and as a governance challenge - was certainly a factor in the RPS exercise runs in all three cities. It was used as an excuse to discount the risks associated with climate change vis-à-vis other factors. For example, when arguing for option A, which may be considered the most vulnerable to climate change, one participant said: “The downside is the risk of flooding due to climate change in the next 20 years, but uncertainty about this is big”. Another participant arguing for A questioned opposition to this proposal by stating that: “Creating a trench [i.e., putting the road below grade] is convenient, especially near a neighborhood, and just because of one uncertainty we should choose a very disturbing [alternative] solution?” In opposition to an option that might be deemed more climate-proof, the Alderman’s representative in a run said: “Option B [the elevated road] is unacceptable for the municipality [...]. For years we have tried to minimize the effects of roads on local citizens, and now we would change that completely for one uncertainty?!” These comments underscore the notion that uncertainty is a problem not only in a technical sense, but also insofar as it can be used as an excuse to discount risks. Uncertainty around climate change was a factor because it provided a convenient argument; decisions need to be made between competing priorities, and parties see certain activities proposed to address climate change as counter to their interests, so discount their necessity by invoking uncertainty.

Uncertainty was also a reason for delaying action, as parties asserted that they needed better information before they could make decisions. In the case of a run in Rotterdam, the Flood Protection Specialist expressed her unwillingness to accept any option without “a very clear risk analysis of the pro's and con's of options A and B on traffic and climate robustness [and...] how extra measures for option A truly effect the availability of the road concerning all uncertainties, both climate and traffic”. She ultimately called for more research. It is not clear if parties were genuinely arguing for a delay in decision-making because of uncertainty, or simply using uncertainty as an excuse because a delay was in their interest; their comments would suggest a little of both. “It was too attractive for some people to say 'let's do more research' instead of making a decision right now”, said a participant during an exercise debriefing.

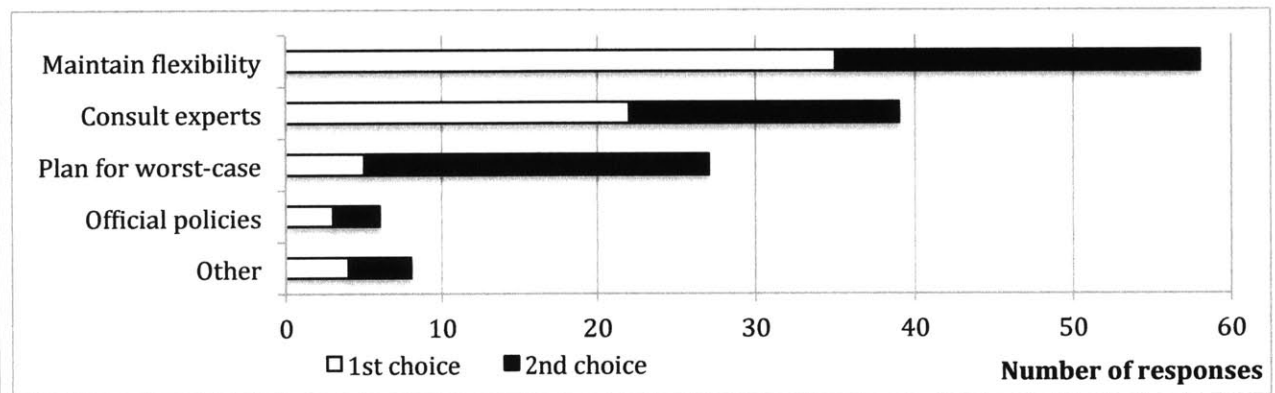
Reflecting on why other interests won out in the end from her perspective, one participant said: “I had the impression that the uncertainties in climate change are enormous. That the old arguments [e.g. projected traffic growth] are true, and there is no room for discussing [them], we had no debates on those arguments whatsoever, while on climate change it was ‘OK, that's were we should debate’”. To some degree the exercise was structured to invoke this dynamic, but participants largely agreed that this is realistic, and perhaps a key reason why climate change is not a more important factor in decision-making. Adapting to climate change is not (yet) well entrenched as a variable to be accounted for in planning and decision-making, especially vis-à-vis the very well established factors, like efficient mobility and air quality. Framed through a lens of punctuated equilibrium (Baumgartner and Jones, 2009), the systemic shocks are not yet sufficient to facilitate a shift from the status quo.

Managing uncertainty: Flexibility

Flexibility is widely regarded as an appropriate way to proceed in the face of uncertainty, but can mean different things. To many, it means leaving policies and plans flexible to changing conditions, while to others it is a matter of engineering and design. Whether a matter of engineering or policy, maintaining flexibility faces substantial institutional challenges in a world accustomed to largely linear planning and decision-making.

Participants in this research project were asked both how they and their agencies currently deal with uncertainties and, post exercise, to rank in order of preference how they think they should deal with uncertainties. Across the three cities, 24 participants (37%) indicated that the primary way in which they deal with uncertainties is by 'consulting experts'; 21 (32%) said by 'maintaining flexibility'; 10 (15%) by 'planning for the worst-case scenario'; 8 (12%) by 'following official policies and guidelines'; and 2 (3%) by 'other' means. These proportions were roughly consistent across the three case cities, with the exception that 'plan for the worst-case scenario' was notably higher in Singapore at 24% (versus 7% in the Netherlands and 9% in Boston). As *figure 5.2* indicates, participants see 'maintaining flexibility' as the best way to proceed with planning and decision-making despite persistent uncertainties. Again, this pattern was largely the same across the three cities, with the exception that 'consult experts' was more popular as a first choice (41% of respondents) in Boston than in Rotterdam (31%) or Singapore (22%). Nonetheless, 'maintain flexibility' was the most popular option in all three cities, at 56%, 48% and 41% as a first choice in Singapore, Boston and Rotterdam respectively.

Figure 5.2 - Preference ranking of how agencies should deal with uncertainties (1st and 2nd choices of respondents)



Participants' comments underscored this preference for flexible approaches, particularly in situations with high degrees of uncertainty. "[We need to] learn to live with uncertainties, and think adaptively", said a participant in the Netherlands, adding that we need to "think in scenarios and make the solution that can be no-regrets, that can be adapted for each scenario". Another participant argued that we should go beyond scenarios to truly embrace uncertainty, and consider how we can be "completely agile or adaptive".

Participants framed flexibility as a design principle *and* an approach to planning. During one-on-one interviews, participants described how flexibility might be built into road projects. One provided an example of making tunnels and bridges wider so that they can more easily accommodate the addition of lanes later, as it is much harder to widen these elements than it is the rest of the road. Dynamic road pricing in Singapore is an example of flexibility in near real-time to respond to changing traffic conditions. The Maasvlakte 2 expansion to the Port of Rotterdam was cited as an example of a major infrastructure project with flexibility as a core principle in its design and ongoing development. Given the significant uncertainties around how the demands on and uses of the port will evolve over the long lifetime of the project, the overarching scheme and infrastructure systems are designed to accommodate various uses as firms develop their respective quays (Taneja et al., 2010). In response to climate uncertainties, the base level of the Maasvlakte 2 was slightly elevated, but the roads and other infrastructure networks were elevated even higher; it is easy to construct the quay walls and harbor side infrastructure higher as the climate changes and the various areas are built-out, but harder to adjust the infrastructure networks later. As the quays are developed, the degree of ongoing flexibility versus robustness will vary depending on the permitted use - container terminals may be build lower for now, but with the ability to elevate them later, while the risk assessments for chemical industries may dictate that they are more robust and thus elevated higher during initial construction. Strategic flexibility in the port is being supported via various decision-support tools, including the use of scenarios, risk analysis, trend break analysis, and simulation gaming (Taneja et al., 2010).

Flexibility was a feature in many of the exercise runs. As discussed later in this chapter, it was particularly prevalent among the scenarios groups, although certainly not exclusively. Most participants in the risk assessment version of the exercise in Rotterdam were ready to accept an option that involved building the road below grade (option A), but with extra space so that additional pumping capacity could be added later if necessary as conditions change. While choosing this below-grade option could be considered the least climate-sensitive, participants asserted in the exercise debrief that, to the contrary, they identified a half-billion dollars that could be used to mitigate climate risks if and when it proves necessary. “In that sense, it wasn't the old fashioned way of doing business. [The risks were] really brought to the table, and someone said 'OK' [to the possible future investments]”, said a participant, adding that this commitment to adapt when necessary was made easier “because you are not certain that you are going to have to spend the money”. The risk is that flexibility can be an excuse for pushing decisions into the future, and then the technical options and resources to implement them are not there when the time comes. To their credit, this group addressed these risks head-on. Technically, the Transportation Agency engineer said that they would incorporate the possibility of additional pumping infrastructure in the future into their designs now. The environmentalist added that they could “include the drainage pipes in the road now and wait with buying the pumps”. Financially, the chair insisted that someone make the commitment to funding now, asserting that “it doesn't really matter if we have to pay now or in the future, we have to make the budget agreements now”. The City (and possibly port) acquiesced and made this commitment.

Participants in both of the scenarios groups in Singapore took an adaptive approach, choosing to invest in improving the current road and cargo rail service now to enhance capacity and provide some additional robustness to climate risks, while committing to monitoring traffic conditions over time and making further investments as necessary ('D+' options). Both groups identified enhanced passenger rail service as an additional investment that could be made in the future to further enhance capacity if necessary. One of the groups also identified dynamic road pricing as a way to flexibility attenuate mobility pressures, should the initial investments prove insufficient. The other group emphasized that they would want to keep the option of building a new road in the future open, in case it should become necessary. In that case, flexibility was in part a way to acquiesce concerns: "It was a way to convince the Port Authority [representative], who wasn't quite sure of the opportunity costs of the economic activities foregone [with this proposal], so we had that [new road option left open] for further feasibility studies", said a participant.

In Boston, all four groups either chose or were leaning towards 'D+' options involving expanding and increasing the flood protection of the existing road, plus adding extra capacity by renovating freight and/or passenger rail in phases. Participants reflected afterwards that this might be considered the most flexible approach, as it involves moving ahead conservatively, making relatively modest investments now to shore up existing vulnerabilities and meet current transportation demand, while leaving various options open as conditions change. They reflected that this approach has both positive and negative features. It allows for responsiveness as conditions change and learning occurs, and recognizes that planning for the 'worst case scenario' can never capture all possible eventualities. However, taking a 'wait and see' approach may leave infrastructure systems unprepared when extreme events do occur. For better or worse, participants saw it as reflective of the realities of decision-making in the U.S. context, in which resources are extremely scarce so infrastructure management often involves making shorter-term decisions to satisfy, with the knowledge that further investments will likely be needed as the situation evolves. The challenge is to put some intentionality into this responsiveness, moving from an ad hoc reactive approach to a strategically flexible approach.

Adaptive approaches inherently involve delaying action until a 'signpost' or a 'tipping point' is reached – that is, until a threshold at which the system is deemed vulnerable or no longer optimized, and thus in need of some corrective action or change of course (van der Vlist, Ligthart and Zandvoort, 2015; Walker, Haasnoot and Kwakkel, 2013). Ideally, there is ample warning and thus time to take any necessary measures as a threshold is approached, but in practice the time it takes to devise and implement said measures may be problematic, as the threshold is passed and the system moves into potentially dangerous territory. Even adaptive systems are not agile in real-time, particularly given the real-world practicalities of making decisions, finding resources and getting work done.

Barriers to flexibility in practice

The examples above notwithstanding, stakeholders engaged in this research project identified various barriers to taking more flexible approaches in practice, particularly if flexibility is to become a norm that permeates infrastructure management. A paradigm

shift from a 'predict and act' to a 'monitor and adapt' approach to infrastructure planning is no simple task. Adaptive approaches value agility over robustness. Rather than devoting the resources to building out infrastructure that can handle the preconceived 'worst-case scenario', or another single benchmark or estimate of the future, the emphasis is on leaving options open and keeping the resources available to implement changes as they become necessary. A participant in the Netherlands put it bluntly, saying: "Design becomes less important - you can make a stupid design as long as you make sure that you monitor everything as you go along". The participant went on to observe that "this is a completely different view [...], were systems are not designed with a deterministic future in mind, but with a completely uncertain future in mind and the control room capabilities [...] to monitor where things are going and be able to adapt". A fundamental question is whether or not planners, decision-makers, and other stakeholders are able and willing to accept less robust infrastructure today with the understanding that adaptive measures will take place as necessary down the road. Actors are often risk-adverse and enjoy a sense of satisfaction when an infrastructure project is 'done'. If adaptive approaches are to succeed, agility may need to be framed as more 'resilient', as opposed to risky; actors sold on the benefits of viewing infrastructure projects as ongoing and iterative, rather than emphasizing their completion as the goal; and institutional arrangements shifted to accommodate these changes. Participants recognized the monumentality of such a paradigm shift - "[Is it] realistic to expect a paradigm shift like this; how do you do it?" asked one.

Adaptive approaches must be squared with the web of laws and regulations that bound planning and decision-making processes, and typically reflect the 'predict and act' paradigm. The hurdles are many: Decision-making and regulatory control is fragmented across agencies and levels of government; at each step, agencies rely upon internal methods of analysis and data collection, and are reticent to involve other stakeholders until late in the process; the incentives discourage the monitoring and evaluation of decisions previously made; and adaptive capacity is minimal (Camacho, 2009). Unfortunately, these barriers to flexibility are often encouraged by regulations, rather than occurring in spite of them. Regulations are also typically difficult and slow to change. "Detailed [standards] are fixed in law, [and] it takes a long time to change them", said a participant. From air quality to design standards, regulations typically stipulate explicit minimum requirements or thresholds because they provide concrete benchmarks against which activities can be measured. Adaptive approaches may call for flexibility in these standards to allow for more contextually efficient and effective responses, rather than the application of 'one size fits all' solutions. A Harboring Uncertainty participant provided an example of this around the regulation of turbidity caused by dredging in the Port of Rotterdam. The government wanted a concrete limit set. Instead, the Port proposed monitoring to assess the turbidity and its consequences in situ, and then responsive decision making without defining a limit. "It was a matter of trust in each other, based on the monitoring; [...] you were controlling without setting hard limits", said the participant. This flexibility may offer advantages, but comes with the risk that environmental quality and other values will suffer when metrics are removed and actors are able to negotiate their standards. It is also a departure from the traditional fixed standards-based regulatory approach.

Another hurdle is fragmentation among agencies and other actors. Flexible approaches will often involve actions that straddle boundaries of responsibility, requiring substantial coordination. By their nature, they also involve ongoing engagement. Traditionally, different actors are responsible for different parts of the system, and for initial construction versus maintenance. These divisions delimit areas of competence and responsibility, and are not always easily worked across. Projects go through more or less linear steps from initial planning, through project proposal and budgeting, design, permitting and negotiation, to construction, involving various actors. For example, a new highway in the United States may be proposed by a state department of transportation, based on internal demand models and/or external political pressures; go through a metropolitan planning organization (MPO) process for coordinated regional planning and approval; involve private engineering firms for evaluation and design work; receive funding from the Federal Highway Administration (FHWA); require permitting from both federal and state environment agencies and other authorities; and ultimately be constructed by private contractors chosen through a competitive bidding process. Later, maintenance will typically involve a variety of actors, some of whom are the same as those involved in capital planning and construction and some that are completely different. A flexible approach requires tighter integration among those responsible for the various steps of design, funding, project review, construction, and maintenance. On a related note, actors must take responsibility for ongoing monitoring. The 'control room' monitoring functions must be strong, if adaptations are going to be timely and effective. "At any given time, situational awareness is a precondition – [you must] know where you are, and what your circumstances are", reflected an interviewee. This requires resources and staff competencies.

Complicating matters further, the different pathways that adaptive infrastructure may follow as conditions evolve might involve the introduction of new actors and regulations. For example, a potentially vulnerable coastal road might initially be constructed with flood resistant materials; be adapted with enhanced drainage capacity when flooding intensifies and a tipping point is reached; and then require the construction of protective berms when flooding becomes even more pronounced. The initial material requirements are relatively easily stipulated in the 'request for proposals' for construction. Enhancing the drainage capacity is likely to invoke additional permitting under regulations like the Clean Water Act (in the United States), and is probably more easily done if the potential need was considered during the initial design and construction. Nonetheless, it is still within the domain of a transportation agency. New protective berms will likely require further environmental and water management permitting, and invoke questions of responsibility – is a berm the responsibility of the transportation agency, or the agency (or agencies) with purview over flood control and/or coastal zone management? Different pathways will require that different actors be at the table and on board. Truly flexible approaches may require coordination with actors that have no role with the initial project, but that would be called upon if certain adaptive measures were initiated down the road. It raises new questions around who is responsible, and thus must be engaged.

Flexible approaches may be more economically efficient over time, but decision-makers need to be convinced of the value. According to participants, the approach a decision-

maker takes will depend on the (real or perceived) relative costs and benefits. “If we can work in climate change when we make a project, and it is cheaper, we will do it then; when it is cheaper to be flexible, then we will be flexible; and when it is cheaper to see what happens and react in the future, then we will do that – Money is the basic parameter for making these kinds of choices”, said a participant. Comparing the costs and benefits of different approaches is, however, difficult when potential future adaptation measures are typically less elaborated and costs will change over time. In general, estimating potential future costs in an adaptive system may be challenging, but nonetheless expected by decision-makers. “The decision-maker needs to know, wants to know, what is the cost of the extras if we are going to [implement them] in five or ten years”, said one participant. Financing adaptive approaches also involves challenges related to the questions of responsibility outlined in the last section: Will the funding be available if and when tipping points are reached, and who should be funding adaptive measures when the agency with primary responsibility may change, depending on the pathways followed.

Infrastructure projects are typically financed through capital planning processes that involve the one-time allocation of funds (Quay, 2010). In the United States, these funds often come, at least in part, from a different level or arm of government. For highways, the FHWA is a major source of money. Typically these funds need to be spent within a certain window of time, and come with explicit conditions that need to be met. Adaptive approaches may require less initial capital outlay, but funding if and when tipping points are reached and adaptive measures required. The question is, can managers count on the support being there when needed? As a practical matter, should funders like the FHWA allocate more than is needed for initial construction, and allow recipients to bank some for later adaptive measures? Or, develop funding mechanisms explicitly for adaptive measures? How much should be allocated, given the uncertainties around what will be necessary and how much it will cost? Interviewees reflected unequivocally that current funding mechanisms are not designed to accommodate ongoing, adaptive approaches. Furthermore, the availability of funds and relative priority of different infrastructures fluctuates over time based on the economy, political dynamics, and other factors, making delaying investments risky when the money is on the table.

It is notable that it may be easier to inject flexibility into some infrastructure systems than others. Agencies in systems with less fragmentation of responsibility, dependence on external financing, and/or regulatory oversight can make decisions with greater independence, and thus act more nimbly. Participants reflected that this may explain why flexible approaches have gained traction in some sectors more than others. The Boston Water and Sewer Commission and the Massachusetts Water Resources Authority are two agencies in the Boston area at the forefront of taking concrete adaptive measures; while both depend on external actors, including each other, they have relatively stable funding streams (water and sewer charges), and relatively autonomous infrastructure networks. As discussed above, the Port of Rotterdam has been a leader in experimenting with more flexible approaches; it is a state-owned but independently operated corporation with a strong funding stream and relative autonomy over its planning and decision-making. None of these organizations operate in a vacuum, but they are relatively less dependent on other actors compared to other infrastructure systems, like land transportation, that are often

extremely fragmented across levels of government and different agencies, and dependent on external funding.

Adaptive approaches to making decisions are no more value free and immune from the interests of different stakeholders than are conventional approaches. Previous assessments of the adaptive management of natural resources suggest that processes can flounder when the interests of the various stakeholders are not accounted for in process design, and there are subsequently poor incentives for actors to engage (Camacho, 2009; Susskind, Camacho and Schenk, 2011). There is no reason to believe that matters would be any different in the context of infrastructure systems, nor when climate change is the driving force of uncertainty. Measham et al. (2011) identify the heterogeneity of interests among stakeholders, fact that adaptation is only one objective among many, even for proponents, and the fact that interests manifest via politics as key barriers to effective climate change adaptation. Planners and decision-makers cannot merely view uncertainty and dynamic conditions as technical problems (Birkmann et al., 2010). Flexibility can be a viable strategy within a widely supported approach to managing climate risks, but must account for the interests and perspectives of the various stakeholders.

Engineers, technicians and other professionals engaged in infrastructure planning have largely been trained, and are most experienced, within the 'predict and plan' paradigm. Participants were somewhat skeptical when asked how confident they are that they and other stakeholders will be able to manage the risks and uncertainties associated with climate change; the average response was only 4.1 on a 7-point scale from 'not at all' at 1 to 'very' at 7.⁴ When queried during the debrief sessions and follow-up interviews, deficient professional capacity was regularly cited as a reason for the lack of confidence, and lack of proficiency with planning and designing flexibility a key factor therein. An engineer from Rijkswaterstaat, the Dutch agency responsible for both transportation and water infrastructure, said: "We have to reeducate our engineers, because our engineers are educated in a linear world – things are true or not true. They learn to discuss risks, but they didn't learn to discuss uncertainty. So, that's a way of thinking that they didn't learn." Participants called this traditional approach that most engineers are trained to take 'deterministic', meaning that engineers see the systems they work within as more or less predictable, and predetermined based on a relatively understandable set of variables. Flexibility requires a substantially different perspective on how systems work, and a different skill set for managing them.

Training is only one factor in the perpetuation of deterministic norms within professions and the organizations they populate. Mechanisms of what DiMaggio and Powell (1983) call 'institutional isomorphism and collective rationality' may also be driving adherence to common norms. 'Coercive isomorphism' may be a product of the pressures put on infrastructure agencies by their political masters to provide consistent and dependable levels of service with no surprises; standards imposed by other organizations, like the conditions the FHWA imposes when funding state and local projects; and the pressures

⁴ The average was 4.1 pre- and 4.4 post-exercise across the three case cities. The differences between the cities are discussed further later in this chapter.

agencies put on the consultants that often do the design and assessment, especially in the United States. “Flexibility isn't really an option when you have to stamp something and leave your liability on it”, said an engineer that participated in Boston. DiMaggio and Powell (1983: 151) explicitly identify “uncertainty [as] a powerful force that encourages imitation”, or ‘mimetic processes’. In the uncertain environment of adapting to climate change, this would explain why similarly designed adaptation planning processes are emerging in cities around the world, despite their questionable efficacy in practice and lack of attention to local norms.

In addition to the ways in which professionals are trained and the institutional, organizational and professional norms they adhere to, another factor is the limited time and resources they have to consider new variables like ‘deep uncertainty’, and possible solutions like flexibility. Even if engineers appreciate the stochastic nature of systems and would like to act more flexibly, they do not necessarily have the time and resources to do so, and subsequently default to deterministic approaches as a way to ‘satisfice’. “[We] just have the manuals, and the standards, and follow them blindly, you don’t think, you don’t have time to think!” said a participant in the Netherlands. Participants in the United States asserted that this barrier is even more acute for them, given that they operate in environments with substantial deferred maintenance and backlog, so infrastructure projects are often ‘emergencies’ to repair or replace dangerous structures.

Actors engaged in infrastructure planning and decision-making need to appreciate the dynamic nature of their systems, and consider how they can manage them adaptively. Institutional norms need to be disrupted, creating opportunities to modify the status quo. Actors also need to see the value in and incentives to making this paradigmatic shift. That is, they need to be convinced of the ‘value of flexibility’, and feel reassured that they will not be punished for taking a new approach (de Neufville and Scholtes, 2011; Taneja, 2013).

Deliberation: Process matters

97% of workshop participants reported that they learned something from the RPS exercise they participated in.⁵ When asked *what* they learned, participants’ responses were overwhelmingly process-related. This was universal across the three case cities, and across groups, including both more technically oriented and more policy oriented participants coming both from within and outside government. The exercise invoked significant reflection around what good process might look like and its importance as groups grapple with emerging challenges like adapting to climate change.

A key theme was the importance of multi-stakeholder engagement as a means for addressing some of the aforementioned challenges associated with proceeding in the face of uncertainty. Participants were asked both before and after the exercise: *How important is it that you engage with other decision-makers and stakeholders as you plan and make decisions?* The average response across the three cities was 5.8 pre- and 6.3 post-exercise

⁵ 66 of the 68 participants that answered the question ‘Did you learn anything from the exercise that you might be able to apply to your own planning and decision-making?’ did so affirmatively.

on a 7-point Likert scale from not at all (1) to very (7). This is a statistically significant increase (see *table 5.2* below), suggesting that participation increased the already high value participants place on multi-stakeholder deliberation. The importance of broad engagement was universal across the three cities, with average responses (post-exercise) of 6.4 in Rotterdam, 6 in Singapore and 6.5 in Boston. However, as discussed in more detail in the next section of this chapter, opinions on *who* should be engaged varied across cities. In Boston, non-governmental actors are playing key roles in the region's nascent adaptation efforts and participants praised their prominence. In contrast, participants in Singapore agreed on the importance of cross-governmental collaboration, but many were weary of involving external stakeholders very extensively.

Table 5.2 – Hypothesis test: Stakeholder engagement

H₁: One-tailed hypothesis that exercise participation will increase participants' opinions on the importance of engagement

Survey question: How important is it that you engage with other decision-makers and stakeholders as you plan and make decisions (1 being not at all and 7 being very)?

Test: Wilcoxon matched pairs signed ranks

Conclusion: The results were **significant** at the $p=0.005$ level, using Wilcoxon's test ($N=43$, $T=253.5$; one-tailed hypothesis). Therefore, the null hypothesis can be rejected and it is concluded that, on average, participants' opinions of the importance of engagement increased from before to after the exercise

One reason why participants deemed multi-stakeholder engagement to be important is because it facilitates the incorporation of various interests and factors into planning and decision-making. Option C (routing the highway through a wetland) was discounted early on in most RPS exercise runs because of strongly expressed environmental concerns. In Boston, the mere threat of a lawsuit from the Environmental Impact representative was sufficient to make this option less attractive to others; agencies did not want to ignore these concerns, and potentially face substantial delays and legal costs defending their choice in court. Even in Singapore, where individual interests were downplayed, participants reflected on the value of understanding the different factors at play as they attempt to deduce what is in the 'national interest'; all four groups implicitly or explicitly identified nurturing the economy as a key national priority, and subsequently spent substantial time looking for creative ways to address the concerns expressed by the port representative.

Getting the various parties together and interests and factors on the table also allowed for creativity. For example, the flood protection specialists in most groups introduced the need to rebuild the dike on which part of the existing A3 motorway runs, and possibility of accessing additional funds if this is done as a joint project with rebuilding the highway (i.e., option D). This had tremendous sway in deliberations. In Boston, one of the regional deputy directors reflected afterwards that this was key to her becoming a proponent of a D+ option, as she saw this as an opportunity to save her agency some money while achieving their transportation goals. Others affirmed that this is realistic in a resource constrained environment in which funding is often the issue. In Rotterdam, this combined dike and road project was framed as 'work with work', which is a concept being promoted by agencies as they institutionalize adaptation. In all cases across the three cities in which

agreement was reached, or almost reached, the outcomes were framed as ‘compromises’ or ‘creative solutions’ that reconciled different interests and integrated different factors.

In line with hypothesis 4D in chapter 1, it is beneficial for participants from different sectors and backgrounds to appreciate each other’s epistemologies. In particular, participants reflected that there is value in bringing technicians, policy makers and other stakeholders together to enhance their mutual understanding of how and why each reaches certain conclusions and makes the decisions they do. Participants in both the Netherlands and Singapore reflected that it is uncommon for technical experts to be at the table in multi-stakeholder forums, but that there is benefit to be had in including them so that they can be more responsive to the needs of decision-makers, and vice versa. This is a call for enhanced and appropriate science-policy interactions, which is followed up on in the recommendations outlined in the next chapter.

Multi-stakeholder deliberation may be invaluable, but the exercise runs drove home how important good *process design and management* is to its efficacy, and the implications different process choices and *participant behaviors* can have on the trajectory and outcomes. That is, participants’ experiences affirmed hypotheses 2A and 2B. While - as discussed in the next two sections of this chapter - there were differences across the three case cities and risk assessment versus scenarios versions of the exercise, there were also features that can best be attributed to the choices of different meeting facilitators (i.e., those filling the regional deputy director of the Transportation Agency role) and other actors.

How deliberations are structured, including the schedule followed, can have significant implications. For example, the scenarios were largely ignored by all but one of the groups at least in part because they were not explicitly integrated into the agenda. The risk assessment group in Rotterdam was the only one that leaned towards an A+ (below grade road) option. This can be explained by the fact that it was presented as the default and focused on inordinately. Temporally, it was discussed first and for 23 minutes during the initial round of discussions, while the other three options were discussed for 10 to 13 minutes each. The same group ultimately failed to reach agreement because the chair stipulated that unanimous consent was required, even though not stated in his instructions. One party, the flood protection specialist, was able to hold out and block an agreement that everyone else was ready to accept.

The performance of chairs (i.e., those filling the deputy director role) varied widely, with implications on the trajectory and outcomes. While efforts were made to put participants with some experience running meetings into that role, a couple of chairs were not very confident. In one instance, in Singapore, the chair essentially stepped back from the process, allowing the group to proceed more or less organically without her involvement. As discussed below, this allowed another player (the environmentalist) to step in and dominate. In contrast, the chair of one of the Boston groups employed strong facilitation techniques – he proposed an agenda and helped the group stick to it, systematically called upon parties to make sure that all voices were heard, employed active listening techniques to confirm what parties were saying, had another participant track key variables on a

flipchart, and held straw polls at various junctures to get a sense of where the group was. Participants reflected afterwards that astute facilitation helped make the process smooth and ultimately successful in reaching agreement. Some facilitators showed more bias than others. A couple explicitly declined to express their preferences in order to remain, in their words, *neutral*. In contrast, some clearly attempted to steer the group in a certain direction. An example is the aforementioned chair in Boston that acknowledged that she wanted them to select a D+ option because it would save her agency money, and was quick to discount other options based on her perspective.

The performance of other parties also had implications. Despite the fact that non-governmental actors would rarely even be at the table in this type of deliberation in Singapore, the environmental NGO representative in one of the scenarios groups dominated both qualitatively, by driving the discussion, and quantitatively, with the highest frequency of interventions. She championed a D+ option involving enhanced rail and was able to convince other participants by making fact-based arguments that supported her cause and discredited some of the assertions of the port representative. For example, she convinced them that new technologies, like advanced traffic management systems, were rapidly evolving and could address congestion much more efficiently and effectively than building new roads. When asked during the debrief how she was able to leverage so much influence, other participants said that she was making sound, rational arguments. “Our NGO talks like a professor”, said one.

Whether or not parties representing stakeholder interest groups get their issues on the agenda and effectively fight for them can also have implications. The aldermen and women (i.e., city councilors) were generally influential in Boston, but one seemed unsure of when and how she should intercede in the fast-paced deliberations to express her concerns around the elevated road (option B) - which is the most important issue to that character - and almost neglected to voice them. In fact, her opinion only came out when the Port Authority representative directly asked her about this issue. An alderwoman in Singapore expressed her concerns, but ultimately accepted an elevated road because she was convinced that it was for the greater good of the wider populace. She reflected afterwards:

I thought the character of the individual also impacts the decision at the end, because I sort of conceded defeat, [saying] ‘Okay, yeah, I agree with you, so okay’. I know that I’m not supposed to go towards that direction, but I sort of agreed because I feel that we should think holistically. So I thought the character of that particular individual, apart from their role, also influences how things go.

In contrast, a port representative in Boston was so obstinate with her demands that she started to irritate other parties at the table, yet ultimately gained more for her constituency than her counterparts in other groups in Boston, including dedicated trucking lanes on the highway and a promise of funding from the city for ‘a fancy crane or something’.

The Port Authority representative’s querying of the alderwoman in the first (Boston) case discussed above is an example of wider attempts at coalition building by those filling that role, particularly in the Boston groups. Port representatives realized that they needed to

get other parties on board if they were to see an acceptable agreement reached and implemented quickly, which was a priority for them. In another Boston group, the port representative worked to build a relationship with the alderman, and explicitly said at one point: “So from my perspective I’m really going to have to agree with the alderman, because when this goes out for public meetings, we want the community to be happy and to not hold this up due to their issues with this going through the community”. In general, after the exercise participants reflected that there is value in working to understand and account for the interests of others. “We should have asked more questions to come to a better decision”, said a participant in Rotterdam. Another reflected that this dynamic is realistic, stating that: “I also experienced this as a real-life experience, because that’s the way we do discussions - everyone starts talking, giving up solutions [instead of listening]”.

The RPS exercise was designed to have some roles that are more clearly interests-driven – the alderperson, port representative and environmentalist – and some that are more technically oriented – the Westerberg Department of Traffic (municipality) project manager, the (national) Transportation Agency senior engineer, and the (national) flood protection specialist. However, the technically oriented characters do have interests and perspectives. Some chose to explicitly reveal their biases and preferences, while others at least ostensibly presented airs of neutrality. A senior engineer in Rotterdam that was particularly opinionated started out by declaring: “It seems clear to me that we are going for either A or B”, and later asserted: “It will cost too much time to study the rail option - We have to take action now, and two options can be 'deleted' immediately; option D doesn't match the traffic growth and option C is expensive, gets a lot of resistance and doesn't do much for congestion”. He was slow to put information he (but not others) had on the rail option on the table. His selective and strategic disclosure of information was a contributing factor to the group concluding with a call for more research. Others carried significant authority by presenting themselves as neutral and very knowledgeable resource people. A senior engineer in a Boston group was very active in putting information on the table, but presented himself as a neutral support person, even acting as a supplementary facilitator at times, saying things like: “I'm trying to hear other people's positions, as we'd like to get the project done. The budget we have could be used for a combination of things”.

Another dimension was the degree to which these experts accentuated or, conversely, downplayed any uncertainties. As discussed later in this chapter, some of this variability is attributable to the version of the exercise they played (i.e., the scenarios versus risk assessment versions), but some is also attributable to how individual participants framed the information they had. A senior engineer in Boston strongly emphasized the uncertainties around the information he was providing, making statements like: “as head of the group that was in charge of developing the cost estimates, we should be careful taking that with too much definiteness until we do our engineering designs”. This had real implications; the port representative was looking for assurances that he felt unable or unwilling to provide, which was a barrier to the group finalizing agreement.

Framing uncertainty: Scenarios versus risk assessments

One of the initial hypotheses in this project was that presenting uncertainty via multiple scenarios (i.e., multiple possible futures) can enhance adaptation planning efforts. As discussed in the first chapter, scenario planning has been proposed as a way for planners and decision-makers to assess the robustness of their proposals. The notion is that a project or policy that is vetted against a range of possible futures - presented as mutually exclusive yet plausible scenarios - will be more robust. This research suggests that there are advantages, disadvantages and significant challenges to using scenarios. They can make uncertainties more explicit, providing a more vivid and accurate sense of the range of possible futures. On the flip side, they complicate the traditional approach of choosing a single possible future as the 'design condition'. It is not clear that planners and decision-makers yet know how to proceed in practice when given scenarios.

This research project revolved around workshops in each of the three case cities during which participants engaged in a role-play simulation (RPS) exercise designed to simulate the challenges of integrating uncertain climate risks into a major transportation infrastructure project. There are two versions of the exercise, with half of the participants engaged in each – one version contains a more conventional risk assessment forecast, while the other contains four qualitative scenarios. These parallel versions were run with similar groups in each city to explore the differences in process and outcomes when uncertainty is presented to stakeholders in these different ways. These differences are discussed below.

Participants reported that scenario planning is widely used in all three countries. 86% of participants in Boston, 82% in Singapore, and 93% in Rotterdam answered 'yes' to the question: *Do you ever use multiple scenarios (i.e., consider multiple possible futures rather than a single forecast) when you have uncertain factors in your planning and decision-making?*

There are examples of scenarios being used both within and outside the context of climate adaptation in the three cases. The *Rotterdam Climate Change Adaptation Strategy* features four 'delta scenarios', which are very similar to those in the exercise run with participants. The axes of uncertainty are socio-economic growth and climate change, and the scenarios are *full* (moderate climate change and high growth), *steam* (high growth and rapid climate change), *calm* (low growth and socio-economic decline), and *hot* (rapid climate change and socio-economic decline) (Rotterdam Climate Initiative, 2013). The Rotterdam scenarios are based on the KNMI (2014) *Climate Scenarios for the Netherlands*, which feature two climate-related axes – changes in air circulation patterns and global temperature – but provide snapshots of different climate variables, including changes in precipitation and sea level rise. In Singapore, scenarios are widely used by the strategic planning and 'foresight' units within various agencies. The Centre for Strategic Futures in the Public Service Division of the Prime Minister's Office prepares high-profile national scenarios, and thematic scenarios on specific topics (Centre for Strategic Futures, 2015). In Boston, the Metropolitan Planning Organization's long-range transportation planning process is using four scenarios based on different potential investment approaches (MPO, 2015c). A FHWA-

funded initiative close to Boston called the *Interagency Transportation, Land Use, and Climate Change Cape Cod Pilot Project* engaged various stakeholders in a scenario planning exercise to consider integrated land use and transportation planning under a changing climate (Volpe Center, 2011).

Participants were positive about the value of scenarios. Participants were asked how ‘useful’ the consideration of multiple scenarios is (or might be) to their work. The average responses among those that answered ‘yes’ to the question of whether or not they have prior experience with scenarios were: 6.2 in Boston, 5.6 in Singapore, and 5.8 in Rotterdam (on a 7-point Likert scale). Participants also reflected positively on the value of scenarios during the exercise debriefings and follow-up interviews. “It was new for me, but new in a good way; good that we could see a world in which very different things could happen”, reflected a participant in Boston.

Despite these positive opinions on their value, the benefits of the scenarios in the RPS exercise runs were far from decisive. *Table 5.3* summarizes the key characteristics and outcomes for each of the ten groups, half of which played the scenarios version of the exercise and the other half the risk assessment version. Each of these runs is summarized in more detail, and more thorough analysis is provided, within the case chapters.

Table 5.3 – RPS exercise process and outcomes highlights

	Scenarios version	Risk assessment version
Rotterdam	Call for more research, but reflection that barriers were largely political. Information withheld by opinionated experts. Active chair	Leaning towards below grade road (A+). Impasse because full consensus rule invoked by chair. Strong expert opinions. Issue of ‘fairness’ around funding
Singapore	Improve existing road and freight rail service (D+). Money for port transition to rail. Active environmental and port representatives, appealing to <i>reason</i>	Elevated road with pollution mitigation measures (B+); Alderwoman convinced on “merit of the arguments”. ‘Community consultation’, but really just information provision. Active experts
Singapore	Improve existing road and freight (D+). Further study of A and B as well. Fact-based process (vs. interests). Active chair, and prominent experts	Leaning towards phased approach based on D+ option, but concerns around ability of rail to meet port’s needs. Dominant chair controlled process, and wanted full agreement (i.e., unanimity). Less information shared by experts
Boston	Call for more research, with D+ popular. Financing emphasized. Introduction of creative ‘E’ options, like alternative routes. Interests directly discussed; threat of lawsuit from enviro. Climate change ignored	Improve existing road with dedicated truck lanes, and <i>passenger</i> rail (D+). <i>If</i> money found, broader rail investments - money not on table immediately. Strong port interests. Coalition building

Boston	Tentative agreement on improving road and freight (D+), but call for more research. Possible additional road in future. Complaints of too much uncertainty, which the senior engineer emphasized. Actively considered scenarios, but assumed wet and busy in decision-making. Creativity (e/g. moving port)	Improve existing road, and freight <i>and</i> passenger rail (D+). Extra money from city, including for creative port compensation. Focus on competing interests, and threat of lawsuit from enviro. (as in all Boston groups). Negotiation tactics, including port and city sidebar. Very skilled chair
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Table 5.4 summarizes the key differences in process and outcomes, comparing and contrasting the groups that played the risk assessment versus scenarios versions of the exercise.

Table 5.4 – Comparison of the scenarios versus risk assessment versions of the exercise

	Scenarios	Risk assessment
Process	Largely <u>ignored scenarios</u> . Most groups implicitly or explicitly defaulted to the worst-case scenario (i.e., ‘wet and busy’) <p>However, <u>accentuated uncertainty</u> (e.g., scenarios groups took longer in Boston)</p>	Parties either <u>accepted</u> or <u>rejected</u> forecast, based on their interests <p>Some debate around why these forecasts should be questioned as more tenuous than others used in decision-making</p>
Outcomes	Greater <u>difficulty reaching agreement</u> . 3 of 5 groups concluded with <u>calls for more research</u> <p>Favored D+ option (chosen in two groups, two others leaning towards and still on table for fifth), which may be seen as the <u>most flexible</u></p>	Mix of outcomes: B+, two D+s, and two no agreements (one almost an A+) <p>No agreements were <u>impasses in negotiations</u>, rather than calls for more research</p>

Despite the instructions given, only one of the five groups that played the scenarios version of the exercise explicitly used the scenarios, methodically evaluating the options against each of them as part of their decision-making process. This instigated discussion on uncertainty and robustness. However, even in that case (in Boston), the chair concluded the exploratory phase of their deliberations by suggesting that they focus in on one scenario as they shift to decision-making, stating:

So now is when we craft a recommendation. [...] We talked about a lot of things, but if we had to come up with a recommendation, what do you think it should be? A, B, C or D? And what I think is important, [...] what are we planning for? What type of scenario are we planning for?

The other groups disregarded the scenarios, typically implicitly or explicitly defaulting to the worst-case scenario (i.e., ‘wet and busy’). This contradicts hypothesis 2F, which suggested that ‘new forms of discourse would emerge’ as a result of the scenarios. Participants reflected that they did not use the scenarios because they felt they needed to base their decision-making on something concrete; the worst-case scenario was believable to them, and encouraged them to be robust. Participants that use scenarios in practice characterized their real-world decision-making as more nuanced, balancing planning for

the worst-case with flexibility, risk assessment and cost-benefit analysis. As discussed in the last section, planning for the worst-case scenario is not the standard practice.

In general, participants reflected that it is difficult to make decisions using multiple scenarios. The challenges are similar to those associated with institutionalizing flexibility; planners, engineers, and decision-makers are used to working with fixed standards, not ranges or multiple possible conditions. This supports the hypothesis (2A) that engineers and technicians are uncomfortable with multiple scenarios rather than fixed standards. “If you want to look at different infrastructure solutions, you don't want to be changing the environmental assumptions”, said a participant in Boston. The importance of fixed design standards and hard criteria is a substantial barrier to the consideration of multiple scenarios and integration of flexible approaches. The qualitative and basic nature of the scenarios presented in the exercise may also have reduced their value. A participant in the Netherlands reflected that the scenarios were very ‘abstract’, requiring users to be ‘very visionary’ to understand what the implications might be. It is notable, however, that many of the scenarios being developed for climate adaptation planning – including those developed within Rotterdam’s adaptation effort – are similar in style.

While difficult to use in project-level decision-making, many participants reflected that the value of scenarios is in the *process* of scenario planning, which encourages them to think methodically and consider various potential future conditions. A participant in Singapore reflected:

I find these exercises valuable because as a process its valuable but I wouldn't use it as a prescriptive kind of thing. [...] I would question the value of these scenarios, but I would say that the process is definitely very much valuable. [...] Its scenario planning, so, you come up with different scenarios. And your certainty of those scenarios happening will never be 100% [...] after you've been through that process, you would also be evaluating the different scenarios, and you would still have to base your decision on something. So, you're making multiple decisions. So what matters to me is that, in arriving at that decision, have you gone through a vigorous process? Have you gone through a comprehensive analysis of it? Because, ultimately, even if you are presented with like say, the four scenarios, you still have to narrow it down in order to make it actionable, in order to come up with a concrete action that you can implement. So the scenarios would have been part of that process. So, for example, in the exercise, yes, we come up with the four scenarios, but then after that we ran those four scenarios into yet another set of considerations, which is 'okay, are there any down sides?' 'No, so, what we can we do?' We selected the worst-case scenario, and then we based our decision on that. So, in a way, it's sort of also part of that analytical process.

Despite the lack of emphasis on the scenarios in the RPS exercise runs, they did seem to have an impact on the process and outcomes by implicitly emphasizing the presence of uncertainty. A participant in Boston reflected in the debriefing:

I think scenario planning inevitably engages people in the discussion, and gives people a concrete understanding, whereas the risk assessment is kind of abstract numbers

that you have to take at face value, or you dispute, but the scenarios really change how people think and get them talking to each other about it. So it's more time consuming, but there is a lot more benefit that comes out of it.

Another participant added that the risk assessment group that he was a part of was tasked with dealing with the 'cold hard facts' they were given, and were 'less able to think outside the box'. Participants could either accept or question the veracity of the forecasts, but the emphasis was not on a shared sense of uncertainty and how to work through it. In general, participants reflected that there are advantages and disadvantages to the scenarios approach; it encourages broader thinking, but may make coming to a conclusion more difficult. These reflections bear out in the results – on average, the scenarios groups had a harder time reaching agreement, and concluded with more calls for research. This reflects the discomfort participants had with embracing uncertainty and finding ways to make decisions in spite of it. The agreements scenarios groups did reach – or were leaning towards when they concluded – were all variations of D+, expanding the existing roadway, climate proofing, and some mix of freight and/or passenger rail, often in phases. This could be considered the most flexible option, emphasizing the viability of flexible and adaptive planning as a way to proceed despite uncertainty. This supports the hypothesis (2C) that by fostering the recognition of multiple possible futures, scenarios guide groups towards more flexible approaches. Unfortunately, as discussed earlier in this chapter, institutionalizing flexible approaches is unlikely to be easy in practice.

These findings suggest that scenarios may be invaluable, insofar as uncertainty is a real and increasing challenge that decision-makers and other stakeholders must acknowledge and work with. However, they also underscore the real challenges facing their use in practice. It may be necessary to accept that there are multiple possible futures, but this represents a significant departure from the status quo of designing infrastructures to fixed, unitary design conditions.

Governance regimes: Cross-case comparison

This dissertation project is examining the integration of climate adaptation into infrastructure planning and decision-making in three cities selected as archetypes of three very different models of governance: Neo-corporatist Rotterdam; neopluralist and neoliberal Boston; and semi-authoritarian and technocratic Singapore. The initial hypothesis was that we would find differences across governance regimes that are currently underappreciated and unaccounted for in adaptation planning, yet are key to the development of best practices. While similarities across the case cities were identified and are equally informative, data collected through the workshops, interviews and background research largely confirms that there are unique features of governance in each of the three case cities that have implications on how the emerging issue of climate adaptation is being institutionalized. Some potential implications for planning and decision-making are discussed in the final prescriptive chapter of this dissertation. This section discusses the variability across the three cities.

Many of the differences between what happened and the outcomes reached (or not) in the different role-play simulation (RPS) exercise groups across the three cities are illustrative of the wider differences in governance regimes and their implications on adaptation planning. The exercise runs were recorded, transcribed and coded for analysis, with further insights into what happened and what it might say about planning and decision making in practice drawn from the post-exercise debriefings and one-on-one follow-up interviews. *Table 5.3* in the previous section summarized the key characteristics and outcomes for each of the ten groups.⁶ Some of these differences across exercise runs can be attributed to the particularities of each group and the individual actions of those involved. Nonetheless, interesting patterns emerge when the outcomes are compared across cities. These are summarized in *table 5.5* below.

Table 5.5 – Key takeaways from exercises, comparing countries/cities

	Rotterdam	Singapore	Boston
Process	<p>Little deference to hierarchy; very opinionated experts</p> <p>Emphasis on <u>info</u>, but <u>to support positions/interests</u></p>	<p>Invocation of <u>national priorities</u> (economy in particular)</p> <p>Appeal to ‘rationality’, and persuasion based on arguments</p>	<p>Explicit recognition of <u>interests</u>, and attention to them</p> <p>Clearest use of <u>negotiation tactics</u></p> <p><u>Financing</u> emphasized as a factor</p>
Outcomes	<p>No agreement in either case, although reason differed (research vs. impasse)</p>	<p>Emphasis on <u>avoiding hardship to port</u>, and creativity to do so</p> <p><u>Community sacrifice</u> for larger concerns (e.g., option B+)</p>	<p>D+ favorite in all groups, because <u>flexible and cost-effective today</u></p> <p>Other options discounted because of strong <u>stakeholder opposition</u> (including fear of lawsuits)</p>

The exercise runs were revealing from a research perspective and invoked reflection among participants. However, they did not provide comprehensive, nor completely accurate, insights into adaptation planning in each of the three cities. In fact, some elements – for example, the dominant role played by the environmentalist in one of the groups in Singapore – were improbable when considered against the constraints of governance in reality. Post-exercise debriefings, follow-up interviews, the surveys, and extensive desk research provided opportunities to ‘ground truth’ what happened in the exercises and gain a richer understanding of what is happening and might be possible in each country. As outlined in more detail in each of the case chapters, data collected via these various tools culminates in comprehensive pictures of how adaptation planning and decision-making is unfolding in each of the three countries/cities, and might proceed in the future. The key characteristics are laid out comparatively in *table 5.6*, and discussed below.

⁶ Each of these runs is summarized in more detail, and more thorough analysis is provided, within the respective case chapters.

Table 5.6 – Cross case comparison on adaptation and infrastructure planning

	Boston Neopluralist/neoliberal	Singapore Semi-authoritarian/technocratic	Rotterdam Neo-corporatist
Awareness of climate risks	Self-reported high degree of awareness; extensive documentation	Self-reported low degree of awareness; very little reporting of risks	Middling awareness reported
Adaptation planning efforts	Many fragmented adaptation efforts, little coordination	Highly coordinated, hierarchically organized adaptation planning	Multiple agencies and other actors, but generally well coordinated
Status of climate adaptation	Numerous assessments and guidance documents; little concrete investment in adaptation so far	Mostly evaluative so far, with some measures to enhance resilience (robust for other risks beyond climate)	Strong, proactive adaptive measures on coastal risks; less, but increasing for other infrastructure systems
Barriers to adaptation	Lack of resources; competing priorities; unclear/undefined responsibility	Lack of prioritization; uncertainty discordant	Coastal defense seen as the panacea; competing priorities
Role of interests	Adjudication and/or reconciliation of competing interests	Pursuit of 'national interests' and appeal to 'rationality'	Reconciliation of different interests (via 'poldering'); notion of 'fairness'
Roles of state and non-state actors	Non-governmental actors (both business and other advocacy orgs.) play key roles	Strong state role, with almost no involvement of non-governmental actors	Strong state role, with some non-governmental actors involved
Priorities in management	Priorities and senior leadership can shift with administrations	Extremely stable, technocratic management	Relatively consistent priorities and management; division between 'political' and 'technical'
Nature of internal deliberations	Different agencies can be at odds, requiring resolution of disputes; some policy entrepreneurship	Hierarchical governance systems, with internal debate at staff level but closed-door and not vertically	Opportunities for staff debate horizontally and vertically, within and across agencies
Response to uncertainties	Consult experts (current); flexibility and consult experts (preferred)	Flexibility, consult experts and robustness (current); flexibility (preferred)	Flexibility and consult experts (current); flexibility (preferred)

Awareness of climate risks

Participants self-reported the highest level of awareness of ‘climate change and the risks it may pose’ in Boston, compared to Singapore and Rotterdam. The average responses pre-exercise were 6 in Boston, 5 in Rotterdam, and 4.3 in Singapore, on a 7-point Likert scale from ‘not at all’ at 1 to ‘very’ at 7. Post-exercise, the average responses to the same question were 6.2, 5.4, and 4.9 respectively. In aggregate, this is a statistically significant shift from pre- to post-exercise (see *table 5.7*), supporting hypothesis 4A, which posited that participation would increase recognition of climate risks. Looking at each case separately, the shift was statistically significant in Singapore but not Boston or Rotterdam.

Table 5.7 – Hypothesis test: Awareness of climate risks

H₁: One-tailed hypothesis that exercise participation will increase participants’ awareness of climate risks

Survey question: How aware would you say you are of climate change and the risks it may pose?

Test: Wilcoxon matched pairs signed ranks

Conclusion: The results were **significant** at the $p=0.005$ level, using Wilcoxon’s test ($N=26$, $T=61$; one-tailed hypothesis). Therefore, the null hypothesis can be rejected and it is concluded that, on average, participants’ self-reported awareness of climate change and the risks it may pose increased from before to after the exercise

Unsurprisingly, the awareness rankings were higher, on average, among those working directly on climate change and/or sustainability issues. Compared with similar counterparts in the other two countries, self-reported awareness was highest in Boston across different groups of participants. Two examples are:

Position	Rotterdam	Singapore	Boston
Transportation agencies	2, 3, 3, 5, 6, 7 (4.3 avg.)	3, 5, 5, N/A (4.3 avg.)	4, 4, 5, 6, 7, 7, N/A (5.5 avg.)
Engineering consulting	3, 5, 5, 6, 6 (5 avg.)	N/A	5, 5, 5, 6, 6, 6, 7 (5.7 avg.)

These differences in level of awareness counter hypothesis 3C in the first chapter, which predicted that awareness would be higher in Rotterdam. However, there are viable reasons for this discrepancy. As discussed further below, numerous reports have been released in the Boston region by various agencies and other organizations detailing the risks climate change poses. In addition to attention within government, the findings of these assessments have received substantial press coverage. The feeling of vulnerability is increasingly widespread, with events like Hurricane Sandy in the New York region serving as a wakeup call. In the Netherlands, flood risk management is highly institutionalized as a government priority. However, some assert that the excellent job done by flood control specialists has fostered complacency among other actors around the various other risks the country may face, and stifled discussion around whether or not continuing to reinforce hard coastal infrastructure is the best approach as conditions evolve. In Singapore, very limited information on the country’s climate vulnerabilities has been released. The Resilience Working Group of the multi-agency National Climate Change Secretariat (NCCS) has conducted a vulnerability assessment but, according to interviewees, is reticent to

release this information until they can also present solutions. In the words of a participant knowledgeable on the process:

We want to share information about climate change, [but] we don't want to get people [worked up], saying 'Okay, your area is flood-prone, so in the long run [...] maybe you have to sell your house, the property price will drop', for instance. So there are certain things, which I think the government, they have a lot of consideration before releasing certain information to minimize the potential, the situation whereby people would start to get afraid. I guess the other reason is because when we want to do something, and climate change is happening slowly, it's moving very slowly, so I guess for us we want to do, or to have some concrete plans before releasing it to the public. For instance, we have actually done quite a number of things [...] under the resilience framework; we have come up with risk assessment and adaptation plans as in the framework itself, but we haven't released it because we want to, okay when you tell them about the risk, the idea is to also tell them what is the solution to the risk.

As a result, not only the public but also government officials not involved in their agencies' climate change efforts are relatively unaware of the risks and potential adaptive responses.

Participants were also asked how significant of a factor they expect climate change to be in their organizations' planning and decision-making over the next ten years. Here too, the average response was highest in Boston at 5.7 (pre-exercise on a seven-point Likert scale), compared to only 4.9 in Rotterdam and 4 in Singapore. Unsurprisingly, the responses were significantly higher among those already working on climate change issues. For example, a participant from the Massachusetts Department of Transportation in Boston that is managing one of their high-profile climate initiatives selected 7, while other employees from the same agency that answered this question ranked it 3 and 4. Similarly, a City of Boston participant involved in their climate initiatives responded with a 7, while others from the City (from various departments) answered 4 and 5. This suggests that there is still a gap in how deeply climate adaptation is integrated into agencies. This gap may be problematic insofar as climate adaptation becomes an important factor throughout all planning and decision-making.

Adaptation planning efforts

Climate change adaptation planning is happening in all three cities, although the efforts vary in structure and character.

In Boston, there are a plethora of initiatives coming from various agencies at four levels of government, and led by non-governmental organizations. At the municipal level, the Greenovate initiative is championing adaptation across city government. The city has released various reports, including its latest Climate Action Plan in 2014. The plan makes various recommendations around how the consideration of climate risks may be integrated into planning and decision-making, although, as discussed in the next subsection, integration remains incomplete. A City-initiated Green Ribbon Commission draws membership from various key private and public organizations, and municipal and state

government in an effort to engender broad support and generate innovative ideas. As discussed in the next subsection, actual implementation of the various recommendations coming out of these planning processes varies.

One challenge is that the municipal landscape is fragmented in the metropolitan area, with over 100 different cities and towns, each with substantial autonomy on key issues like land use planning. Some of these communities are working on climate adaptation, but most are not. The Metropolitan Area Planning Council (MAPC), which attempts to play a coordinating role in the region, is currently updating its Metro Boston Regional Climate Change Adaptation Strategy Report. According to many interviewees a regional approach is needed and the MAPC could play a role, but unfortunately lacks real authority. In the transportation domain, the Metropolitan Planning Organization (MPO), which is affiliated with the MAPC, has teeth insofar as any projects that receive federal funding must pass through its processes, but is not yet accounting for climate change in its planning and project assessment.

Much of the infrastructure in the Boston area is managed by state agencies. Massachusetts passed the Global Warming Solutions Act in 2008, which, among other things, mandated the creation of an adaptation advisory committee. The committee's work culminated in the release of the Massachusetts Climate Change Adaptation Report in 2011. Since then, different agencies have, as discussed in the next subsection, taken various steps. Inter-agency adaptation planning has been coordinated by the Executive Office of Energy and Environmental Affairs, which had a dedicated Policy Advisor for Climate Change Adaptation. She has moved on since the change in administrations at the beginning of 2015, and the current status of adaptation planning is unclear. Some agencies, including the Department of Transportation (MassDOT), are in the midst of vulnerability assessments. In fact, an assessment process being led by MassDOT that was originally intended to examine the vulnerability of the Central Artery tunnels in Boston has mushroomed into a partnership involving the Cities of Boston and Cambridge. Many agencies are awaiting the results of their sophisticated inundation modeling, as it will have implications on their own planning and decision-making. There is no reason why MassDOT is leading such an assessment process with wider implications, but they received a grant from the Federal Highway Administration and so have found themselves in that position.

At the Federal level, discord between Congress and the President (i.e., the legislative and executive branches) has limited action on climate change. Nonetheless, the Obama Administration has used its executive authority to take action, including on climate adaptation. Its various initiatives have included an interagency Council on Climate Preparedness and Resilience; the creation of a State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience; and the U.S. Global Change Research Program. Initiatives have assessed the threats and developed various recommendations on how federal agencies can work with state and local counterparts to better tackle them. At least 16 agencies, ranging from the Federal Highway Administration (FHWA) to the National Oceanic and Atmospheric Administration, have developed guidance documents, and provide clearinghouses for information (Bierbaum et al., 2014). Agencies like the FHWA

can exert influence on the uptake of issues like climate adaptation by placing stipulations on the substantial funding they provide to state and local governments.

As discussed later in this chapter, non-governmental actors are playing key roles in adaptation planning in the Boston region. At the planning level, the Boston Harbor Association has been a key coordinator of climate assessments, and continues to be a recognized convener and source of information. The Barr Foundation has funded various efforts of both non-profits and government agencies. Neighborhood organizations support community-based adaptation.

In Singapore, climate change adaptation planning is coordinated through the National Climate Change Secretariat (NCCS), which is a multi-agency effort chaired by the Deputy Prime Minister. The NCCS's work is conducted via a hierarchy of committees and sub-committees. The Resilience Working Group is responsible for adaptation planning and policy-making. It is comprised of senior representatives from the key agencies, including the Ministry of Environment and Water Resources, the Ministry of National Development, the Ministry of Finance and the Land Transport Authority. Below this are 'thematic clusters' focused on specific issues like 'infrastructure'. A representative from the Land Transport Authority chairs the infrastructure cluster. The NCCS released a National Climate Change Strategy in 2012, and continues to develop adaptation plans. Some agencies are starting to institutionalize adaptation into their processes. For example, the Building and Construction Authority established a Coastal and Project Management Department to address coastal protection and adaptation issues, and is working on a Risk Map Study. The highly coordinated nature of governance in Singapore is a contributing factor to the organized way in which adaptation planning is occurring. The fact that there is only one level of government in the city-state also makes matters easier.

In Rotterdam, multiple agencies at different levels of government are engaged in climate adaptation. The Rotterdam Climate Initiative, which is a partnership between the municipal government, port, Deltalinqs (the port businesses' association), and DCMR (the regional environmental protection agency in the Rijnmond), has been planning for climate change since 2007. The Rotterdam Climate Proof program, which is the adaptation-focused component of the Initiative, has established the goal of making the region 'climate proof' by 2025. Measures to achieve this goal are outlined in an ambitious climate change adaptation strategy. The city has a 'Climate Director' to coordinate its efforts, alongside dedicated staff in other organizations, including the port.

At the national level, there are various initiatives to enhance climate resilience. When it comes to coastal defense, the Dutch have been adapting to the climate since the 13th century, giving strong precedence to today's efforts. The Deltaplan, which was initiated in the 1930s but really accelerated after the disastrous floods of 1953, coordinated the construction of an extremely robust network of coastal defenses. A high-level Second Delta Commission was established in 2007, partly in recognition of the threats climate change might present to flood defense infrastructure. The Commission took an extremely long-range and holistic approach, and recommended various investments and changes to spatial planning. The government is now implementing many of the recommendations, and

planning towards others. Rijkswaterstaat is the executive agency of the Ministry of Infrastructure and the Environment responsible for both the construction and management of water and transportation infrastructure at the national level. It is largely responsible for implementing the recommendations of the Delta Commission. From a planning perspective, it has internal staff conducting vulnerability assessments and considering how climate risks can be integrated into decision-making.

As in Boston, there are various climate adaptation planning processes underway at the local/regional and national levels in the Netherlands. However, there is more coordination among these efforts. For example, the Royal Netherlands Meteorological Institute (KNMI) has established itself as the preeminent source for climate forecasts. KNMI provides information in formats that are accessible and useful to decision-makers, and its veracity is rarely, if ever, challenged.

Adaptation planning efforts in the Boston region are fragmented across various agencies and other stakeholder groups, which is unsurprising in a neopluralist context. This fragmentation may, however, contribute to inefficient duplication of efforts, counteractive investments, and narrow perspectives. On the other hand, the notion of and responsibility for adaptation is more widely disseminated. In contrast, adaptation planning in Singapore is highly coordinated and hierarchically organized, which may bring efficiencies, but leaves less room for innovation. Efforts in the Rotterdam region fall somewhere in between. There are various efforts underway by various agencies, but the level of coordination is higher than in Boston.

Status of climate adaptation

Unfortunately, awareness and aspiration are not yet translating into concrete adaptive measures in all cases. Some concrete changes are occurring in each city, but they are relatively limited thus far, especially in Boston and Singapore. As predicted in hypothesis 3D, Rotterdam is further along in implementing concrete adaptive efforts.

In Boston, there have been numerous assessments and guidance documents released, some more formally than others. The Boston Redevelopment Authority requires that all large projects complete a Climate Change Preparedness & Resiliency Checklist, which includes questions like (Boston Redevelopment Authority, 2013): “What is the full expected life of the project? What is the full expected operational life of key building systems (e.g. heating, cooling, ventilation)? What time span of future Climate Conditions was considered?” The options for each answer are 10, 25, 50 or 75 years. Unfortunately, these standards are process rather than performance based. In the absence of concrete adaptive requirements, some project proponents are diligent, while many are not. The Boston Water and Sewer Commission (BWSC) is furthest along in making concrete changes; the agency took future climate risks into account when developing their 25-year capital asset program. Investments and maintenance decisions are made with consideration of the risks. The Boston Transportation and Public Works Departments are starting to assess the risks climate change poses to their infrastructure, but have made few concrete changes thus far.

At the state level, various agencies, including the Office of Coastal Zone Management (CZM) have released guidance documents and provide technical and financial support through their initiatives, like the CZM office's StormSmart Coasts program. The CZM has also added future climate risks to the assessment processes it expects municipalities and private landowners to go through when conducting coastal and harbor planning. Unfortunately, similarly to the BRA standards discussed above, these are process requirements that lack concrete performance standards. In the context of transportation infrastructure, there are examples of projects responding to climate risks, like the Morrissey Boulevard reconstruction in Boston, but these are rare instances thus far. In fact, interviewees reflected that some projects that may be acutely vulnerable have fallen short in adequately accounting for the risks. Similar to the BWSC at the municipal level, the Massachusetts Water Resource Authority is relatively far along in considering climate risks as it makes infrastructure investments. The Department of Conservation and Recreation, which is responsible for much of the coastal flood defense infrastructure, is starting to consider climate impacts as they assess and design projects. Unfortunately, according to interviewees, resource constraints and competing priorities severely limit how much is done in practice to advance adaptation.

At the federal level, agencies exert most of their influence via their grants programs, regulatory oversight, and the provision of technical support. Regulations have been slow to change in response to changing climate risks, at least in part because they typically require (unlikely) congressional approval. Some agencies, including the Army Corps of Engineers, directly manage some infrastructure. The Corps is taking steps to consider future climate risks in its planning and design after some notable failures, including Hurricane Katrina's devastation of New Orleans. The federal government is also attempting to play a coordinating role, including with recovery from Hurricane Sandy in New York and New Jersey, which is being led by the Department of Housing and Urban Development.

In Singapore, there have been some concrete steps taken to integrate changing climate risks. The most prominent is an increase in the minimum elevation of newly reclaimed land from 1.25 meters above the highest recorded tide observed before 1991 to 2.25 meters. Some steps to enhance infrastructure for other reasons - including the ambitious efforts to achieve water independence by investing in water reclamation, desalinization, and aggressive capture and storage - may provide enhanced robustness as the climate changes. However, many agencies have made little or no progress on climate adaptation. On the transportation front, the Land Transport Agency is at the table in the NCCS efforts, but this does not seem to be percolating into tangible decision-making yet, as evinced by the fact that the latest Master Plan, released in 2013, makes no mention of 'climate change', 'adaptation', 'flooding' or other climate keywords (LTA, 2013). Three of four participants from the LTA engaged in this research concurred that it is not (yet) a high priority for the agency. "The problem is that climate change is too vague, and we operate at the specific level, so if the threat is so vague it is hard to translate into a operational plan that I can put on the ground. [...We] need a very specific assessment to develop a plan; that is what is so tricky about climate change, especially climate change", said one of them.

Rotterdam is the furthest along in taking concrete steps to advance climate adaptation. As discussed in the previous subsection, the national government is assessing when and how to shore up coastal defense infrastructure that is already designed to withstand 1 in 10,000 year storms. At the municipal level there have been various projects, including the construction of a new multi-purpose parking garage close to the central train station that can serve as a water storage tank when needed; a new 'water square' that serves various recreational purposes when dry and stores rainwater when necessary, which was the product of an extensive participatory process with the surrounding community; and a 'paving out and plants in' campaign that is encouraging landowners to remove impermeable surfaces. Climate adaptation is not well integrated into land transportation infrastructure planning yet, although there have been some initial attempts. For example, 10, 20 and 50 year water level projections were considered when designing an 'eco aqueduct' as part of the new A4 motorway extension currently under construction.

Barriers to adaptation

Insofar as climate change adaptation is not yet well integrated into planning and decision-making, it is valuable to understand the obstacles. Many of the barriers appear to vary across the three cities, underscoring how intertwined they are with the respective governance norms and context-specific conditions.

Participants in Boston were asked to rank the reasons why climate change is not a higher priority, and 'lack of resources' was the most popular choice. The RPS exercise groups in Boston focused on funding more than those in Singapore and Rotterdam, mirroring its importance as a factor in decision making. Reflecting afterwards, several participants mentioned chronic underfunding as a barrier to climate adaptation in infrastructure planning and decision-making. Projects are often already long overdue and underfunded, leaving little room for the consideration of other factors like future climate change. "A lot of bridge projects are accelerated almost to the case of being an emergency, so I don't know that [future climate vulnerability is] ever anybody's first question", said a participant.

Acute resource constraints exacerbate competition among priorities. However, it is not the only source of competition. As discussed below, the interests of the various stakeholder groups at the table came out most sharply among the Boston groups playing the RPS exercise. They felt compelled to reject certain options based on vociferous opposition – option B because of the community concerns (voiced by the aldermen and women and option C because of the environmentalists' concerns. The third significant barrier to climate adaptation in Boston is unclear and undefined responsibility in an environment with multiple initiatives but no clear coordination. "As far as regional planning is concerned, I think that's the biggest uncertainty because it's so difficult to come to consensus on what should happen on a larger basis [...] I think we have a big problem with uncertainty insofar as planning is concerned", reflected a participant.

In contrast to Boston, infrastructure in both Singapore and the Netherlands is robust and well funded. Both countries have put substantial resources into infrastructure systems

when deemed a priority, namely the coastal flood defense network in the Netherlands and the 'four taps' strategy for water independence in Singapore.

The presence of 'competing priorities' was identified as an issue in Rotterdam as well. In contrast, in Singapore the emphasis is on 'national interests'. The primary barrier is subsequently that adapting to climate change has not (yet) been identified as a national priority. In the words of one participant:

I think a lot of agencies are having a wait-and-see attitude because [...] we will need a very strong mandate on 'Yes, let's do this, this is the broad, overarching strategy for Singapore', and then agencies, respective policies can come in. Some agencies have started on their own, which is a good attempt, but I think it may really continue that way for some time. [...] I think, at some level, at the very top of this hierarchy, someone would probably have to decide 'this is the strategic direction we're going for Singapore. So different plans, adaptation plans, mitigation plans all have to fit in and draft into this broader strategy'.

Some reflected that the threats would have to be felt first. This stems, at least in part, from discomfort with the notion of persistent uncertainty. In Boston and Rotterdam, participants talked about uncertainty as a problem insofar as it challenges the assumption of static future conditions and has not yet been translated into usable design conditions. In Singapore, some participants still feel that the science itself is too uncertain to make decisions. In the words of one:

We don't pass over the climate change indicators to the different departments or groups [in our Statutory Board] for consideration. I think that's because there is a lot of uncertainty with those forecasts, there's still a lot of uncertainties. Like I mentioned our NCCS is still trying to better understand the impact of climate change on Singapore at this stage, so it is a bit premature to factor in.

In an ostensibly rational, technocratic planning environment, parties want to feel like they are getting the necessary technical information to make the best possible decisions. Rather than embracing uncertainty, experts should be ready to 'speak with conviction' and 'justify why their models are sufficient' asserted a participant.

Given the adaptive measures underway, Rotterdam would appear to have the fewest barriers. Nonetheless, in addition to competing priorities, one challenge is ensuring that all climate threats receive adequate attention. The planning mechanisms and resources have been trained on water management for decades, but climate adaptation will require action on other fronts as well, including transportation infrastructure.

Role of interests

The ways in which interests are understood and managed varies across the three cases, with the starkest difference being between Singapore and the other two countries. In Singapore, the emphasis is on shared 'national interests', whereas in the Netherlands and

the United States there is wider acknowledgement of various interests and the need to adjudicate and/or reconcile them.

In Singapore, participants emphasized the importance of shared national interests. Before the exercise, two different participants approached me to ask what the 'national priorities' are, because they are not explicitly identified in the instructions. Discussing afterwards, some participants reflected that they were uncomfortable not knowing what the shared priorities were. "[Had] I known the national interest or the government interest, I would have pushed for this a little bit more, [...] because if I know that economic growth is the main part, is the national interest, the other agencies will know that, and everyone will have that in their head, and therefore option D would not be that viable", said a participant. In the absence of explicitly identified national priorities, many participants assumed those that have dominated in Singapore, particularly economic growth. All four groups deferred to the port's interests one way or another - two came up with creative solutions, like providing financial assistance to help port users transition to rail; one group concluded with a call for more research to confirm that the D+ option they were leaning towards could really meet the port's needs; and the fourth group chose an elevated road (B+) option, which is the port's second choice and far preferred over the D+ options. It could be interpreted from these outcomes that the port representatives were simply most effective in fighting for their interests. However, the pattern of deliberations and reflections of the participants suggest that the situation was more one of parties coalescing around the importance of the economy and thus need to protect the port's viability. The best example of this is in the group that selected a B+ (elevated road) option. According to her instructions, the alderwoman was supposed to be strongly opposed to option B, but she acquiesced because it would ultimately be in the 'national interest' by supporting job growth and greater mobility. As she reflected afterwards, to some degree it was her personality to accept this ostensibly sub-par option, but she felt responsible for 'thinking holistically' (i.e., about the wider needs and priorities in the region).

In Singapore, the national priorities are well known, and planning and decision-making typically responds to them. Substantial resources have, for example, been invested in the state-of-the-art water system to secure freshwater independence. As discussed in the previous subsection, climate change is not yet deemed a national priority in Singapore. Participants' opinions on if and how climate change might become a greater priority varied. Some feel that it will inherently be reactive, although the work of the NCCS is laying the groundwork for it to emerge as a priority if and when deemed appropriate.

In contrast to Singapore, decision-making in Boston is characterized by the presence of various competing interests that need to be either reconciled or adjudicated. This came out very starkly in the exercise runs. The actors at the table representing interest groups (aldermen and women, environmentalists and port representatives) were unabashed in explicitly stating their interests and directly fighting for them. While they did apply coalitional strategies in some cases, the notion of appealing to (or accepting) a wider or common cause did not emerge. In fact, the environmentalists in all four groups invoked the possibility of a lawsuit if their interests were ignored. Participants reflected afterwards that this is very realistic, as lawsuits have played prominent roles in many of the most

important infrastructure projects in the region in recent decades, and that the concerns of various interest groups regularly shape projects:

The litigation element is important - the transit issues here, the Boston Harbor cleanup - litigation is a very real thing here. If you look at it, the fear of litigation was a big part of killing C [option in the exercise], and the fear of the community opposing something was a big part of killing B. I think that is, I don't know if its unique to Boston, but I think it is a big part of the decision-making - very small impacted groups can have a significant impact on decision-making. Certainly you cannot say 'I think this is best for the region, it's going to get done no matter what'. B was a reasonable alternative, and community opposition basically ended B off the bat.

Stakeholders in the Boston context are forthright in expressing and pursuing their interests. Resolving tensions between competing interests and priorities does not always have to involve litigation or be adversarial; mechanisms are typically in place to consult different groups as projects are developed, although their efficacy is often questionable. The exercise modeled an alternative, deliberative, approach in which parties seek mutually acceptable outcomes that address their various interests. Some participants reflected that they have participated in similar processes in practice, although it is not widespread as an approach. Those for whom it was a new experience reflected that they could see opportunities for similar processes in their work.

Competition among interests did not come out as sharply in Rotterdam as Boston, but still manifested. Exercise participants saw their task as reconciling these various interests, and looked for solutions that everyone could 'live with'. During the debriefings and follow-up interviews, they described the process of planning and decision-making, particularly around large projects, as one involving phases of parties lobbying for their interests, and attempts to 'balance' these interests and find mutually acceptable outcomes. "We try to build-up a case; it will never be a perfect 100% win-win, but as much win as possible", said a participant from an important advocacy organization. A government official described the process as follows:

[The] parties are going to manifest in the newspapers or whatever, and that's the phase when, in my experience in the Dutch setting, it's still possible to have a good conversation. Even though you have very different positions, you can still put everyone around the table and try to exchange them, both in the informal and more formal, depending on what you need in your decision-making. Usually there is an informal round, then more formal for the decision-making. [...] Of course, if there is one preferable solution that everyone can live with, you have consensus, then that would be fine, then you don't have all this fuss, but usually its not so easy and there are very conflicting interests, and [it's] really about trying to organize and balance your powers.

The tradition of seeking consensus in the Netherlands is often referred to as the 'polder mentality'. In the words of a participant in Boston that works in government and has extensive knowledge of the Dutch approach, contrasting the two:

[In the Netherlands] they have the tradition of reaching consensus. The cultural thing that they trace back to the polder mentality, whereas we have much more of a argumentative style, with lots of veto points and maybe a suspicion of governance, and ample opportunities to block moving forward on major projects.

Poldering does not inherently generate optimal outcomes. Participants in Rotterdam were surprised when competing interests overwhelmed climate adaptation goals in the exercise. “It was remarkable that the arguments concerning climate change [were] lost because of all the other arguments - the economy, people in the city, etcetera, etcetera - all of the known old arguments won over the new”, said a participant.

The notion of ‘fairness’ also emerged as a factor in Rotterdam. Participants asserted that any outcome should be fair to all involved. Concern around the fair shouldering of responsibility was a significant complicating factor in the risk assessment group’s deliberations. The Alderman was ready to commit the city to funding half of the cost of the extra remedial flood prevention measures associated with the A+ (below grade road) option they were leaning towards, but only if the port would commit to funding the other half. This despite the fact that his instructions stated that he could fund all of it. To the participant, it was a matter of principle. The group failed to reach consensus within the time allotted anyways, but this issue was left unresolved with the port tasked with ‘looking into’ whether or not they could find funding. In contrast, groups in Singapore did what they could to accommodate the port, seeing its viability as a national priority. In Boston, the port representatives fought hard for their interests, and participants reflected that this is what they would expect, void of any sense of fairness.

In Singapore, climate adaptation will need to be integrated into the national priorities if it is to gain significant traction. Whether adversarial or collaborative, adaptation efforts in Boston and Rotterdam will need to explicitly account for different interests if they are to be successful. This is not necessarily an easy task, given that other interests are often well entrenched and impacts on them acutely felt, while long term climate risks can seem more abstract and adaptation does not have the same type of constituency behind it.

Roles of state and non-state actors in climate adaptation

Non-governmental actors are playing central roles in adaptation planning in the Boston region. The Boston Harbor Association (TBHA) has collaborated with the City, academics and other organizations to produce influential reports, organize events and generally raise the profile of climate risks and potential responses. Despite the fact that it is an advocacy organization, TBHA has significant credibility. The City of Boston has focused on integrating the institutional, business and non-profit communities into its adaptation planning efforts, including via the Green Ribbon Commission. An interviewee actively involved in adaptation efforts in the city reflected:

In Boston, the business community and the institutional community are very involved in the climate change conversation, and we are very fortunate that that is the case.

There are some deniers, there always are, but on the whole we have an extremely supportive business community and benefit from that.

Business organizations like A Better City (ABC) play prominent roles that go far beyond traditional lobbying. These groups leverage their resources, which can be scarce within government, and marshal support to advance research, planning, and decision-making. This is a well-established tradition in the region; ABC was originally created as the 'Artery Business Council' to facilitate communication and coordination between businesses and institutions and the project team during the massive 'big dig' highway project. Today, the organization continues to play a facilitative role in different planning processes, including between government agencies.

At the community level, organizations like Neighborhood of Affordable Housing (NOAH) in East Boston are also playing important roles. NOAH is partnering with academics to better understand the impacts climate change might have on this vulnerable community, and then directly engaging with community members to consider how they might adapt. While government officials are involved, the focus is on independent, community-based adaptation strategies. This is a markedly different approach than those in Singapore or Rotterdam, where government agencies are generally expected to plan and implement measures. Neighborhood-specific business and institutional organizations like the Medical, Academic and Scientific Organization (MASCO) in Boston's Longwood area are also playing coordinating roles between government agencies and their membership.

Private foundations like the Barr Foundation play important roles as sources of support in a resources constrained environment. Barr has established climate change as a priority, and funded various initiatives of both non-profits and governmental agencies.

External consultants and contractors do much of the engineering, project assessment and construction in the Boston region. They are bounded by agency guidelines and their professional norms and standards, which will influence how adaptation is institutionalized into their work. Academics are also playing important roles vis-à-vis climate adaptation by, among other things, providing downscaled climate data.

In Singapore, planning and decision-making, including around climate adaptation, is almost exclusively the purview of government officials. Academics and other experts from both within and outside the country are consulted, but the various committees and working groups of the National Climate Change Secretariat involve only agency officials. This is characteristic of the technocratic paradigm of governance in Singapore. The assumption is that interests-based participants would corrupt processes, while expert officials are able to rationally plan and make the decisions that best meet the aforementioned national priorities. A participant reflected that the direct engagement of external stakeholders is unrealistic and inappropriate, stating that:

In other countries, [...] you can afford not to be seen as fair. But in Singapore, you have to be seen as fair. So, if you want to include one environmental group, you probably have to include a whole bunch. And even if you include a whole bunch, there will be

other opinions as well, and they will start asking, 'Okay, so why don't you bring in the, say, the pet lovers', for example. Or, 'Why don't you bring in the national society for bird watching', or something like that. So you end up having more and more stakeholders and, therefore, more and more diverse views. And, in a country like Singapore, efficiency is one of the things that we are very, very proud of. The more you have [engagement], the slower you become. Then, our advantage is therefore lost, in my opinion.

Participants cited perceived unfairness in involving some actors and not others; capture by certain stakeholders, leading to biased outcomes; low capacity among civil society organizations; aversion to sharing information with external actors when it may be of national security or cause 'unnecessary fear'; inefficiencies, as different interests bloat proposals with their various issues; and time lost to deliberating as barriers or drawbacks to stakeholder engagement.

Supposed 'grassroots' organizations have traditionally focused on disseminating information and fostering cohesion, not coordinating interests-based opposition to government initiatives. It is, however, notable that the situation may be slowly changing in Singapore. The strong network of formal and informal community groups that coalesced in opposition to the construction of a proposed road through Bukit Brown, which is a historical cemetery that also serves as a nature area, is an example of citizens becoming increasingly vocal in demanding that government agencies consider their interests. Social media and changing societal expectations may necessitate stakeholder engagement in the future. Some of the workshop participants (which came from inside government) reflected that further engagement could be useful, particularly around issues like climate adaptation. One reflected on the exercise by saying (supporting hypothesis 4D):

We haven't done really grounded stakeholder engagement, but from the exercise I thought it's really important to engage people right at the beginning. We know this is a fact, it's a bonus if you can do that. But it [struck me] even stronger after the exercise that yeah, it could be potentially more effective and efficient to engage stakeholders at an earlier time as compared to after we have made our decision and telling them 'Okay, this is what we want to do'.

"Increasingly, the problems that we face are getting a bit more complex and increasingly, at least in Singapore, there's a lot more demands for public engagement, so then decision-making has to evolve in a way such that we gather diverse views of the public, of the different stakeholders involved", said another participant.

In the Netherlands, the involvement of multiple stakeholders is a central component of the polder model. As noted previously, Deltalinqs (the port businesses' association) is a partner in the Rotterdam Climate Initiative. However, the involvement of non-governmental actors is not as extensive as in Boston. This is partly a matter of practicality – foundations and non-governmental organizations are filling important roles in the Boston region as facilitators, information providers and drivers of change. In contrast, government initiatives have taken the lead in playing these roles in the Netherlands.

This may change as adaptation becomes a more prominent component of planning and decision-making, and various stakeholder groups expect a seat at the table. The neo-corporatist poldering tradition is well established in certain areas, like labor negotiations, but less so in other domains. Institutions for poldering would need to be created if actors are to effectively and efficiently come together around an issue like how to holistically integrate climate risks. The multi-stakeholder decision-making process around the Maasvlakte 2 expansion to the Port of Rotterdam is an example of how multi-stakeholder collaborative planning processes can be organized around complex projects with multiple dimensions. Representatives from nature protection, community, recreation, industry and other groups were brought together for a facilitated process that resulted in a package (design and other compensatory measures) that everyone could accept.

Management priorities

Priorities in management often shift from administration to administration in the United States, particularly when it comes to less established issues like climate change adaptation. Senior staff also typically changes, often altering the focus and nature of efforts. "A lot of [what shapes the currency of issues] is varying shades of politics - whether it is the Governor's priority, whether there are concerns with equity with each town or city or region getting their fair share", said an interviewee in Boston. This can contribute to instability, as the future of initiatives is in question with each election. Both the City of Boston and State of Massachusetts have gone through changes in administration in the last two years. The new mayor, Marty Walsh, appears to be continuing the climate efforts of the previous mayor, including the Greenovate Boston initiative, but did appoint a new Chief of Environment, Energy, & Open Space. He is also overhauling the traditionally powerful Boston Redevelopment Authority, which has played a role in adaptation efforts, and could play a more important one in the future.

At the State level, Governor Charlie Baker assumed office in January of 2015 and it remains unclear if climate change is a priority for his administration, and how the portfolio will be managed. This was a shift from one political party (Democratic) to another (Republican), precipitating a more significant change in priorities. Climate change was a high priority for the Secretary of Energy and Environmental Affairs in the last (Patrick) administration, but the Secretary has been replaced, the point person responsible for coordinating cross-agency efforts on adaptation has moved on, and the new administration is focused on fiscal prudence, which could translate into less grant money for municipalities and investments in infrastructure.

Because priorities are so politically driven in the United States, they are often short-term in their outlook. A participant reflected:

If you are not somebody like [former] Mayor Menino, God rest his soul, that was able to establish himself for a long time and have a bit of an iron fist with [longer term] stuff that he knew needed to get done or wanted to get done, it's really difficult to get it

done without paying and he even had to pay many times over the years after making certain decisions.

'Leadership' in the Boston context equates to bold political action to take a long-range perspective, despite the fact that electoral calculus might favor shorter-term thinking. Participants opined that this is unfortunately uncommon. As discussed further below, the rest of the civil service is relatively responsive to these changing priorities and shifts in leadership.

In contrast, the People's Action Party has governed in Singapore for more than 55 years. While criticized on democratic grounds, stability in government policy has allowed officials to make unpopular decisions that, they believe, will pay dividends in the longer term or for the greater good of society. The civil service and political class are generally integrated, with priorities permeating downwards. Ho (2000: 157) describes it as:

The political tradition in Singapore favors the top-down, hierarchical model of decision-making. The well-defined, clearly demarcated hierarchical political structure is a classic pyramid organization where the immediate subordinates strictly follow commands from the top. While discretionary power is given, it is usually within the boundaries of strict directives.

At the highest levels, the civil service and political elites intermingle. In general, the civil service is perceived to be extremely competent, blending elements of technocratic management and customer-centric and performance-oriented service delivery to provide high-quality governance across major swaths of the Singaporean economy and society. At least in theory, priorities are established and decisions made on rational grounds, based on dispassionate, sound analysis. In practice, both science and policy preferences have influence. In the context of climate change, a participant reflected:

I think the way that we work, a lot of times people describe the Singapore civil service, as technocrats. We are fairly driven by the hard sciences, the hard numbers, so [...] if an agency who is doing some of these projections and modeling doesn't have the legitimacy or is very new, I think if they have the science behind it to back it up, and the numbers to back it up, I think people will still look to them. Because partly there's no other person to look to and partly we are so driven into looking at hard numbers that I think that is sufficient. Of course, I think, if you're talking about a higher political level of driving climate change direction for Singapore, that is beyond the science of it.

Strong democratic institutions in the Netherlands have facilitated regular shifts in the ruling party, but there is typically more consistency from one administration to the next, both in terms of bureaucratic personnel and policies. There is certainly broad consensus around major priorities like the country's extensive dike network. In fact, according to interviewees, the Delta Commissioner – who is the czar overseeing the flood protection infrastructure – is widely seen to be outside, and in some ways above, the political fray. Similarly at the regional level, the water boards responsible for polder management (i.e., local water management and flood control) are independent institutions with

representation from various stakeholder groups, and are not beholden to other elected bodies. In other domains, participants reflected that both political and technical factors influence prioritization in planning and decision-making in the Netherlands. It is their integration that can pose a challenge.

Nature of deliberations within government

In accordance with hypothesis 3A, agencies and different levels of government in the United States can find themselves at odds around both policies and projects. In some cases, disagreements can devolve to legal action, as happened around expansion of the public transportation system in the City of Somerville; the city, in partnership with a non-governmental organization, took the State to court to demand that they make promised investments in a timely manner. Agencies often have competing priorities; transportation projects are, for example, often complicated by, among other hurdles, Massachusetts Environmental Policy Act review.

Some interviewees spoke of how agencies or units can serve as intermediaries, and the importance of that role. An example of this is the GreenDOT team within the Massachusetts Department of Transportation. GreenDOT can act as a 'bridge' or 'convener' between colleagues within the DOT attempting to advance projects and external environmental regulators and other stakeholders, like the non-profit Conservation Law Foundation. The team understands the objectives and constraints of all sides, and can help them understand each other and find mutually acceptable solutions. An interviewee from the Massachusetts Office of Coastal Zone Management noted that they often find themselves in the 'balancer' role, because they are able to use their position at the nexus of coastal development, environmental and other concerns to facilitate:

[We] can step back and see the different needs and wants and orchestrate things and ask questions that get us to where we need to go. It's really good to have someone like that in the meeting. Not that we don't have an interest, but our interests are broader, so our interest is actually to get everyone to agree and come to a balanced outcome. So, if the [U.S.] Fish and Wildlife Service is happy, and Army Corps of Engineers is happy, and [Massachusetts] Department of Environmental Protection is happy, getting to that place is actually what our goal is. [...]. So, having decision-makers in a room and having a party that has a goal of just having everybody come to an agreement, which I don't think happens all the time, and I like that that's our role.

This kind of bridging and convening is likely to be important as agencies grapple with how to adapt to climate change, and confront the conflicting priorities and cross proposes of other agencies and external actors. Some facilitators acted more neutrally than others. Post-exercise, participants reflected positively on having a substantively neutral facilitator in practice. Some asked questions like: "I wonder what would happen if the person facilitating had no stake and was acting as a mediator instead". Another participant suggested that a similar process in the Boston area could use the MPO as the facilitator.

Bridging and convening is an important element of facilitating the integration of climate adaptation into planning and decision-making. Another is effective policy entrepreneurship. Proponents of climate adaptation must be particularly savvy in environments with significant resource constraints and institutional barriers. On the one hand, many participants spoke of the need for leadership from the top. "There is that whole element - different priorities and not wanting to have to take on the burden of other people's priorities. So, it really needs to be a top down, at least in this building, [with] people at the higher levels telling agencies that are responsible for doing", said a participant from the City of Boston. "People are going to move a lot quicker if they understand that the guy from the top is going to say do this, do this, and get it done", said another interviewee. On the other hand, participants noted the creative ways in which ostensibly less powerful policy champions can facilitate change. They noted the importance of 'strategic partnerships', the ability to speak to people on their own terms, and the personalities of those involved. "You can't just be a tree hugger and [be effective], you have to be somebody who is able to say 'this is important' and be intelligent enough in a number of different realms [...] to speak to what other people are doing [...] what the status is in Boston in general, and be able to correlate that and lay it out in the simplest of terms to somebody like the mayor", said an interviewee. Various interviewees praised now former Chief of Environment, Energy & Open Space Brian Swett for his skills as a policy entrepreneur. Coming from the real estate industry, he understood that important constituency; his team has been 'extraordinarily productive' in championing the climate issue, despite their small size and budget; and he and his team 'articulately make the case' to other departments and external stakeholders. Partnerships with private foundations and non-profits also raise their profile, and provide necessary support.

While leadership and strong policy champions become important as issues increase in profile and require institutionalization to be implemented, participants also spoke of the important background work that can happen at the staff level in advance. Projects often gain traction because staff have built the necessary networks of support and proactively vetted options with their colleagues to ensure that they are palatable and will have buy-in. "I think it's a good thing that there are these meeting of minds that happen independently from anything that is formal, because it's too early to know exactly the direction you want to go, so it's good to just trade information and not know how it's going to bear fruit necessarily, you are just letting people know things that you are interested in and vice versa so what opportunities present themselves in all the right person to call", said an interviewee from the City of Boston. This background work often happens organically, and without official sanction. An interviewee referred to these efforts as 'stealth, independent organic initiatives' to build momentum that can translate into more formal programs when they reach key 'tipping points'.

As discussed earlier in this chapter, decision-making in Singapore is typically hierarchical in nature. 'Leadership' is the top-down definition of priorities. These hierarchies are important not only among staff but also among organizations. For example, ministries would typically have more clout than statutory authorities (i.e., implementing agencies). However, some interviewees noted that informal deliberation among staff at similar levels across agencies is an important part of the planning process, and seems to be increasingly

so over time with a new generation of civil servants that are more proactive in reaching out to their counterparts, rather than channeling everything vertically. In the words of an interviewee:

Traditionally, our approach was to go straight to the permanent secretaries, do a song and dance for them, and expect that they would pass directives down. More recently, because it's a small service everyone knows everyone, it's very common for us to reach out to others and say that we have this project, ask them for recommendations, meet them in workshops. We do get a lot of interconnected, informal channels [...] And [these networks] help, because let's say you are starting this climate change work, you can tap into these networks. [This] interconnectedness at the staff level is with happens with the population of ideas.

Similarly to Boston, these networks at the staff level can establish the groundwork for the institutionalization of new issues, like adaptation to climate change. Interestingly, participants noted that strong hierarchy and the pursuit of technocratic optimization can come into conflict. Participants see themselves as rational and open to persuasion based on the merit of arguments. They reflected that this is why the environmentalist was able to have sway in one of the groups; she made a strong case and the fact that she was 'the greenie' was overlooked. "We are all rational people - if something is put on the table that we all feel is serious, valuable, we will not throw it away, even if it is from the most junior person. [I am] proud to say that in the Singaporean civil service we are very rational, and very practical at the same time", said a participant.

In contrast to Singapore, decision-making in the Netherlands is relatively unconstrained by hierarchy and deference to authority. The RPS exercise runs reflected this, with participants paying little or no attention to their stations vis-à-vis other participants. Ostensibly technical actors expressed their opinions strongly and directly, engaging in a much more frank and open discussion than in either Singapore or Boston.⁷ As discussed earlier in this chapter, participants reflected that the 'poldering' mentality – which emphasizes open deliberation – is an important feature of decision-making in the Netherlands, both among different stakeholders and within government.

Response to uncertainties

As discussed in the previous section of this chapter, there were relatively consistent findings across the three cities around the nature of uncertainty as a challenge in planning and decision-making, and how it should be addressed. However, there were some differences that are noteworthy.

'Flexibility' and 'consult experts' were popular responses to how uncertainty is currently managed across all three cities. In Singapore, robustness (i.e., 'plan for the worst-case scenario') was also popular; 24% of participants selected it, compared to only 7% in the

⁷ In Boston, the explicitly interests-driven actors were very frank in expressing their interests and preferences, but those playing technical roles were typically more guarded in expressing their opinions.

Netherlands and 9% in Boston. It was also the second most popular choice - based on first and second rankings - as the way in which uncertainty should be managed. As discussed previously, Singaporean infrastructure can be typified as robust, particularly in areas the government deems to be priorities. The 'four taps' program for securing water independence via major investments in desalinization, water reclamation and rainwater harvesting and storage is an example of this. Participants reflected that they see flexibility and robustness as complementary responses. They asserted that it is best to be pragmatic in designing to the worst-case scenario within reason, and then maintaining flexibility to allow for changes or unforeseen circumstances. An example provided was that they are elevating the entrances to new Mass Rapid Transit (MRT) stations to reduce flooding risks, but there will be some flexibility in the design to will allow for further protective measures if necessary in the future. While not explicitly linked to climate change, this represents an adaptive response to inland flooding risks that seem to be increasing over time.

'Flexibility' was a favorite response to how agencies *should* deal with uncertainties across all three cities. It was the overwhelming first choice in Singapore (56%) and Rotterdam (48%). In Boston, however, it tied with 'consult experts' as a first choice, with 41% of respondents choosing each. Some participants expressed concern that flexibility can result in a 'wait-and-see' approach that leaves the region underprepared, and is difficult to institutionalize. Instead, they would prefer to have expert guidance that they can simply act upon. These participants asserted that the data does not have to be perfect, but that they would like the political and legal cover of having officially sanctioned models that they know and can plan towards. They acknowledged that there is a certain 'fear of admitting uncertainty' and discomfort in working flexibility, although it may be inevitable:

Because of professional practice and standard of care standards, the firm or individual, licensed professional who says 'here is the stuff I don't know, here are the bands of uncertainty that I have evaluated, I a moving forward with this and here are all the rational scenario-based stakeholder engaged thinking I've done, but here in black and white are all the things that are going to keep me up at night [is taking a huge risk]. The firm that practices and draws inside the lines and sticks to standards and practices can never be found liable in court based on that, for breaching standard of care, but since we don't have a standard [in the context of adaptation] and since I highly question whether there ever will be one such standard because there should be very context-based, stakeholder driven, get it done as soon as you can solutions, this really calls into question some of the foundation stones of our professional practice.

Flexibility may become a necessity, but planners and engineers would still like to have someone else take responsibility for telling them what standard to design to.

Conclusions

This chapter has presented various observations drawn from the three case cities (Rotterdam, Singapore, and Boston). It has compared and contrasted the cases, and the use

of multiple scenarios versus a more conventional risk assessment forecast as tools for planning under conditions of uncertainty. It also introduced general findings that transcend the cases and RPS exercise versions. I conclude with a summary of the lessons learned, which largely undergird the key takeaway: Climate adaptation is not simply a technical optimization problem; effective means of managing complex and uncertain data are important, but adaptation is also a deliberative process among agencies, different levels of government, and external stakeholders with different interests, priorities and perspectives.

Uncertainty and flexibility

Uncertainty is an often-cited feature of climate adaptation, and important theme in this research. The survey responses and other data collected through this project suggest that uncertainty is a pervasive factor in governance, and certainly not exclusive to climate change. Climate adaptation may involve higher degrees of uncertainty, but these uncertainties are just as frequently (and significantly) institutional as they are technical or scientific. They exist around questions of responsibility, expectations, and other governance issues in unsettled institutional environments. Scientific uncertainty can, however, still be a barrier, particularly insofar as it becomes a reason for inaction.

Participants favor ‘flexibility’ as a way to proceed despite persistent uncertainties, making decisions today – whether policy or design – that explicitly account and leave room for future adaptations as conditions change and learning occurs. However, they acknowledge that flexibility can be very difficult to institutionalize in practice. Moving from a ‘predict and act’ paradigm to a more dynamic one will require significant changes in regulations; greater collaboration among agencies in fragmented and typically linear processes of planning, design, construction and ongoing management; changes to funding mechanisms to allow for ongoing investment, rather than one-off capital projects; investment in ongoing monitoring and evaluation; and changes in professional and institutional norms to shift from the traditional ‘design standards’ approach to one that can work with more nuanced and dynamic standards. Competing interests and priorities, and confounding factors remain as influential in adaptive systems as they are in conventional processes, so must be accounted for as well.

Process design and management

The processes of planning and decision-making matter significantly. Participants reflected that multi-stakeholder engagement is an important step in overcoming the barriers noted above and institutionalizing adaptive approaches, although, as discussed below, opinions on who should be at the table varied among the cases. One benefit of multi-stakeholder processes is that decision-makers can come to better understand and can account for the various interests. They can also provide fora for productive science-policy interactions by bringing technical and policy-oriented actors together around scientifically intensive issues like assessing the risks and adapting to climate change.

Participants’ experiences in the RPS exercise and reflections afterwards suggest that *process design and management* matters. Many chairs set the course for their groups by defining and managing the agenda; this had implications, like the exclusion of the scenarios

in many groups. They also set the rules of the game. In a case in Rotterdam, the chair required unanimous consent, which allowed one party to block an agreement that all others were ready to support. Some chairs remained largely neutral, while others influenced the outcomes based on their own interests.

Other participants' behaviors at the table also mattered. Some were better negotiators than others, which had implications. For example, the environmentalist in one of the groups in Singapore was able to interpret the interests of others, devise a compelling proposal, and make a persuasive case that won others over based on the 'merit of her arguments'. In another group, the alderwoman acquiesced to a proposal (elevated highway) that was very much against her constituents' interests. She reflected afterwards that it is partly her personality, but she was also convinced by the arguments of others that it was for the greater good. Some employed coalition-building strategies. The ways in which those filling technical roles behaved also mattered. For example, some presented themselves as authoritative and neutral, and were able to exert influence on those grounds. A senior engineer in Boston, on the other hand, emphasized the uncertainty of the data he was providing, which left participants feeling like they did not know enough to make a decision.

Scenarios versus risk assessment

Participants reported that scenarios are widely used in planning in all three cities, and rated their value very highly. However, the scenarios were not decisively important in the RPS exercise runs. In fact, they were largely disregarded by all but one of the five groups that played the multiple scenarios version. Participants typically defaulted to the worst-case scenario (i.e., 'wet and busy'). Post-exercise, they reflected that it is difficult to make decisions using multiple scenarios; planners, engineers and decision-makers are used to working with fixed standards.

Despite these challenges in use, participants remained overwhelmingly positive. Many asserted that their value is in the *process*, which encourages them to think methodically and consider various potential future conditions. Even when the scenarios were largely disregarded, the exercise runs would seem to support this. Their presence emphasized the uncertainty of the situation, with positive and negative consequences. The scenario groups frequently concluded with calls for more research; had a harder time getting to agreement; and, when they did, preferred variations of option D+ (rebuilding the existing road and adding freight and/or passenger rail), which may be seen as the most flexible. In contrast, the risk assessment version asks users to either accept or contest the forecasts, but places little emphasis on the wider notion of uncertainty.

Cross-case comparison

Observations have been drawn from looking across the cases. These are important, as they suggest the various factors that need to be taken into account when advancing adaptation strategies that are responsive to the particulars of each context.

The level of awareness of the risks posed by climate change varies across the three cities, with those in Singapore reporting the least knowledge and those in Boston the most.

Climate change is not on the radar to the same degree in Singapore as in the other two cities, and participants acknowledged a reticence to disseminate information on the risks until the government has devised solutions. The high level of awareness in Boston mirrors the numerous adaptation efforts underway, led by different agencies at different levels of government, and non-profit organizations. While there are some attempts at coordination, these are largely independent efforts happening in parallel. In Singapore, adaptation planning is highly coordinated through the National Climate Change Secretariat. There are numerous efforts underway in the Rotterdam region and wider Netherlands, but they appear to be more coordinated than in the Boston region. For example, the Royal Dutch Meteorological Institute serves as the dominant source for climate scenarios used by the various initiatives.

Unfortunately, awareness and aspiration do not automatically translate into concrete action. In Boston, there is relatively widespread awareness among key infrastructure stakeholders and numerous initiatives are underway, but they are not translating into project-level changes in many cases. In Singapore, there is a relatively low level of awareness and action. In Rotterdam, adaptation is certainly not a part of every decision-making process, but is being concretely implemented in some cases.

Insofar as climate adaptation is not yet well institutionalized, there are different barriers across the three cities. In Boston, the acute lack of resources is a significant challenge; agencies are often pressed to meet basic standards, let alone consider new issues like climate change. Pressure from competing interests and priorities is another barrier. Thirdly, fragmentation across agencies and levels of government is a challenge. Regional solutions are needed, but are hobbled by ineffective planning and weak coordination. In Rotterdam, insofar as there are barriers, they include competing priorities, and the traditional reliance on coastal flood defense barriers. Other infrastructure systems are just catching up on adaptation planning as they realize that the dike system is not a panacea. In Singapore, climate adaptation is not a national priority yet, which is a barrier to its fuller consideration in planning and decision-making. One reason is persistent uncertainty around how significant the risks are, which is not a major factor in Rotterdam or Boston.

'Interests' mean different things in the different countries. In Singapore, the notion of national interests and priorities is important. In the exercise, parties deferred to the port's needs in all four groups because they assumed that fostering economic growth was in the national interest. Parties made very different assumptions in Boston, expressing their respective interests strongly, and demanding that they be heard. For example, the environmentalists in all four groups threatened lawsuits if their interests were unmet. Others did not see this as a breach of the process, but a legitimate expression of how strongly they felt about an option. The various interests of the different stakeholders shaped what was possible; two of four options were off the table immediately in Boston because they would face community and environmentalist opposition. The respective stakeholder interests also got on the table quickly with the Rotterdam groups, but they framed their deliberations as attempts to have a 'good conversation' in accordance with the 'polder mentality'. The notion of 'fairness' was also broached in Rotterdam.

Non-governmental actors are deeply involved in adaptation planning in Boston. They serve as sources of information, technical capacity, and support, and are important conveners. These include non-profit advocacy organizations like The Boston Harbor Association and business organizations like A Better City. Neighborhood groups also play important roles, representing their residents and advancing community-based adaptation. Private foundations fund much of the work. These organizations are filling voids where the state is unable, while advancing their interests. In stark contrast, decision-making in Singapore is the exclusive domain of government. There are concerns that non-governmental actors could 'corrupt' processes with their interests, and widespread belief that the high-skilled civil service can most effectively and efficiently manage. Recent events suggest that civil society may, however, be increasingly demanding a seat at the table. In Rotterdam, civil society plays less of a role than in Boston, but is engaged. The corporatist institutions for poldering that are established in some domains may need to be extended to others to advance adaptation.

Management priorities in the U.S. can shift significantly from administration to administration. Both the City of Boston and Commonwealth (i.e., state) of Massachusetts have gone through administration changes in the last two years, and how the adaptation portfolio will be managed remains unclear, especially at the state level. Senior staff have changed, as have overarching priorities. In general, there is, unfortunately, often more emphasis in the U.S. on shorter-term priorities based on electoral calculus. In Singapore, the People's Action Party has ruled for over 55 years, providing stability in government. Elected officials and senior bureaucrats are integrated in a model based on technocratic management. In the Netherlands, healthy democratic institutions have led to changes in government, but there is typically more consistency from one administration to the next than in the U.S. Some institutions, like the Delta Commissioner, exist above the political fray on important issues such as the country's flood protection network.

Agencies and levels of government can be at odds in the Boston context, with their interactions even devolving to court proceedings. Some agencies or units may serve as intermediaries, helping to resolve conflicts. Leadership is typically from the top on issues like climate adaptation, but savvy officials can engage in effective policy entrepreneurship, building strategic partnerships, reaching out to other agencies on their terms, and so on. Participants also emphasized the importance of background work; that is, the 'stealth work' done by staff to lay the groundwork across agency lines. These networks are becoming increasingly common and important in Singapore as well, despite the strong hierarchies. Participants in Singapore reflected that there can be tension between the stiff hierarchies and making optimal decisions in the face of emerging issues like climate change, but feel that they are 'rational' and 'pragmatic' first, so able to absorb these things. Decision-making in the Netherlands features very frank and open discussion. In the exercise, ostensibly technical actors were not afraid to strongly share their opinions.

As discussed above, 'flexibility' was popular across all three cities. In Singapore, 'plan for the worst case scenario' was also a popular way to deal with uncertainty, relative to the other two cities. Participants see these two approaches as complementary, building as robustly as reasonable now while leaving room for adaptations over time. In Boston,

'consult experts' was popular because it is seen as a way to shield from liability. Decision-makers and the consultants that do much of the project design and assessment do not want to step out of line from their established professional practices and standards of care, so want someone to tell them what standards they should design to.

This chapter has outlined and examined the lessons learned from this dissertation research project, summarizing broad takeaways and comparative lessons looking across the three cases and two versions of the exercise. The next chapter will examine the implications and provide some prescriptive advice to those grappling with how to institutionalize climate adaptation into their planning and decision-making, based on these findings.

**Institutionalizing Uncertainty:
Exploring how infrastructure stakeholders can
prepare for uncertain climate futures**

Chapter 6 – Implications and Recommendations

The previous chapter of this dissertation discussed the pervasive nature of *uncertainty* as a factor in planning and decision-making, and fact that uncertainty is as much a *governance* challenge as a scientific or technical one. It introduced *flexibility* as a viable response to uncertainty, yet one that faces substantial implementation challenges. Many of these challenges are universal, while others are unique to different *governance regimes* and institutional arrangements. The last chapter also discussed the opportunities and challenges associated with using *multiple scenarios* in project-level decision-making. Last but not least, it emphasized the *deliberative* nature of adaptation efforts, which must reconcile different interests and priorities and in which process design matters. These findings underscore the headline finding: Managing uncertainty is not simply a technical optimization problem, but a governance challenge that requires significant attention to institutional arrangements.

This chapter examines the implications of this research and provides recommendations aimed at informing efforts to integrate climate adaptation into infrastructure planning and decision-making in situations with high degrees of uncertainty and complexity. It emphasizes how this can be done in the context of rapidly shifting institutional environments. The implications and associated recommendations are:

- ***Flexibility and boundary organizations*** - This research suggests that flexibility is a widely supported response to persistent uncertainty. However, there are substantial barriers to adopting more flexible and adaptive approaches in practice. Those looking to overcome these barriers might consider developing ‘productive boundary organizations’ to nurture the kind of dynamic institutions necessary to advance adaptation in situations with substantial uncertainty and ambiguity. Boundary organizations may help groups to clarify the institutional arrangements, resolve differences among perspectives and interests, and remain flexible to changing conditions and new information. This research suggests, however, that attention should be paid to good process design.
- ***Persistent uncertainties and usable science*** – Adaptation efforts need to find ways to marshal usable and widely supported scientific and technical information to inform decision-making, despite persistent uncertainties. Joint fact finding (JFF) may provide an effective way for groups to collaboratively engage in research to arrive at shared *facts* for their adaptation planning. However, JFF processes must remain adaptive in light of persistent change and uncertainty. Scenario planning can offer a way to frame uncertainty within joint fact finding processes.

- ***Role-play simulation exercises for action research*** – This research project revolved around the use of an RPS exercise, which proved to provide both rich research insights and a valuable learning experience for participants. Other researchers should consider using exercises to efficiently and effectively engage in experimentation and reflection with stakeholders. However, there are some caveats that require attention, including the importance of exercise design, debriefings and supplementary research instruments, and convincing participants of their value.

Flexible adaptation and productive boundary organizations

This research suggests that adapting to climate change is often a *governance* problem. As discussed in the last chapter, participants indicated that uncertainty is as much a product of unclear and contested institutional arrangements as it is a scientific issue. Unanswered questions of responsibility, standards and risk tolerance, data interpretation, and the reconciliation of competing interests and priorities stifle attempts to integrate adaptation into planning and decision-making. Models of both climate adaptation planning and adaptive policy-making have been proposed, but they pay little attention to the governance challenges inhibiting their implementation.

Proponents of more flexible approaches might consider fostering new boundary organizations as a way to nurture the institutional arrangements necessary to address these governance challenges. At their best, these can be what Quick and Feldman (2014) call ‘productive boundary organizations’ suited to ‘building efficient resilience’. That is, multi-stakeholder, problem-oriented hybrid arrangements that help parties to clarify the questions of who, what, when and where associated with flexibly adapting infrastructure (or infrastructures) to climate change. Participants in this research across all three case cities strongly indicated that they see multi-stakeholder deliberation as an important component of effective adaptation. Boundary organizations can provide the fora for these deliberations. However, as discussed below, significant attention should be paid to their design.

In terms of what these organizations might look like, we can learn from past innovations when infrastructure systems faced difficult challenges and stakeholders convened to devise collective responses. Various examples emerged throughout this research. One model is *De Verkeersonderneming* (i.e., the Traffic Management Company) in Rotterdam, which was created as a venue for key stakeholders to plan, share information and make complementary decisions in the face of massive infrastructure projects in and around the Port of Rotterdam, including the reconstruction of the A15 highway and the *Maasvlakte 2* port expansion. The Company was created and is jointly supported by the Municipality of Rotterdam, the Rotterdam Metropolitan Region, the national Ministry of Transport, Public Works and Water Management, and the Port of Rotterdam Authority. An advisory board that includes representation from Deltalinqs (the port businesses’ association), the neighboring Municipality of Spijkenisse, the Chamber of Commerce, the Dutch Association for Transport and Logistics, the Province of South Holland and the Rotterdam-Rijnmond

Police, in addition to the four founders, meets regularly. Solutions that have come out of the process include scattering shift changes, enhancing public transit connections to lower vehicle volume, particularly at peak times, and providing recreational opportunities in the port area to further scatter travel times. These measures are relatively simple, but required coordination among private firms and various public agencies. Similar, albeit less formalized, cooperation emerged around the Central Artery (i.e., big dig) highway project in Boston. The business and institutional communities worked with the project team to minimize disruptions. These arrangements can help groups of stakeholders facing significant shared challenges in uncertain institutional terrains to collaboratively devise approaches that maximize the individual and collective benefits while minimizing the costs. Boundary organizations can explicitly recognize the need for collaboration and engage representatives from different agencies, organizations and stakeholder groups both within and outside of government, responding to the high level of support participants in this research placed on multi-stakeholder deliberation, and the importance of good process suggested by the exercise runs.

As evinced by the efforts underway in the three case cities, collaborative, multi-stakeholder hybrid institutions may be emerging to advance climate adaptation. However, as discussed in the previous chapter, it is not clear that these collaborations are always translating into concrete changes in planning and decision-making in practice. The exercise runs, reflections of participants based on their wider experiences, and the lessons that can be gleaned from hybrid institutions in other domains suggest that the success of these organizations is contingent on a variety of factors, including:

- Getting the right people to the table;
- Scoping processes widely enough to capture systemic complexity, but narrowly enough that they remain relevant to and able to handle specific decisions that need to be made;
- General buy-in and organizational support, including provision of the necessary resources; and
- Ensuring that processes have the support of the ultimate decision-makers, and that there are direct avenues from any outcomes back into decision-making.

Most existing climate adaptation efforts seem to fall short on one or more of these fronts. For example, participants from transportation agencies in all three cities that are directly involved in climate adaptation reflected positively on their initiatives, but other participants from the same agencies were often unaware of what is happening and unclear on how adaptation will work in practice. This suggests that broad organizational buy-in and direct avenues to concrete decision-making are not yet established.

Ancillary insights and recommendations addressing these shortcomings and undergirding the recommendation to develop boundary organizations for flexible adaptation include:

Leadership and support

Participants in this research repeatedly reflected that successful adaptation planning processes require that different actors both inside and outside government take them seriously, participate, and invest resources. In most cases, different agencies and actors come to the table because someone in a leadership position has convinced, enticed, and/or directed them to do so. This can be an elected official, a senior bureaucrat, or someone else with the political or moral sway. For example, the National Climate Change Secretariat in Singapore has sway because it is under the Prime Minister's office, and engages other high-level politicians and bureaucrats to chair key committees. The Mayor of Boston is using his stature to bring his counterparts from cities and towns across the region together to discuss how they might take a coordinated approach to adaptation. There is no guarantee of success, but leadership and high-level support seem to be important contributors to the emergence of viable adaptation efforts.

Collaborative boundary organizations

While they varied in their opinions on *who* should be at the table, participants in all three cities emphasized the importance of bringing various actors together. As discussed in the previous chapter, participation in the role-play simulation exercise increased the level of importance participants place on multi-stakeholder engagement. In response, boundary organizations can be collaborative in nature, bringing together actors from the various relevant government agencies and external stakeholder groups. Stakeholder engagement is widely advocated for in different contexts, but there are particularly good reasons to engage in collaborative, multi-stakeholder planning when adapting to climate change: Many of the threats are new, and thus are not yet fully understood and accounted for in existing planning processes and institutions; many of the risks and possible adaptive actions cross sectorial and political boundaries, necessitating conversations among different stakeholders, and across levels of government and neighboring jurisdictions; and efforts often ask stakeholders to take proactive steps before the risks are fully understood, and in the face of changing conditions.

Public participation in planning and decision-making varies from place to place, but is often a critical, and sometimes legally required, part of good governance. Unfortunately, it is often ineffective. Among other shortcomings, processes often involve a subset of the population that is not necessarily representative of wider public opinion or the full breadth of stakeholder groups. At the municipal level, participants in public meetings are often the 'usual suspects', engagement is not always productive, and the participants themselves are often left frustrated that 'no one listens to them'. There are alternatives that can be more appropriate. Consensus-based collaborative models that intensively involve *representatives* of different stakeholder groups – like neighborhood associations, business associations and environmental advocacy organizations – can be a viable alternative (see Innes and Booher, 2010; Margerum, 2011; Susskind, McKearnan and Thomas-Learner, 1999; and Susskind and Cruikshank, 1987). Instead of government officials making plans, and then presenting them and providing limited opportunities for feedback in public meetings, identified stakeholder representatives are involved extensively throughout the process. These

participants represent the interests of their constituencies, and help to keep them abreast of what is happening. This approach does not preclude broader public engagement. In fact, transparency in information sharing, and the provision of opportunities for other members of the public to provide feedback often remains critically important.

An important consideration is effective and appropriate stakeholder representation. Intermediary stakeholder organizations are suggested as a way to incorporate the interests of larger constituencies when having each stakeholder at the table is neither feasible nor effective. These organizations can translate and legitimize emerging ideas and activities among their constituents, as they are often ahead of the curve, and serve as clearinghouses for information and other resources in both directions. This research suggests that some groups are more astute at self-organizing and finding effective ways to engage than others. For example, A Better City (formerly the Artery Business Committee) was formed to facilitate information sharing and coordinate between the business and institutional communities and the project team during the aforementioned 'big dig' highway megaproject in Boston. The group was highly influential as the project unfolded, and continues to remain very active (see Luberoff, 2004a, 2004b). Similarly, Deltalinqs is active in various efforts in Rotterdam, including the city's climate initiatives. Other advocacy organizations can also be very influential, as evinced by the stature of the Boston Harbor Association in the region's adaptation efforts. However, there is variation across cities and among different constituencies. In Singapore, there is a strong tradition of cross-agency coordination – land use, transportation and other infrastructure planning are highly integrated – but very little history of involving outside actors and a relatively weak civil society. In the context of climate adaptation, the National Climate Change Secretariat involves agencies working together, but there is virtually no involvement of outside actors. Even in Boston and Rotterdam, certain groups are better represented than others. Some neighborhood organizations like NOAH in East Boston are very active, but this does not seem to be common across the city, and even in NOAH's case most of their adaptation efforts are community-based, rather than focusing on holding government agencies accountable for the protection of a marginalized and vulnerable community.

In order to be effective, intermediary organizations should be engaged and provided with the support and resources necessary to actively participate. Recent events suggest that even in Singapore there are increasing demands from non-governmental stakeholders for a seat at the table. Efforts to foster wider representation from various constituencies need to recognize that support will be required; civil society needs to be strengthened if there are to be viable partners. Foundations play a critical role in supporting non-profits and developing capacity in the United States, which may be instructional elsewhere.

Groundwork and internal champions

Processes in the three case cities suggest that the emergence of effective boundary organizations can be evolutionary. Participants discussed the importance of background work at the staff level to establish the foundation for emerging efforts. As a next step in the formalization process, units that act as internal champions within organizations and bridge to external actors with similar agendas have proven valuable. An example is the GreenDOT

office within the Massachusetts Department of Transportation. GreenDOT serves as an internal champion for sustainability initiatives, including efforts to lower greenhouse gas emissions by promoting public and non-motorized forms of transportation. It also serves as an intermediary. It can appreciate the goals, priorities, and constraints of units across the DOT, and external actors pushing the agency to enhance its sustainability efforts, including other government agencies (e.g., the Executive Office of Energy and Environmental Affairs) and non-governmental actors (e.g., the Conservation Law Foundation). Similar units – or the extension of offices like GreenDOT - may prove valuable in the context of adaptation.

It is subsequently recommended that: First, agency staff be given both the freedom and opportunities to network around issues like climate adaptation as a precursor to formal efforts. Second, these efforts become formalized as intermediary units within organizations as they evolve.

Flexibility in boundary organizations

As discussed throughout this dissertation, flexibility is an important feature of institutions able to manage uncertainty. Participants expressed strong support for flexible and adaptive approaches as a means for proceeding despite persistent uncertainties. In response, it is recommended that flexibility be a cornerstone of boundary organizations established to advance adaptation. Models of adaptive policymaking have been proposed (see, for example, Marchau, Walker and van Wee, 2010; Rahman, Walker and Marchau, 2008; Walker, Haasnoot and Kwakkel, 2013). They show great promise in theory, but pay insufficient attention to the complex institutional environments that they must be integrated into if they are to be successful. The barriers are particularly substantial in fragmented neopluralist environments, like that in the Boston area. Adaptive policymaking seems unrealistic as long as project approval and funding is so linear, with, for example, the progression of transportation infrastructure projects through the MPO process, one-off funding from Federal Highway Administration block grants, construction via fixed contracts, and so on. Boundary organizations can help by playing coordinating roles in ongoing monitoring and evaluation functions, and facilitating different funding arrangements. It is recommended that actors experiment with different organizational designs to develop the model that meets their needs and is compatible with preexisting institutional norms. The delegation of responsibility to an actor to mind the future and shepherd flexibility, which is discussed later in this section, is one possible approach.

Process design and negotiation skills

Another key lesson from this research is that *process* matters. The exercise outcomes were significantly shaped by the actions of both the chairs (i.e., those filling the deputy director of the Transportation Agency role) and other participants. This was found to be true even in ostensibly rational Singapore. As a result, it is recommended that those designing boundary organizations and new institutional arrangements focus on providing good process. For stakeholders participating, the advice is to recognize that these deliberations are negotiations in which their performance has direct impacts on the outcomes. It is

subsequently recommended that stakeholder groups put thought into who they are sending, and consider how they can hone their negotiation skills.

An important element of good process is appropriate structure, which good chairs can provide and maintain. Some of the RPS exercises floundered because they lacked structure. In contrast, the best chairs engaged participants to systemically get as much information on the table as possible, help their groups to interpret the situation, and facilitate broadly supported agreements. They employed active listening techniques, charted information and interests, and conducted straw polls at various points to clarify the terrain. The rules chairs imposed also had implications, for better or worse. The best example is the Rotterdam risk assessment group, in which the chair invoked a unanimous consent rule; this allowed a single party to hold out and ultimately block agreement. Good process design and facilitation skills warrant substantial attention as efforts are initiated.

Another recommendation is the employment of chairs that are substantively neutral. In the exercise runs, some chairs were at least ostensibly neutral, while others clearly guided processes towards their own interests and/or perspectives. Parties reflected during the debriefings that there are substantial advantages to having neutral facilitators. Professional neutrals can provide both process expertise and neutral services. Alternatively, some organizations are well situated to play neutral facilitative roles. In Boston, for example, a participant reflected that the Metropolitan Planning Organization might be a suitable facilitator in a real-world process like that simulated in the exercise, focused on integrating climate risks into transportation infrastructure decisions. The MPO already plays a coordinating function around transportation infrastructure, and is widely seen to be a neutral forum.

All parties should seek to develop their negotiation skills and tactics to maximize gains for both the group writ large and their respective organizations or constituencies. In the exercise runs, savvy negotiators created more value, and took more for themselves. For example, the environmentalist in the Singapore scenarios group was very persuasive in deducing the interests of others and devising an alternative option that they could support in order to generate an outcome that met her concerns while also leaving others satisfied. In contrast, the concerns of some stakeholders were underappreciated in some exercise runs because those there to represent them did not aggressively or effectively do so. This underscores that organizations and stakeholder groups are wise to consider who they are sending to the table, and invest in developing their negotiation skills.

Another recommendation for those facilitating deliberative processes is to get as much information on the table as possible. Whether or not information was disclosed was a significant factor in the exercise runs; undisclosed information on both financing and technical issues was a key factor in the groups that failed to reach agreement. The senior engineers behaved differently in the different groups; reticence to disclose data on the rail option stifled agreement with the Rotterdam scenarios group. As participants reflected afterwards in Rotterdam, people often assume that they have all the necessary information and know a priori what the best outcome is, and subsequently enter deliberations talking rather than listening. Again, good negotiation skills and processes that encourage richer

deliberations can make a big difference in whether or not groups can reach consensus, and the quality of their agreements.

Contextual differences across cases

While many findings of this research transcend the three case cities, important differences also emerged, as discussed in the last chapter. Acknowledging this, it is recommended that new boundary organizations tailor to the unique characteristics of the institutional environments they will be situated within. Some of these differences may relate to the governance regimes discussed earlier, while others relate to the unique particulars present in any case. In general, one-size-fits-all approaches to climate adaptation are likely not sufficient. Specific recommendations responding to the unique challenges in each of the case cities examined in this research include:

Neopluralist Boston

In Boston, participants acknowledged up front that there are costs and benefits, winners and losers associated with each of the options presented in the RPS exercise, and parties were very forward in expressing their preferences based on their interests. These explicitly recognized interests definitively bounded what was possible; options B (elevated road) and C (road through a wetland) were written off early in all cases because of vocal opposition from the community and environmental groups respectively. Participants reflected that, as in their real world situations, these constituencies hold significant sway, including by threatening lawsuits. The importance of the interests and priorities of the various stakeholders, and their ability to influence the 'zone of possible agreement', is often underappreciated in climate adaptation efforts in the United States. It is recommended that proponents of adaptation find ways to reconcile technically wise responses with the interests and priorities of stakeholder groups. Bringing different interests to the table can help ensure that they are appreciated. On the other hand, the risk is that the most appropriate adaptive responses are taken off the table because of pressure from small but influential constituencies that are very actively engaged, while inchoate future interests are underrepresented. The question of how *the future* might be better represented in deliberations requires greater attention. One potential option is to appoint high-level officials with the explicit task of taking and arguing for a long-term view, like the Delta Programme Commissioner's (2014) role in the Netherlands. This high-level figure is expected to operate above politics and take responsibility for long-term strategic thinking in accordance with the 'Delta Plans' and 'Delta Decisions'.

As discussed in the last chapter, Boston's planning environment is highly fragmented both across levels of government and geographical jurisdictions. Stakeholders might consider building new institutional arrangements off of existing organizations like the Metropolitan Area Planning Council (MAPC), but the challenge is to sufficiently empower an organization that does not have legal authority and has had limited success marshaling a regional approach in the past. Municipalities and other stakeholders need to see the value in buying in to a collective process. The Mayor of Boston's convening of regional mayors suggests

that there may be opportunities to strengthen and empower the MAPC, and/or other vehicles for regional collaboration.

Acute resource shortages are another substantial barrier in Boston, pressing agencies to meet basic needs rather than integrating (perceived) longer-term and optional or 'soft' issues like addressing climate risks into their planning and decision-making. Funds have been found to enhance climate preparedness post-disaster, particularly in the New York City region post Sandy, and New Orleans and Gulf Coast area post-Katrina. However, it should not take disasters to change the criteria in project evaluation, nor to find funding to support adaptive measures. It is recommended that agencies earmark resources for climate adaptation, and revise funding and project assessment criteria to account for climate risks.

Neo-corporatist Rotterdam

The presence of various interests and priorities was also acknowledged in the exercise runs in Rotterdam, but rather than providing clear definition to a 'zone of possible agreement', it motivated 'poldering' (i.e., deliberative discourse) in pursuit of an optimal outcome that parties would support. Unfortunately, the relatively unbounded deliberations did not lead to conclusive agreement. Participants lamented that real-world poldering can be similarly ineffective insofar as it fosters robust discussion but does not always translate into the most appropriate and timely outcomes. Furthermore, as in Boston, some parties have significantly more influence than others. These problems may be particularly acute around complex issues like climate adaptation that lack established neo-corporatist institutions. New institutional arrangements could capitalize on the poldering tradition in this new domain. It is subsequently recommended that stakeholders institutionally formalize poldering to enhance decision-making around climate adaptation.

Fortunately, there are examples of robust processes that marry modern consensus-based approaches with the traditional poldering mentality that can be learned from. These efforts facilitate deliberation that is genuine, yet pointed towards reaching consensus. One example is the extensive effort that was organized around the *Maasvlakte 2* expansion to the Port of Rotterdam, which brought together representatives from various stakeholder groups, including businesses interests, environmentalists, recreational interests, neighboring communities, government agencies, and the port itself. The facilitated process ultimately resulted in an agreement that all parties accepted, which featured some design changes to lessen the environmental impact, compensatory wetland restoration elsewhere along the coast, and the establishment of beaches and infrastructure for swimming, kite surfing and fishing. The tradition of poldering may make multi-stakeholder deliberations more natural in the Dutch context, but prove insufficient for generating agreement in this kind of complex situation that falls outside traditional neo-corporatist institutions. More intentional, facilitated processes like that around the *Maasvlakte 2* are recommended to channel the polder mentality into new arenas and more productive outcomes.

Semi-authoritarian Singapore

Whether or not something is seen as a 'national priority' in Singapore dictates whether or not it receives attention. Participants in the exercise runs in Singapore focused much less on the individual interests of different stakeholder groups, and instead on deducing and addressing shared national priorities. Because they were not explicitly identified in the exercise, many assumed that economic interests were paramount and thus accommodated the port's needs. Climate adaptation efforts are underway in Singapore, but are not identified as high priority at this point. Raising their profile is an important step in seeing adaptation integrated into planning and decision-making at all levels in Singapore's hierarchical governance regime. Rather than downplaying or concealing climate risks, as seems to be the case, the National Climate Change Secretariat should be empowered to enhance understanding of the risks both throughout government and wider society.

As discussed previously, stakeholder groups with divergent interests are becoming increasingly vocal in Singapore, yet thus far their interventions have proven largely unproductive. The government may be increasingly pressured to find ways to integrate divergent interests into planning and decision-making, rather than ignoring them, at which point it can learn from best practice examples of multi-stakeholder engagement elsewhere. Rather than adopting the status quo approaches to public engagement common throughout many Western democracies - which often feature frustrating and unproductive public meetings and information dissemination rather than dialogue - Singaporean agencies might consider how they could develop a facilitated, multi-stakeholder model based on the consensus building approaches discussed earlier in this chapter. A more deliberative democratic model might prove compatible with the rational and 'facts-based' approach to decision-making government officials pride themselves on, insofar as a good process can help parties to get all of the information on the table and find creative outcomes that optimize on various fronts. It also offers a way to engage stakeholders in meaningful deliberation while maintaining government control; even in the United States, most consensus building processes are advisory in nature, as agencies cannot officially abdicate their responsibility.

Potential challenges to flexible boundary organizations

One concern with the kind of hybrid institutional arrangements and boundary organizations described above is that they are typically ad hoc and dynamic in nature, which can bring advantages and disadvantages. A participant directly involved in the Traffic Management Company in Rotterdam asserted that its temporary nature is great, as it is goal-oriented and designed to meet a particular purpose, then conclude. However, climate adaptation efforts are likely to require longer-term monitoring and adaptive decision-making. This necessitates longer-term stakeholder buy-in and institutional support. The unstable nature of organizational priorities and arrangements in the United States, particularly across changes in administration, was identified as a barrier to long-term thinking. This could present substantial challenges to the long-term viability of adaptation efforts. One way in which this might be overcome is by creating governance arrangements that operate at arms length from and among multiple administrations, like

the Metropolitan Planning Organizations. Such arms-length arrangements could also address concerns that these efforts will become politicized, as they could operate above the political fray. However, this is contingent on them having independence, including in their funding arrangements.

External resources may be found to support adaptation efforts, providing stability and a degree of independence. Initiatives like the Rockefeller Foundation's *100 Resilient Cities* program are helping cities and regions to coordinate adaptation efforts. Local foundations, non-governmental organizations, business groups, and academic and research institutions are also providing invaluable support. However, it is important to recognize that these resources are typically contingent on adopting certain methodologies, which may or may not be contextually appropriate and acceptable to agencies, and may not be stable over the long term either.

A potentially significant downside of creating new boundary organizations and fostering separate institutional arrangements is that they can remain disconnected from the agencies and other stakeholders that must actually implement adaptive measures in practice. As discussed previously, many adaptation efforts seem to be struggling with making the transition from planning to concrete changes in decision-making. Addressing these disconnects requires fostering deep buy-in among all of the key partner organizations, and generating recommendations, regulations, information, and so on that directly addresses their needs and fit within their modes of operation. This remains a substantial challenge in all three case cities.

Opposition to the type of multi-stakeholder processes introduced above may be particularly acute in Singapore, particularly insofar as the recommendations include involving non-governmental actors. Agencies need to see the value of engaging other actors, rather than assuming that their presence will be corrupting. It is hoped that agencies will experiment with new modes of engagement, learn from those experiences and devise deliberative arrangements that are locally appropriate.

Persistent uncertainties and usable science

A key takeaway in this research is that uncertainty is a pervasive factor in planning and decision-making, and not just a result of uncertainty around the science. Nonetheless, uncertain and dynamic scientific and technical information appears to be a challenge when planners and decision-makers are used to working with relatively fixed standards and sanctioned forecasts.

Persistent uncertainty and unclear standards require different relationships between scientific and technical experts (and the products they generate), and the decision-makers and other stakeholders that use those products. Joint fact finding (JFF) may be an effective way to mediate between science and policy in the context of adaptation. This is a response for the call in the last chapter for enhanced science-policy interactions. JFF processes have

been employed in various situations. In the context of adaptation, JFF may be an ongoing component of planning and decision-making to support flexible and adaptive responses to changing conditions and new information. Groups engaged in adaptation planning may consider using scenario planning as a way to frame uncertainty, but should recognize its challenges and limitations when concrete decisions are to be made.

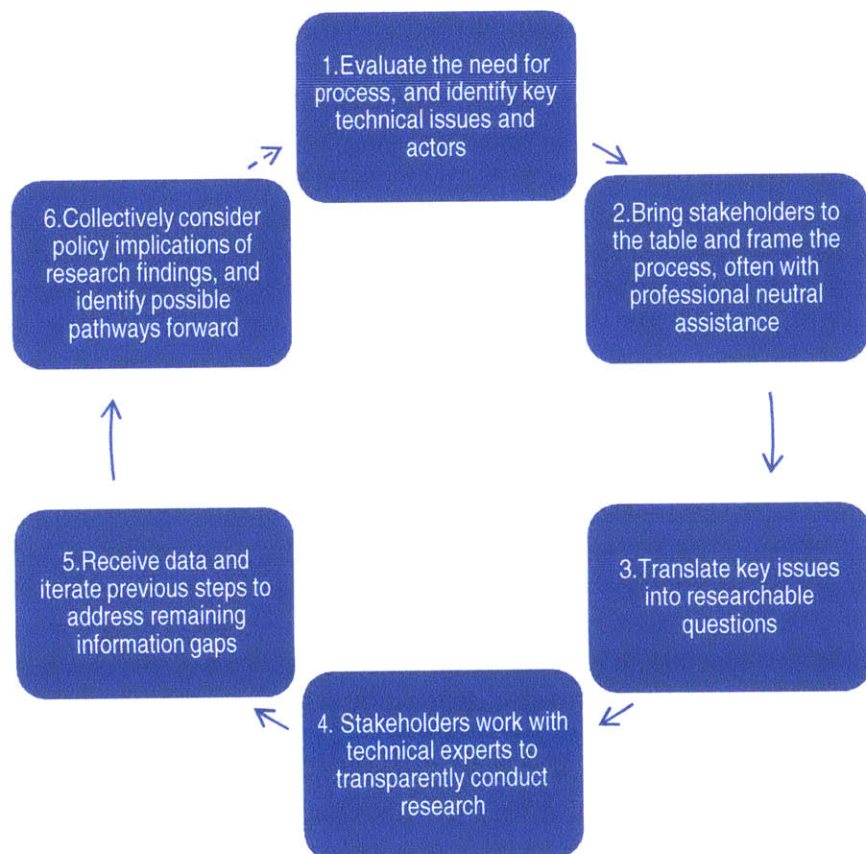
Managing uncertainty: Joint fact finding

Many adaptation efforts are paralyzed by uncertainty, or, more accurately, lack of clarity and consensus around how to respond to uncertainty. Scientific and technical information must meet the *saliency*, *legitimacy*, and *credibility* criteria established by Cash et al. (2002) if it is to be usable. Participants in this research expressed varying opinions on the place and legitimacy of models in the decision-making process. Some feel that they should be deferred to as neutral sources of information. In contrast, many others (in Rotterdam and Boston) emphasized the political nature of models and other forecasts, asserting that they are often manipulated or interpreted to support particular outcomes. Participants asserted that decision-makers are typically not given the full suite of information, nor do they treat models as neutral information. A participant in the Netherlands reflected: “With alternative forecasts and alternative scenarios, the unfavorable ones are discarded very early in the process; the further down in the decision-making process you go, the less objective the information is, the less well-balanced. [...] If we can spend 5 billion, then we should, and we should get rid of all the forecasts that say it’s unnecessary”. Many participants concurred that the use of models and forecasts can quickly become political. “[Policy makers] abuse the models, or they change their rules”, said one, adding that “it is a way of calculation, and you can calculate anything you want, and if there is a little bit too much, you change the rules! [...] I think the models are so inaccurate that you can calculate many, many things out of [them]. It starts with the traffic modeling, which is inaccurate, and then you get the emissions modeling, and then the emissions uptake by nature - there are so many uncertainties!”

In response, Corburn (2009) argues that we need processes of co-production, in which climate science is not treated as separate from, but rather integrated into collaborative processes aimed at crafting solutions. Joint fact finding (JFF) has been recommended as a way to operationalize co-production and enhance saliency, credibility, and legitimacy in practice. JFF is appropriate when there are factual gaps and it is not immediately clear, or parties do not agree on, how those gaps should be filled. That is, JFF can help when scientific and technical information is a necessary ingredient in a decision-making process, but there are questions around how that data should be framed, collected and interpreted. JFF has been employed to collectively identify disagreements or gaps in the data and devise broadly supported ways of answering these questions (Ehrmann and Stinson 1999). Stakeholders are directly involved in framing research questions; working with technical experts to design, and often implement, their research programs; and receive the outcomes within wider collaborative fora (Adler et al., 2011; Karl, Susskind and Wallace, 2007; McCreary, Gamman and Brooks, 2001). Stakeholders will not always agree on what is important and are likely to interpret the data differently, but can explicitly focus on these differing values and interpretations, and on uncertainties remaining in the data.

Climate adaptation disrupts the traditional JFF model, as persistent uncertainty and dynamic conditions make the arrival at a set of stable ‘facts’ impossible. Nonetheless, this research suggests that decision-makers need technical information on which they can base their decisions at various points. Rather than one-off efforts, *iterative* JFF processes may continue indefinitely, facilitating ongoing learning. They can help groups to arrive at technical information that is *salient, credible* and *legitimate* for their purposes at important junctures, while explicitly acknowledging and planning for its contingent nature. *Figure 6.1* outlines an iterative approach that may be appropriate in the context of climate adaptation planning. This approach to JFF responds by adding an iterative element, closing the loop from considering the policy implications and pathways forward back to evaluating the need for technical information on an ongoing basis. It adopts characteristics of ‘adaptive management’ to encourage flexible decision-making. Adaptive management may be employed in concert with collaborative governance processes to remain attuned and responsive to changing conditions and newly emerging information over time (Doremus et al. 2011; Holling 1978; Lee 1993; Williams, Szaro and Shapiro 2009). Other tools like mediated modeling may also be employed to support groups as they work through complex and dynamic situations (van den Belt 2004).

Figure 6.1 – Steps in an iterative joint fact finding process



Source: Schenk et al., forthcoming.

Adapted from: MIT Science Impact Collaborative and the Consensus Building Institute, 2013

While they did not use the term 'joint fact finding' to describe it, some participants in this research did emphasize the value of this kind of process. "I think the best thing you can do is agree upfront on what models you are using with all the stakeholders - so if we are talking noise, we are using this model, 'does everyone agree?' - You prevent that everyone will use his own model to get his own data", said a participant. This is an affirmation of traditional JFF.

Another factor is literacy in models, which can increase through participation in a JFF process. "I think its a matter of knowledge as well, because to understand which models are good and which are not good is only reserved for a privileged few [...] There is a huge group of users - not just politicians, but also the policy-makers and the engineers - who don't really understand, could not distinguish between a number that has scientific backup and a number that doesn't. And I think that's the biggest problem, in a sense, from the modeling perspective". Collaboratively engaging with data, working with modelers and other experts, and being a part of the process can help parties to understand the models and how to interpret them, enhancing their saliency, credibility, and legitimacy.

A critique leveled at JFF is that it can be a challenge for scientists and other technical experts that think of their work as value-free, and are used to working more or less independently from decision-makers and other stakeholders. Ostensibly, there is a divide between the technical and the political within government agencies; interests dominate the political, while data dominates the technical. Participants in all three cities, but especially Singapore, underscored this divide. In fact, some participants in Singapore expressed concern with blurring this line, seeing it as a corruption of their 'data-driven' approach to decision-making. The counterargument is that there is value to be had in fostering mutual understanding, even if one believes that a clear division between the technical and the political can be maintained. A participant reflected: "Decisions should be taken by those who are representing all people; you can't leave that to technicians [...] Yes, it is good to involve [technical experts], but it requires something of them as well - it requires that they speak a language which is understandable for politicians, and not only understandable, but it has to be useful to them." By engaging, technicians can come to better appreciate the needs of policy-makers and understand the other factors that they take into account when making decisions. On the other side, decision-makers and other stakeholders can appreciate the nature of science and the models technicians and other experts are employing. However, this requires openness on both sides. Matters can become even more complicated when decision-makers no longer feel that they are getting the information they need, or question its saliency, credibility, and/or legitimacy. Or, conversely, when technical experts feel unable or uncomfortable with providing data in the way decision-makers would prefer. However, this may make JFF all the more invaluable. Participants reflected that the RPS exercise helped them to gain new appreciation and start to overcome the general lack of mutual understanding and appreciation; this is just one of the benefits of bringing technical and political actors together within multi-stakeholder processes.

Scenarios and scenario planning

This research revealed a paradox – participants almost universally expressed support for and interest in using scenarios to frame uncertainty, yet largely ignored them in the RPS exercise runs. To the degree that they did seem to influence the deliberations, it was by accentuating the presence of uncertainty, complicating matters and making reaching agreement harder. The debriefings and interviews provided some insights into this contradiction, resulting in some recommendations around the opportunities and limitations for the use of scenarios in practice.

Participants with previous experience using scenarios reflected that it is really the *process of scenario planning* that they found useful. By going through the process, decision-makers and other stakeholders get a better understanding of the nature and breadth of the uncertainties they face. The exercise simply presented four scenarios, introducing them as the product of a scenario planning effort, which participants found hard to internalize. Furthermore, many participants argued that they ultimately ‘need a number’ (i.e., a standard) to plan and design towards when it comes to making concrete investment decisions like that simulated in the exercise. The scenarios version did not provide a single design standard that they could work with, causing participants to either default to the worst-case scenario (i.e., ‘wet and busy’) or conclude that there was too much uncertainty to make a decision. As discussed in the last chapter, participants identified various reasons why they feel they need unitary standards, including professional and organizational standards and norms, and questions of liability and responsibility. These findings underscore the substantial challenges associated with using scenarios, but do not mitigate the importance of acknowledging uncertainty in planning and decision-making, and the value scenarios can provide in illustrating these uncertainties.

A recommendation derived from these findings is that proponents should be realistic about the benefits of both the process and products of scenario planning. It can provide tremendous value as groups grapple with developing a shared understanding of the uncertainties they face. However, the products they develop may have limited value in separate decision-making processes, particularly in the public sector. They may be informative, but they are not directly transferrable into decision-making. The fact that the greater value is in the process underscores the importance of engaging decision-makers and other key stakeholders directly in scenario planning efforts if they are to be influential.

The second recommendation is that adaptation efforts establish provisional design standards for decision-making, while explicitly recognizing that they are contingent and providing opportunities for adaptation as conditions change and new information emerges. The debate between picking a model and using it because ‘all models are wrong, but some models are useful’ and rejecting models because they are inadequate in the face of ‘deep uncertainty’ persists but seems to be a false dichotomy. Participants asserted that they need parameters like design storms, derived from probabilistic risk assessments, when making concrete decisions, but they do not need to accept these parameters as fixed. The issue lies not in accepting that a condition will be designed to for today, but in locking

infrastructure into that condition for the future. Tools like scenario planning can help decision-makers to appreciate the need for flexibility and map potential pathways forward as conditions change, while accepting that today's contingent decisions will be made based on the best information available now, coupled with policy choices around issues of risk tolerance and the weighing of the costs and benefits associated with different options. Unfortunately, as discussed above, our governance systems often fall far short of accommodating this kind of flexibility.

Role-play simulation exercises for action research

Role-play simulation (RPS) exercises are a type of serious game in which participants tackle a simulated challenge similar to one they might face in the real world, but abstracted to create a sandbox-like environment for experimentation and learning (Schenk, 2014). Exercises can put participants into situations that they may face in the future; expose them to tools, approaches and potential solutions that they might consider adopting; and help them to appreciate the interests and perspectives of others. RPS exercises are being used in various contexts to help groups advance climate adaptation planning by (Mendler de Suarez et al., 2012; Schenk, 2014; Susskind et al., 2015):

- Facilitating both individual and social learning;
- Catalyzing collective action;
- Providing venues for the brainstorming of new ideas; and
- Researching how actors might react in certain circumstances.

This research employed an RPS exercise as a somewhat innovative although not unprecedented research tool. In the spirit of action research, the goal was to provide value to those that participated in the exercise runs, while generating research insights (Schenk and Susskind, 2014). The experience suggests that RPS exercises can be a valuable tool for researchers that aim to directly engage in reflection and problem solving with stakeholders. The insights gleaned from the exercises are informative to both those that participated as they start to grapple with climate adaptation in their real world planning and decision-making, and to this research.

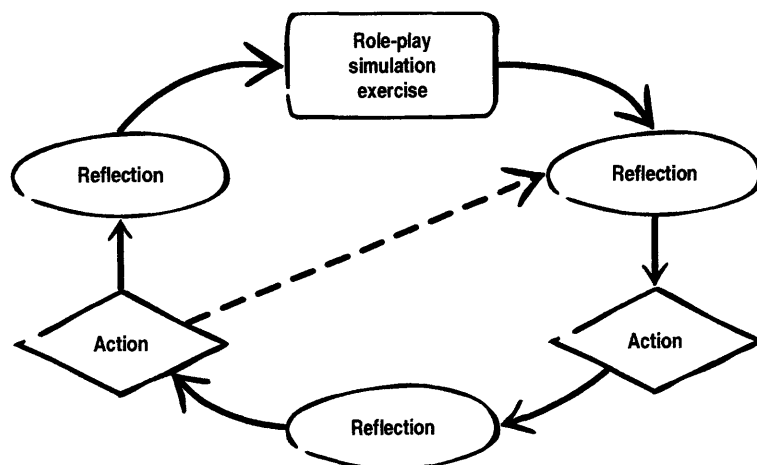
The pre- and post-exercise surveys, debriefing conversations and follow-up interviews indicate that participants learned a great deal. There were statistically significant increases from pre- to post-exercise in key areas, including: Participants' perceptions of how significant of a factor uncertainty is in climate adaptation; how important they feel it is to engage with other decision-makers and stakeholders; and their self-reported awareness of climate change and the risks it may pose. Participants were nearly unanimous in reporting that they learned from the experience. Key themes that emerged when asked what they learned include: The importance of good process, and how different process design and actions on the part of participants can shape the outcomes; the importance of bringing parties together and getting information on the table to generate wise and broadly

supported solutions; and the nature of uncertainty in decision-making, and how it might challenge them to reconsider the ways in which they make decisions.

This experience also suggests that RPS exercises can be very informative from a research perspective. Key stakeholders were willing to engage with this project in all three case cities because they saw it as an opportunity to experiment with others. The decisions they made in the RPS runs and how they reflected on those decisions were highly insightful, undergirding the research findings discussed throughout this dissertation. However, researchers should take a few caveats into account when considering their use: First, attention must be given to exercise design if they are to be effective. Second, no matter how comprehensive the design process, exercises present a simplified and imperfect version of reality. This necessitates extensive debriefing and the application of supplementary research tools to support reflection and enhance learning for both participants and researchers. Third, parties need to see value in participating. Value can be provided, at least in part, by making exercise workshops opportunities for parties that otherwise rarely meet to discuss adaptation issues. This requires significant attention to who is invited.

The effective use of the RPS exercise in this research to induce reflection among participants suggests that they should be considered as a viable approach to action research. RPS exercises can provide a valuable short circuit in the action-reflection cycle (see *figure 6.2*). Participants can simulate an 'action' step, experimenting at low-cost and when real action is not yet feasible. In this context, participants considered how they might respond to uncertain climate risks in project-level decision-making before most of them have been asked to do so in reality. This challenged them to reflect on how they could manage uncertainty, highlighted some of the factors that they would need to take into account, and introduced alternative approaches to both decision-making and framing uncertainty (i.e., the scenarios).

Figure 6.2 - Role-play simulation exercises in the action-reflection cycle



Source: Adapted from Schenk and Susskind, 2014

RPS exercises are most effective if they get at the issues and dynamics that participants are or will be wrestling with as they tackle the challenge they face. They must be credible to participants, while introducing them to something novel and invoking reflection. Participants in this research were asked to assess the accuracy of the RPS exercise in various respects – including who was at the table, the options available, and the method of decision-making – in the post-exercise survey. The results varied from city to city and among the various questions, but largely validated that the exercise approximated their realities, and/or presented a plausible future. The credibility of the exercise was a product of extensive background research and testing, requiring substantial time. It also required the application of best practices in exercise design. The importance of credibility and resonance with participants suggests that there is significant value in creating RPSs tailored to each context, rather than simply using preexisting exercises off the shelf. While important for comparative purposes, a downside in this research was that the same RPS exercise was used across all three cities, reducing how realistic it was in each case. The design process drew from and elements were included to resonate across the three, but some things were foreign to participants. The clearest example of this is that the exercise has two levels of government, while there is only one level in city-state Singapore. The efficacy of RPS exercises for action research is at least somewhat contingent on good design that resonates with participants while presenting something new to invoke reflection.

However, the discrepancies between present and plausible future realities in each case city and the situation presented in the exercise were not fatal. Value was extracted by reflecting on what was unrealistic in the exercise runs, and why. This required thorough debriefing with participants. In general, no matter how good the design, exercises are imperfect and simplified reflections of reality. Interpretation and translation are absolutely required if they are to be useful for action research. Many of the insights for both participants and this dissertation came not directly from the exercise runs, but from the debriefings and follow-up interviews. RPS exercises can offer a valuable inflection point, introducing various issues and concepts, but much of the learning comes from drawing insights from the experience that can inform decision-making back in the real world. Researchers employing exercises need to both leave ample time for debriefing and provide a framework that will invoke reflection on the relevant themes. From a research perspective, supplementary research tools – which included pre- and post-exercise surveys, interviews and background research in this case – are also very important for triangulating findings.

Effective debriefing requires a certain degree of interrogation. Some of the turns and outcomes in the exercise runs were likely unrealistic, compared to the real world situations the participants were coming from. An example is the influence of the environmentalist in one of the Singapore runs. Nonetheless, discussion around why the environmentalist was influential when similar actors would not be at the table in a parallel real world situation was informative. In that case, the particular player's ability to make what others perceived to be strong, factual arguments won them over. Participants reflected that they did not think 'greenies' would engage in the same way in the real world. However, they felt that the power of the 'logical' argument to win the day in their rationalist paradigm was realistic, and telling as adaptation evolves and arguments are made around how it should be integrated into planning and decision-making.

A third caveat is that parties need to believe the exercise will provide value if they are going to be convinced to participate. As discussed previously, participants in this research overwhelmingly reflected afterwards that they found it to be a useful experience. However, some actual and potential participants were skeptical ahead of time. Parties do not necessarily believe 'a game' can be useful. One way to both provide value and entice participants is by promoting workshops featuring exercises as opportunities for parties with a shared emerging challenge, like adapting to climate change, to meet and get a better understanding of the opportunities and barriers they face, and a sense of each other's perspectives and interests. The workshops run under this workshop achieved this to some degree, although some participants reflected that they could have been more targeted towards groups of relevant stakeholders. For example, the workshop in Boston could have been run with parties involved in the Metropolitan Planning Organization (MPO) transportation planning process, plus some additional stakeholders with relevance to the issue, perhaps even under the auspices of the MPO. That would have provided more focus and value to participants facing a shared, real-world challenge. RPS exercises should focus on a particular challenge or issue and serve as opportunities for parties to meet and advance their thinking, which they can subsequently translate to their shared real-world situation.

Closing remarks

Flexibility may very well be an appropriate approach when uncertainty about the future is a barrier to making long-term infrastructure decisions today – whether due to climate change or any other issue. At the conceptual level, flexible and adaptive approaches to both design and policy-making are increasingly well understood. Furthermore, feedback from infrastructure-related stakeholders in Singapore and Rotterdam suggests that flexibility is widely supported.

However, significant work remains if adaptive approaches are to be institutionalized into planning and decision-making in practice. This research suggests that there are some significant barriers to widespread implementation. These include:

- Questions of responsibility, as adaptive measures cross institutional boundaries and require longer-term engagement;
- Challenges in coordinating among the different stakeholders;
- Finding ways to finance ongoing, adaptive measures, rather than treating projects as one-off capital expenditures;
- Accounting for competing interests and priorities within a complex, adaptive management regime;
- Integrating flexibility into established professional and institutional norms; and
- Integrating flexibility into legal and regulatory standards.

This paper has introduced some ways in which these barriers may be tackled, including via collaborative multi-stakeholder engagement; the fostering of hybrid institutions that span traditional institutional boundaries; supporting intermediary organizations that can represent key stakeholder groups; and joint fact finding techniques that use scenarios to generate shared understanding among stakeholders of the uncertainties present, while providing information that is salient, credible and legitimate for decision-making.

The gap between the aspirations in adaptation planning and concrete adaptive measures suggests that there is significant work to do if climate adaptation – including the management of uncertainty – is to be institutionalized in practice. Given the paradigmatic shift involved in moving from ‘predict and act’ to ‘monitor and adapt’ approaches, the fact that progress is slow is perhaps unsurprising. Nonetheless, we can and should continue to learn from examples in other contexts, and support experimentation with new approaches.

Appendix 1 - Pre-Exercise Interview protocol

Interviews were conducted orally, and were semi-structured in nature, so the actual questions and the order in which they were asked varied.

1. Please explain your role in the planning and decision making process around [the infrastructure in question].
2. What information do you use to make decisions around infrastructure like this? Who do you get this information from?
3. Who else at various levels of government, and from outside stakeholder groups, has influence over the long-term design, construction, operation and maintenance of this infrastructure?
4. How is planning and decision-making between these agencies coordinated? How is information shared?
5. What vulnerabilities does this infrastructure face? How (if at all) are these being addressed? Who is addressing them?
6. In addressing these challenges (if any), do agencies work together? What is the nature of these relationships? Are there any challenges faced in working together across traditional institutional boundaries?
7. Is there uncertainty you must deal with in your planning and decision-making? How do you address it?
8. Do you use any tools for managing uncertainty, like scenario planning?
9. Do you think the infrastructure is vulnerable to climate change? If so, how?
10. Has any formal analysis been done to study its vulnerability to climate change? If so, by whom? If not, who should be responsible for this kind of research?
11. If climate change-related vulnerabilities have been uncovered, how are they being incorporated into the planning and decision-making process?
12. Who would you expect to act upon this kind of information, if the research uncovers vulnerabilities?
13. What kind of certainty would you need before you alter your decisions in light of the risks associated with climate change? What knowledge and data (at what scale, in which units and with what certainty) would you optimally have to effectively plan for climate change?
14. How high is climate change on the agenda, despite these uncertainties and compared to other threats or policy issues?

Appendix 2 – Pre-Exercise Survey

By participating in this workshop you are also participating in a research project being conducted by Todd Schenk from the Environmental Policy and Planning group of the Department of Urban Studies and Planning at the Massachusetts Institute of Technology (MIT). The purpose of the study is to explore how managers and other stakeholders can adjust their infrastructure-related planning and decision-making procedures in the face of dynamic risks and uncertainty, particularly those posed by climate change. The results of this study will be included in Mr. Schenk’s PhD dissertation. **We ask that you read the information below, and ask questions about anything you do not understand, before deciding whether or not to participate.**

- Your participation is voluntary. You have the right not to answer any question, and to stop your participation in the exercise, survey and/or follow-up interview at any time or for any reason. We expect that the exercise and surrounding discussions will last approximately four hours, and that the follow-up interview in the coming days will last about one hour.
- You will not be compensated for your participation.
- Unless you object, we plan to put your name and title on a list of those that participated. We will not, however, attribute any assertions or quotes to you without first coming back to you to request your explicit permission to do so. Otherwise, the information you share will be confidential.
- Mr. Schenk would like to record both the exercise and the follow-up interview so that he can use it for his own reference while analyzing the data. We will not record without your permission. If you do grant permission to be recorded, you have the right to revoke recording permission and/or end your participation at any time. As with any written notes, these recordings shall remain confidential and will not be distributed publically in any way.

This project will be completed by September 2015. All recordings will be stored in a secure workspace until a maximum of five years after that date. The audio and video files will then be destroyed.

I understand the procedures described above. My questions have been answered to my satisfaction, and I agree to participate in this study and be recorded. I have been given a copy of this form.

Your name _____

Your signature _____ Date _____

Signature of Investigator (Todd Schenk) _____ Date _____

Please contact Todd Schenk at tschenk@mit.edu or (617) 230-8480 with any questions or concerns.

If you feel you have been treated unfairly, or you have questions regarding your rights as a research subject, you may contact the Chairman of the Committee on the Use of Humans as Experimental Subjects, M.I.T., Room E25-143b, 77 Massachusetts Ave, Cambridge, MA 02139, phone (617) 253-678

Harboring Uncertainty

Pre-Exercise Survey

Thank you for your willingness to participate in the *Harboring Uncertainty* workshop and exercise. I kindly ask you to complete this pre-exercise survey. It will help me to get to know you, and your answers will ultimately inform the broader research on decision-making in the face of uncertainty. I intend to use the data collected, but promise not to share your answers in any format that would make you personally identifiable. In other words, I commit to maintaining your confidentiality.

If you have any questions or concerns, please do not hesitate to speak to me now or later. I can be reached at tschenk@mit.edu or (617) 230-8480.

Name _____

Organization _____

Position _____

E-mail address _____

FOR EACH OF THE QUESTIONS BELOW, PLEASE CIRCLE THE (MOST) CORRECT ANSWER. PLEASE ANSWER FROM YOUR OWN PERSPECTIVE. FOR THE QUESTIONS ON A SCALE FROM 1 TO 7, 1 IS THE LEAST CONFIRMING (I.E., 'NOT AT ALL' OR 'VERY POOR') AND 7 IS THE STRONGEST CONFIRMATION (I.E., 'ALWAYS' OR 'VERY').

Part I. Planning and Decision-Making

1. On average, how frequently do you interact with experts and other stakeholders inside government, but outside your own agency (if you are in government) as you plan, and make decisions or recommendations (either in-person or electronically)?

- More than once a day
- Once every day or so
- Once a week
- Once or twice a month
- Less than monthly

2. On average, how frequently do you interact with experts and other stakeholders outside government as you plan, and make decisions or recommendations (either in-person or electronically)?

- More than once a day
- Once every day or so
- Once a week
- Once or twice a month
- Less than monthly

3. When you interact with stakeholders outside your department, it is typically via...

- Formal meetings only
- Mostly formal meetings, but some informal
- Mostly informal interactions, but some formal
- Only informal interactions

4. How important is it that you engage with other decision-makers and stakeholders as you plan and make decisions (1 being *not at all* and 7 being *very*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

5. Have you ever participated in a facilitated multi-stakeholder decision-making process?

- Yes
- No

6. *IF YES*: How would you rate that process, or those processes on average if you have participated in more than one (1 being *very poor* and 7 being *very good*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

Part II. Uncertainty

7. How much of a problem is uncertainty in general (not just from climate change) to you and your organization as you plan and make decisions (1 being *not at all* and 7 being *very critical*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

8. How do you and your agency typically deal with uncertainties (if more than one, choose the most common)?

- Follow official policies or guidelines
- Consult experts for their best projections
- Plan for worst-case scenario
- Maintain flexibility
- Other (please write):

9. In rank order of preference (1 being highest to 5 lowest), what is the best way to deal with uncertainties?

- ___ Follow official policies or guidelines
- ___ Consult experts for their best projections
- ___ Plan for worst-case scenario
- ___ Maintain flexibility
- ___ Other _____

10. Do you ever use multiple scenarios (i.e., consider multiple possible futures rather than a single forecast) when you have uncertain factors in your planning and decision-making?

- Yes
- No

11. How useful might the introduction of multiple scenarios (i.e., multiple possible futures) be in your work (1 being *not at all* and 7 being *very*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

Part III. Climate Change

12. Compared to all of the other challenges infrastructure stakeholders will face in the next ten years, how big of an issue do you expect adapting to climate risks to be (1 being *not at all* and 7 being *very*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

13. How much of a factor do you expect climate change to be in your organization's planning and decision making over the next ten years (1 being *not at all* and 7 being *very*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

14. To what degree is climate change already on the radar of your organization?

1 - 2 - 3 - 4 - 5 - 6 - 7

15. In rank order (1 being highest to 8 lowest), what are the reasons why climate change is not a higher priority in infrastructure planning and decision-making?

- ___ Other issues are more pressing
- ___ Lack of downscaled climate information (i.e., info on local impacts)
- ___ Lack of technical knowledge on how to adapt
- ___ Lack of resources (financial, staff bandwidth, etc.)
- ___ Legal and/or regulatory restrictions
- ___ Responsibility uncertain or undefined
- ___ Lack of signals and inability to proactively prepare
- ___ Other _____

16. To what degree is uncertainty a factor in how your organization views and plans for climate change adaptation?

1 - 2 - 3 - 4 - 5 - 6 - 7

17. How aware would you say you are of climate change and the risks it may pose?

1 - 2 - 3 - 4 - 5 - 6 - 7

18. How confident are you that you and your organization will be able to manage the risks and uncertainties climate change poses?

1 - 2 - 3 - 4 - 5 - 6 - 7

19. How confident are you that other stakeholders will be able to manage the risks and uncertainties climate change poses to infrastructure systems?

1 - 2 - 3 - 4 - 5 - 6 - 7

Appendix 3 – Exercise Debriefing Questions

Outcomes

- What (if any) agreement did your group reach? Why that option? How did you weigh them comparatively?
- What were the barriers or challenges that made reaching agreement difficult?
- Compared to the 'real world', are these outcomes realistic? Why or why not?

Responsibility

- Who took responsibility for adapting to climate change here?
- Who is taking responsibility in the real-world? Is responsibility clearly allocated? Should it be? To whom?

Process

- Was there a drive among the group to seek consensus, or to extend conflict? How realistic is this compared to your real world?
- How might we generate better process around adaptation in the real-world? What are the advantages and disadvantages of multi-stakeholder processes?
- Were you conscious of any hierarchy among the roles?

Positions

- Did you feel yourself shifting positions as the conversation unfolded? What led to or facilitated these shifts?
- Going in, did you feel that your own character was being irrational or unreasonable? Having walked in their shoes, do you now understand why they might hold that position?

Uncertainty

- How substantial of a challenge was uncertainty in the exercise? How did you manage it?
- How significant of a factor is uncertainty in your own real world decision-making?
- How do you manage uncertainty in the real world?
- Should we attempt to resolve uncertainty or embrace it? How can we best do either?

Scenarios

- SCENARIOS GROUPS: How important were the scenarios presented to your decision-making in the exercise? What role did they play?
- What are the limitations or challenges of using the scenarios? What are the advantages?
- Can you see them being used in your own work? Do you use them already?

Forecasts

- RISK ASSESSMENT GROUPS: How did you deal with the uncertainty in the forecasts? Was it an issue for anyone?
- How do you deal with uncertain forecasts in your own work? Is their uncertainty ever an issue?
- What are the limitations or challenges of using single forecasts (vs. scenarios)? What are the advantages?

Reflection

- In what ways was the situation similar to and different from your own? Decision-making process... Situation/problem... Stakeholders involved... Options...
- Is there anything from the exercise that you might adopt into your own work and/or institutions?
- What are the barriers that prevent their adoption?
- If not, what are the alternatives currently employed that are already generating better results?

Appendix 4 - Post-Exercise Survey (Scenarios Version)

Thank you for participating in the *A New Connection in Westerberg* role-play simulation exercise. We are grateful for your time and insights. As we endeavor to learn from the experience, I kindly ask that you please complete this brief post-exercise survey. I may also be in touch in the coming days to request a follow-up interview. As with the pre-exercise survey, I intend to use the data collected, but promise not to share your answers in any format that would make you personally identifiable. In other words, I commit to maintaining your confidentiality.

If you have any questions or concerns, please do not hesitate to speak to me now or later. I can be reached at tschenk@mit.edu or (617) 230-8480.

Name _____ Group # _____ Role played _____

PLEASE ANSWER THESE QUESTIONS FROM YOUR OWN PERSPECTIVE, NOT BASED ON THE ROLE YOU PLAYED IN THE EXERCISE. FOR THE QUESTIONS ON A SCALE FROM 1 TO 7, 1 IS THE LEAST CONFIRMING AND 7 IS THE STRONGEST CONFIRMATION.

Part I. The Exercise

1. How similar was the situation or problem presented in the exercise to the 'real world' you operate within (1 being *very different* and 7 being *very similar*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

2. How similar were the characters involved to those in the 'real world' you operate within?

1 - 2 - 3 - 4 - 5 - 6 - 7

3. How similar was the interaction between the characters involved to the 'real world' you operate within?

1 - 2 - 3 - 4 - 5 - 6 - 7

4. How similar was the tool introduced for evaluating options (i.e., the scenarios) to those you use in the 'real world'?

1 - 2 - 3 - 4 - 5 - 6 - 7

5. How similar were the options or solutions presented to those you normally have?

1 - 2 - 3 - 4 - 5 - 6 - 7

6. How similar was the method of decision-making in the exercise to that in the 'real world' you work in?

1 - 2 - 3 - 4 - 5 - 6 - 7

7. How important is it that you engage with other decision-makers and stakeholders as you plan and make decisions (1 being *not at all* and 7 being *very*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

8. Did you learn anything from the exercise that you might be able to apply to your own planning and decision-making?

- Yes
- No

9. Briefly, what did you learn from the exercise?

Part III. Uncertainty

10. How significant of a problem is uncertainty (not just from climate change) to you as you plan and make decisions (1 being *not at all* and 7 being *very*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

11. In rank order of preference (1 being highest to 5 lowest), how do you think you should deal with uncertainties?

- ___ Follow official policies or guidelines
- ___ Consult experts for their best projections
- ___ Plan for worst-case scenario
- ___ Maintain flexibility
- ___ Other _____

12. The exercise you participated in introduced *scenarios* as one way to identify and plan for multiple possible futures. How useful do you think scenario planning (or a similar method) could be in your own organization (1 being *not at all* and 7 being *very*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

13. An alternative to scenarios would be a *risk assessment* that provides probabilistic estimates or forecasts of future conditions. Do you ever use probabilistic risk assessments when you have uncertain factors in your planning and decision-making?

- Yes
- No

14. How useful do you think probabilistic risk assessments (or a similar tool) could be to you and your organization (1 being *not at all* and 7 being *very*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

Part III. Climate Change

15. Compared to all of the other issues infrastructure stakeholders will face in the next ten years, how big of an issue do you expect climate-related risks to be (1 being *not at all* and 7 being *very*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

16. How significant of a factor do you expect climate change to be in your organization's planning and decision making over the next ten years (1 being *not at all* and 7 being *very*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

17. How confident are you that you and other stakeholders will be able to manage the risks and uncertainties climate change poses?

1 - 2 - 3 - 4 - 5 - 6 - 7

18. How has your confidence in the ability of your organization and other stakeholders to adapt to the risks climate change poses changed as a result of your participation in this exercise (1 being *less confident*, 7 being *more confident* and 4 being *neutral*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

19. To what degree is uncertainty a factor in climate change adaptation (1 being *not at all* and 7 being *very*)?

1 - 2 - 3 - 4 - 5 - 6 - 7

20. How aware would you say you are of climate change and the risks it may pose?

1 - 2 - 3 - 4 - 5 - 6 - 7

Appendix 5 – Follow-Up Interview Protocol

Interviewee name:

Interview date:

1. Is climate change on the radar in the planning and decision-making processes you are involved in? If not, do you think it should be? Did your opinion on this change at all as a result of your participation in the exercise?
2. What is your agency doing to prepare for the risks and uncertainty posed by climate change?
3. Are you able to do this alone, or does it require collaborating with other agencies? What does this collaboration entail, and with whom?
4. Is this type of collaboration common? If not, how might it be advanced? If so, how does it typically evolve?
5. How are differing perspectives and interests among agencies reconciled when they are not complementary?
6. How much of a factor is *uncertainty* in adapting to climate change? How is it best managed?
7. What, if anything, did you learn from the exercise? Were you surprised by anything?
8. How closely did the exercise reflect the realities of decision-making in your experience? What was similar? What is different in the ‘real world’?
9. Did the actors around the table in the exercise reflect those that would be engaged in or influence decision-making in your experience? Who was missing? Who was present, but would have little influence in reality?
10. Do you ever engage with other stakeholders in a similar way as was simulated via the exercise? If so, can you describe how this typically happens? If not, what are the barriers to engagement processes like this? Who would you expect to initiate processes like this?
11. The exercise loosely introduced scenario planning (if applicable) as one way to deal with uncertainty around the future. Do you ever use this particular tool in your decision-making? If not, how do you handle deep uncertainty around the future in decision-making?

12. What are the advantages and disadvantages of scenario planning, and/or other tools for dealing with uncertainty? What are the barriers to their wider use?
13. What are the barriers preventing greater attention to climate change?

Appendix 6 – Code List

The following codes were applied to qualitatively analyze the RPS exercise runs, debriefings, and interviews using TAMS Analyzer, an open source qualitative research program. For more information on TAMS, see <http://tamsys.sourceforge.net>.

AgencyOrJobDescription	Descriptions of agencies and/or the job descriptions of interviewees. Questions were asked in the interviews to elicit a better understanding of how the various agencies and actors relate to the planning and decision-making process, particularly vis-à-vis managing the risks posed by climate change.
ClimateRisks	A key component of the interviews - particularly in the preliminary stage - was to enumerate the risks climate change poses, how urgent those risks are in the eyes of stakeholders and what is being done to address these risks.
ClimateRisks_Radar	The extent to which climate risks are on the radar of the respective organization and/or interviewee.
ClimateRisks_RadarNO	The extent to which climate risks are NOT on the radar of the respective organization and/or interviewee.
ClimateRisksAddressing	Comments outlining how stakeholders are (or could be) addressing the risks posed by climate change. That is, the concrete ways - both technically and policy-wise - in which the risks posed by climate change are or may be addressed.
ClimateRisksAddressingReactive	A subset of the previous code, but explicitly tags more reactive measures to address climate change (as opposed to more proactive measures).
ClimateRisksDegree	Comments on the degree to which stakeholders believe that climate change poses an imminent threat to the infrastructure they are concerned with, and thus should be considered in planning and decision-making at the present time.
ClimateRisksIssues	The variety of risks that climate change may pose to infrastructure, as enumerated by participants.
CompetingInterestsAndFactors	Other interests and factors that influence decision-making, beyond climate change.
DecisionMaking	A core element of this research is enhancing our understanding how decisions around infrastructure planning are (or may be) made. This code tags comments on how decisions are (or should be) made in the eyes of interviewees.
DecisionMaking_Collaborative	Collaborative approaches to decision-making used.
DecisionMaking_DecisionSupportTools	The use of models, scenarios and other instruments to support decision-making.
DecisionMaking_Financing	The importance, influence and consideration of financing in infrastructure planning and decision-making.
DecisionMaking_GoalsObjectives	What are the goals and objectives of the decision-making process, and how do

	they influence what happens and the outcomes reached.
DecisionMaking_Hierarchy	The importance of hierarchy (or lack thereof) in decision-making institutions.
DecisionMaking_InformationGaps	Information was not available, or not provided, that would have made a difference in decision-making (particularly in the RPS exercise runs).
DecisionMaking_Institutionalization	The institutionalization of new factors, including but not limited to climate change, into decision-making.
DecisionMaking_LawsRegulations	Laws and regulations mandate certain approaches to decision-making.
DecisionMaking_Leadership	The role of a leader or chair in facilitating decision-making, both in the RPS runs, and in how participants describe their real world processes.
DecisionMaking_LowHangingFruit	These are decisions that might be called 'win-win', 'work with work', 'low-cost', or that are otherwise very easy to accomplish.
DecisionMaking_Politics	The political elements of decision-making. I.e., decisions made by politicians, and/or influenced by political factors.
DecisionMaking_Rationality	The elements of decision-making that participants ascribed to 'rationality'.
DecisionMakingBlackBox	Interviewees identified various data points or directives for which the underlying decision-making processes are opaque. This code tags references to processes ill-understood by outsiders, which we might call 'black box' processes.
DecisionMakingFormal	Some decision-making is more formal in nature, following pre-established procedures and resulting in concrete directives that implementing agencies and other stakeholders are expected to follow. This code tags statements related to such formal decision-making processes.
DecisionMakingInformal	In contrast to the above, some decision-making processes are more informal in nature. They only loosely follow pre-established procedures (or do not at all), and instead make decisions on an ad hoc basis.
DecisionMakingMultiStakeholder	Solitary decision-makers make some decisions, while many others are made in concert with (or at least after significant and meaningful consultation of) other stakeholders. This code tags references to the engagement of various stakeholders in decision-making processes.
DecisionMakingPrivatized	Private actors are involved in various aspects of the design, construction, maintenance and use of infrastructure. This code tags statements on how private actors relate to and engage in planning and decision-making. It not only refers to 'privatized' (i.e. formerly public, but now outsourced to private entities) decisions, but the decisions and actions of private actors in general.
Followup	This code is for my reference, tagging statements and notes that I need to follow-up on (i.e., people, documents or ideas that I need to contact or explore further).
Information	Information was not available, or not provided, that would have made a difference in decision-making.
PortPolicy	The role of ports in decision-making is a key element of this research. This code tags references to the policies and practices of the port vis-à-vis decision-making

processes around infrastructure.

ProfessionalNorms	The professional norms of actors involved in planning and decision-making, and how they influence the ways in which they approach processes, their own perspectives, and the ultimate outcomes.
RPS_KeyMoments	Key statements, decisions and actions that shaped the arc of what happened during the RPS exercise runs.
RPS_Learning	What participants learned from participating in the RPS exercise, as reported in the debriefings and follow-up interviews.
RPSOutcome	The outcomes of the RPS exercise runs. This tag is applied as groups conclude their interactions within the exercise, and report back during the debriefings.
RPSrealisticness	How true the RPS was, and was not, to reality in one or more ways (process, tools, decisions, actors, etc.).
StakeholderRolesResponsibilitiesPower	The roles, responsibilities, power and influence of different stakeholders within the decision-making process (in the real world, not the exercise runs).
Uncertainty	Uncertainty is a key challenge in adapting to climate change, often limiting progress. This code tags references to uncertainty in decision-making and how it is managed.
Uncertainty_BarrierChallenge	Uncertainty as a barrier or challenge to decision-making.
Uncertainty_ExpertForecastsProjections	The use of expert forecasts and projections - typically single variables with some probability distribution - to make decisions.
Uncertainty_Opportunity	The opposite to uncertainty as a challenge or barrier. Instead, it provides an opportunity.
UncertaintyAcceptanceTolerance	Rather than adapting to risks, accepting them, increasing tolerance to them.
UncertaintyFlexibility	Flexibility in design and implementation is one way to overcome uncertainty. This code tags references to inserting flexibility into decision-making, allowing infrastructure managers to remain responsive as conditions change and new knowledge on the state of the system emerges.
UncertaintyModels	Modeling is one way in which planners and decision-makers attempt to better understand or frame uncertain futures. This code tags references to modeling, interpreted broadly to include not only formal models, but any projections on what the future may bring, including the use of scenarios.
UncertaintyRobustness	Robustness - that is, designing and building to higher standards than might otherwise be the case - is another way to manage uncertainty. Planners and decision-makers can project 'worst-case scenarios' and build to them, injecting robustness into infrastructure. This code tags references to robustness in design and implementation.

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